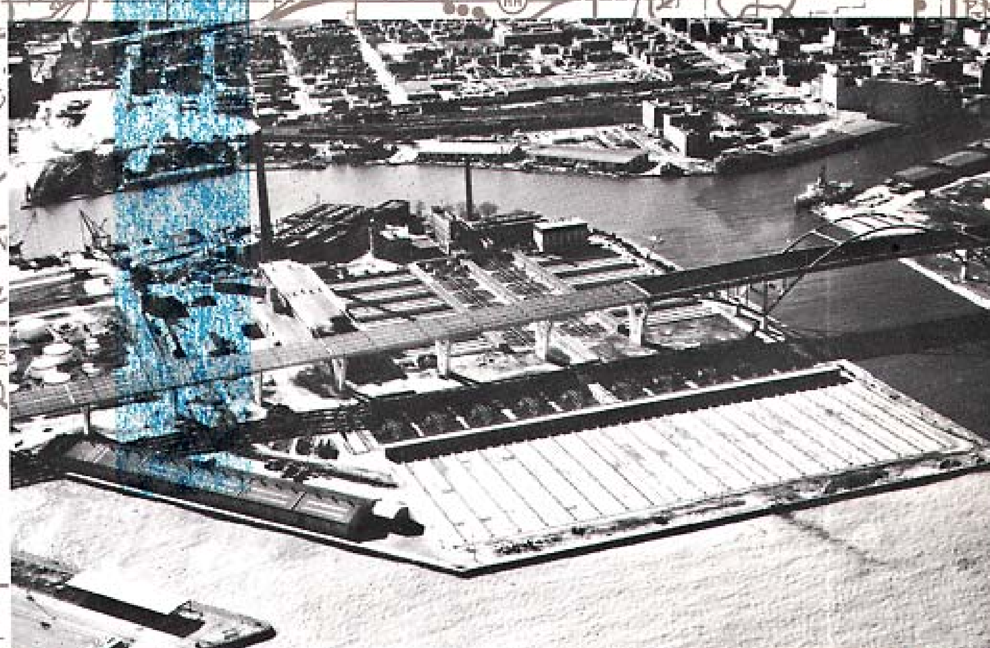
PLANNING REPORT NO. 16

A REGIONAL SANITARY SEWERAGE SYSTEM PLAN FOR SOUTHEASTERN WISCONSIN



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

COMMISSION MEMBERS

KENOSHA COUNTY
Donald L. Klapper
Donald E. Mayew
Francis J. Pitts

RACINE COUNTY
George C. Berteau,
Chairman
John Margis, Jr.
Leonard C. Rauen

MILWAUKEE COUNTY
Richard W. Cutler,
Secretary
Emil M. Stanislawski
Norman C. Storck, P.E.

WALWORTH COUNTY
Anthony F. Balestrieri
John B. Christians
Eugene A. Hollister

OZAUKEE COUNTY
Thomas H. Buestrin
John P. Dries
James F. Egan

WASHINGTON COUNTY
Lawrence W. Hillman,
Vice-Chairman
Paul F. Quick
Joseph A. Schmitz,
Treasurer

WAUKESHA COUNTY
Charles J. Davis
Lyle L. Link
Theodore F. Matt

TECHNICAL COORDINATING AND ADVISORY COMMITTEE ON REGIONAL SANITARY SEWERAGE SYSTEM PLANNING

Ray D. Leary, Chairman . . . . Chief Engineer and General Manager, Milwaukee-Metropolitan Sewerage Commissions
Lester Hoganson, Vice-Chairman . . . . City Engineer, City of Racine
William D. McElwee, Secretary . . . . Chief Environmental Planner, SEWRPC
Vinton W. Bacon . . . . Professor, College of Applied Science and Engineering, University of Wisconsin-Milwaukee
Anthony F. Balestrieri . . . . Consulting Engineer, Elkhorn, Wisconsin; Commissioner, SEWRPC
Kurt W. Bauer . . . . Executive Director, SEWRPC
Richard C. Dess . . . . Engineering Administrator, City of Wauwatosa
Thomas G. Frangos . . . . Administrator, Division of Environmental Protection, Wisconsin Department of Natural Resources
Herbert A. Goetsch . . . . Commissioner of Public Works, City of Milwaukee
Harlan D. Hirt . . . . Chief, Planning Branch, Region V, U. S. Environmental Protection Agency
Donald K. Holland . . . . Director of Public Works, City of Kenosha
George A. James . . . . Acting Director, Bureau of Local and Regional Planning, Wisconsin Department of Local Affairs and Development
Raymond J. Kipp . . . . Dean, College of Engineering, Marquette University
Thomas A. Kroehn . . . . District Director, Southeast District, Wisconsin Department of Natural Resources
Theodore W. Meilahn . . . . County Surveyor, Washington County
Melvin Noth . . . . Director of Public Works, Village of Menomonee Falls
John W. Peters . . . . Assistant Director, Planning and Relocation Branch, U. S. Department of Housing and Urban Development, Milwaukee
Herbert E. Ripley . . . . Director of Environmental Health Services, Waukesha County Department of Health
Donald A. Roensch . . . . Director of Public Works, City of Mequon
Rodney M. Vanden Noven . . . . Director of Public Works, City of Waukesha
Frank A. Wellstein . . . . City Engineer, City of Oak Creek
Henry B. Wildschut . . . . County Highway Commissioner and Director of Public Works, Milwaukee County
James F. Wilson . . . . District Supervisor, Farmers Home Administration, U. S. Department of Agriculture
Harvey E. Wirth . . . . State Sanitary Engineer, Division of Health, Wisconsin Department of Health and Social Services

The following individuals also participated actively in the work of the Committee: John Cain, Chief, Water Resources Planning Section, Wisconsin Department of Natural Resources; Lawrence A. Ernest, Plant Superintendent, Milwaukee-Metropolitan Sewerage Commissions; Donald W. Hook, Chief, Water Quality Monitoring Section, Planning Branch, Region V, U. S. Environmental Protection Agency; Robert M. Krill, Chief, Municipal Wastewater Section, Wisconsin Department of Natural Resources; William Manske, Sewer Research Engineer, Department of Public Works, City of Milwaukee; Jerry McKersie, Chief, Water Quality Evaluation Section, Wisconsin Department of Natural Resources; Duane H. Schuettpelz, Water Quality Evaluation Specialist, Wisconsin Department of Natural Resources; Bernard G. Schultz, Assistant District Director, Southeast District, Wisconsin Department of Natural Resources; Gilbert Vosswinkel, Chief Sewer Design Engineer, Department of Public Works, City of Milwaukee; Donald G. Wieland, Division Engineer, Milwaukee-Metropolitan Sewerage Commissions; and Eugene F. Wojcik, Water Resources Planner, Region V, U. S. Environmental Protection Agency.

COMMISSION STAFF

Kurt W. Bauer, P.E. . . . . Executive Director
Harlan E. Clinkenbeard . . . . Assistant Director
Keith W. Graham, P.E. . . . . Assistant Director
Donald N. Drews . . . . Administrative Officer
John W. Ernst . . . . Data Processing Manager
Philip C. Evenson . . . . Chief Community Assistance Planner
Mark P. Green, P.E. . . . . Chief Transportation Planner
Michael J. Keidel . . . . Chief of Planning Research
Leland H. Kreblin . . . . Chief Planning Illustrator
William D. McElwee, P.E. . . . . Chief Environmental Planner
Bruce P. Rubin . . . . Chief Land Use Planner
Sheldon W. Sullivan . . . . Chief of Data Collection

Special acknowledgement is due Mr. Stuart G. Walesh, P.E., SEWRPC Hydraulic Engineer and Mr. Jerome Chudzik, P.E., SEWRPC Senior Planner, for their efforts in the conduct of this study and the preparation of this report. It is also with sincere thanks and appreciation that the Regional Planning Commission wishes to hereby acknowledge the efforts of the Aerial Photo Interpretation Class of the Geography Department of Carroll College under the direction of Dr. Benjamin R. Richason, Jr., Chairman of the Department of Geography and Karl W. Emrich, Assistant to the Chairman. The following class members obtained the aerial photographs of the existing sewage treatment plants in the Region for use in this planning report: Melissa D. Creamer, Michael G. Dorn, Charles L. Hamilton, Jean A. Hervert, Kenneth E. Johnson, Roger R. Ross, Joseph C. Ruys, Mark W. Sheets, and Ching-Chi Wu.

PLANNING REPORT
NUMBER 16

A REGIONAL SANITARY SEWERAGE SYSTEM PLAN FOR SOUTHEASTERN WISCONSIN

Prepared by the
Southeastern Wisconsin Regional Planning Commission

P. O. Box 769
Old Courthouse
916 N. East Avenue
Waukesha, Wisconsin
53186

The preparation of this report was financed in part through a planning grant from the U. S. Department of Housing and Urban Development under the provisions of Section 701 of the Federal Housing Act of 1954, as amended.

February 1974

Inside Region $10.00
Outside Region $20.00

(This page intentionally left blank)

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO. EAST AVENUE • WAUKESHA, WISCONSIN 53186 • TELEPHONE (414) 547-6721

Serving the Counties of: KENOSHA
MILWAUKEE
OZAUKEE
RACINE
WALWORTH
WASHINGTON
WAUKESHA

February 22, 1974

STATEMENT OF THE CHAIRMAN

Sanitary sewers are among the most important public works facilities affecting the future development, as well as the overall environmental quality, of an area. In recognition of this fact, the Commission, in 1967, upon completion and adoption of a regional land use plan, undertook the preparation of a regional sanitary sewerage system plan. The planning work was funded by the seven constituent county boards and by the U. S. Department of Housing and Urban Development. Technical policy direction for the study was provided from its inception by a Technical Advisory Committee composed of 24 distinguished public works officials and sanitary engineers representing the major universities and certain state and federal, as well as local, units of government within the Region. The complex technical work involved was carried out by the Commission staff with the assistance of a private engineering firm for certain aspects of the work.

Publication of this report represents the product of over four years of intensive planning effort, culminating in a series of public informational meetings and a formal public hearing in which the findings and recommendations of the work were well received by local elected officials and interested citizens. Some modifications in the plan as recommended by the staff and the Advisory Committee were made by the Commission as a result of the informational meetings and public hearing.

The regional sanitary sewerage system plan as set forth herein contains specific recommendations concerning five major aspects of sanitary sewerage system development: the location and extent of desirable future sanitary sewerage service areas; the location of sewage treatment facilities, together with the level of waste treatment to be provided by these facilities; the general alignment and approximate size of the intercommunity trunk sewers required to extend sewer service from the recommended treatment plant locations into the recommended sewer service areas; the means for abating water pollution from combined sewer overflows in the Milwaukee, Racine, and Kenosha areas; and recommendations concerning several auxiliary plan elements, including clear water elimination and full metering of all sewage flows, including bypasses. Importantly, the plan serves to support and reenforce the adopted regional land use plan, and as such, the plan has extremely important implications for sound land use development within the Region. As has been Commission practice, all of the alternatives to the recommended plan elements considered are also presented, along with the recommended elements.

Several important goals are to be attained through implementation of the recommended regional sanitary sewerage system plan, as set forth herein, including protection of the public health, the abatement of water pollution, the sound investment of public funds in efficient and effective sanitary sewerage systems, the more effective guidance of land use development into a sound areawide pattern, and the wise use of the limited land and water resources of the Region. In addition, the plan should, within the context of the overall regional planning program, serve to meet certain federal planning prerequisites and thereby to continue to qualify the state and local units of government concerned for federal assistance in support of the construction of sanitary sewerage facilities.

As is true of all of the Commission's work, the regional sanitary sewerage system plan is entirely advisory to the local, areawide, state, and federal units and agencies of government concerned. Upon formal adoption of the plan by the Commission, a certified copy thereof will be transmitted to all affected units and agencies of government with a request for their consideration and formal endorsement or adoption and appropriate implementing action. Consistent with previous Commission practice, this report contains a chapter outlining the specific actions required to implement the recommended plan. Plan implementation must necessarily be achieved through the cooperation of all of the governmental units and agencies concerned; and, as such, the plan should serve as an important point of departure for the making of land use, as well as sanitary sewerage facility, development decisions within the Region over the next two to three decades.

In its continuing role of acting as a center for the coordination of plan implementation activities within the Region, the Commission stands ready to provide such assistance as may be requested of it by the various units and agencies of government concerned in implementing the recommended regional sanitary sewerage system plan.

Respectfully submitted,

George C. Berteau

George C. Berteau
Chairman

(This page intentionally left blank)

TABLE OF CONTENTS

List of Appendices

List of Tables

Chapter VI

Chapter XI

Chapter XIII

List of Figures

Figure | Page

Chapter IX

Figure | Page

Chapter X

Chapter XII

Chapter XIV

List of Maps

Map Page

Chapter VII

Chapter VIII

Chapter IX

Chapter X

Chapter XII

Chapter I

INTRODUCTION

The regional sanitary sewerage system planning program is the second major planning program to be undertaken by the Southeastern Wisconsin Regional Planning Commission which has as its objective the preparation of an important element of a long-range, comprehensive plan for the physical development of the entire seven-county planning Region. Because the program is an integral part of a broader regional planning program, an understanding of the need for and objectives of regional planning, and the manner in which these needs and objectives are being met in southeastern Wisconsin, is necessary for a complete understanding of the sanitary sewerage system planning program, its findings, and its recommendations.

NEED FOR REGIONAL PLANNING

Regional planning may be defined as comprehensive planning for a geographic area larger than a county but smaller than a state, united by economic interests, geography, and common areawide problems. The need for such planning has been brought about by important social and economic changes which, while national phenomena, have had far-reaching impacts on the problems facing local government. These changes include rapid population growth and urbanization; increasing agricultural and industrial productivity, income levels, and leisure time; generation of mass recreational needs and pursuits; intensive use and consumption of natural resources; development of private water supply and sewage disposal systems; development of extensive electric power and communications networks; and development of limited-access highways and mass automotive transportation. Under these changes, entire regions like southeastern Wisconsin are being subjected to massive internal migration and attendant urban diffusion, and are thereby becoming one large mixed rural-urban complex. This urban diffusion is, in turn, creating areawide environmental and developmental problems of an unprecedented scale and complexity.

The areawide problems which necessitate a regional planning effort in southeastern Wisconsin all have their source in the rapid population growth and in the urban diffusion occurring within the Region. These areawide problems include, among others: inadequate storm water drainage and increasing flood damages; inadequate water supply and increasing water pollution; increasing demand for outdoor recreation and for park and open-space reservation; inadequate transportation facilities; underdeveloped sewerage and inadequate sewage disposal facilities; and, underlying all of the foregoing problems, rapidly changing and unplanned land use development. These problems are all truly regional in scope since they transcend the boundaries of any one municipality, and can only be resolved within the context of a comprehensive regional planning effort and through the cooperation of all levels of government concerned.

THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) represents an attempt to provide necessary areawide planning services for one of the nation's large urbanizing regions. The Commission was created in August 1960, under provisions of Section 66.945 of the Wisconsin Statutes, to serve and assist the local, state, and federal units of government in planning for orderly and economic development in southeastern Wisconsin. The Commission's role is entirely advisory, and participation by local units of government in its work is on a voluntary, cooperative basis. The Commission is composed of 21 citizen members, three from each county in the Region, who serve without pay.

The powers, duties, and functions of the Commission and the qualifications of the Commissioners are carefully set forth in the state-enabling legislation. The Commission is authorized to employ experts and a staff as necessary to execute its responsibilities. Basic funds necessary to support Commission operations are provided by the member counties, with the budget apportioned among the seven counties on the basis of relative equalized assessed property valuation. The Commission is authorized to request and accept aid in any form from all levels and agencies of government to accomplish its objectives, and is authorized to deal directly with the state and federal governments for this purpose. The Commission, its committee structure, staff organization, and relationship to the constituent counties are shown in Figure 1.

THE REGIONAL PLANNING CONCEPT IN SOUTHEASTERN WISCONSIN

Regional planning as conceived by the Commission is not a substitute for, but a supplement to, local, state, and federal planning. Its objective is to assist the various levels and units of government in finding solutions to areawide developmental and environmental problems which cannot be properly resolved within the framework of a single municipality or county. As such, regional planning has three principal functions:

1. Inventory—the collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis, so that in light of such data, the various levels and agencies of government and private investors operating within the Region can better make decisions concerning community development.

2. Plan Design—the preparation of a framework of long-range plans for the physical development of the Region, these plans being limited to functional elements having areawide significance. To this end, the Commission is charged by law with the function and duty of "making and adopting a master plan for the physical development of the Region." The permissible scope and content of this plan, as outlined in the enabling legislation, extend to all phases of regional development, implicitly emphasizing preparation of alternative spatial designs for land use and for supporting transportation and utility facilities.

3. Plan Implementation—promotion of plan implementation through provision of a center to coordinate the planning and plan implementation activities of the various levels and agencies of government in the Region, and through the introduction of information on areawide problems, recommended solutions to these problems, and alternatives thereto into the existing decision-making process.

The work of the Commission, therefore, is seen as a continuing planning process providing outputs of value to the making of development decisions by public and private agencies, and to the preparation of plans and plan implementation programs at the local, state, and federal levels. It emphasizes close cooperation between the governmental agencies and private enterprise responsible for the development and maintenance of land uses in the Region, and for the design, construction, operation, and maintenance of the supporting public works facilities. All Commission work programs are intended to be carried out within the context of a continuing planning program which provides for periodic reevaluation of the plans produced, and for the extension of planning information and advice necessary to convert the plans into action programs at the local, regional, state, and federal levels.

THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Exclusive of Lake Michigan, these seven counties have a total area of 2,689 square miles, or about 5 percent of the total area of Wisconsin. About 40 percent of the state population lives in these seven counties, which contain three of the seven and one-half standard metropolitan statistical areas in Wisconsin. The Region contains about half the tangible wealth in Wisconsin as measured by equalized assessed property valuation, and represents the greatest wealth-producing area of the state, with about 42 percent of the state's labor force being employed within the Region. The Region contains 153 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 major watersheds. It has been subject to rapid population growth and urbanization, and from 1960 to 1970 accounted for approximately 40 percent of the population increase in the state.

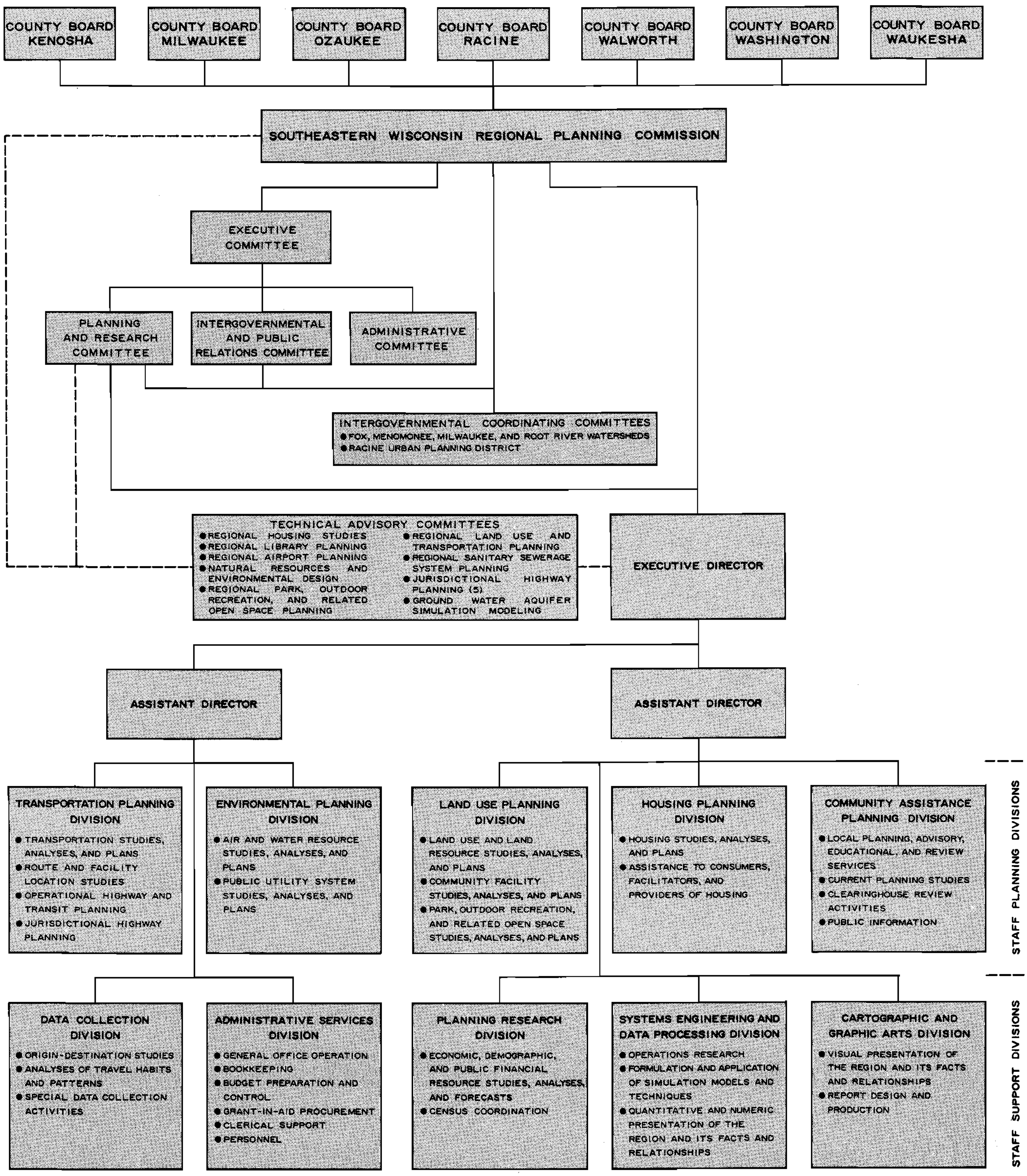
COMMISSION WORK PROGRAMS

Initial Work Program

The Commission's initial work program was directed entirely toward basic data collection. It included six basic regional planning studies, which were initiated in July 1961 and completed by July 1963: a statistical program and data processing study, a base mapping program, an economic base and structure study, a population study, a natural resources inventory, and a public utilities study.

Figure 1

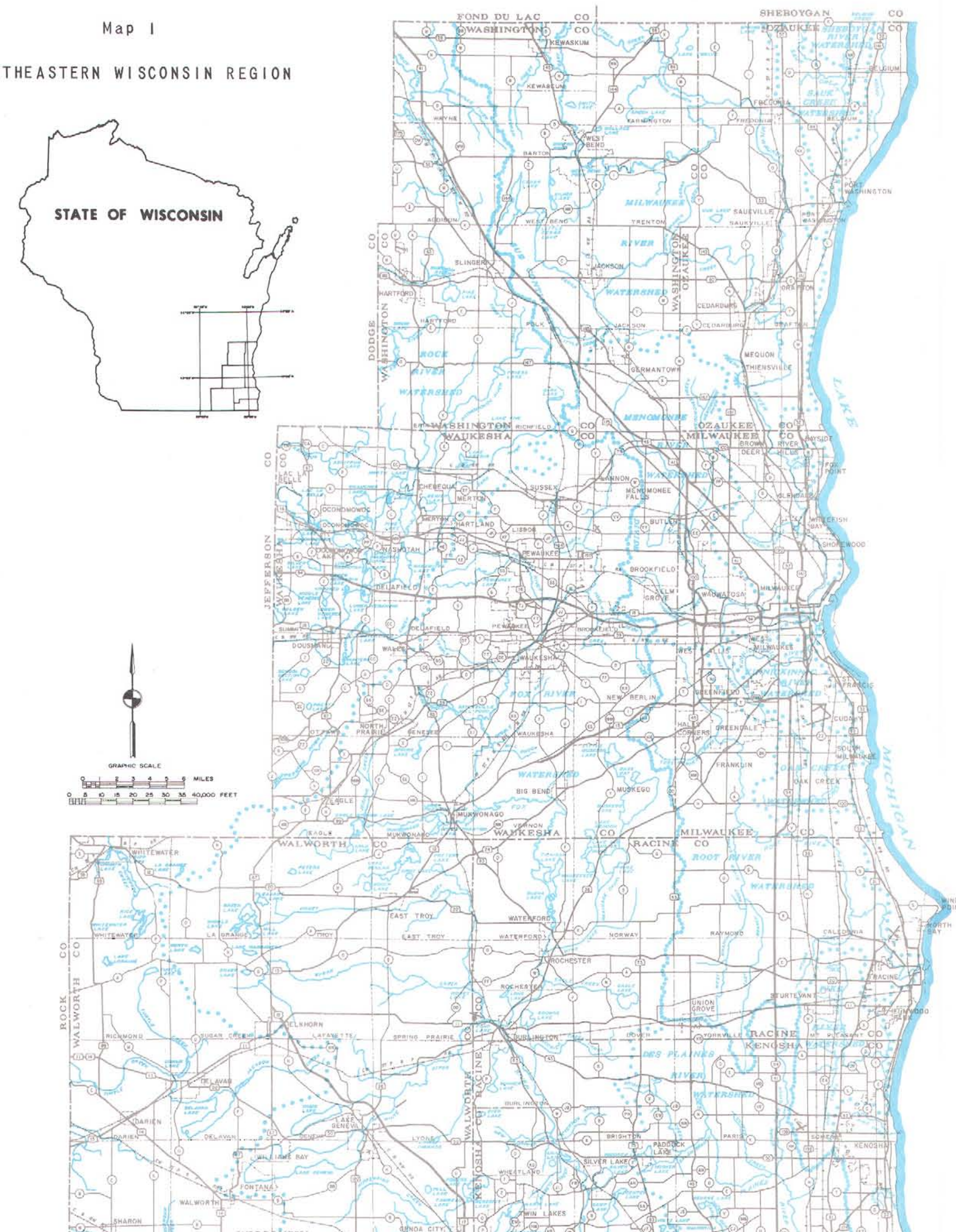
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
EXISTING STAFF AND COMMITTEE STRUCTURE



Source: SEWRPC.

Map 1

SOUTHEASTERN WISCONSIN REGION



The seven-county Southeastern Wisconsin Region encompasses a total area of about 2,689 square miles, or about 5 percent of the total area of the State of Wisconsin. About 40 percent of the state's population, however, resides in these seven southeastern counties. The Region employs about 42 percent of the state's labor force and contains about half of all the tangible wealth in the state as measured by equalized assessed property valuation. The Region has been subject to rapid population growth and urbanization, and from 1960 to 1970 accounted for about 40 percent of the total population increase of the state.

Source: SEWRPC.

These initial studies were directed toward providing basic planning and engineering data for regional planning and were documented in six published reports. None of these studies involved plan preparation, but the findings provided a valuable point of departure for subsequent Commission work, including the regional sanitary sewerage system planning program.

As part of its initial work program, the Commission also adopted a policy of community planning assistance, in which functional guidance and advice on planning problems are provided to local units of government, and regional planning studies are interpreted locally so that the findings and recommendations of these studies may be incorporated into local development plans. Six local planning guides have been prepared under this program to provide information helpful in the preparation of local plans and plan implementation ordinances. These guides are intended to help implement regional and local plans, and to assist local public officials in carrying out day-to-day planning functions. The subjects of these guides are subdivision control, official mapping, zoning, organization of local planning agencies, floodland and shoreland development, and the use of soils data. All include model ordinances and provide a framework for plan implementation through local land use control measures.

Land Use-Transportation Study

The first major work program of the Commission directed toward the preparation of long-range development plans was a regional land use-transportation study, initiated in January 1963 and completed in December 1966. It produced two key elements of a comprehensive plan for physical development of the Region: a land use plan and a transportation plan. The findings and recommendations of the study, which provide important inputs to the regional sanitary sewerage system planning program, have been published in the three-volume SEWRPC Planning Report No. 7, Regional Land Use and Transportation Plans; in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin; and in five supporting technical reports, including SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin.

Comprehensive Watershed Studies

The regional planning program very early recognized the significance of existing and water-related resource problems, including flooding and water pollution. The natural watershed was selected by the Commission as the basic water and water-related resource planning unit, and comprehensive watershed plans have been completed for the Root, Fox, and Milwaukee River watersheds within the Region. In addition, the Commission has initiated a comprehensive planning program for the Menomonee River watershed.

The basic purpose of watershed planning programs, as developed within the context of the overall regional planning program, is to permit public evaluation and choice of alternative water-resource development policies and plans and, through the preparation of a long-range plan for the development of water-related community facilities, to provide for the coordination of local, state, and federal water resource management programs within the Region and its watersheds. The more specific objectives of the watershed planning programs include the abatement of flood damage; the protection of floodways and floodplains from incompatible development; the abatement of water pollution and the protection of water supply; the preservation of land for park and related open space; the preservation of woodlands, wetlands, wildlife habitat, and prime agricultural lands; and the promotion of the wise and judicious use of the Region's limited land and water resources. In addition, the watershed plans serve to refine and adjust the regional land use plan, particularly in the riverine areas, and help achieve a more complete integration of land and water resource planning.

The Root River watershed study, the Commission's first comprehensive watershed planning program, was initiated in July 1964 and completed in July 1966. The results of the study have been published in SEWRPC Planning Report No. 9, A Comprehensive Plan for the Root River Watershed. The Commission adopted that plan on September 22, 1966. To date, it has been well received by local units of government. The recommended plan as of January 1, 1973, had been formally adopted by the Milwaukee and Racine County Boards of Supervisors; by the Metropolitan Sewerage Commission of the County of Milwaukee and the Sewerage Commission of the City of Milwaukee; by the Common Councils of the Cities of Franklin, Oak Creek, and Racine; and by the Town Board of the Town of Mt. Pleasant. Progress toward plan implementation is monitored and reported in the Annual Reports of the Commission.

The Fox River watershed study was the Commission's second comprehensive watershed planning program. It was initiated in November 1965 and completed in February 1970. The results of the study have been published in SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume 1, Inventory Findings and Forecasts, and Volume 2, Alternative Plans and Recommended Plan. The Commission adopted the comprehensive plan for the Fox River watershed on June 4, 1970. As of January 1, 1973, the plan had been formally adopted by the Kenosha, Milwaukee, Racine, Walworth, and Waukesha County Boards of Supervisors; by the Common Council of the City of Burlington; by the Village Board of the Village of Rochester; by the Town Board of the Town of Waterford; by the Kenosha County Soil and Water Conservation District; and by the City of Burlington Plan Commission. The plan has also been endorsed by such important state and federal agencies as the State Departments of Natural Resources and Transportation; the U. S. Department of Agriculture, Soil Conservation Service; the U. S. Department of the Interior, Geological Survey; and the U. S. Department of Housing and Urban Development.

The third comprehensive watershed planning program undertaken by the Commission was for the Milwaukee River watershed. It was initiated in June 1967 and completed in October 1971. The results of that study have been published in SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume 1, Inventory Findings and Forecasts, and Volume 2, Alternative Plans and Recommended Plan. The Commission adopted the comprehensive plan for the Milwaukee River watershed on March 2, 1972. As of January 1, 1973, the plan had been formally adopted by the Milwaukee, Ozaukee, Sheboygan, and Washington County Boards of Supervisors; by the Common Council of the City of Milwaukee; by the Village Board of the Village of River Hills; by the City of Milwaukee Board of Harbor Commissioners; and by the Milwaukee County Park Commission. The plan has also been endorsed by such important state and federal agencies as the State Departments of Natural Resources, Health and Social Services, and Transportation; the State Board of Soil and Water Conservation Districts; the U. S. Department of Agriculture, Soil Conservation Service and Farmers Home Administration; the U. S. Department of the Interior, Bureau of Outdoor Recreation and Geological Survey; and the U. S. Department of Housing and Urban Development.

The Commission initiated a comprehensive planning program for the Menomonee River watershed late in 1972. Upon the completion of this fourth major watershed study, the Commission will have completed such studies for four watersheds covering about two-thirds of the total area of the Region.

The watershed planning programs have important implications for the regional sanitary sewerage system planning program. Although sanitary sewerage facilities often involve problems that cross watershed boundaries, watershed factors are involved in the design of these facilities. These include the desirability of achieving gravity flow sewerage systems, the fact that sewerage systems may discharge pollutants into surface waters, and the existence of certain legal constraints on interbasin water and sewage diversions.

Each watershed plan sets forth stream and lake water use objectives and supporting water quality standards and contains specific recommendations with respect to the best means of attaining these objectives and abating water pollution. These recommendations concern the type, capacity, and location of sewage treatment plants; the location of effluent outfalls; the location, size, and depth of trunk sewers; the adjustment of land use patterns to the ability of surface water and soil resources to sustain development; the attainment of good soil and water conservation practices; and the potential for applying water quality management measures such as low-flow augmentation and diversion.

As more fully discussed in Chapter II of this report, the sanitary sewerage system plan provides an important means for relating the water pollution abatement actions recommended in the individual watershed plans to each other and to development within the Region as a whole. The regional sanitary sewerage system planning program, while related to the protection of water resources, is more directly concerned with the broader, more pervasive need to promote orderly areawide land use development, and thereby offers a logical means for more fully integrating the individual watershed plans and for refining and adjusting these plans as may be necessary.

Other Regional and Subregional Planning Programs

Four additional regional planning programs have been undertaken by the Commission. They include a regional library system planning program, a regional airport system planning program, a regional housing study, and a regional park, outdoor recreation, and related open space study. The Commission has also completed more detailed urban development plans for certain subareas of the Region, including the Kenosha and Racine Planning Districts. These latter plans include public utility elements with important implications for the sanitary sewerage system planning program.

REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM

Early in 1967, the Commission considered a number of potential regional planning programs which might lead to the preparation of additional elements of a comprehensive plan for the physical development of the Region. These programs had been requested by state or local units of government or were required by certain federal planning prerequisites for grants in partial support of capital improvements, and included regional water supply, park and open space, airport, library, mineral conservation, solid waste disposal, and sanitary sewerage system planning programs. After careful consideration, the Commission decided that the preparation of a regional sanitary sewerage system plan would be the logical next step in the preparation of a comprehensive plan for the physical development of the Region. On February 13, 1967, the Executive Committee of the Commission accordingly directed the Commission staff to investigate the need for a regional sanitary sewerage system planning program; determine the scope and content of such a program; and estimate the time, staff, and budgetary requirements of such a program.

The Commission, pursuant to Section 66.945(7) of the Wisconsin Statutes, created a Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning. This Committee, composed of 24 federal, state, and local public officials and private agency representatives, worked during September and October 1968 to prepare a Regional Sanitary Sewerage System Planning Program Prospectus. This Prospectus was endorsed by the Commission on December 5, 1968, was published, and in accordance with the Commission's advisory role was transmitted to government agencies concerned for consideration and action. All seven county boards in the Region formally endorsed the Prospectus and agreed to provide the local funding necessary for the program. The U. S. Department of Housing and Urban Development also endorsed the Prospectus and agreed to provide the necessary federal funding.

Need for Regional Sanitary Sewerage System Planning

Sanitary sewerage system planning programs at various levels have been carried out in the past by individual communities in the Region. Perhaps the largest, most complex, and best of these was carried out by the Metropolitan Sewerage District of the County of Milwaukee in 1956, when it prepared a long-range plan for intercepting sewers and sewage treatment plants to serve the Milwaukee metropolitan area. Even this important study, however, was confined to the Milwaukee urbanized area, a relatively small portion of the Region. Events of the approximately 15 years since the completion of that study indicate the need for its updating and revision. A need also exists to update and revise other locally prepared sanitary sewerage system plans in the Region and to coordinate these plans on an areawide basis.

Seven factors contribute to the need for a regional sanitary sewerage system planning program in the Region:

1. Inadequate sanitary sewer service, particularly in newly developed areas of the Region.

   Since 1950, particularly massive and significant changes in land use development have occurred within the Region. Not only has urban development expanded to include virtually all of Milwaukee County and major portions of Kenosha, Ozaukee, Racine, Washington, and Waukesha Counties, but the density and spatial distribution of the various land uses have changed radically in this expansion. From 1950 to 1970, the population of the Region increased by almost 42 percent, from 1.24 to 1.76 million persons. The amount of land devoted to urban use, however, increased by almost 190 percent from 138 to 397 square miles, so that the overall urban population density within the Region declined over this same period from about 8,500 persons per square mile to about 4,300 persons per square mile. The resulting very low urban population densities sharply contrast with the peak population densities achieved within the Region in 1920 of more than 11,300 persons per square mile, and make the provision of adequate sanitary sewer service to newly developing urban areas increasingly difficult and costly. Declines in the gross overall urban population densities in the Region have been accompanied by some local increases in urban population densities, particularly in some areas of the City of Milwaukee, where the construction of high-rise apartments has replaced one- and two-family homes, thereby increasing population densities and sanitary sewer loadings in small, highly localized areas.

Shifts in the land use development pattern since 1950 have created a demand for sanitary sewerage service in newly developing areas, and have taxed and in some cases exceeded the capacities of existing sanitary sewerage facilities and treatment plants. The resulting overloaded facilities and unsewered areas constitute a major source of water pollution, as well as a potential hazard to public health. Existing facilities and plants in many cases are inadequate to absorb additional loadings required by changing regional development patterns and resultant service demands. The situation brought about by rapid population increase and highly diffused, low-density urban development has been further aggravated by increasing per capita water consumption and sewage contribution, and by the introduction of such sewer-connected waste disposal devices as garbage disposers.

In 1970, between 61 and 85 square miles, or between 23 and 21 percent of the presently urbanized area of the Region, containing more than 139,000 persons, or about 8 percent of the population of the Region, were without public sanitary sewer service. Of the 146 cities, villages, and towns in the Region, 81 were served to some extent by public sanitary sewerage facilities. Local plans have been prepared to extend sanitary sewer service to an additional 447 square miles, or to an area almost five times as large as the presently developed urban area of the Region not now served by such facilities.

The extension and accommodation of sanitary sewer service has failed to keep pace with urbanization. Consequently, large areas of the Region are inadequately served by sanitary sewerage facilities at the present time. This problem has been intensified by the widespread dispersion of low-density urban development throughout the Region, and by the inability of many local government units to provide adequate sewerage facilities for their growing populations and sewage loadings except in an inefficient, piecemeal, and uncoordinated manner.

2. Forecast population growth and concomitant conversion of land in the Region from rural to urban use.

Not only has the extension of sanitary sewer service failed to keep pace with past growth, but the demand for such service to developing areas of the Region may be expected to increase over the next two decades due to continued population growth and urbanization. The population of the Region, which presently stands at about 1.8 million people, is expected to reach 2.7 million persons by 1990. This increase is roughly equivalent to the entire population presently served by the Milwaukee metropolitan sewerage system, which was developed over a period of almost 100 years.

Although urban land uses presently occupy only 397 square miles, or about 15 percent of the total area of the Region, land in the Region is presently being converted from rural to urban use at the rate of approximately 10 square miles per year. If the adopted regional land use plan is carried out, about 123 square miles of land will have to be converted from rural to urban use in the Region by 1990 in order to accommodate the anticipated population increase. Means will have to be found to serve this newly developed area and its residents with sanitary sewerage facilities, not only in a coordinated and economic way but also in such a way as to avoid further deterioration of the Region's surface water resources. If uncontrolled urban sprawl is allowed to continue within the Region, more than 300 square miles of land may be expected to be converted from rural to urban use by 1990, about twice that required under the recommended regional plan, and sanitary sewerage service problems will accordingly be compounded.

3. Deteriorating surface water quality accompanied by increasing conflicts over water use and increasing public demand for water pollution abatement.

The problem of inadequate sanitary sewer service is closely linked to water pollution problems in the Region. The complexity and scope of the water pollution problem, the growing conflicts over water use, and the extent to which the water polluting activities of one community affect other communities all contribute to the need for an areawide approach to planning sanitary sewerage facilities, and this need is becoming increasingly evident to the public officials involved at the local as well as state and federal levels of government.

Surface water quality studies conducted by the Commission and documented in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, indicate that stream pollution is widespread throughout the Region, and that present water quality conditions impair many desirable water uses. Nine of the 11 major drainage systems in the Region are substantially polluted when existing water quality is compared to water use objectives and supporting water quality standards for existing and potential water use.

Except for short reaches of certain as yet unpolluted streams in rural areas of the Region, and streams having established water use objectives limited to industrial and cooling water supply and minimum conditions (no aesthetic nuisance), the present levels of stream water quality in the Region generally fail to meet the water use objectives and supporting water quality standards established by the Wisconsin Department of Natural Resources, Division of Environmental Protection.[1] Stream water quality forecasts prepared by the Commission indicate that unless water quality control plans are prepared and implemented on an areawide basis, stream water quality levels within the Region can be expected to deteriorate rapidly with increasing urbanization. The growing water pollution problem is not limited to stream waters. It is also endangering Lake Michigan, one of the most important elements in the Region's natural resource base, and many of the inland lakes within the Region. As in the case of streams, the lake pollution problem is seen in increasingly obnoxious aquatic growths, deteriorating fisheries, increasing conflicts over water use, and increasing public demand for pollution abatement.

Municipal sewage treatment plants are the major source of surface water pollution in the Region. Sixty-four such plants are presently in operation or under construction within the Region. Public officials and interested citizens are becoming increasingly concerned about the deleterious effect the effluent from these plants has on Lake Michigan and on inland lakes, streams, and watercourses. With few exceptions, these plants were located, designed, and built on a largely uncoordinated, plant-by-plant basis. The location of the plants often shows little consideration for rational urban service areas or for sound spacing along the receiving streams to permit assimilation of waste loadings without serious deterioration in water quality. Water pollution abatement in the Region and the restoration of surface water quality to levels meeting federal and state water use objectives require preparation of an areawide sanitary sewerage system plan. Such a plan must recommend the location, size, and degree of treatment to be provided by existing and proposed sewage treatment plants in view of the effects on the natural resource base and on the extent and location of urban development. Attaining federal and state water use objectives may require increased treatment levels at individual plants; abandonment of certain plants and consolidation of their tributary sewerage systems to convey wastes to larger, more efficient plants; the provision of low-flow

[1] *Standards as adopted by the Wisconsin Resource Development Board on June 14, 1968 for intrastate waters and on April 26, 1967 for interstate waters. The Board has since been succeeded by the Wisconsin Natural Resources Board.*

augmentation for adequately treated waste water dilution; and, perhaps, the export of liquid wastes from certain watersheds in the Region.

4. The widespread occurrence within the Region of soils unsuited to onsite sewage disposal systems.

   As already noted, the planning and construction of new sanitary sewerage systems and the extension of established systems have not kept pace with the rapid, areawide urbanization taking place within the Region. Much of this urbanization has occurred in a highly diffused, low-density "leapfrog" pattern, and cannot be readily served by centralized public sanitary sewerage facilities. This has resulted in the widespread use of individual septic tanks for sewage disposal. About 47 percent of the Region, however, is covered by soils which are unsuited to intensive urban development without public sanitary sewer service and which, therefore, should not be developed with soil absorption sanitary sewage disposal facilities. Failure to adjust urban development to the ability of the underlying soils to sustain such development has resulted in serious problems within the Region such as overflowing septic tanks, public health hazards, water pollution, obnoxious odors, and depreciation of property values.

   Once urban land uses are established and a community developed, replacing individual septic systems with public sewerage facilities presents serious engineering, financial, and political problems. Because lot size requirements are normally large where sewage disposal by onsite system is to be attempted, the cost assessment to individual property owners for the later installation of centralized sewerage facilities can be extremely high. Inconvenience and unnecessary additional costs result from disrupting streets, walks, lawns, and landscaping; and from disconnecting individual plumbing systems from septic systems and reconnecting them to the new facilities; while the initial cost of the onsite sewage disposal facilities which must be abandoned becomes an additional unnecessary economic loss. If problems attendant to the use of septic tank disposal systems are to be avoided, sanitary sewer service must be extended in an orderly manner as land use development proceeds, and in accordance with a carefully prepared long-range sanitary sewerage system plan. Land use development must, in turn, be related to orderly sanitary sewerage system planning.

5. Increasing use of small, isolated sewage treatment plants and tributary sanitary sewerage systems on an uncoordinated, individual basis, without regard for the effect on areawide land use and sewerage system development or on surface water quality.

   The unsatisfactory performance of onsite septic tank sewage disposal systems in the Region, the increasing consumer resistance to the purchase of home sites without centralized sanitary sewerage service, and the failure of such service extensions to keep pace with urban land use development has forced land developers within the Region to consider alternatives to septic systems. One alternative increasingly being proposed is the package sewage treatment plant, designed to treat wastes from an isolated residential subdivision or a single large commercial or industrial development. Since the operation of such plants does not depend on the ability of the soil to absorb liquid wastes, the package plant may solve the immediate problem associated with the unsuitability of the soils on a given site for the use of onsite sewage disposal systems.

   The uncoordinated installation of package plants, however, may also lead to several serious problems. First, package sewage treatment plants within the Region are often located in the headwater areas of watersheds where small intermittent streams and watercourses must be used to receive the treated effluent. Since adequate streamflow is not available to dilute the wastes, the small streams deteriorate rapidly in water quality until they lose even a minimum aesthetic value. Second, package plants for economic reasons are usually designed with just sufficient capacity to treat the wastes generated by the initial development intended to be served. When further development occurs, the plant is often overloaded and unable to continue to provide an adequate level of treatment. In addition, the individual owners, small private associations, and rural governments which must operate the plants usually cannot afford either the degree of maintenance nor the trained staffs which can be provided by a larger municipality, thus making it impractical to provide the advanced levels of waste treatment often necessary to maintain and improve water quality. Finally, when package plants are to be abandoned and the tributary sewerage systems connected to a municipal or metropolitan sewage treatment plant, there is little likelihood that the individually designed systems can be integrated into a unified gravity drainage sewerage system without major modifications and further expense. If the use of package plants is to continue, it is imperative that such plants be located and designed within the framework of a long-range, areawide sanitary sewerage system plan, both to avoid the creation of serious new water pollution problems and to avoid later problems of connection to a centralized public sanitary sewerage system.

6. The importance of the orderly extension of sanitary sewer service throughout the Region to the implementation of the adopted regional land use plan.

In December 1966 the Commission adopted a regional land use plan which would: 1) allocate adequate space to each of the various urban and rural land uses required to meet the social, physical, and economic needs of the growing population of the Region; 2) result in a more efficient, healthful, attractive, and compatible arrangement of land uses; 3) be properly related to supporting transportation and utility systems; and 4) contribute to the protection and wise use of the Region's natural resource base. The regional land use plan, however, is entirely advisory to the implementing federal, state, and local units of government, and requires the coordinated action of all of the levels, units, and agencies of government concerned for full implementation.

The orderly extension of sanitary sewer service to areas proposed for urban development in the land use plan is essential to its implementation. The plan recommends that all new urban development in the Region be provided with sanitary sewer service tributary to existing and proposed public sewerage systems. The importance of sanitary sewer service in guiding land use development was shown by the Commission's plan evaluation studies done with the aid of a regional land use simulation model, a model developed by the Commission under the regional land use-transportation study to test the feasibility of alternative regional land use development patterns.

A number of simulation model runs were performed using different assumed land use control policies as inputs. The best methods of regional land use plan implementation were thereby explored. Results of the model applications showed that given the soil conditions which prevail within the Region, and given the restriction of urban development upon soils poorly suited to such development without sanitary sewerage service warranted by consideration of the public health, safety, and welfare, the availability of sewer service became the singularly most important factor influencing the location and timing of urban land use development. Any attempt to implement the adopted land use plan in the absence of sound, coordinated sanitary sewerage development policies would almost certainly fail. The land use plan test and evaluation studies indicated that a regional sanitary sewerage system plan would thus be important to the attainment of the adopted land use plan, and that the preparation of such a sewerage system plan should be undertaken as soon as possible.

7. The need to meet the areawide planning prerequisites of federal sewerage facility construction grant-in-aid programs.

The federal government is increasingly requiring the preparation and adoption of areawide system plans as a prerequisite for the approval of federal grants in partial support of all types of public works construction. Two significant federal grant programs—the Waste Water Treatment Works Construction Program, administered by the U. S. Environmental Protection Agency, and the Basic Water and Sewer Facility Construction Program, administered by the U. S. Department of Housing and Urban Development—require as a prerequisite for the award of a federal grant the preparation, adoption, and certification of areawide sanitary sewerage system plans. Preliminary planning guidelines issued under these two grant programs have established July 1, 1973 as the date when the areawide sanitary sewerage system plans must be completed, adopted, and certified if constituent local units of government are to continue to qualify for federal grants. The Commission, therefore, would be remiss in its responsibilities to its constituent units of government if it failed to prepare, adopt, and certify to appropriate state and federal agencies a regional sanitary sewerage facility system plan at this time.

It is important to note that U. S. Office of Management and Budget (OMB) Circular A-95 requires review by metropolitan and state clearinghouses of all applications for federal grants in partial support of the acquisition of land for, and the construction of, public facilities and utilities, including sanitary sewers and sewage treatment plants. The Regional Planning Commission is recognized as the metropolitan clearinghouse for southeastern Wisconsin by the federal and state units of government under OMB Circular A-95. Intelligent review by the Commission of applications for sewerage system improvement projects requires preparation of an areawide sanitary sewerage system plan. Only within the context of such a plan can the areawide desirability of individual sewerage system improvements be properly determined, and the interests of the local units of government concerned, as well as the interests of the state and federal governments, properly recognized.

It should be noted that these seven factors apply specifically to the Southeastern Wisconsin Region. They are in addition to and support the more general need in an urbanizing region for a regional sanitary sewerage system plan which derives from sound planning and engineering practice. Such practice dictates that individual sewer lines, pumping stations, and sewage treatment plants be planned and designed not in isolation on an ad hoc, piecemeal basis, but rather as integral parts of an areawide system in which the major sewerage facilities are carefully fitted to projected waste loadings derived from adopted land use plans, and are designed to meet regional as well as local development objectives and standards, including water use objectives and standards.

The Prospectus was a preliminary design prepared to obtain support and financing for the study, an objective that was achieved. It outlined the major work elements, specified a staff organization, established a time schedule, and provided cost estimates. Work on the study began in February 1969.

Study Objectives

The primary objective of the regional sanitary sewerage system planning program as set forth in the Prospectus is to produce an additional important element of a comprehensive plan for the physical development of the Region—a regional sanitary sewerage system plan. This plan should provide for the extension of sanitary sewerage service to developing areas of the Region consistent with the adopted regional land use plan, the abatement of water pollution problems, and the protection and wise use of the natural resource base so that, through plan implementation, sewerage-related problems may be abated.

More specifically, the planning program should clearly delineate areas to be served by septic tank or other private onsite waste water disposal systems and areas to be served by public sanitary sewerage facilities, distinguishing between existing, committed, and recommended future sanitary sewer service areas. The program should also identify the physical facilities needed to provide the recommended sanitary sewer service, showing, as appropriate, the approximate location, size, and capacity of the required trunk sewers and the approximate location and capacities of necessary sewage treatment facilities and pumping stations; recommend types and levels of treatment; estimate system development costs; and recommend a capital improvement program based on a proposed staging of the system plan through the design year of 1990. The sanitary sewerage system facility plan must be based on careful analyses of topographic data, capacity of existing facilities, and probable load factors. The total system, consisting of trunk sewers, pumping stations, and treatment plants must be designed as an integrated system, or as separate but coordinated subsystems, for the Region. Each link in the system or subsystem must be fitted to projected loadings, and the effect of each proposed facility on the remainder of the system must be tested and evaluated.

Additional objectives of the planning program include analysis of the existing and probable future demand for sanitary sewerage service within the Region; promotion of a better understanding by public officials, planners, and engineers of the interrelationships existing between land use and sanitary sewerage system development; and promotion of an increased awareness of the effect of local community plans on surrounding communities and the Region, thereby encouraging coordinated areawide land use and sanitary sewerage facility planning and plan implementation efforts at all levels of government.

Staff, Consultant, and Committee Structure

The basic organizational structure for the study is outlined in Figure 2 and consists of consultant and Commission staffs reporting to the Commission Chief Environmental Planner. As project coordinator, the Chief Environmental Planner was responsible for maintaining interstaff and interagency coordination during the study, as well as for supervising the work of the Commission Environmental Planning Division. The Commission Executive Director was responsible for generally administering and directing the study and, as a professional engineer, sponsored it. The Executive Director reports to the Southeastern Wisconsin Regional Planning Commission, which has ultimate legal authority and responsibility for the entire planning program. The responsibilities of the consultant and Commission staffs for various work elements in the program are also indicated in Figure 2.

Through the establishment of advisory committees, pursuant to Section 66.945(7) of the Wisconsin Statutes, the Commission seeks to obtain the active participation of concerned governmental agencies in the regional planning program. To provide for this active participation and for the necessary technical and policy guidance in the conduct of the regional sanitary sewerage system planning program, the Commission created in August 1968 the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning. This Committee consists of governmental officials, university faculty, and private consultants to local government particularly knowledgeable about sanitary sewerage system development and related water pollution problems within the Region. In light of the Commission's advisory role in shaping regional development, involvement by local public officials in the planning program through this Committee is particularly important to implementation of the recommended sanitary sewerage system plan. An important function of the Committee members is, therefore, to familiarize local elected officials with the study and its findings and recommendations, and to generate understanding of the study objectives, the plan recommendations, and plan implementation procedures among such officials. The Committee has a particularly important role in selecting the final plan and assuring its financial and administrative feasibility. The full membership of this Committee is set forth in Appendix A.

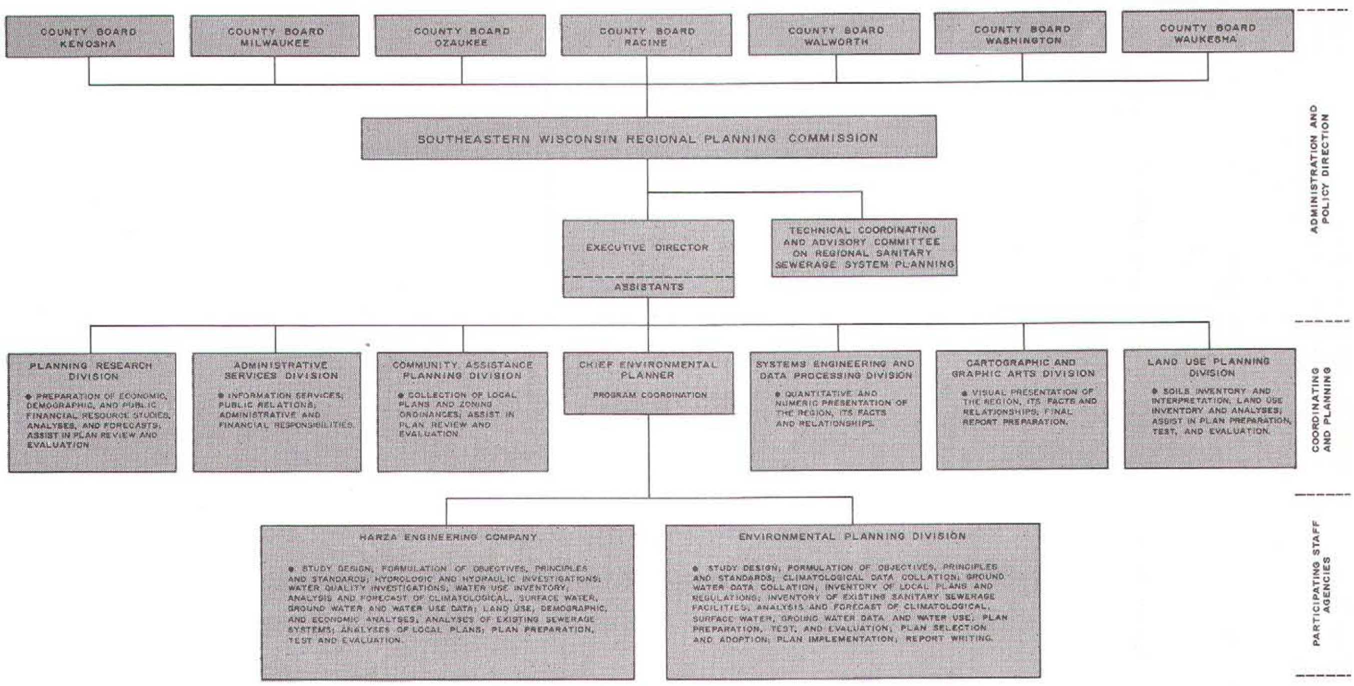
The sewerage system planning program has been conducted by the Commission staff, supplemented by the contractual services of the Harza Engineering Company, Chicago, Illinois, under the guidance of the Technical Coordinating and Advisory Committee. The Commission staff assumed responsibility for those work elements of a general regional planning nature, as well as for certain work elements of a functional planning nature. These included preparation of the study design; land use, demographic, and economic data collation, analyses, and forecasts; climatological data collation; groundwater data collation and analyses; inventory of existing sanitary sewerage facilities; inventory of local land use and sanitary sewerage system plans; and preparation of plan implementation recommendations. The Harza Engineering Company was responsible for all other functional planning elements. These included hydrologic, hydraulic, and water quality investigations; analysis and forecast of surface and groundwater use data; analyses of existing sanitary sewerage systems; and analyses of local sanitary sewerage system plans. Work elements shared by the Commission staff and consultants included formulation of sanitary sewerage system development objectives, principles, and standards; plan preparation, test, and evaluation; and report writing.

Scheme of Presentation

The major findings and recommendations of the regional sanitary sewerage system planning pro-

Figure 2

ORGANIZATIONAL STRUCTURE FOR THE REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM



Source: SEWRPC.

gram are documented and presented in this report. It sets forth the basic concepts underlying the program and the salient findings of the program inventories and analyses. It identifies and, to the extent possible, quantifies, the developmental and environmental problems associated with sanitary sewerage system development, and forecasts future economic activity, population growth, and concomitant future land use demand as necessary for areawide sanitary sewerage system planning. The report explores alternative plans relating to land use and sanitary sewerage system development, and recommends a plan for developing a regional sanitary sewerage system based on regional development objectives adopted by the Technical Coordinating and Advisory Committee and the Commission. In addition, it contains a financial analysis and specific implementation recommendations.

The final report is intended to allow careful, critical review of the alternative plan elements by public officials, agency staff personnel, and citizen leaders within the Region and to provide the basis for plan adoption and implementation by the federal, state, and local agencies of government concerned. The report can only summarize in brief fashion the information assembled in the extensive data collection, analysis, and forecasting phases of the regional sanitary sewerage system planning program. Although, due to its magnitude and complexity, the reproduction of all of this information in report form is impractical, all of the basic data is on file in the Commission offices and is available to member units and agencies of government and to the public in general upon specific request. This report, therefore, serves the additional purpose of indicating the type of data available from the Commission which may be of value in assisting federal, state, and local units of government and private investors in making better decisions about sanitary sewerage system and related land use development in the Region.

Chapter II

BASIC PRINCIPLES AND CONCEPTS

INTRODUCTION

Next to transportation facilities, sanitary sewerage[1] facilities are the singularly most important public works influencing the development of an urbanizing region. The location and adequacy of these facilities greatly affect the public health, safety, and welfare; the overall quality of the environment; recreational activity; industrial productivity; and the value and use to which land may be put. If not properly attended to, sewerage system development will inevitably emerge as a major obstacle to the sound growth and development of the Region, and will become a major policy issue facing public officials, citizen leaders, and technicians.

Sanitary sewage[2] is among the most obnoxious and hazardous of the by-products of an urban society. Its safe collection, treatment, and disposal should always be a matter of public concern. Improperly conveyed, treated, and disposed of, sanitary sewage can:

1. Spread disease among men and animals.[3]
2. Increase the cost and complexity of purifying water supplies. Waters containing sewage can stain, foul, and corrode transportation vehicles and industrial structures and equipment, and reduce the efficiency of manufacturing equipment and operations through sludge formation, scale deposits, foaming, and organic growths.
3. Contribute to stream and lake sedimentation and fertilization, causing accompanying noxious algal and weed growths.
4. Destroy the ability of receiving waters to support fish and other desirable aquatic life.
5. Destroy opportunities for swimming, boating, fishing, and other forms of water-based recreation.
6. Reduce property values and create severe aesthetic nuisances.

Although not the only source of water pollution, sanitary sewage if improperly treated and disposed of can cause virtually all of the harmful effects of water pollution. Because of the hazardous nature of sanitary sewage, its safe collection, treatment, and disposal is critical in the interests of maintaining a safe, healthful environment and avoiding severe public health problems and property value deterioration.

Sanitary sewerage facilities also have a major impact on land use development, and, therefore, on the social and economic as well as physical development of an area. This is particularly true in regions such as southeastern Wisconsin, where significant areas are covered by soils unsuited to the use of onsite sewage disposal systems. There can be no effective guidance of areawide land use development in the public interest without full coordination between sanitary sewerage system plans and areawide land use plans. Sanitary sewerage system planning should, therefore, be conducted as an integral part of comprehensive regional planning, and should be designed to support and implement long-range areawide land

---

[1] *The term "sewerage" is defined as the physical plant for the collection, conveyance, treatment, and disposal of sewage. This plant may consist of gravity flow sewers, lift and pumping stations, force mains, treatment plants, outfalls, and appurtenances.*

[2] *The term "sewage" is defined as the spent or waste water of a community consisting of a combination of the liquid and water-carried solid wastes from streets and other open areas, residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and storm water that may be present.*

[3] *The fact that sanitary sewage can transmit certain serious human diseases has been recognized since before the turn of the century. These diseases include cholera, typhoid, dysentery, and certain virus-produced diseases such as hepatitis. High concentrations of nitrates in water supplies, which can result from sanitary sewage entering the water supply, may cause infant death by depleting the oxygen in the bloodstream through biochemical reduction. Although direct health hazards associated with the pollution of water by sanitary sewage are known, the latent effects of such pollution are still largely unknown.*

use plans. Only within the framework of a comprehensive areawide planning effort can both land use development and the planning, design, and construction of sanitary sewerage systems be purposefully directed in the public interest.

Although detailed land use decisions are primarily of local concern and properly subject to local planning and control, the aggregate effects of many such decisions may be of regional concern. Changes in the land use patterns not only interact strongly with the need for regional transportation, recreation, and public utility facilities—in particular sanitary sewerage facilities—but also exert a heavy demand on the limited natural resource base. The wise use of this resource base, as well as the functional relationships existing between land use and sanitary sewerage facilities, must be recognized in both land use and sanitary sewerage facility planning.

THE GEOGRAPHIC PLANNING UNIT

Sanitary sewerage system planning must be done on a regional basis. Land use patterns, which determine the amount and spatial distribution of the hydraulic and pollution loadings to be accommodated by the sanitary sewerage system, develop over an entire urban region in response to basic social and economic forces and to the operation of the urban land market, without regard to artificial corporate limit lines or natural watershed boundaries. The sanitary sewerage facilities, in turn, determine to a considerable extent the use to which land areas may be put. These facilities often cross not only corporate limits but also watershed boundaries. Thus, sanitary sewerage facility planning cannot be accomplished successfully within the context of a single municipality or county if the municipality or county is part of a larger urban complex. Nor can such planning be accomplished successfully solely within natural watershed areas.

Unlike transportation facilities, however, sanitary sewerage facilities need not form a single integrated system over an entire urbanizing region. Sanitary sewerage facilities may form subsystems related to existing urban concentrations and natural watershed boundaries, provided that such subsystems are fully coordinated on a regional basis. Although sanitary sewerage facilities may cross minor watershed boundaries, the watershed must be recognized as an important influence on the development of areawide sanitary sewerage systems. This is true because sanitary sewerage facilities should be developed, to the maximum extent possible, as gravity drainage systems; because treated wastes are often discharged to surface streams; and because legal considerations may prohibit or constrain the transfer of water and sewage across the major watershed boundaries. Existing urban concentrations with well-developed sewerage systems must also be recognized as an important influence on the development of areawide sanitary sewerage systems. This is necessary if maximum use of the capacity of these systems and the public capital invested in them is to be made and if proper recognition is to be given to the placement of new land use development within or near such concentrations and systems.

The urbanizing region must then form the basic geographic unit for sanitary sewerage system planning to assure coordination of related subsystems. But the planning effort must recognize the existence of subregional planning areas relating both to existing urban concentrations and natural watershed boundaries. The need to coordinate sanitary sewerage system development in an urbanizing region to effect economies in providing such facilities, to guide land use development, and to protect the natural resource base may dictate the need to adjust and change the delineation of such subregional areas for a more efficient overall system.

RELATIONSHIP OF SANITARY SEWERAGE SYSTEM PLANNING PROGRAM TO COMPREHENSIVE WATERSHED PLANNING PROGRAM

Water resources planning can conceivably be carried out on the basis of a number of different geographic areas, including areas defined by governmental jurisdictions, social and economic linkages, or natural watershed boundaries. None of these areas is perfect as a comprehensive water resources planning unit. There are, however, certain advantages to the selection of the natural watershed as a comprehensive water and water-related natural resources planning unit.

Storm water drainage and flood control facilities should form a single integrated system over an entire watershed, a system capable of carrying off present and future runoff loads generated by changing land use and water control facility patterns within the watershed. Therefore, storm water drainage and flood control problems can best be considered on a watershed basis. Drainage and flood control problems are closely related to other land and water use problems. Consequently, floodland protection, the provision of park and outdoor recreation facilities that are related to water resources, and natural resource conservation-related open space reservation can also best be considered on a watershed basis.

Similarly, surface water quality problems can best be considered on a watershed basis in which the sources of the pollutants being discharged into the surface water system from all point and diffused sources can be identified, their effects analyzed, and their relationship to other water resource-related problems established. The effects on water and water-related natural resources of changes in land use, not only within shoreland and floodland areas but also within entire catchment areas, can best be studied on a watershed basis. This recognizes that a watershed is more than a system of interconnected waterways, shorelands, and floodlands which, in fact, comprise only a small portion of the total watershed area. Land treatment measures, soil and water conservation practices, and land use over the entire watershed are of major importance in the conservation and wise use of water and water-related resources. Land use within the watershed affects the amount and spatial distribution of the hydraulic and pollution loadings to be accommodated by the surface water resources and related water control facilities. In turn, water control facilities and their effect upon both water quality and the historic floodways and floodplains determine to a considerable extent the use to which such land areas may be put.

Finally, the interrelated physical problems of a watershed tend to create a strong community of interest among the residents of the watershed. Consequently, citizen action groups can more readily be formed to assist in solving water and water-related resource problems on a watershed basis.

It may be concluded, therefore, that the watershed is a logical areal unit to be selected for water and water-related natural resources planning purposes. Accordingly, the Commission's regional planning program embodies a recognition of the need to consider watersheds within the Region as rational planning units if workable solutions are to be found to interrelated land and water use problems. The Commission has, to date, completed comprehensive watershed plans for the Root (completed in July 1966), Fox (completed in February 1970), and Milwaukee (completed in October 1971) River watersheds within the Region and has initiated a comprehensive watershed planning program for the Menomonee River watershed. Thus, comprehensive watershed planning programs have been completed or are underway for four major watersheds which encompass a total area of 1,702 square miles, or about 63 percent of the Region. These comprehensive watershed plans constitute long-range plans which provide, within the limits of each watershed, one of the key elements of a comprehensive regional development plan; namely, a long-range plan for water-related community facility development.

While the watershed plans may appear to be centered on water quality and flood control facilities, it must be recognized that these plans are prepared in consideration of all of the related problems of land and water use, including park, outdoor recreation, and related open space preservation; soil and water conservation; propagation of fish and wildlife; and maintenance and protection of ground, as well as surface, water resources. As such, the watershed plans are intended to achieve full coordination of local, state, and federal natural resource management programs within the various watersheds of the Region. Important among the goals to be achieved by these plans are the protection of floodways and floodplains and the abatement of flood damages, protection of water quality and supply, the preservation of land for park and related open-space use, and in general the promotion of the wise and judicious use of the limited land and water resources of each of the watersheds. Thus, the Commission's watershed planning programs are closely linked to the broad problem of natural resource conservation.

Although recognizing the importance of the watershed as a rational planning unit within the Region, the Commission's planning program also recognizes the necessity to conduct individual watershed planning programs within the broader framework of comprehensive, areawide planning. This is essential for two reasons. First, areawide urbanization indiscriminately crosses watershed boundaries and exerts an overwhelming external influence on the physical development of the affected watershed. Second, the meandering pattern of watershed boundaries rarely if ever coincides with the artificial generally rectangular boundaries of civil divisions and special-purpose districts.

Water supply and sanitary sewerage frequently involve problems that cross watershed boundaries, and therefore are problems which, while having watershed implications, must be approached on a regional basis. Indeed, sanitary sewerage and public water supply system planning become one of the most important and specific means for interrelating and coordinating the individual watershed plans. Recognition of the need to relate comprehensive watershed plans and the water control facility elements of such plans to areawide regional development plans through sanitary sewerage and public water supply system planning is perhaps the singularly most important factor which determines the unique nature of the Commission's water resource planning efforts.

In summary, the Commission's comprehensive watershed planning programs may be thought of as natural resource conservation-oriented planning efforts which provide a broad approach to water control facility and related land and water use planning and development. The Commission's sanitary sewerage planning program, on the other hand, may be thought of as urban development-oriented planning efforts which seek to provide the facilities necessary to permit sound urban development within the Region, while protecting the underlying and sustaining natural resource base. The watershed, sanitary sewerage, and water supply plan elements must be carefully coordinated and must comprise integrated elements of a single comprehensive, areawide development plan. The integration of the sanitary sewerage system plan and the water quality management elements of the completed comprehensive watershed plans is, however, subtle as well as complex. The relationship of the sanitary sewerage system plan as documented in this report, and the Commission's comprehensive watershed plans as documented in separate planning reports must, therefore, always be considered one in light of the other to be properly understood and used.

THE SANITARY SEWERAGE PLANNING PROBLEM

The location and capacity of sanitary sewerage facilities are closely related to such problems as the protection of public health, the abatement of water pollution, the attainment of a proper relationship between the location and capacity of such facilities and land use development, and the need to adjust land use patterns and sewerage systems to the natural resource base. Because of this the development of these facilities involves important public policy determinations, which should be based on a comprehensive planning process that weighs changing demands against the ability of the existing sanitary sewerage system and limited natural resource base to meet these demands. Only through such a process can the effect of different courses of action be evaluated, the best course of action chosen, and available funds most effectively invested.

The purpose of such a planning process with respect to sewerage facility development is twofold:

1. To permit public evaluation and choice of alternative sanitary sewerage system development policies and plans.

2. To provide, through an agreed-upon long-range plan for sanitary sewerage development, for the coordination of local, state, and federal sanitary sewerage facility development programs.

Goals to be attained by this process include protection of public health; abatement of water pollution; sound investment of public funds in efficient and effective sanitary sewerage systems; development of a sound, areawide pattern of land use development; and wise use of limited land and water resources.

BASIC PRINCIPLES

Based on these considerations, five principles were formulated which form the basis for the planning process applied in the regional sanitary sewerage system planning program:

1. Sanitary sewerage system planning must be regional in scope, but must recognize subregional planning areas related to natural watershed boundaries and urban concentrations with well-developed sewerage systems. A regional approach is essential because the land use pattern which such systems support develops on an areawide basis without regard to artificial corporate limits or natural watershed boundaries. Subregional planning areas must also be recognized in order to take into account the effects of existing urban concentrations and natural watershed boundaries on efficient provision of sanitary sewerage services.

2. Sanitary sewerage system planning must be conducted concurrently with land use planning. The land use pattern determines the amount and spatial distribution of hydraulic and pollution loads to be accommodated by the system. The system, in turn, is one of the most important determinants of the land use pattern.

3. Both land use and sanitary sewerage facility planning must recognize the existence of a limited natural resource base to which rural and urban development must be adjusted to ensure a pleasant and habitable environment. Sewage treatment plant locations and sewage treatment levels must be adjusted to the waste assimilation capacity of the receiving environment, particularly to the soils, lakes, and streams, and must assist in attaining areawide land and water use objectives.

4. Sanitary sewerage facilities must be planned as integrated systems or coordinated subsystems. The capacity of each proposed facility in the total system or subsystem must be carefully fitted to present and probable future hydraulic and pollution loadings. The hydraulic and biochemical performance of the proposed facilities and the effects on the rest of the system must be quantitatively determined and evaluated.

5. Primary emphasis should be placed on solutions within the watershed to sanitary sewerage system development problems related to water pollution abatement. The export of water resource problems to other watersheds and downstream areas should be considered only as a last resort.

THE SANITARY SEWERAGE SYSTEM PLANNING PROCESS

The Commission has developed a seven-step planning process through which principal functional relationships in the Region affecting sanitary sewerage system development can be described graphically and numerically; the operation of the sanitary sewerage system or subsystem simulated; and the effect of different actions with respect to land use, resource management, and sanitary sewerage facility development tested and evaluated. These steps are study design; formulation of objectives and standards; inventory; analysis and forecast; preparation, test, and public evaluation of alternative plans; plan selection and adoption; and preparation of precise plans. Plan implementation, although beyond the foregoing planning process, must be considered throughout the process if the plans are to be realized.

The result of this process is a regional sanitary sewerage system plan to extend sanitary sewerage service to developing areas of the Region, consistent with the adopted regional land use plan; to abate water pollution problems; and to protect and wisely use the natural resource base. In addition, the process is the beginning of a continuing planning effort that permits modification and adaptation to changing conditions of the plans and the means of implementation.

Each step in this process includes individual operations which must be carefully designed, scheduled, and controlled to fit the overall process. An understanding of this is essential to appreciate and understand the results. Each step and its major component operations is diagrammed in Figure 3 and described briefly below.

Study Design

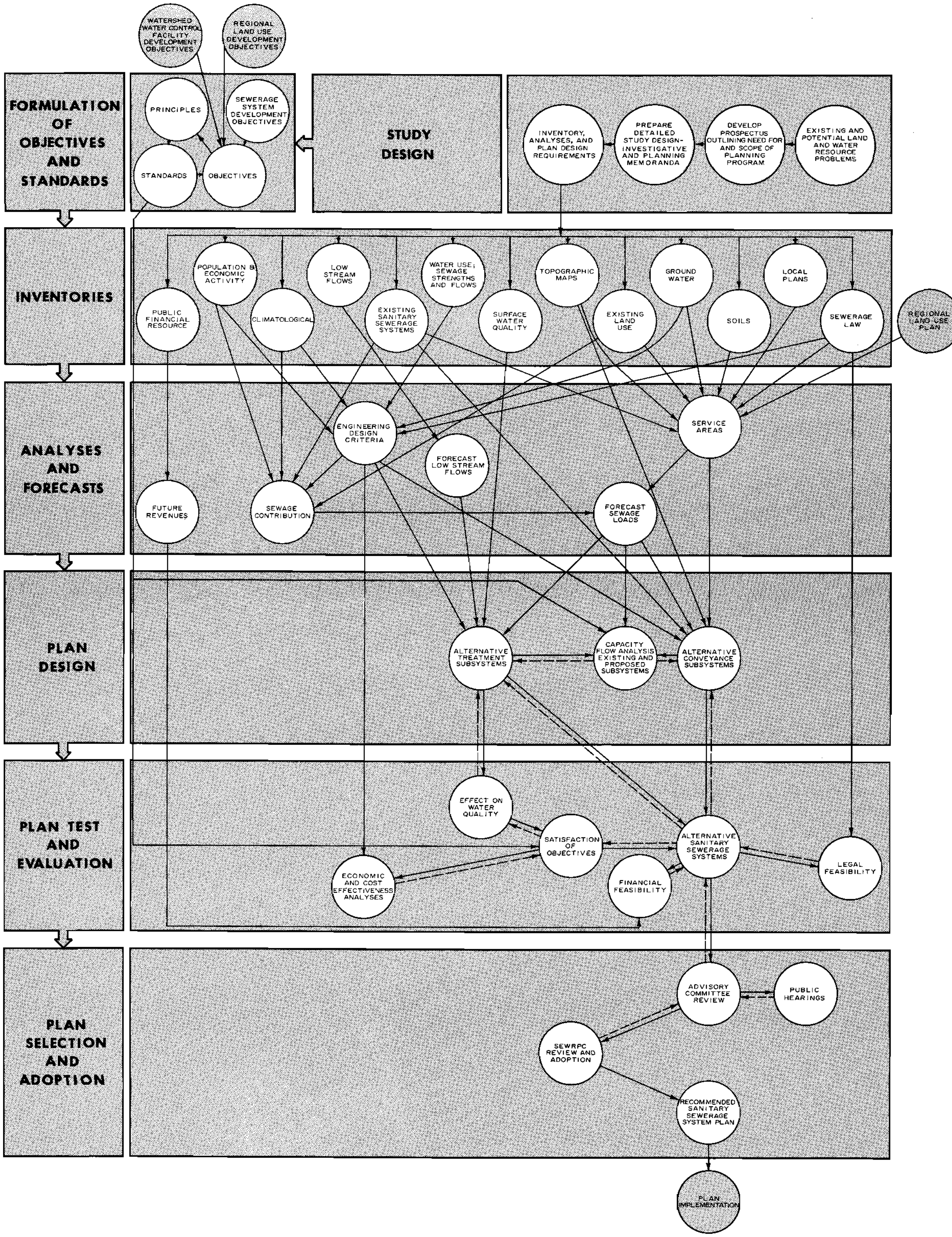
Every planning program must include a formal structure or study design so it can be carried out logically and consistently. The study design must specify the content of the fact-gathering operations, define the geographic area for which data will be gathered and plans prepared, outline the manner in which data is to be processed and analyzed, specify requirements for forecasts and forecast accuracy, and define the nature of the plans to be prepared and the criteria for their evaluation and adoption.

The study design for the regional sanitary sewerage system planning program, prepared jointly by the staffs of the Commission and the Harza Engineering Company, took the form of detailed staff memoranda setting forth methods and procedures to be followed in accomplishing each work element.[4] As each staff memorandum was com-

[4] *The Study Design was comprised of the following Commission staff memoranda: Investigation Memoranda No. 1, "Regional Sewerage Plan Study Design;" No. 2, "Groundwater Studies;" No. 3, "Proposed Computer Useage;" No. 4, "Proposed Study of State of the Art of Sewerage System Planning;" No. 5, "Plan Preparation, Test, and Evaluation;" and No. 6, "Design Criteria." It also included Planning Memoranda No. 1, "Final Planning Report Outline and Preparation Procedures;" No. 2, "Sewage Flow and Climatological Relationship;" and No. 3, "Surface Water Data Collection and Analysis." These memoranda are on file at the Commission offices.*

Figure 3

GENERAL STEPS IN A REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM



Source: ***SEWRPC.***

pleted, it was presented to the Technical Coordinating and Advisory Committee for review and approval before becoming the working guide for program execution and review.

Formulation of Objectives and Standards

In its most basic sense, planning is a rational process to establish and meet objectives. The formulation of objectives is, therefore, essential before plans can be prepared. In order to be useful, the objectives must be stated clearly, be logically sound, and must relate to alternative physical development proposals. It is the duty and function of the Commission to prepare a comprehensive plan for the Region's physical development and its component parts, and it is the objective of the regional sanitary sewerage system study to prepare one of the key elements of such a plan—a long-range plan for areawide sanitary sewerage facility development. Only if the objectives clearly relate to physical development and are subject to objective test can a choice be made from alternative plans to select the one which best meets agreed-upon objectives. Logically conceived and well-expressed objectives must be translated into detailed design standards to provide the basis for plan preparation, test, and evaluation. The sanitary sewerage development objectives and standards formulated ranged from general objectives on extension of adequate sanitary sewer service to urbanizing areas to detailed design standards on per capita waste water flow contributions. All objectives and standards were carefully reviewed and adopted by the Technical Coordinating and Advisory Committee.

Inventory

Reliable planning and engineering data collected on a uniform, areawide basis is essential to the formulation of workable development plans. Consequently, inventory becomes the first operational step in any planning process, since no intelligent forecasts can be made or alternatives selected without knowledge of the state of the system being planned.

Sound sanitary sewerage system plan formulation requires data on climate; the hydrologic and hydraulic characteristics of the Region's lakes and streams, especially their waste assimilation capacities; existing surface water quality conditions; groundwater conditions and the location of groundwater discharge and recharge areas; water use; soil capabilities; the kind, location, and intensity of existing and probable future land uses; population levels and densities; economic activity; location and capacity of existing sanitary sewerage facilities; locally prepared sanitary sewerage facility development plans; and the state of the art of sanitary sewage collection and treatment. In the regional sanitary sewerage system study, data collection included review of prior publications, perusal of agency files, personal interviews with knowledgeable public officials, committee meetings of staff and technical advisors, and original field investigations.

Analysis and Forecast

Inventories provide factual information about past and present situations, but analyses and forecasts are necessary to estimate future conditions, particularly the need for land and supporting sanitary sewerage facilities. Future needs must be determined from a sequence of interlocking forecasts. Economic activity and population forecasts provide estimates of the probable future growth in the Region, and can be translated into future demands for land and water use and sanitary sewerage service. These demands can then be scaled against the existing supply of sanitary sewerage capacity and plans formulated to meet deficiencies.

Two important and difficult considerations in preparing necessary forecasts are the target date and accuracy requirements. Both the land use pattern and the supporting sanitary sewerage facilities must be planned for anticipated demand at a selected future point in time. In designing certain public works facilities, particularly for transportation, the design period is established on the basis of the expected life of the first facilities to be constructed in plan implementation, and normally extends 20 to 25 years into the future. It may be argued that the design year for land use development plans should be extended farther into the future than that for the transportation facilities because of the irreversibility of many land development decisions. But practical considerations, including limitations on the ability to make necessary economic and demographic forecasts, dictate that the land use plan design year be scaled to the facility design year requirement. Thus, the Commission's land use and transportation plans have both been designed for the target year 1990, a design period of 25 years from the time of plan selection and adoption.

The need to coordinate sanitary sewerage system development with areawide land use and transportation system development dictates using the same basic forecast and design year of 1990. This period, while conservative, provides the means for locking the sanitary sewerage forecast and design periods and requirements into the previously determined regional land use-transportation forecast and design periods.

Certain sanitary sewerage system components, however, have longer periods of physical life than transportation system components, extending in some cases to more than 50 years. This is well beyond the period for which population, economic activity level, and land use demand forecasts can be made with any acceptable degree of reliability. Yet the sanitary sewerage system planning process must provide a means for evaluating the potential effect of long facility life on the structure and economic soundness of the plans. To do this, an "ultimate" land use pattern which might be expected to evolve within the Region by the year 2020 under a continuation of land use development policies consistent with the objectives and standards underlying the adopted regional land use plan, was postulated for each of the sanitary sewerage system planning subareas in the Region as defined by the location of existing urban concentrations and natural watershed boundaries.

It was initially intended to fully explore two alternative sanitary sewerage systems for each subarea—one initially sized to serve development through the year 1990 with parallel facilities proposed to serve development through the year 2020, and the other initially sized to serve development through the year 2020. After conducting several engineering and economic analyses of such alternative systems for selected subareas in the Region, it became apparent that on an equivalent annual cost basis, where substantial incremental urban development could be anticipated in a service area beyond the year 1990, it would generally be more economical to construct parallel trunk sewer facilities after 1990 to accommodate the relatively large increases in flows from the anticipated additional development than to provide the larger capacity initially. The analyses indicated that such later construction of parallel sewers would not only require a lower initial capital investment, but would provide greater flexibility to respond to unforeseen changes in conditions by virtue of the staged development entailed. Where the anticipated incremental urban development was relatively small, it became apparent that the trunk sewer design criteria utilized for 1990 development generally yielded commercial pipe sizes which would provide sufficient excess capacity to accommodate the relatively modest increases in flows from the anticipated additional development. Accordingly, it was concluded that rarely would there be an economic advantage in providing for 2020 trunk sewer design capacity and this analytical step was deleted from the alternative areawide plan preparation phase of the study. Major trunk and relief sewer facilities to be constructed in deep tunnels constituted an exception to the foregoing conclusions, and all such sewers included in the plan were sized and analyzed to the design year 2020. It is recognized, however, that such analyses may appropriately be included in subsequent engineering studies for individual trunk sewers.

Plan Design

Plan design is the heart of the planning process. The most well-conceived objectives; the most sophisticated data collection, processing, and analysis operations; and the most accurate forecasts are of little value if they do not lead to sound development plans. The outputs of these planning operations—formulation of objectives and standards, inventory, and forecast—become inputs to the design problems of plan synthesis.

The sanitary sewerage system plan design problem requires a reconciliation among hydraulic and pollution loadings derived from the adopted land use plan, sanitary sewerage system design standards, existing sanitary sewerage system capacity, and new facility costs. In the system design phase, future sanitary sewerage system networks are synthesized to satisfy the regional land use and sanitary sewerage development objectives and standards formulated under the study, while meeting criteria of system integration and cost. To a considerable extent, the process is one of successively approximating the best design solutions, proposing specific solutions for specific system problems in each iteration, and then testing through simulation the operation of the proposed system by applying hydraulic and pollution loadings.

The procedure requires careful analysis of the assigned hydraulic and pollution loadings to identify deficiencies in the existing system under future demand conditions, and thereby the system parts requiring relief. Future facilities are then postulated to provide necessary relief. Finally, loadings derived from the adopted land use plan are applied to test the adequacy of the proposals, with the entire procedure repeated until a workable system has been evolved.

In the regional sanitary sewerage system plan synthesis, preliminary design solutions to be tested and evaluated were drawn from three sources:

1. Sanitary sewerage system improvement proposals advanced through the Technical Coordinating and Advisory Committee by the local municipal public works agencies responsible for such system development in the Region.

2. Analysis of network loadings, which provided knowledge of the existing and probable future loadings of sanitary sewerage systems in the Region and made solutions to correct system deficiencies apparent.

3. Land use planning, from which requirements for service based on land use development objectives were defined.

These improvement proposals originated with experienced professional engineers working for state and local units of government, with intimate knowledge of and long standing experience with the existing sanitary sewerage system in the Region. Wherever assignments of future sewer loadings to the existing network indicated that existing facilities were inadequate to meet future demand, members of the Technical Coordinating and Advisory Committee were consulted for improvements to alleviate the deficiency. These were added to the network and the resulting system tested. Where design solutions from the first source proved inadequate, or where no solution had been proposed, the second source of design solutions was used. The third source for design solutions was primarily advanced for newly developing areas in the Region.

Since the entire plan synthesis was directed towards attaining regional land use and sanitary sewerage system development objectives set forth in Chapter VIII of this report, it was essential to evaluate the resulting plans in light of their ability to meet these objectives. This was done by applying to each plan the supporting standards formulated for each development objective.

Several overriding considerations were recognized in applying regional development objectives and standards. First, each proposed sanitary sewerage facility plan must be part of an integrated and continuous system or subsystem. This required application of sanitary sewage flow models to quantitatively test the proposed system, thereby permitting adjustment of the spatial distribution and capacities of the system to existing and future loadings derived from the land use plan. The effect of pollution loadings associated with various locations and degrees of waste treatment on the receiving environment was also evaluated. Second, it was recognized that economic analysis is vital to the public planning process and must be an important guide to selecting the most suitable plan. The cost of each alternative, including the time cost of associated monetary investment, was therefore carefully explored.

Plan Test and Evaluation

If plans developed in the design stage are to be realized in terms of facility development, some measures must be applied to quantitatively test them before they are adopted and implemented. Engineering performance and technical and economic feasibility are tested in the plan design stage. The plans must also be rigorously subjected to additional review and evaluation, including financial feasibility, legality, and political reaction. Testing and evaluation range from assigning hydraulic and pollution loadings to the existing and proposed sewerage facilities to interagency meetings and public hearings. Plan test and evaluation should clearly show which plans or parts of plans are technically and economically sound, financially feasible, legally possible, and politically realistic.

Plan Selection and Adoption

The regional sanitary sewerage system study developed alternative plans capable of serving the adopted regional land use plan. The approach used to select one plan from the alternatives was to present the alternatives and their technical, economic, financial, and legal feasibility to the Technical Coordinating and Advisory Committee, at interagency meetings, and public hearings. The Commission then made a final decision and adopted a plan in accordance with the provisions of the state regional planning enabling legislation. The Commission's role is solely to recommend to federal, state, and local units of government and to private investors the best final plan for consideration and action. The final step is the acceptance or rejection by the federal, state, and local units of government concerned, and subsequent plan implementation by public and private action. The use of advisory committees and formal and informal public hearings appears to be the most practical, effective way to involve government bodies, technical agencies, and private interest groups in the planning process, and for reaching agreement on a final plan which can be cooperatively adopted and jointly implemented.

(This page intentionally left blank)

Chapter III

DESCRIPTION OF THE REGION—MAN-MADE FEATURES

INTRODUCTION

The seven-county Southeastern Wisconsin Region is an interrelated complex of natural and man-made features which together form a rapidly changing environment for human life. The important man-made features of the Region include its land use pattern, public utility networks, and transportation systems. Together with the population residing and the economic activities taking place in the Region, these features may be thought of as the socioeconomic base of the Region. An understanding of this base is essential to sound areawide sanitary sewerage system planning.

Because the basic purpose of sanitary sewerage system planning includes the protection and improvement of the quality of the environment for urban life, as well as the provision of a public utility service to meet the needs of the existing and probable future resident population, an understanding not only of the present but also of the probable future size, composition, and spatial distribution of the population is essential to sound sanitary sewerage system planning and development. The present and probable future size, composition, and spatial distribution of the population are, however, greatly influenced by growth and change in the economy. The present and probable future spatial distribution of the population is also directly related to trends and changes in land use development patterns; the availability of other public utilities, such as water supply and gas and electric power facilities; and the characteristics of existing and planned transportation facilities.

A description of the socioeconomic base of the Region is herein presented in seven sections. The first section describes the Region and its internal political and governmental boundaries. The second and third sections describe the demographic and economic base of the Region in terms of historic trends, as well as existing conditions with respect to population size, distribution, and composition and employment levels and distribution. The fourth section describes the patterns of land use in the Region in terms of historical development and existing (1970) conditions. The fifth and sixth sections describe the public utility and transportation facility systems within the Region. A final section summarizes the material presented in the chapter.

REGIONAL SETTING AND POLITICAL BOUNDARIES

As noted in Chapter I of this report, the Southeastern Wisconsin Planning Region is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. These seven southeastern Wisconsin counties have a total area of 2,689 square miles, or about 5 percent of the total area of Wisconsin. About 40 percent of the state's population, however, resides within these seven counties. The Region contains about one-half of all the tangible wealth in the state as measured by equalized assessed property valuation and represents the greatest wealth producing area of the state, with about 38 percent of the total work force of the state being employed in the Region. From 1960 to 1970, the Region accounted for about 40 percent of the total population increase in the state.

Geographically the Region is located in a relatively good position with regard to continued growth and development. It is bounded on the east by Lake Michigan, which provides an ample supply of fresh water for both domestic and industrial use, as well as being an integral part of a major international transportation network. It is bounded on the south by the rapidly expanding northeastern Illinois metropolitan region and on the west and north by the fertile agricultural lands and desirable recreational areas of the rest of the State of Wisconsin. Many of the most important industrial areas and heaviest population concentrations in the midwest are located approximately within 250 miles of the Region, and slightly more than 35 million people reside within this radius, an increase of approximately 5 million persons over the 1960 level.

A complex of 153 general-purpose local units of government and an even greater number of special-purpose units of government comprise the Southeastern Wisconsin Region. The 153 general-purpose local units of government include the seven counties comprising the Southeastern Wisconsin Region: Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha; 28 cities, 53 villages, and 65 towns.

Certain of the special-purpose units of government are of particular interest to the sanitary sewerage system planning program. Among these are the 41 active, legally established town sanitary and utility districts operating within the Region.[1] This type of special-purpose local unit of government is created to provide various urban-type services, such as sanitary sewerage, water supply, and solid waste collection and disposal to designated portions of rural towns having certain urban service needs. These districts encompass a total area of about 110 square miles, or about 4 percent of the total area of the Region. The name, location, and service areas of these districts are shown on Map 2.

Another special-purpose unit of government within the Region having important areawide responsibilities for drainage and flood control and for water pollution control, as well as for the provision of sanitary sewerage service and sewage treatment, is the Metropolitan Sewerage District of the County of Milwaukee. This District presently provides sewerage service outside Milwaukee County under contract to portions of the Cities of New Berlin and Brookfield and to all of the City of Mequon and the Villages of Bayside, Butler, and Elm Grove, as well as to the District itself which includes all of Milwaukee County except the City of South Milwaukee. In addition the District has contracts to serve portions of the City of Muskego and the Village of Menomonee Falls as trunk sewers are extended. The system operated by the District is also designed to provide service to all of the Village of Thiensville, all of the Village of Germantown, that portion of the City of Milwaukee lying in Washington County, and portions of northern Racine County.

Another special-purpose unit of government in the Region having important responsibilities for the provision of areawide sanitary sewerage service and sewage treatment is the Western Racine County Sewerage District. This District serves the Villages of Rochester and Waterford and a portion of the Town of Rochester.

The total existing and proposed service areas of the Milwaukee and Western Racine County Metropolitan sewerage districts are 415 and 2.8 square miles, respectively, or about 16 and 1 percent of the total area of the Region. These areas are also shown on Map 2.

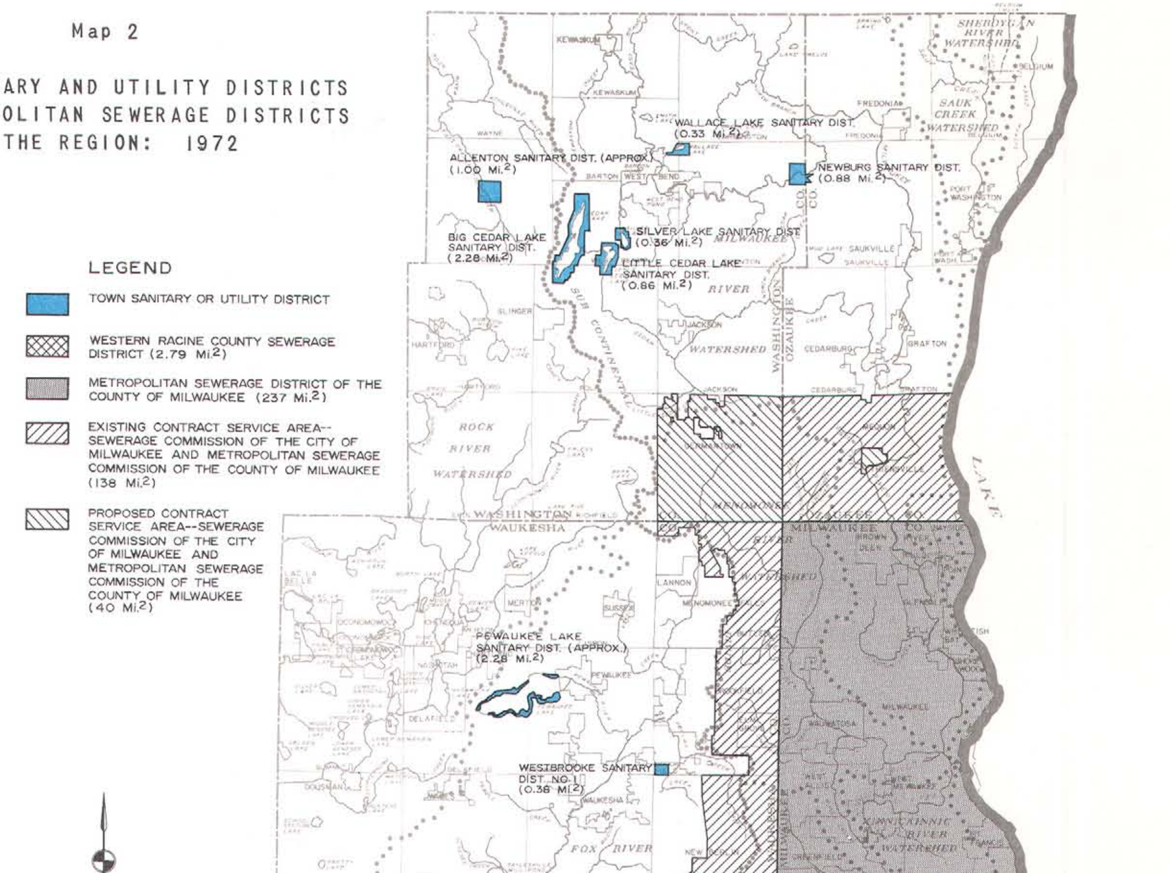
In addition to these special areawide and local units of government directly concerned with the provision of sanitary sewerage service, there are certain other special-purpose units and agencies of government in existence within the Region of concern to any areawide sanitary sewerage system planning program. These include the soil and water conservation districts and the drainage districts, both of which have important water resource or water resource-related management responsibilities. There are seven soil and water conservation districts within the Region, the boundaries of these districts being coterminous with the boundaries of the seven counties. There are a total of 6 drainage districts within the Region, which, according to official records, are both legally constituted and active, including five agricultural drainage districts and one urban storm water drainage district. These districts encompass a total area of 106 square miles, or about 4 percent of the total area of the Region (see Map 3). Other areas in the Region with

---

[1] *In addition to the 41 active, legally established town sanitary and utility districts in the Region found in the inventory, records of the Wisconsin Department of Natural Resources indicate other town sanitary or utility districts which apparently had been formed in the past, but which presently are either totally inactive or have been supplanted by city or village utility services. These include in Kenosha County the Town of Bristol Sanitary District No. 2, the Town of Pleasant Prairie Sanitary District No. 1, the Paddock Lake Dells Sanitary District in the Village of Paddock Lake, and the Edgewater Sanitary District and Town of Somers Sanitary District No. 3 in the Town of Somers; in Milwaukee County the Broson Manor, Hales Corners, and Lapham-Orchard Sanitary Districts in the Town of Greenfield; the Lakeside Sanitary District in the Town of Lake; the First New Deal, Oak View, and Rowan Estates Sanitary Districts in the Town of Oak Creek; and the Blue Mound Manor and Lovers Lane Estates Sanitary Districts in the Town of Wauwatosa; in Racine County the Trautwein, West Terrace, Colonial Heights, Consolidated Town, and Fairlawn Sanitary Districts in the Town of Mount Pleasant; in Washington County the Germantown Sanitary District No. 1 in the Town of Germantown; and in Waukesha County the Greenfield Heights, Hidden Woods Estates, and Westchester Sanitary Districts in the Town of Brookfield. A number of the foregoing sanitary districts at one time operated relatively small sewerage systems which have been connected to and made a part of larger, centralized municipal sanitary sewerage systems.*

Map 2

TOWN SANITARY AND UTILITY DISTRICTS AND METROPOLITAN SEWERAGE DISTRICTS IN THE REGION: 1972

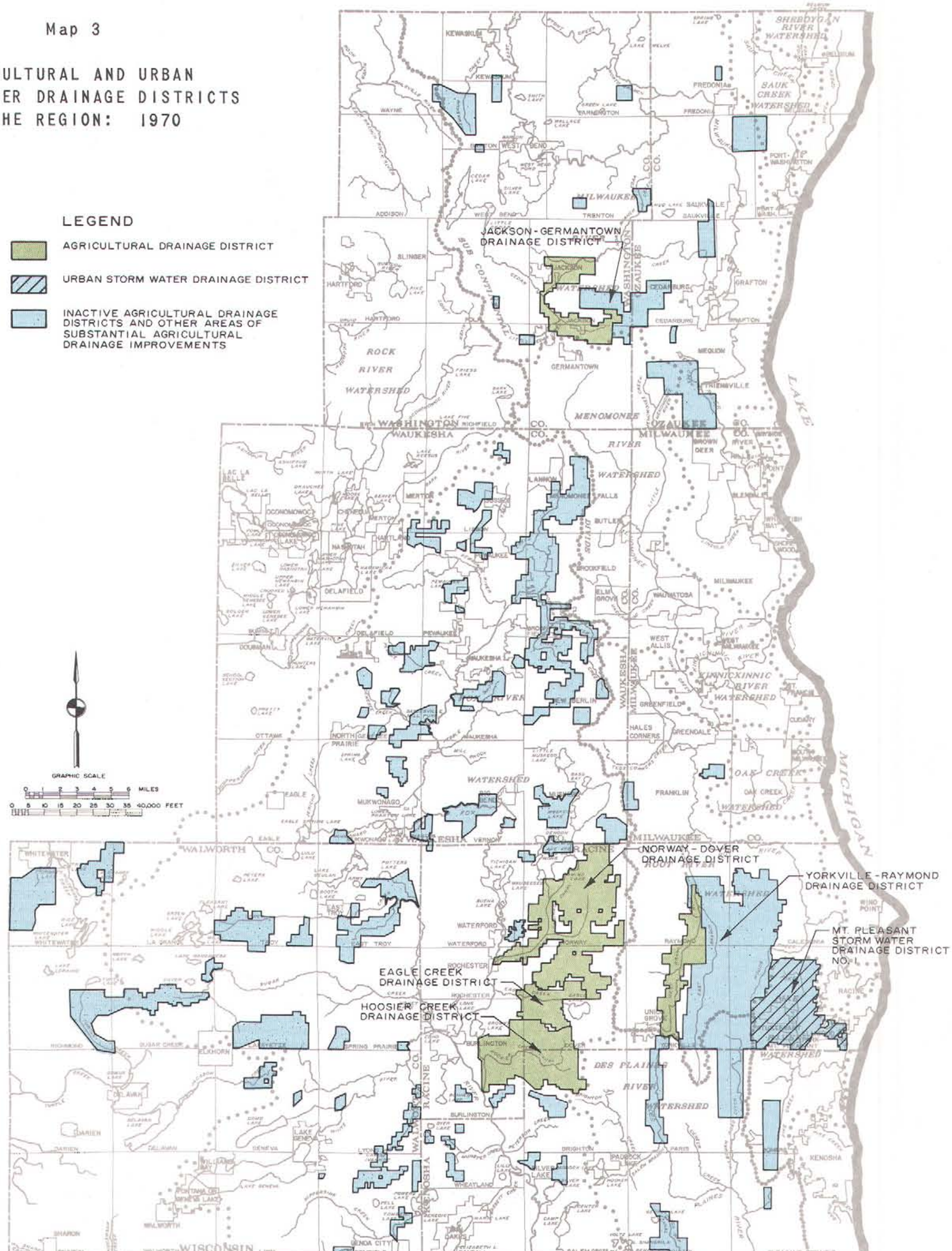


Particularly pertinent to the regional sanitary sewerage system planning program are special-purpose units of government that have the capability of providing sanitary sewer service. There are a total of 41 active, legally established town sanitary or utility districts operating in unincorporated areas of the Region, which together encompass a total area of 110 square miles, or 4 percent of the total area of the Region. Many of these districts have been formed to provide sewer service to lake-oriented urban development. In addition, there are two metropolitan sewerage districts operating in the Region. By far the largest such district is the Metropolitan Sewerage District of the County of Milwaukee, which includes all of Milwaukee County except the City of South Milwaukee, and which provides contract services to 138 square miles of area in seven communities adjacent to Milwaukee County in Ozaukee and Waukesha Counties. The other metropolitan sewerage district is the Western Racine County Sewerage District which provides conveyance and treatment for sewage generated in a 2.8 square mile area, which includes the Village of Rochester and Waterford and the Town of Rochester Sewer Utility District No. 1.

Source: SEWRPC.

Map 3

AGRICULTURAL AND URBAN STORM WATER DRAINAGE DISTRICTS IN THE REGION: 1970



There are six active, legally constituted drainage districts in the Southeastern Wisconsin Region at the present time. Of this total, five are agricultural drainage districts located in Racine and Washington Counties. The remaining district is an urban storm water drainage district in the Town of Mt. Pleasant. Together, these districts encompass a total area of about 106 square miles, or nearly 4 percent of the total area of the Region. In addition, there are more than 325 square miles of land throughout the Region for which extensive agricultural drainage improvements have been made in the past either through informal agreements between individual farmers or through now inactive agricultural drainage districts. Because of the capital investments made in such improvements, and because such areas normally contain extensive amounts of soils poorly suited for urban development, land use and sewerage system planning should seek to avoid the placement of urban development in these areas.

Source: SEWRPC.

substantial agricultural drainage improvements, including several inactive agricultural drainage districts, are also shown on Map 3.

Superimposed upon these local and areawide units and agencies of government are the state and federal governments, certain agencies of which also have important responsibilities for water resource, or water resource-related, management, and for the development of sanitary sewerage systems and sewage treatment plants. These include the Wisconsin Department of Natural Resources; the Wisconsin Department of Health and Social Services: the University of Wisconsin-Extension Service; the State Geological and Natural History Survey; the Soil Conservation Board of Wisconsin; the U. S. Department of the Interior, Geological Survey; the U. S. Environmental Protection Agency; the U. S. Department of Agriculture, Soil Conservation Service; the U. S. Army Corps of Engineers; and the U. S. Department of Housing and Urban Development.

DEMOGRAPHIC BASE

Population Size

The population of the Region, which in 1970 totaled 1,756,100 persons, grew at the rate of about 18,000 persons per year from 1960 to 1970, a rate considerably lower than the approximately 33,000 persons per year growth rate experienced from 1950 to 1960. While the population of the Region increased by 182,000 persons from 1960 to 1970, the population of the central City of Milwaukee—the 12th largest city in the nation—following national trends actually decreased by nearly 24,000 persons. Certain adjacent first-ring suburbs also showed population decreases, while large increases in population occurred in the newer outlying suburban areas and particularly in the rural-urban fringe areas of the Region.

Population growth within the Region over the past century has generally occurred at a higher rate than for the state and nation (see Figure 4 and Table 1). Consequently, the regional share of the total national population has increased from 0.49 percent in 1850 to 0.86 percent in 1970, while the regional share of the state population has increased from about 37 percent in 1850 to nearly 40 percent in 1970.

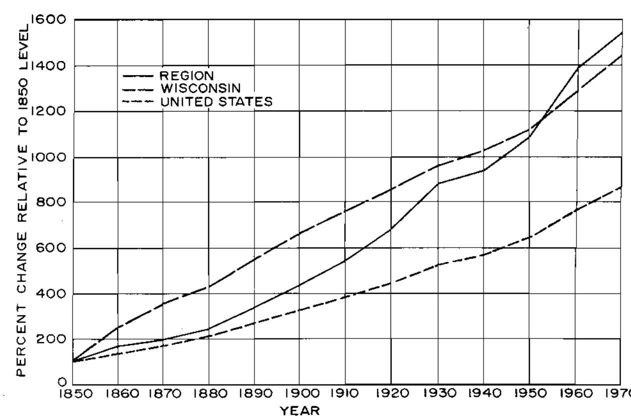
Population Distribution

The Southeastern Wisconsin Region, like most metropolitan regions in the United States, is becoming increasingly urban. In 1850 the population of the Region was approximately 75 percent rural and 25 percent urban; by 1900 this relationship had nearly reversed to 30 percent rural and 70 percent urban; and by 1970 only 12 percent of the regional population was rural while 88 percent was urban. Moreover, 10 percent of the total population was classified as rural non-farm and only 2 percent as rural-farm. The entire 120-year rural-urban change is shown graphically in Figure 5. This trend to urbanization is one of the most significant distributional changes taking place within the Region, the state, and the nation today.

Population growth has not been uniform throughout the seven counties comprising the Region. During the 30-year period from 1900 to 1930, the highest

Figure 4

RELATIVE POPULATION GROWTH IN THE REGION, WISCONSIN, AND THE UNITED STATES: 1850-1970



Source: U. S. Bureau of the Census and SEWRPC.

Table 1

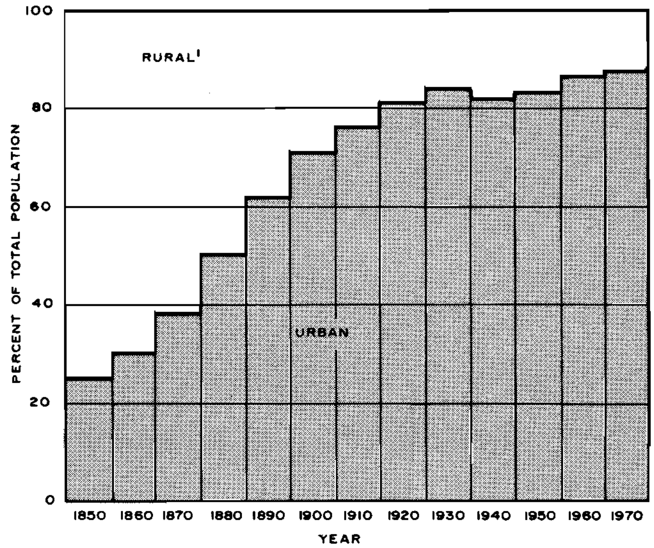
POPULATION TRENDS IN THE REGION, WISCONSIN, AND THE UNITED STATES: 1850-1970

Year	Population			Region Population as a Percent of	
	Region	Wisconsin	United States	United States	Wisconsin
1850	113,389	305,391	23,196,876	0.49	37.1
1860	190,409	775,881	31,443,321	0.61	24.5
1870	223,546	1,054,670	38,558,371	0.58	21.2
1880	277,119	1,315,497	50,155,783	0.55	21.0
1890	386,774	1,693,330	62,947,714	0.61	22.8
1900	501,808	2,069,042	75,994,575	0.66	24.2
1910	631,161	2,333,860	91,972,266	0.69	27.0
1920	783,681	2,632,067	105,710,620	0.74	29.7
1930	1,006,118	2,939,006	122,775,046	0.82	34.2
1940	1,067,699	3,137,587	131,669,270	0.81	34.0
1950	1,240,618	3,434,575	151,325,798	0.82	36.1
1960	1,573,620	3,952,771	179,323,175	0.88	39.8
1970	1,756,086	4,417,933	203,184,772	0.86	39.7

Source: U. S. Bureau of the Census.

Figure 5

DISTRIBUTION OF URBAN AND RURAL POPULATION IN THE REGION: 1850-1970



[1] RURAL POPULATION INCLUDES RURAL NON-FARM RESIDENTS.

Source: U. S. Bureau of the Census and SEWRPC.

rates of population increase occurred in the three urban counties of Milwaukee, Racine, and Kenosha. Urban decentralization over the last four decades, however, has reversed this trend; and the highest rates of population increase are presently occurring in certain outlying counties of the Region, notably Waukesha and Ozaukee Counties (see Figure 6 and Map 4).

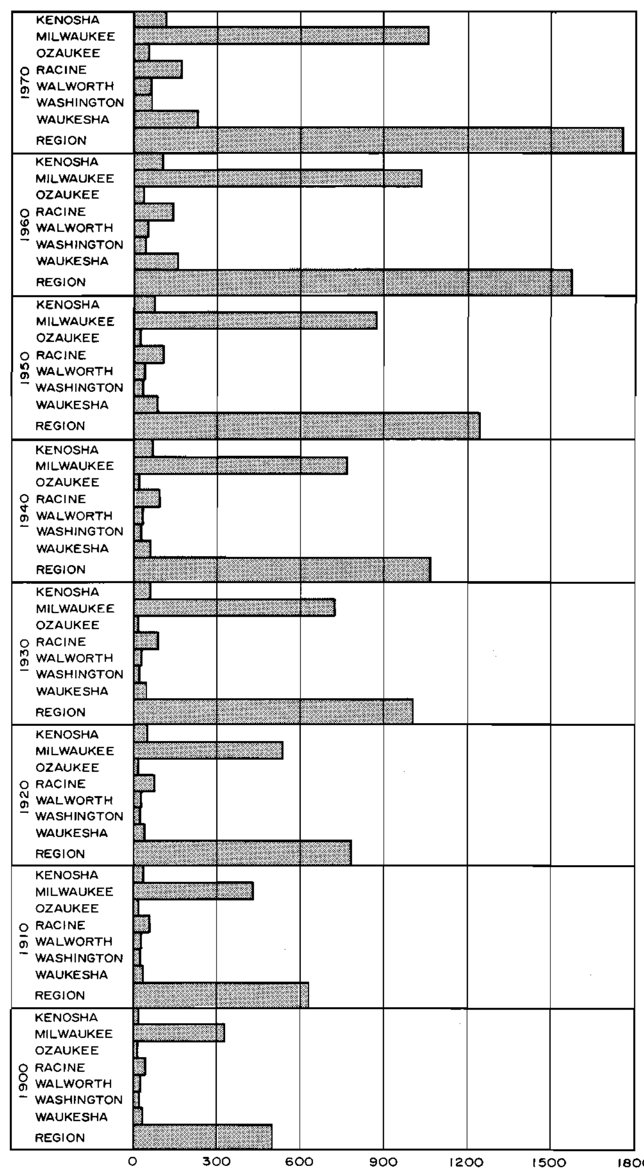
These varying rates of change of population growth in the counties of the Region have resulted in significant distributional shifts of population among the seven counties. As shown in Table 2, the most dramatic distributional changes over the entire 70-year period have occurred in Milwaukee and Waukesha Counties. The Milwaukee County proportion of the total regional population increased by about 6 percent from 1900 to 1930 and then decreased by more than 12 percent from 1930 to 1970. The proportion of the total regional population in Waukesha County decreased by about 2 percent from 1900 to 1930 and then increased by about 8 percent from 1930 to 1970. The result of the most recent changes in population distribution within the Region has been an areawide spread of population around the Milwaukee, Racine, and Kenosha urbanized areas. This diffusion of population has resulted in many areawide development problems, including problems relating to the collection and disposal of sanitary sewage.

Population Characteristics

The geographic distribution of age throughout the Region is shown on Map 5. This map shows a concentration of children and younger people in suburban areas adjacent to the large central cities and of older people in many areas of the Cities of Milwaukee, Racine, and Kenosha. There is also a notable concentration of older persons in southern Ozaukee County, western Waukesha County, and southern Walworth County.

Figure 6

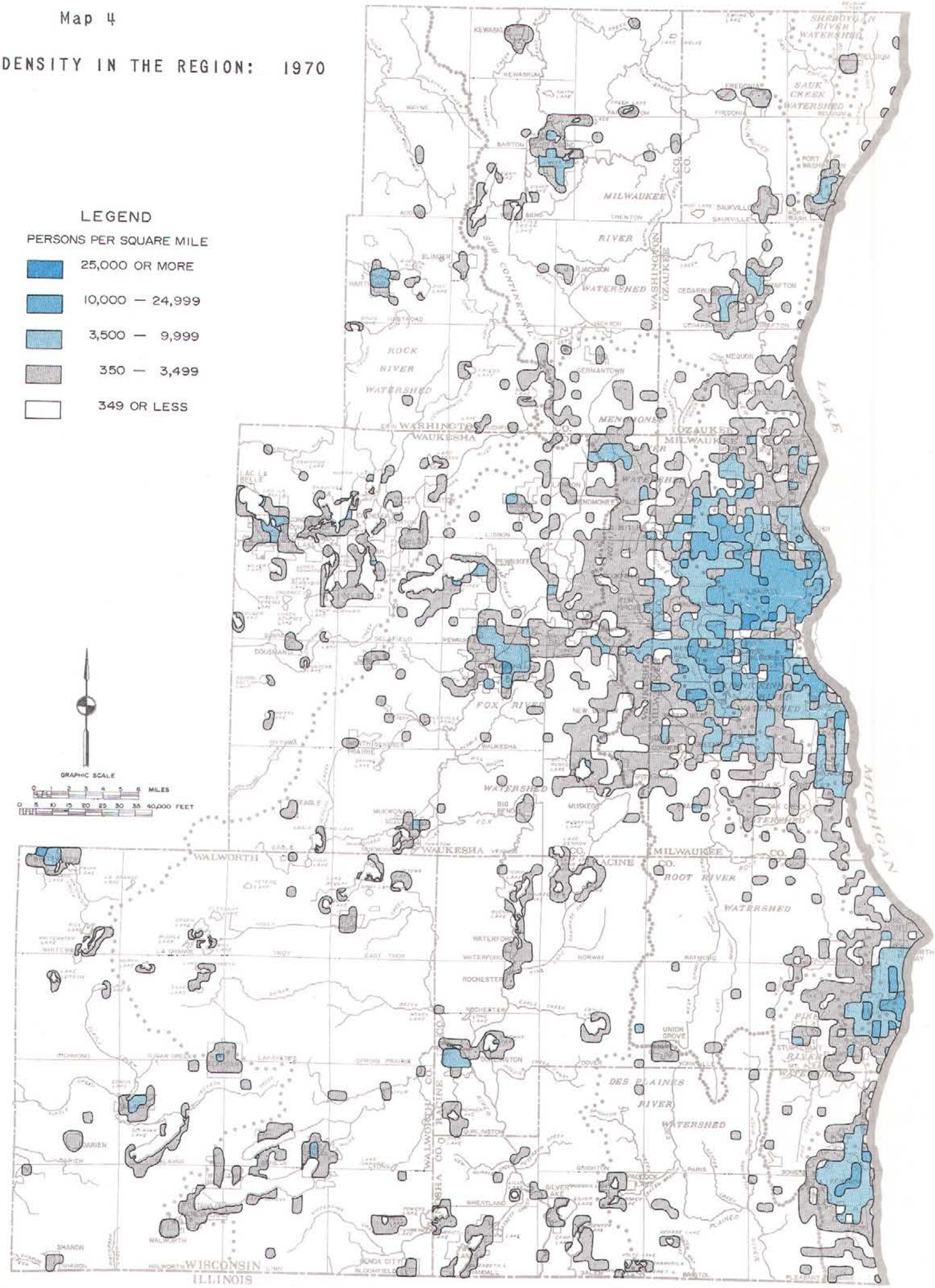
DISTRIBUTION OF POPULATION IN THE REGION BY COUNTY: 1900-1970



Source: U. S. Census of Population and SEWRPC.

Map 4

POPULATION DENSITY IN THE REGION: 1970



This map depicts population densities within the Region at the time of the 1970 U. S. Census of Population and Housing. Of the total regional population of about 1.8 million persons, about 80 percent resided within Kenosha, Milwaukee, and Racine Counties. As might be expected, the higher population densities occur in the older central cities and suburbs of the Region, while the lower population densities occur in the newer suburbs and in the rural urban fringe areas. Development in the latter areas is occurring in a highly diffused pattern throughout the Region, and much of this scattered urban development is not now served and cannot readily be served with centralized public sanitary sewerage and water supply facilities.

Source: SEWRPC.

Table 2

POPULATION DISTRIBUTION IN THE REGION BY COUNTY: 1900, 1930, 1960, AND 1970

County	1900		1930		1960		1970	
	Population	Percent of Region	Population	Percent of Region	Population	Percent of Region	Population	Percent of Region
Kenosha	21,707	4.3	63,277	6.3	100,615	6.4	117,917	6.7
Milwaukee	330,017	65.8	725,263	72.1	1,036,047	65.8	1,054,249	60.0
Ozaukee	16,363	3.3	17,394	1.7	38,441	2.5	54,461	3.1
Racine	45,644	9.1	90,217	9.0	140,781	9.0	170,838	9.7
Walworth	29,259	5.8	31,058	3.1	52,368	3.3	63,444	3.6
Washington	23,589	4.7	26,430	2.6	46,119	2.9	63,839	3.7
Waukesha	35,229	7.0	52,350	5.2	158,249	10.1	231,338	13.2
Region	501,808	100.0	1,005,989	100.0	1,573,620	100.0	1,756,086	100.0

Source: U. S. Bureau of the Census and SEWRPC.

One of the most important characteristics of the regional population, in terms of sanitary sewerage system planning, is the number and size of the households in the Region. The number of households in the Region has been increasing at a higher rate than has the total population since 1950 (see Table 3), and as a result the household size has been declining. The geographic distribution of average household sizes in the Region is shown on Map 6. The smaller average household sizes occur in the central cities and smaller outlying cities and villages. The larger average household sizes occur in suburban and rural farm areas throughout the Region.

Personal income in the Region has been increasing at a rapid rate, and in 1969 total personal income stood at just under 5.2 billion dollars (see Table 4). From 1949 to 1969, total personal income in the Region increased by nearly 2.9 billion, measured in constant 1967 dollars, or by about 126 percent. This compares to a regional population increase over the same period of approximately 42 percent. Because the total amount of personal income in the Region has been increasing at a higher rate than has the total population since 1949, per capita and per household incomes have increased markedly. Per capita incomes increased from $1,853 in 1949 to $2,954 in 1969, measured in constant 1967 dollars. The median per household income increased from $5,743 to $8,563 over the same period. The per household income increase reflects not only an increase in the earnings of the heads of each household but also the tendency for other household members, wives in particular, to supplement household incomes. The distribution of personal income on a per household basis throughout the Region is shown on Map 7. It is evident that the areas of highest household income are presently located in northern and western Milwaukee County, in eastern Waukesha County, in southern Ozaukee County, and in southeastern Washington County, and that the lowest household income areas are presently in the City of Milwaukee and in certain outlying rural areas of the Region.

ECONOMIC BASE

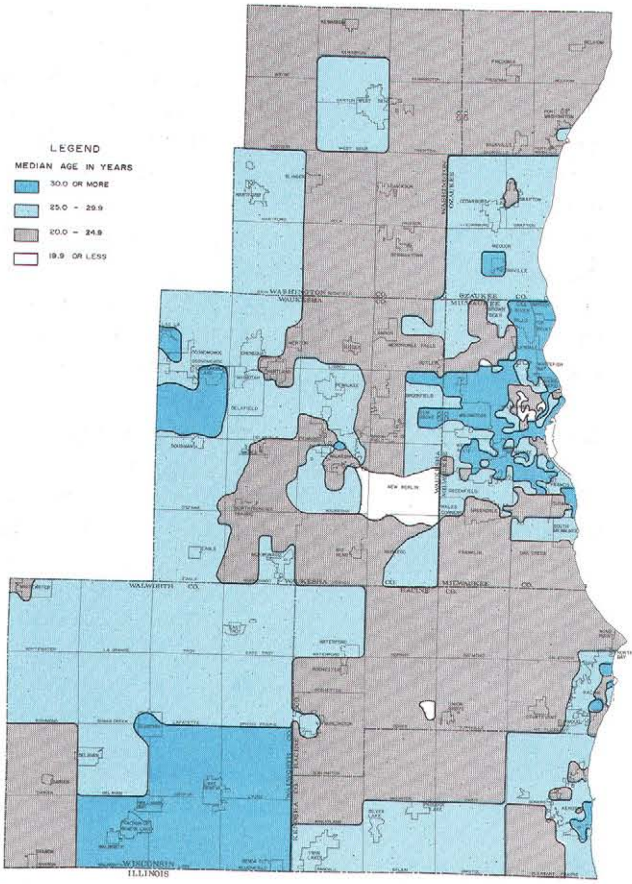
Changes in the population of an area are closely related to changes in the amount of economic activity in that area. This is true not only because much of the population migration into an area is dependent upon the availability of jobs in that area, but also because jobs must ultimately be available to hold the natural increase and prevent the outmigration of native young people entering the labor force. The rapid growth in the population of the Region may, therefore, be basically attributed to increasing economic activity in the Region.

Size of the Economy

One of the best measures of economic activity is the number of employment opportunities, or jobs, available within the planning area. The amount of economic activity in the Region, as measured by the number of jobs available, has increased at varying rates in the recent past. From 1954 to 1957, there was a rapid increase in the number of jobs available, followed by a sharp decline in 1958 corresponding with a general recession in the national economy. From 1958 to 1960, there was again a rapid increase, followed by another sharp decline in 1961, again corresponding with another national recession. Since 1961 there has been a more moderate but steady increase in jobs

Map 5

MEDIAN AGE DISTRIBUTION IN THE REGION: 1970



This map depicts the age distribution of the population of the Southeastern Wisconsin Region. The map indicates a high concentration of young persons in the near north side of Milwaukee County and in the New Berlin area of Waukesha County, areas inhabited by relatively large families. The map indicates concentrations of older median age levels occurring in both the older central city areas and in certain rural areas of the Region. In 1970 the median age of the regional population was 27.6 years, compared to 29.7 years in 1960.

Source: SEWRPC.

within the Region, except for a slight economic slowdown during 1966 and 1967 and the recent recession of 1970 (see Figure 7).

Distribution of Economic Activity

Nearly 69 percent of the economic activity of the Region, as measured by jobs, was located in Milwaukee County in 1970. An additional 14 percent was located in Racine and Kenosha Counties combined. Approximately 83 percent of the regional jobs are, therefore, located in these three counties. The remaining 17 percent of the regional jobs are distributed as follows: Waukesha County, about 9 percent; Walworth County, about 3 percent; Washington County, about 3 percent; and Ozaukee County, about 2 percent (see Table 5).

Table 3

HOUSEHOLD POPULATION TRENDS IN THE REGION: 1950, 1960, AND 1970

Year	Number of Households	Household Population	Persons Per Household
1950	354,544	1,190,193	3.36
1960	465,913	1,537,235	3.30
1970	536,486	1,714,200	3.20
Percent Change 1950-1970	51.3	44.0	- -

Source: U. S. Bureau of the Census and SEWRPC.

The trend in the intraregional distribution of jobs is toward a decreasing concentration of jobs in Milwaukee County and, in turn, toward an increasing concentration of jobs in the other six counties of the Region. Waukesha County has shown the largest increase in the proportion of total regional jobs since 1955, an increase from about 3 percent to about 9 percent in 1970. This increase is in direct contrast to Milwaukee County, where the proportion of total regional jobs decreased from nearly 78 percent to about 69 percent over the same period. These changes reflect a general historic trend toward decentralization of manufacturing, distribution, and service activities from highly urbanized areas to more suburban and rural-urban fringe areas.

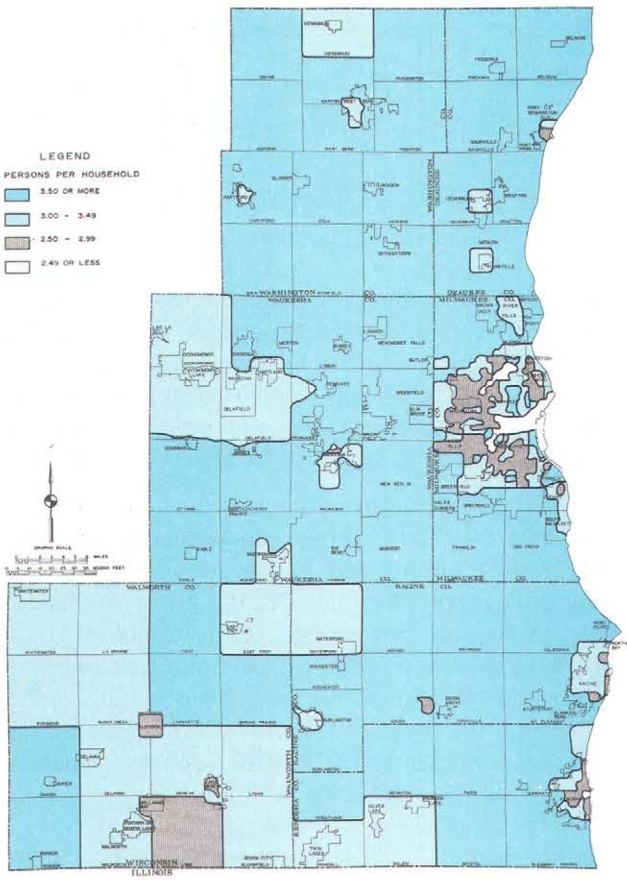
Structure of the Economy

The character of the regional economy can best be described in terms of its industrial structure, since the number and types of industry directly affect land use and transportation needs. In this regard, economic activity within the Region can be classified into nine major industry groups: 1) agriculture; 2) mining; 3) construction; 4) manufacturing; 5) transportation, communication, and utilities; 6) trade; 7) finance, insurance, and real estate; 8) services; and 9) government.

Economic activity within the Region is heavily concentrated in manufacturing (see Figure 8). In 1970 approximately 34 percent of the total jobs in the Region were in manufacturing compared to 26 percent nationally. The proportion of economic activity in all other industry groups within the Region except private services, as measured by jobs, was less than the national averages.

Map 6

AVERAGE HOUSEHOLD SIZE
IN THE REGION: 1970



As depicted on the map, the areas within the Region with large household size are those which developed or have been developing subsequent to 1950. With the exception of some rural farm areas and the near north side of Milwaukee County, smaller household size can be found in the older central city areas. It should be noted that the average household size for the Region in 1970 was 3.2 persons compared to an average household size of 3.3 persons in 1960.

Source: SEWRPC.

The structure of economic activity within the regional manufacturing industry, which is so important in the regional economy, is also quite different from the structure of the manufacturing industry nationally (see Figure 9). In contrast to the manufacturing industry of the United States, the manufacturing industry in the Region is more heavily concentrated in the production of durable goods, particularly machinery, electrical equipment, and transportation equipment. In 1970 more than 52 percent of the total manufacturing jobs within the Region were in these industries, compared to less than 32 percent nationally. Compared to the national distribution, there is also a concentration of fabricated metal product manufacturing and printing and publishing activities. On the other hand, there is a relatively low concentration of activity associated with the production of nondurable goods, such as textile, apparel, leather, paper, wood, chemical, petroleum, rubber, and plastic products. The only nondurable goods manufacturing activity which has a proportion of manufacturing employment approximating that of the national economy, in addition to printing and publishing, is the production of food and beverage products. This is due primarily to the location in the Region of a number of very large breweries.

It is interesting to note that the most important manufacturing activity nationally, in terms of proportionate employment, is the production of textile, apparel, and leather goods. These industries accounted for nearly 15 percent of total national manufacturing employment in 1970. Within the Region they accounted for only 4 percent of the total manufacturing employment in 1970. Because of locational and other factors, it is likely that the structure of the regional manufacturing industry group will continue to be oriented to heavy durable equipment manufacturing in the future as it has in the past.

LAND USE BASE

One of the central concepts underlying the regional sanitary sewerage system planning program is that land use and the need for public utilities such as sanitary sewerage systems are closely interrelated. The type, intensity, and spatial distribution of land use determines the need for sanitary sewerage service and the physical configuration and capacity of sewerage systems and their component elements. A complete inventory of existing land use is necessary to identify and quantify the

Table 4

PERSONAL INCOME TRENDS IN THE REGION:
1949, 1959, AND 1969

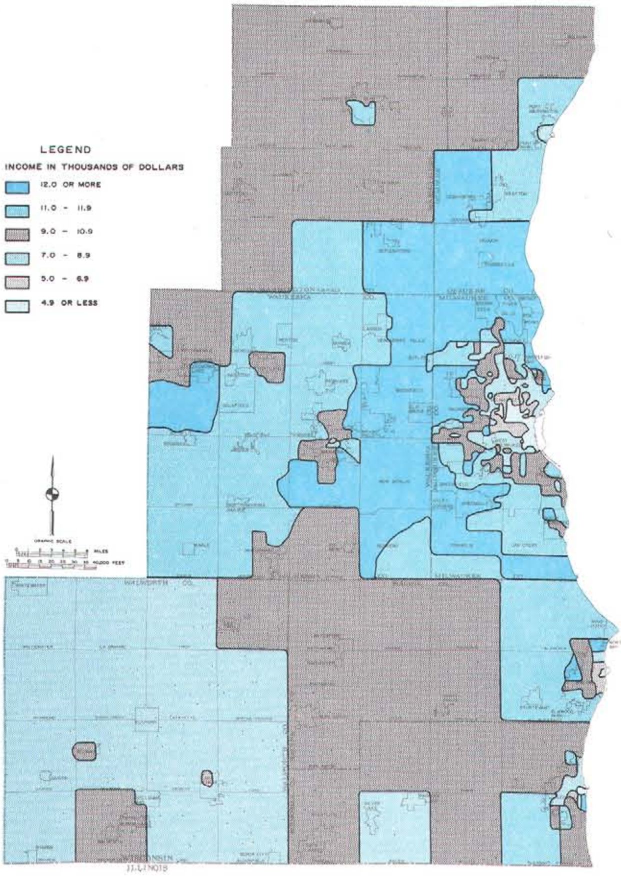
Year	Total Income (Millions of Dollars)		Per Capita Income		Per Household Income (Median)	
	Actual	Constant[1]	Actual	Constant[1]	Actual	Constant[1]
1949	$1,660	$2,299	$1,338	$1,858	$4,145	$5,743
1959	3,492	3,941	2,219	2,505	6,637	7,491
1969	6,029	5,189	3,433	2,954	9,950	8,563

[1]Adjusted for price change, base year equals 1967.

Source: U. S. Bureau of the Census and SEWRPC.

Map 7

MEDIAN HOUSEHOLD INCOME
IN THE REGION: 1969



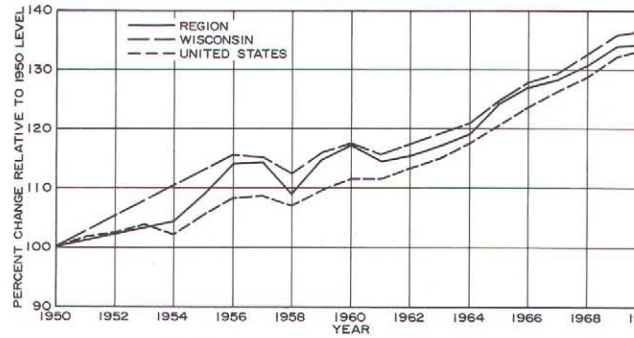
This map depicts the geographic distribution of household or family income in the Region. The lower income families are generally concentrated in the older central city areas and in the outlying predominantly rural areas of the Region. Concentrations of higher income families can be found in those newer communities that have been developed within the Region since 1950. It should be noted that the median household income for the Region as a whole increased from $5,743 in 1949 to $8,563 in 1969, measured in constant 1967 dollars.

Source: *SEWRPC.*

existing sewerage service needs through identification of existing developed urban areas outside of the established urban centers which already are providing sewerage services. Moreover, such an inventory when coupled with a knowledge of historic development patterns provides one of the best available bases for understanding urban activity and probable future land use patterns.

Figure 7

RELATIVE JOB GROWTH IN THE REGION,
WISCONSIN, AND THE UNITED STATES:
1958-1970



Source: *U. S. Department of Labor; Wisconsin Department of Industry, Labor, and Human Relations; and SEWRPC.*

Historic Growth Patterns

The first permanent European settlement in the Region was established in 1795 as a trading post on the east side of the Milwaukee River, just north of what is now Wisconsin Avenue in the City of Milwaukee. The origins of most of the other major cities and villages within the Region can be traced to the establishment of such trading posts or to the establishment of certain types of agricultural services such as saw and grist mills. The location of these earliest urban activities was heavily influenced by water power and water transportation needs. The rapid settlement by Europeans of what is now the Southeastern Wisconsin Region had its beginning following the Indian cessions of 1829 and 1833, which transferred to the federal government ownership of all of the lands that now comprise the State of Wisconsin south of the Fox River and east of the Wisconsin River. Federal surveyors, after the close of the Blackhawk War of 1832, began to survey, subdivide, and monument the federal lands; and by 1836 the U. S. Public Land Surveys has been essentially completed in southeastern Wisconsin. Completion of the U. S. Public Land Survey in the Region and subsequent sale of the public lands brought many settlers from New England, Germany, Austria, and Scandinavia. Initial urban development occurred along the Lake Michigan shoreline at the ports of Milwaukee, Port Washington, Racine, and Southport (now Kenosha), as these settlements were more directly accessible to immigration from the East Coast through the Erie Canal-Great Lakes transportation route. By 1850 there were more than 113,000 people in the Region, and the accompanying historic devel-

Table 5

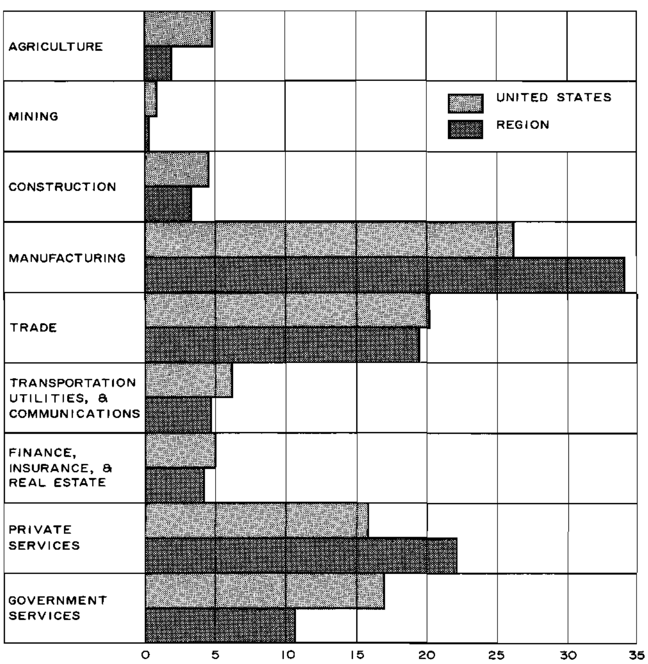
DISTRIBUTION OF JOBS IN THE REGION BY COUNTY: 1955, 1960, 1965, AND 1970

County	1955		1960		1965		1970	
	Jobs	Percent	Jobs	Percent	Jobs	Percent	Jobs	Percent
Kenosha	35,600	6.3	40,100	6.2	42,100	6.1	39,200	5.3
Milwaukee	440,100	77.9	486,400	75.1	487,400	71.0	510,900	68.9
Ozaukee	7,900	1.4	9,700	1.5	13,600	2.0	17,900	2.4
Racine	44,600	7.9	49,500	7.6	58,900	8.6	61,900	8.3
Walworth	8,500	1.5	19,000	2.9	22,000	3.2	24,200	3.3
Washington	9,600	1.7	12,400	1.9	18,300	2.7	20,300	2.7
Waukesha	18,600	3.3	30,800	4.8	43,600	6.4	67,200	9.1
Region	564,900	100.0	647,900	100.0	685,900	100.0	741,600	100.0

Source: Wisconsin Department of Industry, Labor, and Human Relations and SEWRPC.

Figure 8

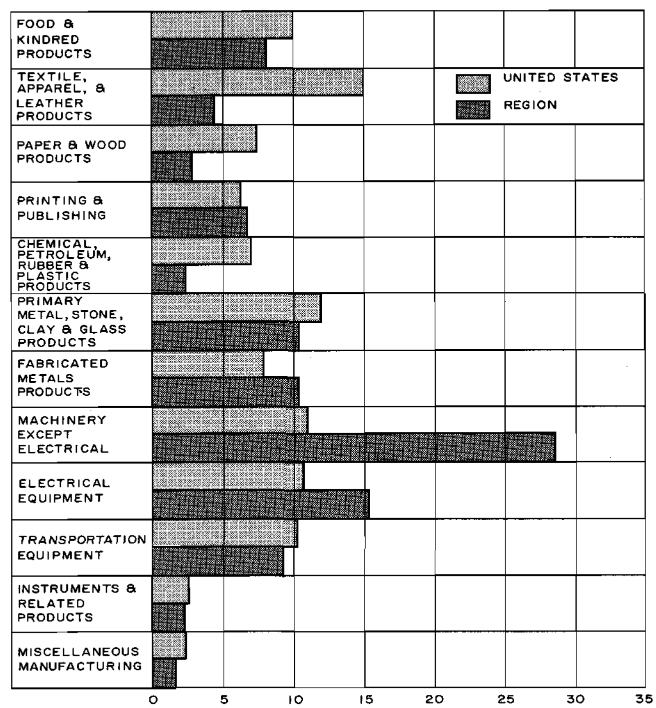
PERCENTAGE DISTRIBUTION OF TOTAL JOBS IN THE REGION AND THE UNITED STATES BY MAJOR INDUSTRY GROUP: 1970



Source: *U. S. Department of Labor; Wisconsin Department of Industry, Labor, and Human Relations; and SEWRPC.*

Figure 9

PERCENTAGE DISTRIBUTION OF MANUFACTURING JOBS IN THE REGION AND THE UNITED STATES BY TYPE OF MANUFACTURE: 1970



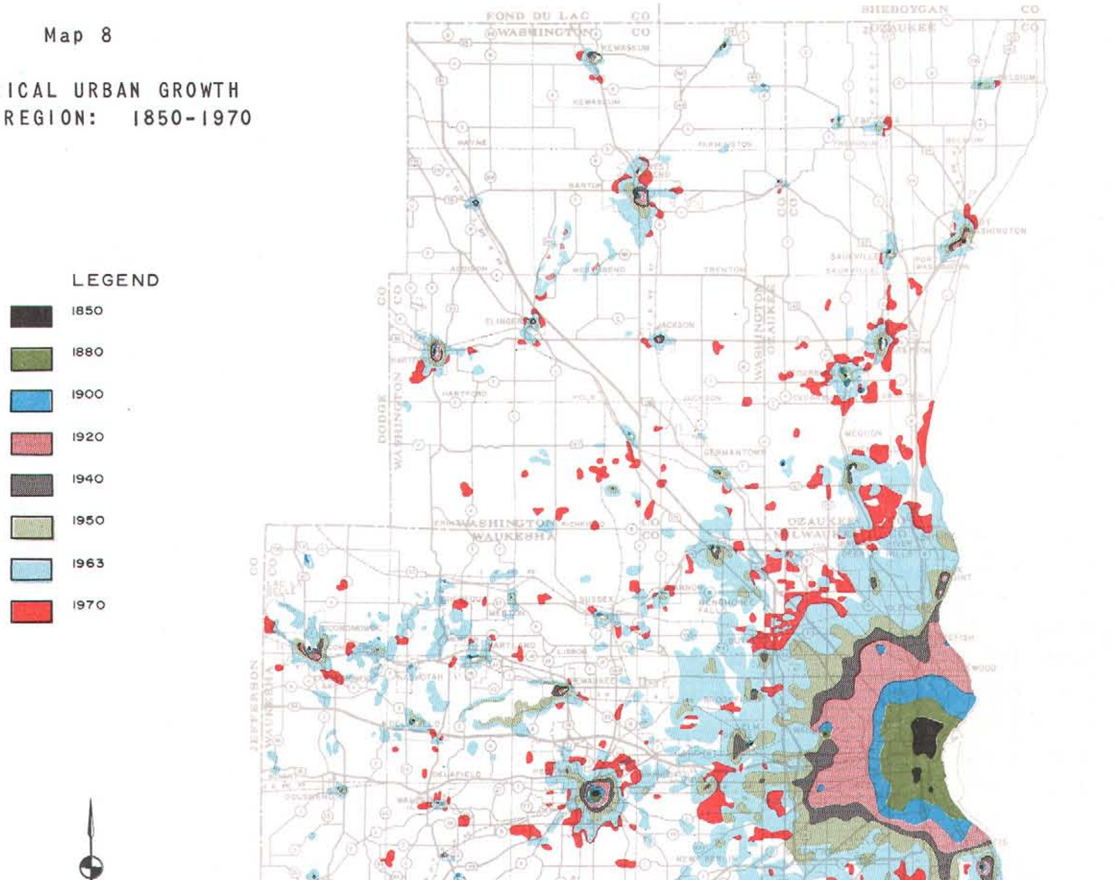
Source: *U. S. Department of Labor; Wisconsin Department of Industry, Labor, and Human Relations; and SEWRPC.*

opment map indicates the many scattered urban developments existing in the Region at the time (see Map 8).

Changes over time in the amount of land devoted to urban use within the Region are indicated in Table 6, while the historic urban growth pattern is indicated on Map 8. The amount of land devoted to urban development within the Region has increased steadily since 1850. Over the 100-year period extending from 1850 to 1950, urban development within the Region occurred in relatively tight, concentric rings outward from the established urban centers of the Region, a pattern resembling the annual growth rings of a tree. A very dramatic change in the pattern of urban development within the Region, however, occurred in about 1950. From 1950 to 1963, while the regional population increased by about 30 percent, or by about a third of a million persons, the

Map 8

HISTORICAL URBAN GROWTH IN THE REGION: 1850-1970



Urban development within the Region occurred in a fairly regular pattern until about 1950, forming concentric rings of relatively high-density urban development contiguous to, and outward from, the existing urban areas and long-established mass transit, utility, and community facility systems. Soon after World War II, however, the character of urban growth in the Region began to change to a much more diffused pattern of development, with relatively low densities and high proliferation of clusters of noncontiguous development. Between 1963 and 1970, this sprawl pattern of development continued with an additional 96 square miles of land committed to urban use within the Region over the period, representing a rate of approximately 14 square miles per year. The continuation of this sprawl pattern of land use development threatens further destruction of prime agricultural lands and of the underlying and sustaining natural resource base, and the creation of urban enclaves in essentially rural areas that will be difficult to serve economically, if at all, with necessary public utilities and services.

Source: SEWRPC.

Table 6

POPULATION DENSITY TRENDS IN THE REGION: 1850-1970

Year	Urban Population		Rural Population		Total Population	Area (square miles)		Persons Per Square Mile	
	Number	Percent of Total	Number	Percent of Total		Urban	Total	Urban	Total
1850	28,623	25.2	84,766	74.8	113,389	4	2,689	7,155.8	42.2
1880	139,509	50.3	137,610	49.7	277,119	18	2,689	7,750.5	103.1
1900	354,082	70.5	147,726	29.5	501,808	37	2,689	9,569.8	186.6
1920	635,376	81.0	148,305	19.0	783,681	56	2,689	11,346.0	291.4
1940*	996,535	93.3	76,164	6.7	1,067,699	90	2,689	11,072.6	397.1
1950*	1,179,084	95.0	61,534	5.0	1,240,618	138	2,689	8,544.1	461.4
1963*	1,634,200	97.6	40,100	2.4	1,674,300	340	2,689	4,806.5	619.2
1970*	1,728,949	98.4	27,420	1.6	1,756,369	397	2,689	4,355.0	653.2

**The "rural-nonfarm" population is included in the urban total.*
Source: U. S. Bureau of the Census and SEWRPC.

amount of land devoted to urban use increased by almost 150 percent, or by about 102 square miles. Urban development became discontinuous and highly diffused, the term "urban sprawl" being quite descriptive of this more recent pattern of urban development within the Region. This pattern continued from 1963 to 1970, over which period an additional 60 square miles of land were actually converted from rural to urban use within the Region and an additional 36 square miles of land were committed to urban development. If regional development trends continue as in the recent past, between 10 and 15 square miles of rural land may be expected to be converted to urban use each year within the Region. Under this type of urbanization, the entire seven-county Region is becoming a single mixed rural-urban complex. Many once isolated and independent communities are growing together, and urban development is spilling over the subcontinental divide, which traverses the Region, into the Fox-Illinois River Valley.

The influence of the amenities afforded by certain elements of the natural resource base upon the pattern of urban development within the Region is clearly indicated on Map 8 by the pattern of development ringing the shorelines of the many inland lakes within the Region, as well as the urban development bordering the shoreline of Lake Michigan. Although much of this lake-related development originally consisted of summer residences, most of these have been converted to year-round residences, and new lake-oriented development has been almost entirely of a year-round residential nature. This lake-oriented urban development within the Region has created certain serious lake water quality problems and holds important implications for the provision of sanitary sewerage services.

Historic Density Trends

The changes in population density within the Region from 1850 to 1970 are also shown in Table 6. During this 120-year period, the population of the Region increased nearly 15-fold, from 113,378 persons to 1,756,100 persons, while the amount of land devoted to urban use increased almost 100-fold, from 4 square miles to 397 square miles. Overall population densities within the Region increased steadily from 42 persons per square mile in 1850 to 653 persons per square mile in 1970. As already noted in Chapter I of this report, overall population densities within the developed urban area of the Region, however, have exhibited a quite different trend. Such population densities increased steadily from 7,156 persons per square mile in 1850 to a peak of 11,346 persons per square mile in 1920. Urban population densities then began a steady decline to a level of 8,544 persons per square mile in 1950. After 1950, urban population densities declined even more sharply to about 4,800 persons per square mile in 1963, and continued to decline to 4,300 persons per square mile in 1970. It should be noted, however, that, although overall population densities within the developed urban areas of the Region have been steadily declining since 1920, this decline has been accompanied by localized increases in population densities. Such localized population increases may be the result of urban renewal activities or, in isolated instances, of what in effect constitutes new community development. For example, the Northridge Lakes community development within the northwestern portion of the City of Milwaukee will have population densities of about 15,000 persons per square mile when fully developed. Similarly, the redevelopment of certain older residential areas of the central cities and older suburbs within the Region, which replace single family, duplex, or flat type residential development with apartment development—often high-rise apartment development—may result in population density increases in localized areas. With respect to overall population densities within the Region, however, such high-density development and redevelopment is offset by large areas of new suburban and exurban development which, even when it involves apartment projects, results overall in a relatively low urban population density. This continued overall decline in urban population density, accompanied, however, by localized increases, has important implications for the provision of many urban facilities and services, including the provision of sanitary sewerage facilities and services, and complicates the planning and design for such facilities and services.

These increases in population and urban land use and decreases in population density were accompanied by significant changes in the way of life within the Region. Widespread urban development in the rural-urban fringe areas of the Region well beyond the historic central cities and their suburbs is a fairly recent phenomenon. In this area residents can enjoy many of the amenities of rural life, yet also avail themselves of a wide variety of urban services, including employment in urban industries. Such widespread urban development, however, serves to intensify certain longstanding, and to create new, environmental and developmental problems of an unprecedented complexity and scale, including, as already noted, problems of ground and surface water pollution and of sanitary sewerage service.

Existing Land Use

The amount and spatial distribution of land uses existing within the Region (April 1970) is summarized graphically on Map 9. This map provides a striking picture of existing regional development at a given point in time, and its study can provide many valuable insights into an understanding of regional activity and development and of the areawide problems related thereto. The absolute and proportional areas presently devoted to each major land use category within the Region are summarized by county in Table 7.

Although southeastern Wisconsin is a highly urbanized region, less than 20 percent of its total area is presently devoted to urban type land uses. The largest land use category within the Region is still agriculture, which presently occupies about 60 percent of the total area of the Region. The next largest land use category is the water and wetland group, which occupies about 10 percent of the total area, and woodlands and open lands, which presently occupy another 10 percent of the total area of the Region. Therefore, more than 80 percent of the Region is presently devoted to agriculture, woodlands, other open lands, or lies underwater.

The "urban" type land use occupying the greatest area is residential, which presently accounts for about 9 percent of the total area of the Region. A close second is the use category of transportation, utilities, and communications, which accounts for about 6 percent of the total area. The very small amount and proportion of land presently devoted to the urban economic activities, which are so important to the support of regional growth and development, are both surprising and significant. The total land area presently devoted to commercial, manufacturing, and wholesaling functions within the Region (minus onsite parking) amounts to only 16,554 acres, or 1 percent, of the total land area, yet this small area provides the basis for more than 212,900 commercial, 252,100 manufacturing, and 32,000 wholesale jobs, or, in all, about two-thirds of the total jobs in the Region.

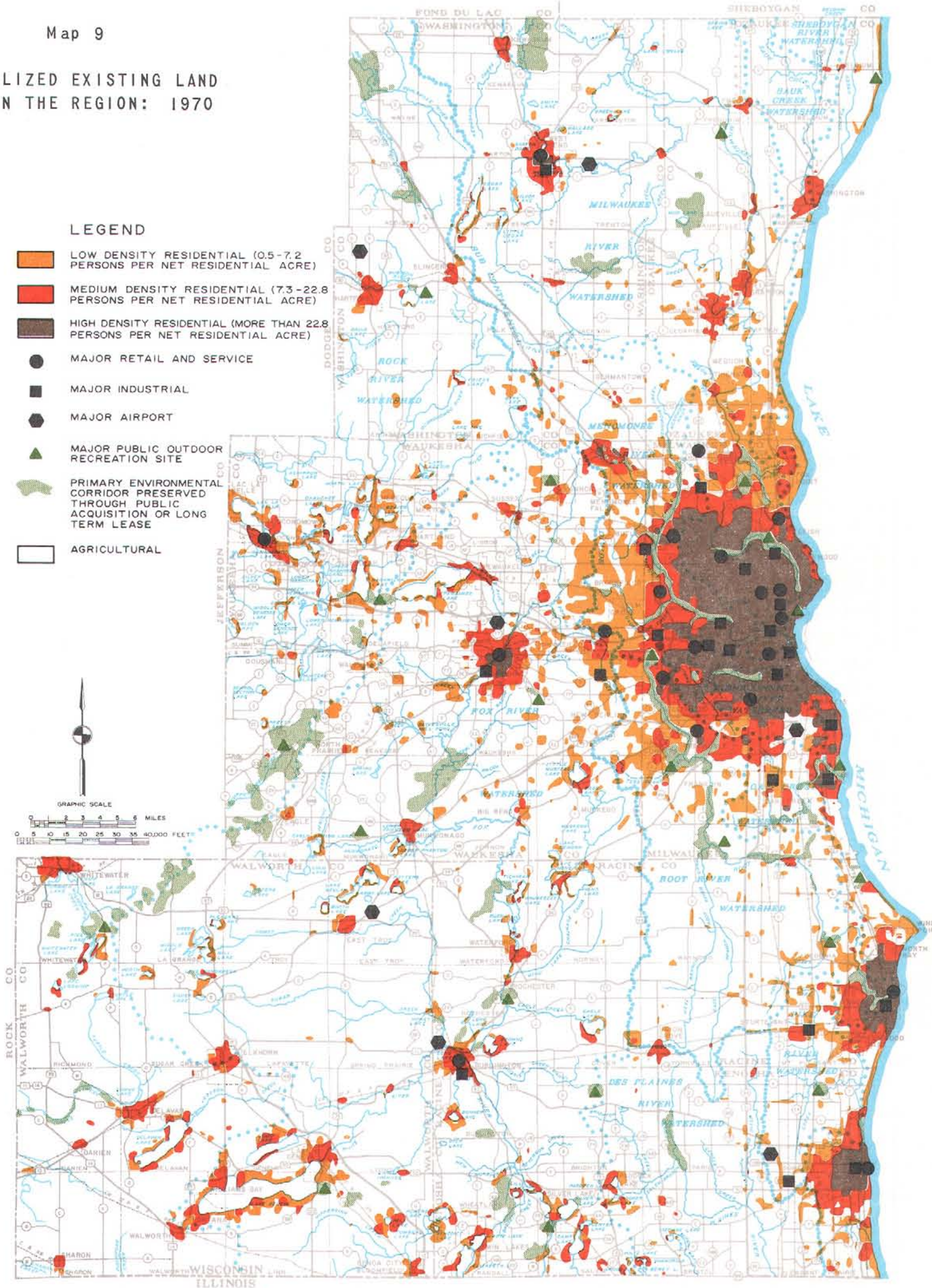
Residential: The residential land use category of the inventory included and identified both land actually occupied by a residence of some kind and vacant land which was either under development for residential use or immediately available for such use. The latter category included vacant building sites between existing residences and improved but still vacant residential subdivisions.

At the time of the 1970 land use inventory, there were 156,281 acres of residential land in the Region, or about 9 percent of the regional total devoted to this land use. Table 8 details the amounts and relative proportions of land devoted to the different types of residential use. The largest land consumer in this group is the single-family detached residence, which occupies about 78 percent of the total residential land area in the Region. Lands under residential development accounted for about 16 percent of the total, while two-family residences accounted for about 4 percent of the total. Mobile homes and multi-family residences combined consumed less than 2 percent of the total residential land in the Region.

Commercial: The commercial land use category includes all retail and service-type commercial

Map 9

GENERALIZED EXISTING LAND USE IN THE REGION: 1970



The spatial distribution of land uses existing within the Region as of April 1970 is summarized on this map. Although southeastern Wisconsin is a highly urbanized Region, less than 20 percent of its total area is presently devoted to urban-type land uses. Agriculture, while declining in economic importance within the Region, still occupies 60 percent of the total land area within the Region, with the remaining 20 percent of the area occupied by water, wetlands, and woodlands. The diffusion of low-density urban development which has occurred within the Region since 1950 is evident from an examination of the map. While some of these areas currently shown as low-density development may eventually through additional development become medium density, many of these areas are scattered far from the existing and proposed service areas of public utility systems. They represent, therefore, a permanent commitment to urban development without centralized public sanitary sewer and water supply services. It is important that future urban development within the Region be encouraged to occur in those areas recommended for such development in the adopted regional land use plan so that essential public utility services can be provided in an efficient and economical manner.

Source: SEWRPC.

Table 7

DISTRIBUTION OF LAND USE IN THE REGION BY COUNTY: 1970

County		Land Use Category[1] Residential[2]	Commercial	Industrial[3]	Transportation[4]	Governmental[5]	Water & Wetlands	Open Lands[6]	Agricultural	Total
Kenosha	Acres	13,477	504	811	8,927	4,287	19,325	16,834	113,935	178,100
	Percent	7.6	0.3	0.5	5.0	2.4	10.8	9.4	64.0	100.0
Milwaukee	Acres	45,633	2,875	4,898	35,431	19,185	3,550	15,042	28,448	155,062
	Percent	29.4	1.9	3.2	22.8	12.4	2.3	9.7	18.3	100.0
Ozaukee	Acres	12,321	330	444	8,054	2,802	14,865	10,717	100,480	150,013
	Percent	8.2	0.2	0.3	5.4	1.9	9.9	7.1	67.0	100.0
Racine	Acres	16,625	575	1,099	12,442	4,605	17,683	17,391	147,142	217,562
	Percent	7.7	0.3	0.5	5.7	2.1	8.1	8.0	67.6	100.0
Walworth	Acres	13,422	593	827	12,020	5,822	39,074	36,498	261,726	369,982
	Percent	3.6	0.2	0.2	3.2	1.6	10.5	9.9	70.8	100.0
Washington	Acres	11,525	299	434	11,286	2,738	35,705	30,278	186,469	278,734
	Percent	4.1	0.1	0.2	4.0	1.0	12.8	10.9	66.9	100.0
Waukesha	Acres	43,278	1,341	1,524	21,292	9,752	49,676	43,343	201,441	371,647
	Percent	11.6	0.4	0.4	5.7	2.6	13.4	11.7	54.2	100.0
Region	Acres	156,281	6,517	10,037	109,452	49,191	179,878	170,103	1,039,641	1,721,100
	Percent	9.1	0.4	0.6	6.4	2.8	10.4	9.9	60.4	100.0

[1]*The nine major land use categories as inventoried were: residential, retail and service, wholesale and storage, manufacturing, transportation, institutional and governmental, recreational, agricultural, and open land and water. These categories have been rearranged for presentation and analysis purposes.*

[2]*Includes residential areas developed and under development.*

[3]*Includes all manufacturing, wholesaling, and storage.*

[4]*Includes utilities, communication facilities, and off-street parking of over 10 spaces.*

[5]*Includes institutional and active recreational areas.*

[6]*Includes woodlands, open pits, and quarries.*

Source: SEWRPC.

Table 8

RESIDENTIAL LAND USE IN THE REGION BY TYPE: 1970

Type of Residential Use	Acres	Percent
Single-family	122,521	78.4
Two-family	5,574	3.6
Multi-family (less than 4 stories)	2,969	1.9
Multi-family (4 or more stories)	118	0.1
Mobile Homes	515	0.3
Residential Land Under Development	24,584	15.7
Total	156,281	100.0

Source: SEWRPC.

uses, including both local and regional shopping centers, highway-oriented commercial areas, and professional and executive offices, excluding, however, onsite parking of 10 or more spaces. There are presently 6,517 acres of land, or less then 1 percent of the regional total, devoted to this land use category.

Industrial: This land use category includes all manufacturing activities, wholesaling offices, warehouses, and storage yards but excludes onsite parking of 10 or more spaces. There are presently 10,037 acres of land, or less than 1 percent of the regional total, devoted to this land use category.

Transportation, Communication, and Utility: The transportation, communication, and utility land use category includes all street and highway rights-of-way; railroad rights-of-way and yards; airport, rail, ship, bus, and truck terminals; communications facilities, such as radio or television stations and transmission towers; utility rights-of-way and plants, such as sewage disposal and water treatment and storage facilities; and all off-street parking areas containing more than 10 parking spaces. There are presently 109,452 acres of land, or about 6 percent of the regional total, devoted to this land use category.

Governmental, Institutional, and Recreational: The land areas devoted to governmental, institutional, and active recreational uses were classified in the land use inventory according to local or regional service orientation. If the service emphasis of a governmental or institutional use was oriented toward more than one community (minor civil division), it was classified as regional. If such service emphasis was oriented toward a single community or neighborhood, except for high schools in the City of Milwaukee, it was classified as local. Regional uses included universities and colleges, certain high schools, large central libraries, museums, zoological and botanical gardens, golf courses, bathing beaches, marinas, major athletic fields, hospitals, county courthouses, welfare agencies, and military installations. Local uses included elementary schools; certain high schools; churches; branch libraries; fire stations; all active park areas other than those classified as regional; and city, village, and town halls. All recreation facilities were further classified as public or nonpublic. There are presently 49,191 acres of land, or about 3 percent of the regional total, devoted to this land use category. Of these 49,191 acres, 22,331 acres, or about 45 percent, are oriented toward Region-serving activities. This is not surprising when the land-consuming nature of such uses as golf courses, cemeteries, and military installations are considered.

Woodlands and Open Lands: This land use category includes all land areas presently containing trees or heavy brush; lands which are not presently devoted to urban use, cropped, or grazed; land areas presently devoted to such temporary uses as open pits for trash or garbage disposal; and quarries either operating or nonoperating. There are presently 170,103 acres of land, or nearly 10 percent of the regional total, devoted to this land use category. Approximately 73 percent of this area is devoted to woodlands, and most of the remaining 23 percent is in the open lands category. Only 4 percent, or 6,844 acres, are classified as quarries or pits.

Water and Wetlands: The water and wetland use category includes all inland lakes excluding Lake Michigan; all streams, rivers, and canals more than 50 feet in width; and open lands which are intermittently covered with water or which are wet due to a high water table. Presently there are 179,878 acres of water and wetland areas in the Region, or about 10 percent of the regional total.

Agricultural: The agricultural land use category includes all croplands, pasturelands, orchards, nurseries, and fowl and fur farms. Farm dwelling sites were classified as residential land and assigned a site area of 20,000 square feet. All other farm buildings were included in the agricultural land use. Agriculture is the singularly largest land use in the Region, and about 60 percent of the total area of the Region, or 1,039,641 acres, is devoted to this use.

PUBLIC UTILITY BASE

Public utility systems are one of the most important and permanent elements of urban growth and development. Urban development today is highly dependent upon these utility systems which provide the individual land uses with power, light, communication, heat, water, and sewerage. Water supply and sanitary sewerage utilities have a particularly important interrelationship. Water supply facilities bring potable water from its sources to the user, while sanitary sewerage facilities collect the used water, convey it to a treatment plant, and after treatment return it to the natural environment from which it came.

The majority of water and sewerage utilities in the Region are organized as water and sewer departments of incorporated municipalities, and serve only those areas within the political boundaries of that municipality. Where sanitary districts have been organized, sewer and water service area limits may not be coterminous, although the individual service areas will often tend to approximate one another. Therefore, a general pattern of water and sewer service areas following political boundary lines rather than natural topographic boundaries, such as watershed boundaries, exists within the Region. The governing bodies of these existing utilities tend to be concerned primarily, if not solely, with the problems existing within the individual political subdivisions served, rather than with problems affecting the area as a whole and the individual political subdivisions in part. The artificial limitations thus placed on sewerage system planning and development at the local level make it extremely difficult to realize the benefits which may be available.

Sanitary Sewerage Utilities

Virtually all sanitary sewer service within the Region is provided by publicly owned agencies. These agencies generally take the form of commissions in the case of utilities providing areawide sewer service, a department in the case of utilities providing sewer service to an incorporated municipality, or a town sanitary or utility district in the case of a utility providing sewer service to an unincorporated area. As discussed in more detail in Chapter V of this report, inventories conducted under the regional sanitary sewerage system planning program revealed there are a total of 91 centralized public sanitary sewerage systems presently operated by utilities within the Region. These 91 systems serve a total area of about 309 square miles, or about 11 percent of the total area of the Region, and a total population of about 1.5 million persons, or about 85 percent of the total population of the Region.

A total of 64 sewage treatment facilities are currently operated by the utilities owning, operating, and maintaining the 91 public sanitary sewerage systems, with many of the utilities contracting with adjacent utilities for sewage treatment purposes. In addition, there are 59 privately owned sewage treatment plants presently in operation within the Region. These generally serve isolated land use enclaves, mainly for industrial, commercial, and recreational enterprises. In all, then, there are 123 sewage treatment facilities within the Region. Detailed information concerning each of the 91 public sanitary sewerage systems and the 123 sewage treatment facilities in the Region is presented in Chapter V of this report.

Septic Tank System Development: The construction of public sanitary sewerage facilities has not fully kept pace with the rapid urbanization of the Region, and this has been a contributing factor to the widespread use of onsite soil absorption sewage disposal systems. An estimated total of 268,000 persons in the Region, or about 15 percent of the total Region population, rely on such septic tank sewage disposal systems for domestic sewage disposal. About 27,000 of these persons live on farms. The remaining 241,000 persons constitute urban dwellers generally living in scattered fashion throughout the rural and rural-urban fringe areas of the Region. About 139,000 of the 241,000 urban dwellers live within urbanizing areas of the Region, however, and within potential service areas of centralized sanitary sewer systems. The area presently devoted to urban land uses within the Region but unserved by sanitary sewerage facilities is estimated to total from 61 to 85 square miles, or from 23 to 21 percent of the presently urbanized area of the Region, depending upon the definition of the term "urban development" used.

Water Utilities

Most of the water supply service within the Region is provided by public water utilities. As shown in Table 9, there are a total of 67 publicly owned water utilities within the Region. Of these 67 utilities, all but one—the North Shore Water Utility in Milwaukee County—provide retail water service to consumers. The North Shore Water Utility provides only wholesale water service to three other water utilities—the Glendale Water Utility, the Village of Whitefish Bay Water Utility, and the Water Utility of the Village of Fox Point. Together, these 67 publicly owned water utilities serve an area of about 259 square miles, or about 10 percent of the total area of the Region, and about 1.4 million persons, or about 80 percent of the total 1970 resident population of the Region. The population, service area, and consumption characteristics of the 67 public utilities in the Region are shown in Table 9. The existing (1970) service areas of these utilities all are shown on Map 10.

In addition to the publicly owned water utilities, there are at least 59 private or cooperatively owned water systems throughout the Region (see Table 10). Many of these small water systems serve isolated residential enclaves, while some serve summer residents only and suspend operations during cold weather. Very few of these private systems have standby supply or storage facilities, and the great majority do not keep detailed records or file annual reports with state or regulatory bodies. It is anticipated that many of these systems will eventually be absorbed into publicly owned municipal water utilities.

All water supplied by the publicly owned water utilities is drawn either from Lake Michigan or from wells. The Region is not only rich in surface water resources but in ground water resources, being underlain by two separate aquifers. Treated Lake Michigan water in an amount averaging 197 mgd (millions of gallons per day) was supplied in 1970 to an aggregate service area of about 199 square miles, or about 7 percent of the total area of the Region, and a population of about 1.2 million persons, or about 68 percent of the total population of the Region. Twenty-one of the 67 public utilities in the Region utilize Lake Michigan as a source of supply. Of these 21, 7 own and operate water intake and treatment facilities, while 14 utilities purchase water on a wholesale basis. Generally, Lake Michigan offers an unusually good source of supply to those areas lying east of the subcontinental divide and within economic reach of this source of supply.

Well water in an amount averaging about 25 mgd was supplied in 1970 to an aggregate area of about 60 square miles, or about 2 percent of the total area of the Region, and a population of about 190,000 persons, or about 14 percent of the total resident population of the Region. Forty-six of the public utilities in the Region utilize the ground water as a source of supply. In general, water service from a municipal utility is a matter of local policy furnished to only property within the the municipal limits of that municipality. Only the

Table 9

PUBLIC WATER UTILITIES IN THE REGION: 1970

Public Water Utility		Area Served (Square Miles)	Estimated Population Served	Estimated Average Consumption (MGD)
Name	Location			
Kenosha County				
Kenosha Water Utility[1] [2]	City of Kenosha	15.20	78,810	11.85
Pleasant Park Utility Co., Inc.[3]	Town of Pleasant Prairie - Pleasant Homes Subdivision	0.28	420	0.04
Pleasant Prairie Water Works[3]	Unincorporated Village of Pleasant Prairie	0.25	340	0.02
Sanitary District No. 1, Town of Somers[1]	Town of Somers	0.60	1,020	0.13
Town of Bristol Water Utility	Town of Bristol	0.11	370	0.02
Subtotal - - Kenosha County		16.44	80,960	12.06
Milwaukee County				
Brown Deer Public Water Utility[1]	Village of Brown Deer	3.68	12,620	1.11
City of Oak Creek Water & Sewer Utility	City of Oak Creek	5.00	5,700	0.88
Cudahy Water Department[1]	City of Cudahy	4.72	22,080	2.52
Glendale Water Utility[1]	City of Glendale	5.93	13,440	2.45
Milwaukee Water Works[1] [4]	City of Milwaukee	107.66	750,390	131.65
North Shore Water Utility[1] [5]	City of Glendale	— —	— —	— —
Village of Greendale Water & Sewer Utility[1]	Village of Greendale	3.49	15,090	1.06
Village of Whitefish Bay Water Utility[1]	Village of Whitefish Bay	2.12	17,390	1.81
Water Utility of the Village of Fox Point[1]	Village of Fox Point	2.87	7,940	0.94
Wauwatosa Water Works[1]	City of Wauwatosa	13.23	58,680	5.25
West Allis Water Utility[1]	City of West Allis	10.20	71,720	11.42
Shorewood Municipal Water Utility[1]	Village of Shorewood	1.58	15,580	1.62
South Milwaukee Water Utility[1]	City of South Milwaukee	4.68	23,300	4.20
Subtotal - - Milwaukee County		165.16	1,013,390	164.91
Ozaukee County				
Belgium Municipal Water Utility	Village of Belgium	0.23	800	0.06
Cedarburg Light & Water Commission	City of Cedarburg	2.19	7,700	1.32
Fredonia Municipal Water & Sewer Utility	Village of Fredonia	0.44	1,050	0.07
Grafton Sewer & Water Utility	Village of Grafton	1.47	6,000	0.77
Port Washington Municipal Water Utility[1]	City of Port Washington	2.23	8,750	0.93
Saukville Municipal Water & Sewer Utility	Village of Saukville	0.61	1,390	0.33
Subtotal - - Ozaukee County		7.17	25,690	3.48
Racine County				
Burlington Water Works	City of Burlington	2.33	7,480	1.36
Caddy Vista Sanitary District	Town of Caledonia	0.25	1,180	0.06
Crestview Sanitary District	Town of Caledonia	0.46	1,600	0.09
North Cape Sanitary District	Towns of Norway & Raymond	0.09	110	0.01
North Park Sanitary District[1] [6]	Town of Caledonia	3.01	3,250	0.54
Racine Water Department[1] [7]	City of Racine	13.40	95,160	18.73
South Lawn Sanitary District[1]	Town of Mount Pleasant	0.40	2,040	0.13
Sturtevant Water & Sewer Utility[1]	Village of Sturtevant	0.81	3,380	0.16
Town of Caledonia Water Utility District No. 1[1]	Town of Caledonia	1.98	690	0.07
Union Grove Water Department	Village of Union Grove	0.65	2,700	0.33
Waterford Water Utility	Village of Waterford	0.57	1,920	0.15
Wind Point Municipal Water Utility[1]	Village of Wind Point	1.28	1,390	0.10
Subtotal - - Racine County		25.23	120,900	21.73
Walworth County				
Darien Municipal Water & Sewer Utility	Village of Darien	0.35	840	0.07
Delavan Water & Sewage Commission	City of Delavan	2.24	5,530	0.55
East Troy Municipal Water Utility	Village of East Troy	0.58	1,710	0.23
Elkhorn Light & Water Commission	Village of Elkhorn	1.50	3,990	0.42
Fontana Municipal Water Utility	Village of Fontana-on-Geneva Lake	0.95	1,460	0.20
Genoa City Municipal Water & Sewer Utility	Village of Genoa City	0.58	1,090	0.06
Lake Geneva Water Commission	City of Lake Geneva	1.54	4,890	0.72
Lyons Sanitary District No. 1	Town of Lyons	0.03	240	0.02
Sanitary District No. 1, Town of Troy	Town of Troy	0.04	140	0.01
Village of Sharon Water Works & Sewer System	Village of Sharon	0.49	1,220	0.06
Walworth Municipal Water & Sewer Utility	Village of Walworth	1.14	1,640	0.22
Whitewater Municipal Water Utility	City of Whitewater	2.04	12,040	1.03
Williams Bay Municipal Water Utility	Village of Williams Bay	1.19	1,550	0.19
Subtotal - - Walworth County		12.67	36,340	3.78

Table 9 (continued)

Public Water Utility		Area Served (Square Miles)	Estimated Population Served	Estimated Average Consumption (MGD)
Name	Location			
Washington County				
Allenton Sanitary District No. 1	Town of Addison	0.27	610	0.03
City of Hartford Utilities Department	City of Hartford	1.57	6,500	1.05
City of West Bend Water Department	City of West Bend	4.33	16,560	2.50
Jackson Municipal Water Utility	Village of Jackson	0.31	560	0.05
Kewaskum Municipal Water Department	Village of Kewaskum	0.52	1,930	0.52
Slinger Utilities	Village of Slinger	0.40	1,020	0.19
Village of Germantown Water Utility	Village of Germantown	0.69	1,120	0.08
Subtotal - - Washington County		8.09	28,300	4.42
Waukesha County				
Butler Water Utility	Village of Butler	0.78	2,260	0.22
City of Brookfield Water Utility	City of Brookfield	1.39	3,830	0.37
City of Oconomowoc Electric and Water Departments	City of Oconomowoc	3.20	8,740	0.89
Hartland Municipal Water Department	Village of Hartland	2.35	2,760	0.21
Mukwonago Municipal Water Utility	Village of Mukwonago	0.72	2,370	0.16
New Berlin Water Utility	City of New Berlin	1.30	2,400	0.29
Pewaukee Water & Sewage Utility	Village of Pewaukee	0.92	3,270	0.32
Village of Eagle Water Utility	Village of Eagle	0.27	750	0.03
Village of Menomonee Falls Water Utility	Village of Menomonee Falls	4.01	17,200	1.67
Westbrooke Sanitary District No. 1	Town of Brookfield	0.35	560	0.03
Waukesha Water Utility	City of Waukesha	9.32	40,260	7.54
Subtotal - - Waukesha County		24.61	84,400	11.73
Region Total		259.37	1,390,520	222.11

[1]These utilities utilize Lake Michigan as the sole source of water supply.
[2]The Kenosha Water Utility provides retail water service to portions of the Towns of Pleasant Prairie and Somers and wholesale water service to the Town of Somers Sanitary District No. 1. The data presented in this table for the Kenosha Water Utility includes the communities served on a retail basis.
[3]The Pleasant Park Utility Company, Inc. and the Pleasant Prairie Water Works are not public water utilities since they are privately owned. Because, however, these utilities operate in the same fashion as a public water utility and because they are capable of ready expansion much the same as a public water utility, they have been classified for analysis purposes in this study as public water utilities.
[4]The Milwaukee Water Works provides retail water service to the Cities of Greenfield and St. Fancis and the Village of West Milwaukee and provides wholesale water service to the Cities of Wauwatosa and West Allis and the Villages of Brown Deer, Greendale, and Shorewood. The data presented in this table for the Milwaukee Water Utility includes the communities served on a retail basis.
[5]The North Shore Water Utility provides no retail water service and exists only to sell water on a wholesale basis to the City of Glendale and the Villages of Fox Point and Whitefish Bay.
[6]The North Park Water Utility provides water on a wholesale basis to the Wind Point Municipal Water Utility.
[7]The Racine Water Department provides retail water service to the Villages of North Bay and Elmwood Park and the Town of Mount Pleasant and wholesale water service to the Village of Sturtevant, the North Park Sanitary District, the South Lawn Sanitary District, and the Town of Caledonia Utility District No. 1. The data presented in this table for the Racine Water utility includes the communities served on a retail basis.

Source: Wisconsin Public Service Commission, Wisconsin Department of Natural Resources, and SEWRPC.

Cities of Kenosha, Milwaukee, and Racine in the Region provide water service beyond their corporate limits in any substantial amounts.

Gas Utilities

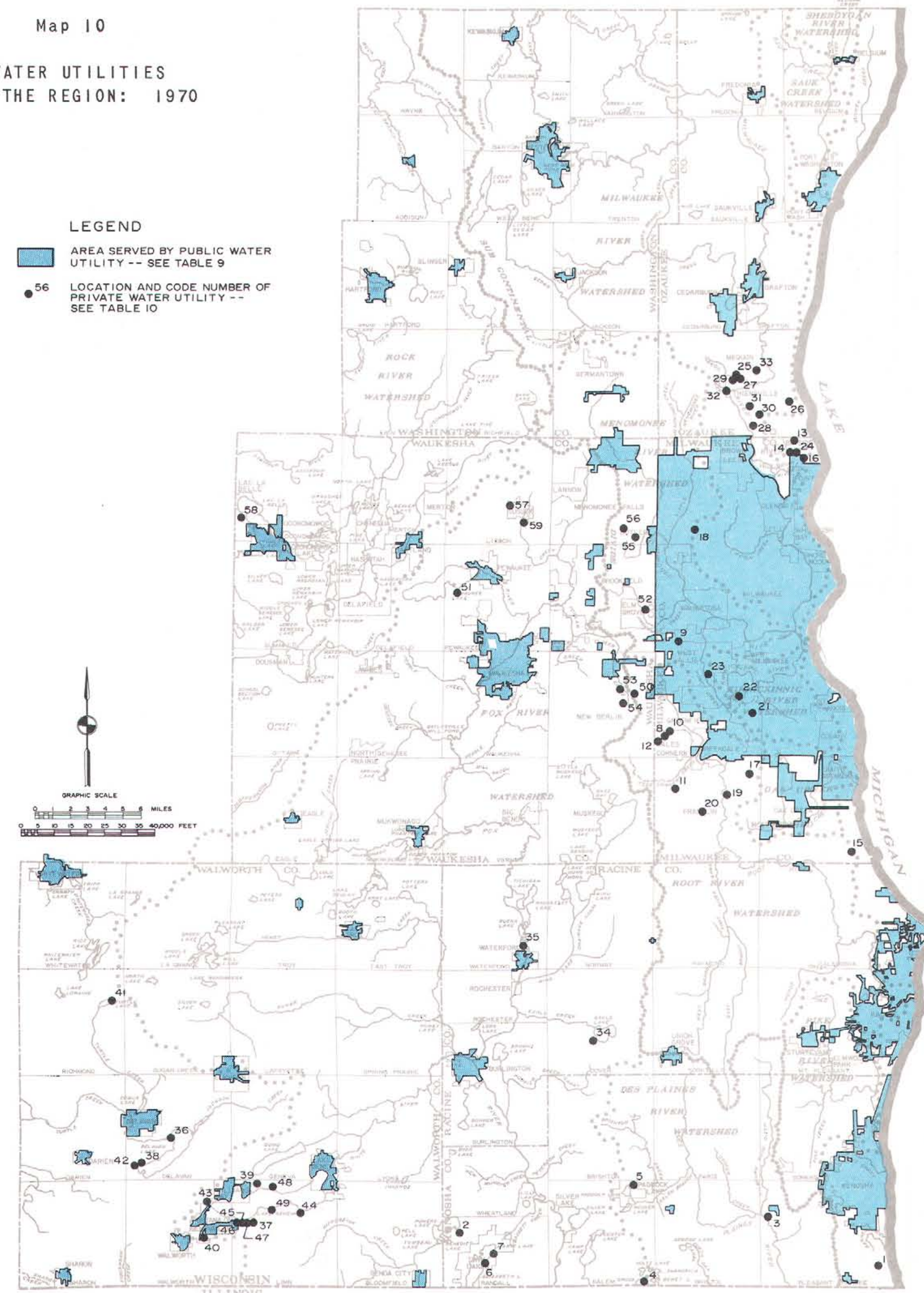
Three gas utilities are authorized to operate within the Region and provide all public gas service therein. The Wisconsin Gas Company is authorized to operate in parts of Milwaukee, Ozaukee, Washington, and Waukesha Counties. The Wisconsin Natural Gas Company is authorized to operate in parts of Kenosha, Milwaukee, Racine, Walworth, and Waukesha Counties. The Wisconsin Southern Gas Company is authorized to operate in parts of Kenosha, Racine, and Walworth Counties. Only in the Towns of Erin and Wayne, both in Washington County, is there no gas utility presently authorized to operate. Natural gas is supplied to the three gas utilities by the Michigan-Wisconsin Pipeline Company and the Natural Gas Pipeline Company of America. Gas service may be considered to be virtually ubiquitous and does not constitute a major constraint on the location and intensity of urban development in the Region.

Electric Utilities

Two major privately owned electric utilities are authorized within the Region which, together with five small municipal utilities, provide service to the entire Region. The Wisconsin Electric Power Company is authorized to operate throughout nearly the entire Region. The Wisconsin Power and Light Company is authorized to operate in parts of Kenosha and Walworth Counties. Municipal electric power utilities are operated by the Cities of Cedarburg, Elkhorn, Hartford, and Oconomowoc and the Village of Slinger. Generally, an adequate supply of electric power is available

Map 10

WATER UTILITIES
IN THE REGION: 1970



Most of the water supply service in the Region is provided by 67 publicly owned water utilities. The service areas of these 67 utilities are shown on this map. In addition, there are at least 59 private or cooperatively owned water supply systems in the Region which provide water service generally to individual subdivisions. The location of these private systems is also shown on this map. Lake Michigan is by far the most important source of water supply in the Region, with about 1.2 million persons, or 68 percent of the total Region population, currently being supplied from that source. An additional 190,000 persons, or about 14 percent of the total Region population, are supplied by public utilities relying on groundwater.

Source: SEWRPC.

Table 10

PRIVATE WATER UTILITIES
IN THE REGION: 1970

	Private Water Utility	
Code Number on Map 10	Name	Civil Division
	Kenosha County	
1	Carol Beach Water Co., Inc.	Town of Pleasant Prairie
2	Lake Knolls	Town of Randall
3	Oak Hi Subdivision	Town of Pleasant Prairie
4	Oakwood Knolls	Town of Salem
5	Paddock Lake Delles	Village of Paddock Lake
6	Twin Lakes Park Water Company	Village of Twin Lakes
7	Wy-wood Co-op	Village of Twin Lakes
	Milwaukee County	
8	Blossom Heath Water Trust	Village of Hales Corners
9	Colony Homes Co-op[1]	City of West Allis
10	Hales Happiness Homesites	Village of Hales Corners
11	Mission Hills	City of Franklin
12	Monaco Heights	Village of Hales Corners
13	North Shore East	Village of Bayside
14	Northway Water Co-op No. 2	Village of Bayside
15	Oakview No. 3	City of Oak Creek
16	Pelham Heath	Village of Bayside
17	Rawson Homes	City of Franklin
18	Robert William Park	City of Milwaukee
19	Root River Heights	City of Franklin
20	Security Acres	City of Franklin
21	Southgate Manor	City of Greenfield
22	Town View Water Co-op	City of Greenfield
23	Van Dyke Water Co-op[1]	City of West Allis
24	Vista Del Mar	Village of Bayside
	Ozaukee County	
25	Alberta Subdivision	Village of Thiensville
26	Bonnie Lynn Highlands	City of Mequon
27	Century Estates No. 1 and Additions	Village of Thiensville
28	Lac Du Cours	City of Mequon
29	Laurel Acres	Village of Thiensville
30	North Shore Estates	City of Mequon
31	North Shore Heights	City of Mequon
32	Village Heights Co-op	Village of Thiensville
33	Villa du Parc (Country Club Estates)	City of Mequon
	Racine County	
34	Eagle Lake Manor	Town of Dover
35	Waterford Woods Association	Town of Waterford
	Walworth County	
36	Assembly Grounds Association	Town of Delavan
37	Camp Sybil	Town of Linn
38	Chicago Club	Town of Delavan
39	Cisco Beach Subdivision	Town of Linn
40	Country Club Estates	Village of Fontana
41	Crystal Bowl	Town of Raymond
42	Delavan Lake	Town of Delavan
43	Gardens Association	Town of Walworth
44	Lake Geneva Beach Subdivision	Town of Linn
45	Lake Geneva Club	Town of Linn
46	Oak Shores Association	Town of Linn
47	Shore Haven Association	Town of Linn
48	Sunset Hills Association, Inc.	Town of Linn
49	Woodale Subdivision	Town of Linn
	Washington County	
	None	
	Waukesha County	
50	Glendale Park	City of New Berlin
51	Highlands Co-op	Town of Pewaukee
52	Marion Heights	Village of Elm Grove
53	Monterey Park	City of New Berlin
54	Regal Manors	City of New Berlin
55	Riverview Manor Co-op	Village of Menomonee Falls
56	Silver Spring Terrace	Village of Menomonee Falls
57	Spring Green Heights	Village of Sussex
58	Sunnyfield Acres	Town of Oconomowoc
59	Sussex Estates	Village of Sussex

[1]These private utilities were connected to the City of West Allis Public Water Utility system in 1971.

Source: Wisconsin Public Service Commission, Wisconsin Department of Natural Resources, and SEWRPC.

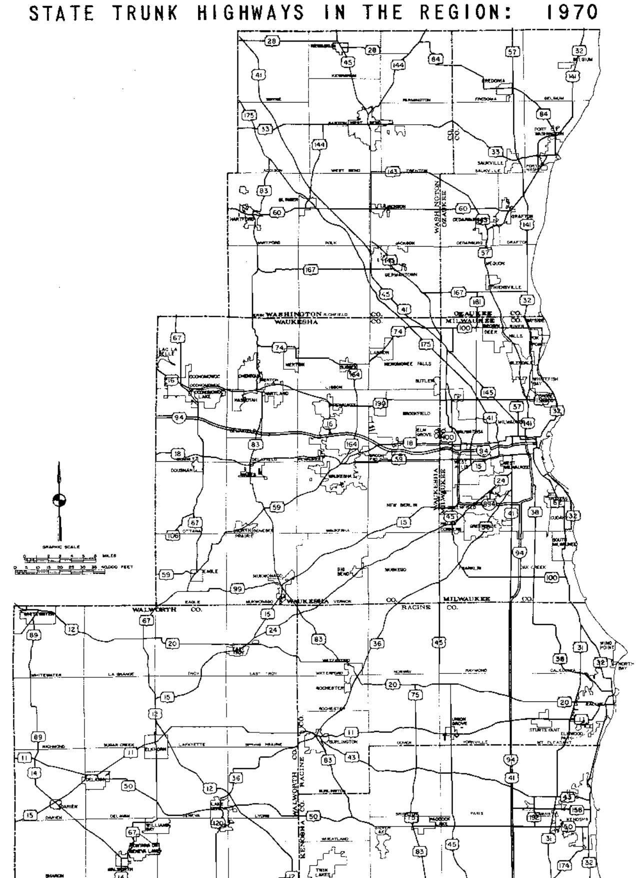
throughout the Region. Residential service is available on demand anywhere within the Region, and low voltage lines are in place along virtually every rural highway. Therefore, electric power service, like gas service, may be considered virtually ubiquitous and not a major constraint on the location and intensity of urban development in the Region.

TRANSPORTATION BASE

The extensively developed, all-weather, high-speed highway system within the Region has had a marked influence on the spatial location of urban development. This influence has, however, been significantly modified by the location within the Region of such natural resources as lakes, streams, woodlands, and fertile farmlands. The major arterial street and highway network within the Region, as shown on Map 11, consists of

Map 11

EXISTING INTERSTATE, UNITED STATES, AND STATE TRUNK HIGHWAYS IN THE REGION: 1970



The major arterial street and highway network within the Region, consisting of all interstate, United States, and state trunk highway facilities, is shown on this map. This network consists of 1,258 miles of facilities, including 162 miles of recently constructed freeway facilities. This extensively developed all-weather, high-speed transportation system may be expected to have a marked influence upon the spatial location of urban development within the Region, and thus open the need for centralized public sanitary sewer service.

Source: SEWRPC.

an essentially radial pattern of federal and state highways interconnecting the urban and rural areas of the Region, supplemented by an essentially grid pattern of local arterials.

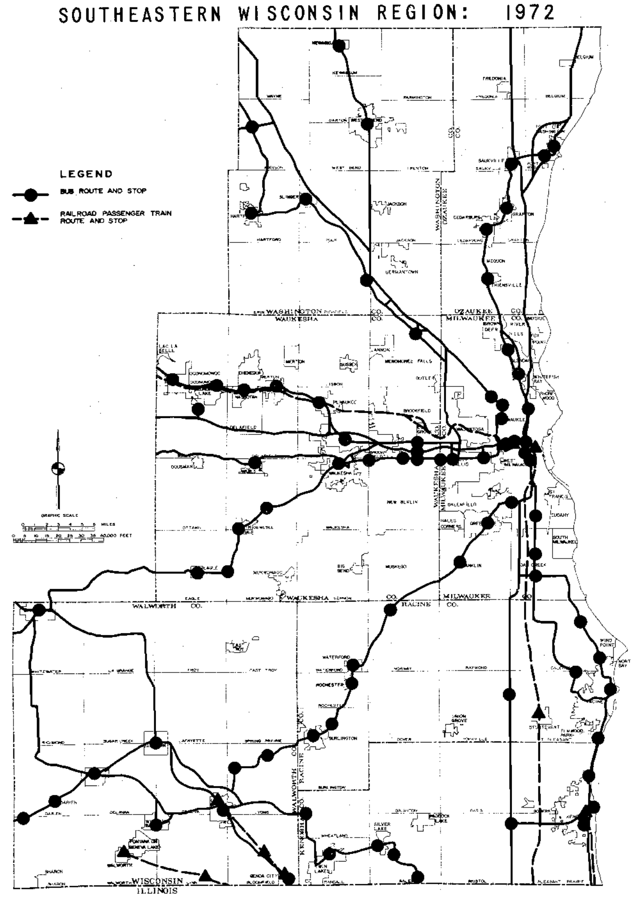
Intercity bus service is provided between the various communities comprising the Region, as shown on Map 12. This intercity bus service is provided by seven private companies: Badger Coaches, Inc.; Greyhound Lines West; La Grange-La Grange Park Transit Co., Inc.; Peoria-Rockford Bus Co.; Tri-State Coach Lines, Inc.; Wisconsin Coach Lines, Inc.; and Wisconsin-Michigan Coaches, Inc., which together operate bus lines over 484 miles of streets and highways.

Intraurban bus service is provided (1971) within Milwaukee County by the Milwaukee and Suburban Transport Corporation and by the Wisconsin Coach Lines, Inc.; within the City of Racine by Flash City Transit; within the City of Kenosha by the Kenosha Parking and Transit Commission; and within the City of Waukesha by the Wisconsin Coach Lines, Inc. Together these four companies operate intraurban bus lines over 531 miles of streets and highways (see Map 13).

Intercity rail service in the Region presently (1972) is limited to freight hauling, except for scheduled passenger service, as shown on Map 12, to the City of Milwaukee and the Village of Sturtevant by the National Railroad Passenger Corporation (AMTRAK) operating over the trackage of the Chicago, Milwaukee, St. Paul, and Pacific Railroad Company (Milwaukee Road). Commuter service to Chicago from the Village of Walworth and the unincorporated place of Zenda is provided by the Milwaukee Road. Other Chicago area commuter service is provided by the Chicago and North Western Railway (C&NW) from the City of Lake Geneva, the Village of Genoa City, the unincorporated place of Pell Lake, and the City of Kenosha. One other major railway line operating within the Region, but providing freight service only, is the Soo Line Railroad Company.

Map 12

INTERURBAN AND SUBURBAN BUS AND RAILROAD PASSENGER SERVICE IN THE SOUTHEASTERN WISCONSIN REGION: 1972



Seven private companies provide intercity bus service within the Region, operating bus lines over a total of 484 miles of public streets and highways. The only remaining scheduled rail passenger service in the Region consists of the national AMTRAK service, operated over the Milwaukee Road trackage, and Chicago-oriented commuter service operated by the Chicago and Northwestern Railway from communities in Kenosha and Walworth Counties. The intercity transportation service, particularly as provided by fixed rail facilities, may marginally influence the location of urban development within the Region, and therefore the need for sewer service. Conversely, the provision of sewer service may by engendering urban development influence the location and level of intercity bus service.

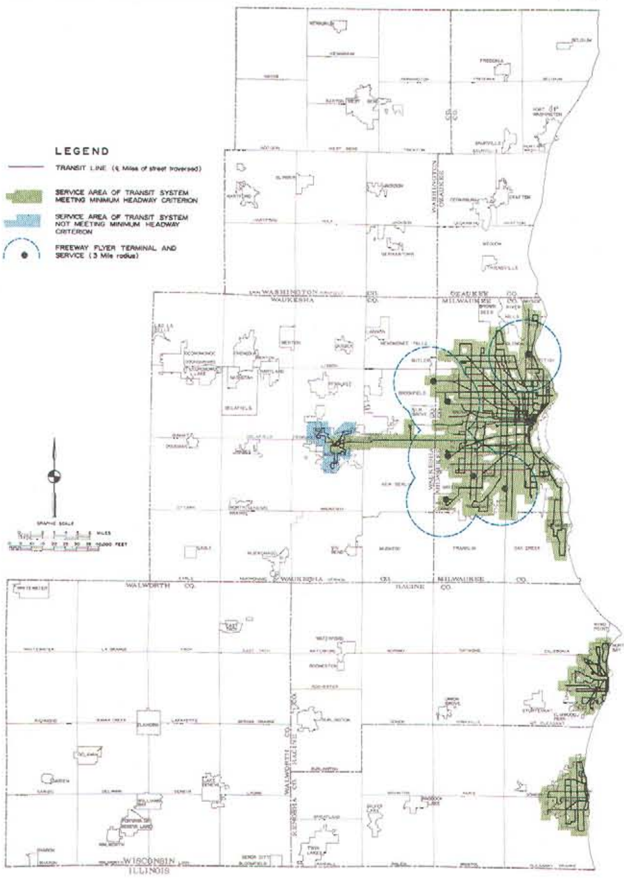
Source: SEWRPC.

SUMMARY

The seven-county Southeastern Wisconsin Region is an interrelated complex of natural and manmade features, which together form a rapidly changing environment for human life. The important man-made features of the Region include its land use pattern, its public utility networks, and its transportation system. Together with the population residing in and the economic activities taking place within the Region, these features may be thought of as the socioeconomic base of the Region. An understanding of this base is essential to sound areawide sanitary sewerage system planning, and to this end this chapter constitutes a description of the socioeconomic base of the

Map 13

MASS TRANSIT LINES AND SERVICE AREAS IN THE SOUTHEASTERN WISCONSIN REGION: 1971



Mass transit service in the major urbanized areas of the Region is provided by three private companies. Together these agencies operate bus lines over 531 miles of public streets and highways, and provide service to an area in which about 75 percent of the population of the Region resides. The availability of mass transit service has not been a major factor in determining the location of urban development within the Region in the recent past. Moreover, since mass transit service is presently provided, and is expected to continue to be provided, by motor coaches which are not tied to fixed ways, it is unlikely that transit service will become a major factor in determining the location of future urban development within the Region. Sewer service areas, by encouraging urban development at relatively higher population densities, may, however, affect the need for and feasibility of transit service.

Source: SEWRPC.

Region. The most important aspects of that description are summarized below.

The Southeastern Wisconsin Region consists of a seven-county area encompassing 2,689 square miles of land and inland water area, or about 5 percent of the total area of the State of Wisconsin. About 40 percent of the state's population, however, resides within these seven counties, which employ about 38 percent of the total work force of the state and which contain about half of all the tangible wealth in the State of Wisconsin as measured by equalized assessed valuation. The Region contains 153 local units of government exclusive of school and other special-purpose districts and encompasses all or parts of 11 major watersheds.

The population of the Region has been increasing at an average rate of about 18,000 persons per year from 1960 to 1970, and as of 1970 totaled 1,756,100 persons. This rate of population growth, although higher than state and national growth rates, is considerably lower than the approximately 33,000 persons per year growth rate experienced within the Region from 1950 to 1960. Population growth within the Region has been occurring primarily in the newer outlying suburban and rural-urban fringe areas of the Region, while the populations of the older central cities and suburbs of the Region have remained relatively stable or have actually declined.

The population growth has been accompanied by marked changes in certain characteristics of the population. The composition of the population is becoming increasingly urban, and at the present time only about 12 percent of the total regional population is classified as rural. Moreover, of the total population, about 10 percent is classed as rural non-farm and only 2 percent as rural farm. The number of households within the Region has been increasing faster than the total population, with an attendant decline in the household size. Personal income has been increasing at a higher rate than has the total population so that per capita and per household incomes have increased markedly over the last two decades, with the areas of highest average household income being located in the most rapidly growing newer suburban and rural-urban fringe areas of the Region.

Employment opportunities have increased at a rate of approximately 9,370 jobs per year over the last decade to a current level of approximately 741,600 jobs within the Region. The economic factors which promote population growth and urbanization in the Region are largely centered in and around the major urban centers of Milwaukee, Racine, and Kenosha, although a diffusion of economic activity into the outlying areas of the Region is occurring.

Land within the Region has been undergoing a particularly rapid conversion from rural to urban use. Recent urban development within the Region has been discontinuous and highly diffused, consisting primarily of many scattered, low-density, isolated enclaves of residential development located away from established urban centers. Urban population densities within the Region, which peaked in 1920 at a level of about 11,000 persons per square mile, have been steadily declining since then to a level of about 4,300 persons per square mile in 1970. The highly diffused nature of recent urban development and the sharp decline in urban population density have intensified many long-standing environmental problems within the Region and have created new environmental and developmental problems of an unprecedented scale and complexity, including problems of sanitary sewerage system development. The concentration of urban development around the shorelines of many of the inland lakes within the Region has further intensified the need for sanitary sewerage service in order to assure protection and preservation of the natural resource base and to provide such service efficiently and economically. If regional development trends continue as in the recent past, between 10 and 15 square miles of rural land may be expected to be converted to urban use each year within the Region. Under this type of areawide urban development, many once-isolated and independent communities have grown together, and urban development is spilling over the subcontinental divide which traverses the Region into the Fox-Illinois River Valley, complicating the sewage disposal as well as the sewage collection and transmission problems existing within the Region.

There are a total of 91 centralized public sanitary sewerage systems presently operated by utilities within the Region. These 91 systems serve a total area of about 309 square miles, or about 11 percent of the total area of the Region, and a total population of about 1.5 million persons, or about 85 percent of the total population of the Region. A total of 64 sewage treatment facilities are currently operated by the utilities owning, operating, and maintaining the 91 public sanitary sewerage systems, with many of the utilities contracting with adjacent utilities for sewage treatment purposes. In addition, there are 59 privately owned sewage treatment plants presently in operation within the Region. These generally serve isolated land use enclaves, mainly for industrial, commercial, and recreational enterprises. In all, then, there are 123 sewage treatment facilities within the Region.

The construction of public sanitary sewerage and water supply facilities has not fully kept pace with the rapid urbanization of the Region, necessitating the widespread use of onsite sewage disposal systems. An estimated 268,000 persons, or about 15 percent of the total Region population, rely on such septic tank sewage disposal systems. Only 27,000 of these persons actually live on farms, with the remaining 241,000 persons constituting urban dwellers generally living in scattered fashion throughout the Region. About half of the total area of the Region is covered by soils which are unsuitable to the use of onsite sewage disposal facilities.

The Region is unusually rich with respect to water resources. Urban development located east of the subcontinental divide, which traverses the Region, can utilize both Lake Michigan and the two underlying ground aquifers as a source of supply. Urban development west of that divide must depend primarily upon the two groundwater aquifers. Public water supply system service areas have generally tended to follow public sanitary sewerage service areas within the Region, although the extension of public water supply services has generally lagged behind the extension of sanitary sewerage service.

Gas and electric power services can be considered to be readily available throughout the Region, and therefore do not constitute a major constraint on the location or intensity of urban development within the Region. Transportation facilities similarly provide a very high level of service throughout the Region, with the extensively developed high-speed, all-weather highway system having had a particularly important influence on the spatial location of urban development within the Region in the recent past, although this influence has been significantly modified by the location within the Region of such natural resource base elements as streams, lakes, woodlands, wetlands, and fertile farmlands.

Chapter IV

DESCRIPTION OF THE REGION—NATURAL RESOURCE BASE

INTRODUCTION

The natural resource base is a primary determinant of the development potential of a region and of its ability to provide a pleasant and habitable environment for all forms of life. The principal elements of the natural resource base are climate, physiography, geology, soils, mineral and organic resources, vegetation, water resources, and fish and wildlife. Without a proper understanding and recognition of these elements and of their interrelationships, human use and alteration of the natural environment proceeds at the risk of excessive costs in terms of both monetary expenditures and destruction of nonrenewable or slowly renewable resources. In this age of high resource demand, urban expansion, and rapidly changing technology, it is especially important that the natural resource base be a primary consideration in any areawide planning effort since these aspects of contemporary civilization make the underlying and sustaining resource base highly vulnerable to misuse and destruction. An understanding of the natural resource base is, therefore, essential to sound areawide sanitary sewerage system planning.

This chapter identifies and describes the significant elements of the natural resource base of the Southeastern Wisconsin Planning Region; indicates and quantifies the spatial distribution and extent of those resources; characterizes, where possible, the quality of each component element of the natural resource base; and seeks to identify those elements and characteristics of the natural resource base which must be considered in the planning, design, construction, and operation of sanitary sewerage systems. The importance of such consideration cannot be overemphasized, since sanitary sewerage system development, by its impacts on the natural resource base, has the potential to either degrade or to protect and enhance the Region's natural heritage and environmental quality.

CLIMATE[1]

General Climatic Conditions

Wisconsin's mid-continent location, far removed from the moderating effect of the oceans, gives the Region a typical continental type climate characterized primarily by a continuous progression of markedly different seasons and a large range in annual temperature. Low temperatures during the long, cold winter are accentuated by prevailing frigid northwesterly winds during the winter period, while summer high temperatures are reinforced by the warm southwesterly winds common during that season.

The Southeastern Wisconsin Region is positioned astride cyclonic storm tracks along which low pressure centers move from the west and southwest. The Region also lies in the path of high pressure centers moving in a generally southeasterly direction. This location at the confluence of major migratory air masses results in the Region as a whole being influenced by a continuously changing pattern of different air masses having alternately low and high pressure centers, and results in frequent weather changes being superimposed on the aforementioned large annual range in weather characteristics, particularly in winter and spring when distinct weather changes normally occur at least once every two or three days. These temporal weather changes consist of marked variations in temperatures, type and amount of precipitation, relative humidity, wind magnitude and direction, and cloud cover.

In addition to these distinct temporal variations in weather, the Region exhibits spatial variations in weather due primarily to its proximity to Lake Michigan, particularly during the spring, summer, and fall seasons when the temperature differential between the lake water and the land air masses tends to be the greatest. During these periods, the presence of the lake tends to moderate the climate of the eastern border of the Region. It is common, for example, for midday summer temperatures in shoreline areas to abruptly drop to a temperature level 10°F lower than inland areas

---

[1] *Unless otherwise indicated, climatic and weather descriptions and data presented herein are based on information extracted from various periodic publications of the National Weather Service, U. S. Department of Commerce, formerly known as the Weather Bureau, U. S. Department of Commerce.*

because of cooling lake breezes generated by air rising from the warmer land surfaces. This Lake Michigan temperature influence is, however, generally limited to a narrow band of the Region lying within several miles of the shoreline.

Temperature

Temperatures in southeastern Wisconsin exhibit a large annual range and, as such, are a relevant factor to be considered in the planning, design, construction, and operation of sanitary sewerage systems. The ease with which outdoor construction and maintenance activities can be carried out is temperature dependent, and therefore annual temperature variations enter into the planning and scheduling of such activities. Seasonal temperature changes affect the amount of heat energy needed for sludge digestors at sewage treatment plants. Seasonal temperatures also determine the kinds and intensities of the recreational uses to which surface waters may be put, and, consequently, the periods over which the highest levels of water quality should be maintained.

More importantly, aerobic and anaerobic biochemical processes fundamental to the operation of conventional activated sludge and trickling filter units at sewage treatment plants, which units are normally exposed to the atmosphere, as well as similar processes occurring in stabilization lagoons, and naturally in surface waters, are temperature dependent, since reaction rates approximately double with each 20°F rise in temperature within the temperature range normally encountered in nature. An ample supply of oxygen is critical to aerobic sewage treatment processes as well as aerobic natural self-purification processes. The supply of oxygen available for such processes is a function of oxygen solubility in water, or the maximum concentration of oxygen that can be retained in solution, which is highly dependent on temperature. For example, a stream or lake at or near freezing temperatures can hold about 15 mg/l of dissolved oxygen, while the surface waters of that same stream on a hot 80°F day will have its oxygen solubility reduced by almost one-half. The summer period is therefore, primarily because of atmospheric temperature, critical and limiting in both natural and artificially induced aerobic processes, since oxygen demands are at their annual maximum due to accelerated reaction rates, while the oxygen supply is at its annual minimum because of solubility limitations associated with those high temperatures.

Regional temperature characteristics are also important in that they place restrictions on those sewage treatment plant effluent disposal methods which involve application to the soil rather than discharge to the surface waters. The Region's approximately six-month period of potential subfreezing temperatures, for example, precludes the possibility of utilizing spray irrigation systems without the provision of attendant large storage reservoirs.

Data for six selected temperature observation stations in southeastern Wisconsin, three of which—Port Washington, Milwaukee, and Kenosha—are located at the Lake Michigan shoreline, and three of which—West Bend, Waukesha, and Lake Geneva—are located at least fifteen miles inland, are presented in Table 11 and Figure 10. These data, which encompass periods of record ranging from 10 to 30 years for the various observation stations, indicate the temporal and spatial variations in temperature and the temperature ranges which may be expected to occur within the Region. The temperature data also illustrate how regional air temperatures lag approximately one month behind summer and winter solstices during the annual cycle with the result that July is the warmest month in southeastern Wisconsin and January the coldest.

The effects of Lake Michigan are also indicated by this data when comparisons are made between inland and shoreland observation stations that have the same latitude, that is, are generally located along the same east-west line so as to eliminate temperature effects attributable to latitude. It is also possible to identify latitudinal temperature effects by comparing data for observation stations generally located along the same longitudinal or north-south line.

Summer temperatures throughout the Region, as reflected by monthly means for July and August, are in the 67.5°F to 73.0°F range with northerly lakeshore locations exhibiting lower monthly mean summer temperatures than southerly inland locations. Lake Michigan's influence on summer temperatures may be demonstrated by contrasting Waukesha and Milwaukee data. Waukesha's monthly mean temperatures for July and August are 72.1°F and 70.8°F, respectively, whereas Milwaukee, which lies east of Waukesha and is subject to the influence of Lake Michigan, exhibits monthly means for July and August that are 3.4°F and 3.0°F, respectively, lower than those at Waukesha. The influence of Lake Michigan on summer temperatures is also demonstrated by average daily maximum and average daily minimum temperatures for inland locations as opposed to lakeshore locations. For example, average daily maximum temperatures at Waukesha for July and August are 84.1°F and 82.6°F, respectively, whereas Milwaukee, because of its close proximity to Lake Michigan, has July and August average daily maximum temperatures that are 7.4°F and 5.9°F, respectively, lower than those measured at Waukesha. Thus in addition to abrupt daytime drops in summer shoreland temperatures attributable to wind shifts that produce cooling lake

Table 11

TEMPERATURE CHARACTERISTICS AT SELECTED LOCATIONS IN THE REGION

	Observation Station[1]																					
	Lakeshore Location									Inland Location												
	Port Washington Period of Record: 1961-1970			Milwaukee Period of Record: 1931-1960			Kenosha Period of Record: 1945-1959			West Bend Period of Record: 1930-1959			Waukesha Period of Record: 1930-1959			Lake Geneva Period of Record: 1945-1959			Regional Summary			
Month	Average Daily Maximum[2]	Average Daily Minimum[2]	Mean[3]	Average Daily Maximum[2]	Average Daily Minimum[2]	Mean[3]	Average Daily Maximum[2]	Average Daily Minimum[2]	Mean[3]	Average Daily Maximum[2]	Average Daily Minimum[2]	Mean[3]	Average Daily Maximum[2]	Average Daily Minimum[2]	Mean[3]	Average Daily Maximum[2]	Average Daily Minimum[2]	Mean[3]	Average Daily Maximum[4]	Average Daily Minimum[4]	Mean[5]	Month
January	26.1	10.1	18.1	28.3	12.8	20.6	31.4	14.9	23.2	28.6	11.7	20.2	29.0	12.3	20.7	29.8	13.2	21.5	28.9	12.5	20.7	January
February	30.5	14.0	22.3	30.2	14.6	22.4	34.2	18.0	26.2	31.0	13.5	22.3	31.6	14.5	23.1	33.2	16.4	24.8	31.8	15.2	23.5	February
March	39.1	24.2	31.7	38.8	23.2	31.0	42.8	26.6	34.7	39.9	23.0	31.5	40.8	23.4	32.1	42.6	24.5	33.6	40.7	24.2	32.4	March
April	50.4	34.3	42.4	53.1	34.1	43.6	55.7	36.8	46.2	54.9	34.6	44.8	56.0	34.7	45.4	58.6	36.4	47.5	54.8	35.2	45.0	April
May	60.8	42.9	51.9	63.9	42.9	53.4	66.4	45.1	55.8	67.5	45.4	56.5	68.2	44.8	56.5	69.6	45.9	57.8	66.1	44.5	55.3	May
June	71.0	52.1	61.6	73.9	52.6	63.3	77.1	55.7	66.4	77.4	55.8	66.6	78.6	55.2	66.9	79.2	56.8	68.0	76.2	54.7	65.5	June
July	76.7	59.2	68.0	78.9	58.4	68.7	81.9	62.3	72.1	82.9	60.7	71.8	84.1	60.1	72.1	84.0	61.9	73.0	81.4	60.4	71.0	July
August	76.7	58.3	67.5	77.7	57.8	67.8	81.5	62.3	71.9	80.8	59.5	70.2	82.6	59.0	70.8	82.6	61.3	72.0	80.3	59.7	70.0	August
September	69.1	51.7	60.4	70.7	49.9	60.3	74.0	53.8	63.9	72.4	51.3	61.9	74.1	50.6	62.4	74.1	52.4	63.3	72.4	51.6	62.0	September
October	59.3	41.8	50.6	60.1	39.9	50.0	64.2	44.2	54.2	60.8	41.1	51.0	62.3	40.2	51.3	63.7	42.7	53.2	61.7	41.7	51.7	October
November	45.3	30.4	37.9	44.1	27.5	35.8	47.3	30.2	38.8	44.1	27.8	36.0	44.8	27.9	36.4	45.0	28.7	36.9	45.1	28.8	37.0	November
December	28.9	15.3	22.1	32.0	17.1	24.6	35.6	19.5	27.6	32.0	16.7	24.4	32.4	17.4	24.9	33.2	18.6	25.9	32.4	17.4	24.9	December
Year	52.8	36.2	44.5	54.3	35.9	45.1	57.7	39.1	48.4	56.0	36.8	46.4	57.0	36.7	46.9	58.0	38.2	48.1	56.0	37.2	46.6	Year

[1]*Observation stations were selected both on the basis of the length of record available and geographic location within the Southeastern Wisconsin Region. Port Washington, Milwaukee, and Kenosha are representative of areas with temperatures influenced by Lake Michigan, whereas West Bend, Waukesha, and Lake Geneva are typical of inland areas having temperatures that are not generally influenced by Lake Michigan. Kenosha and Lake Geneva are representative of southerly areas in the Region, whereas Port Washington and West Bend typify northern locations.*

[2]*The monthly average daily maximum temperature and the monthly average daily minimum temperature are obtained by using daily measurements to compute an average for each month in the period of record; the results are then averaged for all the months in the period of record.*

[3]*The monthly mean temperature is the mean of the average daily maximum temperature and the average daily minimum temperature for each month.*

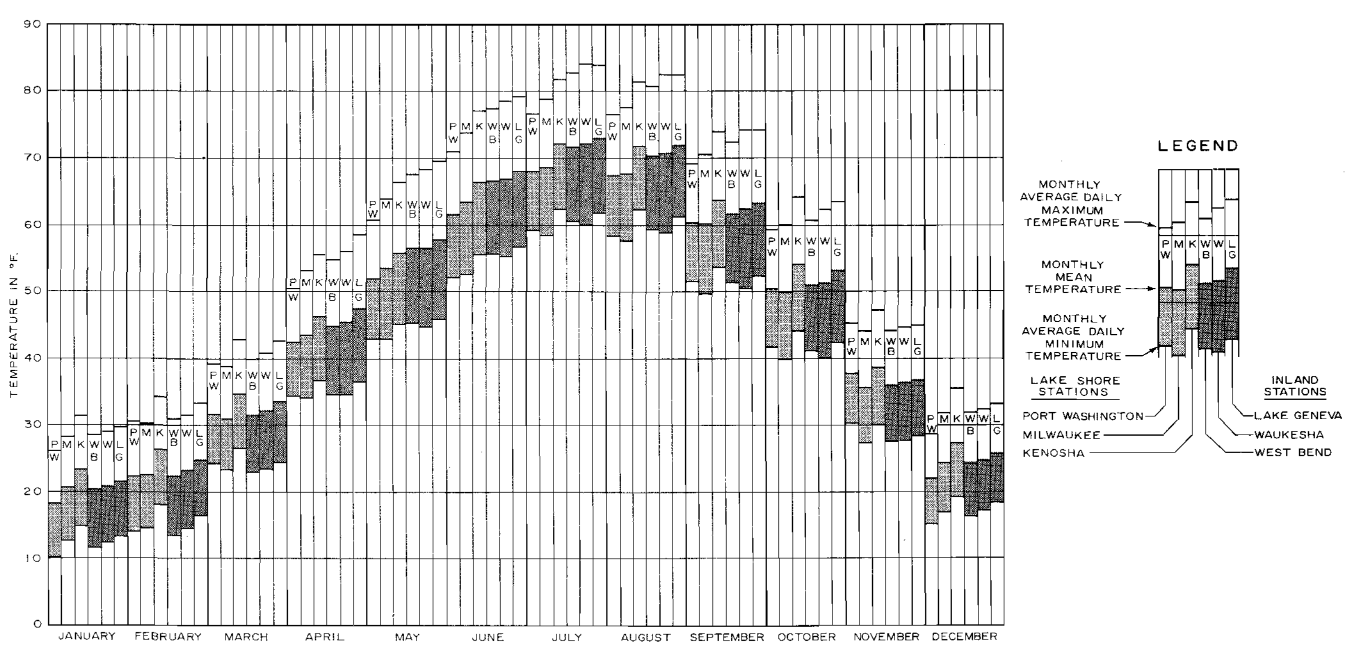
[4]*The monthly average daily maximum and minimum temperatures for the Region as a whole were computed as averages of the corresponding values for the six observation stations.*

[5]*The monthly mean for the Region as a whole is the mean of the Regional monthly average daily maximum and average daily minimum, which is equivalent to the average of the monthly means for the six observation stations.*

Source: Wisconsin Statistical Reporting Service, National Weather Service, and SEWRPC.

Figure 10

TEMPERATURE CHARACTERISTICS AT SELECTED LOCATIONS IN THE REGION



Source: Wisconsin Statistical Reporting Service and National Weather Service.

breezes, Lake Michigan also affects the overall summer temperature conditions as reflected by markedly lower monthly mean and average daily maximum temperatures for land areas in close proximity to the lake compared to inland areas located approximately along the same latitudinal line.

Winter temperatures in southeastern Wisconsin, as measured by monthly means for January and February shown in Table 11 and Figure 10, are in the range of 18.0°F to 26.0°F for all stations, there being no significant region-wide difference in monthly means, average daily minimum, and average daily maximums noted for inland locations contrasted with areas in close proximity to Lake Michigan.

Lake Michigan significantly affects temperatures of the Region during the transitional period of March, April, and May between winter and summer, at which time the lake, because it warms more slowly than the adjacent land areas, retards the temperature rise for land areas located along the shoreline relative to inland locations as evidenced by data presented in Table 11 and in Figure 10. Monthly mean temperatures for Waukesha during March, April, and May are 32.1°F, 45.4°F, and 56.5°F, respectively, whereas Milwaukee, since its temperature rise during the winter-spring transitional period is retarded by Lake Michigan, exhibits monthly mean temperatures during March, April, and May that are 1.1°F, 1.8°F, and 3.1°F, respectively, below those measured at Waukesha. Lake Michigan never does achieve a temperature level as high as that reached in inland areas, and thus the end result of this winter to summer transition process is, as discussed earlier, summer conditions characterized by lower temperatures in shoreland areas than at inland locations. The summer to winter transition period is, as shown graphically on Figure 10, characterized by a slightly greater drop in monthly mean temperature in inland areas compared to shoreline areas, since the former begin the transition period at a higher level than the latter and both inland and shoreline areas converge to similar temperature levels in winter.

Marked latitudinal differences, clearly evident on Figure 10, occur along the approximately 80-mile long portion of Lake Michigan shoreline which comprises the eastern boundary of the planning Region. Southerly locations, as typified by Kenosha, exhibit significantly higher monthly mean, average daily maximum, and average daily minimum temperatures than do northerly areas as typified by Port Washington. For example, January and February monthly mean temperatures at Kenosha are 23.2°F and 26.2°F, respectively, which is 5.1°F and 3.9°F, respectively, greater than those recorded at Port Washington. Observed monthly mean temperatures at Kenosha for July and August are 4.1°F and 4.4°F, respectively, above those recorded at Port Washington.

The growing season, which is defined as the number of days between the last 32°F freeze in spring and the first in the fall, averages about 165 days for the Region, with the lakeshore area having a growing season of about 175 days while inland locations exhibit a shorter growing season of about 155 days. The last 32°F frost in the spring normally occurs within the last week of April for areas in close proximity to Lake Michigan and during the first half of May for inland locations, whereas the first freeze in the fall usually occurs in the two week span during mid-October for all locations in the Region. Lake Michigan's moderating effect inhibits spring frost formation in the eastern extremities of southeastern Wisconsin, thereby giving that portion of the Region a slightly longer growing season.

Extreme high and low temperatures for southeastern Wisconsin, based on thirty years or more of historic records at observation stations distributed throughout the Region, are shown on Figure 11. The data indicate that extreme high temperatures within the Region have ranged from 104°F in the extreme eastern portion of Racine County to slightly more than 110°F in the western extremities of Washington, Waukesha, and Walworth Counties, whereas extreme low temperatures have ranged from about -20°F along the entire Lake Michigan shoreline to -33°F in the northwestern corner of Washington County. Lake Michigan has influenced temperature extremes in that lakeshore areas exhibit extreme summer high temperatures that are lower than those experienced inland because of the summer cooling effect of the lake. Moreover, unlike winter monthly mean, and winter average daily minimum and maximum temperatures, the lake apparently has influenced extreme winter low temperatures, in that those temperatures are higher for lakeshore areas than those experienced inland because of the winter warming effect of the lake. The range in historic extreme temperatures is, therefore, smaller along the Lake Michigan shoreline than at inland locations because of the lake's moderating effect. The expected extreme high temperature during an average year for a particular location within the Region may be estimated by subtracting 10°F to 15°F from the value shown on Figure 11, whereas the expected extreme low temperature during an average year for a particular location may be approximated by adding 10°F to 15°F.

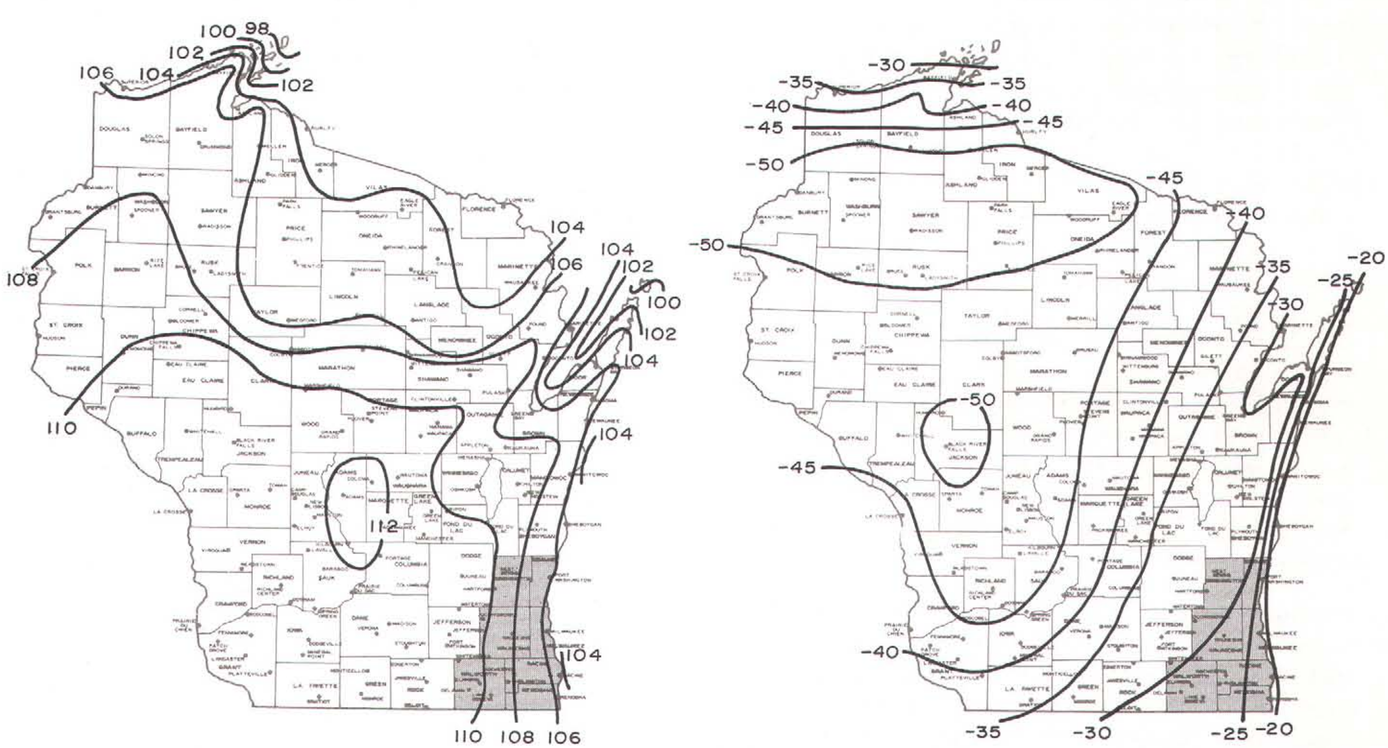
In addition to utilizing the regional data summarized on Figure 11, historic extreme temperatures and the moderating influence of Lake Michigan on those temperatures may also be demonstrated by examining data for specific observation stations having similar latitudes. Historic data for the 100-year period at Milwaukee extending through 1970 indicate that the highest temperature ever recorded in that city was 105°F in July 1934, while the lowest temperature ever recorded was -25°F in January of 1875. The highest temperature recorded during the 30-year period 1930 through 1959 at Waukesha, which is located approximately 15 miles inland from Milwaukee and therefore is farther removed from the moderating influence of Lake Michigan, was 109°F in July 1936. The lowest was -27°F in January, 1944. Even though the 30-year Waukesha record is considerably shorter than the 100-year record available at Milwaukee, observed temperatures have been more extreme at the former location.

Figure 11

EXTREME HIGH AND LOW TEMPERATURES IN THE REGION BASED ON DATA FOR STATIONS HAVING AT LEAST 30 YEARS OF RECORD

EXTREME HIGH TEMPERATURE [a] (°F)

EXTREME LOW TEMPERATURE [b] (°F)



[a] THE EXPECTED EXTREME LOW TEMPERATURE FOR AN AVERAGE YEAR AT A GIVEN LOCATION MAY BE APPROXIMATED BY ADDING 10 TO 15°F TO THE EXTREME LOW TEMPERATURE SHOWN ON THE FIGURE.

[b] THE EXPECTED EXTREME HIGH TEMPERATURE FOR AN AVERAGE YEAR AT A GIVEN LOCATION MAY BE APPROXIMATED BY SUBTRATING 10 TO 15°F FROM THE EXTREME HIGH TEMPERATURE SHOWN ON THE FIGURE.

Source: Wisconsin Statistical Reporting Service, National Weather Service, and SEWRPC.

Precipitation

Precipitation within the Region takes the form of rain, sleet, hail, and snow, and ranges from gentle showers of trace quantities to destructive thunderstorms, as well as major rainfall-snowmelt events causing property and crop damage, inundation of poorly drained areas, and stream flooding. The kind and amount of precipitation that may be expected to occur within the Region influences the nature of man's activities in general, and particularly sanitary sewerage system design, construction, operation, and maintenance. Existing sewerage system problems such as overflows from combined sewers in certain urban areas are the direct result of even the smallest precipitation events. For example, the Commission's Milwaukee River watershed study determined that an average of approximately 50 rainfall events may be expected to occur each year during which the intercepting devices which connect the combined sewer outfalls to the intercepting sewers intended to convey the dry weather waste water flows to the Jones Island sewage treatment plant will operate to discharge a mixture of sanitary sewage and storm water runoff directly to the Milwaukee, Menomonee, and Kinnickinnic Rivers and to Lake Michigan through up to 112 combined sewer outfalls. Rainfall events may also cause separate sanitary sewerage systems to surcharge and overflow to surface water courses, and may require sewage treatment plants to bypass large volumes of untreated sewage in excess of the hydraulic capacity of the plants. Such surcharging of separate sanitary sewerage systems is caused by the entry of excessive quantities of rain, snowmelt, and groundwater into the sanitary sewers via manholes, building sewers, building downspouts, and foundation drain connections, and by infiltration through faulty sewer pipe joints, manhole structures, and cracked pipes.

Precipitation and snowfall data for six representative precipitation observation stations in southeastern Wisconsin located on the Lake Michigan shoreline at Port Washington, Milwaukee, and Kenosha and inland at West Bend, Waukesha, and Lake Geneva are presented in Table 12 and Figure 12. These data, which encompass periods of record ranging from 15 to 65 years for the various observation stations, illustrate the temporal and spatial variations in the type and amount of precipitation that normally occur within the Region.

The data indicate that the average annual total precipitation in the Region, based on data for the six representative stations, is 30.3 inches, expressed as water equivalent, and that the average annual snowfall measured as snow at the time of snowfall is 43.2 inches. Average total monthly precipitation for the Region ranges from 1.32 inches in February to 3.86 inches in June. The principal snowfall months are December, January, February, and March when average monthly snowfalls are 8.8, 11.9, 8.4, and 9.3 inches, respectively, and during which time 89 percent of the average annual snowfall may be expected to occur. Snowfall is the predominant form of precipitation during these months since over one-half of the total precipitation during these months, expressed as water equivalent, usually occurs as snow. Approximately 20 inches, or two-thirds of the average annual precipitation, normally occurs during the late April through mid-October growing season, primarily as rainfall. Assuming that 10 inches of measured snowfall is equivalent to one inch of water, the average annual snowfall of 43.2 inches is equivalent to 4.32 inches of water and, therefore, only 14.3 percent of the average annual total precipitation occurs as snowfall. It is of interest to note that approximately three-quarters of the 30.3-inch average annual precipitation leaves the Region as evapo-transpiration; the remaining one-quarter is transported from the Region as streamflow.

The balance, on an annual basis, between water input to the Region in the form of precipitation and water removal from the Region in the form of evapo-transpiration and streamflow, indicates that there is no significant net annual change in groundwater storage. Although there is no such annual change, there is, of course, an annual cycle of groundwater recharge in the spring and early summer followed by discharge from the shallow groundwater reservoir during the remainder of the summer and during the fall and winter period.

Precipitation data indicate that Lake Michigan does not have as pronounced an effect on precipitation within the Region as it does on temperature. A minor Lake Michigan effect is evident in a rainfall reduction of up to about 0.5 inch per month in late spring and summer in the eastern areas of the Region relative to the western areas, which reduction may be attributable to the cool lake waters maintaining a cooler lower atmosphere that inhibits convective precipitation.

The influence of Lake Michigan as a source of moisture is reflected by slightly higher seasonal

Table 12

PRECIPITATION CHARACTERISTICS AT SELECTED LOCATIONS IN THE REGION

Month	Observation Station[1]												Regional Summary		Month
	Lakeshore Location						Inland Location								
	Port Washington		Milwaukee		Kenosha		West Bend		Waukesha		Lake Geneva				
	Period of Record: 1896-1960[2]		Period of Record: 1931-1960		Period of Record: 1945-1959		Period of Record: 1930-1959		Period of Record: 1930-1959		Period of Record: 1945-1959				
	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	
January	1.61	11.5	1.83	12.7	1.56	11.9	1.68	12.3	1.70	11.8	1.73	11.0	1.69	11.9	January
February	1.56	10.2	1.40	8.0	1.08	12.1	1.36	8.1	1.26	6.6	1.26	5.5	1.32	8.4	February
March	2.21	8.0	2.31	9.3	2.29	7.3	2.01	10.5	2.16	10.7	2.55	10.1	2.26	9.3	March
April	2.73	1.9	2.53	1.2	3.19	1.4	2.54	1.2	2.52	1.1	3.24	1.1	2.79	1.3	April
May	3.37	0.1	3.16	0.0	3.49	0.2	2.98	0.4	3.46	0.4	3.69	0.1	3.36	0.2	May
June	3.32	0.0	3.64	0.0	4.05	0.0	3.96	0.0	3.72	0.0	4.46	0.0	3.86	0.0	June
July	2.79	0.0	2.95	0.0	3.23	0.0	3.34	0.0	3.31	0.0	4.18	0.0	3.30	0.0	July
August	2.92	0.0	3.06	0.0	3.08	0.0	2.89	0.0	3.06	0.0	3.60	0.0	3.10	0.0	August
September	3.20	0.0	2.72	0.0	2.19	0.0	3.16	0.0	2.93	0.0	1.98	0.0	2.70	0.0	September
October	2.30	0.2	2.10	0.0	1.85	0.1	2.21	0.1	2.09	0.0	2.13	0.0	2.11	0.1	October
November	2.06	3.0	2.18	2.5	1.96	2.5	2.13	2.9	2.30	3.5	2.16	4.5	2.13	3.2	November
December	1.55	7.2	1.63	9.8	1.89	9.7	1.50	7.8	1.56	7.7	2.12	10.8	1.71	8.8	December
Year	29.62	42.1	29.51	43.5	29.86	45.2	29.76	43.3	30.07	41.8	33.10	43.1	30.33	43.2	Year

[1]*Observation stations were selected both on the basis of the length of record available and geographic location within the Southeastern Wisconsin Region. Port Washington, Milwaukee, and Kenosha are representative of areas where precipitation would be influenced by Lake Michigan, whereas West Bend, Waukesha, and Lake Geneva are typical of inland areas having precipitation that is not generally influenced by Lake Michigan. Kenosha and Lake Geneva are representative of southerly areas in the Region, whereas Port Washington and West Bend typify northern locations.*

[2]*Snow and sleet data for Port Washington is based on the 56 year period 1894 through 1950.*

Source: Wisconsin Statistical Reporting Service, National Weather Service, and SEWRPC.

snowfalls for the entire Region relative to inland areas lying west of the Region.[2] Minor intra-regional spatial snowfall differences occur in that seasonal snowfall tends to be greatest in the topographically higher northwest portion of the Region because moisture masses moving through that area are forced up onto the higher terrain where lower temperatures normally associated with increased height induce more snowfall than that which would occur in the absence of the topographic barrier.

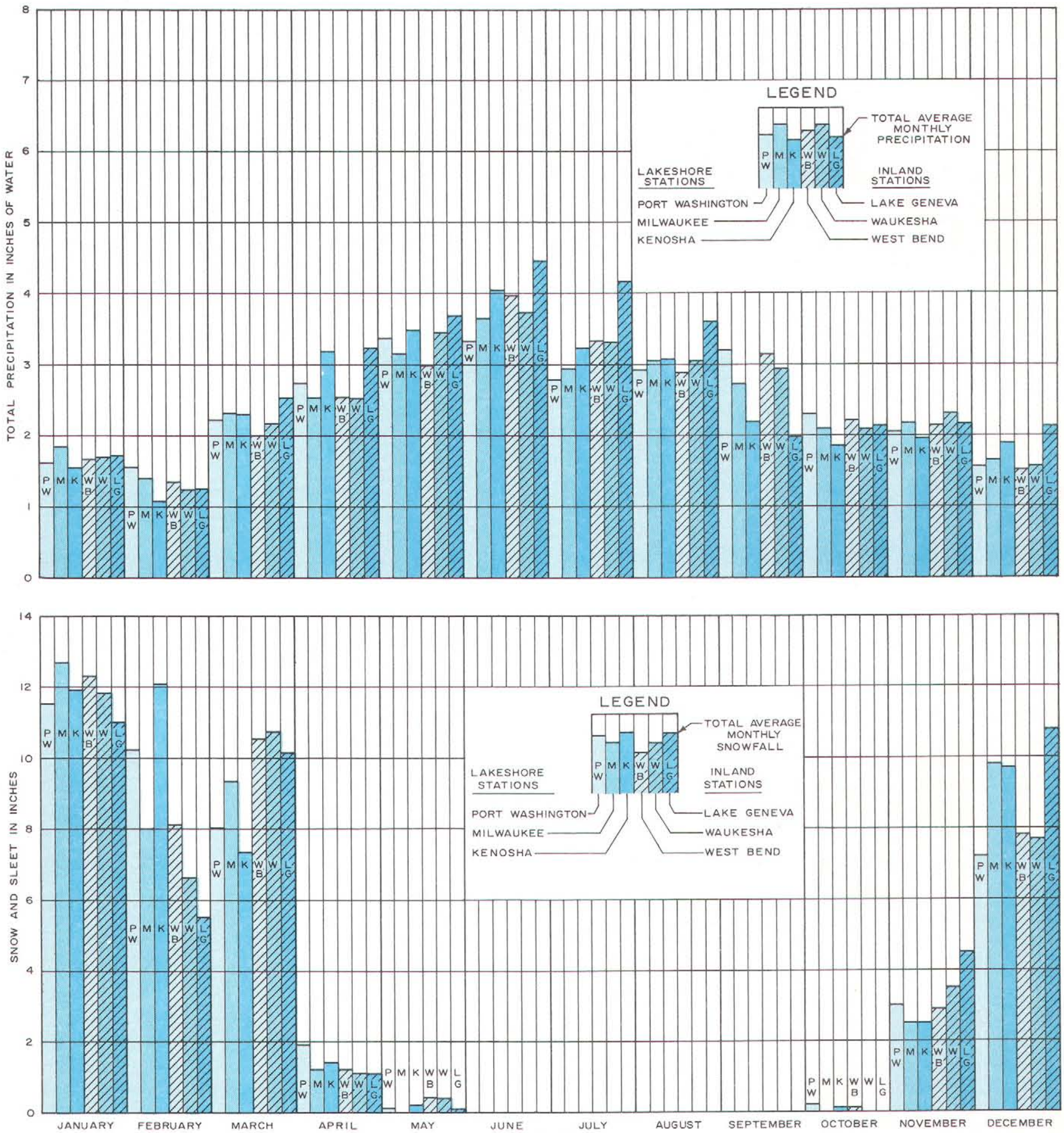
Extreme precipitation data for the entire Region, based on observations for stations located throughout southeastern Wisconsin having relatively long periods of record, are presented in Table 13. The minimum annual precipitation within the Region, as determined from the tabulated data for the indicated observation period, occurred at Waukesha in 1901, when only 17.30 inches of precipitation occurred, or 57 percent of the average annual precipitation of 30.3 inches for southeastern Wisconsin. The maximum annual precipitation within the Region occurred at Milwaukee in 1876 when 50.36 inches of precipitation occurred, or 166 percent of the average annual precipitation for southeastern Wisconsin. The minimum seasonal snowfall was 5.0 inches, or about 11.5 percent of the regional annual average snowfall, and was recorded at Racine during the winter of 1901-1902, whereas the maximum annual or seasonal snowfall was 109 inches, or about 251 percent of the regional annual average, and was recorded at Milwaukee during the winter of 1885-1886.

The maximum monthly precipitation measured in the Region was 13.17 inches, which occurred at West Bend in August of 1924, while the maximum monthly snowfall was 56.0 inches as recorded at Waukesha in January of 1918. The maximum 24-hour or daily precipitation ever recorded in southeastern Wisconsin, based on the data presented in Table 13, occurred in the West Bend area on August 4, 1924, when 7.58 inches of rain fell, and the greatest 24-hour or daily snowfall was 30.0 inches recorded at Racine in February 1898.

[2]*The effect of Lake Michigan on the annual snowfall in southeastern Wisconsin is minor relative to lake-effect snowfall experienced on the eastern shore of the lake. In the winter, prevailing northwesterly winds move cold, dry air over the relatively warm surface of Lake Michigan. The air gains moisture and heat energy and rises, producing annual snowfalls in excess of 80 inches, about twice that experienced in Wisconsin, over most of the western portion of the State of Michigan. For additional information see: Dewey, K. F., "Lake-Effect Snowfall and Some Implications for a Great Lakes Air Pollution Model," Northern Illinois University, Department of Geography, September 1970.*

Figure 12

PRECIPITATION CHARACTERISTICS AT SELECTED LOCATIONS IN THE REGION



Source: Wisconsin Crop Reporting Service, National Weather Service, and SEWRPC.

As noted above, there are numerous ways in which excessive quantities of rain, snowmelt, and groundwater can enter separate sanitary sewer systems causing surcharge of the conveyance works and excessive hydraulic loading at the sewage treatment plants which, in turn, results in

Table 13

EXTREME PRECIPITATION EVENTS IN THE REGION

Observation Station[1]		Period of Precipitation Records Except Where Indicated Otherwise	Total Precipitation (Water Equivalent)											Snowfall										
			Maximum Annual		Minimum Annual		Maximum Monthly			Maximum Daily				Maximum Annual		Minimum Annual		Maximum Monthly			Maximum Daily			
Name	County		Amount	Year	Amount	Year	Amount	Month	Year	Amount	Day	Month	Year	Amount	Year	Amount	Year	Amount	Month	Year	Amount	Day	Month	Year
Milwaukee	Milwaukee	1870-1970	50.36[3]	1876	18.69[3]	1901	10.03	June	1917	5.76[4]	22-23	June	1917	109.0[5]	1885-1886	11.0[5]	1884-1885	52.6	Jan.	1918	20.3[6]	4-5	Feb.	1924
Racine	Racine	1895-1970	48.33	1954	17.75	1910	10.98	May	1933	4.00	11	Sept.	1933	85.0	1897-1898	5.0[7]	1901-1902	38.0	Feb.	1898	30.0[6]	19-20	Feb.	1898
Waukesha	Waukesha	1892-1970	43.57	1938	17.30	1901	11.41	July	1952	5.09	18	July	1952	83.0[7]	1917-1918	9.1	1967-1968	56.0	Jan.	1918	20.0[6]	5-6	Jan.	1918
West Bend	Washington	1922-1970	40.52	1938	19.72	1901	13.17[2]	Aug.	1924	7.58[2]	4	Aug.	1924	86.5	1935-1936	19.6	1967-1968	38.0	Jan.	1943	21.0	10-11	Dec.	1970

[1]An observation station was included if a minimum of 30 years of record was available.

[2]Based on the period 1895-1959 as reported in "A Survey Report for Flood Control on the Milwaukee River and Tributaries," U.S. Army Engineer District, Chicago, Corps of Engineers, November 1964.

[3]Based on the period 1841-1970.

Source: Wisconsin Statistical Reporting Service, National Weather Service, U. S. Army Corps of Engineers, and SEWRPC.

[4]Maximum precipitation for a 24-hour period.

[5]Maximum and minimum snowfalls for a winter season.

[6]Maximum snowfall for a 24-hour period.

[7]Estimated from incomplete records.

the discharge of untreated or partially treated sewage to surface waters. Since the entry of rainwater and snowmelt runoff into sanitary sewerage systems may be expected to result in surface water pollution, and since storm water drainage systems are intended to control by means of retention and conveyance facilities the spatial and temporal distribution of rain and snowmelt runoff, it follows that sanitary sewerage systems and stormwater drainage systems should be designed and developed concurrently so as to assure the separate function and integrity of each of the two systems, to immediately achieve the drainage and pollution abatement benefits of the integrated design, to realize construction economy, and to minimize disruption to both the natural resource base and the existing urban development.

The Commission has developed rainfall intensity-duration-frequency relationships, which are fundamental to the design of storm water drainage systems, based on a 64-year precipitation record at the Milwaukee National Weather Service Station. These relationships are shown graphically in Figure 13 and are presented in equation form in Table 14. The equations are intended primarily for incorporation into digital computer programs used in storm drainage system analysis and design. The intensity-duration-frequency relationships are directly applicable to urban storm water drainage system design throughout the Region using design procedures such as the rational method[3] and may also be used in the design of replacements for trunk and intercepting sewers in existing combined sewer service areas.

Snow Cover

The likelihood of snow cover and the depth of snow on the ground are important precipitation-related factors that influence the planning, design, construction, and maintenance of sanitary sewerage systems. Snow cover, particularly early in the winter season, significantly influences the depth and duration of frozen ground which in turn affects engineered works involving extensive excavation and underground construction. Accumulated snow depth at a particular location and time is primarily dependent on antecedent snowfall, rainfall, and temperature characteristics, and the amount of solar radiation. Rainfall is relatively unimportant as a melting agent but can, because of compaction effects, significantly affect the depth of snow cover on the ground.

Snow depth as measured at Milwaukee for the 70-year period of 1900 through 1969 and published in "Snow and Frost in Wisconsin," a 1970 Wisconsin Statistical Reporting Service report, is summarized and presented in Table 15. It should be emphasized that the tabulated data pertains to snow depth on the ground as measured at the place and time of observation and is not a direct measure of average snowfall. Recognizing as discussed above that snowfall and temperatures and therefore snow accumulation on the ground vary spatially within the Region, the Milwaukee area data presented in Table 15 should be considered only as an approximation of conditions that would be encountered in other parts of the Region. As indicated by the data, snow cover is most likely

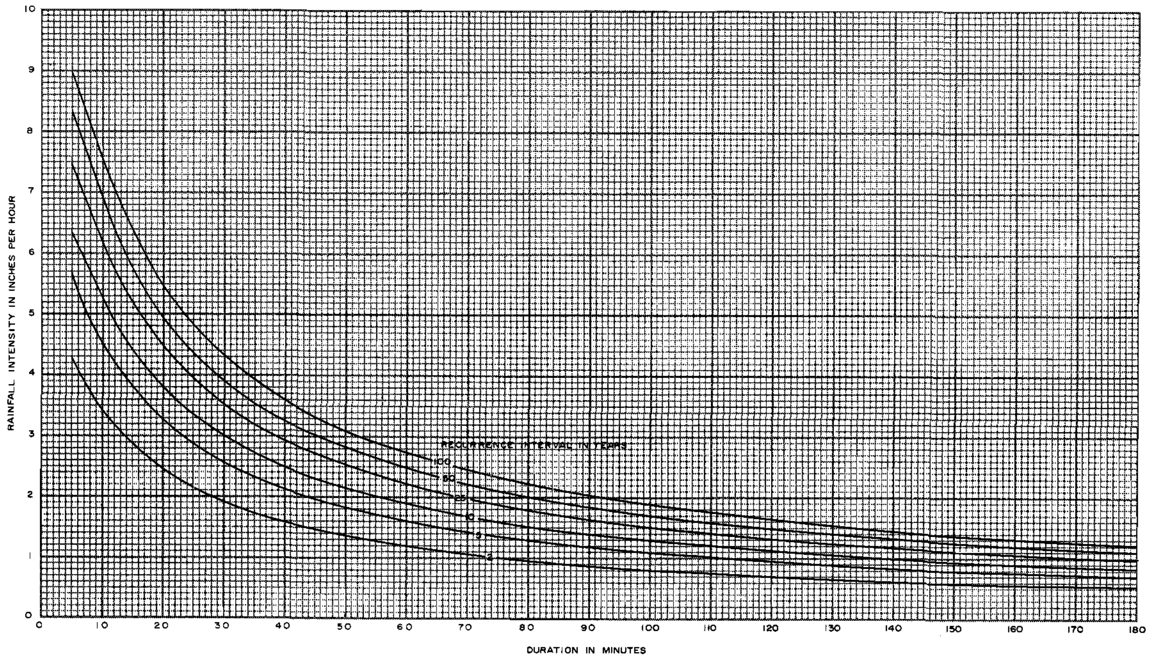
---

[3]For a detailed description of the rational method with emphasis on the use of soils, mapping, land use, and hydrologic data available for the seven-county planning Region, refer to Bauer, K. W., "Determination of Runoff for Urban Storm Water Drainage System Design," SEWRPC Technical Record, Vol. 2, No. 4, April-May 1965. The procedures used to obtain equations for intensity-duration-frequency relationships are described in Walesh, S. G., "Development of Equations for Intensity-Duration-Frequency Relationships," SEWRPC Technical Record, Vol. 3, No. 5, March 1973.

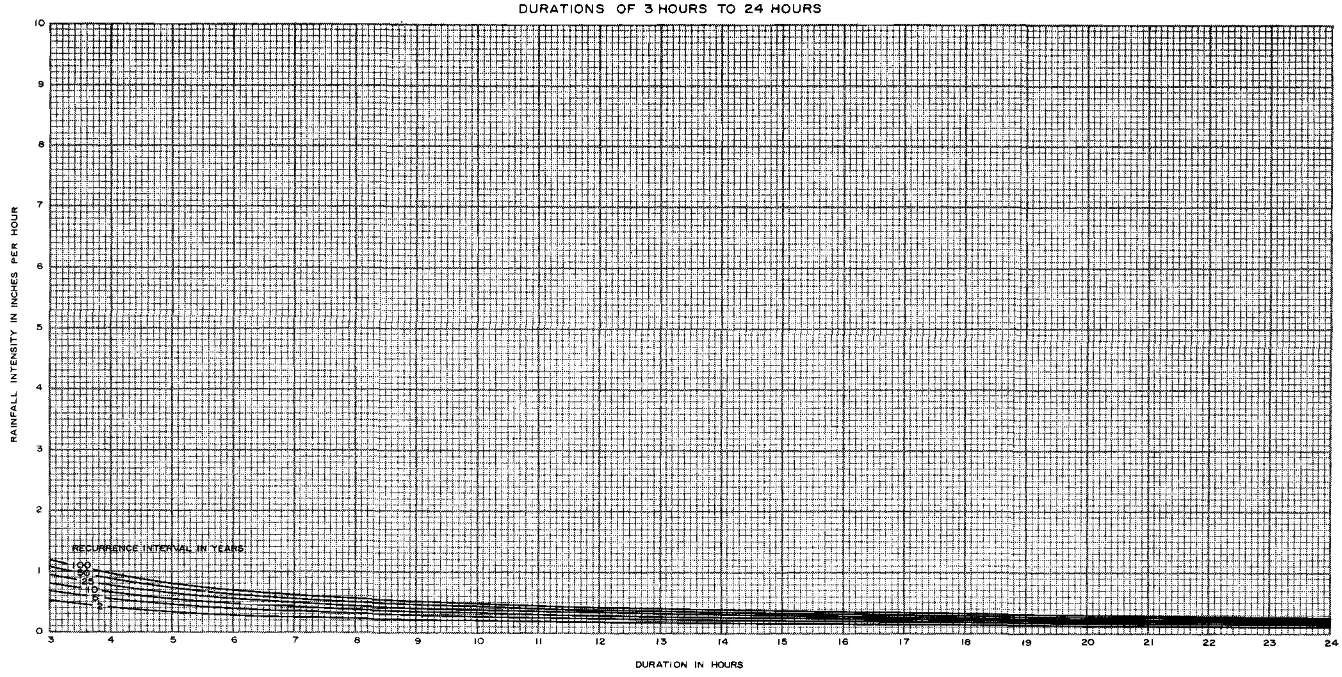
Figure 13

POINT RAINFALL INTENSITY-DURATION-FREQUENCY CURVE
BASED ON MILWAUKEE DATA FOR 1903-1966

DURATIONS OF 5 MINUTES TO 180 MINUTES



DURATIONS OF 3 HOURS TO 24 HOURS



Source: SEWRPC.

during the months of December, January, and February during which period of time at least a 0.40 probability exists of having one inch or more of snow cover at Milwaukee. Furthermore, during January and the first half of February, at least a 0.25 probability exists of having five or more inches of snow on the ground. During March, the month in which severe spring snowmelt-rainfall flood events are most likely to occur, at least a 0.30 probability exists of having one inch or more of snow on the ground during the first half of the month while the probability of having that much snow cover diminishes to 0.07 by the end of the month.

Table 14

POINT RAINFALL INTENSITY-DURATION-FREQUENCY EQUATIONS BASED ON MILWAUKEE DATA FOR 1903-1966

Recurrence Interval (Years)	Equation[2]	
	Duration of 5 Minutes or More But Less Than 60 Minutes	Duration of 60 Minutes or More Through 24 Hours
2	$I = \frac{87.5}{15.4 + T}$	$I = 28.9\ T^{-0.781}$
5	$I = \frac{120.2}{16.6 + T}$	$I = 38.2\ T^{-0.776}$
10	$I = \frac{141.8}{17.1 + T}$	$I = 44.2\ T^{-0.772}$
25	$I = \frac{170.1}{17.8 + T}$	$I = 52.3\ T^{-0.771}$
50	$I = \frac{190.1}{18.0 + T}$	$I = 57.3\ T^{-0.768}$
100	$I = \frac{211.4}{18.4 + T}$	$I = 63.5\ T^{-0.768}$

[1]The equations are based on Milwaukee rainfall data for the 64-year period of 1903 to 1966. These equations are applicable, within an accuracy of ±10 percent, to the entire southeastern Wisconsin planning region.
[2]I = Rainfall intensity in inches per hour.
T = Duration in minutes.
Source: SEWRPC.

The aforementioned table facilitates an estimation of the probability that a given snow cover will be reached or exceeded at any given time and should, therefore, be useful in planning winter outdoor work and construction activities as well as estimating runoff for sewer design purposes. There is, for example, only a 0.07 probability of encountering one or more inches of snow cover on November 15 of any year whereas there is a much higher probability, 0.61, of having that much snow cover on January 15.

Frost Depth

Ground frost or frozen ground refers to that condition in which the ground contains variable amounts of water in the form of ice. Frost influences hydrologic processes, particularly the percent of rainfall or snowmelt that will run off the land directly to sewerage systems and to surface watercourses in contrast to that which will enter and be temporarily detained in the soil. Anticipated frost conditions influence the design of engineered works in that structures and facilities are designed so as to either prevent the accumulation of water and, therefore, the formation of damaging frost, as in the case of pavements and retaining walls, or structures and facilities are designed so as to be partially or completely located below the frost susceptable zone in the soil, as in the case of foundations and water mains. For example, in order to avoid or minimize the danger of structural damage, foundation

Table 15

SNOW COVER PROBABILITIES AT MILWAUKEE BASED ON DATA FOR THE PERIOD 1900-1970

Date		Snow Cover[1]									
		1.0 Inch or More		5.0 Inches or More		10.0 Inches or More		15.0 Inches or More		Average (Inches)	
Month	Day	Number of Occurrences[2]	Probability of Occurrence[3]	Number of Occurrences[2]	Probability of Occurrence[3]	Number of Occurrences[2]	Probability of Occurrence[3]	Number of Occurrences[2]	Probability of Occurrence[3]	Per Occurrence[4]	Overall[5]
November	15	5	0.07	0	0.00	0	0.00	0	0.00	1.2	0.09
	30	12	0.17	1	0.01	1	0.01	0	0.00	2.8	0.49
December	15	33	0.47	10	0.14	0	0.00	0	0.00	3.3	1.54
	31	32	0.46	9	0.13	1	0.01	0	0.00	3.6	1.66
January	15	43	0.61	17	0.24	4	0.06	2	0.03	4.9	2.94
	31	48	0.69	22	0.31	9	0.13	4	0.06	6.2	4.26
February	15	44	0.63	23	0.33	7	0.10	3	0.04	6.0	3.69
	28	27	0.39	8	0.11	3	0.04	1	0.01	4.5	1.69
March	15	23	0.33	6	0.09	4	0.06	0	0.00	3.9	1.21
	31	5	0.07	1	0.01	1	0.01	0	0.00	3.4	0.24

[1]Data pertains to snow depth on the ground as it was measured at the time and place of observation, and is not a direct measure of average snowfall.
[2]Number of occurrences is the number of times during the 70-year period of record when measurements revealed that the indicated snow depth was equaled or exceeded on the indicated date.
[3]Probability of occurrence for a given snow depth and date is computed by dividing the number of occurrences by 70, and is defined as the probability that the indicated snow cover will be reached or exceeded on the indicated date.
[4]Average snow cover per occurrence is defined as the sum of all snow cover measurements in inches for the indicated date divided by the number of occurrences for that date, that is, the number of times in which 1.0 inch or more of snow cover was recorded.
[5]Overall average snow cover is defined as the sum of all snow cover measurements in inches for the indicated date divided by 70, that is, the number of observation times.

Source: Wisconsin Statistical Reporting Service, National Weather Service, and SEWRPC.

footings must be placed at a sufficient depth in the ground so as to be below that zone in which the soil may be expected to contract, expand, or shift due to frost action. A similar consideration exists in the design and construction of sanitary sewers.

Snow cover is a primary determinant of the depth of frost penetration and of the duration of frozen ground. The thermal conductivity of snow cover is less than one-fifth that of moist soil so that heat loss from the soil to the cold atmosphere is greatly inhibited by an insulating snow cover. An early, major snowfall that is retained on the ground as a substantial snow cover will inhibit or prevent frost development in unfrozen ground and may even result in a reduction or elimination of frost in already frozen ground. If an early, significant snow cover is maintained by additional regular snowfall throughout the winter season, frozen ground may not develop at all or, at most, a relatively small frost penetration will occur. Frost depth is also dependent on vegetal cover and soil type. Assuming similar soil types, for example, frost will penetrate more deeply into bare, unprotected soil than into soil covered with an insulating layer of sod.

Frost conditions for the Region are available on a bimonthly basis for the months of November through March as shown in Figure 14, and are based upon data for an eight-year period of record, extending from 1961 through 1968 as set forth in the report "Snow and Frost in Wisconsin," published in 1970 by the Wisconsin Statistical Reporting Service. These data are provided for representative locations on a weekly basis by funeral directors and cemetery officials from about thirty frost depth reporting sites in southeastern Wisconsin. Since cemetery soils are normally overlain by an insulating layer of turf, the frost depths shown in Figure 14 should be considered minimum values. During the period that frost depth observations have been made in southeastern Wisconsin, one of the deepest regionwide frost penetrations occurred in early March 1963 when 25 to 30 inches of frost occurred throughout the seven-county planning Region. Recorded frost depths have actually exceeded 36 inches in parts of Ozaukee, Milwaukee, Racine, and Kenosha Counties, and 48 inches in Washington and Waukesha Counties.[4]

---

[4]*Letter from M. W. Burley, Wisconsin State Climatologist to SEWRPC, April 5, 1965.*

The data indicate that frozen ground is likely to exist throughout the Region for approximately four months each winter season extending from late November through March, with six or more inches of frost normally occurring during January, February, and the first half of March. Historic data indicate that the more severe frost conditions normally occur in February when between 12 and 18 inches of frost may be expected.

Minor Climatic Elements

Evaporation rate, wind magnitude and direction, the amount of daylight, and the expected extent of sky cover, are considered minor climatic factors and, as such, detailed data within the Region are available primarily for the Milwaukee area. It is, however, possible to develop a generalized description of evaporation, wind, sunshine and sky cover conditions for the Region by using Milwaukee data supplemented with information from other sources such as the Commission's current regional airport system planning program.

Evaporation: Evaporation is the natural process whereby water is transformed from the liquid or solid state to the vapor state and returned to the atmosphere. Total evaporation includes evaporation from water and snow surfaces and directly from the soil. It also includes evaporation of precipitation intercepted by vegetation and evaporation of water transpired by vegetation.

The magnitude and annual variation in evaporation from water surfaces and the relation of that evaporation to precipitation is of importance to sewage treatment plant operation primarily because of its implications for the design and operation of sludge drying beds. Digested sludge is spread on the drying beds which are normally open to the atmosphere, constructed of graded layers of gravel or crushed stone, and provided with an underdrain system. Dewatering occurs by the dual processes of filtration through the porous material and evaporation to the atmosphere.

Limited evaporation data available for the Region indicates an average annual evaporation from a water surface of about 28 inches, with about three-quarters of this, or 21 inches, occurring during the six-month May through October period. As indicated earlier in this chapter and summarized in Table 12, the average annual precipitation for the Region is about 30 inches, which exceeds the average annual evaporation by about two inches. During the aforementioned six-month May through

October period, regional precipitation is about 18 inches and, therefore, evaporation from a water surface may be expected to exceed precipitation by about three inches during this period.

The approximate equality between annual evaporation and precipitation indicates that the process of evaporation should not be considered the primary dewatering mechanism for uncovered, open-air sludge drying beds used in the Southeastern Wisconsin Region. Instead it is necessary to rely primarily on the underdrain system to achieve successful sludge dewatering or to provide covers for the drying beds.

Wind: Prevailing winds in the Region follow a clockwise pattern in terms of the prevailing direction over the seasons of the year, being northwesterly in the late fall and winter, northeasterly in the spring, and southwesterly in the summer and early fall. Wind velocities in southeastern Wisconsin may be expected to be less than five miles per hour about 15 percent of the time, between five and 15 miles per hour about 60 percent of the time, and in excess of 15 miles per hour about 25 percent of the time.

Figure 15 presents wind direction data for seven locations within the Region and for six additional sites located immediately north or west of the Region. As shown by the wind roses, the Region exhibits a rather uniform distribution of wind direction, that is, there are no extreme differences in the frequency of wind direction from one location to another in or near the Region on an annual basis. Of the eight compass points depicted for each of the seven in-Region locations in Figure 15, the dominant directions from which the wind blows tend to be the southwest, northwest, northeast, and southeast, while the wind may be expected to originate from due north, south, east, or west only a relatively small proportion of the time. Based on averages of the indicated percentages for each of the seven in-Region locations, the wind may be expected to blow from the southwest and northwest each about 20 percent of the time, and from the southeast and northeast each about 15 percent of the time. Thus, the winds in southeastern Wisconsin may be expected to blow from these four of the eight compass points about 70 percent of the time.

One beneficial effect of wind, in the context of regional sanitary sewerage system planning, design, and operation, is the increased rates of oxygen absorption that occur in lakes and streams as well as sewage treatment units open to the atmosphere as a result of continuous air movement which oxygen is, as discussed earlier, required for desirable aerobic biochemical processes. Wind also accelerates evaporation and, thus, sludge drying beds should be designed, located, and oriented so as to maximize the evaporation and, therefore, the sludge drying process. Potential undesirable wind effects, which can be precluded or at least minimized by careful engineering, planning, design, and operation of sewage treatment facilities, include transmission of odorous gases into urban areas and the concentration of treatment plant effluent along certain downwind lakeshore areas resulting in excessive concentrations of floating and rooted aquatic plant growth. Actual or potential odor problems in the proximity of sewage treatment plants may be eliminated or minimized by siting that recognizes the prevailing westerly winds in southeastern Wisconsin and by proper plant management. Prevailing winds, and the surface water currents induced by those winds, constitute primary considerations in the location of discharge points for sewage treatment plant effluent.

Daylight and Sky Cover: The annual variation in the time of sunrise and sunset and the daily hours of sunlight are presented in Figure 16. Expected sky cover information, in the form of the expected percent of clear, partly cloudy, and cloudy days each month, are also summarized in Figure 16. These daylight and sky cover data have some value in planning outdoor construction and maintenance work and are also useful in analyzing and explaining diurnal changes in observed surface water quality. For example, marked changes in measured stream dissolved oxygen levels are normally correlated with the transition from daytime to nighttime conditions when photosynthetic oxygen production by algae and aquatic plants is replaced by oxygen utilization through respiration by those algae and aquatic plants. As illustrated in Figure 16, the annual variation in daylight ranges from a minimum of 9.0 hours on about December 22, the winter solstice, to a maximum of 15.4 hours on about June 21, the summer solstice.

Mean monthly sky cover for the sunrise to sunset period varies somewhat during the year. The smallest amount of daytime sky cover may be expected to occur during the four-month July through October period when the mean monthly

Figure 14

AVERAGE FROST DEPTH IN SOUTHEASTERN WISCONSIN FOR NOVEMBER THROUGH MARCH BASED ON DATA FOR THE PERIOD 1961-1966

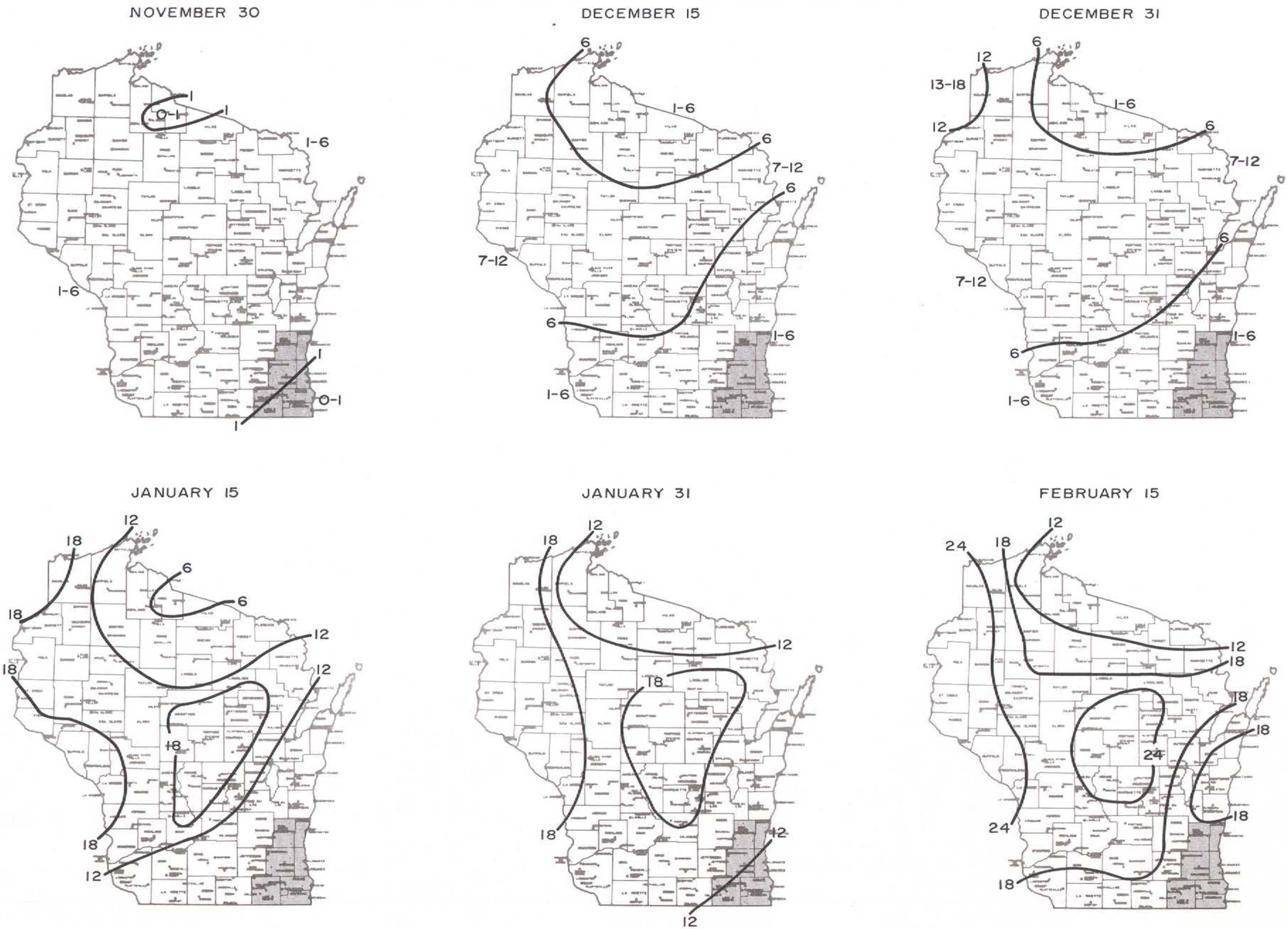
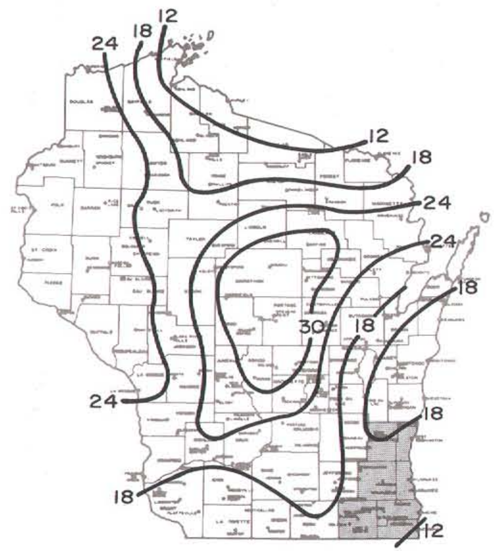
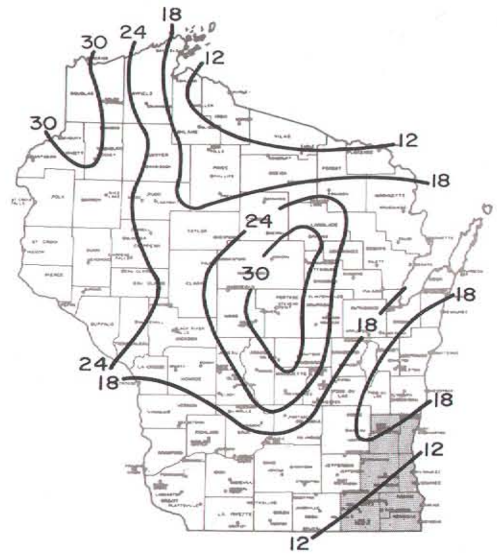


Figure 14 (continued)

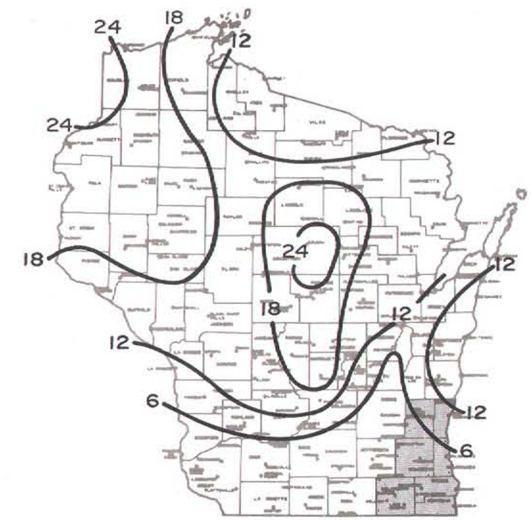
FEBRUARY 28



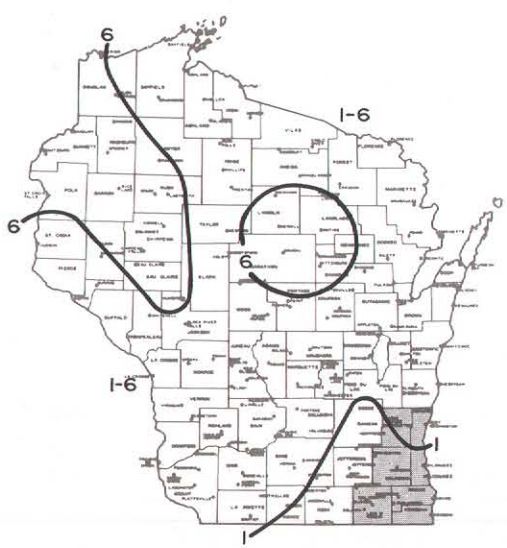
MARCH 15



MARCH 31



APRIL 15

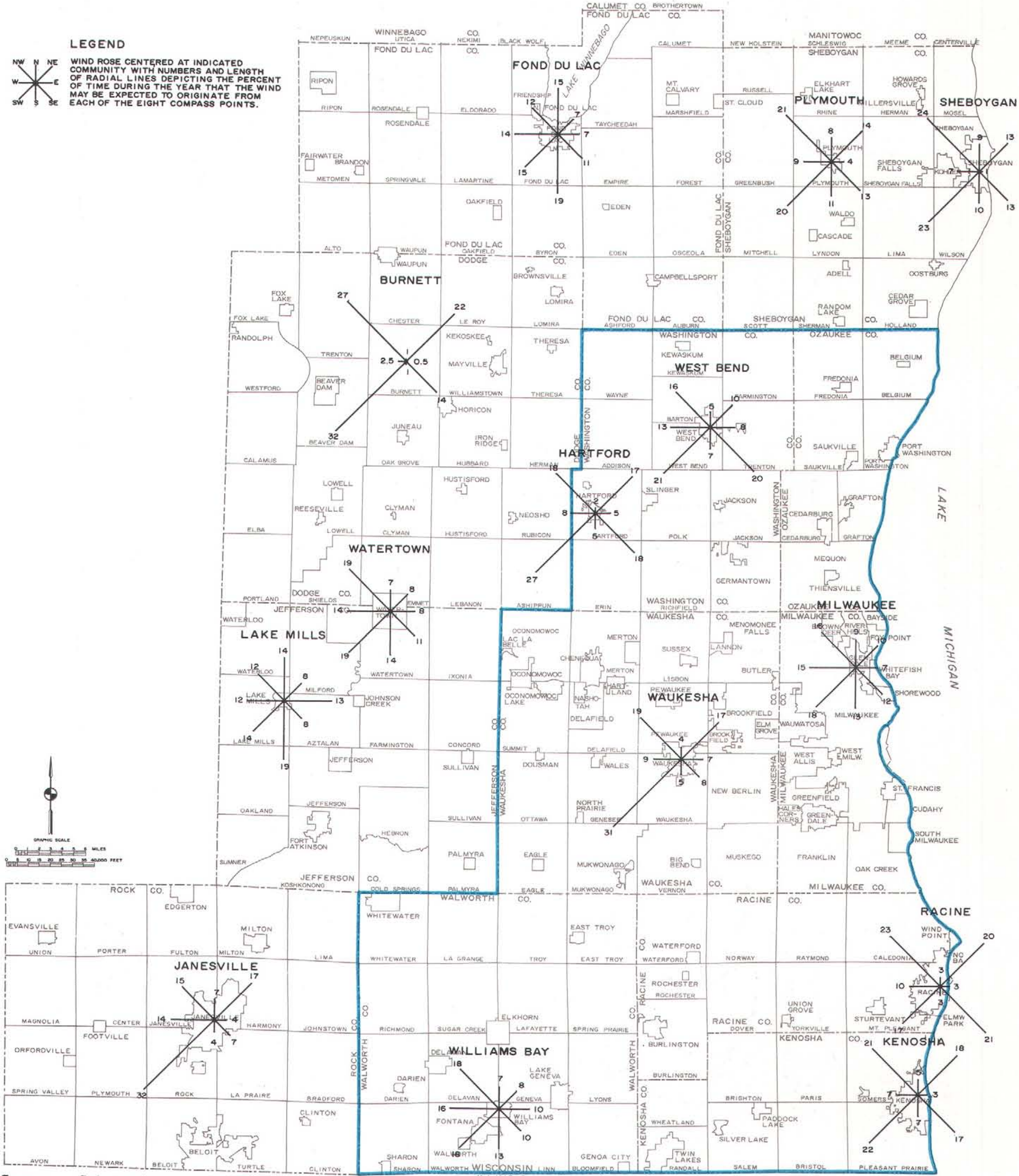


[a] THESE MAPS WERE CONSTRUCTED ON THE BASIS OF FROST DEPTHS FOR CEMETERIES AS REPORTED BY FUNERAL DIRECTORS AND CEMETERY OFFICIALS. SINCE CEMETERIES HAVE SOILS THAT ARE OVERLAIN BY AN INSULATING LAYER OF TURF, THE MAPPED FROST DEPTHS SHOULD BE CONSIDERED AS MINIMUM VALUES.

Source: Wisconsin Statistical Reporting Service, National Weather Service, and SEWRPC.

Figure 15

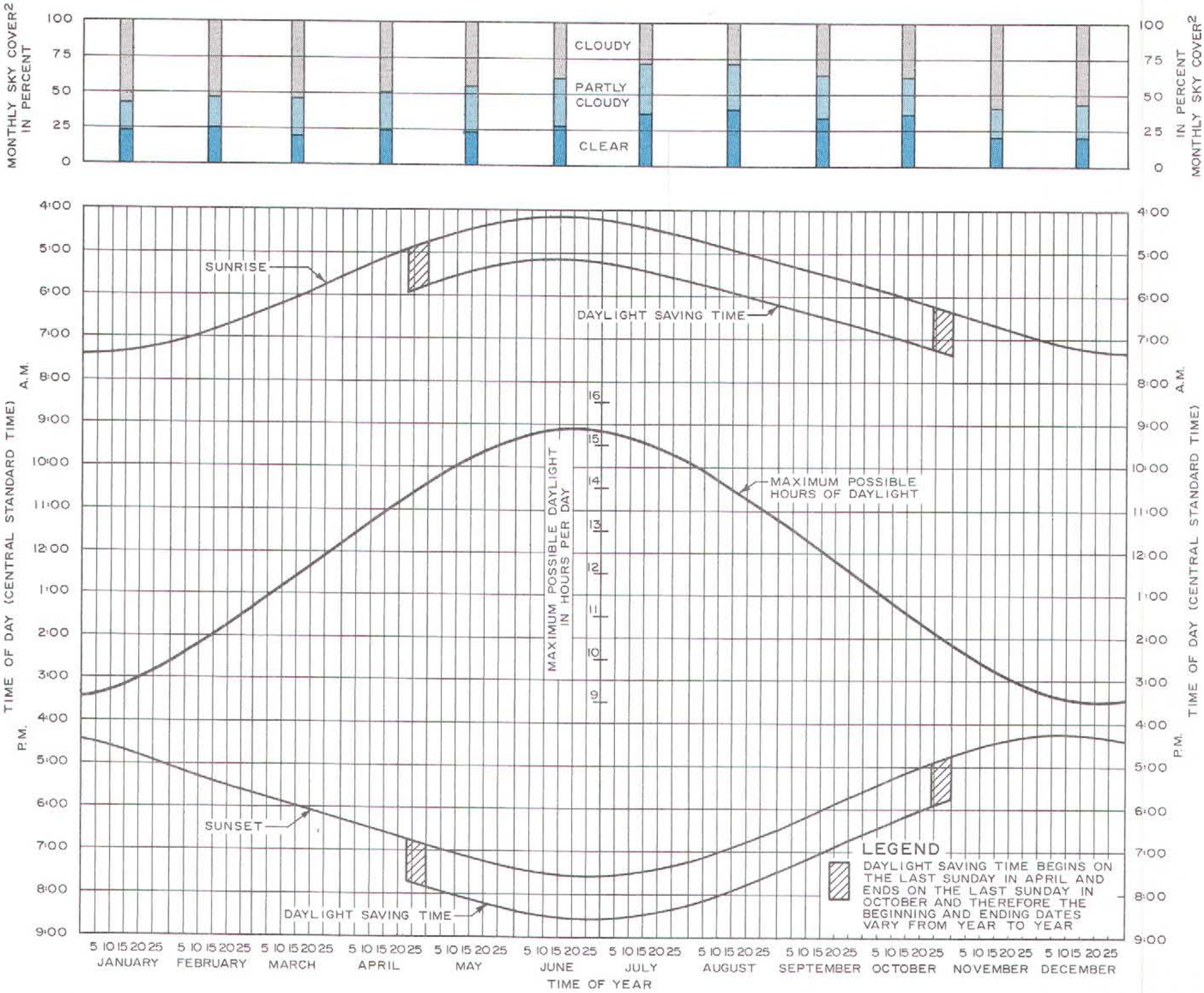
ANNUAL FREQUENCY DISTRIBUTION OF WIND DIRECTION IN SOUTHEASTERN WISCONSIN



Source: Substation monthly record sheets compiled by the Wisconsin State Planning Board in 1944. (Data adjusted to equal 100 percent.)

Figure 16

SUNRISE, SUNSET, AND SKY COVER AT MILWAUKEE



[1] MILWAUKEE SKY COVER DATA ARE SIMILIAR TO THOSE OBSERVED AT MADISON AND AT GREEN BAY WHICH SUGGESTS THAT THERE IS VERY LITTLE VARIATION IN THIS DATA FOR THE LARGE GEOGRAPHIC REGION, RELATIVE TO SOUTHEASTERN WISCONSIN, REPRESENTED BY THESE THREE NATIONAL WEATHER SERVICE STATIONS. THEREFORE, THE MILWAUKEE DAYLIGHT AND SKY COVER DATA MAY BE CONSIDERED APPLICABLE TO THE ENTIRE SEVEN COUNTY REGION.

[2] SKY COVER CONSISTS OF CLOUDS OR OTHER OBSCURRING PHENOMONA AND IS EXPRESSED IN TENTHS. A DAY IS CLASSIFIED AS CLEAR IF THE SKY COVER DURING THE DAYLIGHT PERIOD IS 0-0.3, PARTLY CLOUDY IF THE SKY COVER IS 0.4-0.7, AND CLOUDY IF THE SKY COVER IS 0.8-1.0. MONTHLY SKY COVER INDICATES, BY MONTH, THE PERCENT OF THE DAYS THAT HAVE HISTORICALLY BEEN CLEAR, PARTLY CLOUDY, OR CLOUDY.

Source: *Adapted by SEWRPC from National Weather Service and U. S. Naval Observatory data.*

sky cover is at or slightly above 0.5. Clouds or other obscuring phenomena are most prevalent during the five-month November through March period when the mean monthly daytime sky cover is about 0.7. The tendency for maximum annual sky cover in the winter and minimum annual sky cover in the summer is also illustrated by examining the expected relative number of days classified as clear, partly cloudy, and cloudy for months in each of those seasons. During the summer months, as shown in Figure 16, about one-third of the days may be expected to be categorized as clear, one-third as partly cloudy, and one-third as cloudy. Greater sky cover occurs in the winter, however, when over one-half of the days are classified as cloudy, with the remainder being approximately equally divided between partly cloudy and clear.

Lake Michigan Currents

It is appropriate to describe Lake Michigan current characteristics in the context of climate since, as discussed earlier in this chapter, the lake influences the Region's climate and weather and, as discussed below, one climatic factor—prevailing wind direction—is a primary determinant of current behavior. There is, in effect, an intimate interaction between the Region's climate and the characteristics of Lake Michigan currents near the seven-county Region.

The behavior of Lake Michigan currents near southeastern Wisconsin is of importance to sanitary sewerage system planning because the lake serves multiple, potentially conflicting roles. On the one hand, Lake Michigan is used as a waste depository, or sink, that receives a variety of waste water from many different sources. Municipal sewage treatment plants discharge treated effluent directly to the lake. Overflow from combined sewer systems in the Cities of Milwaukee, Racine, and Kenosha discharge sanitary sewage to the lake either directly via outfalls located on the lake shore or indirectly to streams tributary to Lake Michigan. Streams tributary to Lake Michigan, which include the Milwaukee, Root, Menomonee, Pike, Kinnickinnic, and Sheboygan Rivers and Sauk and Oak Creeks, transport a variety of potential pollutants into the lake. These pollutants originate inland from point sources such as municipal and industrial waste water treatment plant outfalls and nonpoint sources such as storm water and snowmelt runoff from both urban and rural areas. The lake also receives pollutants directly contained in rural and urban runoff from those areas which drain directly to the lake and from waste water discharges of vessels, and has, in the past, served as a depository for harbor dredgings.

In addition to serving as a disposal point for much of the waste water of southeastern Wisconsin, Lake Michigan serves as the principal source of water supply for the Region. Thirty-one percent of the public water utilities serving 68 percent of the resident population of the Region rely on Lake Michigan as their source of water supply. The lake is also a focal point for numerous recreational activities including swimming, boating, and sport fishing, and of course is generally regarded as a valuable aesthetic feature of southeastern Wisconsin. Since Lake Michigan serves potentially conflicting functions—waste water disposal, water supply, and recreational resource—and since the successful coordination of these functions may be influenced by the direction and magnitude of lake currents, it is important that the behavior of those currents be understood and integrated into future water resources planning for the lake shore area within the Region.

Lake current data are available as a result of an extensive study[5] of Lake Michigan conducted by the Federal Water Pollution Control Administration. Information pertinent to southeastern Wisconsin extracted from that study is presented herein for the purpose of characterizing the behavior of lake currents near the Region and to permit an evaluation of some implications of current phenomena to sanitary sewerage system planning.

Physical Setting: The Lake Michigan basin is separated into two glacially formed subbasins by an east-west ridge crossing the lake at a point near the northern boundary of the seven-county Region. Thus most of the 80-mile Lake Michigan shoreline in southeastern Wisconsin lies adjacent to the southern basin. This basin, which has a maximum depth of about 525 feet, is smaller and shallower than the northern basin. The east-west ridge separating the two basins generally lies within about 300 feet of the surface at the midlake, and as such, constitutes a significant barrier to flow patterns. The ridge influences lake currents to the extent that each of the two subbasins exhibits a unique current pattern.

Current Characteristics: Lake Michigan water movements in the southern basin near the Region occur in two rather separate configurations referred to as the nearshore currents and the offshore currents. The offshore currents consist essentially of a rotating mass of water that in terms of the area encompassed, is large relative to the nearshore currents. With regard to the use of Lake Michigan as a waste water depository and as a water supply-recreation resource, however, offshore currents are of little consequence relative to nearshore currents, since the aforementioned uses of Lake Michigan occur almost exclusively in the nearshore area.

---

[5] *"Lake Currents--a Technical Report Containing Background Data for a Water Pollution Control Program-Lake Michigan Basin," Federal Water Pollution Control Administration, Great Lakes Region, Chicago, Illinois, November 1967.*

The width of the nearshore current varies during the year from two to 10 miles, and while this may be a widely fluctuating band, the narrowest limit of the band—two miles—will always encompass that narrow zone paralleling the shore in which most of man's uses are concentrated. For example, municipal sewage treatment plant outfalls at the Cities of Port Washington, South Milwaukee, Racine, and Kenosha; along with those of the North Park Sanitary District and the Sewerage Commission of the City of Milwaukee, are either located on the shore or discharge within one-half mile of the shore. Municipal water treatment plant intakes at the Cities of Port Washington, Milwaukee, Cudahy, South Milwaukee, Oak Creek, Racine, and Kenosha, as well as that of the North Shore Water Utility, are all located within 1.5 miles of the shore. Most recreational uses of Lake Michigan will occur on, or be concentrated near, the shore and thus be within the nearshore current.

The nearshore current, at least the heavily used two-mile-wide portion immediately adjacent to the shore, extends to the lake bottom, or to a depth of at least 50 feet, most of the time. An exception occurs during the spring and early summer as a result of the position of the thermocline which determines the lower limit of the nearshore current and is defined as the undulating surface separating the warm, less dense upper layer, or epilimnion, of the stratified lake from the cold, more dense lower layer, or hypolimnion. The epilimnion is in a formative stage during the spring and early summer during which time it increases in thickness from the water surface downward. By midsummer, which is the critical time of the year in that pollutants are most likely to produce adverse effects because of relatively high water temperatures and because recreational use is at its annual peak, the thermocline descends to about 50 to 65 feet. The thermocline position remains essentially stationary until the late fall or early winter overturn when, as a result of cooling at the water's surface combined with the energy of the wind, the entire depth of the water in the nearshore zone is subjected to mixing. This mixing process may be expected to continue until spring when, once again, epilimnion begins to form.

Thus, the nearshore current will be in excess of 50 feet thick most of the year including the critical midsummer period. The aforementioned municipal sewage treatment plant outfalls all discharge within about 30 feet of the surface, whereas all municipal water supply intakes withdraw water from within approximately 50 feet of the surface.

Regardless of the season of the year, the primary driving force for the nearshore currents is the prevailing wind, with the general direction of these currents being determined by wind direction combined with the tendency of the coastal boundary to orient the flows in a northerly or southerly direction parallel to the shore. If the year is roughly divided into a "summer" period and a "winter" period, lake current observations reveal that the nearshore currents will flow primarily toward the north during the summer whereas they will flow both north and south approximately equal proportions of the time during the winter. On an annual basis, the nearshore current will flow northerly about 65 percent of the time and southerly the remaining 35 percent of the time. Wind driven nearshore currents, regardless of whether the motion is northerly or southerly, may be expected to move at a velocity of about 2.5 to 5.5 miles per day.

Implications for Sewerage System Planning: The following general conclusions may be drawn from the lake current information presented with respect to areawide sewerage system planning:

1. The portion of Lake Michigan of direct concern to the seven-county planning Region is the two- to ten-mile wide zone occupied by the wind-driven nearshore current. Nearshore currents move parallel to the shore and are essentially independent of, that is, do not readily mix with, offshore water movements.

2. Southeastern Wisconsin utilizes Lake Michigan as a waste water depository and as a water supply-recreation resource, with these potentially conflicting uses all being concentrated in the aforementioned nearshore zone. Since the nearshore current zone approximates a closed system, both water supply uses and the recreational activities should be carefully managed and monitored.

3. Inasmuch as the nearshore current near southeastern Wisconsin may be up to 10 miles wide, that is, extends out into the lake for a distance of up to 10 miles, it does not seem economically feasible to attempt to discharge potential pollutants east of

the nearshore current zone by constructing long—10 or more miles—municipal sewage treatment plant outfalls. A less costly and equally effective approach would probably be to continue to locate such outfalls within the nearshore zone—with the precise location determined by supplemental field studies of local currents—and to provide adequate levels of treatment so as to eliminate the introduction of pathogenic organisms into the lake and to minimize the discharge of nutrients, oxygen-demanding materials, solids, and other potentially troublesome substances which would interfere with the use of the lake as a water supply and recreational resource.

4. The nearshore current is not, on an annual basis, unidirectional, since it flows northerly about two-thirds of the time and southerly the remaining one-third. In evaluating the potential adverse effects of waste water discharges, therefore, due consideration should be given to water supply intakes and recreation areas located both north and south of each waste water outfall.

PHYSIOGRAPHY

The Southeastern Wisconsin Planning Region is located in the upper Midwest between Lake Michigan on the east, the Green Bay-Lake Winnebago lowlands on the north, the Rock River basin on the west, and the low dunes and swampland at the headwaters of the Illinois River on the south. The seven-county Region within the jurisdiction of the Southeastern Wisconsin Regional Planning Commission extends for approximately 52 miles from east to west at its widest extent, and approximately 72 miles from north to south. The Region encompasses approximately 2,621 square miles of land area and 68 square miles of inland water area exclusive of Lake Michigan, or a total gross land and water area of approximately 2,689 square miles or 1,720,000 acres. Topographic elevations range from approximately 580 feet above mean sea level at the Lake Michigan shore to about 1,320 feet above mean sea level at Holy Hill in southwestern Washington County. The Region lies astride a major subcontinental divide between the upper Mississippi River and the Great Lakes-St. Lawrence River drainage basins.

Physiographic and Topographic Features

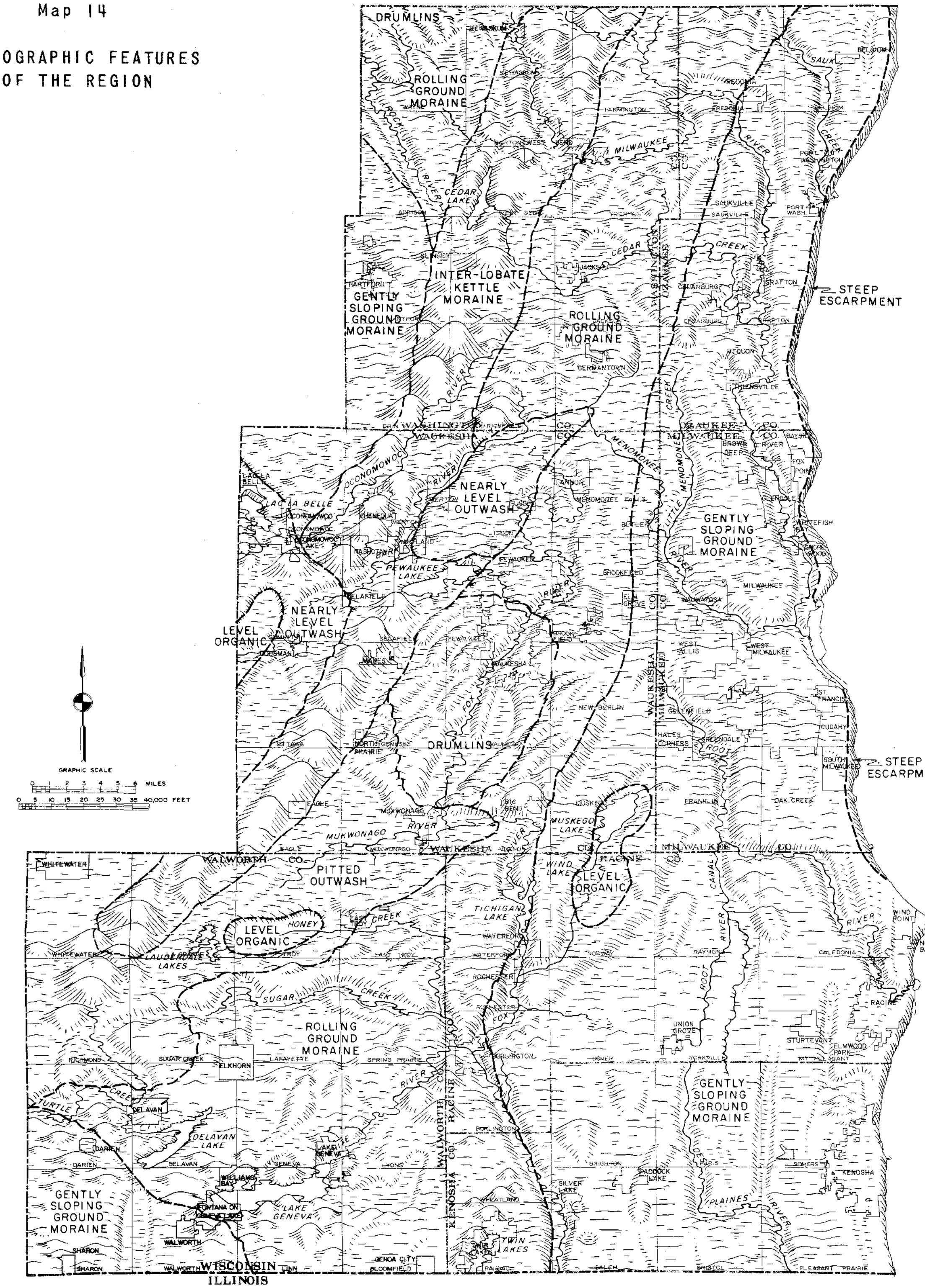
Glaciation has largely determined the physiography and topography as well as the soils of this part of the state. The physiographic features or surficial land forms of southeastern Wisconsin are shown on Map 14 whereas regional topography or variation in elevation is generalized on Map 15. There is evidence of four major stages of glaciation in the Region, the last and most influential in terms of present physiography and topography was the Wisconsin stage which is believed to have ended about 11,000 years ago.

The dominant physiographic and topographic feature is the Kettle Moraine, an interlobate glacial deposit, or moraine, formed between the Green Bay and Lake Michigan tongues, or lobes, of the continental glacier which moved in a generally southerly direction from its point of origin in what is now Canada. Topographically high points in the Kettle Moraine include areas around Lake Geneva in Walworth County, areas in southwestern Waukesha County north of Eagle, areas in central Waukesha County around Lapham Peak, and areas around Holy Hill and Hartford in southwestern and western Washington County. The Kettle Moraine, which is oriented in a general northeast-southwest direction across western Washington, Waukesha, and Walworth Counties, is a complex system of kames, or crudely stratified conical hills; kettle holes marking the site of glacial ice blocks that became separated from the ice mass and melted to form depressions; and eskers, consisting of long, narrow ridges of drift deposited in abandoned drainageways. It forms some of the most attractive and interesting landscapes within the Region as well as being the area of the highest elevation and the area of greatest local elevation difference, or relief, within southeastern Wisconsin. The Kettle Moraine of Wisconsin, much of which lies within the Region, is considered as one of the finest examples of a glacial interlobate moraine in the world. Because of its still predominantly rural character and its exceptional natural beauty, the Kettle Moraine and surrounding area is and may be expected to continue to be subjected to increasing pressure for urban development.

The remainder of the Region is covered by a variety of glacial land forms and features including kames, ground moraine or heterogeneous material deposited beneath the ice, recessional moraines consisting of material deposited at the forward margins of the ice sheet, lacustrine

Map 14

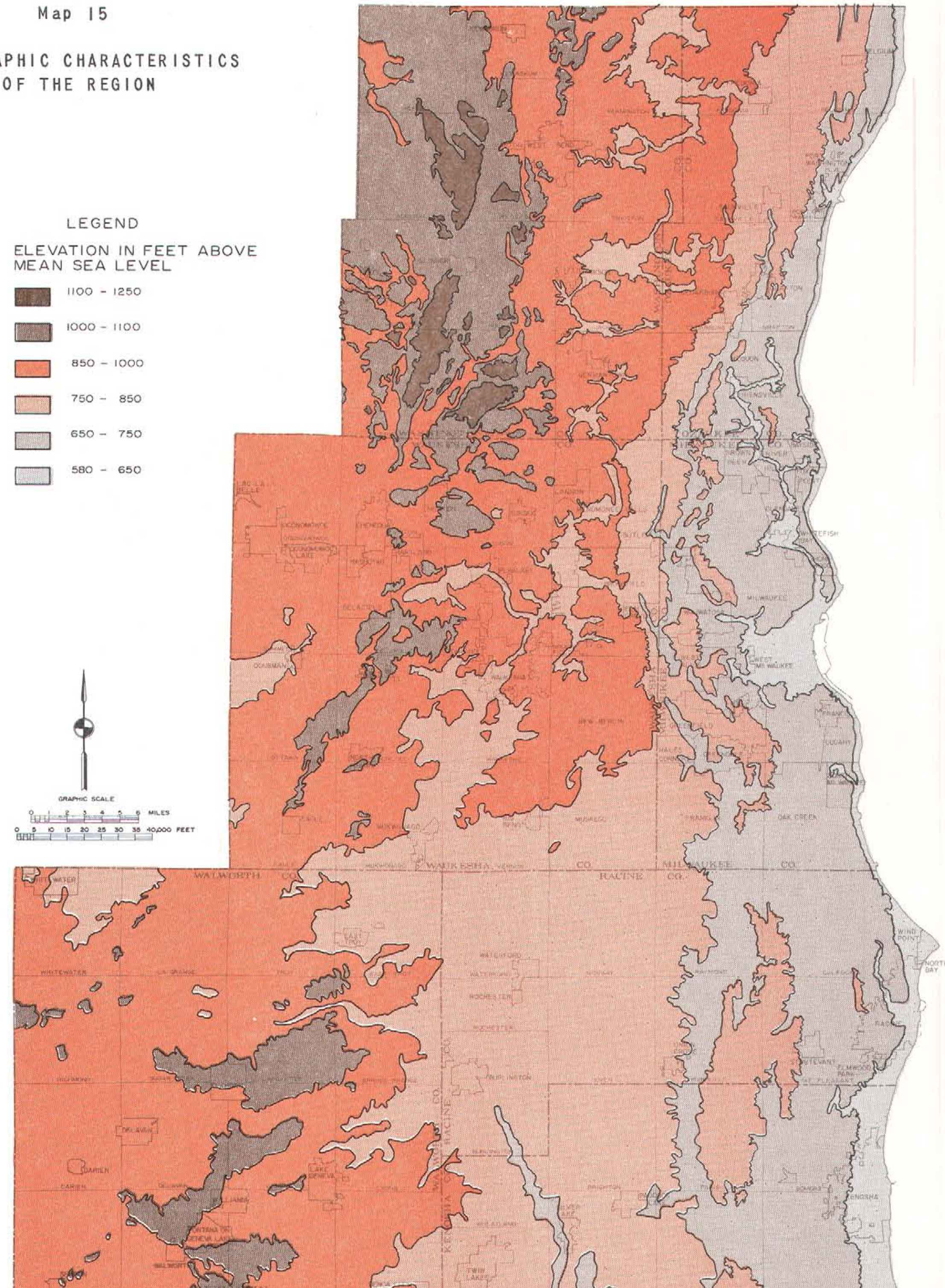
PHYSIOGRAPHIC FEATURES
OF THE REGION



Physiographic features, or surficial land forms, throughout southeastern Wisconsin were determined largely by repeated stages of glaciation, the last of which, the Wisconsin stage, is believed to have ended about 10,000 years ago. Included in the great variety of interesting and attractive glacial land forms covering the Region are *ground* and *recessional* moraines, abandoned lake basins, outwash plains, kames, eskers, and drumlins. The dominant feature is the Kettle Moraine, an interlobate moraine lying in a northeasterly-southwesterly direction within the western part of the Region and formed by and between the Green Bay and Lake Michigan lobes of the continental glacier.
Source: SEWRPC.

Map 15

TOPOGRAPHIC CHARACTERISTICS OF THE REGION



The topography, or relative elevation of the land surface throughout the Region, is determined by the configuration of the bedrock geology in combination with overlying glacial deposits. Elevations within southeastern Wisconsin range from a low of about 580 feet MSL on the Lake Michigan shore to a high of 1,320 feet MSL at Holy Hill in southwestern Washington County. Topographic highs and some of the most attractive landscapes and scenic vistas in the Region are coincident with the interlobate Kettle Moraine area in the western portion of the Region.

Source: SEWRPC.

basins or former lake sites, outwash plains formed by the action of flowing glacial meltwater, eskers, or elongated meandering ridges of rudely stratified water-lain sand and gravel deposits, and drumlins, or elongated mounds of drift molded by and parallel to the advancing glacier.

Glacial land forms are of economic significance because some are prime sources for sand and gravel for highway and other construction purposes. Many of the larger topographic depressions of the Region, including the kettle holes, have developed into the numerous lakes which dot large areas of western Washington, Waukesha, and Walworth Counties and which are becoming increasingly popular both as recreational areas and as residential centers.

Topography is important to sanitary sewerage system planning since it influences the route, size, and slope of trunk sewers, as well as the need for, location and capacity of pumping and lift stations. As a result of the Commission's continuing mapping program, large-scale mapping (1" = 100' and 1" = 200' scale, 2-foot and 4-foot contour interval) prepared to National Map Accuracy Standards is available for 502 square miles, or 21 percent of the total area of the Region.[6] This topographic mapping, together with 1" = 400' scale aerial photographs available for the entire Region, will be most valuable for detailed sewerage system design during implementation of the regional sanitary sewerage system plan.

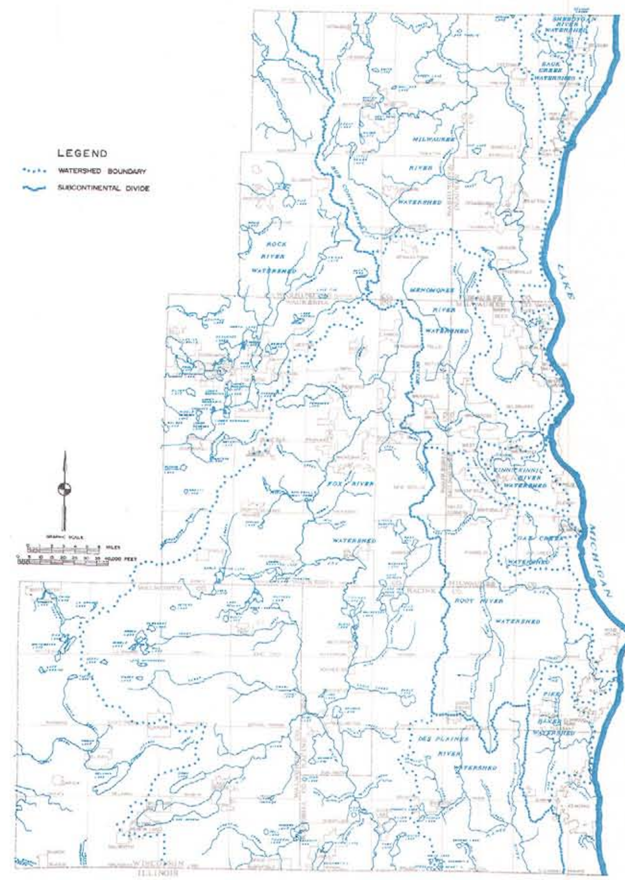
Surface Drainage

Surface drainage is poorly developed but highly diverse within the planning Region due to the effects of the relatively recent glaciation. The land surface, as a result of being covered by glacial drift, is complex, containing thousands of closed depressions that range in size from mere pits to large areas. Significant areas of the Region are covered by wetlands, and many streams are mere threads of water through these wetlands. The eleven major watersheds of southeastern Wisconsin are depicted on Map 16 along with the surface drainage pattern of the major perennial stream system.

A major subcontinental divide, oriented in a generally northwesterly-southeasterly direction, approximately bisects the Region so that about 1,685 square miles, or 63 percent of the Region lying west of the divide, drains to the Mississippi River, while the remaining 1,004 square miles, or 37 percent, is tributary to the Great Lakes-St. Lawrence River drainage basin. The subconti-

Map 16

WATERSHEDS AND SURFACE WATER RESOURCES OF THE REGION



A subcontinental divide traverses the Southeastern Wisconsin Region. That part of the Region lying east of this divide is tributary to the Great Lakes-St. Lawrence River drainage system, while that part of the Region lying west of this divide is tributary to the Mississippi River drainage system. This subcontinental divide has certain important implications for water resources planning and management, since major diversions of water across this divide are restricted by law and interstate and international compacts. The generally dendritic surface water drainage pattern of the Region, which is the result of the glacial land forms and features, divides the Region into 11 individual watersheds, three of which--the Des Plaines, Fox, and Rock River watersheds--lie west of the subcontinental divide. In addition to the 11 watersheds, there are numerous small catchment areas along the Lake Michigan shoreline that drain directly to the lake, which areas together may be considered to comprise a twelfth watershed.

Source: SEWRPC.

---

[6] *Data as of January 1, 1973. Refer to the most recent SEWRPC Annual Report for an index map showing topographic mapping and control survey coverage in the Southeastern Wisconsin Region.*

nental divide not only exerts a major physical influence on the gross drainage pattern of the Region, but also carries with it certain legal constraints on the diversion of water across the divide, and thereby constitutes an important consideration in sewerage system planning.

The surface water drainage pattern of southeastern Wisconsin may be further subdivided so as to identify 11 major watersheds, five of which, the Root River, Menomonee River, Kinnickinnic River, Oak Creek, and Pike River watersheds, are wholly contained within the Region. In addition to these 11 major watersheds, there are numerous small catchment areas contiguous to Lake Michigan that drain directly to the lake by local natural watercourses and artificial drainageways, and these areas together may be considered as comprising a twelfth watershed.[7] The drainage in the Region tends to exhibit a disordered dendritic pattern except for a small area of trellised or rectangular drainage evident in the Des Plaines River watershed and in the Racine County portion of the Root River watershed. The Fox River watershed and the headwaters of the Rock River and Des Plaines River watersheds drain to the south and southwest towards their confluences with the Illinois River, a tributary of the Mississippi River. The remainder of the Region drains in a generally easterly direction towards Lake Michigan by way of the Milwaukee, Menomonee, Root, and other drainages.

The surface drainage pattern and the location of watershed boundaries are pertinent to preparation of the regional sanitary sewerage system plan, since emphasis on in-watershed solutions is one of the five basic principles governing sewerage system planning formulated under the regional sanitary sewerage system planning program. Furthermore, sanitary sewerage systems within that portion of southeastern Wisconsin tributary to Lake Michigan are subject to certain water pollution abatement recommendations made by the Federal Lake Michigan Enforcement Conference. This conference, originally convened by the Secretary of the U. S. Department of the Interior at Chicago, Illinois, in 1968, formulated and jointly agreed to 26 recommendations dealing with water pollution control efforts in the Lake Michigan basin. Of particular significance to the regional sanitary sewerage system planning program are recommendations that waste treatment be provided by all municipalities in the basin to achieve at least 80 percent reduction of total phosphorus,[8] that continuous disinfection be provided throughout the year for all municipal waste treatment plant effluent, that industries not connected to municipal sewerage systems provide sewage treatment so as to meet the water quality standards for Lake Michigan, that unified sewage collection systems serving contiguous areas be encouraged, and that pollution from combined sewer areas be controlled either through separation or through other techniques by July 1977.

GEOLOGY

Bedrock

The bedrock formations underlying the unconsolidated surficial deposits of southeastern Wisconsin consist of Cambrian through Devonian Period rocks of the Paleozoic Era that attain a thickness in excess of 1,500 feet along the eastern limits of the Region, which are in turn underlain by older, predominantly crystalline rocks of the Precambrian Era. The bedrock geology of the Region is depicted on Figure 17 by means of a map of the surface of the bedrock supplemented with a representative vertical section.

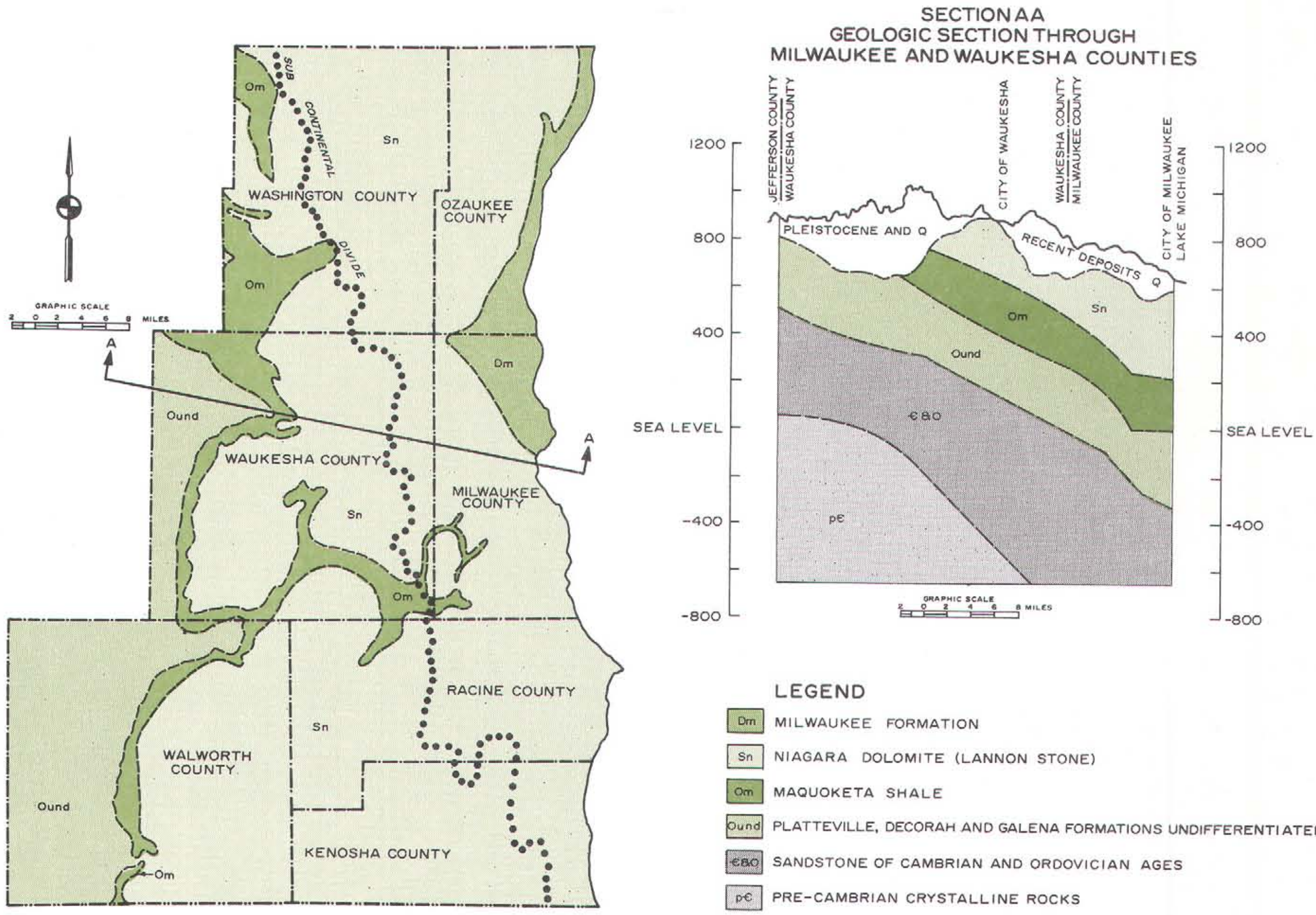
A stratigraphic column including a description of the lithologic characteristics of bedrock formations beginning with those dating back to the Ordovician Period and of glacial deposits is presented in Table 16. Bedrock formations in the Region dip gently down toward the east at an average slope of about 20 feet per mile with the result that the bedrock lying immediately beneath the unconsolidated surficial deposits in the western extremities of the Region are older rocks of the Ordovician Period whereas, in the east along Lake Michigan, younger

[7] *The Commission has completed comprehensive watershed studies for the 197 square mile Root River watershed; the 939 square mile Fox River watershed; and the 694 square mile Milwaukee River watershed, 430 square miles of which lies in the Region. Comprehensive watershed studies have, therefore, been completed for 1,566 square miles, or 58 percent, of the 2,689 square mile seven-county Region. The Commission is currently (1973) conducting a comprehensive planning program for the 136 square mile Menomonee River watershed which, upon completion, will increase the portion of the Region included in watershed studies to 1,702 square miles, or 63 percent, of the total area of the Region.*

[8] *See Chapter VII of this report for a discussion of the implementation of the phosphorus removal requirement in Wisconsin.*

Figure 17

MAP AND CROSS SECTION OF BEDROCK GEOLOGY IN THE REGION



Source: *SEWRPC,*

Table 16

STRATIGRAPHIC COLUMN OF BEDROCK AND GLACIAL DEPOSITS IN THE REGION

System	Series	Formation	Lithologic Description
Quaternary		Recent Deposits	Soils, muck, peat, alluvium, beach sand and gravel. 0 to 5 feet thick.
		Pleistocene Deposits	Till and outwash sand and gravel. 0 to 430 feet thick.
		Kenwood	Shale, black, carbonaceous. Fossiliferous. No outcrops. Found in City of Milwaukee intake tunnel – Lake Michigan. Approximately 55 feet thick.
Devonian		Milwaukee	Shale, shaly limestone; lower 1/3 dolomite. Fossiliferous. Approximately 130 feet thick.
	Middle Erian	Thiensville	Dolomite, thick to thin-bedded. Some fossils. Small amounts of bitumen. Approximately 65 feet thick.
		Lake Church	Dolomite, thick to thin-bedded. Fossiliferous. Pyritic in places. Approximately 27 feet thick.
Silurian	Cayugan	Waubakee	Dolomite, thin-bedded, hard and brittle. Fossils scarce. Approximately 30 feet thick.
	Niagaran	Racine	Dolomite, fine to coarsely crystalline. Thick to thin-bedded. Barren to fossiliferous. Approximately 100 feet thick.
		Manistique	Dolomite - lower part thin-bedded. Fossils. Upper - fairly thin-bedded, cherty. Many corals. Approximately 150 feet thick.
		Burnt Bluff	Dolomite, thick bedded or thin-bedded. Lower part, a few fossils. Upper part, semilithographic. No fossils. Approximately 110 feet thick.
	Alexandrian	Mayville	Dolomite, thick bedded, compact to coarsely crystalline. Brecciated in places, cherty, many reef structures. Approximately 175 feet thick.
Ordovician	Cincinnatian	Neda	Red-brown oolitic iron ore and nonoolitic ore. Missing in Racine, Milwaukee, Ozaukee, Door and Dodge counties. In lenses up to approximately 55 feet thick.
		Maquoketa	Shale, dolomitic and beds of dolomite. Fossiliferous. 90 to 225 feet thick.
	Champlainian	Galena	Dolomite, thick to thin-bedded, fine to coarsely crystalline. Cherty. Shaly and sandy in places; some fossils. Approximately 227 feet thick.

Source: SEWRPC.

rocks of the Silurian and Devonian Periods lie immediately beneath the surficial deposits.

Surficial Deposits

The bedrock of the Region is, for the most part, covered by deep, unconsolidated glacial deposits, attaining a thickness in excess of 500 feet in some buried, preglacial valleys. Bedrock lies within 20 feet of the ground surface within areas of the Region which together total only about 150 square miles in extent, and a few localized areas exist where the bedrock is actually exposed at the surface. These shallow drift areas and rock outdrops tend to occur in Washington and Waukesha Counties along a northeasterly-southwesterly alignment generally paralleling the interlobate Kettle Moraine and reflect the presence of a preglacial ridge.

Map 17 depicts the spatial variation of the thickness of surficial deposits overlying the bedrock that may be generally expected within the Region. The outcrop areas, as well as those portions of the Region having less than twenty feet of unconsolidated surface material, are an important consideration in the design and construction of onsite sewage disposal systems, sanitary sewerage systems, and various public works projects that are dependent on soil characteristics or involve extensive tunneling, trenching, and excavation. Outcrops and shallow drift areas also serve to identify those portions of the planning Region that are especially susceptible to pollution of the groundwater as a result of malfunctioning septic systems or exfiltration from sanitary sewers.

The characteristics of surficial deposits and the nature of the bedrock constitute the two geologic factors that establish, in combination with certain hydrologic, surface, and cultural considerations, the potential for land disposal of liquid wastes in a particular rural area. Surficial deposits provide favorable conditions for land disposal of liquid wastes if those deposits have moderate rates of permeability in their upper layers coupled with good filtration characteristics so as to prevent bacterial or chemical contamination of the underlying aquifers. Underlying bedrock should be dense and free of extensive fractures so as to inhibit rapid downward and lateral movement of waste water and possible aquifer pollution.

Map 18 shows the Region's variable suitability for liquid waste disposal based primarily on the aforementioned geologic conditions.[9] It should be emphasized that the map is based primarily on geologic factors and does not reflect a detailed evaluation of important hydrologic factors, such as local and regional groundwater flow systems; surface conditions, such as topography and cover crop; and cultural considerations such as distance from roads, wells, and surface water and soil compaction and soil breakdown attributable to man's activities. Map 18 is thus explicitly intended to constitute a preliminary guide to be used in the analysis of the potential for land disposal of liquid wastes on an areawide basis in connection with the regional sanitary sewerage system planning effort.

Bedrock conditions and the nature of surficial deposits in the seven-county planning Region, as shown on Map 18, are such that, at most, only a relatively small portion of the Region, consisting of the western half of Ozaukee County and scattered areas comprising about one-half of Washington County, is well suited for the land disposal of liquid wastes on a scale sufficient to meet municipal needs. Other areas in the Region suitable for land disposal of liquid waste consists of the undeveloped areas of Milwaukee County and the eastern two-thirds of Racine and Kenosha Counties. The latter areas are not covered by surficial deposits which have the most favorable characteristics for liquid waste disposal, but, nevertheless, have some potential for such disposal because very few groundwater supplies are taken from aquifers within 150 feet of the ground surface, thereby minimizing the groundwater pollution potential.

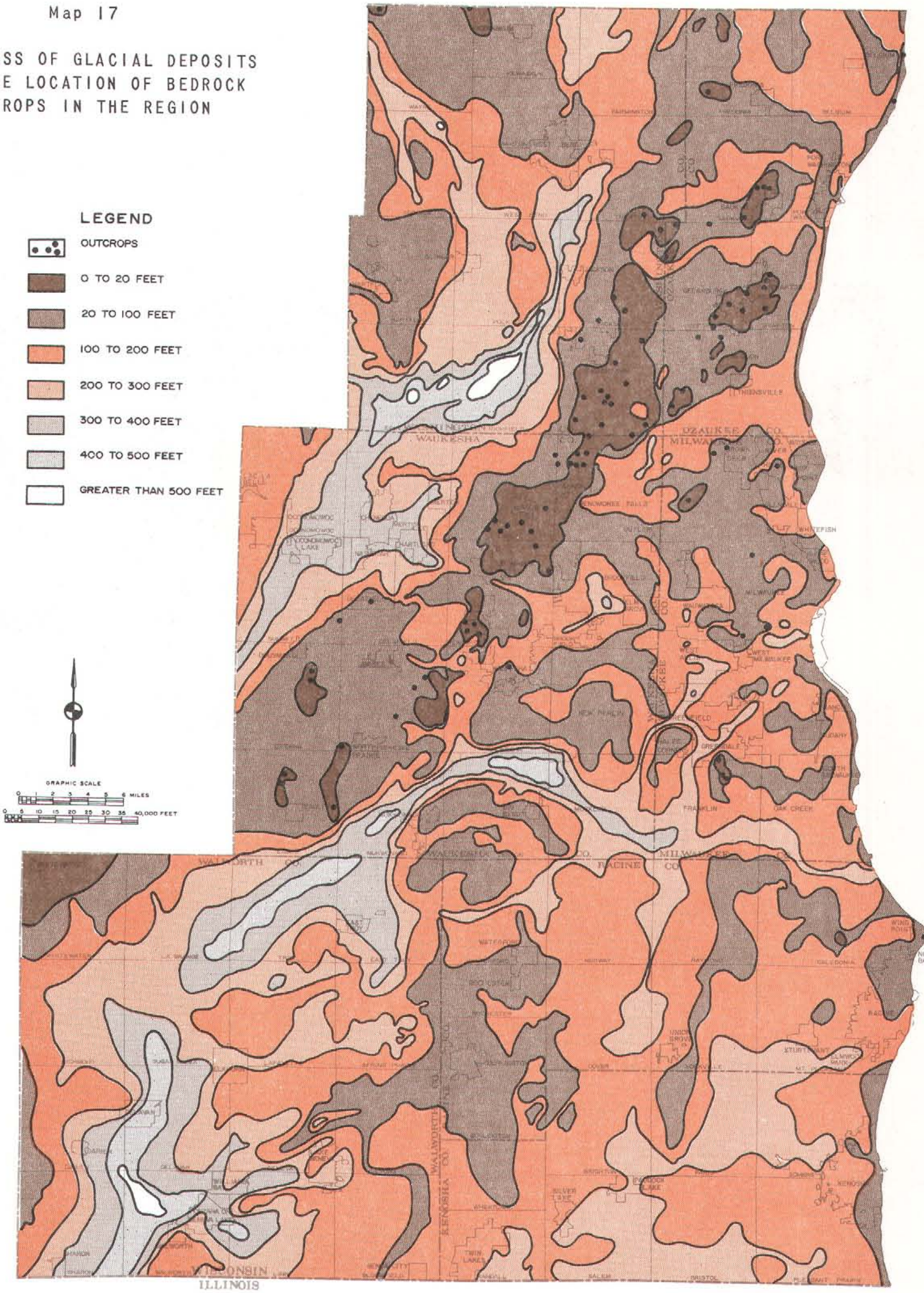
In summary, then, based primarily on the two critical geologic factors—the nature of surficial deposits and the characteristics of bedrock—only a relatively small portion of the Southeastern Wisconsin Region is well suited for land disposal of liquid wastes. It is likely that these areas with good potential for liquid waste disposal would be reduced even further in size upon more detailed investigation involving consideration of hydrologic conditions, surface conditions, and cultural considerations, particularly existing land use.

---

[9] *For a detailed discussion of the development of Map 18 and the limitations of that map, and for a complete discussion of criteria recommended for use in determining suitability for liquid waste disposal see: Ketelle, Martha J., "Hydrogeologic Considerations in Liquid Waste Disposal, With a Case Study in Southeastern Wisconsin," SEWRPC Technical Record, Vol. 3, No. 3, September 1971.*

Map 17

THICKNESS OF GLACIAL DEPOSITS AND THE LOCATION OF BEDROCK OUTCROPS IN THE REGION

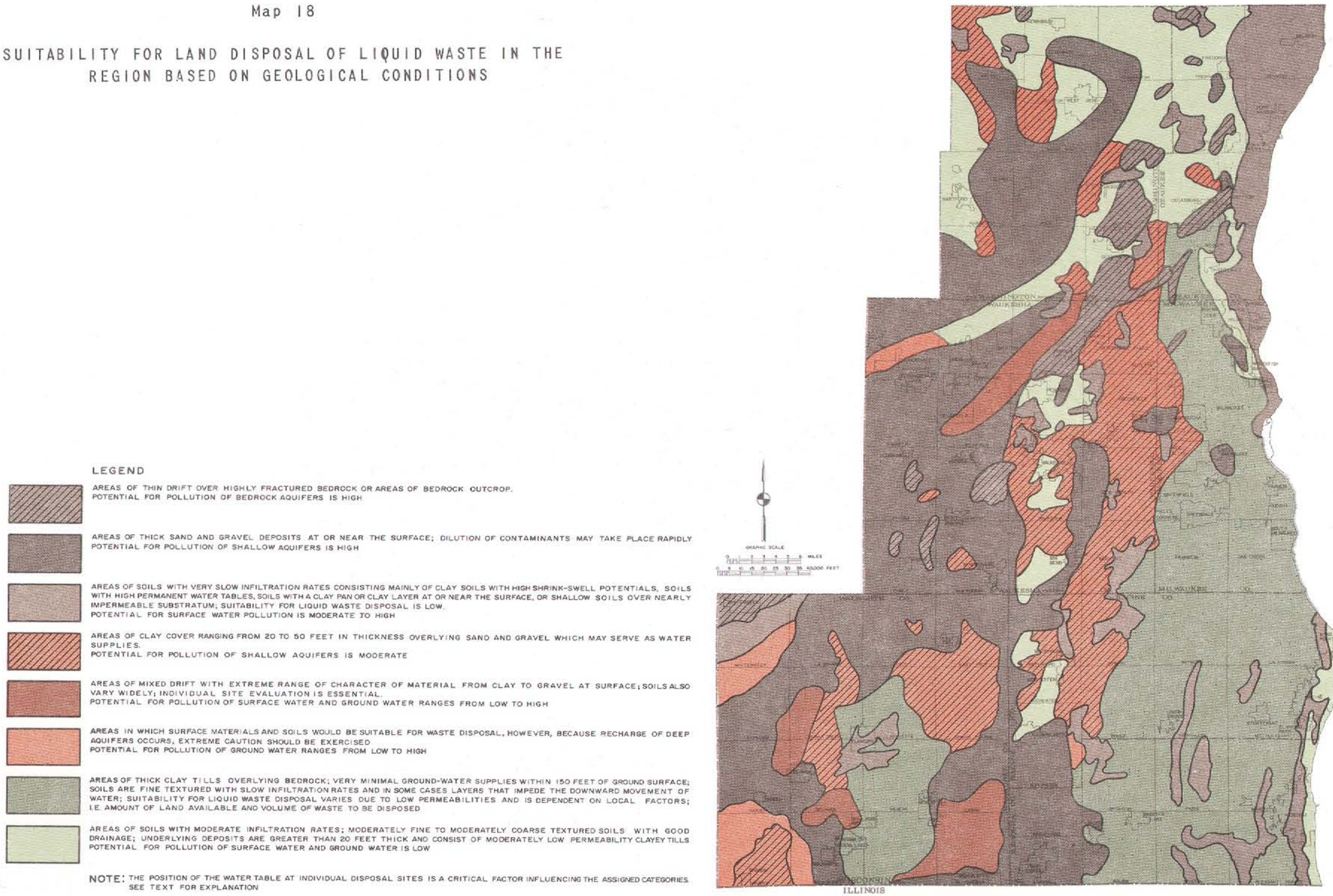


Most of the Region is covered by unconsolidated glacial drift deposited by continental glaciers. This drift attains a thickness in excess of 500 feet in some preglacial valleys. Dolomitic bedrock lies within 20 feet of the surface or is actually exposed as outcrops in areas totaling about 150 square miles. The northeasterly-southwesterly alignment of the rock outcrop sites indicates the presence of a buried preglacial bedrock ridge which is an important consideration in planning for and construction of septic tank systems, public sewerage systems, and other public works projects that involve extensive trenching and excavation.

Source: T. O. Friz, Man and the Materials of Construction, How They Interrelate in the Seven Counties of Southeastern Wisconsin, Ph.D. Dissertation, University of Wisconsin, Madison, Wisconsin, 1969.

Map 18

SUITABILITY FOR LAND DISPOSAL OF LIQUID WASTE IN THE REGION BASED ON GEOLOGICAL CONDITIONS



Bedrock conditions and the nature of surficial deposits in the Southeastern Wisconsin Planning Region are such that only a relatively small portion of the Region, consisting of the western half of Ozaukee County and scattered areas comprising approximately one-half of Washington County, is well suited for the land disposal of liquid waste. The extent of these well-suited areas would probably be reduced, moreover, upon more detailed consideration of hydrologic conditions, surface conditions, and cultural factors.

Source: Martha J. Ketelle, "Hydrogeologic Considerations in Liquid Waste Disposal, With A Case Study in Southeastern Wisconsin," SEWRPC Technical Record, Vol. 3, No. 3, September 1971.

MINERAL AND ORGANIC RESOURCES

Sand and gravel, dolomite building stone, and organic material are the three principal mineral and organic resources in the Region that have significant commercial value as a result of their quantity, quality, and location. The commercial utilization of the Region's mineral resources, which is limited to the mining of nonmetal deposits, is primarily directed toward supplying the construction materials needed for the continuing development of southeastern Wisconsin.

Sand and Gravel

The Region as a whole has an abundant supply of sand and gravel deposits as a result of its glacial history, with the highest quality deposits being found in glacial outwash areas, particularly near the interlobate Kettle Moraine, where the washing action of flowing meltwaters has sorted the unconsolidated material so as to form more or less homogeneous and therefore commercially attractive deposits.

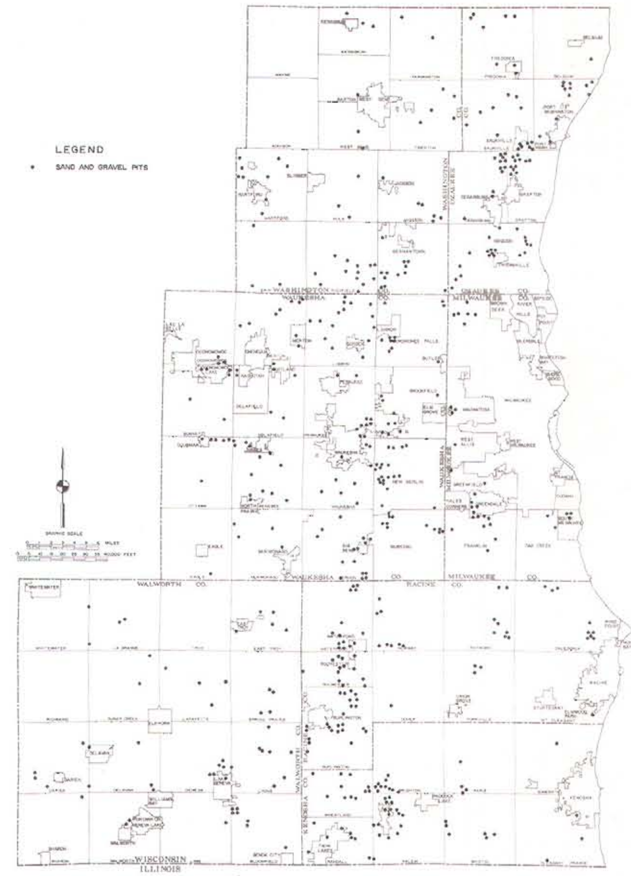
Deposits of sand and gravel are, as shown on Map 19, scattered throughout the Region. The greatest concentration of commercial strip mining activity, however, occurs in Waukesha County because sand and gravel in that area has the most favorable quantity and quality characteristics. Sand and gravel deposits are important sources of concrete aggregate, gravel for road subgrade and surfacing, sand for mortar, and molding sand. Depending on the nature of the deposits, particularly their depth and areal extent, and grain size of the particles, and the depth to the water table, sand and gravel deposits may seriously hamper tunneling, trenching, and excavation work, and therefore detailed field investigations should be conducted in areas of known or expected deposits prior to initiation of sanitary sewerage system construction.

Stone Quarries

Niagara dolomite, which lies immediately below the glacial deposits throughout most of the Region (see Figure 17), has commercial value where it is found relatively close to the ground surface, both as a dimensional building stone and, when crushed, as an aggregate for construction or as a fertilizer for agricultural purposes. The dolomite is mined in open quarries, and all the Regional commerical operations that produce stone for building purposes are located in Waukesha County, where they are concentrated in

Map 19

SAND AND GRAVEL PITS IN THE REGION



An abundant supply of sand and gravel deposits are scattered throughout southeastern Wisconsin, with the highest quality sources being found in glacial outwash areas where flowing melt waters tended to sort the sand and gravel so as to form more or less homogeneous, and therefore commercially attractive, deposits. Sand and gravel deposits, which are commercially mined by strip mining techniques, constitute a very important raw material for construction and certain industrial activities in the Region in that they provide concrete aggregate, gravel for road subgrades and surfacing, sand for mortar, and molding sand.

Source: Wisconsin Geological and Natural History Survey and SEWRPC.

rock outcrop areas (see Map 17) in the northeastern portion of the county. Waukesha County quarries yield thinly bedded, compact, and fine-grained dolomite well suited for the mining and production of dimensional building stone. Although it is in fact dolomite—that is, primarily calcium magnesium carbonate—the high quality dimensional building stone commercially mined and produced in Waukesha County is commonly known or referred to as limestone—that is, primarily calcium carbonate—or lannon stone. Crushed limestone is produced not only in Waukesha County but also at other quarries located throughout the Region. The presence of quarrying operations in an area indicates relatively thin glacial deposits and close proximity of bedrock to the ground surface and is, therefore, an important consideration in the planning and conduct of construction projects such as sanitary sewerage systems, that entail extensive tunneling, trenching, and excavation.

Organic Deposits

Organic deposits are widely distributed throughout southeastern Wisconsin in small, scattered, low-lying, poorly drained areas. At these locations, excessive moisture inhibits oxidation and decay of the residues of water-tolerant plants producing organic peat deposits and muck soils with significant resulting fertilization potential. These organic deposits overlay the glacial drift of the Region and exhibit variable depths ranging from less than a foot to many feet.

Organic deposits have environmental value, often covering areas suitable for certain kinds of wildlife habitat and recreation areas, and have commercial value in their ability to support field crops such as corn or soybeans, specialized crops such as vegetables, and sod farming and peat mining, the last of which is excavated from open pits and marketed as an additive to improve soils for potted plants, gardens, and greenhouse nurseries. Agricultural use of organic deposits is contingent upon sufficient depth so that artificial drainage can be developed and maintained.

Organic deposits generally serve to identify those areas of southeastern Wisconsin that are least suited for extensive urbanization and attendant major construction activity. The presence of organic deposits may constitute a serious problem for the development of onsite sewage disposal systems, primarily because of the inherent moisture problem and resultant poor drainage characteristics, and may also prevent or complicate the construction of sanitary sewerage systems because of the difficulty of operating heaving equipment on, and of working with, organic deposits; because of the poor foundation characteristics of such deposits; and because of the potential infiltration problems through sewer pipe joints, attributable to the high moisture content of such deposits.

SOILS

The nature of soils within southeastern Wisconsin has been determined primarily by the interaction of the parent glacial deposits covering the Region, and by topography, climate, plants, animals, and time. Within each soil profile the effects of these soil-forming factors are reflected in the transformation of soil material in place, chemical removal of soil components by leaching or physical removal by wind or water erosion, additions by chemical precipitation or by physical deposition, and transfer of some soil components from one part of the soil profile to another.

Soil Diversity and the Regional Soil Survey

Soil forming factors, particularly topography and the nature of the parent glacial materials, exhibit wide spatial variations in southeastern Wisconsin; and therefore hundreds of different soil types have developed within the Region. In order to assess the significance of these unusually diverse soil types to sound regional development, the Commission in 1963 negotiated a cooperative agreement with the U. S. Soil Conservation Service under which detailed operational soil surveys were completed for the entire planning Region. The results of the soil surveys have been published in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin. The regional soil survey has not only resulted in the mapping of the soils within the Region in great detail, and provided data on the physical, chemical, and biological properties of the soils, but has also provided interpretations of the soil properties for planning, engineering, agricultural, and resource conservation purposes.

Soil Characteristics and Properties

Soil characteristics, resulting from the interaction of soil-forming factors and processes, are important to the prediction of soil properties, the making of soil interpretations, and the classification of soils. The principal soil characteristics used in the regional soil survey to describe and interpret soils are soil texture, structure, color, consistence, reaction, slope, and position.

Soil texture is an expression of the proportion of sand, silt, and clay-sized particles in the soil mass. Soil texture is one of the more important soil characteristics because of the number of properties and interpretations that are affected by it, including soil permeability or the relative ease with which water passes through the soil, which is a critical factor in the proper operation of onsite sewage disposal systems; available moisture capacity and fertility holding capacity, soil erodibility, and bearing capacity.

The shape and stability of soil particles in the soil mass is a characteristic expressed as soil structure. This soil characteristic influences, to some degree, the aforementioned soil permeability and erodibility properties of the soil. Soil color is a characteristic used as an indicator of the relative organic matter content and the quality of soil drainage. Consistence is described in terms that indicate resistence to change of form or rupture and is an expression of the adhesion between soil particles comprising the soil mass, and is an important consideration in the design of public works projects involving extensive trenching, tunneling, and excavation.

Soil reaction, expressed as the soil's position within the acid through alkaline range, indicates soil crop suitability or type and degree of treatment necessary to develop agricultural potential. Because metal corrodes more rapidly in alkaline soils and concrete in acid soils, the alkaline or acid reaction of a soil mass is valuable in selecting materials such as concrete, vitrified clay, or metal for use in underground pipeline construction, such as for sanitary sewerage systems.

Soil slope is a primary determinant of the amount of runoff that occurs and of the rate at which it occurs and therefore slope is a measure of erossion susceptibility. Slope is also a limiting factor in construction activity and in the development and operation of onsite sewage disposal systems. Soil position relative to the surrounding topography is the principal controlling factor in determining the quality of drainage and therefore also has important implications for the construction and operation of public sanitary sewerage systems as well as private septic tank systems.

Findings of the Regional Soil Survey

Regional soils were mapped, their characteristics and properties as noted above were identified and, most important, the data were interpreted so as to provide a detailed description on a consistent, areawide basis of the soil resources of southeastern Wisconsin. The usefulness of generalized soil maps for definitive planning purposes within the Region is severely limited because of the wide range of soil diversity resulting from the Region's glacial history, and therefore one of the primary values of the operational soil surveys lies in their detail. Any generalization of the findings of the soil surveys can only be meaningful in light of a full understanding of the complexity of the soil relationships in the Region and of the fact that such a generalization, while useful to a broad identification of general areawide development problems relating to soils, cannot be used in plan preparation and implementation.

Generalized Soil Suitability Interpretations: Map 20 shows, in very generalized form, the major soil relationships existing within the Region, based upon seven broad suitability associations. The soils designated on this map as Group "A," which cover about 29 percent of the Region, are generally well suited for both agricultural use and urban development. These soils are not only very productive as cropland but have good drainage and foundation characteristics for all types of urban development. This soils group occurs generally in a belt lying between the present westerly limits of intensive urban development and the easterly limits of the Kettle Moraine. It is interesting to note that this broad soils group does not occur at all in Milwaukee County and occurs to only a very limited extent in Ozaukee, Kenosha, and Racine Counties.

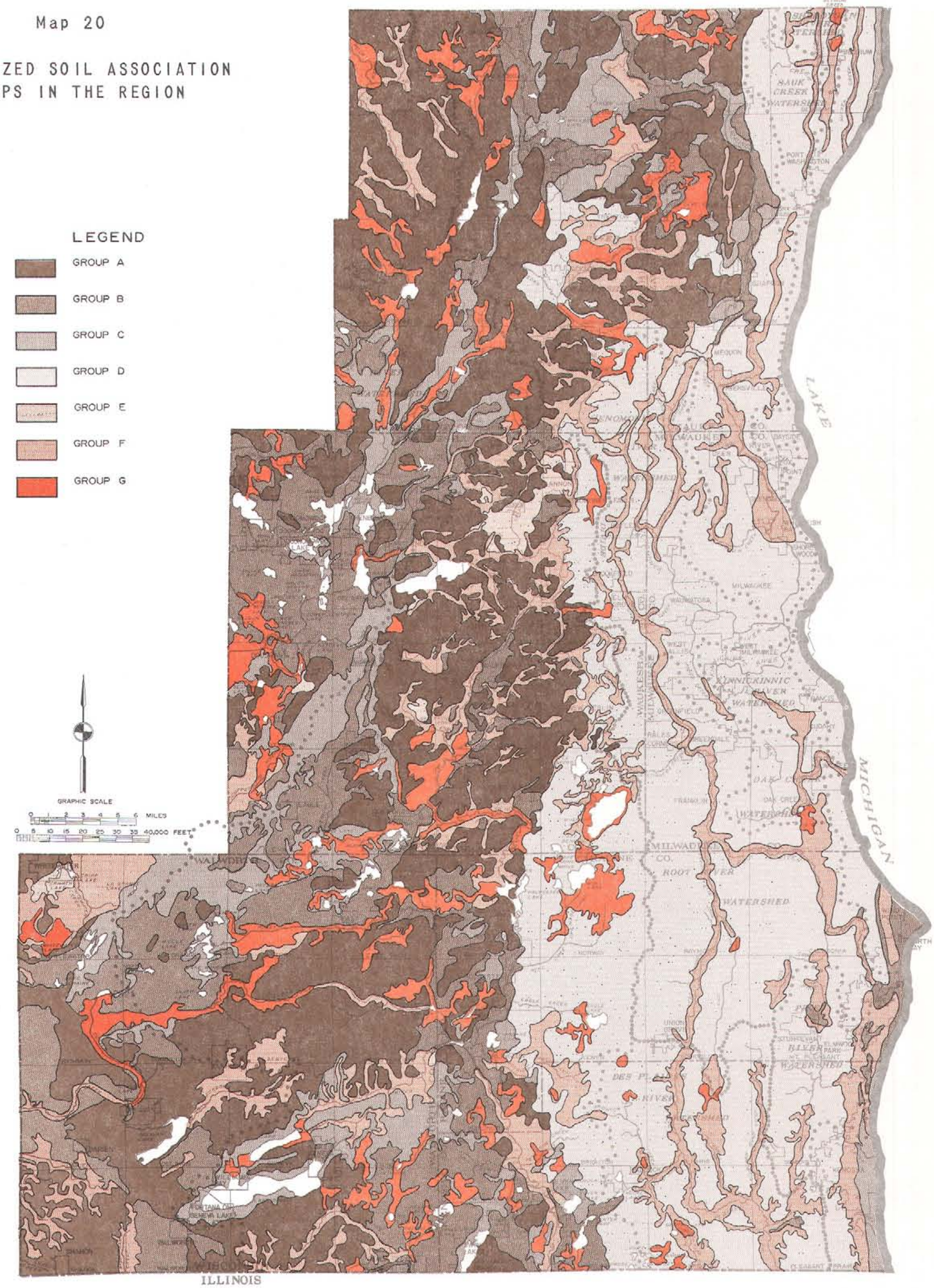
The soils designated as Group "B" generally have a sandy-gravelly subsurface and are well suited to both agricultural use and urban development with septic tank sewage disposal systems. Approximately 14 percent of the Region is covered by this general soils group, which occurs in the Kettle Moraine and the Recessional Moraine areas of the Region and to a limited extent along the Lake Michigan shore.

The soils designated as Group "C" are fair to poorly suited for agricultural use. Their suitability for urban development is limited by characteristically steep slopes. These soils are suited for very large lot residential development which does not disturb the natural topography. Approximately 8 percent of the Region is covered by this soils group, which is prevalent in the Kettle Moraine and the Recessional Moraine areas of the Region.

The soils designated as Group "D" are generally well suited for agricultural use but generally unsuited for urban development requiring the use of onsite septic tank sewage disposal systems. Urban development on these soils generally re-

Map 20

GENERALIZED SOIL ASSOCIATION GROUPS IN THE REGION



As shown on this generalized soil map of the seven-county Southeastern Wisconsin Region, nearly one-half of the 2,689 square mile Region is covered by soils in groups D, E, F, or G which are generally poorly suited for development with onsite soil absorption sewage disposal systems. The detailed soil survey completed for the Region in 1966 provides more definitive soils data for use in local, as well as regional, planning and development.

Source: U. S. Soil Conservation Service and SEWRPC.

quires a high level of municipal improvements and careful attention to storm water drainage. Nearly 31 percent of the Region is covered by this general soils group, which occurs primarily between the Lake Michigan shore and the westerly limits of present urban development. Much of the existing urban development in the Region has occurred on the soils in this group.

The soils designated as Group "E" are generally not well suited for either cropland or urban development. Bedrock normally occurs within four feet of the surface, and bedrock outcrops are common. Good gravel and rock deposits, which are suitable for commercial development, occur in this group. Approximately 1 percent of the Region is covered by this group, which occurs primarily in isolated pockets throughout the Region.

The soils designated as Group "F" are generally poorly drained, have a high water table, and are interspersed with areas of peat, muck, and other organic soils. Approximately 11 percent of the Region is covered by this group, which generally occurs along streams and watercourses of the Region; and for this reason the soils in this group are commonly subject to flooding. These characteristics generally preclude their use for nearly all forms of development except limited agricultural, wetland, forest, wildlife conservation, and recreational uses.

The soils designated as Group "G" are peat and muck soils generally unsuited for urban development of any kind. These areas, when left in a natural state, are ideally suited for wildlife habitat and if properly drained are suitable for certain types of agricultural use. Approximately 6 percent of the Region is covered by this soils group, which occurs in scattered corridors and pockets throughout the Region.

It is important to note that, irrespective of the generalized groupings described above, analysis of the detailed soil survey data to date indicates that soils having questionable characteristics for onsite sewage disposal are widespread throughout the Region. Approximately 40 percent of the estimated 125 soils series[10] occurring within the Region have been found to be troublesome in this respect. Urban development undertaken in disregard of these soil conditions has actually created severe environmental problems within the Region, with the result that the state health authorities have placed restrictions on the development of new subdivision plats in certain areas of the Region and has issued orders for the installation of public sanitary sewer facilities in other areas originally developed with onsite soil absorption sewage disposal systems. It should also be noted that soils poorly suited or unsuited for urban development, even if served by public sewer, are also widespread throughout the Region. These include generally wet soils which either have a high water table, a high water holding capacity, or are poorly drained. Urban development on these soil types is not only expensive to construct initially but expensive to maintain. Again, it should be stressed that the widespread occurrence of soils having questionable characteristics for certain types of urban development, coupled with the highly complex soil relationships, indicates the need for basing regional and local development plans on the results of the detailed soil surveys rather than on any generalized soils data.

Detailed Soil Suitability Interpretations: Particularly important to utility planning are the soil suitability interpretations for specified types of urban development. These are: residential development with public sanitary sewer service, residential development without public sanitary sewer service on lots smaller than one acre in size, and residential development without public sanitary sewer service on lots one acre or larger in size. Some of the more important considerations in determining soil suitability for urban development include depth to bedrock, depth of water table, likelihood of flooding, soil permeability, and slope.

On the basis of the detailed soil surveys, it is evident that much of the Southeastern Wisconsin Region exhibits severe or very severe limitations for specific types of urban development. As illustrated by Map 21, approximately 716 square miles, or about 27 percent of the area of the Region, are covered by soils which are poorly suited for residential development with public sanitary sewer service, or stated differently, poorly suited for residential development of any kind. Approximately 1,637 square miles, or about 61 percent of the area of the Region, are, as shown on Map 22, covered by soils which are poorly suited for residential development without public sanitary sewer service on lots smaller than one acre in size. As

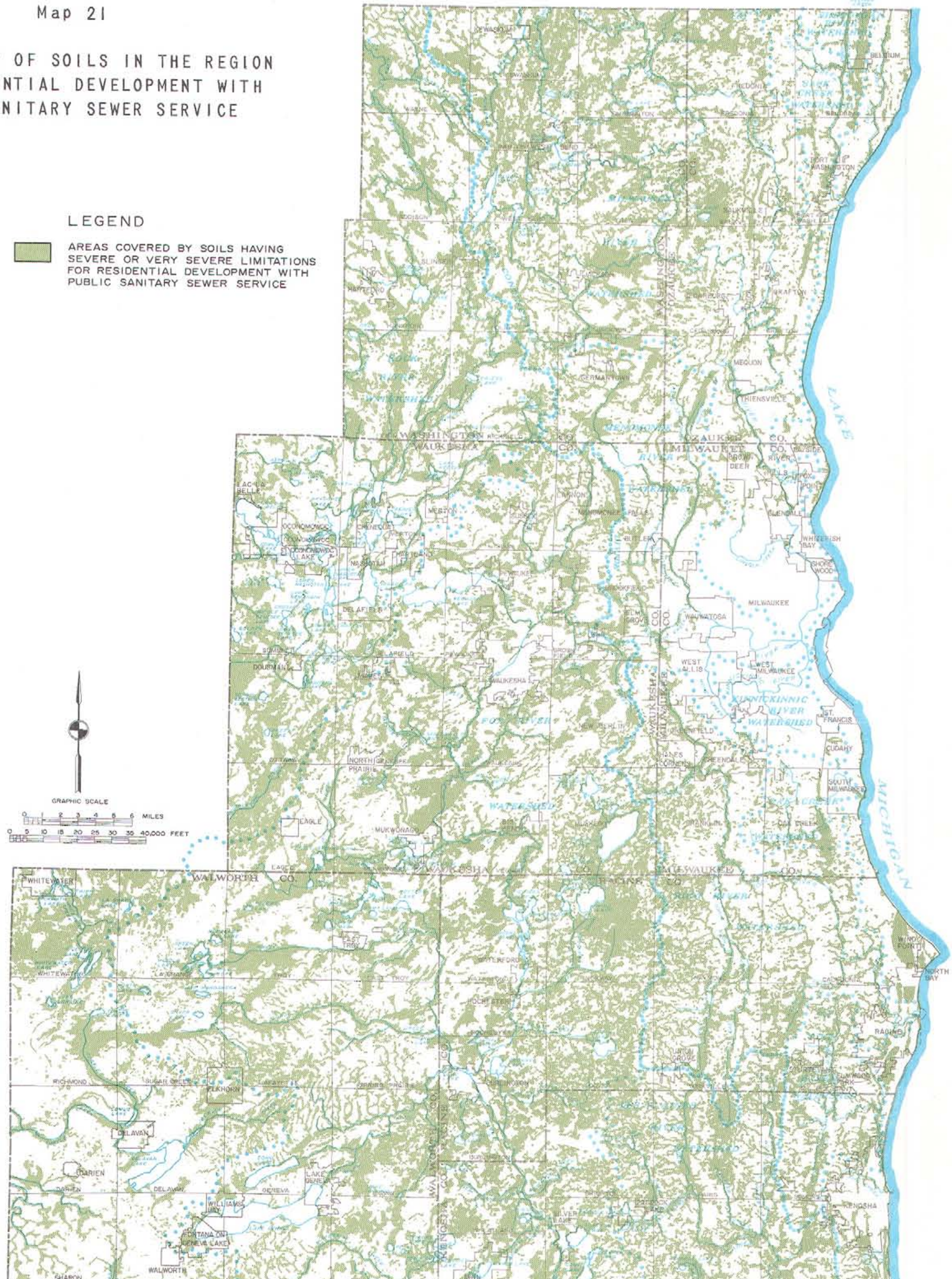
[10] *A soil series is defined as a group of soils developed from a common parent material and having horizons with similar characteristics, except for the texture of the surface soil.*

Map 21

SUITABILITY OF SOILS IN THE REGION FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER SERVICE

LEGEND

AREAS COVERED BY SOILS HAVING SEVERE OR VERY SEVERE LIMITATIONS FOR RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER SERVICE

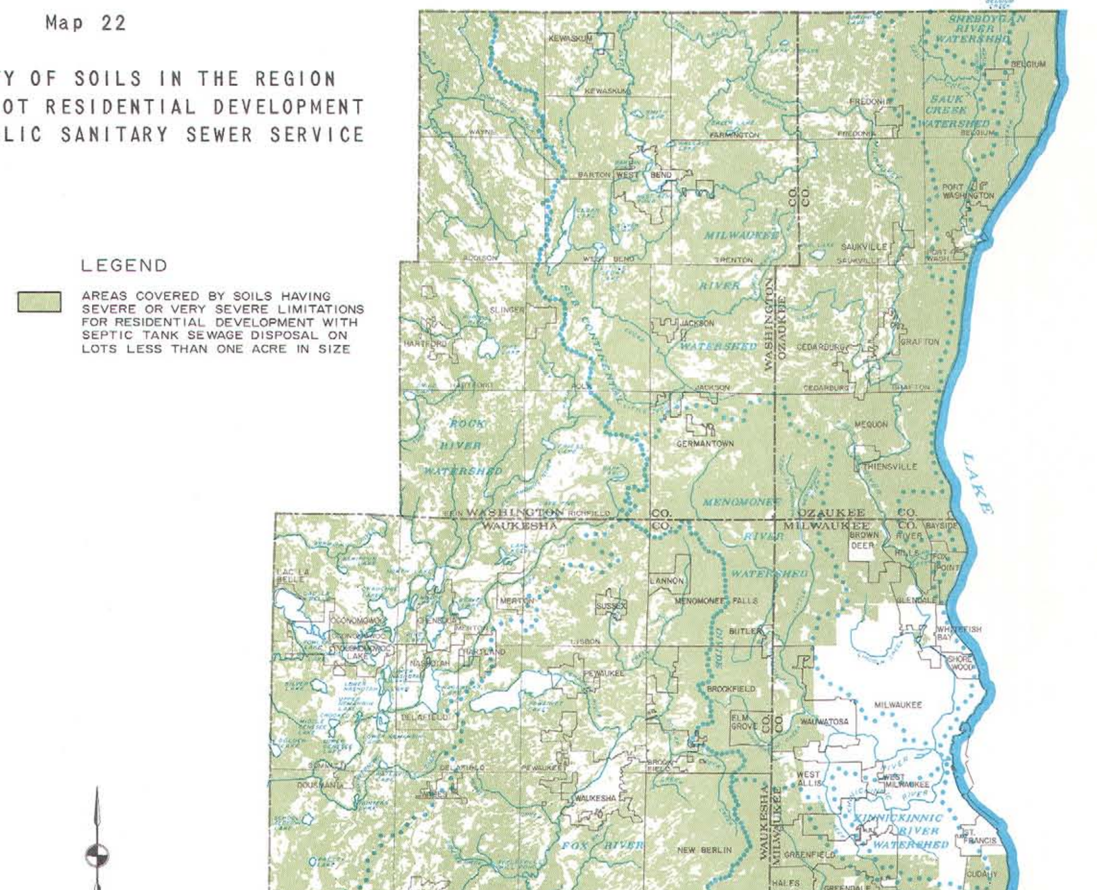


A recognition of the limitations inherent in the soil resource base is essential to the sound urban and rural development of the Region. About 716 square miles, or 27 percent of the area of the Region, are covered with soils which are poorly suited for residential development with public sanitary sewer service, or, more precisely, residential development of any kind. These soils, which include wet soils having a high water table or poor drainage, organic soils which are poorly drained and provide poor foundation support, and soils which have a flood hazard, are especially prevalent in the riverine areas of the Region.

Source: U. S. Soil Conservation Service and SEWRPC.

Map 22

SUITABILITY OF SOILS IN THE REGION FOR SMALL LOT RESIDENTIAL DEVELOPMENT WITHOUT PUBLIC SANITARY SEWER SERVICE



Approximately 1,637 square miles, or about 61 percent of the area of the Region, are covered by soils poorly suited for residential development on lots having an area smaller than one acre and not served by public sanitary sewerage facilities. Reliance on septic tank sewage disposal systems in these areas, which are covered by relatively impervious soils or are subject to seasonally high water tables, can only result in eventual malfunctioning of such systems and the consequent intensification of water pollution and public health problems in the Region.

Source: U. S. Soil Conservation Service and SEWRPC.

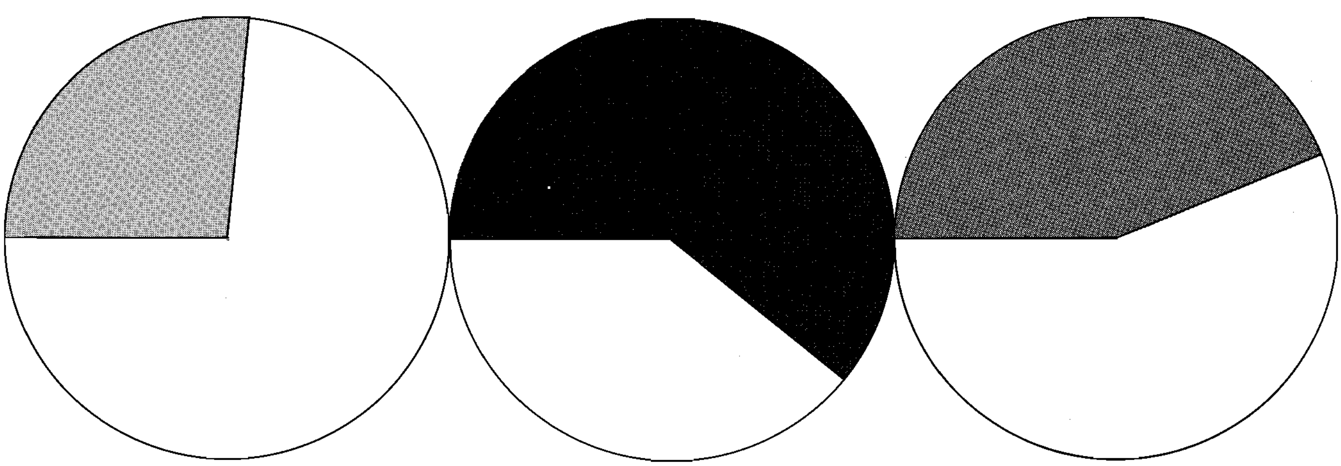
illustrated by Map 23, approximately 1,181 square miles, or about 44 percent of the area of the Region, are covered by soils poorly suited for residential development without public sanitary sewer service on lots one acre or larger in size. It should be noted that the use suitability ratings on which these maps are based are empirical, being based upon the performance of similar soils elsewhere for the specified uses as well as upon such physically observed conditions as high water table, slow permeability, high shrink-swell potential, low bearing capacity, frost heave, and frequent flood overflow. Figure 18 summarizes the soil suitability situation within the Region with respect to the construction of sanitary sewerage systems and the use of onsite sewage disposal systems.

It is useful to interpret the soil suitability data presented in Figure 18 in light of the Commission's 1990 regional land use plan. Whereas urban land uses currently (1970) encompass about 397 square miles, or 15 percent of the total area of the Region, the 1990 plan would accommodate increases in urban population by converting an additional 123 square miles of rural land to urban land use, with that incremental urban development occurring primarily in compact, concentric rings around existing urban centers. Most of the incremental 123 square miles of urban development is, pursuant to the regional land use development objectives upon which the regional land use plan is based, to be served by sanitary sewers. Figure 18 indicates that soils will in no way inhibit such planned urban development since about 1,973 square miles, or about 73 percent of the area of the Region, is covered by soils suitable for the construction of sanitary sewers. Even if all of the present 397 square miles of urban development were conservatively assumed to lie within that 73 percent of the seven-county Region, it is apparent that more than a sufficient amount of land with favorable soil conditions is available to accommodate forecast 1990 urban expansion.

Approximately 694 square miles, or about 26 percent of the area of the Region, is classified as prime agricultural land. The extent and spatial distribution of these areas are shown on Map 24. It is important to note that in addition to having soils particularly well suited for agricultural use, the delineation of these prime agricultural lands are based upon the size and extent of the area farmed; the historic capability of the area to con-

Figure 18

SUMMARY OF SOIL SUITABILITY RATINGS WITH RESPECT TO SEWERAGE SYSTEMS IN THE REGION



LEGEND

SEVERE LIMITATIONS FOR THE CONSTRUCTION OF SANITARY SEWERS (716 SQUARE MILES OR 26.6 PERCENT OF THE REGION, RESIDENTIAL I)

SEVERE LIMITATIONS FOR UTILIZATION OF ON-SITE WASTE DISPOSAL SYSTEMS ON SMALL LOTS, THAT IS, LOTS SMALLER THAN ONE ACRE (1637 SQUARE MILES OR 60.9 PERCENT OF THE REGION, RESIDENTIAL II)

SEVERE LIMITATIONS FOR UTILIZATION OF ON-SITE WASTE DISPOSAL SYSTEMS ON LARGE LOTS, THAT IS, LOTS LARGER THAN ONE ACRE (1181 SQUARE MILES OR 43.9 PERCENT OF THE REGION, RESIDENTIAL III)

NOTE: EACH COMPLETE CIRCLE REPRESENTS THE TOTAL 2689 SQUARE MILE AREA OF THE SOUTHEASTERN WISCONSIN REGION

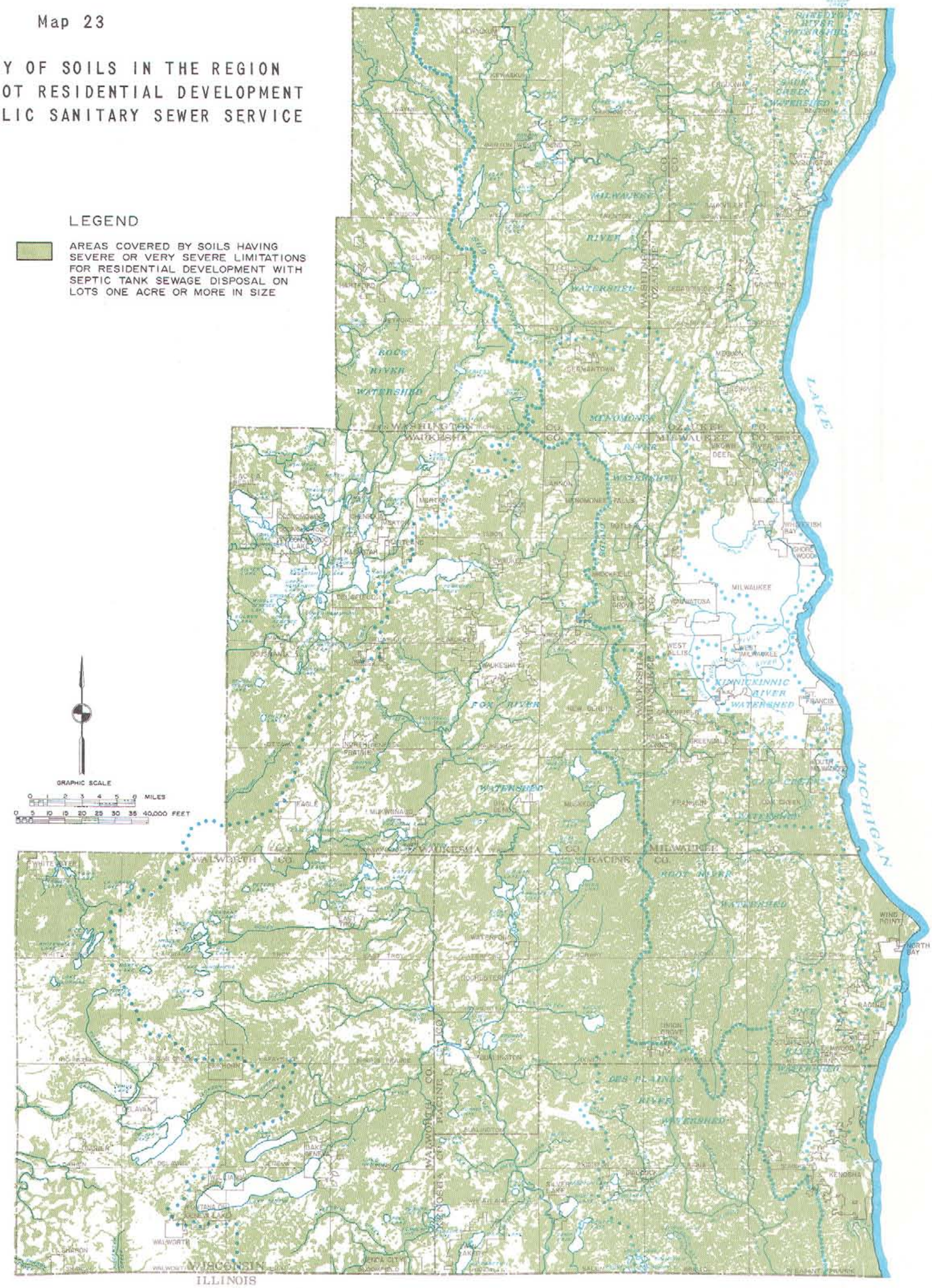
Source: SEWRPC.

Map 23

SUITABILITY OF SOILS IN THE REGION FOR LARGE LOT RESIDENTIAL DEVELOPMENT WITHOUT PUBLIC SANITARY SEWER SERVICE

LEGEND

AREAS COVERED BY SOILS HAVING SEVERE OR VERY SEVERE LIMITATIONS FOR RESIDENTIAL DEVELOPMENT WITH SEPTIC TANK SEWAGE DISPOSAL ON LOTS ONE ACRE OR MORE IN SIZE

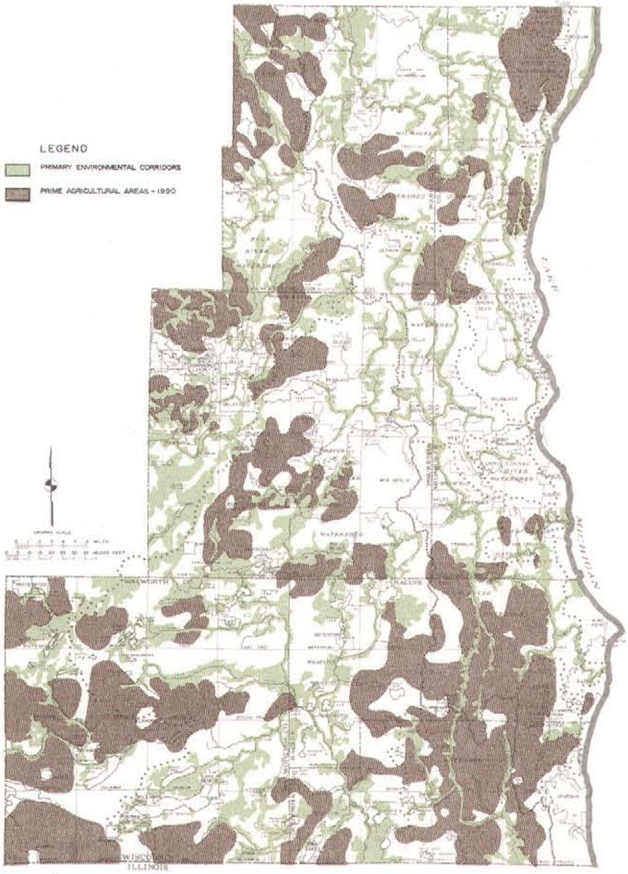


Approximately 1,181 square miles, or about 44 percent of the area of the Region, are covered by soils poorly suited for residential development on lots having an area of one acre or more and not served by public sanitary sewerage facilities. The inherent limitations of these soils for septic tank sewage disposal systems cannot be overcome simply by the provision of larger lots, and the use of such systems on these soils which cannot absorb the sewage effluent ultimately results in surface ponding and runoff of partially treated wastes into nearby watercourses.

Source: U. S. Soil Conservation Service and SEWRPC.

Map 24

PRIME AGRICULTURAL AREAS IN THE REGION



About 694 square miles, or nearly 26 percent of the area of the Region, have been identified in regional planning analyses as prime agricultural lands. The preservation of these lands in agricultural use will contribute significantly to the maintenance of a healthy ecological balance within the Region; provide for the production of certain food commodities within close proximity to the urban centers of the Region; provide open space to give form and structure to urban development; and contribute to the charm and beauty of the Region. To the extent practicable, sanitary sewer service should be planned so as to discourage urban development in these prime agricultural areas.

Source: SEWRPC.

sistently produce better than average crop yields; and the relationship of such lands to important high value recreational, cultural, or scientific resource areas.

VEGETATION

Presettlement Vegetation

Historically, vegetational patterns in the Region were influenced by climate, glacial deposits, soil, fire, topography, and natural drainage characteristics. Historical records, including the original U. S. Public Land Survey carried out within the Region in 1836, indicate that frequent fires set by the Indians or initiated by natural causes maintained large portions of southeastern Wisconsin either as open level plains containing orchard-like stands of oak or as prairies dominated by big bluestem grass and colorful prairie forbs. Other portions of the Region that were protected from fire by the drainage pattern or local relief developed into mixed hardwood forests. The upland timber for the most part consisted of the hardwood species: sugar maple, oak, elm, ash, hickory, beech, linden, walnut, and ironwood; and one coniferous species, white pine. Common species found in the lowland forests included black ash, elm, willow, cedar, tamarack, aspen, and soft maple.

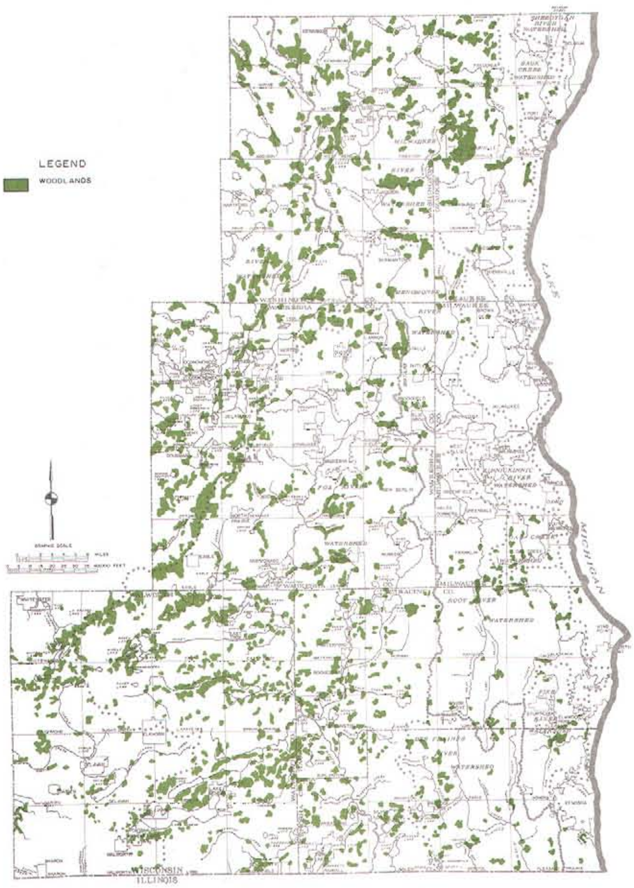
Woodlands

An inventory of all woodland areas in the planning Region having an area of 20 acres or more was carried out cooperatively by the Wisconsin Department of Natural Resources (formerly the Wisconsin Conservation Commission) and the Commission in 1963. At that time woodlands covered approximately 133,000 acres, or 8 percent of the Region, as shown on Map 25, with 99,200 acres, or 75 percent of that total, located in Waukesha, Walworth, and Washington Counties, which contained 35,700, 34,500, and 29,000 acres, respectively. Primarily located on ridges and slopes, along lakes and streams, and in wetlands, these remaining woodlands provide an attractive natural resource of immeasurable value. Not only is the beauty of the lakes, streams, and glacial land forms of the Region accentuated by the woodlands, but these woodlands are essential to the maintenance of the overall environmental quality of southeastern Wisconsin.

Classified in accordance with their primary values, woodlands fall into two specific groups: aesthetic and commercial. Aesthetic woodlands comprised 51 percent of the regional forest resource; and commercial woodlands, the remaining 49 percent. It should be noted that, under the inventory methodology, woodlands classified as commercial timber may also have aesthetic value whereas woodlands classified as aesthetic would not have commercial woodland value. Six forest types are recognized within the Region: central hardwoods, northern hardwoods, oak, upland conifers, wetland conifers, and hardwoods, and lowland

Map 25

WOODLANDS IN THE REGION: 1963



As of 1963, woodlands in the Region covered a total combined area of about 133,000 acres, or approximately 8 percent of the total southeastern Wisconsin area. These woodlands assist in maintaining a unique natural relationship between plants and animals; reduce storm water runoff; contribute to atmospheric oxygen and water supply; aid in reducing soil erosion and stream sedimentation; provide the resource base for the forest product industries; and provide valuable recreational opportunities, as well as a desirable aesthetic setting for attractive rural and planned urban development. Woodlands within the Region are presently being lost at the rate of approximately 600 acres per year.

Source: Wisconsin Department of Natural Resources and SEWRPC.

hardwoods. The central and northern hardwoods and oak types are the most common in the Region. The three hardwood types are most utilized for production of commercial forest products.

Natural stands of trees within the Region consist largely of even-aged mature or nearly mature specimens with insufficient reproduction and saplings to maintain the stands when the old trees are harvested or die of disease or age. This lack of young growth is an unnatural condition brought about by mismanagement and associated with many years of excessive grazing by livestock.

Woodlands within the Region are present only in areas where the pressures for conversion to agricultural or urban use have been such as to permit the continued existence of the woodland. Moreover, woodlands within the Region are presently being lost at the rate of approximately 600 acres per year. These losses are due primarily to conversion to urban land uses through land clearing, highway construction, and development of sanitary sewer systems and other public utilities, although some losses are due to the drainage of wetlands and to neglect. These forces of destruction will rapidly and appreciably reduce the woodland acreage unless corrective measures are taken. The present rate of loss may be expected to accelerate rapidly in the foreseeable future unless balanced use and sustained yield management are applied.

Woodlands in the Region even in their present condition have much value beyond monetary return for their forest products. Under good management they can serve a variety of uses compatible with other benefits. It is becoming more apparent that the interaction between man and his environment is intensifying and becoming critical. The quality of life within an area is greatly influenced by the overall quality of the environment, as measured in terms of clean air, clean water, scenic beauty, and diversity. In addition to contributing to clean air and water, the maintenance of woodlands within the Region can contribute to the maintenance of a diversity of plant and animal life in association with human life. The existing woodlands of the Region, which required a century or more to develop, can be destroyed through mismanagement within a comparatively short period of time. The deforestation of hillsides contributes to the siltation of lakes and streams and the destruction of wildlife habitat. Woodlands can and should be maintained for their total values: scenic, wildlife, open space, education, recreation, and watershed protection, as well as for their forest products. Under balanced use and sustained yield management, woodlands can serve many of these benefits at the same time. Clearly, sanitary sewerage systems should be planned, designed, and constructed so as to encourage the preservation of the remaining woodlands of the Region, particularly all those woodlands having significant environmental value.

Wetlands

Wetlands represent a variety of stages in the natural filling of lake and pond basins, as well as floodplain areas. Wetlands are considered herein as areas which have the water table at or near the land surface and are generally unsuited or poorly suited for most agricultural or urban development purposes. In the context of the regional sewerage study, wetland areas present severe limitations to the development of both public sanitary sewerage systems and private onsite waste disposal systems. Wetlands, however, also have important ecological value in a natural state. Wetlands contribute to control of floods and stream purification, since such areas naturally serve to temporarily store excess runoff and thereby tend to reduce peak flood flows. It has also been found that except during exceptional periods of high runoff following prolonged drought, concentrations of nutrients in waters leaving such areas are considerably lower than in water entering the wetlands.

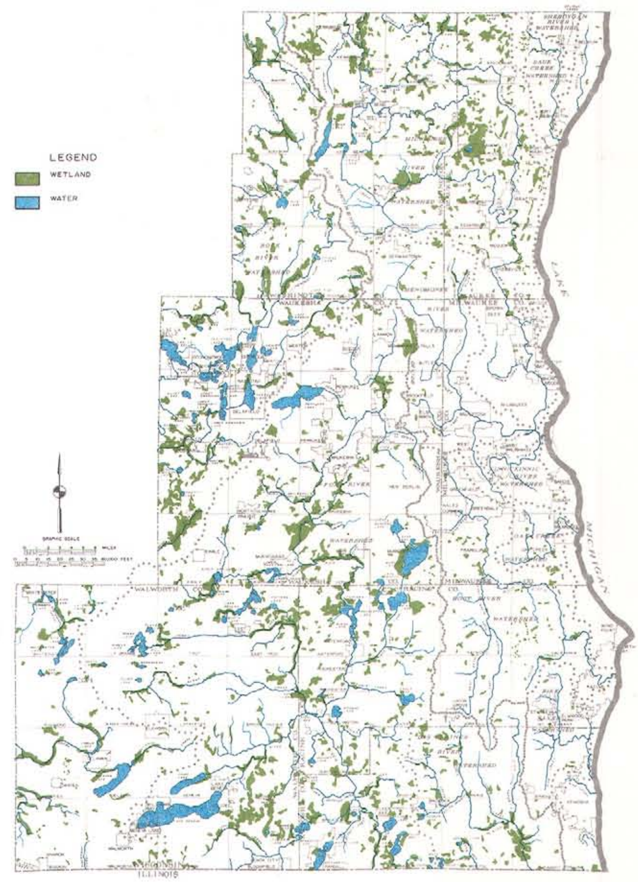
Wetlands within Wisconsin have been classified by the Wisconsin Department of Natural Resources according to the national wetland classification system.[11] Under this system seven major classes of wetlands are recognized, including potholes, fresh meadows, shallow marshes, deep marshes, shrub swamps, timber swamps, and bogs.

The wetlands with standing water are well suited for waterfowl and marsh furbearers, while drier types support upland game due to the protection afforded by the vegetative cover. Shallow-water wetlands are subject to winter freeze and summer drought and therefore are considered to be lower in value than the deep-water types of wetlands.

An inventory of all wetland areas 50 acres or more in size, termed wetland units, within the planning Region was carried out cooperatively by the Wisconsin Department of Natural Resources and the Commission in 1963. Smaller areas were inventoried if they were considered to have a particularly high recreation or wildlife habitat value. Small noncontiguous wetland areas were also inventoried if such areas enhanced a lake, stream, or other nearby recreation area. Wetland and water areas are shown on Map 26 as they existed in 1963, when they covered about 280 square miles, or 179,000 acres, or about 10 percent of this total area of the Region, with 28 percent of the regional total being located in Waukesha County. The drier types of wetlands greatly predominate over the wetter types in southeastern Wisconsin. The drier types include meadows, shrub swamps, and timber swamps, while the wet types include the shallow and deep marshes, potholes, and bogs.

Map 26

WETLAND AND WATER AREAS IN THE REGION: 1963



Nearly 179,000 acres, or approximately 10 percent of the area of the Region, were covered by water and wetlands in 1963. These wetlands constitute a valuable recreational resource; support a wide variety of desirable forms of plant and animal life; and assist in reducing storm water runoff, stabilizing streamflows, and enhancing stream water quality by functioning as nutrient and sediment traps. Wetlands within the Region are presently being lost at the rate of 120 acres per year.

Source: Wisconsin Department of Natural Resources and SEWRPC.

---

[11] *Classification of Wetlands in the United States, Special Scientific Report: Wildlife No. 20, Fish and Wildlife Service, 1953.*

Wetlands within the Region are presently being lost at a rate of approximately 120 acres per year. Most of the loss in wetland area has been the result of conversion to agricultural use through extensive drainage improvements, although some wetland areas have been lost to urban use. There has been increased public interest in the recreational use of more desirable open-water wetlands in recent years, and as a result a slight increase has occurred in the acreage of open-water wetlands that are subject to public control. Recognizing the many environmental attributes of wetland areas and also the severe limitations they present for both public sanitary sewerage systems and onsite waste disposal systems, sanitary sewerage system planning and design should seek to protect the best remaining wetlands in the planning Region by discouraging costly (both in monetary and environmental terms) wetland draining, filling, and urbanization.

Aquatic Vegetation

An aquatic plant survey involving 67 of the major lakes of the Southeastern Wisconsin Planning Region has been conducted by the Wisconsin Department of Natural Resources, with the cooperation of the Southeastern Wisconsin Regional Planning Commission as a part of the Commission's Milwaukee and Fox River watershed planning programs. The primary purpose of the aquatic plant survey was to determine the distribution and abundance of aquatic plants, to identify some of the factors affecting distribution and abundance, and to establish a record of the present status of aquatic plants for future reference.[12]

These aquatic plant surveys indicated that the lakes in the planning Region may be expected to have moderate to abundant vegetation in areas extending from the shore zone to depths as great as 20 to 30 feet. Higher densities of aquatic vegetation generally occur in lakes having extensive shallow areas, clear water, and muck bottoms, whereas lower aquatic vegetation densities are associated with lakes having limited shallow areas, turbid or tea-colored water and marl, sand, gravel, or suspended-ooze bottoms. Southern Wisconsin lakes contain 300 to 2,500 times as much plant material per unit of area as lakes in northern Wisconsin, the greater plant production of the former being partly attributable to their very hard, alkaline nature coupled with their relatively high dissolved mineral and nutrient content conducive to aquatic plant growth.

Some of the lakes within the planning Region were found to display unusually rank aquatic plant growth resulting from those effects of urbanization that serve to artificially enrich the nutrient content of lakes above the natural levels. These effects include malfunctioning or improperly placed onsite sewage disposal systems, inadequate operation of waste treatment facilities, careless agricultural practices, and inadequate soil conservation practices. An overabundance of nutrients transforms desirable, beneficial levels of plant growth into a noxious and unsightly condition. Future nutrient control and the management of aquatic vegetation is in part dependent on the preparation and implementation of a comprehensive regional sanitary sewerage system plan.

WATER RESOURCES

Surface water resources, consisting of lakes, streams, and associated floodlands, form the singularly most important element of the natural resource base of the Region. Their contribution to the economic development of the Region, to recreational activity, and to the aesthetic quality of the Region is immeasurable. The groundwater resources of southeastern Wisconsin are closely interrelated with the surface water resources, inasmuch as they sustain lake levels and provide the base flow of streams. The groundwater resources, along with Lake Michigan, constitute the major sources of supply for domestic, municipal, and industrial water users.

Surface Water Resources

Lakes and streams constitute an extremely valuable part of the natural resource base of southeastern Wisconsin, inasmuch as they are focal points for water-related recreational activities popular with the inhabitants of the Region, they provide extremely attractive sites for properly planned residential development, and, when viewed in the context of open-space areas, they greatly enhance the aesthetic aspect of the environment. In addition to being valued highly by the urban and rural population of the Region, it is important to note that lakes and streams are extremely sus-

[12] See *Aquatic Plant Survey of Major Lakes in the Fox River Watershed*, *Research Report No. 39*, *Wisconsin Department of Natural Resources, 1969*, and *Aquatic Plant Survey of Milwaukee River Watershed Lakes*, *Research Report No. 52, Wisconsin Department of Natural Resources, 1970.*

ceptible to deterioration through the activities of that population. Water quality can degenerate as a result of excessive nutrient loads from malfunctioning or improperly placed septic systems, inadequate operation of waste treatment facilities, careless agricultural practices, and inadequate soil conservation practices. Lakes and streams are also adversely affected by the excessive development of lakeshore and riverine areas in combination with the filling of peripheral wetlands, which processes remove valuable nutrient and sediment traps while adding nutrient and sediment sources. The regional surface water resources must be properly managed to adjust man's uses to the quantity and quality of surface waters that are available and to achieve a reasonable balance between public and private use and enjoyment of those surface water resources. Lake and stream water quality, therefore, constitutes one of the most important considerations in the regional sanitary sewerage system planning effort, since the future condition, potential uses, and aesthetic quality of the surface waters of southeastern Wisconsin will be largely determined by regional land use policies, and in particular by sewerage system planning, design, construction, and operation.[13]

Lakes: Major lakes are defined herein as those having 50 acres or more of surface water area, a size capable of supporting reasonable recreational use with relatively little degradation of the resource. There are 100 major lakes within the Region, the location and relative sizes of which are shown on Map 16. A tabular summary,[14] by county, of the surface water resources of southeastern Wisconsin is presented in Table 17. Major lakes in the planning Region have a combined surface water area of 57 square miles or about 2 percent of the area of the Region, and provide a total of 448 miles of shoreline. The number of major lakes per county ranges from none in Milwaukee County to 33 in Waukesha County. The remaining five counties of Walworth, Kenosha, Washington, Racine, and Ozaukee each contain, respectively, 25, 15, 15, 10, and 2 major lakes. Lake Geneva is by far the largest lake in southeastern Wisconsin, having a surface area of 5,262 acres, and is 2.1 times as large as Pewaukee Lake, which, with an area of 2,493 acres, is the second largest lake in the Region.

The lakes of southeastern Wisconsin are almost exclusively of glacial origin, being formed by depressions in outwash deposits, terminal and interlobate moraines, and ground moraines. Some lakes, such as Green Lake in northeastern Washington County or Browns Lake in southwestern Racine County, owe their origins to kettles, that is, depressions formed in the glacial drift as a result of the melting of ice blocks that became separated from the melting continental ice sheet, and the subsequent subsidence of sand and gravel contained on and within those blocks. By virtue of their origin, glacially formed lakes are fairly regular in shape, with their deepest points located predictably near the center of the basin, or near the center of each of several connected basins. The beaches are characteristically gravel or sand on the wind-swept north, east, and south shores, while fine sediments and encroaching vegetation are common on the protected west shores and in the bays.

There are 228 lakes and ponds in the Region of less than 50 acres of surface water area, which are considered in this report as minor lakes. These minor lakes, the regional distribution of which is summarized in Table 17, have a combined surface water area of 4 square miles or about 0.15 percent of the area of the Region, and provide 141 miles of shoreline. These small lakes generally have few riparian owners and only marginal fisheries. In most cases, the value of the minor lakes is primarily aesthetic, and these lakes are incapable of retaining even this value with any degree of related, improper shoreland development.

The foregoing discussion of lakes has concentrated on the quantity of this portion of the surface water resources, but it is also important to consider the present overall quality of the lakes in southeastern Wisconsin. The 694 square mile Milwaukee River watershed, 430 square miles of

[13] *For definitions of water quality parameters used in this chapter and for discussions of the significance of each, refer to Appendix C of this report, "Water Quality Parameters--Definitions and Significance."*

[14] *See Appendix C of SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, for a detailed tabulation, by county, of lakes and ponds in southeastern Wisconsin, which indicates the location of each lake and pond and also summarizes pertinent morphometric parameters such as surface area, maximum depth, and shoreline length. Some of the morphometric parameters for major lakes have been revised under the Commission's Fox and Milwaukee River watershed studies published as SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volumes 1 and 2, and SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volumes 1 and 2.*

Table 17

LAKES AND STREAMS IN THE REGION BY COUNTY

County		Lakes														Major Streams[4]			
		Major[2]						Minor[3]				Total							
			Total Surface Area		Total Shoreline	Largest Lake			Total Surface Area		Total Shoreline		Total Surface Area		Total Shoreline			Total Surface Area	
Name	Area (Square Miles)	Number	Square Miles	Percent of County	Length (Miles)	Name	Area (Acres)	Number	Square Miles	Percent of County	Length (Miles)	Number	Square Miles	Percent of County	Length (Miles)	Number	Total Length (Miles)	Square Miles	Percent of County
Kenosha	278.28	15	5.06	1.82	48.62	Elizabeth Lake	637.80	9	0.27	0.10	5.85	24	5.33	1.92	54.47	19	106.40	0.73	0.03
Milwaukee	242.19	— —	— —	— —	— —	— —	— —	40	0.26	0.11	14.99	40	0.26	0.11	14.99	15	102.99	0.62	0.03
Ozaukee	234.49	2	0.47	0.20	4.75	Mud Lake	245.40	36	0.63	0.27	25.40	38	1.10	0.47	30.15	29	112.20	1.25	0.05
Racine	339.87	10	5.48	1.61	59.52	Wind Lake	936.20	7	0.17	0.05	4.59	17	5.65	1.66	64.11	14	100.55	0.96	0.01
Walworth	578.08	25	19.52	3.38	131.40	Lake Geneva	5,262.40	9	0.35	0.06	9.10	34	19.87	3.44	140.50	29	173.00	0.58	0.01
Washington	435.50	15	4.22	0.97	40.59	Big Cedar	932.00	43	0.70	0.16	24.32	58	4.92	1.13	64.91	38	219.80	1.03	0.02
Waukesha	580.66	33	22.07	3.80	162.89	Pewaukee	2,493.00	84	1.62	0.28	57.08	117	23.69	4.08	219.97	50	333.30	1.31	0.02
Region	2,689.07	100	56.82	2.11	447.77	— —	10,506.80	228	4.00	0.15	141.33	328	60.82	2.26	589.10	194	1,148.24	6.48	0.02

[1]*Appendices B, C, and D to SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, contain detailed tabulations, by county, of all streams, lakes, and ponds in the Southeastern Wisconsin Region. These appendices indicate the location of each stream, lake, and pond and summarize pertinent morphometric parameters. Surface areas and shoreline lengths for some of the major lakes have been revised under the Commission Fox and Milwaukee River watershed studies, documented in SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volumes 1 and 2, and SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volumes 1 and 2. Entries in this table reflect the revised figures for major lakes.*

[2]*A major lake is defined as one having 50 acres or more of surface water area.*

[3]*A minor lake is defined as one having less than 50 acres of surface water area.*

[4]*A major stream is defined as one which maintains, at a minimum, a small, continuous flow throughout the year except for unusual drought conditions.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

which lies in southeastern Wisconsin, has 21 major lakes; and the 942 square mile Fox River watershed, which has 45 major lakes, was the subject of recently completed SEWRPC comprehensive watershed studies which included the collection, collation, and analysis of extensive lake water quality data for the purpose of assessing pollution problems in the major lakes and of developing plan elements to solve those problems. Since these two watershed studies were completed recently, so that the water quality data may be considered current, and since the in-Region portions of these watersheds comprise just over 50 percent of the 2, 689 square mile area of the Region and contain 57 of the 100 major lakes in southeastern Wisconsin, the quality characteristics of the major lakes in the Milwaukee and Fox River watersheds, as determined in the Commission's watershed studies, may be taken as representative of regional lake water quality conditions and trends.

At least 13 of the 57 major regional lakes in these two watersheds were found to be in advanced stages of eutrophication as indicated by high phosphorus concentrations, low dissolved oxygen contents, and excessive growths of algae and aquatic weeds. Many other major lakes within the Fox and Milwaukee River watersheds were found to be receiving nutrients at rates such that nuisance growths of algae and aquatic weeds may be expected in the near future. In general, some indication of over-fertilization was found in all major lakes in the Fox and Milwaukee River watersheds.

Domestic sewage pollution, as indicated by measured coliform levels and chloride concentrations, was found to constitute a health hazard in several of the lakes, including Little Cedar Lake in the Milwaukee River watershed and Little Muskego Lake in the Fox River watershed. High pesticide levels were encountered in the two watersheds, indicating another form of surface water contamination.

It is therefore apparent that many of the major lakes of southeastern Wisconsin are being degraded as a result of man's activities to the point where they now have, or soon will have, little or no value for recreational purposes, as desirable locations for properly planned and controlled lake-oriented residential development, or even as aesthetic assets in the Region.

Streams: As discussed earlier and as shown on Map 16, the surface drainage system of southeastern Wisconsin may be viewed as existing within 11 individual watersheds, five of which, the Root River, Menomonee River, Kinnickinnic River, Oak Creek, and Pike River watersheds, are contained entirely within the Region. In addition to the 11 watersheds, numerous small catchment areas immediately adjacent to the Lake Michigan shoreline drain directly to the lake via local natural streams and artificial drainageways, and these tributary areas together may be considered to comprise a twelfth watershed. The Region contains only a very small part of the Wisconsin portion of the large Rock River watershed, the streams of that watershed within the Region being limited to the headwater portions of such tributaries to the Rock as the Bark and Oconomowoc Rivers and Turtle Creek.

Three of the twelve watersheds contained wholly or partly in southeastern Wisconsin—the Fox, Rock, and Des Plaines River watersheds—which have a combined area of 1,685 square miles, or 63 percent of the area of the Region, lie west of the subcontinental divide and as a result, the rivers and streams within these catchment areas flow in a generally south and southwesterly direction and are a part of the Mississippi River drainage system. The rivers and streams in the nine watersheds comprising the remainder of southeastern Wisconsin, which have a combined area of 1,004 square miles, or 37 percent of the area of the Region, flow in an easterly direction and discharge into Lake Michigan and are a part of the Great Lakes-St. Lawrence River drainage system. A tabular summary of watershed characteristics for southeastern Wisconsin is presented in Table 18 and a graphical representation of the range of watershed sizes appears as Figure 19.

One of the most interesting, variable, and occasionally unpredictable features of each watershed is its river and stream system in its ever changing, sometimes widely fluctuating, discharges and stages. The stream systems of the Region receive a relatively uniform flow of groundwater from the shallow aquifer underlying the Region. This groundwater discharge constitutes the baseflow of the streams. The streams also periodically intercept surface water runoff from rainfall and snowmelt, which runoff is superimposed on the baseflow and sometimes causes the streams to leave their channels and occupy the adjacent floodlands. The volume of water drained annually from southeastern Wisconsin by the stream system is equivalent to seven-to-eight inches of water spread over the seven-county Region, a volume of runoff which amounts to about one-fourth of the average annual precipitation.

Major streams are defined herein as perennial streams which maintain, at a minimum, a small, continuous flow throughout the year except under unusual drought conditions. Within the Region, there are approximately 1,148 lineal miles of such major streams, as summarized by county in Table 17. The length of major streams per county ranges from a low of 100 lineal miles in Racine

Table 18

WATERSHEDS IN THE REGION BY COUNTY

Watershed[2]	County														Total Watershed Area Within Region (Square Miles)	Percent of Region
	Kenosha		Milwaukee		Ozaukee		Racine		Walworth		Washington		Waukesha			
	Area (Square Miles)	Percent of Watershed	Area (Square Miles)	Percent of Watershed	Area (Square Miles)	Percent of Watershed	Area (Square Miles)	Percent of Watershed	Area (Square Miles)	Percent of Watershed	Area (Square Miles)	Percent of Watershed	Area (Square Miles)	Percent of Watershed		
Fox River[4,6]	96.46	10.28	0.47	0.05	- -	- -	164.44	17.52	341.46	36.37	0.31	0.03	335.59	35.75	938.73	34.91
Rock River[4]	- -	- -	- -	- -	- -	- -	- -	- -	236.62	38.64	179.91	29.38	195.84	31.98	612.37	22.77
Milwaukee River[5,6]	- -	- -	56.97	13.24	150.54	34.99	- -	- -	- -	- -	222.76	51.77	- -	- -	430.27	16.00
Root River[3,5,6]	2.19	1.11	58.83	29.80	- -	- -	123.41	62.51	- -	- -	- -	- -	13.00	6.58	197.43	7.34
Menomonee River[3,5]	- -	- -	55.75	40.97	11.58	8.51	- -	- -	- -	- -	32.52	23.90	36.23	26.62	136.08	5.06
Des Plaines River[4]	122.85	91.96	- -	- -	- -	- -	10.74	8.04	- -	- -	- -	- -	- -	- -	133.59	4.97
Minor Tributaries to Lake Michigan[3,5]	26.99	28.87	18.22	19.49	27.44	29.35	20.84	22.29	- -	- -	- -	- -	- -	- -	93.49	3.48
Pike River[3,5]	29.79	59.31	- -	- -	- -	- -	20.44	40.69	- -	- -	- -	- -	- -	- -	50.23	1.87
Sauk Creek[5]	- -	- -	- -	- -	33.72	100.00	- -	- -	- -	- -	- -	- -	- -	- -	33.72	1.25
Oak Creek[3,5]	- -	- -	26.29	100.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	26.29	0.98
Kinnickinnic River[3,5]	- -	- -	25.66	100.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	25.66	0.95
Sheboygan River[5]	- -	- -	- -	- -	11.21	100.0	- -	- -	- -	- -	- -	- -	- -	- -	11.21	0.42
Total	278.28	- -	242.19	- -	234.49	- -	339.87	- -	578.08	- -	435.50	- -	580.66	- -	2,689.07	100.00

[1]*Includes only that area of each watershed that lies within the seven-county Southeastern Wisconsin Region.*

[2]*Watersheds are listed in order of decreasing size within the Region.*

[3]*Indicates watershed wholly contained within the Region.*

[4]*Indicates watershed west of the subcontinental divide that is tributary to the Mississippi River basin. Three watersheds having a combined area of 1,684.69 square miles, or 62.7 percent of the Region, are in this category.*

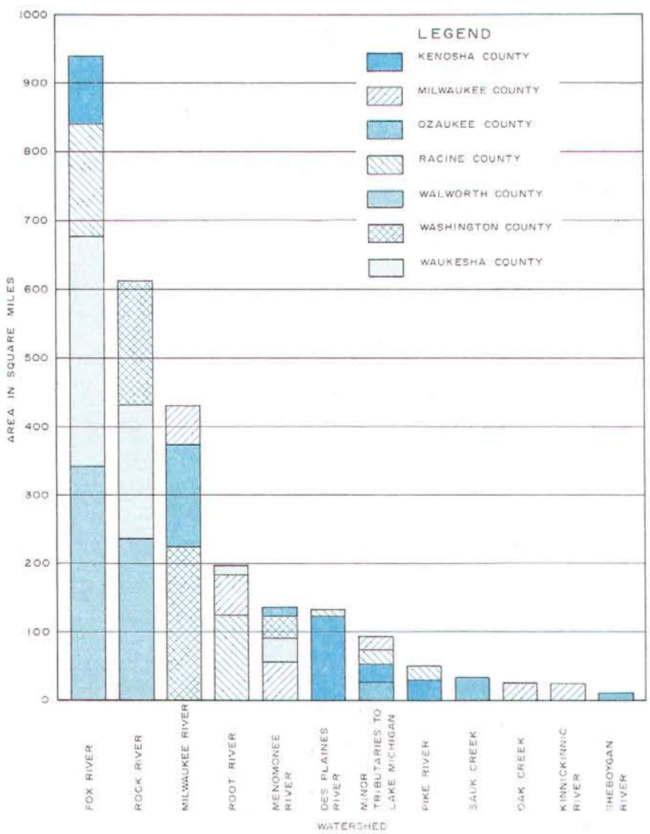
[5]*Indicates watershed east of the subcontinental divide that is tributary to the Great Lakes-St. Lawrence River basin. Nine watersheds having a combined area of 1,004.38 square miles, or 37.3 percent of the Region, are in this category.*

[6]*Indicates watersheds for which comprehensive watershed plans have been prepared and adopted by the Southeastern Wisconsin Regional Planning Commission.*

Source: SEWRPC.

Figure 19

SIZE AND DISTRIBUTION OF WATERSHEDS IN THE REGION BY COUNTY



Source: SEWRPC.

County to a high of 333 lineal miles in Waukesha County. The latter county also has the largest number of major lakes and is, therefore, particularly well endowed with surface water resources.

Low flow characteristics of the Region's streams relative to the forecast 1990 rate of discharge of sewage treatment plant effluent to those streams is of particular importance to regional sanitary sewerage system planning. For the purposes of this report, low flows are defined as the lowest average flow for any period of seven consecutive days in the most recent ten years. Such low flows for the major streams of the Region under existing conditions are shown on Map 27. The procedures used to develop those flows are described in Chapter IX of this report. The dilution potential of the Region's streams, as measured by the dilution ratio—that is, the ratio of low streamflow to municipal sewage treatment plant hydraulic design capacity—is generally very limited and, therefore, high levels of treatment are apt to be required to meet established water use objectives and supporting water quality standards. Forecast 1990 stream low flow estimates, treatment plant average hydraulic design capacities, and dilution ratios at municipal sewage treatment plant sites are presented in Chapter XI of this report, along with necessary treatment levels.

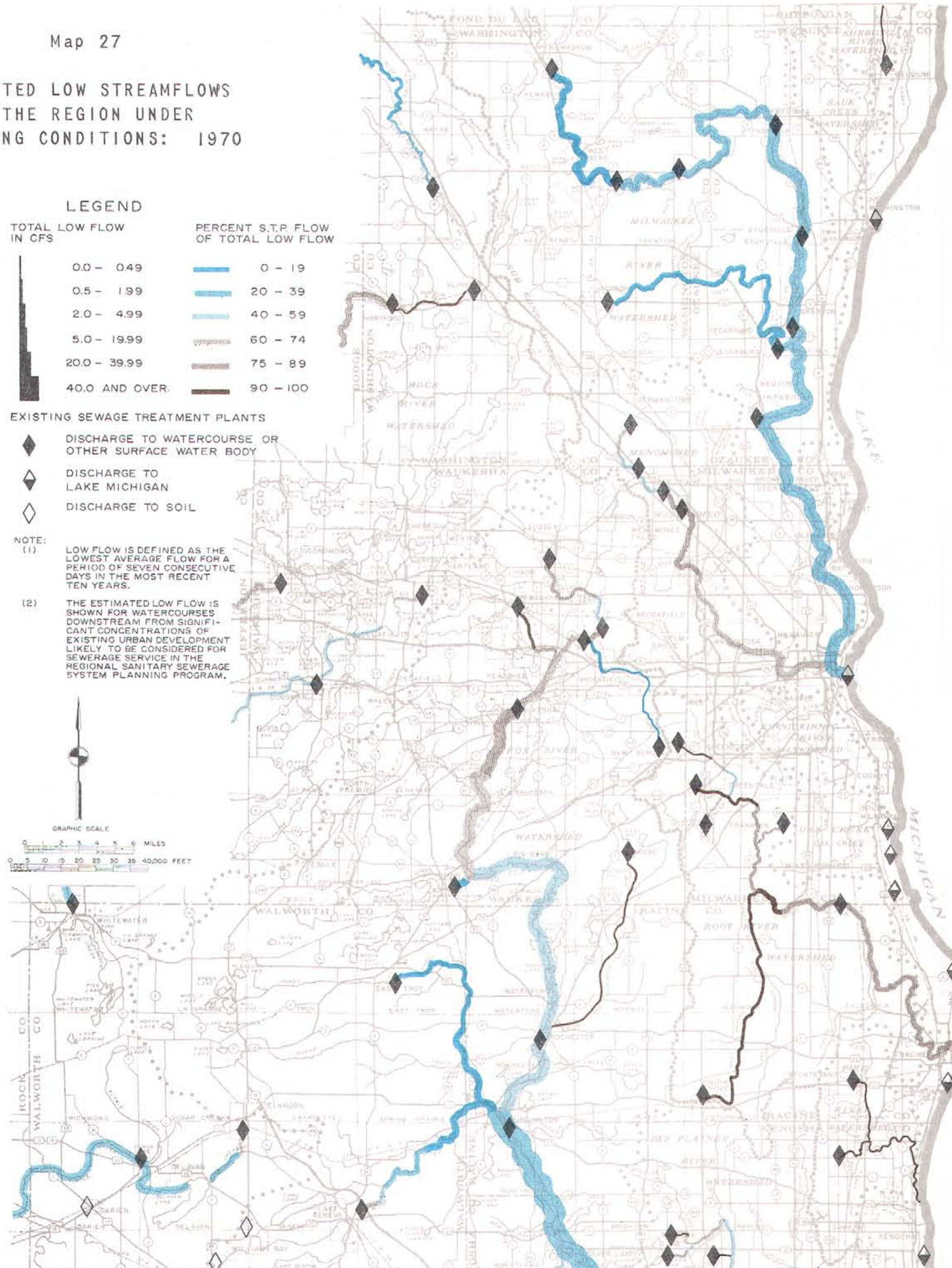
In addition to delineating the areas drained by the major streams of the Region; delineating the length, general orientation, and location of the streams themselves; and determining the low flow characteristics of the streams, it is necessary to consider in any sound sewerage system planning effort the overall water quality characteristics of the streams. The status of stream water quality in the Region has been established through a number of Commission studies and documented in published reports.

During a 14-month period extending from January 1964 through February 1965, the Commission conducted an extensive stream water quality sampling program during which 3,933 water samples were collected at 87 sampling stations established on 43 streams in the Region. The samples were analyzed for 32 chemical, physical, biochemical, and bacteriological water quality indicators for the purpose of assessing the then existing condition of stream water quality in relation to pollution sources, land use, and population distribution and concentration. Data developed during this regional stream water quality study were used to forecast probable future stream water quality conditions. Regional stream water quality data as of 1964 and 1965, interpretations of that data, and forecasts of future stream water quality conditions were published in 1966 in SEWRPC Technical Report No. 4, Water Quality and the Flow of Streams in Southeastern Wisconsin.

The study found that the original naturally high quality of the streams in the Region had been markedly deteriorated by the activities of man, as indicated by such key indicators of pollution as chlorides, dissolved solids, dissolved oxygen, and coliform bacteria. This deterioration may be attributed to the failure to properly adjust both rural and urban development within the Region to the capability of streams and watercourses to assimilate the pollution loadings attendant to such development. Evidence of occasional or persistently severe stream pollution was found in all of the 12 watersheds contained wholly or partly in the seven-county planning Region. The regional

Map 27

SELECTED LOW STREAMFLOWS IN THE REGION UNDER EXISTING CONDITIONS: 1970



The low flow characteristics of streams receiving discharge from municipal sewage treatment plants are a primary factor in establishing the level of treatment to be provided by those facilities. The dilution potential of southeastern Wisconsin's streams, as measured by the ratio of low streamflow to municipal sewage treatment plant average hydraulic design capacity, is generally very limited and therefore high levels of treatment will be needed to achieve established stream use objectives and supporting water quality standards.

Source: SEWRPC.

stream water quality study also revealed that not only has stream water quality markedly deteriorated as a result of man's activities, but that the deteriorated stream water quality has, in turn, impaired or prohibited the very aesthetic and recreational uses sought by the expanding urban population of the Region. Of the 43 streams in the Region, 21 were found to be unsuitable for the preservation and enhancement of aquatic life, with 33 found to be unsuitable for any recreational activities in all or portions of the stream.

The primary source of region-wide stream pollution was found to be municipal sewage treatment plants. This does not necessarily mean, however, that the existing waste water treatment facilities were defective or operating below design efficiency. Sewage treatment plants providing secondary treatment are not designed to remove nutrients from sanitary sewage and, therefore, stream enrichment may be expected to occur regardless of how efficiently the treatment facilities are operated. Furthermore, the Region's streams, because of the low natural base flow, have relatively little capacity to assimilate and dilute nutrients and organic, oxygen-demanding materials as discharged by most sewage treatment plants.

In 1967 the Commission undertook a comprehensive study of the Fox River watershed, including a determination of existing stream water quality conditions in the watershed and the development of a stream water quality simulation model to be used as a tool in the construction of a comprehensive watershed development plan having as a major element thereof a stream water quality management plan. Because this study was completed soon after the region-wide water quality study, and because the Wisconsin Department of Natural Resources had conducted additional sampling efforts as part of a stream basin survey, no major additional data collection efforts with respect to stream water quality were mounted in the study. The existing data were, however, thoroughly analyzed and utilized in the development and calibration of a stream water quality simulation model for the Fox River watershed. Primary emphasis in the study was given to eight parameters of particular importance to the stream water quality management plan. These eight parameters were: dissolved oxygen, carbonaceous biochemical oxygen demand, coliform bacteria, chloride, nitrogen, phosphorus, temperature, and aquatic organisms. In general, the findings of this study indicated that stream water pollution was very evident in most areas of the upper Fox River watershed and was forecast to increase as the urbanization of this upper watershed area proceeded. Municipal sewage treatment plant discharges were found to be by far the most significant cause of water pollution in the Fox River and its tributaries. The discharge of treated wastes from sewage treatment plants in the watershed was found to result in depressed oxygen levels and high coliform concentrations below some of the effluent outfalls and was further found to stimulate the growth of algae and other aquatic plants in many areas. The study concluded that pollution in the Fox River watershed rendered four of the 13 major streams unsuitable for the preservation and enhancement of aquatic life, with the remaining 9 unsuitable for any recreational activities either in some sections of the stream or throughout the entire stream.

In 1968 the Commission undertook a comprehensive study of the Milwaukee River watershed. In addition to all of the stream water quality data previously collected as part of the regional stream water quality study in 1964 and 1965, a special stream water quality sampling program was mounted in the Milwaukee River watershed study in order to provide definitive data to permit a more thorough analysis of the existing stream water quality conditions in the watershed and the development and calibration of a stream water quality simulation model. Seventy-two hour sampling programs were conducted at 30 stations throughout the watershed in both the spring, when flows were high, and late summer, when flows were low. Eight specific parameters were sampled: dissolved oxygen, carbonaceous biochemical oxygen demand, dissolved phosphorus, total phosphorus, ammonia, nitrate, pH, and temperature. The data collected from the previous regional stream water quality study together with the additional data collected under the Milwaukee River watershed study indicated that, although water quality conditions varied greatly from the upper to the lower reaches of the watershed, pathogenic concentrations and nutrient pollution, as indicated by coliform count and phosphorus concentration, are serious problems throughout almost all of the watershed. Organic pollution, as indicated by dissolved oxygen levels, was not found to be as serious a problem in the Milwaukee River watershed as in the Fox River watershed. Nevertheless, relatively long reaches of the Milwaukee River were found to exist in which dissolved oxygen levels fell below the minimum levels required to sustain fish life. Aesthetic pollution was clearly found, particularly in the lower reaches of the watershed. Municipal sewage treatment plant discharges were found to constitute the major cause of water pollution in the middle and upper reaches of the Milwaukee River watershed, while sanitary and combined sewer overflows were found to be the major cause in the lower reaches of the watershed. Over 84 miles of the main stem of the Milwaukee River, or about 85 percent of its total length, was found not to meet the standards for the established stream water use objectives. About 20 percent of the total length of the 29 major tributaries of the Milwaukee River, or about 44 miles, similarly did not meet the standards for the established water use objectives. In general, the Milwaukee River and its tributaries in the lower reaches were considered to be grossly polluted.

Also in 1968 the Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources whereby that department and the Commission undertook a continuing stream water quality monitoring program within the Region. The objective of the program was to build upon the bench mark water quality data initially collected under the regional stream water quality study and the Milwaukee River watershed study by providing, on a continuous basis, the water quality information necessary to permit assessment of the long-term trends in stream water quality within the Region. Initially, this continuing program called for stream water samples to be collected twice yearly during periods of high stream flow in the spring and low stream flow in late summer or early autumn. Such samples were to be collected at the 87 sampling stations previously established by the Commission. Each sample was to be analyzed for nine key water quality indicators: dissolved oxygen, temperature, fecal and total coliform, nitrate, nitrite, dissolved phosphorus, pH, chloride, and specific conductance. In an effort to provide additional information on the diurnal fluctuations of the stream water quality in the Region, the continuing stream water quality monitoring program was revised in 1970 to provide for the collection of six stream water samples over a 24-hour period once yearly during a period of low stream flow at each sampling station, each sample being analyzed for the following five parameters: temperature, pH, dissolved oxygen, chloride, and specific conductance. In addition, once during the 24-hour period the following parameters would be analyzed: dissolved phosphorus, nitrate, nitrite, and fecal coliform. The yearly samplings in the spring during periods of high stream flow were deleted from the program.

Although the stream water quality data collected under this continuing program has not to date been analyzed in detail, review of the data on a selected basis indicates that no significant, long term changes in stream water quality conditions within the Region are as yet apparent. Consequently, although localized changes in water quality conditions have undoubtedly occurred since the initial 1964-1965 sampling period, the general conclusions of the Commission's regional stream water quality survey remain essentially valid and provide, together with the findings of the stream water quality analyses conducted under the Commission's watershed studies, a basic framework upon which a regional sanitary sewerage system plan can be constructed.

In general, it is, then, apparent from all of the Commission's stream water quality to date that many miles of major streams in southeastern Wisconsin are being degraded as a result of existing waste water treatment and disposal practices such that they are unsafe for most recreational activities and have a greatly reduced aesthetic value. All of the aforementioned Commission studies also clearly demonstrate the very basic interrelationship between land use and stream water quality, and thereby emphasize the need for concurrent areawide planning of land use and water quality control measures.

Floodlands

The floodplain of a river is a wide, relatively flat area contiguous with and usually lying on both sides of the channel. The floodplain, which is bounded on its outer fringes by even higher topography, is gradually formed over a long period of time by the river during flood stage as that river meanders in the floodplain continuously eroding material from concave banks of meander loops while depositing it on the convex banks. A river or stream may be expected to occupy and flow on its floodplain on the average of approximately once every two years, and therefore the floodplain should be considered as an integral part of a natural stream system.

The location of the floodplains of southeastern Wisconsin is important to sanitary sewerage system planning primarily for two reasons. First, floodplain areas are generally not well suited to urban development because of flood hazards, high water tables, and inadequate soils. But they are, in contrast, generally prime locations for much needed park and open-space areas and therefore, within the context of regional land use planning and development policies and practices with respect to public utilities and services in general and sanitary sewerage systems in particular, should be such as to discourage indiscriminant urban development in floodplains while encouraging open-space uses. Second, floodplain soil conditions and high water tables generally may be expected to result in significantly higher construction, operation, and maintenance costs for sanitary sewerage systems and therefore, in the interest of achieving construction and operation economies in public utilities and services in general, and sanitary sewerage systems in particular, floodplain development should be minimized.

For planning and regulatory purposes in southeastern Wisconsin, the floodplain has been identified as that area, excluding the channel, that would be inundated by a 100-year recurrence interval flood. Under the Commission's comprehensive studies of the Root, Fox, and Milwaukee River watersheds, digital computer flood flow simulation techniques were used to compute 100-year recurrence interval flood stages which were in turn used to delineate the 100-year floodplain for a total of 538 miles of major stream channel in the three watersheds. The resulting floodplains are shown on Map 28 and were found to encompass, along with the stream channels, about 7 percent of the total area of the watershed, a figure which must be taken as a lower limit for the three watersheds since the floodplains were delineated only for the major perrenial streams in the three watersheds. The Corps of Engineers, at the request of the Southeastern Wisconsin Regional Planning Commission, extended its Des Plaines River floodplain investigation[15] into the Region. The resulting 100-year floodplain corresponding to 20 miles of major stream channel in that portion of the Des Plaines River watershed lying within southeastern Wisconsin is also shown on Map 28. That floodplain encompasses an area of 8.4 square miles, or 6.3 percent of the area of the watershed within the Region. If floodlands—that is, the area within the 100-year recurrence interval flood hazard lines and the stream channel—are assumed to encompass at least 7 percent of the area of any given watershed, then a minimum of 188 square miles of southeastern Wisconsin may be expected to lie within the 100-year flood inundation lines of the Region's major streams.

[15] *Floodplain Information Report on the Des Plaines River-Illinois and Wisconsin*, *Department of the Army, Chicago District, Corps of Engineers, March 1966.*

Groundwater Resources

The seven-county Southeastern Wisconsin Region is richly endowed with groundwater resources. Continuous, relatively uniform discharge from groundwater storage provides for the base flow of the major streams within the Region. As of 1970, groundwater is the source of water supply for 46 public water utilities, or 69 percent of the 67 public water utilities within the Region. Together these 46 utilities serve a resident population of about 190,000 persons, or about 11 percent of the total resident population of the Region and 14 percent of the population of the Region served by public water utilities. In addition, many major industries within the Region utilize ground water as a source of supply.

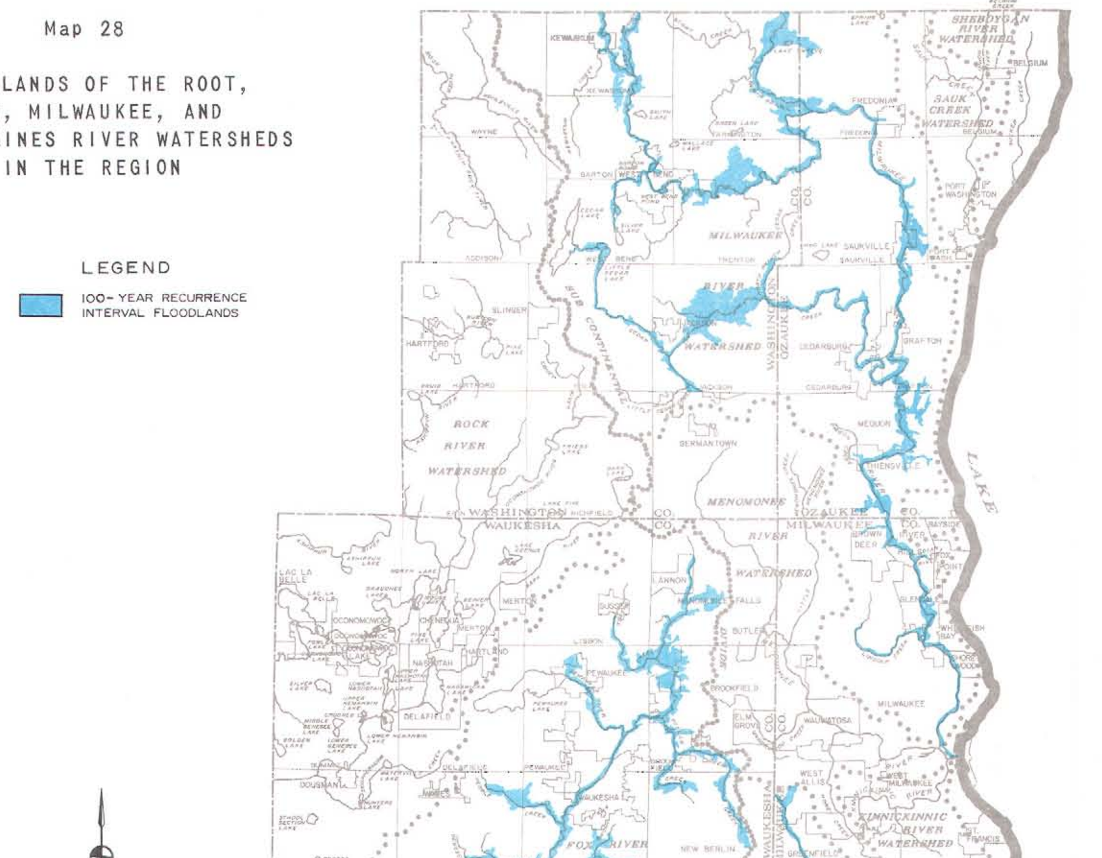
The rock units within the Region differ widely in the yield of stored water. Rock units that supply water in usable amounts to pumping wells and in important amounts to lakes and streams are called aquifers. The aquifers of southeastern Wisconsin extend to great depths attaining a thickness in excess of 1,500 feet in the eastern portions of the Region. An enormous reservoir of groundwater, therefore, lies beneath the Region. Three major aquifers exist within the seven-county Region. In order, from land surface downward, they are: 1) the sand and gravel deposits in the glacial drift; 2) the shallow dolomite strata in the underlying bedrock; and 3) the deeper sandstone, dolomite, siltstone, and shale strata. Because of their relative nearness to the land surface, and because of the hydraulic interconnection, the first two aquifers are commonly referred to collectively as the "shallow aquifer," while the latter is referred to as the "deep aquifer." Wells tapping these aquifers are referred to as shallow or deep wells, respectively. The shallow and deep aquifers are separated by the Maquoketa shale which forms a relatively impermeable barrier between the two aquifers. The spatial distribution of the unconsolidated surficial material and the thickness and orientation of the bedrock strata are depicted on Map 17 and Figure 17, and lithologic descriptions of the surficial deposits and the bedrock are provided in Table 16.

Map 28

FLOODLANDS OF THE ROOT, FOX, MILWAUKEE, AND DES PLAINES RIVER WATERSHEDS IN THE REGION

LEGEND

100- YEAR RECURRENCE INTERVAL FLOODLANDS



Based on the size of the floodland areas which have been delineated for the Root, Fox, Milwaukee, and Des Plaines River watersheds, floodlands comprise at least 7 percent of the total area of southeastern Wisconsin. These floodprone areas are generally unsuited for intensive urban development because of their susceptibility to recurrent inundation, their critical function as floodwater conveyance and storage areas, and the presence of high water tables and unsuitable soils. Floodlands are, however, generally prime locations for much needed park and open-space areas. The flood-prone characteristics of such lands are completely consistent with recreational use and aesthetic enjoyment; the presence of the river enhances the overall recreational experience; and the linear, continuous nature of riverine lands provides areas close and readily accessible to urban residents. Sanitary sewerage system planning should direct urbanization to suitable areas lying outside of and above the Region's floodlands and at the same time encourage the preservation of those floodlands for the recreational use and aesthetic enjoyment of the public.

Source: U. S. Army Corps of Engineers and SEWRPC.

Some water is recharged to the deep sandstone aquifer underlying the Region by vertical movement through wells open to both the shallow and deep aquifers and by some vertical movement downward through the Maquoketa shale. The principal source of recharge to the deep aquifer, however, is precipitation percolating downward through glacial deposits into the deep aquifer which, as shown in Figure 17, is exposed beneath the glacial deposits only in the western one-half of Walworth County and the western one-quarter of Waukesha County. The deep aquifer recharge area for southeastern Wisconsin is a long narrow zone oriented in a generally north-south direction. It is bounded on the east by the Maquoketa shale and on the west by a groundwater divide—the separation between eastward and westward groundwater movements—that is located along the western edge of Waukesha and Walworth Counties. Groundwater in the deep aquifer beneath the Region moves in a generally easterly direction from the primary western recharge areas toward Lake Michigan. Thus, most of the water withdrawn from the deep sandstone aquifer by communities and industries in the seven-county Region originally entered the aquifer via the Waukesha and Walworth County recharge areas. As a result of groundwater withdrawal in the Region, as well as groundwater withdrawal in the Chicago area, the potentiometric surface[16] of the deep aquifer has been continuously declining. Local depressions of as much as 300 feet have occurred in the potentiometric surface in the Milwaukee area since the deep aquifer was first tapped by wells in the last century. Regional sanitary sewerage system planning in particular, and water disposal practices in general, should carefully consider any potential detrimental affects upon the deep sandstone aquifer. To this end, the recharge areas should be protected against incompatible land use development and waste disposal practices.

Whereas the primary source of recharge for the deep sandstone aquifer is located partly outside of southeastern Wisconsin, the shallow aquifer, composed of the glacial drift and interconnected dolomitic bedrock, is recharged locally by downward percolation of precipitation and surface water. Contrasted with the deep aquifer, the direction of water movement in the shallow aquifer is much more variable and complex. Movement occurs from local recharge areas toward multiple points of discharge such as streams, lakes, marshes, and wells. Relative to the deep aquifer, the shallow aquifer is more susceptible to pollution by waste water because it is nearer, both in terms of distance and time, to potential pollution sources, thus minimizing the potential for dilution, filtration, and other natural processes that tend to reduce the potential detrimental effects of pollutants.

The current quality of groundwater in both the shallow and deep aquifers throughout the Region is generally good, although it is very hard containing high concentrations of calcium, magnesium, sulfate, and other dissolved solids, and therefore, softening is required for almost all water uses. Localized water quality problems include hardness, expressed as calcium carbonate, in excess of 500 mg/l in the deep sandstone aquifer along much of the eastern edge of the Region with some wells, for example in the Village of River Hills in Milwaukee County, having measured hardnesses exceeding 1,500 mg/l and total dissolved solids concentrations in excess of 6,000 mg/l.

If the large quantity of groundwater underlying the Region is to remain a valuable asset to southeastern Wisconsin, regional development must be managed so as to protect the quality of that resource. It is important that public sanitary sewerage systems, as well as private onsite sewage disposal systems, be located, designed, constructed, and operated with due cognizance of the need for safeguarding groundwater quality, since poorly located, malfunctioning public and private systems can readily pollute the sand and gravel aquifer and may also contaminate the dolomite aquifer in areas where it is creviced and covered by thin, permeable glacial deposits. Areas of southeastern Wisconsin with bedrock outcrops and relatively shallow glacial deposits are shown on Map 17 and serve to identify locations of potential pollution of the dolomite aquifer.

FISH AND WILDLIFE RESOURCES

Lake and Stream Fisheries

As noted earlier in this chapter, water quality data for 57 of the 100 major lakes in the Region was obtained under the Commission's Fox and Milwaukee River watershed studies. Only four of these 57 lakes were considered incapable of supporting significant populations of desirable fish under existing conditions. Assuming that the fore-

[16] *The potentiometric surface represents the static head of the water in an aquifer and is defined by the levels to which water will rise in wells penetrating the aquifer.*

going 57 lakes are representative of the 100 major lakes in the Region, it follows that most of the major lakes in southeastern Wisconsin are capable of supporting significant fish populations under existing conditions.

The earlier discussion of water quality in major lakes also noted, however, that 13 of the 57 major regional lakes were found to be in advanced stages of eutrophication as revealed by excessive phosphorus concentrations, low dissolved oxygen content, and excessive algae and aquatic weed growths. Thus, while most of the 100 major lakes in the Region are currently capable of supporting significant fish populations, a decline in water quality in general, and fishery suitability in particular, is occurring. This decline may be expected to continue in the absence of a sound areawide water quality management plan and proper implementation of that plan.

Dominant fish species of lakes within the Region in order of importance to its fishery include bluegill, largemouth bass, northern pike, walleye, bullhead, black crappie, yellow perch, and carp. Other fish species existing in the lakes and streams, but of lesser importance to the fisherman, are pumpkinseed, warmouth, white sucker, and green sunfish. Nearly every lake capable of supporting a fishery has a fish population comprised of northern pike, largemouth bass, bluegill, and bullhead. A few of the lakes in the Region, however, also support good walleye, muskellunge, cisco, and trout populations.

Lake fisheries are sustained primarily by natural spawning areas within the lakes. Presently, there are adequate shallow weedbed areas available for fish spawning within most major lakes. Other factors, however, such as deteriorating water quality, fluctuating water quality, and the lack of adequate boating regulations to protect spawning areas, tend to limit the effectiveness of these areas for natural spawning. In many instances, therefore, lake fisheries must be sustained by fish stocking procedures. Deteriorating lake water quality with its adverse effects on lake fisheries is partly attributable to the direct or indirect discharge of sanitary sewage from public sewerage systems or private onsite waste disposal systems into the surface waters prior to receiving proper treatment. The regional sanitary sewerage system plan, therefore, should incorporate measures to protect the lakes and their fisheries.

Only limited quality stream fisheries are available within the Region. The Commission's Fox and Milwaukee River watershed studies, for example, found that stream fisheries were generally limited in that only some of the relatively large streams in these two watersheds are capable of supporting self-sustaining populations of walleye, smallmouth bass, northern pike, or panfish. Very few streams presently support trout populations. It is recognized that not every stream in the Region can, or should, be of such quality that it can support walleye, smallmouth bass, or trout. These species are, however, important indicators of environmental quality and should be maintained or restored in selected streams throughout the area. Temperatures, dissolved oxygen levels, and other water quality characteristics that determine suitable conditions for such species will be significantly influenced by regional sewerage system planning and development and are, therefore, considered in following chapters.

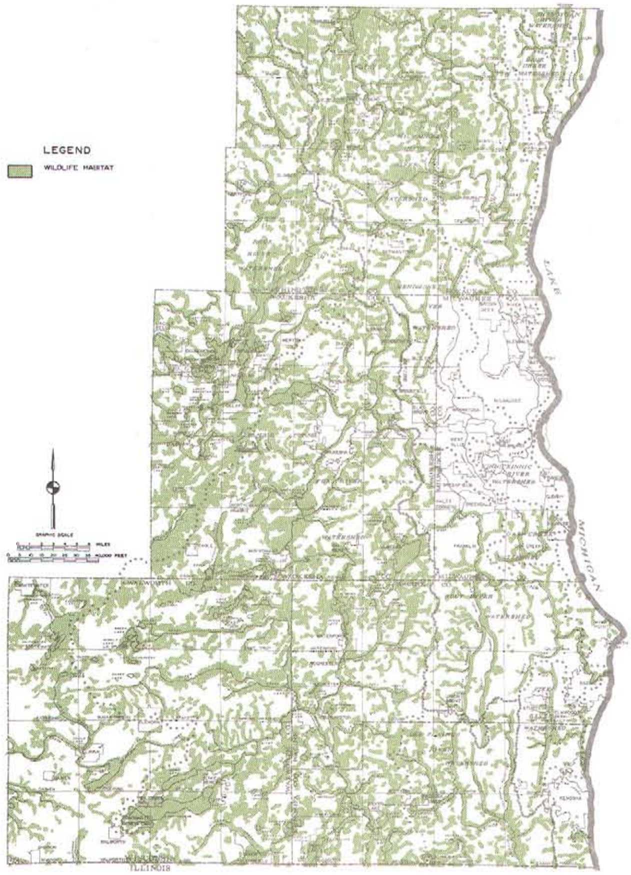
Wildlife Habitat Areas

Wildlife in southeastern Wisconsin is composed primarily of small upland game such as rabbit and squirrel, some predators such as fox and raccoon, game birds including water fowl, and pan and game fish. Deer are also found in some areas, but the herds are small when compared with other regions of the state. The remaining wildlife habitat and wildlife therein provide a valuable and much sought recreational resource, constitute an immeasurable aesthetic asset of southeastern Wisconsin, and contribute both directly and indirectly to economic activity within the Region.

An inventory of land and inland water in the planning region known to be inhabited by various forms of wildlife was carried out cooperatively by the Wisconsin Department of Natural Resources and the Commission in 1963. At that time, wildlife habitat covered approximately 259,000 acres, or 15 percent of the land and inland water area of the Region as shown on Map 29 as the best wildlife habitat. Wildlife habitat must furnish food, cover, and protection. Consequently, areas of the Region having large proportions of forest, wetland, pasture land, cropland, and small proportions of land devoted to urban development have the largest areas and highest quality of the remaining wildlife habitat. Significant concentrations of high value wildlife habitat occur in the Kettle Moraine area in northwestern Walworth County, western Waukesha and Washington Counties, and in a band 12 to 16 miles wide along the Fox River in eastern

Map 29

WILDLIFE HABITAT IN THE REGION: 1963



The remaining wildlife habitat areas and the wildlife therein provide an important recreational resource and constitute a valuable aesthetic asset of southeastern Wisconsin. As of 1963, approximately 259,000 acres, or 15 percent of the area of the Region, were identified as wildlife habitat. Unless consciously protected through measures such as the adopted regional land use plan and a fully coordinated regional sanitary sewerage system plan, these areas will decrease rapidly in both quantity and quality as urbanization spreads over the Region's landscape.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Walworth County and western Racine and Kenosha Counties. It is significant that a majority of the inland lakes within the Region also lie within these two areas.

If the remaining wildlife habitat in the Region is to be preserved, the forest lands, wetlands, and related surface water, together with the proximate croplands and pasture lands, must be protected from mismanagement and continued urban encroachment. The extent and nature of urban encroachment into wildlife habitat areas will be significantly influenced by regional sanitary sewerage system plans and policies.

ENVIRONMENTAL CORRIDORS

The Corridor Concept

One of the most important tasks which was completed as part of the regional land use planning effort was the identification and delineation of those areas of the Region in which concentrations of scenic, recreational, and historic resources occur and which, therefore, should be preserved and protected. Such areas normally include one or more of the following seven elements of the natural resource base which are essential to the maintenance of both the ecological balance and natural beauty of the Region:

1. Lakes, rivers, and streams and their associated floodlands.
2. Wetlands.
3. Forests and woodlands.
4. Wildlife habitat areas.
5. Rugged terrain and high-relief topography.
6. Significant geological formations and physiographic features.
7. Wet or poorly drained soils.

Although the foregoing elements comprise the integral parts of the natural resource base, there are four additional elements which, although not a part of the natural resource base per se, are closely related to or centered on that base and are a determining factor in identifying and delineating areas with scenic, recreational, and historic value. These additional elements are:

1. Existing outdoor recreation sites.
2. Potential outdoor recreation and related open-space sites.
3. Historic sites and structures.
4. Significant scenic areas and vistas.

The delineation of these natural resource and natural resource-related elements on a map of the Region results in an essentially lineal pattern encompassed in narrow, elongated areas which have been termed "environmental corridors" by the Commission. Primary environmental corridors are defined as those areas which encompass three or more of the aforementioned eleven environmental elements, whereas secondary environmental corridors are contiguous areas exhibiting one or two of the eleven necessary elements.

Regional Environmental Corridors

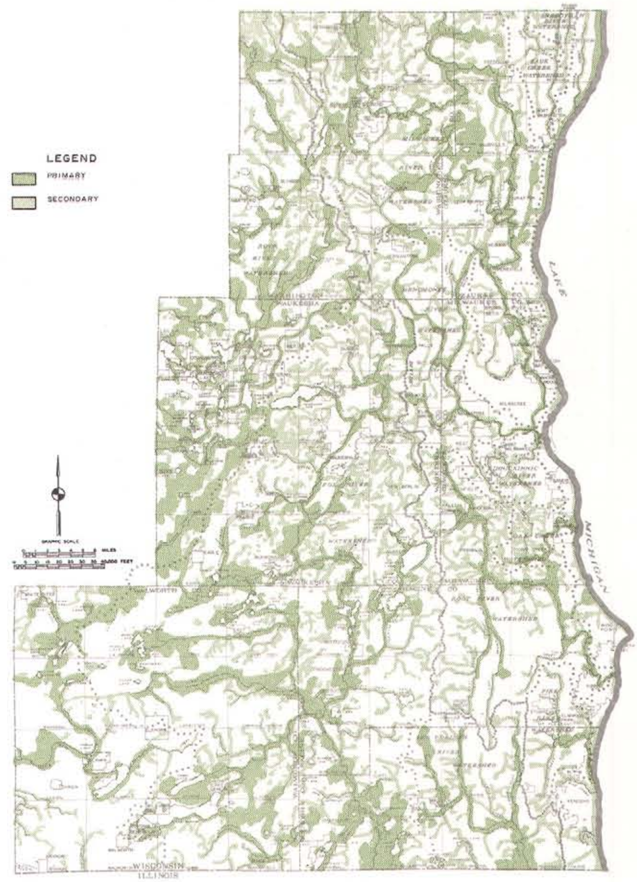
The primary and secondary environmental corridors of southeastern Wisconsin are shown on Map 30. The primary environmental corridors of southeastern Wisconsin are found to occupy approximately 486 square miles of land and inland water area or 18 percent of the total area of the Region. Most of the primary environmental corridors lie along major stream valleys, surround major lakes, or are found in the Kettle Moraine area. It is important to note that the primary environmental corridors contain almost all of the remaining high value wildlife habitat areas and woodlands within the Region in addition to most of the wetlands, lakes and streams, and associated floodlands. These corridors also contain many of the best remaining potential parksites. The primary environmental corridors are, in effect, a composite of the best of the individual elements of the natural resource base of southeastern Wisconsin. These elements have been separately discussed in this chapter.

Recent trends within southeastern Wisconsin have resulted in the encroachment of urban development into the primary environmental corridors. Unfortunately, unplanned or poorly planned intrusion of urban development into these corridors not only tends to destroy the very resources and related amenities sought by the development, but tends to create severe environmental problems having areawide effects.

The preservation of the primary environmental corridors from further degradation is one of the principal objectives of the adopted regional land use plan upon which the regional sanitary sewerage system plan is based. They should be considered inviolate and their preservation in a natural state or in park and related open-space uses, including limited agricultural and country estate type uses, will serve to maintain a high level of environmental quality in the Region and protect its unique natural beauty. Secondary environmental corridors should be at least partially retained in open space by using them as the basis for, or by integrating them into, greenways, drainageways, storm water retention basins, parks, and open spaces in developing areas of the planning region.

Map 30

PRIMARY AND SECONDARY ENVIRONMENTAL CORRIDORS IN THE REGION: 1964



Approximately one-sixth of the Region lies within primary environmental corridors, which encompass almost all of the best remaining woodlands and wetlands, the best remaining wildlife habitat areas, almost all of the streams and lakes and associated undeveloped floodlands and shorelands, as well as many of the significant topographical, geological, and historical features remaining in the Region. The preservation of these corridors in compatible open uses is essential to maintaining the overall quality of the environment within the Region. Sanitary sewer service should be planned so as to discourage urban development in these primary environmental corridors.

Source: SEWRPC.

SUMMARY

This chapter has described the natural resource base of the seven-county area served by the Southeastern Wisconsin Regional Planning Commission, which base, together with the socioeconomic base, comprises the complex and changing environment of this rapidly urbanizing area. Each of the significant elements of the natural resource base has been identified and described, the spatial distribution and extent quantified, the quality characterized, and relationships to sanitary sewerage system planning identified. The importance of considering the elements of the natural resource base herein identified and described in sanitary sewerage system planning cannot be overemphasized, since sanitary sewerage system development, by its impacts on that base has the potential to either degrade or to protect and enhance the natural heritage and environmental quality of the Region. Furthermore, the monetary costs attendant to the planning, design, construction, and operation of sanitary sewerage systems are, in part, a function of how well such systems are adjusted to the supporting capabilities of the natural resource base.

Certain elements of the natural resource base have particular significance to the regional sanitary sewerage system planning program, and these elements, along with their importance to the planning program, are reviewed in the following paragraphs.

The Region has a continental type climate characterized primarily by a continuous progression of markedly different seasons and a large range in annual temperature, onto which is superimposed frequent distinct changes in weather conditions which, particularly in the winter and spring, normally occur once every two or three days. In addition to marked temporal weather changes, the Region exhibits spatial weather differences, the most significant of which is the summer cooling attributable to Lake Michigan experienced primarily by areas in close proximity to the lake.

The annual temperature range, which is based on monthly means for six geographically representative observation stations, extends from a January low of 20.7°F to a July high of 71.0°F. Temperature determines the ease with which outdoor construction and maintenance activities can be carried out; defines the portion of the year when the Region's surface waters are subject to the most intensive recreational use and the types of such use; affects the amount of heat energy needed for sludge digestion at sewage treatment plants; and, because of freezing problems, places restrictions on those sewage treatment plant effluent disposal methods which involve application to the soil in lieu of discharge to surface waters. More importantly, however, temperature markedly affects the reaction rates of aerobic and anaerobic processes which are fundamental to the operation of conventional activated sludge and trickling filter sewage treatment processes as well as self-purification processes occurring naturally in lakes and streams. Aerobic biochemical processes in sewage treatment plants and natural waters are also influenced by temperature in that these processes require an ample supply of oxygen, the solubility of which decreases markedly with increasing temperatures.

Precipitation within the planning region occurs as rain, sleet, hail, and snow, and precipitation events range in intensity, duration, and significance from gentle showers to destructive thunderstorms and a major rainfall or rainfall-snowmelt events resulting in property and crop damage, inundation of poorly drained areas, and stream flooding. The annual total precipitation, based on six geographically representative observation stations, is 30.3 inches expressed as water equivalent, with monthly averages ranging from a February low of 1.32 inches to a high of 3.86 inches in June. The principal snowfall months are December, January, February, and March, during which time 89 percent of the 43.2-inch average annual snowfall occurs. Relative to total annual precipitation, annual snowfall quantities are extremely variable as demonstrated by historical records at Milwaukee, which indicate that snowfall ranged from a low of 11.0 inches during the winter of 1884-85 to a high of 109 inches during the winter of 1885-86. The maximum 24-hour precipitation recorded in the Region was 7.58 inches in the West Bend area on August 4, 1924, and the greatest 24-hour snowfall recorded was 30.0 inches at Racine in February 1898. Precipitation is relevant to the development and operation of sanitary sewerage systems primarily because it is a major causative factor in combined sewer and separate sanitary sewer overflows and sewage treatment plant bypasses which, as typified by the operation of the existing inadequate combined and separate sewerage system in the Milwaukee metropolitan area, can cause serious pollution of the surface water resources.

Snow cover is most likely in southeastern Wisconsin during the months of December, January, and February, there being at least a 0.40 probability of having one inch or more of snow cover during that period and at least a 0.25 probability of five inches or more snow cover during January and the first half of February. Snow cover is of importance primarily because the insulating capability of accumulated snow significantly influences the depth and duration of frozen ground which, in turn, directly influences the planning and conduct of sanitary sewerage system construction and maintenance activities.

A minimum of six or more inches of frozen ground normally exists throughout southeastern Wisconsin during January, February, and the first half of March, and frost depths in excess of four feet have been reported. The ease of outdoor construction and maintenance activities is affected by frost conditions, and, more importantly, the design of structural foundations as well as the design of subsurface utilities, such as sanitary sewers, must incorporate either adequate drainage or sufficient depth provisions in order to prevent costly and disruptive frost heave damage.

The annual evaporation in the Region is about 28 inches and is approximately equal, both annually and seasonally, to the precipitation. Therefore, the evaporation process should not be considered the principal dewatering mechanism for sludge handling.

Prevailing winds follow a clockwise pattern in terms of the prevailing direction over the seasons of the year, being northwesterly in the late fall and in winter, northeasterly in the spring, and southwesterly in the summer and early fall. Beneficial effects of wind include the increased rate of oxygen absorption that occurs in lakes and streams, as well as waste water treatment units open to the atmosphere and accelerated evaporation from sludge-drying beds. Potential undesirable wind effects include transmission of odorous gases into urban areas and the concentration of treatment plant effluent along certain downwind lakeshore areas, resulting in excessive concentrations of floating and rooted aquatic plant growth.

Data on the variation in the time of sunrise and sunset and the daily hours of sunlight are of some value in planning outdoor work and may affect observed diurnal changes in surface water quality. Daylight hours range from a minimum of 9.0 hours on about December 22 to a maximum of 15.4 hours on about June 21. The smallest amount of sky cover occurs during the July through October period when the mean monthly daytime sky cover is approximately 0.5, whereas a sky cover of about 0.7 may be expected during the November through March period.

The 2,689 square mile Southeastern Wisconsin Region was once subjected to the influence of several stages of continental glaciation, the last of which, the Wisconsin stage, terminated about 11,000 years ago and largely determined the physiographic and topographic features of the entire Region. That glaciation provided southeastern Wisconsin with an interesting, varied, and attractive landscape exemplified by the Kettle Moraine area that is still very much in evidence because of the predominantly rural as opposed to urban and therefore altered nature of the existing land use pattern. Protection of the aesthetic quality as well as the educational and recreational value of the Region's glacial landscape is largely dependent on future public policy with regard to the development and extension of public sanitary sewerage systems and private onsite sewage disposal systems.

Topography affects the routing, sizing, and slope of trunk sewers and the location and capacity of pumping and lift stations. As a result of efforts by the Commission and the local units of government, large-scale topographic maps prepared to National Map Accuracy Standards and based upon a monumented control survey network are available for about 21 percent of the total area of the Region.

Regional surface drainage is characterized by a disordered dendritic pattern, primarily because of the hetergeneous nature of the glacial drift. There is a preponderance of ponds and lakes, and much of the Region is covered by wetlands with many streams being mere threads of water through those wetlands. A major subcontinental divide, which bisects the planning region such that 1,685 square miles or 63 percent of the Region drains toward the Mississippi River, while 1,004 square miles or 37 percent of the Region are tributary to the Great Lakes-St. Lawrence River drainage basin, determines the gross surface water drainage pattern and also creates certain legal and water use problems. For example, sanitary sewerage systems within the 1,004 square mile portion of the seven-county area that is tributary to Lake Michigan are subject to the federal Lake Michigan Enforcement Conference convened at Chicago in 1968 by the Secretary of the U. S. Department of the Interior. The conference recommended that waste treatment be provided by all municipalities in the Region to achieve at least 80 percent reduction of total phosphorus, that continuous disinfection be provided throughout the year for all municipal waste treatment plant effluent, that industries not connected to municipal sewerage systems provide sewage treatment so as to meet the water quality standards for Lake Michigan, that unified sewage collection systems serving contiguous areas be encouraged, and that pollution from combined sewer areas be controlled either through separation or through other techniques by July 1977.

The surface water drainage pattern of southeastern Wisconsin may be further subdivided so as to identify 11 individual watersheds, five of which—the Root River, Menomonee River, Kinnickinnic River, Oak Creek, and Pike River watersheds—are wholly contained within the Region. In addition to the 11 watersheds, there are numerous small catchment areas contiguous with Lake Michigan that are drained directly to the lake by local natural streams and artificial drainageways; and these areas may be considered as comprising a twelfth watershed. The surface drainage pattern and location of watershed boundaries are pertinent to the regional sanitary sewerage system plan since emphasis on in-watershed solutions is one of the five basic principles formulated under the regional sanitary sewerage system planning program.

The glacial drift of southeastern Wisconsin is underlain by bedrock formations of the Cambrian through Devonian Periods that dip gently down toward the east at a slope on the order of 20 feet per mile, and attain a thickness in excess of 1,500 feet beneath the eastern boundary of the Region. The bedrock of the seven-county planning region is, for the most part, covered by unconsolidated glacial deposits that are over 500 feet thick in some buried preglacial valleys. In contrast, there are approximately 150 square miles of southeastern Wisconsin, generally east of and parallel to the Kettle Moraine area, where bedrock lies within 20 feet of the ground surface and a few localized areas where bedrock is actually exposed. Outcrop areas and those portions of the Region having less than 20 feet of glacial drift overlying the bedrock constitute an important consideration in the design and construction of private onsite sewage disposal systems and public sanitary sewerage systems, since the operation of the former is dependent on favorable soil characteristics while the latter involves extensive trenching and excavation. Outcrops and shallow drift areas also serve to identify those portions of the planning region that are particularly susceptible to pollution of both the sand and gravel aquifer and the underlying dolomite aquifer as a result of malfunctioning septic systems and exfiltration from sanitary sewers.

The nature of surficial deposits and the characteristics of the bedrock are the two important geologic factors that determine, in conjunction with selected hydrologic and cultural considerations, the potential for land disposal of liquid wastes on a large scale. Geologic conditions within the Region are such that only a relatively small portion of the Region, consisting of the western one-half of Ozaukee County and scattered areas comprising about one-half of Washington County are well suited for the land disposal of treated sewage effluent.

Sand and gravel, dolomite building stone known locally as lannon stone or limestone, and organic material are the three primary mineral and organic resources of southeastern Wisconsin that have commercial value as a result of their quantity, quality, and location. As a result of its glacial history, the Region has an abundant supply of sand and gravel deposits, the most productive of which are concentrated in the Kettle Moraine area and are important sources of concrete aggregate and of gravel for general construction purposes. Depending on the nature of the deposits, particularly their depth and areal extent and the size of the gravel and rocks, sand and gravel deposits may seriously hamper trenching, excavation, and tunneling work. Niagara dolomite is mined in open quarries, most of which are located in Waukesha County, and supplies high quality dimensional building stone and, when crushed, concrete aggregate and gravel for construction purposes. The presence of a quarrying operation in an area indicates relatively thin glacial deposits and close proximity of bedrock to the ground surface and is, therefore, an important consideration in the planning and conduct of construction projects, such as sanitary sewerage system, that entail extensive trenching and excavation.

Organic deposits are widely distributed throughout the Region in small, scattered, low-lying, poorly drained areas, and form the basis for some wildlife, for wetland and recreation areas, and because of the fertilization potential have commercial value in their ability to support certain field and specialized crops as well as sod farming and peat mining. Organic deposits identify areas having severe limitations for development of onsite sewage disposal systems because of poor drainage characteristics, and because of potential infiltration problems through sewer pipe joints and cracks. They also complicate the construction of sanitary sewerage systems because of the difficulty of operating heavy equipment on, and of working with, organic deposits.

A wide variety of soil types have developed in southeastern Wisconsin as a result of the interaction of parent glacial deposits covering the Region, of topography, climate, plants, animals, and time. As a result of a detailed soil survey, all the diverse soil types of southeastern Wisconsin have been mapped; their physical, chemical, and biological properties identified; and interpretations have been made for planning purposes. Soil survey data and interpretations reveal that approximately 716 square miles, or about 27 percent of the Region, are covered by soils that are poorly suited for residential development with public sanitary sewer service; approximately 1,637 square miles, or about 61 percent of the Region, are poorly suited for residential development without sanitary sewer service on lots smaller than one acre in size; and about 1,181 square miles, or approximately 44 percent of the Region, are poorly suited for residential development without public sanitary sewer service on lots one acre or larger in size.

Historically, vegetational patterns in southeastern Wisconsin were determined by natural factors such as climate, glacial deposits, soil type, fire, topography, and drainage characteristics, but man, since his settlement of the Region, has increasingly influenced the quantity and quality of woodlands, wetlands, and aquatic vegetation. Woodlands comprised 133,000 acres or approximately 8 percent of the regional land area in 1963, and in addition to commercial value have significant aesthetic value when viewed in conjunction with the beauty of the Region's lakes, streams, and glacial land forms. Wetlands, which covered about 179,000 acres or about 10 percent of the seven-county planning region in 1963, attenuate peak flood flows, protect stream water quality by serving as nutrient and sediment traps, and provide necessary wildlife habitat.

The proper planning and development of public sanitary sewerage systems, combined with control of private onsite sewage disposal systems, is necessary if the best remaining woodlands and wetlands are to be protected and managed.

Lakes, streams and their floodlands, and ground water, which comprise the water resources of southeastern Wisconsin, constitute the most important single natural resource category because of their multi-faceted functions including support of numerous, popular water-oriented recreation activities; habitat for fish and wildlife; desirable sites for vacation homes and permanent residential developments; and provision of water for domestic, municipal, and industrial water users. The Region contains 1,148 lineal miles of major streams and 100 major lakes, the latter having a total surface area of 57 square miles, or about 2 percent of the area of the Region, and a total shoreline length of 448 miles.

These surface water resources are very vulnerable to man's activities in that their quality can easily degenerate as a result of excessive nutrient and organic loads from malfunctioning or improperly placed private onsite sewage disposal systems, combined sewer and separate sanitary sewer overflows, inadequate waste treatment facilities, and careless agricultural fertilization practices. Furthermore, lakeshore and riverine development may adversely affect lake and stream water quality by increasing pollution loadings while, at the same time, removing wetlands which serve as valuable nutrient and sediment traps. Many of the streams in the Region are particularly vulnerable to pollution because the low flows are small relative to forecast municipal treatment plant discharges.

Commission studies indicate that many of the major lakes and many miles of major streams in the planning Region are being degraded as a result of man's activities to the point where they now have, or soon will have, little or no value for recreational purposes, as desirable locations for controlled water-oriented residential development, or as aesthetic assets of southeastern Wisconsin. Of the 43 major streams in the Region, 21 are unsuitable for the preservation and enhancement of aquatic life, with 33 unsuitable for recreational activities. In general, the surface waters of the Region may be characterized as being highly polluted. Surface water degradation is primarily attributable to mismanagement of human wastes, and therefore the regional sanitary sewerage system planning program has the potential to protect the Region's surface water resources.

At least 7 percent, or 188 square miles, of southeastern Wisconsin, is estimated to lie within the inundation limits of a 100-year recurrence interval flood event. The 100-year floodplain has been delineated for 558 lineal miles of major stream channel in the Root, Fox, Milwaukee, and Des Plaines River watersheds within the seven-county planning region. This floodplain serves to identify those portions of the Region poorly suited for urban development because of flood hazards, high water tables, inadequate soils, and high cost for public utilities and services such as sanitary sewerage systems; while at the same time identifying areas well suited for much needed open-space uses. Regional land use policies in general, and sanitary sewerage system planning and development policies in particular, should direct urban development to more suitable areas outside of the floodplains, thereby reserving the floodplains for open-space uses consistent with the underlying natural resource base.

Groundwater is the principal source of water supply for about two-thirds of the water utilities operating within the Region, for about 14 percent of the resident population of the Region served by such utilities, and for many industries. Groundwater also sustains lake levels and provides the base flow of streams. The aquifers lying beneath the Region, which attain a combined thickness in excess of 1,500 feet in the east, may be subdivided so as to identify three distinct groundwater sources. In order from the land surface downward they are the sand and gravel deposits in glacial drift, the shallow dolomite strata in the underlying bedrock, and the deeper Cambrian and Ordovician Period strata composed of sandstone, dolomite, siltstone, and shale. Regional groundwater quality is generally good, although it is very hard so that softening is required for most uses. Regional development must be managed to protect the valuable groundwater resources, with particular emphasis on public sanitary sewerage systems and private onsite sewage disposal systems, since these systems may easily contaminate the surficial sand and gravel aquifer and also have the potential to pollute the underlying dolomite aquifer in areas where it is creviced and covered by thin, permeable, glacial deposits.

The lakes and streams within the seven-county planning region are capable of supporting a limited fishery relative to heavy fishing demand that is placed on them. A 1963 wildlife habitat inventory revealed that 259,000 acres, or 15 percent of the Region, contained high quality wildlife habitat furnishing food and cover for small upland game, larger predators, game birds, and fish. Wildlife habitat areas constitute both a valuable recreation resource and an aesthetic asset, the protection of which is strongly dependent on rational land use, especially policies pertaining to the extension of sanitary sewerage systems.

The delineation of selected natural resource and natural resource-related elements on a regional map produces an essentially lineal pattern encompassed in narrow, elongated areas which have been termed "environmental corridors" by the Southeastern Wisconsin Regional Planning Commission. Primary environmental corridors occupy approximately 486 square miles or 18 percent of the planning region, and contain almost all of the remaining high value wildlife habitat areas and woodlands within southeastern Wisconsin; most of the wetlands, lakes and streams, and associated floodlands; as well as many significant physiographic features and historic sites. The primary environmental corridors are a composite of the best of the individual elements comprising the natural resource base of southeastern Wisconsin. The preservation of these primary environmental corridors in a natural state or in park and related open-space uses included limited agricultural and country estate type use, is essential to maintaining a high level of environmental quality in the Region and to the protection of its natural beauty, and as such is one of the principal objectives of the adopted regional land use plan upon which the regional sanitary sewerage system plan is based.

(This page intentionally left blank)

Chapter V

EXISTING SANITARY SEWERAGE SYSTEMS

INTRODUCTION

A large network of sanitary sewers consisting of many individual systems presently exists within the Region to serve existing urban land use development. This network has been under continuous development for about 125 years, ever since construction of the first sewer within the Region was begun within the City of Milwaukee in the late 1840s. In the 1850s and 1860s small networks of combined sanitary and storm sewers were constructed to serve the Cities of Milwaukee, Racine, and Kenosha. By the mid-1920s the last extensions of these combined sewer systems were made, and since then all sewers constructed to serve developing areas of the Region have been constructed as separate sewers. Any sanitary sewerage system planning program must include an evaluation of this existing network through an inventory of the location, capacity, and service areas of the existing sanitary sewerage facilities. The capabilities of these existing systems to be expanded and thereby meet future needs, as well as any deficiencies in these existing systems to meet present needs, may thereby be identified and an important step toward plan synthesis achieved. Accordingly, one of the initial steps in the regional sanitary sewerage system planning program was an inventory of all existing sanitary and combined sewerage systems within the Region, whether publicly or privately owned.

This chapter presents the results of this inventory of the existing public sanitary sewerage systems and of an inventory of locally prepared sanitary sewerage system plans and engineering reports. Included in this chapter are descriptive analyses of all existing public sanitary and combined sewerage systems and of all other sewage treatment facilities serving industrial, commercial, institutional, or recreational land use development within the Region. In addition, significant concentrations of existing urban development not currently served by public sanitary sewerage facilities are identified and described. Finally, known point sources of waste water other than sewage treatment plants are identified.

The inventory data presented in this chapter have been organized on a county-by-county basis rather than on a watershed basis. This method of organization is thought to be more convenient for the presentation and use of information pertaining to a particular sanitary sewerage system, since most local officials and interested citizens are more familiar with county boundaries than with watershed boundaries. Since stream and lake water quality management problems are, however, largely determined by waste discharges to natural drainage systems from sewage treatment facilities, the alternative plan elements and the recommended plan presented in later chapters of this report are presented on a subregional rather than a county basis, with the subregions approximating natural watershed boundaries but recognizing other factors such as the location and extent of existing and probable future urban land use development.

Inventory Procedures

Two separate but related inventories were conducted under the regional sanitary sewerage system planning program: an existing sanitary sewerage facilities inventory and a local sanitary sewerage system plans inventory. The inventory of existing sanitary sewerage facilities was designed to update a 1964 inventory of such facilities conducted by the Commission under its initial public utilities study. In that 1964 inventory, all existing sanitary sewerage systems were mapped on a uniform basis by county, at a scale of 1" = 2000'. The sizes of all trunk sewers[1] and of all combined sewers were recorded on the maps;

[1] *Under the 1964 Commission inventory of sanitary sewerage facilities, trunk sewers were defined as follows: for a community up to 5,000 population, 10" diameter minimum; for a community of 5,000 to 50,000 population, 12" diameter minimum; and for communities over 50,000 population, 15" diameter minimum. In addition, smaller size lines were regarded as trunk sewers if they provided trunk service to unserviced portions of the same or adjacent communities. The 1970 update of this inventory utilized the same criteria for recording and mapping the trunk sewers, although the capacity analyses conducted under the regional sanitary sewerage system planning program were limited to those trunk sewers through which other sewer service areas might be connected to a sewage treatment facility as part of an areawide sanitary sewerage system.*

and, where available from local records, sewer slopes and invert elevations were shown at critical points in the system. In addition, existing and committed future service areas were determined and mapped along with combined sewer service areas. Individual subsystem plans were also acquired at various larger map scales from the individual cities, villages, and sanitary and utility districts in the Region. These subsystem maps indicate the location of all existing sanitary sewers, sewage pumping and lift stations, and sewage treatment plants, together with pertinent invert slopes and elevations.

In addition to the mapped sewerage system data, certain additional data pertaining to the existing sewerage systems were acquired and tabulated in the 1964 inventory. These data included name of operating agency, communities served, area served in square miles, treatment levels provided, location of disposal of treatment plant effluent, date of original construction of sewage treatment plant and of major additions, treatment plant design capacities and loadings, population presently served, average per capita flow, total population equivalent presently served, and reserve hydraulic capacity of the sewage treatment plant. These data were all updated to the base year 1970 under the regional sanitary sewerage system planning program. In addition, data were collected on the following: location of known sewage overflow points and the location and capacity of sewage pumping and lift stations.

Both the 1964 Commission inventory of sanitary sewerage systems and the 1970 update of that inventory were designed to make full use of all existing and available surveys, studies, reports, and other pertinent data. Additional data collection activities were limited to those essential to developing the information base necessary to the preparation of a sound regional sanitary sewerage system plan.

While the sheer magnitude and complexity of the foregoing data preclude full presentation in published form for each individual sanitary sewerage system in the Region, the descriptive analyses presented in this chapter do include the following:

1. The location, configuration, and capacity of selected major trunk sewers serving a given area through which other service areas may be connected to a treatment facility to form an areawide system, and the location and capacity of appurtenant pumping and lift stations.

2. The location of all known points of sanitary sewage flow relief, including relief pumping stations, portable pumping stations, crossovers, bypasses, and combined sewer outfalls.

3. The location, type and level of treatment, capacity, existing loading, and means of effluent disposal for all sewage treatment plants serving centralized public sanitary sewerage systems.

4. The location, owner, type of treatment, capacity, and means of effluent disposal for all sewage treatment plants serving isolated land use enclaves, including isolated residential, recreational, commercial, industrial, and institutional land use concentrations.

5. The size and extent of the existing and committed sewer service areas and the estimated population served in each existing service area. The population estimates are based on U. S. Public Land Survey quarter section approximations of the service areas.

6. All known existing point sources of wastes other than sewage treatment plants, consisting primarily of industrial cooling and wash water outfalls but including some industrial wastes.

7. The administrative structure and financing arrangements of each municipal sanitary sewerage system, together with estimated 1970 expenditures for capital improvements and operation and maintenance.

The inventory of existing sanitary sewerage facilities was conducted by the SEWRPC staff and consisted of site visits to the location of each individual sanitary sewerage system in order to obtain system maps and other data and to obtain from the operators and administrators of each system information on existing points of sewage overflow and existing, committed, and proposed service areas. In addition, certain data were obtained from the files of the Wisconsin Department of Natural Resources and the Wisconsin Public Service Commission.

The inventory of locally prepared sanitary sewerage system plans was conducted by contacting each municipality in the Region and requesting that copies of such plans be provided to the Commission. It should be understood in this connection that, in many cases, local sanitary sewerage system plans consist of engineering reports prepared by consulting engineers and submitted to the governing body of the municipality. As such, these reports are rarely formally adopted by either a local plan commission or a local governing body. In most cases, however, such reports do represent at least the informal long-range plan for sanitary sewerage system development for a given municipality. If a community did not have a formally documented plan or engineering report available, it was assumed that no long-range sanitary sewerage system plan existed for the area. Subsequent to the 1970 inventory of such locally prepared sanitary sewerage system plans, the Commission received a number of locally proposed sanitary sewerage system improvement projects under its areawide planning review and clearinghouse function carried out pursuant to U. S. Office of Management and Budget Circular A-95. While these projects were submitted during 1971 and 1972, and thus reflect local sewerage system planning carried out subsequent to the base year of the regional sanitary sewerage system plan, the system plans on which these projects are based have been included in this chapter because of the obvious need to consider the proposed projects in the development of a regional sanitary sewerage system plan.

Definition of Terms

Before presenting the findings of the inventories of existing sanitary sewerage systems and local sanitary sewerage system plans in the Region, it is necessary to define the terms used in the discussion in order to provide a common frame of reference. Accordingly, the following are the definitions of all sanitary sewerage related terms, with the exception of water quality indicators, adopted for use in presenting the inventories, analyses, alternative plans, and recommended plan in this report. Definitions of water quality indicators are set forth in Appendix C of this report.

Activated Sludge Process—A biological waste treatment process in which a mixture of sewage and activated sludge is agitated and aerated in a tank to clarify and oxidize the sewage. The activated sludge, which consists of a growth of zoogleal organisms, is subsequently separated from the treated sewage by sedimentation and wasted or returned to the process as needed.

Aeration, Extended—A modification of the activated sludge process which provides for aerobic sludge digestion within the aeration system.

Aeration, Step—A procedure for adding increments of settled sewage along the line of flow in the aeration tanks of an activated sludge sewage treatment plant.

Appurtenances—Appliances or auxiliary structures comprising an integral part of the sewerage system, such as manholes, manhole covers, ladders, frames, and screens to provide for ventilation, inspection, and maintenance of the sewerage system, as well as specialized structures for conveying sewage, such as depressed siphons and junctions.

Bypass—A flow relief device by which sanitary sewers entering a lift station, pumping station, or sewage treatment plant can discharge a portion or all of their flow, by gravity, directly into a receiving body of surface water to alleviate sewer surcharge; also a flow relief device by which intercepting or main sewers can discharge a portion or all of their flow, by gravity, into a receiving body of surface water to alleviate surcharging of intercepting or main sewers.

Chlorination—The application of chlorine to sewage, generally for disinfection.

Contact Stabilization Process—A modification of the activated sludge process in which raw sewage is aerated with a high concentration of activated sludge for a relatively short period of time to obtain CBOD removal by absorption, the solids being subsequently removed by sedimentation, and transferred to a stabilization tank where aeration is continued to further oxidize and condition the sludge before reintroduction to the raw sewage flow.

Crossover—A flow relief device by which sanitary sewers discharge a portion of their flow, by gravity, into storm sewers during periods of sanitary sewer surcharge or by which combined sewers discharge a portion of their flow, by gravity, into storm sewers to alleviate sanitary or combined sewer surcharge.

Design Capacity, Average Hydraulic—The average influent sewage flow at which a sewage treatment plant will operate at design pollutant removal efficiencies.

Design Capacity, Organic—The average biochemical oxygen demand of the influent sewage, expressed as pounds of $CBOD_5$ per day, which the sewage treatment plant is designed to treat.

Design Capacity, Peak Hydraulic—The maximum influent sewage flow for which the plant is designed to operate without flooding; pollutant removal is still performed under this flow condition but at a much lower efficiency than the design efficiency.

Digestion, Aerobic—The decomposition of organic matter in the presence of elemental oxygen.

Digestion, Anaerobic—The decomposition of organic matter resulting in gasification, liquification, and mineralization through the action of microorganisms in the absence of elemental oxygen.

Flash Mixer—A device for quickly dispersing chemicals uniformly throughout a liquid.

Force Main—A pipeline joining the discharge of a pumping station with a point of gravity flow designed to transmit sewage under pressure flow throughout its length.

Grit Chamber—A detention chamber designed to reduce the velocity of the influent sewage to permit the removal of coarse minerals from organic solids by differential sedimentation.

Intercepting Structure—A structure designed to intercept all dry-weather sanitary sewage flow in a combined sewer and a proportionate amount of the mixed storm water and sanitary sewage flow during periods of rainfall or snowmelt and discharge such flows to an intercepting sewer.

Loading, Average Hydraulic—The arithmetic average of the total metered daily flow at a sewage treatment plant for any selected year.

Loading, Peak Hydraulic—The greatest total daily sewage flow received by a treatment plant in any selected year.

Microstrainer—An extremely fine rotating screen for the removal of very small suspended solids in sewage.

Package Plant—A relatively small, usually prefabricated, sewage treatment plant.

Population Equivalent—The existing or design organic loading to a sewage treatment plant expressed in population and based on an average normal domestic sewage strength and flow.[2]

Pretreatment—The conditioning of a waste at its source before discharge to remove or to neutralize substances injurious to sewers and treatment processes or to effect a partial reduction in load on the treatment process. Within the content of this report, the term generally applies to the conditioning of industrial wastes before discharge to municipal sewerage systems.

Private Sanitary Sewerage System—A waste water disposal system providing conveyance, treatment, and final disposal for wastes from users who have agreed-upon rights to the benefits of the facility which is owned and operated by an individual owner, either a private business or a public institution.

---

[2] *In the regional sanitary sewerage system planning program the average sewage strength is assumed to be 200 mg/l of $CBOD_5$ and the average domestic sewage flow is assumed to be 125 gallons per capita per day. This concentration and daily per capita flow are equivalent to 0.21 pound of $CBOD_5$/capita/day. The population equivalent is computed for either the existing or design loading by dividing the daily $CBOD_5$ loading in pounds by 0.21 pound of $CBOD_5$/capita/day. The computation of equivalent population can also be based on suspended solids by dividing the daily suspended solids loading in pounds by 0.21 pound suspended solids/capita/day.*

Public Sanitary Sewerage System—A waste water disposal system providing conveyance, treatment, and final disposal for wastes from users who all have equal rights to the benefits of the utility which is owned and operated by a legally established governmental body.

Screening—The removal of floating and suspended solids in sewage by straining through racks or screens.

Sedimentation—The process of subsidence and deposition of the suspended matter in sewage by gravity, usually accomplished by reducing the velocity of the sewage below the point at which it can carry suspended matter. Primary sedimentation occurs in a complete sewage treatment process before biological or chemical treatment; secondary sedimentation occurs after such treatment.

Septic Tank—A settling tank in which the settled sludge is in immediate contact with sewage flowing through the tank, and the organic solids in the sewage are settled out and decomposed by anaerobic bacterial action. The treated sewage is then discharged to the groundwater reservoir by underground tile lines.

Sewage—the spent water of a community consisting of a combination of liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, or storm water which may be unintentionally present.

Sewage Lagoon—A shallow body of water containing partially treated sewage in which aerobic stabilization occurs.

Sewage Treatment Plant—An arrangement of devices and structures for treating sewage in order to remove or alter its objectionable constituents and thus render it less offensive or dangerous.

Sewage Treatment Plant Efficiency—The ratio of the amount of pollutant removed by the sewage treatment plant to the amount of pollutant in the influent sewage expressed in percent. (For example, the $CBOD_5$ removal efficiency of a sewage treatment plant is calculated as the ratio of the $CBOD_5$ of the influent sewage minus the $CBOD_5$ of the effluent to the $CBOD_5$ of the influent sewage expressed in percent.)

Sewer—A pipe or conduit, generally closed but not normally flowing under pressure, for carrying sewage.

Sewer, Branch—A common sewer receiving sewage from two or more lateral sewers serving relatively small tributary drainage areas.

Sewer, Building—A private sewer conveying sewage from a single building to a common sewer; also called house connection.

Sewer, Combined—A common sewer intended to carry sanitary sewage, with component domestic, commercial, and industrial wastes, at all times, and which, during periods of rainfall or snowmelt, is intended to also carry storm water runoff from streets and other sources.

Sewer, Common—A sewer in which all abutters have equal rights; also called public sewer.

Sewer, Intercepting—A common sewer that receives dry-weather sanitary sewage flows from a combined sewer system and predetermined proportionate amounts of the mixed storm water and sanitary sewage flows during periods of rainfall or snowmelt and conducts these flows to a point of treatment or disposal.

Sewer, Lateral—A common sewer discharging into a branch or other common sewer and having no other common sewer tributary to it.

Sewer, Main—A common sewer which receives flows from many lateral and branch sewers serving relatively large tributary drainage areas for conveyance to a treatment plant; also called trunk sewer.

Sewer, Outfall—A sewer that receives flows from a collection system or from a treatment plant and conveys the untreated or treated waste flows to a point of discharge into a receiving body of surface water.

Sewer, Relief—A common sewer built to carry the flows in excess of the capacity of an existing sewer, thus relieving surcharging of the latter.

Sewer, Sanitary—A common sewer which carries sewage flows from residences, commercial buildings, and institutions, certain types of liquid wastes from industrial plants, together with minor amounts of storm, surface, and ground waters that are not intentionally admitted.

Sewer, Storm—A common sewer which carries surface water and storm water runoff from open areas, rooftops, streets, and other sources, including street wash and other wash waters, but from which sanitary sewage or industrial wastes are specifically excluded.

Station, Lift—A relatively small sewage pumping installation designed to lift sewage from a gravity flow sewer to a higher elevation when the continuance of the gravity flow sewer would involve excessive depths of trench, or designed to lift sewage from areas too low to drain into available sewers. Lift stations normally discharge through relatively short force mains to gravity flow points located at or very near the lift station.

Station, Portable Pumping—A point of flow relief at which flows from surcharged sanitary sewers are discharged into storm sewers or directly into a receiving body of surface water through the use of portable pumping units.

Station, Pumping—A relatively large sewage pumping installation designed not only to lift sewage to a higher elevation but also to convey it through force mains to gravity flow points located relatively long distances from the pumping station.

Station, Relief Pumping—A flow relief device by which flows from surcharged main sewers are discharged into storm sewers or directly into a receiving body of surface water through the use of permanent lift or pumping stations.

Treatment, Advanced—This may be defined as additional physical and chemical treatment to provide removal of additional constituents, particulary phosphorus and nitrogen compounds, by such means as chemical coagulation, sedimentation, charcoal filtration, and aeration. Although advanced treatment is traditionally conceived of as following secondary treatment or as combined with tertiary treatment, it can be performed following primary treatment or as an integral part of secondary treatment. Advanced treatment may remove 90 percent or more of the raw influent phosphorus and may remove up to 90 percent of the raw influent nitrogen, or effect up to 95 percent reduction in the oxygen demand of ammonia in the sewage treatment plant influent by coverting the ammonia compounds to nitrates.

Treatment, Auxiliary—This may be defined as a treatment measure used in combination with all other treatment methods, and includes, for example, effluent aeration and disinfection by chlorination.

Treatment, Primary—This may be defined as physical treatment of raw sewage in which the coarser floating and settleable solids are removed by screening and sedimentation. Primary treatment normally provides 50 to 60 percent reduction of the influent suspended matter and 25 to 35 percent reduction of the influent carbonaceous biochemical oxygen-demanding organic matter ($CBOD_{ult}$). It removes little or no colloidal and dissolved matter.

Treatment, Secondary—This may be defined as biological treatment of the effluent from primary treatment, in which additional oxygen-demanding organic matter is removed by trickling filters or activated sludge tanks and additional sedimentation. Secondary treatment normally provides up to 90 percent removal of the raw influent suspended matter and 75 to 95 percent removal of the raw influent $CBOD_{ult}$. Secondary treatment facilities can be designed and operated to also remove 30 to 50 percent of the raw influent nitrogenous biochemical oxygen demand ($NBOD_{ult}$) and 30 to 40 percent of the raw influent phosphorus content of the influent sewage.

Treatment, Tertiary—This may be defined as physical and biological treatment of the effluent from secondary treatment, in which additional oxygen-demanding matter is removed by use of shallow detention ponds to provide additional biochemical treatment and settling of solids or filtration using sand or mechanical filters. Tertiary treatment normally provides up to 99 percent removal of the raw influent suspended matter and 95 to 97 percent of the raw influent $CBOD_{ult}$.

Trickling Filter Process—A biclogical waste treatment process in which sewage is applied in spray form from nozzles or other distribution devices over a filter consisting of an artificial bed of coarse material, such as broken stone, through which the sewage trickles to underdrains, giving opportunity for the formation of zoogleal slimes which clarify and oxidize the sewage.

Vacuum Filter—A filter consisting of a cylindrical metal drum covered with cloth or other media revolving on a horizontal axis with partial submergence in liquid sludge. A vacuum is maintained under the media to extract mositure from the sludge which adheres to the cloth or media and is scraped off continuously for disposal.

INVENTORY FINDINGS—KENOSHA COUNTY

Existing Public Sanitary Sewerage Systems

There are a total of 15 existing public sanitary sewerage systems in Kenosha County which provide centralized sanitary sewer service to subareas of the county. These include the systems operated by the City of Kenosha; the Villages of Paddock Lake, Silver Lake, and Twin Lakes; the Town of Bristol Utility District No. 1; the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, C, and D; the Pleasant Park Utility Company, Inc., located in the Town of Pleasant Prairie; the Town of Salem Sewer Utility District No. 1; and the Town of Somers Sanitary Districts Nos. 1 and 2. Together these systems serve a total area of about 24 square miles, or about 9 percent of the total area of the county, and a total population of about 94,000, or about 80 percent of the total population of the county. Each of these public sanitary sewerage systems is described in the following paragraphs. Pertinent characteristics of each system are presented in Tables 19 and 20.

City of Kenosha: The existing service area of the City of Kenosha sanitary sewerage system is shown on Map 31. This area totals about 18.4 square miles and has a resident population of about 80,900 persons. In addition, the City of Kenosha provides on a contract basis sewage treatment for sewage generated in the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C and the Town of Somers Sanitary District No. 1. The sewer service area

Table 19

AREA AND POPULATION SERVED BY EXISTING AND LOCALLY PROPOSED SANITARY SEWERAGE SYSTEMS IN KENOSHA COUNTY: 1970

Name of Public Sanitary Sewerage System	Estimated Service Area				Estimated Population Served[2]	Treatment of Sewage (See Table 20)
	Existing		Proposed[1]			
	Acres	Square Miles	Acres	Square Miles		
Existing Systems						
City of Kenosha	11,749	18.39	18,546	29.00	80,900	Operates a Facility
Village of Paddock Lake	503	0.79	- -	- -	1,500	Operates a Facility
Village of Silver Lake	251	0.39	942	1.47	1,200	Operates a Facility
Village of Twin Lakes	513	0.80	1,859	2.90	1,700	Operates a Facility
Town of Bristol Utility District No. 1	124	0.19	683	1.07	500	Operates a Facility
Town of Pleasant Prairie						
Sewer Utility District No. 1	274	0.43	- -	- -	1,400	Contracts with City of Kenosha
Sewer Utility District No. 2	176	0.28	- -	- -	600	Contracts with City of Kenosha
Sewer Utility District A	118	0.18	- -	- -	400	Contracts with City of Kenosha
Sewer Utility District B	43	0.07	- -	- -	900	Contracts with City of Kenosha
Sewer Utility District C	53	0.08	- -	- -	400	Contracts with City of Kenosha
Sewer Utility District D	376	0.59	924	1.44	800	Operates a Facility
Pleasant Park Utility Co., Inc.	137	0.21	- -	- -	800	Operates a Facility
Town of Salem Sewer Utility District No. 1	240	0.38	1,156	1.81	800	Operates a Facility
Town of Somers						
Sanitary District No. 1	573	0.89	- -	- -	1,700	Contracts with City of Kenosha
Sanitary District No. 2	102	0.16	142	0.22	400	Operates a Facility
Proposed Systems						
Town of Bristol - Proposed Utility District	- -	- -	555	0.87	- -	- -
Town of Salem Sewer Utility District No. 2	- -	- -	8,433	13.18	- -	- -
County Total	15,232	23.83	33,240	51.96	94,000	- -

[1]*As identified in locally prepared plans and engineering reports.*
[2]*Based upon an approximation of the existing sewer service area by U. S. Public Land Survey quarter section.*

Source: SEWRPC.

Table 20

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN KENOSHA COUNTY: 1970

Name of Public Sewage Treatment Facility	Estimated Total Area Served (Square Miles)	Estimated Total Population Served	Date of Original Construction and Major Modification	Type of Treatment Provided	Level of Treatment Provided	Disposal of Effluent	Design Capacity: Population[1]	Design Capacity: Average Hydraulic (MGD)	Design Capacity: Peak Hydraulic (MGD)	Design Capacity: Average Organic (Pounds $CBOD_5$/Day)	Design Capacity: Population Equivalent[1]
City of Kenosha	20.32[2]	86,300[2]	1941, 1967	Activated Sludge	Secondary	Lake Michigan	N/A	18.00	40.00	78,000	372,000
Village of Paddock Lake	0.79	1,500	1958, 1967	Activated Sludge	Secondary	Marsh Drained by Brighton Creek	3,250	0.40	0.80	553	2,600
Village of Silver Lake	0.39	1,200	1966	Activated Sludge	Secondary	Fox River	3,000	0.30	0.50	510	2,400
Village of Twin Lakes	0.80	1,700	1958,1970	Trickling Filter and Activated Sludge	Secondary	Basset Creek	8,200	0.82	1.64	1,390	6,600
Town of Bristol Utility District No. 1	0.19	500	1965	Activated Sludge	Secondary	Ditch Tributary to Des Plaines River	600	0.06	0.12	102	500
Town of Pleasant Prairie Sewer Utility District D	0.59	800	1966	Activated Sludge	Secondary	Des Plaines River	1,200	0.13	0.25	213	1,000
Pleasant Park Utility Co., Inc.	0.21	800	1960	Activated Sludge	Secondary	Ditch Tributary to Lake Michigan	600	0.06	N/A	126[3]	600
Town of Salem Sewer Utility District No. 1	0.38	800	1968	Activated Sludge	Secondary	Brighton Creek	3,000	0.30	0.60	510	2,400
Town of Somers Sanitary District No. 2	0.16	400	1963	Activated Sludge	Secondary	Pike River	N/A	0.03	0.05	240	1,100

Name of Public Sewage Treatment Facility	Existing Loading — 1970: Average Hydraulic (MGD)	Average Per Capita (GPD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Reserve Hydraulic Capacity (MGD)	Sewage Strength Parameters in Influent Sewage: $CBOD_5$ (mg/1)	Suspended Solids (mg/1)	Total Phosphorus (mg/1)	Organic Nitrogen-N (mg/1)	Ammonia Nitrogen-N (mg/1)	Industrial Flows: Design Average Daily Flow (MGD)	Estimated Daily Flow 1970 (MGD)	Overall Plant Efficiency Percent Removals: $CBOD_5$ (Percent)	Suspended Solids (Percent)	Total Phosphorus (P) (Percent)	Number of Days in 1970 Plant Flow Exceeded Plant Meter Capacity
City of Kenosha	16.26	188	29.15	12,700	1.74	94	123	N/A	N/A	N/A	N/A	4.50	82	64	N/A	N/A
Village of Paddock Lake	0.15	100	N/A	N/A	0.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Silver Lake	0.14	117	N/A	N/A	0.16	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Twin Lakes	0.22	129	N/A	N/A	0.60	N/A	N/A	NA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Town of Bristol Utility District No. 1	0.06	120	N/A	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Town of Pleasant Prairie Sewer Utility District D	0.09	113	N/A	N/A	0.04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pleasant Park Utility Co., Inc.	0.05	63	N/A	N/A	0.01	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Town of Salem Sewer Utility District No. 1	0.05	63	N/A	N/A	0.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Town of Somers Sanitary District No. 2	0.03	75	N/A	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: N/A indicates data not available.

[1]The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design $CBOD_5$ loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of $CBOD_5$ per day. If the design engineer assumed a different daily per capita contribution of $CBOD_5$, the population equivalent design capacity will differ from the population design capacity shown in the Table.

[2]Includes the City of Kenosha; the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C; and the Town of Somers Sanitary District No. 1 (see Table 19).

[3]$CBOD_5$ loading for this plant estimated by multiplying the design population of 0.21 pounds of $CBOD_5$ per capita per day.

Source: Wisconsin Department of Natural Resources and SEWRPC.

of these special-purpose districts connected to the City of Kenosha sanitary sewerage system totals about 1.9 square miles and has a total resident population of about 5,400 persons. Thus, the City of Kenosha sewage treatment facility serves a total sewer service area of about 20.3 square miles and a total resident population of about 86,300 persons.

As noted above, the sanitary sewerage system for the City of Kenosha serves an area of about 18.4 square miles. Of this total, about 16.8 square miles, or about 91 percent, are served by a separate sewer system and about 1.6 square miles, or about 9 percent, are served by a combined sewer system. Until the early 1940s, almost all urban development in the Kenosha area was served by combined sewers which discharged untreated sewage directly to Lake Michigan. Intercepting sewers were subsequently constructed to intercept the normal dry weather flow of sanitary wastes in combined sewers, as well as a portion of the storm flows, and convey these flows to the City of Kenosha sewage treatment plant, which was constructed in 1941. During periods of heavy rainfall, overflow devices discharge a portion of the combined sanitary-storm water flow, untreated, directly to Lake Michigan. There are six known combined sewer outfalls in the Kenosha area (see Map 31). A recent engineering report prepared for the City of Kenosha has estimated that such combined sewer overflows occurred about 70 times during 1970.[3]

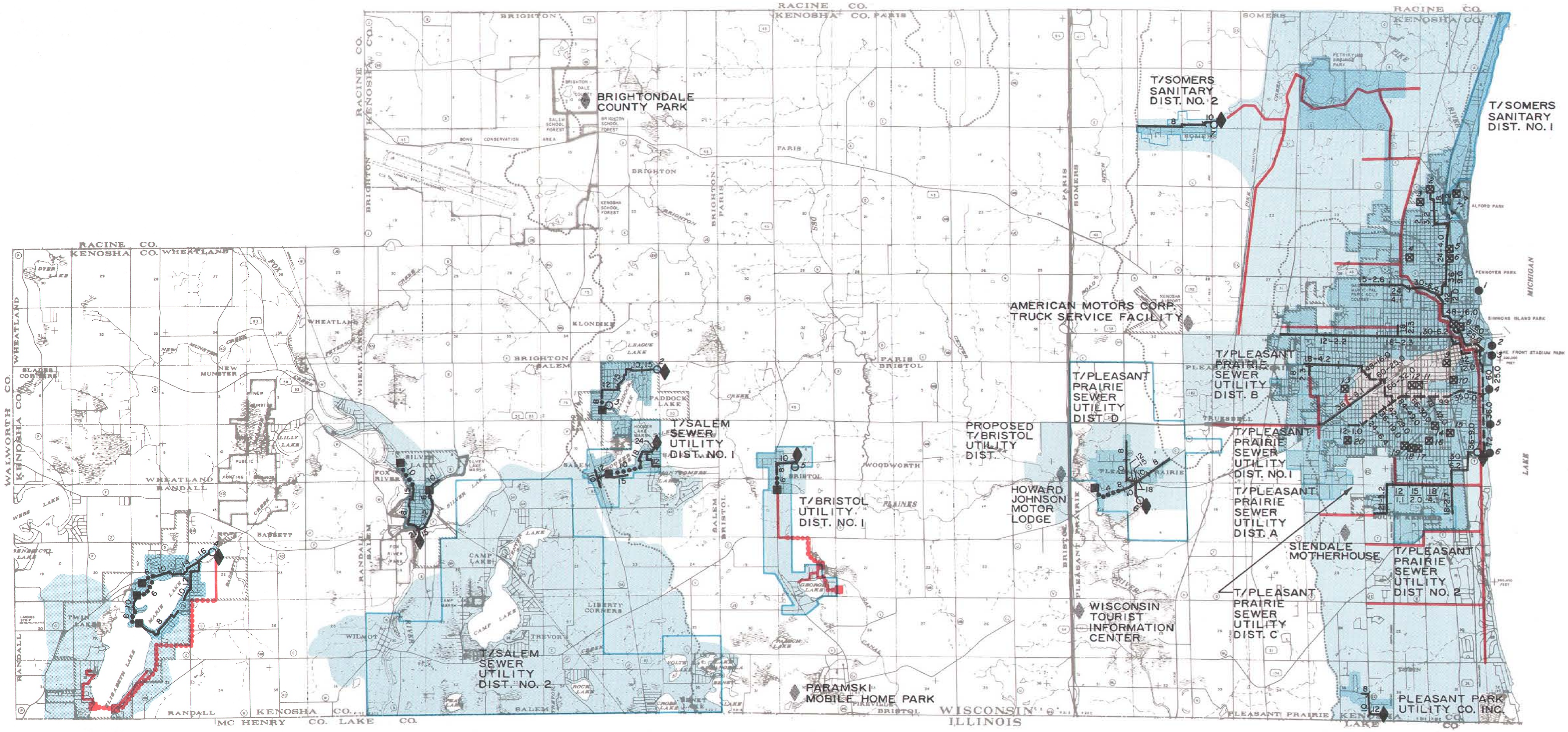
In 1970 the City of Kenosha undertook a sewerage improvement program to effect a greater degree of separation within the combined sewer system. This program is scheduled to be completed by 1976 at an approximate cost of $20 million. It is not anticipated, however, that the program will result in the complete separation of the existing

---

[3] *See "Report on Kenosha Water Pollution Control Plant, Phosphorus Removal and Oil, Grease Sludge Disposal--1971," Alvord, Burdick, and Howson, Engineers, Chicago, Illinois.*

Map 31

EXISTING AND LOCALLY PROPOSED PUBLIC SANITARY SEWERAGE SYSTEMS AND OTHER SEWAGE TREATMENT FACILITIES IN KENOSHA COUNTY 1970



LEGEND

SEWER SERVICE AREAS

- EXISTING-SEPARATE
- EXISTING-COMBINED
- PROPOSED

SEWAGE TREATMENT FACILITIES

- EXISTING-PUBLIC
- EXISTING-PRIVATE
- PROPOSED-PUBLIC

SEWERS AND APPURTENANT FACILITIES

- EXISTING MAJOR TRUNK, RELIEF, OR INTERCEPTING SEWER
- EXISTING MAJOR COMBINED SEWER
- PROPOSED MAJOR TRUNK, RELIEF, OR INTERCEPTING SEWER
- EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- EXISTING LIFT STATION
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- PROPOSED PUMPING STATION

SEWERS AND APPURTENANT FACILITIES (Continued)

18-2.3 / $\frac{18}{2.3}$ SIZE (in Inches) AND CAPACITY (in MGD) OF SEWER OR APPURTENANT FACILITY

KNOWN FLOW RELIEF DEVICES

- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION
- *8* IDENTIFICATION NUMBER--SEE APPENDIX B

GRAPHIC SCALE

0 1 2 3 4 5 MILES

0 8000 16000 24000 32000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

(This page intentionally left blank)

combined sewer system or eliminate all overflows or bypassing during periods of wet weather.[4] In an attempt to find alternative solutions to the combined sewer overflow problem, the City of Kenosha, in cooperation with the U. S. Environmental Protection Agency, recently began a demonstration project to determine the feasibility of using a biological absorption process to treat up to 20 mgd of combined sewer flows at the site of the existing sewage treatment facility. This project will enable a thorough evaluation of the economic as well as the physical feasibility of the process selected, and may offer a viable alternative to complete separation of the combined sewer system in the City of Kenosha.

The area committed to future sanitary sewer service in local plans, totaling about 29 square miles, is also shown on Map 31. This area is bounded generally by the subcontinental divide on the west, the Racine-Kenosha County line on the north, Lake Michigan on the east, and the Wisconsin-Illinois state line on the south. This recommended future sanitary sewer service area was initially proposed in a 1966 engineering report prepared for the city[5] and was included in the comprehensive plan for the Kenosha Planning District prepared jointly for the City of Kenosha and the Towns of Somers and Pleasant Prairie in 1967 by the Regional Planning Commission.[6]

The Kenosha sewage treatment facility, an activated sludge type, is located on the Lake Michigan shoreline adjacent to Southport Park (see Figure 20). The plant has a site area of about 24 acres, of which about 15 acres are currently utilized, leaving nine acres available for future use. The plant site is bounded by public park lands on the east, residential development on the north and

---

[4] *Ibid., pp. 24 and 36.*

[5] *See "Relief, Extension and Conversion of Sewer Facilities," Consoer, Townsend, and Associates, Consulting Engineers, Chicago, Illinois, 1966.*

[6] *See SEWRPC Planning Report No. 10, Volumes One and Two, A Comprehensive Plan for the Kenosha Planning District, 1967.*

Figure 20

CITY OF KENOSHA SEWAGE TREATMENT PLANT

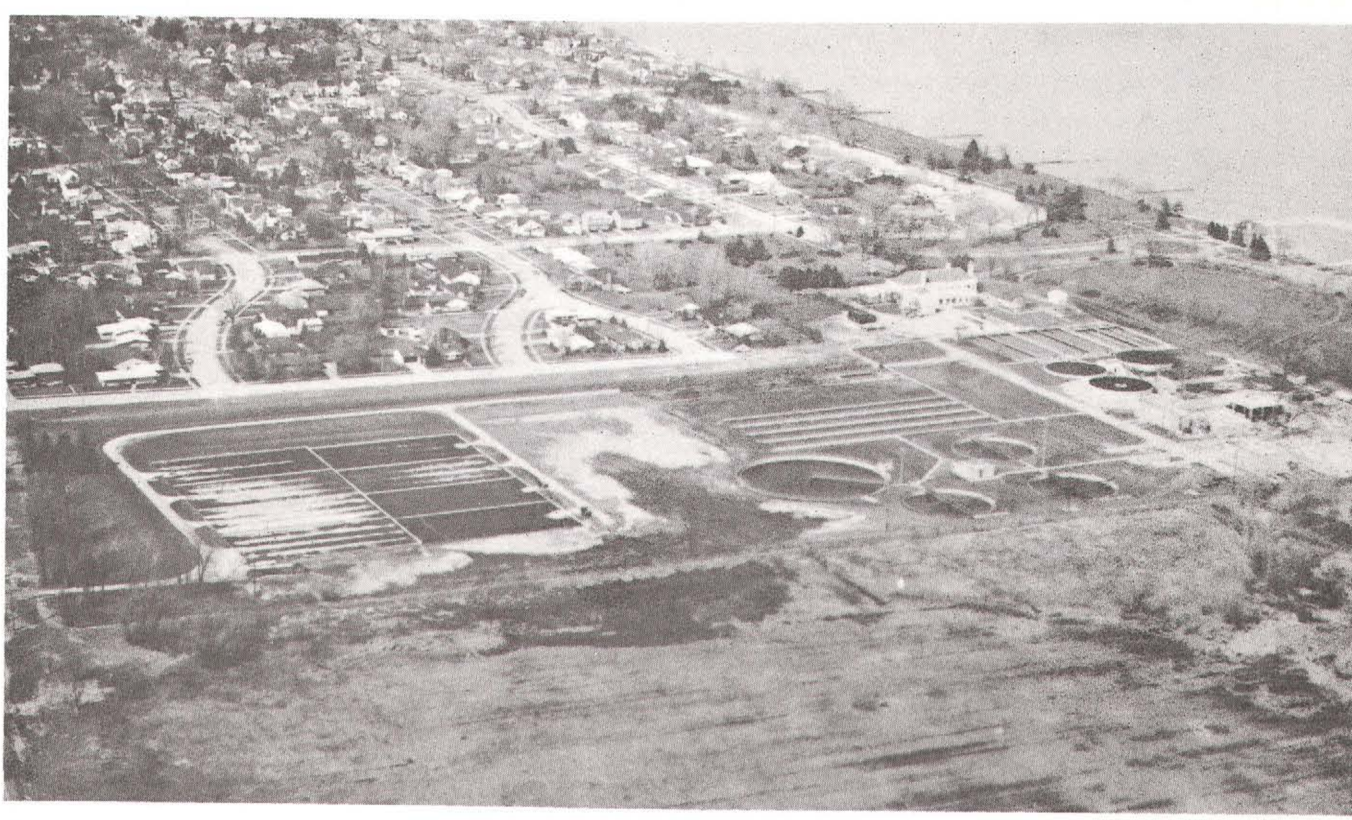


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

west, and open lands on the south. The plant was constructed in 1941 with an initial average hydraulic design capacity of 10 mgd and a primary level of sewage treatment. In 1967 the plant was expanded to an average hydraulic design capacity of 18 mgd with a secondary level of treatment. The peak hydraulic design capacity of the plant is 40 mgd. Effluent disposal is via a 1,200-foot outfall sewer to Lake Michigan.

As noted above, the City of Kenosha has begun a demonstration project to determine the feasibility of using a biological absorption process to treat combined sewer overflows at the site of the existing sewage treatment plant rather than bypass such overflows directly to Lake Michigan. A 20 mgd design capacity auxiliary treatment unit to demonstrate the feasibility of this system was put into operation in 1971. The unit provides for high-rate biological treatment of combined sewage through the utilization of activated sludge, clarification, and disinfection. Sludge is stored in a biosolids reservoir, and a contact tank and a solids stabilization tank are maintained in an empty and ready condition. During a rainfall event, sewage which normally is bypassed to Lake Michigan is directed to the contact tank and activated sludge is proportionately introduced. The tank has a 15- to 30-minute contact time. The flow is directed from the contact tank to a clarifier for solids separation. The effluent is then disinfected and discharged to Lake Michigan, with solids returned to the solids stabilization tank and thus reused or, in the alternative, wasted to the digesters. If this demonstration project should prove successful, the city would propose to construct a large intercepting sewer to eliminate all combined sewer overflows at the six outfall points along the Lake Michigan shoreline and convey such overflows to the auxiliary treatment unit, thus hopefully providing a less expensive alternative to the costly and disruptive process of complete separation of the combined sewer system.

In 1970 the average hydraulic loading on the Kenosha sewage treatment facility was 16.26 mgd, with a peak hydraulic loading of 29.15 mgd and a minimum hydraulic loading of 9.80 mgd. The peak hydraulic loading on the plant, however, does not include unmeasured flows bypassed either at flow relief points in the separate sewer system, at the six combined sewer outfall locations on Lake Michigan, or at the sewage treatment plant itself. The peak loadings occur during heavy rainfall periods and when industrial contributions to the sewerage system are high. The existing 18 mgd capacity is sufficient to adequately treat the average hydraulic loading. The biochemical oxygen demand ($CBOD_5$) loadings during 1970 ranged from about 18,700 to about 5,840 pounds per day, with an average loading of about 12,700 pounds per day. Suspended solids loadings averaged about 16,700 pounds per day, with a maximum of 55,400 and a minimum of 9,240 pounds per day. During 1970 an average of 64 percent of the suspended solids and 82 percent of the $CBOD_5$ were removed in the treatment process.

The location, configuration, and approximate capacities of all major trunk sewers comprising the City of Kenosha sanitary sewerage system are shown on Map 31. The known flow relief devices in the City of Kenosha sewerage system, consisting of six combined sewer outfalls, 20 points of crossover from the sanitary sewer system to the storm sewer system, and a bypass at the sewage treatment plant, are also shown on Map 31. The major trunk sewer extensions into the proposed future sewer service area, as documented in the previously referenced 1966 Consoer, Townsend, and Associates engineering report and the adopted comprehensive plan for the Kenosha Planning District, are also shown on Map 31.

Management of the City of Kenosha sanitary sewerage system is under the direction of the City of Kenosha Water Utility and the City Council. The Utility is governed by a six-member Board of Water Commissioners appointed by the Mayor and subject to confirmation by the City Council. In practice, all of the members of the Board of Water Commissioners are also aldermen and concurrently serve as the Public Works Committee of the Kenosha City Council. Day-to-day administration of the sanitary sewerage system is provided by the staff of the Water Pollution Control Division of the Kenosha Water Utility and the City Public Works Department.

Local financing of the City of Kenosha sanitary sewerage system is provided through a sewer service charge based upon water consumption. Water consumers currently pay a monthly sewer service charge equal to 45 percent of the monthly water charge. The contractual agreement between the Kenosha Water Utility and the Town of Somers Sanitary District No. 1 provides for a metered rate. In 1970 this rate was $150 per million gallons. By 1972 this charge had increased to $210 per million gallons. Contracts between the

Kenosha Water Utility and the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C provide for an annual fee payment per sewer connection. In 1970 this fee was $24 annually. By 1972 this fee had increased to $40 annually. Each of the special districts contracting for sewage treatment with the City of Kenosha Water Utility is responsible for the operation and maintenance of its local collection sewer system. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Kenosha sanitary sewerage system approximated $966,668, or about $12 per capita. Of this total, $378,494, or about $5 per capita, was expended for operation and maintenance and $588,174, or about $7 per capita, was expended for capital improvements.

Village of Paddock Lake: The existing service area of the Village of Paddock Lake sanitary sewerage system is shown on Map 31. This area totals about 0.79 square mile and has a resident population of about 1,500 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Paddock Lake is treated in an activated sludge type sewage treatment plant located at the northeastern village limits (see Figure 21). The plant has a site area of about six acres, of which about two acres are currently utilized, leaving nearly four acres available for future use. The remaining acreage, however, is within a natural wetland area. The plant site is bounded by residential development on the west and by agricultural and open lands on the north, south, and east. The effluent from the plant is discharged to a marsh which is drained by Brighton Creek, a tributary of the Des Plaines River. The plant was constructed in 1958 as a private utility facility by L. B. Harris and Sons, Inc., Chicago, Illinois, to serve the Paddock Lake Dells Subdivision. In 1967 ownership of the plant was assumed by the Village of Paddock Lake and the plant was expanded to provide sufficient capacity to serve the entire village. The average hydraulic design capacity of the plant is 0.40 mgd, with a peak hydraulic design capacity of 0.80 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.15 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the single major trunk sewer serving the Village of Paddock Lake is shown on Map 31. There are two known points of sewage flow relief in the system—both of which are bypasses including one at the sewage treatment plant. The inventory revealed that the village had no documented plan for the extension of trunk sewers to provide service to additional areas. Thus, no locally proposed service area or trunk sewers are shown on Map 31.

Management of the Village of Paddock Lake sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village President and the Sewer Committee of the Village Board. Operation and maintenance of the system are financed through a monthly service charge of $7 per sewer connection and a connection charge for new residences. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Paddock Lake sanitary sewerage system were not made available by the village.

Figure 21

VILLAGE OF PADDOCK LAKE
SEWAGE TREATMENT PLANT

Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

Village of Silver Lake: The existing service area of the Village of Silver Lake sanitary sewerage system is shown on Map 31. This area totals about 0.39 square mile and has a resident population of about 1,200 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Silver Lake is treated in an activated sludge type sewage treatment plant located near the southern village limits on the Fox River, to which effluent is discharged (see Figure 22). The plant has a site area of about seven acres, of which about two acres are currently utilized, leaving nearly five acres available for future use. The plant site is bounded by the Fox River and park lands on the west and by agricultural and open lands on the north, south, and east. The plant was constructed in 1966 and has an average hydraulic design capacity of 0.30 mgd, with an estimated peak hydraulic design capacity of 0.5 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.14 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains comprising the Village of Silver Lake sanitary sewerage system are shown on Map 31. There are no known points of sewer overflow or bypassing in the system. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 1.5 square mile area, which area is shown on Map 31. However, no locally proposed trunk sewers were found in the inventory.

Management of the Village of Silver Lake sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Deputy Village Clerk. Operation and maintenance of the system is financed through a monthly service charge of $5 per residential sewer connection, with the monthly charge for nonresidential connections

Figure 22

VILLAGE OF SILVER LAKE SEWAGE TREATMENT PLANT

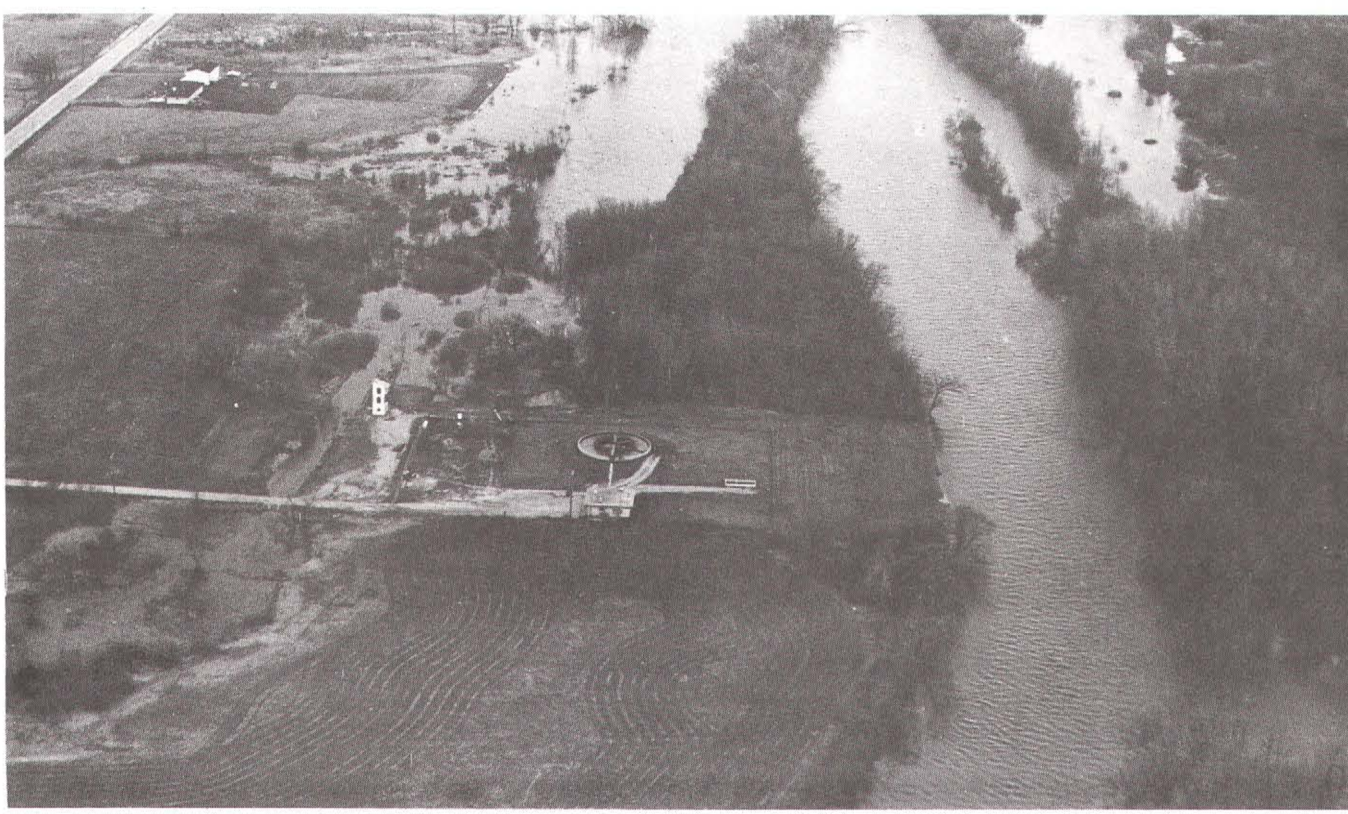


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

negotiated on a case-by-case basis. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Silver Lake sanitary sewerage system approximated $80,700, or about $67 per capita. Of this total $14,944, or about $12 per capita, was expended for operation and maintenance and $65,756, or about $55 per capita, was expended for capital improvements.

Village of Twin Lakes: The existing service area of the Village of Twin Lakes sanitary sewerage system is shown on Map 31. This area totals about 0.80 square mile and has a resident population of about 1,700 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Twin Lakes is treated at two parallel treatment facilities located at the northeastern village limits on Basset Creek, a tributary of the Fox River, to which effluent is discharged (see Figure 23). The plant has a site area of about 10 acres, of which about two acres are currently utilized, leaving eight acres available for future use. The plant site is bounded on the south by a golf course and residential development and on the east, west, and north by agricultural and open lands. The first plant, a trickling filter type, was constructed in 1958. The second plant, an activated sludge type, was constructed in 1970. The combined average hydraulic design capacity of the two plants is 0.82 mgd, with a combined peak hydraulic design capacity of 1.64 mgd. The average hydraulic loading on the combined plant in 1970 was estimated at 0.22 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided by both the trickling filter and the activated sludge plants are classified as secondary level.

Figure 23

VILLAGE OF TWIN LAKES SEWAGE TREATMENT PLANT

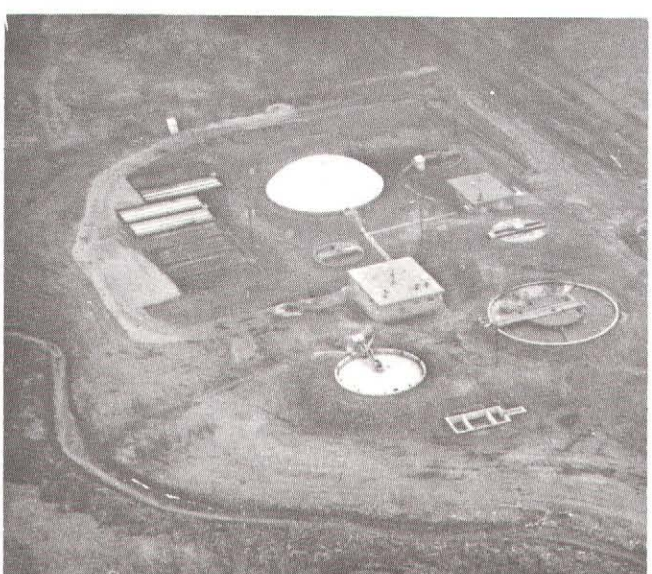


Photo by Roger R. Ross and Joseph C. Ruys.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains comprising the Village of Twin Lakes sanitary sewerage system are shown on Map 31. Except for a bypass located at the 1958 trickling filter plant, there are no known points of sewer overflow or bypassing in the system. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 2.9 square mile area, which area is shown on Map 31. Locally proposed trunk sewers to serve this additional area are also shown on Map 31.

Management of the Village of Twin Lakes sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Sewer Committee of the Village Board. Operation and maintenance of the system are financed through a monthly service charge of $6.50 per residential sewer connection, with a monthly charge for nonresidential connections negotiated on a case-by-case basis. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Twin Lakes sanitary sewerage system approximated $44,651, or about $26 per capita. Of this total $15,651, or about $9 per capita, was expended for operation and maintenance and $29,000, or about $17 per capita, was expended for capital improvements.

Town of Bristol Utility District No. 1: The existing service area of the Town of Bristol Utility District No. 1 sanitary sewerage system is shown on Map 31. This area totals 0.19 square mile and has a resident population of about 500 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Town of Bristol Utility District No. 1 is treated in an activated sludge type sewage treatment plant located at the northeastern district limits (see Figure 24). The plant has a site area of about three acres, of which about two acres are currently utilized, leaving one acre available for future use. The plant site is bounded on the west and south by residential development and on the east and north by agricultural and open lands. The effluent from the plant is discharged to an unnamed tributary of the Des Plaines River. The plant was constructed in 1965 and has an average hydraulic design capacity of 0.06 mgd, with a peak hydraulic design capacity of 0.12 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.06 mgd, indicating that the plant is currently operating at the average hydraulic design capacity. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewer, pumping station, and force main serving the Town of Bristol Utility District No. 1 are shown on Map 31. Except for a bypass located at the sewage treatment plant, there are no known points of sewer overflow or bypassing in the system. The inventory revealed that the district had a documented plan for the provision of sewer service to an additional 1.07 square mile area, which area includes the urban development encompassing George Lake and which is shown on Map 31. The proposed trunk sewers, pumping stations, and related force mains designed to serve this additional area are also shown on Map 31. To provide the capacity to serve this additional area, the district has proposed to construct an addition to the existing treatment facility in order to add an additional average hydraulic design capacity of 0.10 mgd, thus increasing the total average hydraulic design capacity of the plant to 0.16 mgd.[7]

Figure 24

TOWN OF BRISTOL UTILITY DISTRICT NO. 1
SEWAGE TREATMENT PLANT

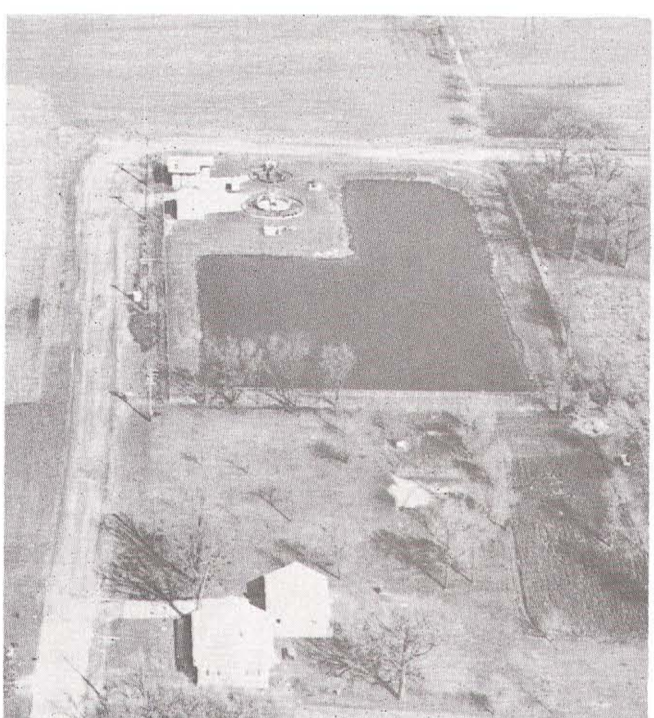


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

Management of the Town of Bristol Utility District No. 1 sanitary sewerage system is under the direction of a three-member commission. At the present time, this commission is comprised of the members of the Bristol Town Board. Day-to-day administration of the system is provided by the Chairman of the commission. Operation and maintenance of the system is financed through a monthly service charge of $8 per residential sewer connection, with industrial users charged on the basis of $8 per month for each 25 employees and schools charged on the basis of $8 per month for each 25 pupils. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Town of Bristol Utility District No. 1 sanitary sewerage system approximated $66,081, or about $132 per capita. Of this total $4,744, or about $9 per capita, was expended for operation and maintenance and $61,337, or about $123 per capita, was expended for capital improvements.

Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C: The existing service areas of the sanitary sewerage systems serving the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C are shown on Map 31. As noted above under the discussion of the City of Kenosha sanitary sewerage system, these five districts contract with the Kenosha Water Utility for sewage treatment. Taken together, the service areas of these five districts total about 1.04 square miles and have a resident population of about 3,700 persons. All

[7] *This addition to the Town of Bristol Utility District No. 1 sewage treatment plant was completed and put into operation in 1972.*

five areas are served by separate sanitary sewer systems. There are no known points of sewer overflow or bypassing in these systems.

Management of the five utility districts is under the direction of the Town Board. Contracts between the Kenosha Water Utility and these five districts provide for an annual flat fee payment per sewer connection. In 1970 this fee was $24 annually. By 1972 this fee had increased to $40 annually. In addition, an annual charge per sewer connection to cover the cost of the maintenance of the local collection sewer systems within the five districts is added to the above fee. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the sanitary sewerage systems serving the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C approximated $86,183, or about $23 per capita. Of this total $34,418, or about $9 per capita, was expended for operation and maintenance and $51,765, or about $14 per capita, was expended for capital improvements.

Town of Pleasant Prairie Sewer Utility District D: The existing service area of the Town of Pleasant Prairie Sewer Utility District D sanitary sewerage system is shown on Map 31. This area totals about 0.59 square mile and has a resident population of about 800 persons. The entire area is serviced by a separate sanitary sewer system.

Sewage from the Town of Pleasant Prairie Sewer Utility District D is treated in an activated sludge type sewage treatment plant located in the southeastern portion of the district (see Figure 25). The plant has a site area of about nine acres, of which about seven acres are currently utilized, leaving two acres available for future use. The plant site is bounded on the north by residential development and on the west, south, and east by agricultural and open lands. The effluent from the plant is discharged to an unnamed tributary of the Des Plaines River. The plant was constructed in 1966 and has an average hydraulic design capacity of 0.13 mgd, with a peak hydraulic design capacity of 0.25 mgd. The average hydraulic loading on the plant in 1970 was 0.09 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains comprising the Town of Pleasant Prairie Sewer Utility District D sanitary sewerage

Figure 25

TOWN OF PLEASANT PRAIRIE SEWER UTILITY DISTRICT D SEWAGE TREATMENT PLANT

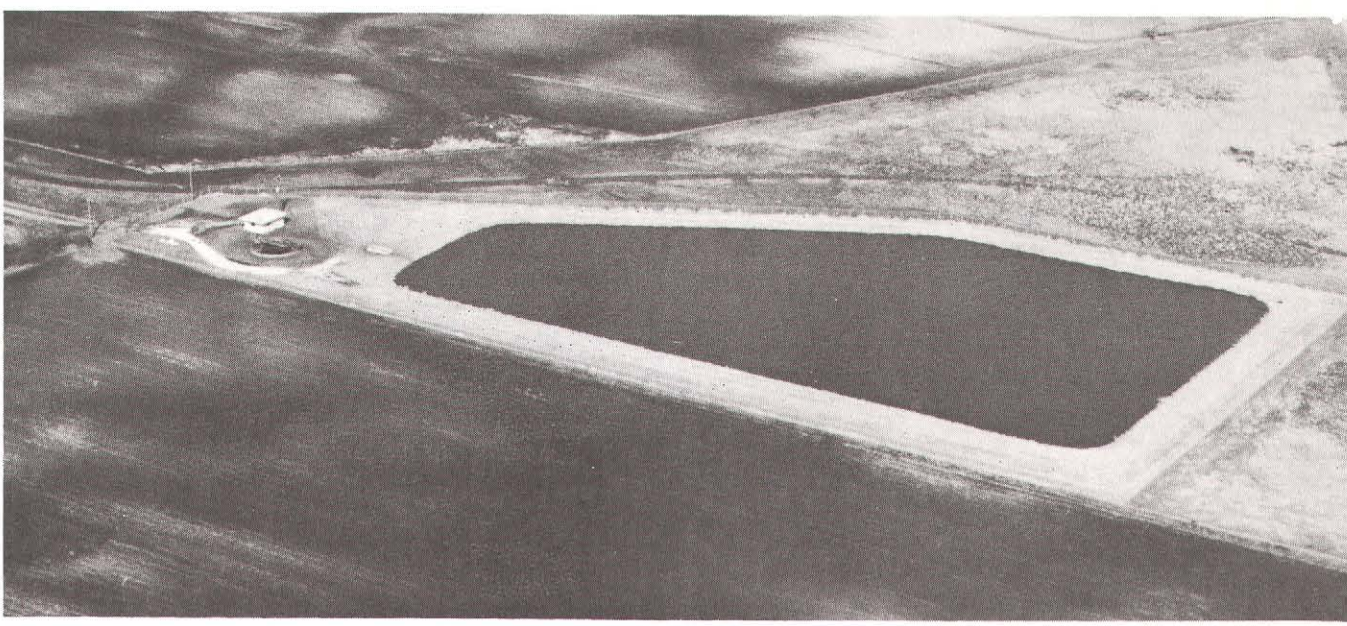


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

system are shown on Map 31. Except for a bypass located at the sewage treatment plant, there are no known points of sewer overflow or bypassing in the system. The area proposed for expansion by 1990 in the comprehensive plan for the Kenosha Planning District within this special-purpose utility district is shown on Map 31. This future sanitary sewer service area totals about 1.44 square miles. The comprehensive plan for the Kenosha Planning District, however, contains no proposed new trunk sewers to serve this expanded area.

Management of the Town of Pleasant Prairie Sewer Utility District D sanitary sewerage system is under the direction of the Town Board. Day-to-day administration of the system is provided by the Town Clerk. Operation and maintenance of the system is financed through a monthly service charge of $6 per residential sewer connection, with industrial users charged on the basis of $6 per month for each 10 employees. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Town of Pleasant Prairie Sewer Utility District D sanitary sewerage system approximated $45,315, or about $57 per capita. Of this total $10,071, or about $13 per capita, was expended for operation and maintenance and $35,244, or about $44 per capita, was expended for capital improvements.

Pleasant Park Utility Company, Inc.: The Pleasant Park Utility Company, Inc. is a privately owned and operated sanitary sewerage utility. Not unlike a town sanitary district, it serves a significant concentration of urban development in the Town of Pleasant Prairie and for inventory purposes has been regarded herein as a public system. The existing service area of the Pleasant Park Utility Company, Inc. sanitary sewerage system is shown on Map 31. This area totals about 0.21 square mile and has a resident population of about 800 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Pleasant Park Utility Company, Inc. is treated in an activated sludge type sewage treatment plant located at the southeastern limits of the service area (see Figure 26). The plant has a site area of about 19 acres, of which about two acres are currently utilized. The plant site is bounded on the north by residential development and on the east, west, and south by agricultural and open lands. The effluent from the plant is discharged to an unnamed stream draining directly to Lake Michigan. The plant was constructed in 1960 and has an average hydraulic design capacity of 0.06 mgd. No data for the peak hydraulic design capacity are available. The average hydraulic loading on the plant in 1970 was estimated at 0.05 mgd, indicating that the plant is currently operating near the average hydraulic

Figure 26

PLEASANT PARK UTILITY COMPANY, INC. SEWAGE TREATMENT PLANT

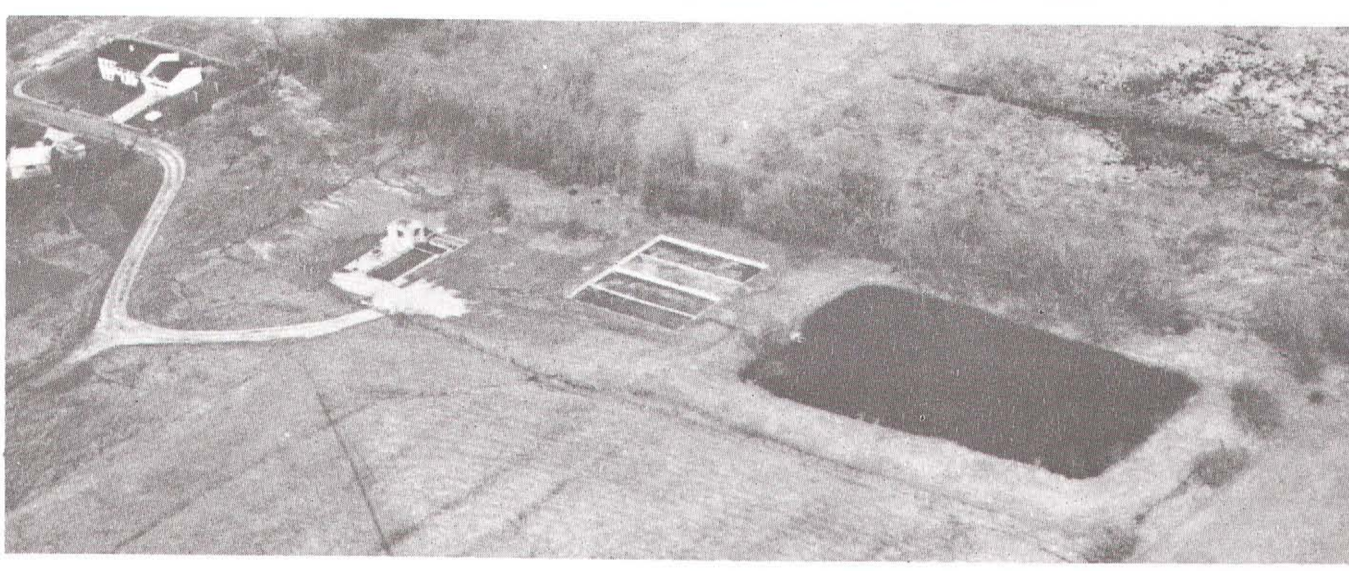


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

design capacity. The treatment processes provided at the plant are classified as secondary level. The comprehensive plan for the Kenosha Planning District recommends that this sewage treatment facility be ultimately abandoned as trunk sewer service is extended from the City of Kenosha sanitary sewerage system.

The location and configuration of the single trunk sewer serving the Pleasant Park Utility Company, Inc. sanitary sewerage system are shown on Map 31. There are no data available to determine whether or not there are any points of sewage flow relief in this system. Records of the Wisconsin Department of Natural Resources, however, do indicate a significant clear water problem in the system. Since the service area of the Pleasant Park Utility Company, Inc. is completely encompassed by the future service area of the Kenosha sanitary sewerage system, no future service area or proposed trunk sewers for the Pleasant Park Utility Company, Inc. are shown on Map 31.

Management of the Pleasant Park Utility Company, Inc. is provided by the officers of the private corporation. Day-to-day administration of the system is provided by the president of the corporation. Operation and maintenance of the system are financed through a monthly service charge of $3 per residential sewer connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Pleasant Park Utility Company, Inc. sanitary sewerage system approximated $3,865, or about $5 per capita. Of this total $2,230, or about $3 per capita, was expended for operation and maintenance and $1,635, or about $2 per capita, was expended for capital improvements.

Town of Salem Sewer Utility District No. 1: The existing service area of the Town of Salem Sewer Utility District No. 1 sanitary sewerage system is shown on Map 31. This area, which nearly encompasses Hooker Lake, totals about 0.38 square mile and has a resident population of about 800 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Town of Salem Sewer Utility District No. 1 is treated in an activated sludge type sewage treatment plant located near the northeastern district limits (see Figure 27). The plant has a site area of about 14 acres, all of which are currently utilized. The plant site is bounded on the south by residential development and on the east, west, and north by agricultural and open lands. The effluent from the plant is discharged to the Salem Branch of Brighton Creek, a tributary of the Des Plaines River. The plant was constructed in 1968 and has an average hydraulic design capacity of 0.30 mgd, with a peak hydraulic design capacity of 0.60 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.05 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Town of Salem Sewer Utility District No. 1 sanitary sewerage system are shown on Map 31. There are no known points of sewer overflow or bypassing in the system. The inventory revealed that the district had a documented plan for the provision of sewer service to an additional 1.8 square mile area, which includes the urban development encompassing Montgomery Lake, and which is shown on Map 31. However, no locally proposed trunk sewers were found in the inventory.

Management of the Town of Salem Sewer Utility District No. 1 sanitary sewerage system is under the direction of a three-member commission. At the present time, this commission is comprised of the members of the Salem Town Board. Day-to-day administration of the system is also provided directly by the Town Board. Operation and maintenance of the system is financed through a monthly service charge of $10 per residential sewer connection and $20 per commercial sewer connection. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Town of Salem Sewer Utility District No. 1 sanitary sewerage system were not made available by the district.

Town of Somers Sanitary District No. 1: The existing service area of the Town of Somers Sanitary District No. 1 sanitary sewerage system is shown on Map 31. This area totals about 0.89 square mile and has a resident population of about 1,700 persons. The entire area is served by a separate sanitary sewer system. As noted above under the discussion of the City of Kenosha sanitary sewer system, the Town of Somers Sani-

Figure 27

TOWN OF SALEM SEWER UTILITY DISTRICT NO. 1 SEWAGE TREATMENT PLANT

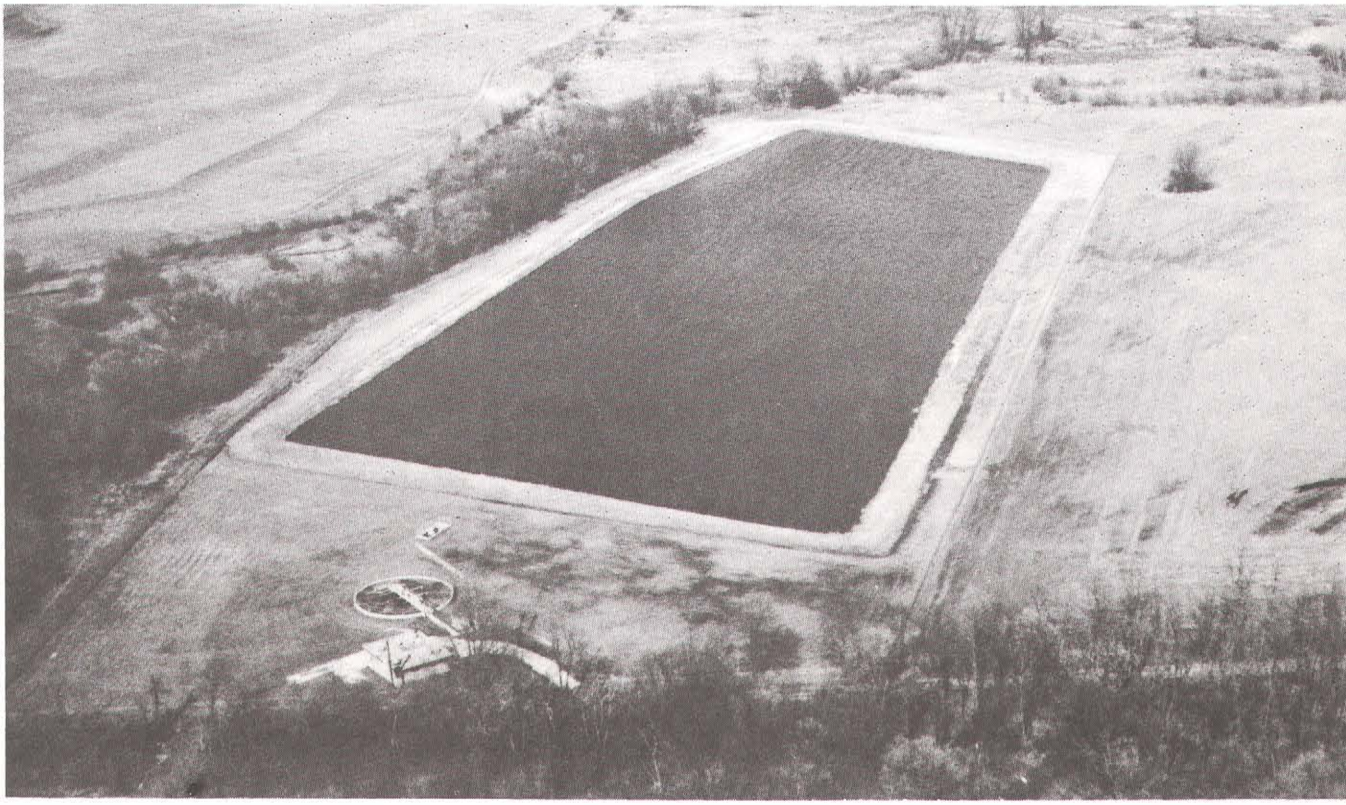


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

tary District No. 1 contracts with the Kenosha Water Utility for sewage treatment. There are no known points of sewer overflow or bypassing within the system.

Management of the Town of Somers Sanitary District No. 1 sanitary sewerage system is under the direction of a three-member commission. The contract between the Kenosha Water Utility and the district provides for a metered rate. In 1970 this rate was $150 per million gallons. By 1972 this charge had increased to $210 per million gallons. The district itself is responsible for the operation and maintenance of the local collection sewer system within the district. Financing of the Town of Somers Sanitary District No. 1 sanitary sewerage system is provided in part through a sewer service charge and in part through the local property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Town of Somers Sanitary District No. 1 sanitary sewerage system approximated $59,257, or about $35 per capita. Of this total $22,894, or about $13 per capita, was expended for operation and maintenance and $36,363, or about $22 per capita, was expended for capital improvements.

Town of Somers Sanitary District No. 2: The existing service area of the Town of Somers Sanitary District No. 2 sanitary sewerage system is shown on Map 31. This area totals about 0.16 square mile and has a resident population of about 400 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Town of Somers Sanitary District No. 2 is treated in an activated sludge type sewage treatment plant located at the northeastern district limits (see Figure 28). The plant has a site area of about 1.5 acres, of which about one acre is currently utilized. The plant site is bounded on the south by residential development and on the north, east, and west by agricultural and open lands. The effluent from the plant is discharged to the Somers Branch of the Pike River. The plant was constructed in 1963 and has an average hydraulic design capacity of 0.03 mgd, with a peak

Figure 28

TOWN OF SOMERS SANITARY DISTRICT NO. 2
SEWAGE TREATMENT PLANT

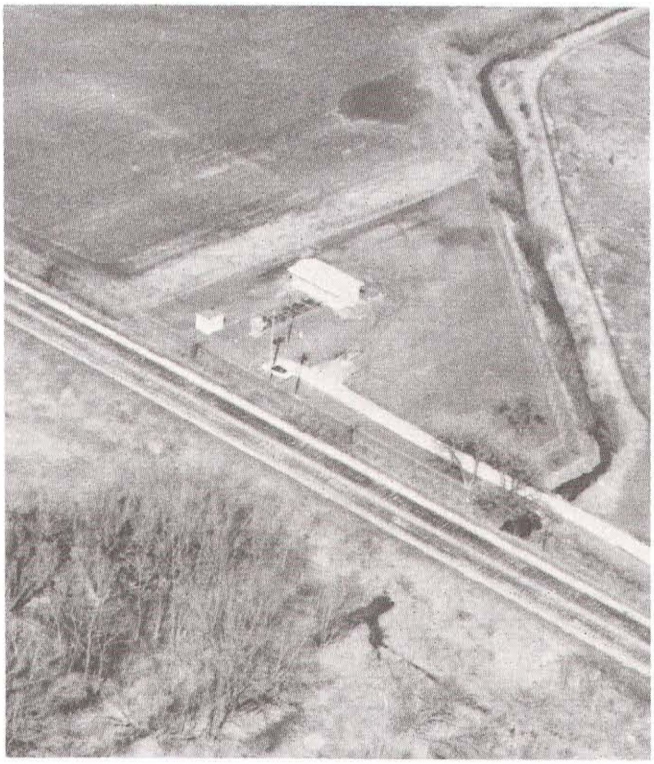


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

hydraulic design capacity of 0.05 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.03 mgd, indicating that the plant is currently operating at the average hydraulic design capacity. The treatment processes provided at the plant are classified as secondary level. The comprehensive plan for the Kenosha Planning District recommends that this sewage treatment facility be abandoned and its sewer service area connected to the City of Kenosha sanitary sewerage system as trunk sewer service becomes available.

The location and configuration of the single major trunk sewer serving the Town of Somers Sanitary District No. 2 are shown on Map 31. Except for a bypass located at the sewage treatment plant, there are no known points of sewer overflow or bypassing in the system. Since the comprehensive plan for the Kenosha Planning District recommends the eventual abandonment of this plant, there is no future service area or proposed trunk sewers shown on Map 31, other than that area and those sewers proposed for expansion of the City of Kenosha sanitary sewerage system.

Management of the Town of Somers Sanitary District No. 2 sanitary sewerage system is under the direction of a three-member commission. Day-to-day administration of the system is also provided directly by the commissioners. Operation and maintenance of the system is financed in part through a monthly service charge of $6 per residential sewer connection and in part through the property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Town of Somers Sanitary District No. 2 sanitary sewerage system approximated $9,094, or about $23 per capita. Of this total $3,318, or about $8 per capita, was expended for operation and maintenance and $5,776, or about $15 per capita, was expended for capital improvements.

Proposed Public Sanitary Sewerage Systems

The inventory revealed that as of 1970 there were two proposed public sanitary sewerage systems in Kenosha County which would provide centralized sanitary sewer service to subareas of the county. These two proposed systems include a utility district to serve a portion of the Town of Bristol and a utility district to serve a portion of the Town of Salem. Together these two proposed systems would serve a total area of about 14.0 square miles, or about 5 percent of the total area of the county, and a total existing population of about 3,900, or about 3 percent of the total population of the county. Each of these two proposed public sanitary sewerage systems is described in the following paragraphs.

Town of Bristol Proposed Utility District: The proposed service area of a second sewer utility district in the Town of Bristol is shown on Map 31. This area totals about 0.9 square mile and has a current resident population of less than 100 persons. The proposed system would serve existing and proposed urban land uses along IH 94 from STH 50 to CTH C, including an existing motel and restaurant complex, gasoline service stations, and a major truck terminal facility. At the present time, the motel and restaurant complex and one of the gasoline service stations are served by a private sewage treatment facility.

The treatment plant to serve this proposed sewer utility district in the Town of Bristol is proposed to be located on a site adjacent to the Des Plaines

River, to which it would discharge sewage effluent. The proposed sewage treatment facility would have an average hydraulic design capacity of 0.21 mgd and a peak hydraulic design capacity of about 0.5 mgd, and would be an activated sludge type sewage treatment plant providing a secondary level of treatment. This proposal includes the establishment of a new Town of Bristol sewer utility district to provide management, administration, and financing for this proposed public sanitary sewerage system.

Town of Salem Sewer Utility District No. 2: A second sewer utility district has been formed in the Town of Salem for the purpose of providing sanitary sewer service to existing and proposed urban development in the town, including urban development on the shores of Camp Lake, Center Lake, Rock Lake, Cross Lake, Bennett Lake, Voltz Lake, and Shangrila Lake and in the unincorporated place of Wilmot. This proposed service area totals about 13.2 square miles and would serve an existing resident population of about 3,800 persons.

The proposed sewage treatment facility would be located on a site southwest of Camp Lake and would discharge its effluent into the Fox River below Wilmot. The plant would be an activated sludge type and would provide a secondary level of treatment. Detailed design data for the plant are not yet available. This proposal represents a locally proposed expansion of the recommendation contained in the Fox River watershed plan to provide sanitary sewer service to the urban development located along shores of Camp and Center Lakes.

Other Sewage Treatment Facilities

In addition to the 15 public sanitary sewerage systems discussed above, there are a total of six sewage treatment facilities in Kenosha County which serve, in most cases, a single isolated land use enclave. These six sewage treatment facilities serve the Howard Johnson Motor Lodge at the intersection of IH 94 and STH 50 in the Town of Bristol; the Paramski Mobile Home Park located near the intersection of STH 45 and the Wisconsin-Illinois state line in the Town of Bristol; the Siennadale Motherhouse located near the unincorporated place of South Kenosha in the Town of Pleasant Prairie; the Wisconsin Tourist Information Center located at the intersection of IH 94 and CTH V in the Town of Pleasant Prairie; the American Motors Corporation truck service facility located at the intersection of STH 158 and STH 192 in the Town of Somers; and the Brightondale County Park located on a portion of the abandoned Bong Air Force Base in the Town of Brighton. Pertinent characteristics pertaining to each of these six sewage treatment facilities are presented in Table 21.

It should be noted that of the foregoing six sewage treatment facilities serving single land uses, two—the Siennadale Motherhouse and the American Motors Corporation truck service facility—lie within the planned service area of the City of Kenosha sanitary sewerage system and one—the Howard Johnson Motor Lodge facility—lies within the proposed service area of the Town of Bristol Utility District, and are subject to future abandonment upon completion of the necessary trunk sewer extensions.

Table 21

SELECTED CHARACTERISTICS OF PRIVATE SEWAGE TREATMENT FACILITIES IN KENOSHA COUNTY: 1970

Name	Civil Division Location	Type of Land Use Served	Type of Treatment Provided	Average Hydraulic Design Capacity (Gallons/Day)	Disposal of Effluent
American Motors Corporation Truck Service Facility	Town of Somers	Industrial	Activated Sludge and Sand Filter	2,000	Soil Absorption
Brightondale County Park[1]	Town of Brighton	Recreational	Activated Sludge and Flow-through Lagoon	10,000	Brighton Creek
Howard Johnson Motor Lodge	Town of Bristol	Commercial	Activated Sludge and Flow-through Lagoon	18,300	Des Plaines River
Paramski Mobile Home Park	Town of Bristol	Residential	Activated Sludge and Seepage Lagoon	40,000	Soil Absorption
Sienadale Motherhouse	Town of Pleasant Prairie	Institutional	Activated Sludge and Seepage Lagoon	3,200	Soil Absorption
Wisconsin Tourist Information Center	Town of Pleasant Prairie	Institutional	Imhoff Tank and Flow-through Lagoon	9,950	Des Plaines River

[1]This facility constructed since 1970.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 22

KNOWN EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN KENOSHA COUNTY: 1970

Point Source[1]		Civil Division Location	Type of Waste	Known Pretreatment	Receiving Water Body
Number[2]	Name				
1	American Motors Corporation	City of Kenosha	Industrial and Cooling Water	- -	Pike Creek
2	American Motors Corporation	City of Kenosha	Industrial and Cooling Water	- -	Lake Michigan
3	Anaconda American Brass Company	City of Kenosha	Rinse and Cooling Water	Copper ion Removal	Lake Michigan
4	Kenosha Water Treatment Plant	City of Kenosha	Waste Water Sludge	Sedimentation	Lake Michigan
5	Pilgrim Farms	Town of Somers	Canning Wastes	Lagoons	Pike River

[1]As identified in Wisconsin Department of Natural Resources river basin survey reports and pollution abatement orders and by selected municipal public works departments; does not include industrial waste sources discharging to municipal sanitary sewerage systems.
[2]See Map 32.

Source: SEWRPC.

Other Known Point Sources of Waste Water

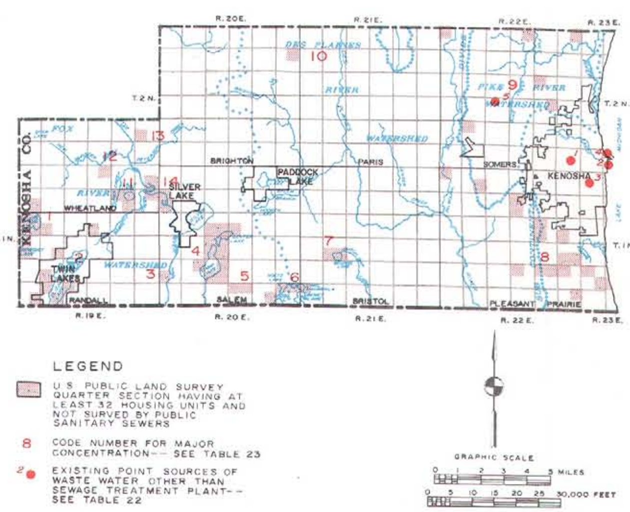
In addition to identifying all existing public and private sewage treatment plants which discharge treated wastes to streams and watercourses within the Region, and all known sewage overflow points on both the existing sanitary and combined sewerage systems within the Region which discharge untreated wastes to streams and watercourses, an attempt was made in the regional sanitary sewerage system planning program to identify, through existing secondary sources, all other known point sources of waste water discharge. These other point sources of pollution consist primarily of industrial cooling, rinse, and wash waters, which may be discharged directly and without treatment to streams and watercourses or to storm sewers tributary to such streams and watercourses. The secondary sources consulted included river basin survey reports and pollution abatement orders of the Wisconsin Department of Natural Resources and records of municipal public works departments. Five such known point sources of industrial waste water were identified in Kenosha County. The name, civil division location, type of waste, known pretreatment, and receiving water body of these five waste sources are identified in Table 22. The location of these five point sources is shown on Map 32.

Existing Urban Development Not Served by Public Sanitary Sewers

As noted earlier, public sanitary sewerage systems in Kenosha County serve a total area of about 24 square miles, or about 9 percent of the total area of the county, and a total population of about 94,000, or about 80 percent of the total population of the county. An inventory was conducted in the study to determine the approximate amount of urban development, and the population residing

Map 32

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS AND EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN KENOSHA COUNTY: 1970



Significant concentrations of unsewered urban development in Kenosha County, as shown on this map, are of two types. The first type consists of noncontiguous residential land subdivisions located in the Towns of Pleasant Prairie and Somers representing "leapfrog" urban development in the Kenosha urban area. The second type consists of both seasonal and year-round recreation oriented homes in the western portion of the county located primarily along lakeshores. It is interesting to note that the Town of Paris has no significant concentrations of unsewered urban development. This map also shows the location of the five additional known point sources of surface water pollution other than sewage treatment plants in Kenosha County, all of which are located east of IH 94.

Source: Wisconsin Department of Natural Resources and SEWRPC.

therein, in Kenosha County not served in 1970 by public sanitary sewer service. Each U. S. Public Land Survey quarter section not having development served by centralized sanitary sewerage system was examined to determine if a significant amount of urban development was present in 1970. Any quarter section with at least 32 housing units, or an average of one housing unit per five gross acres, was deemed to be urban. The major purpose in identifying such concentrations of urban development was to provide a basis for analyzing the potential of providing public sanitary sewer service to such areas in accordance with recommendations contained in the adopted regional land use plan.

The nonsewered urban development areas identified in Kenosha County are shown on Map 32. Together these areas total about 5.6 square miles, or 2 percent of the total area of the county, and contain a total population of about 11,800, or 10 percent of the total population of the county. For analysis purposes, the existing nonsewered urban development has been combined into 14 named major urban concentrations. The estimated population and urban development areas in each of these major concentrations are shown in Table 23.

Concluding Remarks—Kenosha County

Inventories conducted under the regional sanitary sewerage system planning program revealed that in 1970 there existed in Kenosha County a total of 15 public sanitary sewerage systems which together served a total area of about 24 square miles, or about 9 percent of the total area of the county, and a total population of about 94,000, or about 80 percent of the total population of the county. Nine sewage treatment facilities provide treatment for sewage generated in these 15 public sanitary sewerage systems. Six of the 15 systems are operated by small special-purpose districts in the Towns of Somers and Pleasant Prairie which contract with the City of Kenosha for sewage treatment service. In addition to the 15 public sanitary sewerage systems, an additional six sewage treatment facilities serving primarily single land uses, such as motels and institutions, were found in the inventory. The inventory revealed that as of 1970 there were two proposed public sanitary sewerage systems, one each in the Town of Bristol and the Town of Salem. Finally, in 1970 there were an estimated 11,800 persons residing in urban areas in Kenosha County not served by public sanitary sewer service. Together these areas totaled about 5.6 square miles.

Table 23

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN KENOSHA COUNTY BY MAJOR URBAN CONCENTRATION: 1970

Major Urban Concentration[1] Number[2]	Name	Estimated Resident Population	Developed Urban Area (Acres)
1	Powers, Tombeau, Benedict Lake Area	700	417
2	Village of Twin Lakes	800	306
3	Wilmot	300	88
4	Camp and Center Lake Area	1,600	604
5	Rock Lake Area	400	65
6	Voltz, Cross, and Shrangila Lake Area	1,000	300
7	George Lake	300	92
8	Town of Pleasant Prairie	4,100	1,137
9	Town of Somers	1,100	217
10	Town of Brighton - Section 12	300	13
11	Lilly Lake	300	126
12	New Munster	100	38
13	Town of Wheatland - Section 25	200	20
14	Oakwood Shores Area	600	190
	Kenosha County Total	11,800	3,613[3]

[1]Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.
[2]See Map 32.
[3]Equal to 5.6 square miles.
Source: SEWRPC.

INVENTORY FINDINGS—MILWAUKEE COUNTY

Existing Public Sanitary Sewerage Systems

Sanitary sewer service in Milwaukee County is provided by a combination of a metropolitan and a number of local sewerage systems. There are 22 systems, including those operated by the Metropolitan Sewerage Commission of the County of Milwaukee and the Sewerage Commission of the City of Milwaukee; the Cities of Cudahy, Franklin, Glendale, Greenfield, Milwaukee, Oak Creek, South Milwaukee, St. Francis, Wauwatosa, and West Allis; the Villages of Bayside, Brown Deer, Fox Point, Greendale, Hales Corners, River Hills, Shorewood, West Milwaukee, and Whitefish Bay; the Mission Hills Water and Sewer Trust in the City of Franklin; and the Rawson Homes Sewer and Water Trust in the City of Franklin. Together, these systems serve a total area of about 179 square miles, or about 74 percent of the total area of the county, and a total population of about 1.03 million, or about 98 percent of the total population of the county. Each of these public sanitary sewerage systems is described in the following paragraphs. Pertinent characteristics of each system are presented in Tables 24, 25, and 26.

Milwaukee-Metropolitan Sewerage Commissions: The Sewerage Commission of the City of Milwaukee, which was established pursuant to Chapter 608, Laws of Wisconsin 1913, and the Metropoli-

Table 24

AREA AND POPULATION SERVED BY EXISTING AND LOCALLY PROPOSED PUBLIC SANITARY SEWERAGE SYSTEMS IN MILWAUKEE COUNTY: 1970

Name of Public Sanitary Sewerage System	Estimated Service Area: Existing Acres	Existing Square Miles	Proposed[1] Acres	Proposed[1] Square Miles	Estimated Population Served[2]	Treatment of Sewage (See Table 25)
Existing Systems						
City of Cudahy	3,053	4.77	- -	- -	22,000	Part of Milwaukee-Metropolitan Sewerage District
City of Franklin	4,917	7.68	12,794	19.99	2,600	Part of Milwaukee-Metropolitan Sewerage District
City of Glendale	3,795	5.93	- -	- -	18,700	Part of Milwaukee-Metropolitan Sewerage District
City of Greenfield	5,102	7.97	2,630	4.11	21,800	Part of Milwaukee-Metropolitan Sewerage District
City of Milwaukee	56,205	87.82	5,207	8.14	703,700	Part of Milwaukee-Metropolitan Sewerage District
City of Oak Creek						
Area Connected to Metropolitan District	4,363	6.82	13,658	21.34	9,800	Part of Milwaukee-Metropolitan Sewerage District
Oak View Subdivision	156	0.25	- -	- -	800	Operates a Temporary Facility
City of South Milwaukee	2,992	4.68	- -	- -	23,300	Operates a Facility
City of St. Francis	1,638	2.56	- -	- -	11,200	Part of Milwaukee-Metropolitan Sewerage District
City of Wauwatosa	8,467	13.23	- -	- -	59,500	Part of Milwaukee-Metropolitan Sewerage District
City of West Allis	7,219	11.28	61	0.10	78,200	Part of Milwaukee-Metropolitan Sewerage District
Village of Bayside	1,478[3]	2.31	- -	- -	3,900	Part of Milwaukee-Metropolitan Sewerage District
Village of Brown Deer	2,797	4.37	- -	- -	12,500	Part of Milwaukee-Metropolitan Sewerage District
Village of Fox Point	1,837	2.87	- -	- -	8,600	Part of Milwaukee-Metropolitan Sewerage District
Village of Greendale	2,429	3.80	1,120	1.75	14,700	Part of Milwaukee-Metropolitan Sewerage District
Village of Hales Corners	1,232	1.92	826	1.29	7,300	Part of Milwaukee-Metropolitan Sewerage District
Village of River Hills	3,405	5.32	- -	- -	1,900	Part of Milwaukee-Metropolitan Sewerage District
Village of Shorewood	1,011	1.58	- -	- -	12,600	Part of Milwaukee-Metropolitan Sewerage District
Village of West Milwaukee	710	1.11	- -	- -	5,600	Part of Milwaukee-Metropolitan Sewerage District
Village of Whitefish Bay	1,357	2.12	- -	- -	14,900	Part of Milwaukee-Metropolitan Sewerage District
Mission Hills Water and Sewer Trust	306	0.48	- -	- -	500	Operates a Facility
Rawson Homes Sewer and Water Trust	80	0.13	- -	- -	600	Operates a Facility
Proposed Systems None	- -	- -	- -	- -	- -	- -
County Total	114,549	179.00	36,296	56.72	1,034,700	- -

[1]As identified in locally prepared plans and engineering reports.
[2]Based upon an approximation of the existing sewer service area by U.S. Public Land Survey quarter section.
[3]Does not include 58 acres located in Ozaukee County.
Source: SEWRPC.

tan Sewerage Commission of the County of Milwaukee, which was established pursuant to the provisions of Section 59.96 of the Wisconsin Statutes, together act as agents for the Metropolitan Sewerage District of the County of Milwaukee.[8] This District, as a special purpose areawide unit of government, was established pursuant to and operates under the provisions of Section 59.96 of the Wisconsin Statutes. The Metropolitan Sewerage Commission has the power to plan and construct main sewers; pumping and temporary disposal facilities for the collection and transmission of domestic, industrial, and other sanitary sewage to and into the intercepting sewers of the District; and may improve any watercourse within the District by deepending, widening, or otherwise changing the same where, in the judgment of the Commission, it may be necessary in order to carry off surface or drainage waters. The Metropolitan Sewerage Commission, however, may only exercise its powers within the District and outside of the City of Milwaukee. The Sewerage Commission of the City of Milwaukee, on the other hand, is empowered to construct, operate, and maintain treatment facilities and main and intercepting sewers within its jurisdictional area, which is the City of Milwaukee. The Sewerage Commission of the City of Milwaukee also may improve watercourses within the City of Milwaukee.

In order to coordinate the activities of the two Commissions, the Wisconsin Statutes provide that the Metropolitan Sewerage Commission must secure the approval of the Sewerage Commission of the City of Milwaukee before it is empowered to engage in any work and, when it has completed the work it proposes to do, it then conveys title to the facilities to the Sewerage Commission of the City of Milwaukee for operation and maintenance. In addition, the Rules of the Sewerage Commissions adopted pursuant to State Statutes further require that all towns, cities, and villages lying within the

---

[8]*For a brief summary of the historical development of the Milwaukee-Metropolitan sewerage system, see SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume One, Inventory Findings and Forecasts, December 1970, pp. 215-218.*

Table 25

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN MILWAUKEE COUNTY: 1970

Name of Public Sewage Treatment Facility	Estimated Total Area Served (Square Miles)	Estimated Total Population Served	Date of Original Construction and Major Modification	Type of Treatment Provided	Level of Treatment Provided	Disposal of Effluent	Design Capacity: Population[1]	Design Capacity: Average Hydraulic (MGD)	Design Capacity: Peak Hydraulic (MGD)	Design Capacity: Average Organic (Pounds $CBOD_5$/Day)	Design Capacity: Population Equivalent[1]
Milwaukee-Metropolitan Sewerage Commissions											
Jones Island Plant	192.53	1,033,900	1925, 1935, 1969, 1970	Activated Sludge	Advanced	Lake Michigan	N/A	200.00	300.00	422,000	2,000,000
South Shore Plant			1969	Sedimentation	Primary	Lake Michigan	N/A	120.00	320.00	N/A	N/A
Hales Corners Plant	1.92	7,300	1941, 1958	Trickling Filter	Secondary	Root River	8,000	0.90	N/A	1,333	6,350
City of Oak Creek (Oakview Subdivision)[2]	0.25	800	1955	Stabilization Pond	Secondary	Minor Tributary to Lake Michigan	1,500	0.20	N/A	N/A	N/A
City of South Milwaukee	4.68	23,300	1937, 1950, 1962	Sedimentation	Primary	Lake Michigan	18,000	3.00	6.00	N/A	N/A
Mission Hills Water and Sewer Trust	0.48	500	1968	Activated Sludge	Secondary	Minor Tributary to Root River	N/A	0.33	N/A	118	560
Rawson Homes Sewer and Water Trust	0.13	600	1954	Activated Sludge	Secondary	Minor Tributary to Root River	402	0.04	N/A	67	320

Name of Public Sewage Treatment Facility	Existing Loading – 1970: Average Hydraulic (MGD)	Average Per Capita (GPD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Reserve Hydraulic Capacity (MGD)	Sewage Strength Parameters in Influent Sewage: $CBOD_5$ (mg/1)	Suspended Solids (mg/1)	Total Phosphorus (mg/1)	Organic Nitrogen-N (mg/1)	Ammonia Nitrogen-N (mg/1)	Industrial Flows: Design Average Daily Flow (MGD)	Estimated Daily Flow 1970 (MGD)	Overall Plant Efficiency Percent Removals: $CBOD_5$ (Percent)	Suspended Solids (Percent)	Total Phosphorus (P) (Percent)	Number of Days in 1970 Plant Flow Exceeded Plant Meter Capacity
Milwaukee-Metropolitan Sewerage Commissions																
Jones Island Plant	169.60	183	223	296,300	30.40	209	207	8.2	N/A	N/A	N/A	N/A	93	90	87	N/A
South Shore Plant	19.30		25	57,400	100.70	362[3]	494[3]	N/A	N/A	N/A	N/A	5[3]	42[3]	75[3]	N/A	None
Hales Corners Plant	0.80	110	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
City of Oak Creek (Oakview Subdivision)[2]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
City of South Milwaukee	3.80	163	5.4	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mission Hills Water and Sewer Trust	0.04	80	N/A	N/A	0.29	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Rawson Homes Sewer and Water Trust	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: N/A indicates data not available.

[1]The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design $CBOD_5$ loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of $CBOD_5$ per day. If the design engineer assumed a different daily per capita contribution of $CBOD_5$, the population equivalent design capacity will differ from the population design capacity shown in the Table.

[2]This plant was abandoned in November 1971 and its tributary service area connected to the Milwaukee-metropolitan sewerage system.

[3]Digester supernatant is added to the influent sewage prior to sampling.

Source: Wisconsin Department of Natural Resources and SEWRPC.

District or under service agreements with the District submit local sewerage system and construction plans for approval to the Sewerage Commission of the City of Milwaukee before they may connect to the main and intercepting sewers owned by the District. The two Commissions have the power to promulgate and enforce reasonable rules for the supervision, protection, management, and utilization of the entire sewerage system. For the purposes of this report, the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee will be hereinafter referred to as the "Milwaukee-Metropolitan Sewerage Commissions," and the Metropolitan Sewerage District of the County of Milwaukee will be referred to as the "Milwaukee-Metropolitan Sewerage District."

As noted above, the Milwaukee-Metropolitan Sewerage Commissions jointly act as agent for the special purpose unit of government known as the Metropolitan Sewerage District of the County of Milwaukee. This District at the present time includes all of the area of Milwaukee County except the City of South Milwaukee, which has elected not to become part of the District. The District, through the Milwaukee-Metropolitan Sewerage Commissions, may enter into contracts with municipalities in the same general drainage area and adjacent to the District to accept sewage for transmission and treatment from those municipalities. The term "same general drainage area" has been defined by the Milwaukee-Metropolitan Sewerage Commissions to include all of the Kinnickinnic, Menomonee, and Milwaukee River watersheds, the Oak Creek watershed, and those portions of the Root River watershed draining into Milwaukee County.

The centralized sanitary sewerage system developed and operated by the Milwaukee-Metropolitan Sewerage Commissions is by far the largest

Table 26

SERVICE AREA, POPULATION, AND SEWAGE FLOW CHARACTERISTICS OF THE MILWAUKEE-METROPOLITAN SEWERAGE SYSTEM BY CIVIL DIVISION: 1970

Civil Division	Total Area Planned For Service By Milwaukee-Metropolitan Sewerage System (Square Miles)	Area Currently Served (Square Miles)			Population Currently Served[1]			Average Hydraulic Loading (MGD)			Area Locally Proposed for Sewer Service[2] (Square Miles)
		By Milwaukee-Metropolitan Sewerage System	By Other Public Sewerage Systems	Total	By Milwaukee-Metropolitan Sewerage System	By Other Public Sewerage Systems	Total	On the Milwaukee-Metropolitan Sewerage System	On Other Public Sewerage Systems	Total	
In Metropolitan Sewerage District of the County of Milwaukee											
City of Cudahy	4.77	4.77	- -	4.77	22,000	- -	22,000	5.5	- -	5.5	- -
City of Franklin	34.63	7.68	0.61	8.29	2,600	1,100	3,700	0.1	N/A	0.1	19.99
City of Glendale	5.93	5.93	- -	5.93	18,700	- -	18,700	2.9	- -	2.9	- -
City of Greenfield	12.08	7.97	- -	7.97	21,800	- -	21,800	2.0	- -	2.0	4.11
City of Milwaukee	95.96	87.82	- -	87.82	703,700	- -	703,700	134.0	- -	134.0	8.14
City of Oak Creek	28.41	6.82	0.25	7.07	9,800	800	10,600	1.0	N/A	1.0	21.34
City of St. Francis	2.56	2.56	- -	2.56	11,200	- -	11,200	2.1	- -	2.1	- -
City of Wauwatosa	13.23	13.23	- -	13.23	59,500	- -	59,500	7.1	- -	7.1	- -
City of West Allis	11.38	11.28	- -	11.28	78,200	- -	78,200	10.3	- -	10.3	0.10
Village of Bayside	2.31	2.31	- -	2.31	3,900	- -	3,900	0.6	- -	0.6	- -
Village of Brown Deer	4.37	4.37	- -	4.37	12,500	- -	12,500	1.1	- -	1.1	- -
Village of Fox Point	2.87	2.87	- -	2.87	8,600	- -	8,600	1.2	- -	1.2	- -
Village of Greendale	5.55	3.80	- -	3.80	14,700	- -	14,700	1.3	- -	1.3	1.75
Village of Hales Corners	3.21	1.92	- -	1.92	7,300	- -	7,300	0.8	- -	0.8	1.29
Village of River Hills	5.32	5.32	- -	5.32	1,900	- -	1,900	0.5	- -	0.5	- -
Village of Shorewood	1.58	1.58	- -	1.58	12,600	- -	12,600	2.1	- -	2.1	- -
Village of West Milwaukee	1.11	1.11	- -	1.11	5,600	- -	5,600	4.5	- -	4.5	- -
Village of Whitefish Bay	2.12	2.12	- -	2.12	14,900	- -	14,900	1.7	- -	1.7	- -
Subtotal	237.39	173.46	0.86	174.32	1,009,500	1,900	1,011,400	178.8	N/A	178.8	56.72
In Existing Contract Service Area											
City of Brookfield	14.20	3.70	- -	3.70	8,500	- -	8,500	1.5	- -	1.5	10.50
City of Mequon	46.88	8.79	- -	8.79	6,600	- -	6,600	0.9	- -	0.9	16.56
City of Muskego	28.80	- -	1.80	1.80	- -	4,500	4,500	- -	0.4	0.4	14.55
City of New Berlin	25.30	4.38	0.21	4.59	7,900	800	8,700	1.0	0.7	1.7	20.71
Village of Bayside	0.09	0.09	- -	0.09	- -[3]	- -	- -	- -	- -	- -	- -
Village of Butler	0.78	0.78	- -	0.78	2,100	- -	2,100	0.4	- -	0.4	- -
Village of Elm Grove	3.25	3.25	- -	3.25	6,600	- -	6,600	0.9	- -	0.9	- -
Village of Menomonee Falls	18.30	- -	3.77	3.77	- -	17,400	17,400	- -	2.4	2.4	14.53
Subtotal	137.60	20.99	5.78	26.77	31,700	22,700	54,400	4.7	3.5	8.2	76.85
In Proposed Contract Service Area											
City of Milwaukee	0.02	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.02
Village of Germantown	34.31	- -	0.56	0.56	- -	2,400	2,400	- -	0.4	0.4	11.35
Village of Thiensville	1.03	- -	0.99	0.99	- -	3,600	3,600	- -	0.7	0.7	0.04
Town of Caledonia	0.50	- -	0.18	0.18	- -	1,200	1,200	- -	0.1	0.1	0.32
Town of Raymond	4.20	- -	- -	- -	- -	- -	- -	- -	- -	- -	4.20
Subtotal	40.06	- -	1.73	1.73	- -	7,200	7,200	- -	1.2	1.2	15.93
Total	415.05	194.45	8.37	202.82	1,041,200	31,800	1,073,000	183.5[4]	4.7	188.2	149.50

NOTE: N/A indicates data not available.

[1]Based upon an approximation of the existing sewer service area by U. S. Public Land Survey quarter section.

[2]As identified in locally prepared plans and engineering reports. These areas, when summed with the existing sewer service areas, do not necessarily correspond to the total areas planned for service by the Milwaukee-Metropolitan Sewerage Commissions, since some communities do not plan to serve all the area permitted to be served under contracts with the joint Commissions.

[3]The population residing in this area is included in the estimated population served for that portion of the Village of Bayside in Milwaukee County.

Source: SEWRPC.

[4]The average hydraulic loading during 1970 on the three sewage treatment facilities operated by the Milwaukee-Metropolitan Sewerage District - Jones Island, South Shore, and Hales Corners - was 189.9 mgd. In addition to the 183.5 mgd derived from the municipalities in the Milwaukee-Metropolitan Sewerage District and in the existing contract service area, an additional 6.4 mgd was processed through the plants from miscellaneous sources, including hauled sewage from holding tanks; sewage from federal government installations and county parks; and, most significantly, plant cooling and wash water.

sewerage system in the Southeastern Wisconsin Region.[9] As shown on Map 33, the existing service area of this system is comprised of portions of the Milwaukee-Metropolitan Sewerage District and portions of the existing contract service area in Ozaukee and Waukesha Counties outside of the District. This area totals about 194 square miles, of which 173 square miles represent the area now served within the Metropolitan Sewerage District

[9]*The statutes authorizing the creation of the Metropolitan Sewerage District of the County of Milwaukee and granting it authority to contract with municipalities outside of the District for sewage treatment apply only to counties in Wisconsin having a population of 500,000 or more. Since, at the present time, no other county even approaches this population size, this legislation is, as a practical matter, uniquely designed for Milwaukee County. There are, however, other areawide sanitary sewerage systems in the Region, as described in other sections of this chapter. One other formal metropolitan sewerage district--the Western Racine County Sewerage District--exists in the Region. In addition, other cities, such as the City of Kenosha and the City of Racine, operate sanitary sewerage systems which, while not organized under statutes specifically creating special-purpose districts, are through the operation of intergovernmental contracts and agreements in fact areawide or metropolitan sewerage system.*

and 21 square miles represent the area now served within the existing contract service area. About 1,041,200 persons are now served by the Milwaukee-Metropolitan sanitary sewerage system, including 1,009,500 persons who reside within the Metropolitan Sewerage District and 31,700 persons who reside within the existing contract service area. In addition, it should be noted that about 6.6 square miles and about 24,600 persons who reside within either the Metropolitan Sewerage District or the existing contract service area are currently provided with public sanitary sewer service, with sewage treatment for such areas provided by temporary sewage treatment facilities pending connection to the centralized system. With respect to the District, these areas lie within the Cities of Franklin and Oak Creek; with respect to the existing contract service area, these areas lie within the Cities of Muskego and New Berlin and the Village of Menomonee Falls (see Map 33). All of these service areas will eventually be connected to the Milwaukee-Metropolitan centralized sewerage system as trunk sewer service and capacity become available. The service area and population characteristics of the Milwaukee-Metropolitan sewerage system are summarized in Table 26.

The area committed to future sanitary sewer service in the plans of the Milwaukee-Metropolitan Sewerage Commissions and the communities which contract or have agreed to contract with the Commissions for sewage treatment service are also shown on Map 33. This area includes all of the currently unserved area within the Milwaukee-Metropolitan Sewerage District, which area totals about 63 square miles. In addition, this area includes all of the areas currently under contract for future sanitary sewer service in Ozaukee and Waukesha Counties, such areas lying within the Cities of Brookfield, Mequon, Muskego, and New Berlin and the Village of Menomonee Falls, and totaling about 101 square miles. Finally, this area includes proposed future contract service areas within the Villages of Germantown and Thiensville and the Towns of Caledonia and Raymond, totaling about 40 square miles. The foregoing planned future sewer service areas, totaling about 204 square miles, reflect the total area planned for ultimate service by the Milwaukee-Metropolitan Sewerage Commissions. Of this total, about 150 square miles are actually planned for sewer service within the next 20 years by the local communities served by the metropolitan system (see Map 33 and Table 26). It should be noted, in this respect, that provision of sewer service to portions of the Towns of Caledonia and Raymond was recommended in the Root River watershed plan and to the Village of Thiensville in the Milwaukee River watershed plan, as such plans were prepared and adopted by the Southeastern Wisconsin Regional Planning Commission. Concomitantly, the plans recommend the abandonment of the existing Caddy Vista sewage treatment plant in the Town of Caledonia and the existing Village of Thiensville sewage treatment plant.

The location and configuration of all existing and locally proposed major trunk, relief, and intercepting sewers and pumping and lift stations and related force mains comprising the Milwaukee-Metropolitan centralized sewerage system are shown on Map 33. This major sewer system serves both the combined sewer areas in parts of the City of Milwaukee and the Village of Shorewood and the separate sewer areas in the remainder of the District and the existing contract areas.

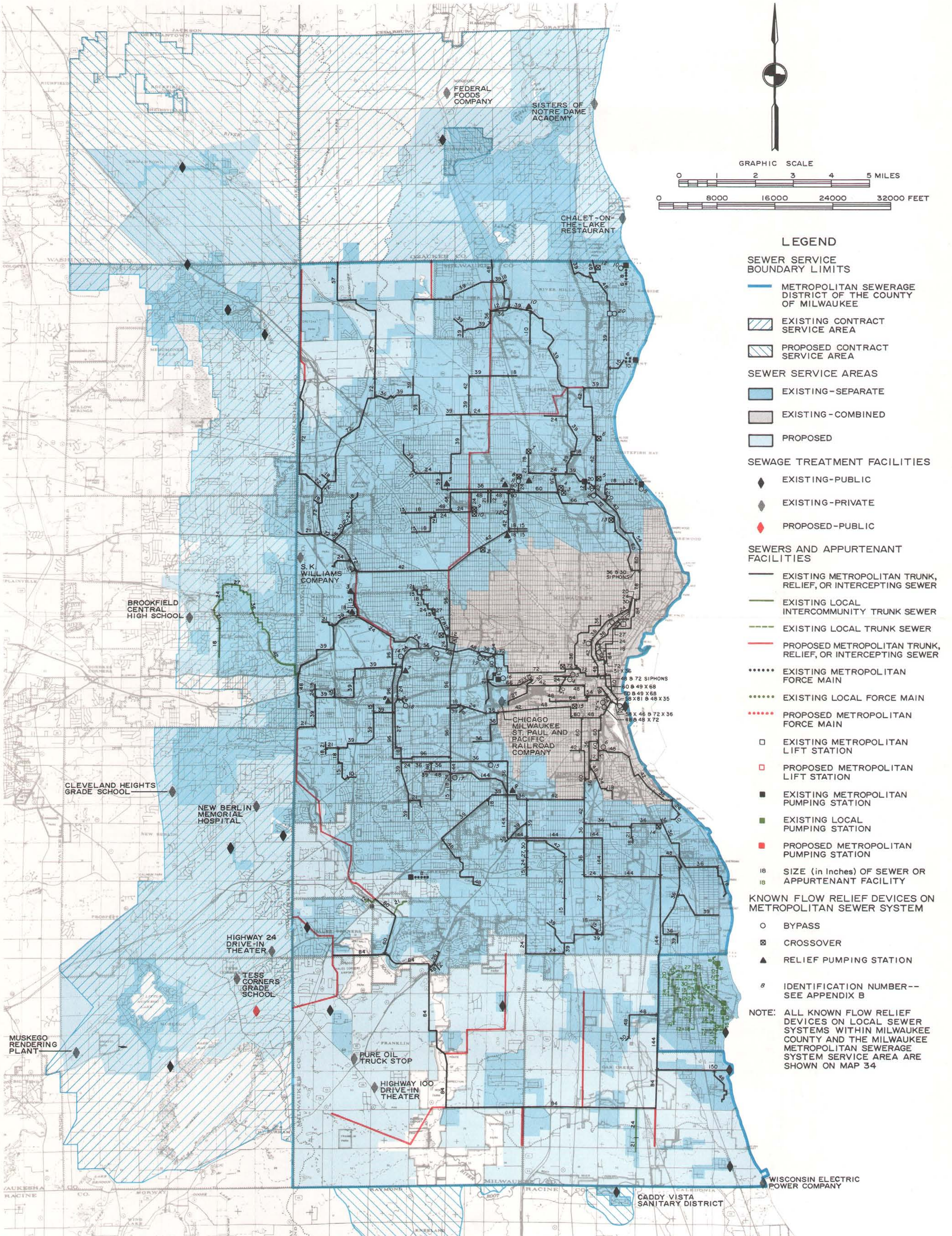
There are 45 known sewer relief discharge points on the Milwaukee-Metropolitan sewerage system, including 15 crossovers, 22 bypasses, and 10 relief pumping stations which discharge raw sewage to surface watercourses (see Map 34). The intercepting sewers contained in the Milwaukee-Metropolitan sewerage system are designed to carry all the dry weather sanitary flow from the combined sewers and, through control devices, a portion of the wet weather flow, with the remaining wet weather flow discharged directly to the streams in the District or to Lake Michigan. Such outfalls are a part of the City of Milwaukee local sewerage system and are described later in this chapter.

Proposed additions to the major trunk, relief, and intercepting sewer system in the Milwaukee-Metropolitan Sewerage District are shown on Map 33. These proposed system additions are part of a long-range trunk and relief sewer construction plan adopted by the Milwaukee-Metropolitan Sewerage Commissions in 1959. It is anticipated that, according to current construction schedules, all of the proposed new trunk and relief sewers will be completed by 2005.

Sewage from the Milwaukee-Metropolitan centralized sewerage system is treated at two large permanent sewage treatment plants and one small interim sewage treatment plant. The older of the two permanent plants, known as the Jones Island

Map 33

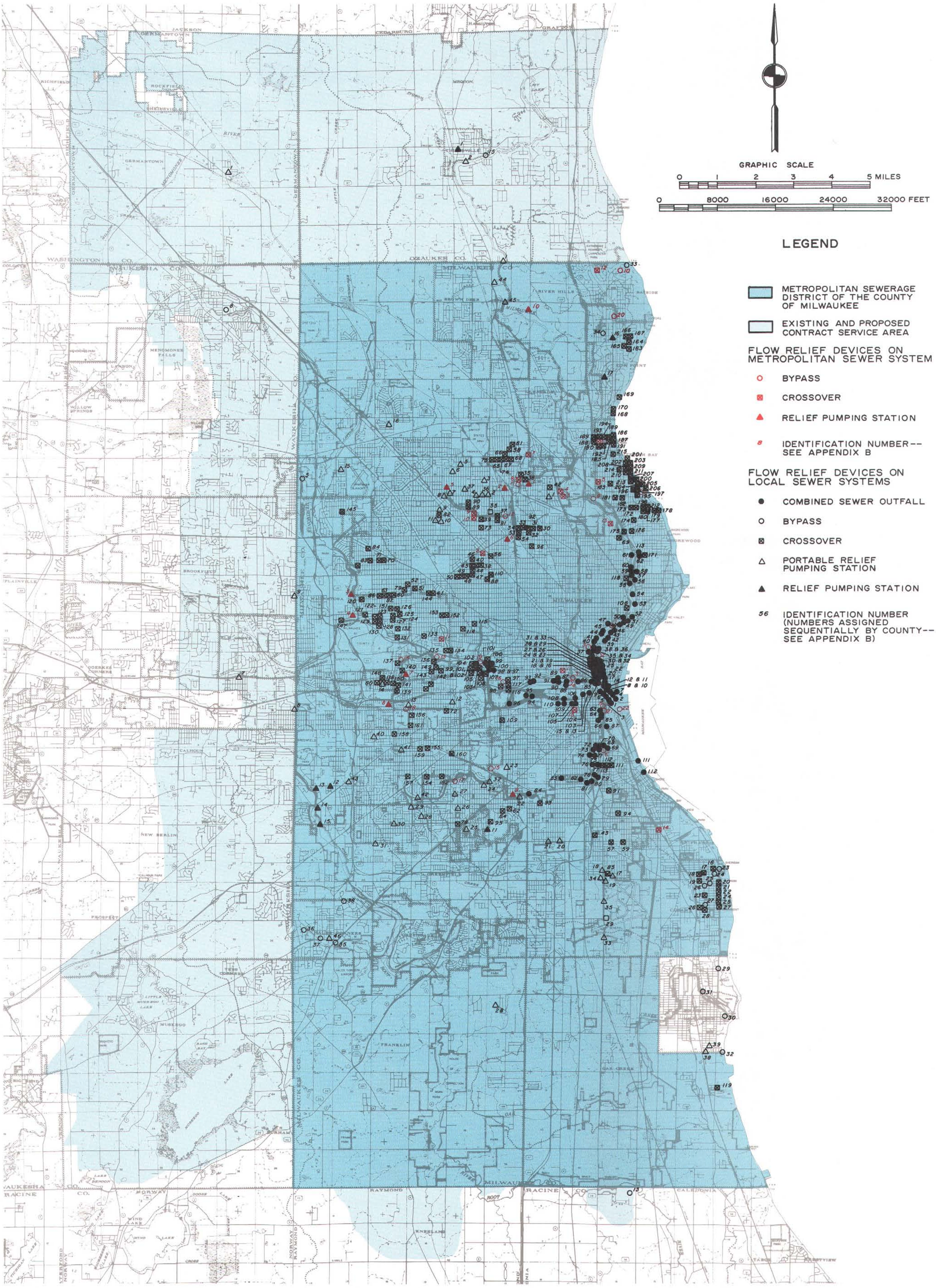
EXISTING AND LOCALLY PROPOSED PUBLIC SANITARY SEWERAGE SYSTEMS AND OTHER SEWAGE TREATMENT FACILITIES IN MILWAUKEE COUNTY AND IN AREAS NOW SERVED OR PROPOSED TO BE SERVED BY THE MILWAUKEE-METROPOLITAN SEWERAGE COMMISSIONS: 1970



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 34

KNOWN FLOW RELIEF DEVICES IN MILWAUKEE COUNTY AND IN EXISTING AND PROPOSED MILWAUKEE-METROPOLITAN SEWERAGE SYSTEM CONTRACT SERVICE AREA: 1970



Source: Wisconsin Department of Natural Resources and SEWRPC.

sewage treatment plant, was put into operation in 1925. It is located in the City of Milwaukee on the Lake Michigan shoreline just south of the Milwaukee harbor entrance (see Figure 29). Major expansions to this plant were completed in 1935, 1969, and 1970. The plant now has an average hydraulic design capacity of 200 mgd, with a peak hydraulic design capacity of 300 mgd, the latter being based upon the capacity of the primary units of the total plant. The primary treatment accorded, however, includes only coarse and fine screening and grit removal. In addition post-chlorination is provided. In 1970 the average hydraulic loading on the Jones Island sewage treatment facility was 170 mgd, with a peak hydraulic loading of 223 mgd and a minimum hydraulic loading of 116 mgd. The peak hydraulic loadings on the plant, which occur during periods of wet weather, however, do not include unmeasured flows bypassed either at flow relief points throughout the system or at the sewage treatment plant itself, nor flows exceeding the capacity of the flow meters installed at the plant. The existing 200 mgd average hydraulic design capacity is sufficient to adequately treat the average daily flow. The biochemical oxygen demand ($CBOD_5$) loadings ranged during 1970 from about 93,600 to about 510,400 pounds per day, with an average daily loading of about 296,300 pounds per day. Suspended solids loadings averaged about 293,500 pounds per day, with a maximum of 516,100 and a minimum of 137,500 pounds per day. Phosphorus loadings averaged about 11,600 pounds per day, with a maximum of 19,300 and a minimum of 4,500 pounds per day.[10]

[10]*Estimates of pounds/day loadings were computed by using the high, low, and average daily concentrations as listed in EPA publication 11010FLQ0371 entitled "Phosphorus Removal With Pickle Liquor in an Activated Sludge Plant" and the average daily sewage flow for 1970.*

Example

Lowest average day $CBOD_5$ loading in 1970 66 mg/l
Highest average day $CBOD_5$ loading in 1970 360 mg/l
Average daily sewage flow for 1970 170 MGD

Low 1970 $CBOD_5$ loading: 66 mg/l x 170 MGD x 8.34 pounds/(MGD mg/l) = 93,600 pounds/day
Highest 1970 $CBOD_5$ loading: 360 mg/l x 170 MGD x 8.34 pounds/(MGD mg/l) = 510,400 pounds/day.

Figure 29

MILWAUKEE-METROPOLITAN SEWERAGE COMMISSIONS JONES ISLAND SEWAGE TREATMENT PLANT

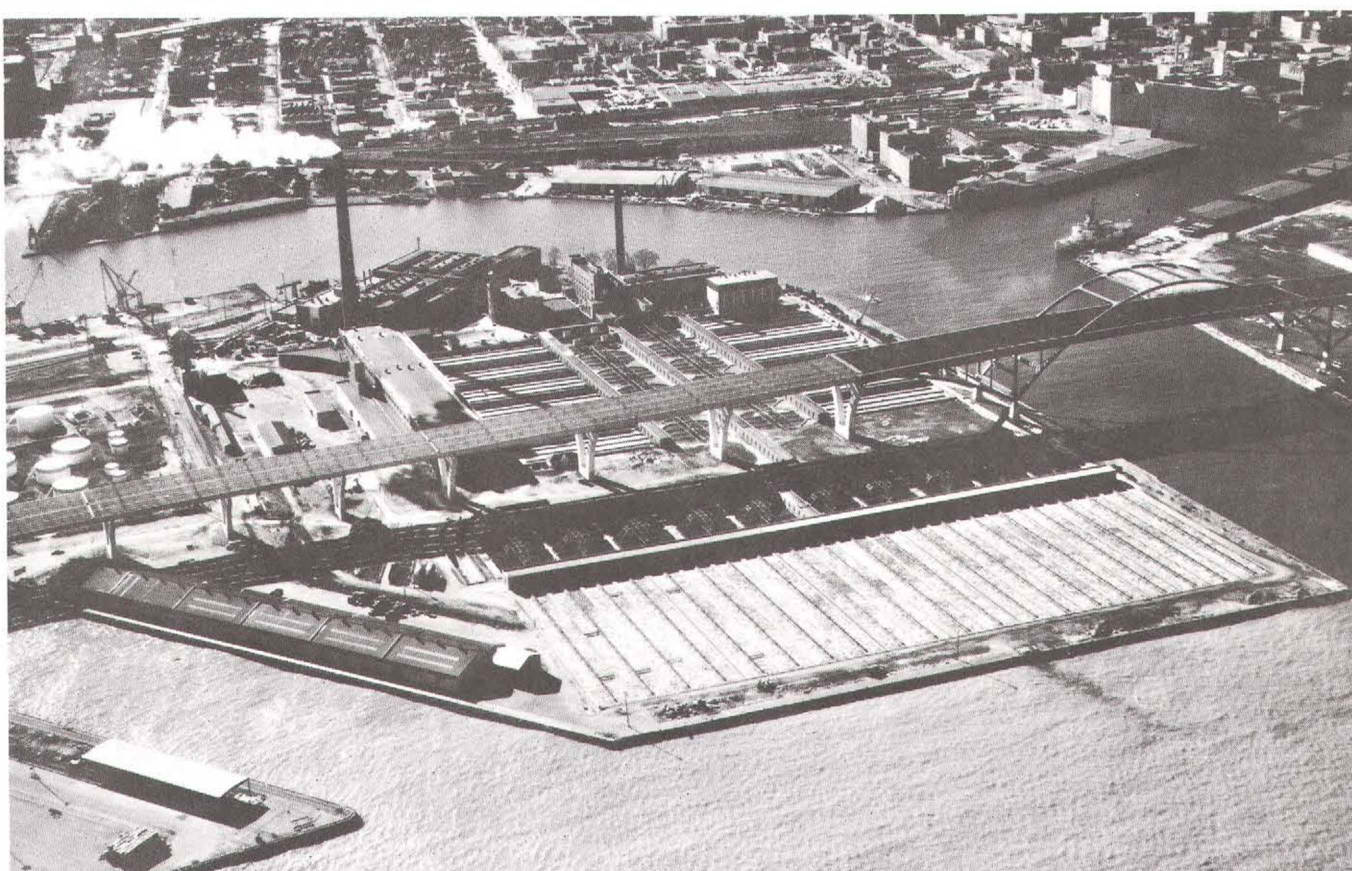


Photo by Karl W. Emrich and Ching-Chi Wu.

During 1970 an average of 90 percent of the suspended solids, 93 percent of the $CBOD_5$, and 87 percent of the phosphorus were removed in the treatment process. The plant is an activated sludge type sewage treatment plant and the treatment process provided at the plant is classified as advanced level since it provides phosphorus removal. Effluent disposal is directly to the Milwaukee Harbor at the plant site. The Jones Island plant has a site area of about 60 acres, all of which are currently utilized. The plant site is bounded by the Kinnickinnic River and the Ferry Terminal of the Chesapeak and Ohio Railroad on the west; by the Milwaukee harbor entrance on the north; the outer harbor on the east; and by railroad yards, petroleum products storage areas, and related port facilities on the south.

The second of the two permanent plants, known as South Shore sewage treatment plant, is located on the Lake Michigan shoreline in the City of Oak Creek and was put into operation in 1968 (see Figure 30). At the present time the plant provides only a primary level of treatment with chlorination of effluent. The plant has an average hydraulic design capacity of 120 mgd, with a peak hydraulic design capacity of 320 mgd. Construction of secondary and advanced treatment capacity at the South Shore treatment plant is currently underway. Upon completion of these facilities at the South Shore sewage treatment plant, the rated average hydraulic design capacity will remain at 120 mgd, since no physical alterations will be made to the existing primary treatment facilities. In 1970 the average hydraulic loading on the South Shore sewage treatment facility was 19 mgd, with a peak hydraulic loading of 25 mgd and a minimum hydraulic loading of 15 mgd. The existing 120 mgd average hydraulic design capacity is sufficient to adequately treat the average daily flow. During 1970 an average of 75 percent of the suspended solids and 42 percent of the $CBOD_5$ were removed in the treatment process. Effluent disposal is via a 1,930-foot outfall sewer to Lake Michigan. The South Shore plant has a site area of about 150 acres, of which about 90 acres are currently

Figure 30

MILWAUKEE-METROPOLITAN SEWERAGE COMMISSIONS SOUTH SHORE SEWAGE TREATMENT PLANT

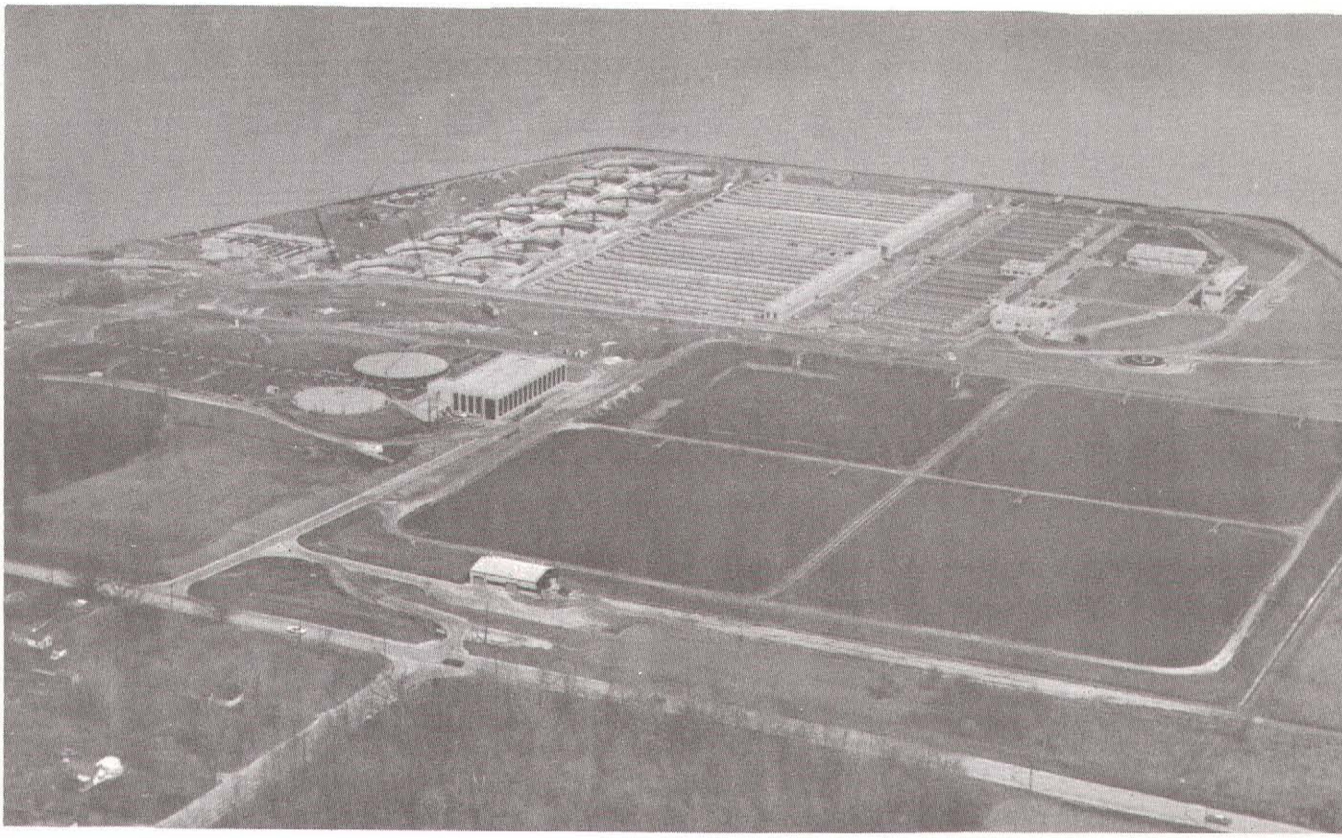


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

utilized, leaving about 60 acres available for future use. The plant site is bounded by Lake Michigan on the east, residential development on the north, industrial development on the south, and by 5th Avenue and residential development on the west.

The temporary treatment facility operated by the Milwaukee-Metropolitan Sewerage Commissions serves only the Village of Hales Corners. This facility, a trickling filter type, discharges its effluent to the Root River (see Figure 31), and is scheduled to be abandoned upon completion of a metropolitan trunk sewer in 1974. The plant, constructed in 1941, has an average hydraulic design capacity of 0.9 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.8 mgd. The treatment processes provided at the plant are classified as secondary level.

The plans of the Milwaukee-Metropolitan Sewerage Commissions indicate that, with the completion of the trunk and relief sewer construction program noted above and the addition of secondary and advanced treatment capacity at the South Shore plant, the plant should be capable of treating sewage flows from all of the existing and proposed service area lying generally west of 60th Street, east of the subcontinental divide which forms the westerly boundary of the service area, and south of W. Howard Avenue. At that time the loading on the Jones Island plant and the frequency of bypassing at the Jones Island plant during wet weather periods would be greatly reduced. The sewers at junction points of old sewers and the new trunk sewers are being designed to permit selective routing of sewage from most points in the metropolitan system to either the Jones Island or the South Shore plants, thus utilizing the full capacity of the plants at all critical times.

Figure 31

MILWAUKEE-METROPOLITAN SEWERAGE COMMISSIONS
HALES CORNERS SEWAGE TREATMENT PLANT

Photo by Karl W. Emrich and Ching-Chi Wu.

Management of the Milwaukee-Metropolitan sewerage system is, as noted above, under the direction of both the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee. These two Commissions act jointly in all matters affecting the Milwaukee-Metropolitan Sewerage District. The Sewerage Commission of the City of Milwaukee consists of five members who are appointed by the Mayor, subject to confirmation by the Common Council. The Metropolitan Sewerage Commission of the County of Milwaukee consists of three members all appointed by the Governor. One member is certified to the Governor by the Sewerage Commission of the City of Milwaukee and one member is certified to the Governor by the Wisconsin Department of Natural Resources. The Governor must appoint to the Commission those persons certified. The Governor appoints the third member on his own motion, with the limitation that the member be a resident within the drainage area of Milwaukee County but outside of the City of Milwaukee. Day-to-day administration of the Milwaukee-Metropolitan sanitary sewerage system is provided by a joint staff headed by a Chief Engineer and General Manager.

The capital improvements budget for the Milwaukee-Metropolitan Sewerage District is adopted on an annual basis jointly by the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee. The budget is then forwarded to the Milwaukee County Board of Supervisors. The Board then determines the amount of the proposed budget which will be raised by the selling of general obligation bonds for the forthcoming year and the amount which will be raised by a tax levy upon all taxable property within the District. Thus, all capital improvements, including sewage treatment facilities, main sewers, relief sewers, intercepting sewers, and appurtenant facilities that are part of the Milwaukee-Metropolitan sewerage system, whether these facilities are constructed within the City of Milwaukee or within any of the other 17 municipalities in Milwaukee County which belong to the Milwaukee-Metropolitan Sewerage District, are paid for by the taxpayers of the entire District.

The cost of operating and maintaining the Milwaukee-Metropolitan sewerage system is based upon the relative amount of sewage each of the 18 municipalities in the District contributes to the total sewage flow. This cost is determined each year and the 18 communities in effect receive a bill directly from the Sewerage Commission of the City of Milwaukee for operation and maintenance services. Each local governing body then must levy a tax against all taxable property in the local unit of government in an amount sufficient to provide for the billed amount.

The communities within the contract service area outside of the Milwaukee-Metropolitan Sewerage District are billed each year by the Milwaukee-Metropolitan Sewerage Commissions on a fixed charge per million gallons of metered sewage. Such fixed charge is adjusted at five-year intervals. Currently, each of the service contracts provides that the fixed service charge, which currently is $244 per million gallons of sewage, be based on the following three components:

1. A depreciation component based on 2 percent of the total investment for permanent assets.

2. A fair-return-on-capital component based on 6 percent of the depreciated value of the system components.

3. An annual operations and maintenance component based on metered sewage flow.

The total expenditures in 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Milwaukee-Metropolitan sanitary sewerage system approximated $14,870,892, or about $14 per capita, the per capita cost being based upon the total estimated population served of 1,041,200. Of this total cost, $5,352,340, or about $5 per capita, was expended for operation and maintenance, and $9,518,552, or about $9 per capita, was expended for capital improvements. The foregoing expenditure data include all costs associated with the operation and maintenance of the Jones Island, South Shore, and Hales Corners sewage treatment plants; with maintenance of the Milwaukee-Metropolitan trunk sewer and storm water drainage systems; and with capital improvements to the entire system—treatment plants, trunk sewers, and watercourse improvements—attributable to the year 1970. Because most of the capital cost attributable to 1970 consists of debt retirement on bonds sold in previous years to finance both sanitary sewer and storm water drainage improvements, it was not possible to determine precisely how much of the total 1970 capital improvement cost was due to sanitary sewerage improvements and how much was due to watercourse improvements. A review of 10 years of capital budgets prepared and adopted by the joint Milwaukee-Metropolitan Sewerage Commissions reveals, however, that an average of about 15 percent of capital expenditures are directed at watercourse improvements, with the remaining 85 percent directed at sanitary sewerage improvements. The foregoing cost estimate for capital investment contains a relatively small increment for watercourse improvements. The estimate for operation and maintenance also includes costs attributable to the maintenance of storm water drainage channels. These costs, however, are negligible and do not affect the validity of comparing the per capita operation and maintenance cost of the Milwaukee-Metropolitan sewerage system with other systems.

The total expenditures noted above for the Milwaukee-Metropolitan sanitary sewerage system during 1970 have been apportioned back to the 18 municipalities in the Metropolitan Sewerage District in the ensuing portion of this chapter in order that such costs may be summed with any applicable local sewerage expenditures to effect the true per capita cost of providing sewer service within each community in the District. The capital improvement costs have been prorated back to the communities based upon equalized assessed valuation. The operation and maintenance costs have been prorated back to the communities based upon sewage flow. Thus, any total and per capita costs attributed to communities in the Milwaukee-Metropolitan Sewerage District include that community's share of constructing, operating, and maintaining the metropolitan sewerage system. Such prorated costs are, however, subject to the same qualification noted above relating to the inclusion of certain relatively minor storm water drainage improvements in the capital cost component.

City of Cudahy: The existing service area of the City of Cudahy sanitary sewerage system, which area encompasses the entire city, is shown on Map 33. This area totals about 4.8 square miles and has a resident population of about 22,000 persons. The entire area is now served by a separate sanitary sewer system, the city having completed in 1966 a program of separating all existing combined sewers.

Since the City of Cudahy is part of the Milwaukee-Metropolitan Sewerage District, sewage from the city is treated in the South Shore and Jones Island sewage treatment plants operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of Cudahy in 1970 was 5.5 mgd. There are 18 known points of sewage flow relief in the City of Cudahy sanitary sewerage system, including 13 crossovers and five bypasses (see Map 34).

Management of the City of Cudahy sanitary sewerage system is under the direction of a 10-member Board of Public Works. This Board is composed of all 10 aldermen. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Cudahy sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated \$536,254, or about \$24 per capita. Of this total, \$183,161, or about \$8 per capita, was expended for operation and maintenance and \$353,093, or about \$16 per capita, was expended for capital improvements.

City of Franklin: The existing service area of the City of Franklin sanitary sewerage system is shown on Map 33. This area totals about 7.68 square miles and has a resident population of about 2,600 persons. The entire area is served by a separate sanitary sewer system. This area does not include portions of the City of Franklin served by private water and sewer trusts, which trusts are described later in this chapter.

Since the City of Franklin is part of the Milwaukee-Metropolitan Sewerage District, sewage from the city is treated in the South Shore sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of Franklin in 1970 was 0.1 mgd. There are no known points of sewage flow relief in the City of Franklin sanitary sewerage system. The city proposes to provide sewer service to the entire developable area within the city.

Management of the City of Franklin sanitary sewerage system is under the direction of the Committee of the Whole of the City Council. Day-to-day administration of the system is provided by the City Engineer. Financing of the system is provided through a sewer service charge. Currently, this charge is \$6 per quarter per residential sewer connection, with special flat fees and quantity-of-flow charges for nonresidential connections. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Franklin sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated \$1,203,591, or about \$463 per capita. Of this total, \$2,402, or about \$1 per capita, was expended for operation and maintenance and \$1,201,189, or about \$462 per capita, was expended for capital improvements.

City of Glendale: The existing service area of the City of Glendale sanitary sewerage system, which area encompasses the entire city, is shown on Map 33. This area totals about 5.93 square miles and has a resident population of about 18,700 persons. The entire area is served by a separate sanitary sewer system.

Since the City of Glendale is part of the Milwaukee-Metropolitan Sewerage District, sewage from the city is treated in the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of Glendale in 1970 was 2.9 mgd. There are no known points of sewage flow relief in the City of Glendale sanitary sewerage system.

Management of the City of Glendale sanitary sewerage system is under the direction of the City Council. Day-to-day administration of the system is provided by the City Engineer. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Glendale sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated $485,213, or about $26 per capita. Of this total, $96,322, or about $5 per capita, was expended for operation and maintenance and $388,891, or about $21 per capita, was expended for capital improvements.

City of Greenfield: The existing service area of the City of Greenfield sanitary sewerage system is shown on Map 33. This area totals about 7.97 square miles and has a resident population of about 21,800 persons. The entire area is served by a separate sanitary sewer system.

Since the City of Greenfield is a part of the Milwaukee-Metropolitan Sewerage District, sewage from the city is treated in the Jones Island and South Shore sewage treatment plants operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of Greenfield in 1970 was 2.0 mgd. There is one known point of sewage flow relief in the City of Greenfield sanitary sewerage system—a relief pumping station (see Map 34). The city plans to extend sanitary sewer service to all areas of the city not now served.

Management of the City of Greenfield sanitary sewerage system is under the direction of the City Council. Day-to-day administration of the system is provided by the Superintendent of Public Works. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Greenfield sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage systems, approximated $253,204, or about $12 per capita. Of this total, $58,913, or about $3 per capita, was expended for operation and maintenance and $194,291, or about $9 per capita, was expended for capital improvements.

City of Milwaukee: The existing service area of the City of Milwaukee sanitary sewerage system is shown on Map 33. This area totals about 87.82 square miles and has a resident population of about 703,700 persons. About 61.72 square miles containing about 337,700 persons, or about 70 percent of the area served and 48 percent of the population served in the city, are served by a separate sewer system, and about 26.10 square miles containing about 366,000 persons, or about 30 percent of the area served and 52 percent of the population served, are served by a combined sewer system.

Since the City of Milwaukee is part of the Milwaukee-Metropolitan Sewerage District, sewage from the city is treated at both the Jones Island and South Shore sewage treatment plants operated by the Milwaukee-Metropolitan Sewerage Commissions. Since sewage is metered from all other municipalities contributing sewage to the Milwaukee-Metropolitan sewerage system, sewage from the City of Milwaukee is estimated as the residual after subtracting all of the measured sewage from the total sewage treated. The average daily flow from the City of Milwaukee in 1970 was estimated at 134.0 mgd.

There are 239 known points of sewage flow relief in the City of Milwaukee sanitary sewerage system, including 90 crossovers, 37 portable pumping stations, and 112 combined sewer outfalls. As noted earlier in this chapter, the intercepting sewers of the Milwaukee-Metropolitan sewerage system convey all of the dry weather sewage flow and a portion of the wet weather sewage flow from the combined sewer area of the City of Milwaukee to the sewage treatment plants. The remaining wet weather flow for the combined sewer area is discharged directly to the streams in the city or to Lake Michigan. The location of these 112 known combined sewer outfalls, as well as the 90 crossovers and 37 portable pumping stations, in the City of Milwaukee is shown on Map 34.

The city intends to provide sewer service to the remaining areas of the city not now served. As shown on Map 33, these areas are concentrated in the northwestern portion of the city in the former Town of Granville.

Management of the City of Milwaukee sanitary sewerage system is under the direction of the Water and Sewerage Control Policy Board, a subcommittee of the Public Improvements Committee of the Common Council. Day-to-day administration of the system is provided by the Commissioner of Public Works. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Milwaukee sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated $16.8 million, or about $24 per capita. Of this total, \$4.4 million, or about \$6 per capita, was expended for operation and maintenance and \$12.4 million, or about \$18 per capita, was expended for capital improvements.

City of Oak Creek: The existing service area of the City of Oak Creek sanitary sewerage system is shown on Map 33. This area totals about 7.07 square miles and has a resident population of about 10,600 persons. The entire area is served by a separate sanitary sewer system. Of this total, about 6.82 square miles having a resident population of about 9,800 persons are served through the Milwaukee-Metropolitan sewerage system, and about 0.25 square mile having a resident population of about 800 persons is served directly by the City of Oak Creek through a small sewage treatment facility located in the extreme southeasterly portion of the city.[11]

Since the City of Oak Creek is part of the Milwaukee-Metropolitan Sewerage District, all sewage from the city, except that treated at the small flow-through stabilization pond serving the Oak View Subdivision noted above, is treated at the South Shore sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of Oak Creek into the Milwaukee-Metropolitan

[11] *This sewage treatment facility, known as the Oak View Stabilization Pond, was abandoned in November 1971 and its tributary service area connected to the Milwaukee-Metropolitan sewerage system.*

CITY OF OAK CREEK, OAKVIEW SUBDIVISION SEWAGE TREATMENT PLANT (ABANDONED 1971)

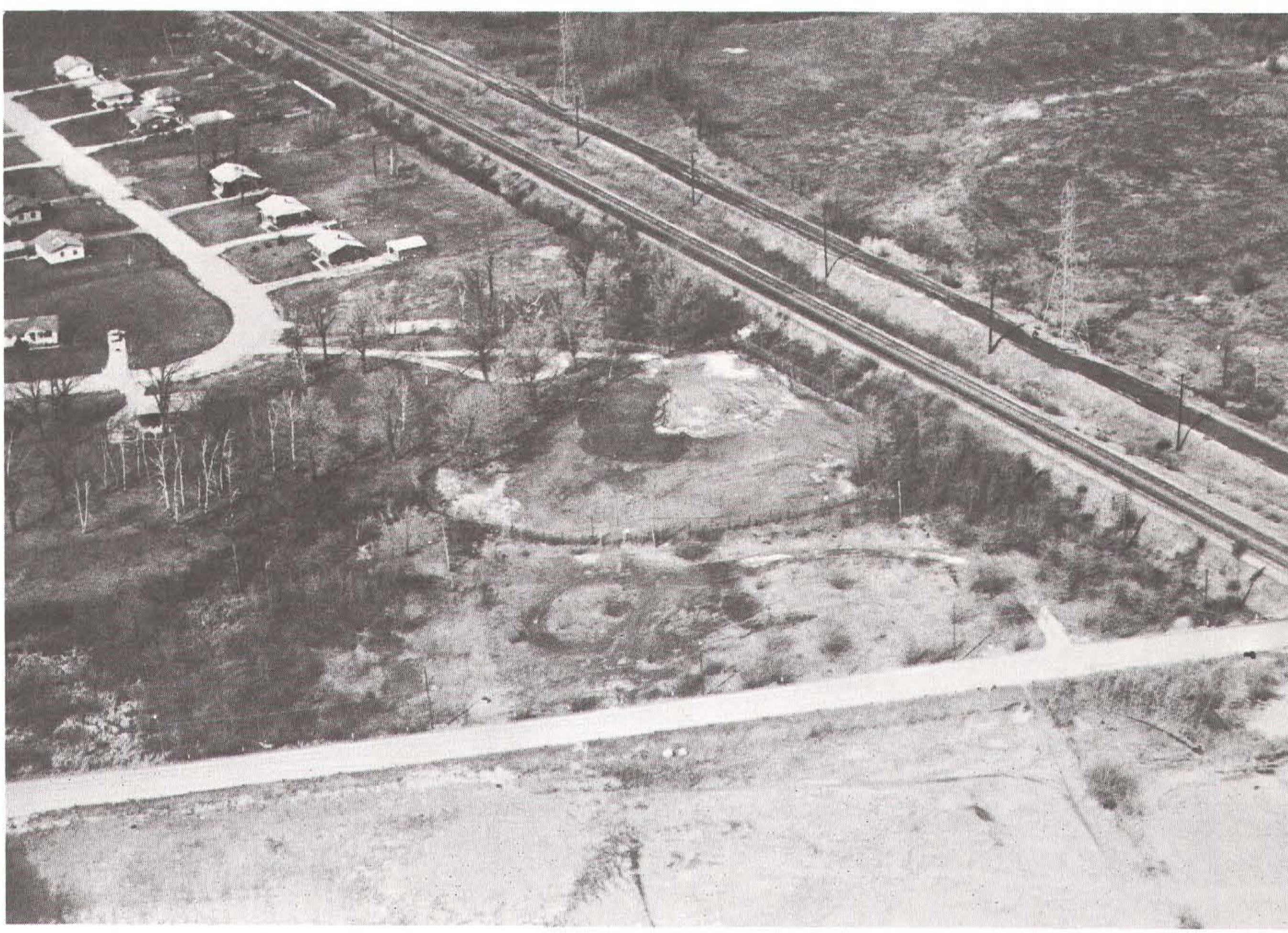


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

sewerage system during 1970 was 1.0 mgd.[12] The average daily flow at the treatment facility serving the Oak View Subdivision during 1970 was not available. There is one known point of sewage flow relief in the City of Oak Creek sanitary sewerage system—a crossover (see Map 34). The city proposes to provide sewer service to the entire area within the city.

Management of the City of Oak Creek sewerage system is under the direction of a five-member Board of Water Works and Sewer Commissioners, which Board is appointed by the Mayor, subject to confirmation by the Common Council. Day-to-day administration of the system is provided by the City Engineer. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Oak Creek sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated $2.7 million, or about $251 per capita. Of this total, $103,000, or about $10 per capita, was expended for operation and maintenance and $2.6 million, or about $241 per capita, was expended for capital improvements.

City of South Milwaukee: The existing service area of the City of South Milwaukee sanitary sewerage system, which area includes all but a very small portion of the entire city, is shown on Map 33. The area served totals about 4.68 square miles and has a resident population of about 23,300 persons. The entire area is served by a separate sanitary sewer system.

As noted earlier in this chapter, the City of South Milwaukee is the only municipality in Milwaukee County which has elected not to become part of the Milwaukee-Metropolitan Sewerage District. Sewage from the City of South Milwaukee is treated at a sewage treatment plant located on the Lake Michigan shoreline about one mile north of the South Shore sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions (see Figure 32). The plant has a site area of about 10 acres, of which six acres are currently utilized leaving four acres available for future use. The plant site is bounded by industrial land uses on the north, Lake Michigan on the east, vacant lands on the south, and residential land uses on the west. This plant was initially placed into operation in 1937 and had major modifications in 1950 and 1962. The average hydraulic design capacity of the plant is 3.0 mgd, with a peak hydraulic design capacity of 6.0 mgd. The average hydraulic loading on the plant in 1970 was estimated at 3.8 mgd, indicating the plant was operating over the average hydraulic design capacity. In 1970 the treatment process provided at the plant was classified as primary level. In 1971 the City of South Milwaukee began construction of additions to the sewage treatment plant designed to result in the provision of a secondary level of treatment for an average hydraulic design capacity of 6.0 mgd.

The location and configuration of all trunk sewers and lift and pumping stations and related force mains comprising the City of South Milwaukee sanitary sewerage system are shown on Map 33. There are six known points of sewage flow relief in the City of South Milwaukee sanitary sewerage system, including four bypasses and two portable pumping stations (see Map 34).

Management of the City of South Milwaukee sanitary sewerage system is under the direction of a five-member Sewerage Commission elected by the City Council. Day-to-day administration of the system is provided by the Superintendent of the sewage treatment plant. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvement, including debt retirement, for the City of South Milwaukee sanitary sewerage system approximated $306,752, or about $13 per capita. Of this total, $92,883, or about $4 per capita, was expended for operation and maintenance and $213,869, or about $9 per capita, was expanded for capital improvements.

City of St. Francis: The existing service area of the City of St. Francis sanitary sewerage system, which area encompasses the entire city, is shown on Map 33. This area totals about 2.6 square miles and has a resident population of about 11,200 persons. The entire area is served by a separate sanitary sewer system.

Since the City of St. Francis is a part of the Milwaukee-Metropolitan Sewerage District, sew-

[12] *It should be noted that a major step increase in the average daily flow from the City of Oak Creek to the metropolitan sewerage system occurred in 1971 due to the connection of certain industrial land uses. In 1971 the average daily flow from the city was 5.5 mgd.*

Figure 32

CITY OF SOUTH MILWAUKEE SEWAGE TREATMENT PLANT

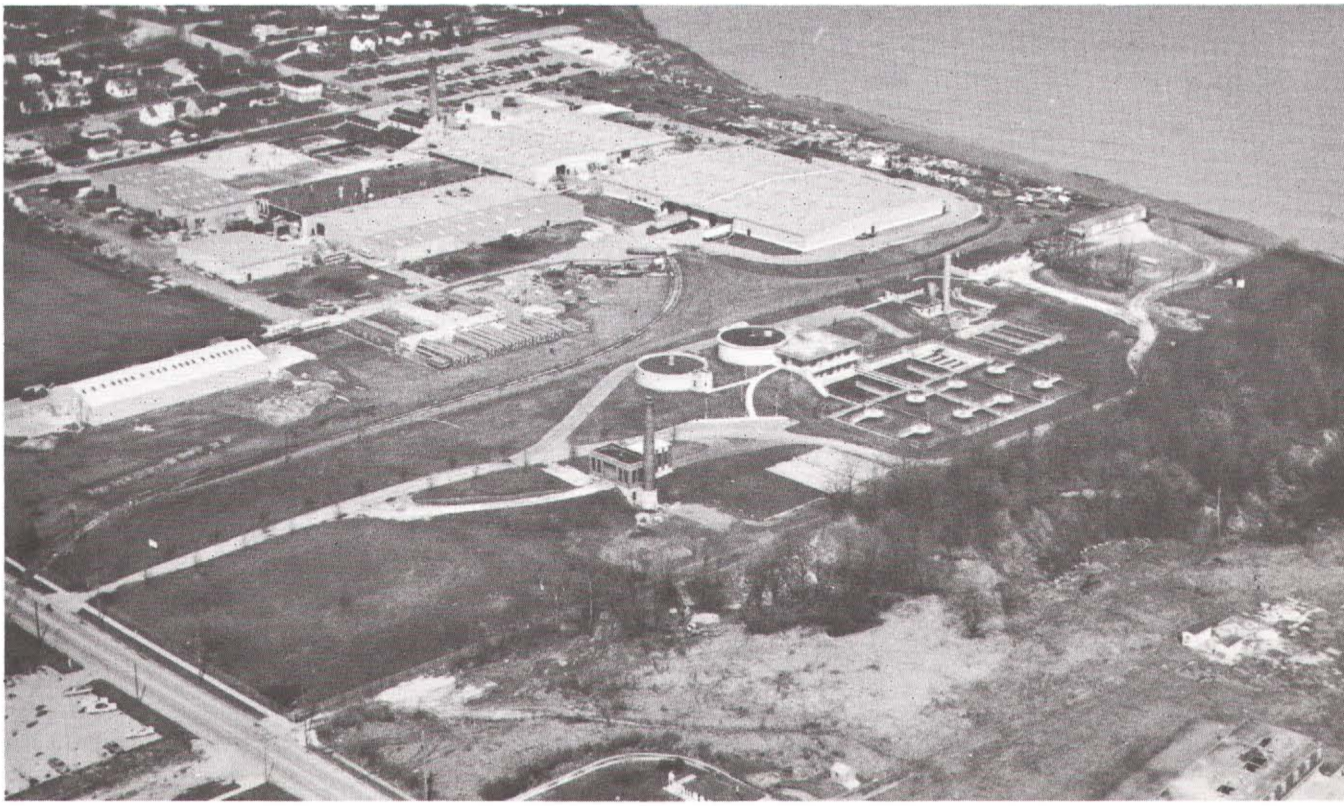


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

age from the city is treated in the Jones Island and South Shore sewage treatment plants operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of St. Francis in 1970 was 2.1 mgd. There are no known points of sewage flow relief in the City of St. Francis sanitary sewerage system.

Management of the City of St. Francis sanitary sewerage system is under the direction of the City Council. Day-to-day administration of the system is provided by the City Engineer. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of St. Francis sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated $125,136, or about $11 per capita. Of this total, $61,734, or about $5 per capita, was expended for operation and maintenance and $63,402, or about $6 per capita, was expended for capital improvements.

City of Wauwatosa: The existing service area of the City of Wauwatosa sanitary sewerage system, which area encompasses the entire city, is shown on Map 33. This area totals about 13.2 square miles and has a resident population of about 59,500 persons. The entire area is served by a separate sanitary sewer system.

Since the City of Wauwatosa is part of the Milwaukee-Metropolitan Sewerage District, sewage from the City is treated in the Jones Island and South Shore sewage treatment plants operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of Wauwatosa in 1970 was 7.1 mgd. There are 34 known points of sewage flow relief in the City of Wauwatosa sanitary sewerage system, all of which are crossovers (see Map 34).

Management of the City of Wauwatosa sanitary sewerage system is under the direction of a Board of Public Works. Day-to-day administration of the system is provided by the operations Administrator of the Public Works Department. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Wauwatosa sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated $1,045,980, or about $18 per capita. Of this total, $234,524, or about $4 per capita, was expended for operation and maintenance, and $811,456, or about $14 per capita, was expended for capital improvements.

City of West Allis: The existing service area of the City of West Allis sanitary sewerage system, which area encompasses the entire city, is shown on Map 33. This area totals about 11.3 square miles and has a resident population of about 78,200 persons. The entire area is served by a separate sanitary sewer system.

Since the City of West Allis is part of the Milwaukee-Metropolitan Sewerage District, sewage from the city is treated in the Jones Island and South Shore sewage treatment plants operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of West Allis in 1970 was 10.3 mgd. There are 17 known points of sewage flow relief in the City of West Allis sanitary sewerage system, including nine crossovers, four portable pumping stations, and four relief pumping stations (see Map 34).

Management of the City of West Allis sanitary sewerage system is under the direction of a Board of Public Works. Day-to-day administration of the system is provided by the Superintendent of Public Works. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of West Allis sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated $2,053,307, or about $26 per capita. Of this total, $303,037, or about $4 per capita, was expended for operation and maintenance and $1,750,270, or about $22 per capita, was expended for capital improvements.

Village of Bayside: The existing service area of the Village of Bayside sanitary sewerage system, which area encompasses the entire village, is shown on Map 33. This area totals about 2.3 square miles and has a resident population of about 3,900 persons. The entire area is served by a separate sanitary sewer system.

The Village of Bayside is located partly within the Milwaukee-Metropolitan Sewerage District, and partly within the contract service area. All of the sewage from the village, however, is treated in the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of Bayside in 1970 was 0.6 mgd. There is one known point of sewage flow relief in the Village of Bayside sanitary sewerage system—a bypass (see Map 34).

Management of the Village of Bayside sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Manager. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Bayside sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage system, approximated $89,885, or about $23 per capita. Of this total, $28,601, or about $7 per capita, was expended for operation and maintenance and $61,284, or about $16 per capita, was expended for capital improvements.

Village of Brown Deer: The existing service area of the Village of Brown Deer sanitary sewerage system, which area encompasses the entire village, is shown on Map 33. This area totals about 4.4 square miles and has a resident population of about 12,500 persons. The entire area is served by a separate sanitary sewer system.

Since the Village of Brown Deer is part of the Milwaukee-Metropolitan Sewerage District, sewage from the village is treated in the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of Brown Deer in 1970 was 1.1 mgd. There are two known points of sewage flow relief in the Village of Brown Deer sanitary sewerage system, both of which are portable pumping stations (see Map 34).

Management of the Village of Brown Deer sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Manager. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Brown Deer sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage systems, approximated $303,700, or about $24 per capita. Of this total, $43,496, or about $3 per capita, was expended for operation and maintenance and $260,204, or about $21 per capita, was expended for capital improvements.

Village of Fox Point: The existing service area of the Village of Fox Point sanitary sewerage system, which area encompasses the entire village, is shown on Map 33. This area totals about 2.9 square miles and has a resident population of about 8,600 persons. The entire area is served by a separate sanitary sewer system.

Since the Village of Fox Point is part of the Milwaukee-Metropolitan Sewerage District, sewage from the village is treated in the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of Fox Point in 1970 was 1.2 mgd. There are 11 known points of sewage flow relief in the Village of Fox Point sanitary sewerage system, including eight crossovers, one bypass, and two relief pumping stations (see Map 34).

Management of the Village of Fox Point sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Manager. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Fox Point sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewage systems, approximated $160,764, or about $19 per capita. Of this total, $34,869, or about $4 per capita, was expended for operation and maintenance and $125,895, or about $15 per capita, was expended for capital improvements.

Village of Greendale: The existing service area of the Village of Greendale sanitary sewerage system is shown on Map 33. This area totals about 3.8 square miles and has a resident population of about 14,700 persons. The entire area is served by a separate sanitary sewer system.

Since the Village of Greendale is part of the Milwaukee-Metropolitan Sewerage District, sewage from the village is treated at the South Shore sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of Greendale in 1970 was 1.3 mgd. There are no known points of sewage flow relief in the Village of Greendale sanitary sewerage system.

Management of the Village of Greendale sanitary sewerage system is under the direction of the Sewerage Committee of the Village Board. Day-to-day administration of the system is provided by the Village Manager. Financing of the system is provided through the general property tax and a sewer service charge equal to 48 percent of the water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Greendale sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage systems, approximated $306,603, or about $21 per capita. Of this total, $92,323, or about $6 per capita, was expended for operation and maintenance and $214,280, or about $15 per capita, was expended for capital improvements.

Village of Hales Corners: The existing service area of the Village of Hales Corners sanitary sewerage system is shown on Map 33. This area totals about 1.9 square miles and has a resident population of about 7,300 persons. The entire area is served by a separate sanitary sewer system.

As noted earlier in this chapter, all sewage from the Village of Hales Corners is treated at a temporary facility operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of Hales Corners in 1970 was 0.8 mgd. There are five known points of sewage flow relief in the Village of Hales Corners sanitary sewerage system, including four bypasses and one portable pumping station (see Map 34).

Management of the Village of Hales Corners sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Superintendent of Public Works. Day-to-day administration of the system is provided through special assessments, the general tax, and a sewer service charge of $7.50 per quarter per residence. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Hales Corners sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage systems, approximated $239,806, or about $33 per capita. Of this total, $59,395, or about $8 per capita, was expended for operation and maintenance and $180,411, or about $25 per capita, was expended for capital improvements.

Village of River Hills: The existing service area of the Village of River Hills sanitary sewerage system, which area encompasses the entire village, is shown on Map 33. This area totals about 5.3 square miles and has a resident population of about 1,900 persons. The entire area is served by a separate sanitary sewer system.

Since the Village of River Hills is a part of the Milwaukee-Metropolitan Sewerage District, sewage from the village is treated in the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of River Hills in 1970 was 0.5 mgd. There are no known points of sewage flow relief in the Village of River Hills sanitary sewerage system.

Management of the Village of River Hills sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Manager. Financing of the system is provided through the general property tax and sewer service charge of $5 per month per residential connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of River Hills sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage systems, approximated $73,618, or about $39 per capita. Of this total, $17,620, or about $9 per capita, was expended for operation and maintenance and $55,998, or about $30 per capita, was expended for capital improvements.

Village of Shorewood: The existing service area of the Village of Shorewood sanitary sewerage system is shown on Map 33. This area totals about 1.6 square miles and has a resident population of about 12,600 persons. About 0.7 square mile containing about 4,300 persons, or about 44 percent of the area served and 34 percent of the population served in the village, are served by a separate sewer system, and about 0.9 square mile containing about 8,300 persons, or about 56 percent of the area served and about 66 percent of the population served, are served by a combined sewer system.

Since the Village of Shorewood is part of the Milwaukee-Metropolitan Sewerage District, sewage from the village is treated at the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of Shorewood in 1970 was 2.1 mgd.

There are 11 known points of sewage flow relief in the Village of Shorewood sanitary sewerage system, including 10 crossovers and one combined sewer outfall (see Map 34). As noted earlier in this chapter, the intercepting sewers of the Milwaukee-Metropolitan sewerage system convey all of the dry weather sewage flow and a portion of the wet weather sewage flow from the combined sewer area of the Village of Shorewood to the sewage treatment plant. The remaining wet weather flow for the combined sewer area is discharged directly to the Milwaukee River.

Management of the Village of Shorewood sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Manager. Financing of the system is provided through the general property tax and a sewer service charge based on water consumption. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Shorewood sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage systems, approximated $213,876, or about $17 per capita. Of this total, $61,629, or about $5 per capita, was expended for operation and maintenance and $152,247, or about $12 per capita, was expended for capital improvements.

Village of West Milwaukee: The existing service area of the Village of West Milwaukee sanitary sewerage system, which area encompasses the entire village, is shown on Map 33. This area totals about 1.1 square miles and has a resident population of about 5,600 persons. The entire area is served by a separate sanitary sewer system.

Since the Village of West Milwaukee is part of the Milwaukee-Metropolitan Sewerage District, sewage from the village is treated in the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of West Milwaukee in 1970 was 4.5 mgd. There are no known points of sewage flow relief in the Village of West Milwaukee sanitary sewerage system.

Management of the Village of West Milwaukee sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Superintendent of Public Works. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of West Milwaukee sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage systems, approximated $334,260 or about $60 per capita. Of this total, $124,915, or about $22 per capita, was expended for operation and maintenance and $209,345, or about $38 per capita, was expended for capital improvements.

Village of Whitefish Bay: The existing service area of the Village of Whitefish Bay sanitary sewerage system, which area encompasses the entire village, is shown on Map 33. This area totals about 2.12 square miles and has a resident population of about 14,900 persons. The entire area is served by a separate sanitary sewer system.

Since the Village of Whitefish Bay is part of the Milwaukee-Metropolitan Sewerage District, sewage from the village is treated in the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the Village of Whitefish Bay in 1970 was 1.7 mgd. There are 35 known points of sewage flow relief in the Village of Whitefish Bay sanitary sewerage system, all of which are crossovers (see Map 34).

Management of the Village of Whitefish Bay sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Manager. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Whitefish Bay sanitary sewerage system, including its share of the costs of constructing, operating, and maintaining the metropolitan sewerage systems, approximated $258,560, or about $17 per capita. Of this total, $71,556, or about $5 per capita, was expended for operation and maintenance and $187,004, or about $12 per capita, was expended for capital improvements.

Mission Hills Water and Sewer Trust: The existing service area of the Mission Hills Water and Sewer Trust sanitary sewerage system in the City of Franklin is shown on Map 33. This area totals about 0.5 square mile and has a resident population of about 500 persons. This area includes the Mission Hills Subdivision and nearby institutional land uses.

Sewage from the Mission Hills Water and Sewer Trust service area is treated in an activated sludge type sewage treatment plant constructed in 1968 (see Figure 33). The effluent from the plant is discharged to an unnamed tributary of the Root River. The average hydraulic design capacity of the plant is 0.33 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.04 mgd. The treatment processes provided at the plant are classified as secondary level. This plant was constructed as a temporary sewage treatment facility and is scheduled to be abandoned late in 1973 as local trunk sewer service from the City of Franklin is made available.

Management of the Mission Hills Water and Sewer Trust sanitary sewerage system is provided by a five-member Board of Trustees. Day-to-day administration of the system is provided by the President of the Board. Financing of the system is provided through a sewer service charge of $12 per month per residential connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Mission Hills sanitary sewerage system approximated $10,429, or about $21 per capita. Of this total, $3,829, or about $8 per capita, was expended for operation and maintenance and $6,600, or about $13 per capita, was expended for capital improvements.

Rawson Homes Sewer and Water Trust: The existing sewer service area of the Rawson Homes

Figure 33

MISSION HILLS WATER AND SEWER TRUST SEWAGE TREATMENT PLANT

Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

Sewer and Water Trust sanitary sewerage system in the City of Franklin is shown on Map 33. This area totals about 0.1 square mile and has a resident population of about 600 persons. The system serves the Rawson Homes Subdivision located in the northeasterly portion of the City of Franklin.

Figure 34

RAWSON HOMES SEWER AND WATER TRUST SEWAGE TREATMENT PLANT

Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

Sewage from the Rawson Homes Sewer and Water Trust service area is treated in an activated sludge type sewage treatment plant discharging its effluent to a tributary of the Root River (see Figure 34). The plant was constructed in 1954 and has an average hydraulic design capacity of 0.04 mgd. The average hydraulic loading on the plant in 1970 was not available. The treatment processes provided at the plant are classified as secondary level. The plant was constructed as a temporary sewage treatment facility and is scheduled to be abandoned as soon as local trunk sewer service from the City of Franklin is made available.

Management of the Rawson Homes Sewer and Water Trust is under the direction of a 10-member Board of Trustees. Day-to-day administration of the system is provided by the President of the Board. Financing of the system is provided through a sewer service charge of $8 per month per residential connection. Total expenditures during 1970 for operation and maintenance of the Rawson Homes sanitary sewerage system approximated $3, 550, or about $6 per capita.

Proposed Public Sanitary Sewerage Systems

The inventory revealed that as of 1970 there were no new proposed public sanitary sewerage systems for Milwaukee County. All areas of the county not now provided with public sanitary sewer service are scheduled to be provided with such service through the orderly extension of the trunk sewer systems of both the local communities and the Milwaukee-Metropolitan Sewerage Commissions.

Other Sewage Treatment Facilities

In addition to the 22 public sanitary sewerage systems discussed above, there are a total of five sewage treatment facilities in Milwaukee County which serve, in most cases, a single isolated land use enclave. These five sewage treatment facilities serve the Highway 100 Drive-In Theatre in the City of Franklin; the Pure Oil truck stop in the City of Franklin; the Wisconsin Electric Power Company in the City of Oak Creek; the S. K. Williams Company in the City of Wauwatosa; and the yards of the Chicago, Milwaukee, St. Paul, and Pacific Railroad Company in the City of Milwaukee. Pertinent characteristics pertaining to each of these sewage treatment facilities are presented in Table 27.

Of the foregoing five facilities, three—the Wisconsin Electric Power Company facility, the S. K. Williams Company facility, and the Milwaukee Railroad facility—are specialized types of sewage treatment facilities and constitute permanent facilities. The remaining two facilities could be abandoned at such time as local trunk sewer service becomes available.

Other Known Point Sources of Waste Water

In addition to identifying all existing public and private sewage treatment plants which discharge treated wastes to streams and watercourses within the Region, and all known sewage overflow points on both the existing sanitary and combined sewerage systems within the Region which discharge untreated wastes to streams and watercourses, an attempt was made in the regional sanitary sewerage system planning program to identify, through existing secondary sources, all other known point sources of waste water discharge. These other point sources of pollution consist primarily of industrial cooling, rinse, and wash waters, which may be discharged directly and without treatment to streams and watercourses or to storm sewers tributary to such streams and watercourses. The secondary sources consulted included river basin survey reports and pollution abatement orders of the Wisconsin Department of Natural Resources and records of municipal public works departments. A total of 87 such known point sources of industrial waste water were identified in Milwaukee County. The name, civil division location, type of waste, known pretreatment, and receiving water body of these 87 waste sources are identified in Table 28. The locations of these 87 point sources are shown on Map 35.

Existing Urban Development Not Served by Public Sanitary Sewers

As noted earlier, public sanitary sewerage systems in Milwaukee County serve a total area of

Table 27

SELECTED CHARACTERISTICS OF PRIVATE SEWAGE TREATMENT FACILITIES IN MILWAUKEE COUNTY: 1970

Name	Civil Division Location	Type of Land Use Served	Type of Treatment Provided	Average Hydraulic Design Capacity (Gallons/Day)	Disposal of Effluent
Chicago, Milwaukee, St. Paul and Pacific Railroad Company	City of Milwaukee	Transportation	Oil Separation	1,000,000[1]	Menomonee River
Highway 100 Drive In Theater	City of Franklin	Commercial	Clarifiers, Sand Filter, and Flow-through Lagoon	6,000	Root River
Pure Oil Truck Stop	City of Franklin	Commercial	Activated Sludge	10,000	Root River
S. K. Williams Company	City of Wauwatosa	Industricl	Chemical	400,000[2]	Menomonee River
Wisconsin Electric Power Company	City of Oak Creek	Utility	Activated Sludge	40,000	Lake Michigan

[1]*Based on discharge pump capacity.*
[2]*Estimate by S. K. Williams personnel.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 28

KNOWN EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN MILWAUKEE COUNTY: 1970

Point Source[1]		Civil Division Location	Type of Waste	Known Pretreatment	Receiving Water Body
Number[2]	Name				
1	Badger Meter Company	Village of Brown Deer	Cooling Waters	- -	Milwaukee River
2	City of Cudahy Water Treatment Plant	City of Cudahy	Waste Water Sludge	Sedimentation	Lake Michigan
3	Ladish Company	City of Cudahy	Cooling Water; Rinse Water	Lagoon	Kinnickinnic River
4	Packard Avenue Sunoco Car Wash	City of Cudahy	Inorganic Solids	Settling Basin	Kinnickinnic River
5	Willow Car Wash	City of Greenfield	Car Washing Waters	Settling Basin	Kinnickinnic River
6	A. O. Smith Corporation	City of Milwaukee	Cooling Waters	Catch Basin	Milwaukee River
7	American Can Company	City of Milwaukee	Cooling Waters	- -	Milwaukee River
8	American Motors Corporation	City of Milwaukee	Cooling Waters	- -	Milwaukee River
9	Automatic Auto Wash	City of Milwaukee	Car Washing Waters	Settling Basin	Milwaukee River
10	City of Milwaukee Asphalt Plant	City of Milwaukee	Inorganic Solids	Settling Basin	Menomonee River
11	City of Milwaukee Bureau of Electric Service	City of Milwaukee	Floor Washing Waters	Catch Basin	Milwaukee River
12	City of Milwaukee 5th District Police Station	City of Milwaukee	Garage Waters	Catch Basin	Milwaukee River
13	City of Milwaukee Howard Avenue Water Treatment Plant	City of Milwaukee	Waste Water Sludge	Sedimentation	Lake Michigan
14	City of Milwaukee Linwood Avenue Water Treatment Plant	City of Milwaukee	Waste Water Sludge	Sedimentation	Lake Michigan
15	Commerce St. Power Plant, Wisconsin Electric Co.	City of Milwaukee	Cooling Waters	- -	Milwaukee River
16	Continental Can Company, Inc.	City of Milwaukee	Cooling Waters	Catch Basin	Milwaukee River
17	Cornell Paperboard Plant, Division of St. Regis Paper Company	City of Milwaukee	Cooling Waters from Power House	- -	Milwaukee River
18	Crucible Steel Casting Company	City of Milwaukee	Rotoclone Wastes	Settling Pond	Kinnickinnic River
19	Delta Oil Products Corporation, Ricketson Color Division	City of Milwaukee	Oily Wastes	- -	Milwaukee River
20	Dickten and Masch Manufacturing Co.	City of Milwaukee	Cooling Waters	- -	Milwaukee River
21	Edison Street Power Plant, Wisconsin Electric Company	City of Milwaukee	Cooling Waters; Lime-Softening Wastes	- -	Milwaukee River
22	Evinrude Motors Division, Outboard Marine Corp.	City of Milwaukee	Oily Wastes	Oil Separator	Milwaukee River
23	Harley-Davidson Motor Company	City of Milwaukee	Cooling Water, Oily & Greasy Wastes	Grease Trap	Menomonee River
24	Hercules Power Company, Inc.	City of Milwaukee	Cooling Waters	- -	Milwaukee River
25	Interstate Drop Forge Company	City of Milwaukee	Oily Wastes, Cooling Waters	Oil and Grease Separator	Milwaukee River
26	Joseph Schlitz Brewing Company	City of Milwaukee	Cooling Waters	- -	Milwaukee River
27	Maynard Electric Steel Casting Company	City of Milwaukee	Oily Wastes, Rotoclone Wastes, Quench Waters	Oil Separators and Settling Basin	Kinnickinnic River
28	Miller Brewing Company	City of Milwaukee	Pasteurizer Water and Cooling Waters	- -	Menomonee River
29	Milwaukee County Park Commission, Holler Park	City of Milwaukee	Swimming Pool Water	- -	Kinnickinnic River
30	Milwaukee County Zoo	City of Milwaukee	Surface Runoff Water	- -	Menomonee River
31	Milwaukee Marble Company	City of Milwaukee	Inorganic Grinding Solids	Settling Basin	Menomonee River
32	Milwaukee School Board, Marshall High School	City of Milwaukee	Pool Drainage	- -	Milwaukee River
33	Modern Car Wash, Inc.	City of Milwaukee	Car Washing Waters	Settling Basin	Milwaukee River
34	Moss American Company	City of Milwaukee	Industrial Wastes	Gravity Separation Coke Filter	Little Menomonee River
35	Paul J. Schmidt Trucking	City of Milwaukee	Inorganic Grinding Solids	Settling Ponds	Milwaukee River
36	Penny-Wise Car Wash Systems — Mitchell Field	City of Milwaukee	Car Washing Waters	Settling Basin	Kinnickinnic River
37	Pelton Steel Casting Company	City of Milwaukee	Rotoclone Wastes	Lagoon	Kinnickinnic River
38	Perfex Corporation	City of Milwaukee	Cooling Waters	- -	Kinnickinnic River
39	Pure Oil Capitol Court Auto Wash	City of Milwaukee	Car Washing Waters	Settling Basin	Milwaukee River
40	Pure Oil Car Wash	City of Milwaukee	Car Washing Waters	Settling Basin	Milwaukee River
41	Sealtest Foods, Division of Dairy Products, Kraftco Corporation	City of Milwaukee	Loading Dock Washing (Loading Dock Waste from Spillage)	Catch Basin	Milwaukee River
42	Solvay Coke Company	City of Milwaukee	Quench Waters	Quench Tanks	Kinnickinnic River
43	Suburban Car Wash	City of Milwaukee	Car Washing Waters	Settling Basin	Menomonee River
44	The Falk Corporation	City of Milwaukee	Cooling Waters	- -	Menomonee River
45	The Heil Company	City of Milwaukee	Cooling Waters	Catch Basins	Kinnickinnic River
46	White Construction Company	City of Milwaukee	Inorganic Solids	Settling Basins	Menomonee River
47	WISCO 99 Car Wash	City of Milwaukee	Car Washing Waters	Settling Basin	Milwaukee River
48	Wisconsin Electric Power Company	City of Milwaukee	Cooling Waters	- -	Menomonee River
49	Wisconsin Gas Company, North Service Center	City of Milwaukee	Auto and Truck Washing Waters	Settling Basin	Milwaukee River
50	Wisconsin Gas Company, South Service Center	City of Milwaukee	Auto and Truck Washing Waters	Settling Basin	Kinnickinnic River
51	Peter Cooper Corporation	City of Oak Creek	Backwash Water & Sludge	- -	Lake Michigan
52	Wisconsin Electric Power Company	City of Oak Creek	Industrial Waste Water & Cooling Waters	Sedimentation	Lake Michigan
53	A & P Warehouse (Meat Building)	City of Wauwatosa	Cooling Waters	- -	Menomonee River
54	Blue Crest Motel	City of Wauwatosa	Sand Filter Backwash Water & Pool Drainage	- -	Menomonee River

Table 28 (continued)

Point Source[1]		Civil Division Location	Type of Waste	Known Pretreatment	Receiving Water Body
Number[2]	Name				
55	City of Wauwatosa, Municipal Garage	City of Wauwatosa	Garage Waste Waters	Catch Basin	Menomonee River
56	Stroh Die Casting Company, Inc.	City of Wauwatosa	Cooling Waters	- -	Menomonee River
57	Tews Lime and Cement Company, Butler Plant	City of Wauwatosa	Inorganic Solids	Settling Basin	Menomonee River
58	The Falk Corporation	City of Wauwatosa	Cooling Waters	- -	Menomonee River
59	Wauwatosa School Board, Whitman Junior High	City of Wauwatosa	Sand Filter Backwash Water & Pool Drainage	- -	Menomonee River
60	Allied Smelting Corporation	City of West Allis	Cooling Waters	- -	Kinnickinnic River
61	Allis Chalmers Manufacturing Corp.	City of West Allis	Cooling Waters	Ponding & Recirculation	Menomonee River
62	Benlo Chemicals	City of West Allis	Floor Washings & Possible Sulfuric Acid Spills	Neutralizing Basin	Menomonee River
63	Bordens, Incorporated	City of West Allis	Cooling Waters	Gravity Separator	Underwood Creek
64	Briggs and Stratton Corporation	City of West Allis	Cooling Waters	Neutralizing Basin	Kinnickinnic River
65	City of West Allis Incinerator Plant	City of West Allis	Cooling Waters	Settling Basin	Kinnickinnic River
66	Crestwood Bakery	City of West Allis	Cooling Waters	- -	Menomonee River
67	Fruehauf Trailer	City of West Allis	Trailer Washing Waters	Catch Basin	Menomonee River
68	Hansen Laboratories, Incorporated	City of West Allis	Cooling Waters	- -	Honey Creek
69	Kearney and Trecker Corporation	City of West Allis	Cooling Waters	- -	Menomonee River
70	King Car Wash	City of West Allis	Car Washing Waters	Settling Basin	Menomonee River
71	Midwest Trucking	City of West Allis	Garage Washing Waters	Catch Basin	Kinnickinnic River
72	Motor Castings Corporation	City of West Allis	Cooling Waters	- -	Kinnickinnic River
73	Oilgear Company	City of West Allis	Oily Waste Water	Oil Separator	Kinnickinnic River
74	Pressed Steel Tank Company	City of West Allis	Cooling Waters	Oil Separator	Menomonee River
75	Seven-Up Bottling Company	City of West Allis	Cooling & Rinse Water	- -	Menomonee River
76	Theim Products	City of West Allis	Cooling Waters	- -	Underwood Creek
77	Unit Drop Forge Corporation	City of West Allis	Cooling Waters	Oil Separator	Kinnickinnic River
78	Wehr Steel Company	City of West Allis	Foundry Wastes	Lagoon-Settling Ponds	Kinnickinnic River
79	Wisconsin Electric Power Company (Bluemound Sub-station)	City of West Allis	Cooling Waters	- -	Menomonee River
80	Wisconsin Grey Iron Foundry	City of West Allis	Cooling Waters	- -	Honey Creek
81	Wisconsin Motors Corporation	City of West Allis	Cooling Waters	- -	Menomonee River
82	General Electric X-Ray Corp.	Village of West Milwaukee	Cooling Waters	- -	Kinnickinnic River
83	Harnischfeger Corporation	Village of West Milwaukee	Cooling Waters	Settling Tanks	Menomonee River
84	Hotpoint Division of General Electric Company	Village of West Milwaukee	Cooling Waters	Oil Reclaiming	Kinnickinnic River
85	Kurth Malting Company	Village of West Milwaukee	Cooling Waters	- -	Menomonee River
86	Nordberg Company	Village of West Milwaukee	Cooling Waters	Settling Waters	Menomonee River
87	City of South Milwaukee Water Treatment Plant	City of South Milwaukee	Waste Water Sludge	Sedimentation	Oak Creek

[1]As identified in Wisconsin Department of Natural Resources river basin survey reports and pollution abatement orders and by selected municipal public works departments; does not include industrial waste sources discharging to municipal sanitary sewerage systems.
[2]See Map 35.

Source: SEWRPC.

about 179 square miles, or about 74 percent of the total area of the county, and a total population of about 1.03 million, or about 98 percent of the total population of the county. An inventory was conducted in the study to determine the approximate amount of urban development, and the population residing therein, in Milwaukee County not served in 1970 by public sanitary sewer service. Each U. S. Public Land Survey quarter section not having development served by a centralized sanitary sewerage system was examined to determine if a significant amount of urban development was present in 1970. Any quarter section with at least 32 housing units, or an average of one housing unit per five gross acres, was deemed to be urban. The major purpose in identifying such concentrations of urban development was to provide a basis for analyzing the potential of providing public sanitary sewer service to such areas in accordance with recommendations contained in the adopted regional land use plan.

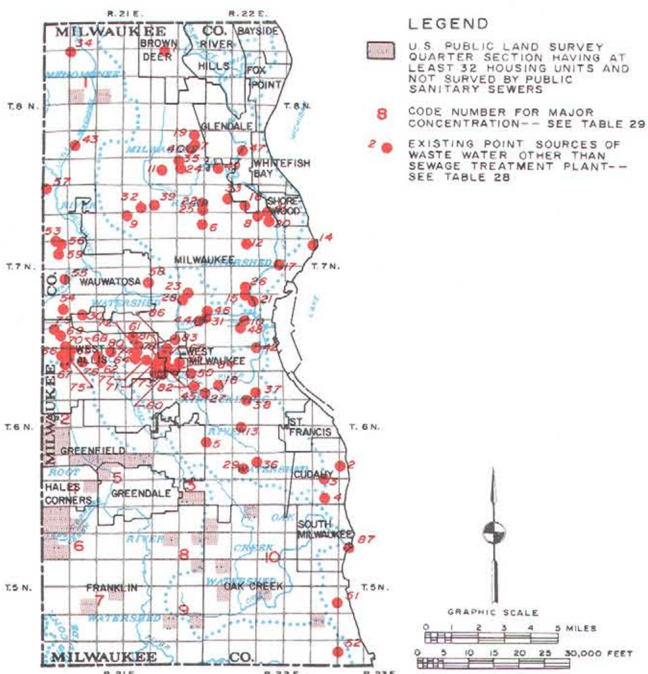
The nonsewered urban development areas identified in Milwaukee County are shown on Map 35. Together these areas total about 4.5 square miles, or 2 percent of the total area of the county, and contain a total population of about 12,700, or 1 percent of the total population of the county. For analysis purposes, the existing nonsewered urban development has been combined into 10 named major urban concentrations. The estimated population and urban development areas in each of these major concentrations are shown in Table 29.

Concluding Remarks—Milwaukee County

Inventories conducted under the regional sanitary sewerage system planning program revealed that in 1970 there existed in Milwaukee County a total of 22 public sanitary sewerage systems which together served a total area of about 179 square miles, or about 74 percent of the total area of the county, and a total population of about 1.03 million, or about 98 percent of the total population of

Map 35

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS AND EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN MILWAUKEE COUNTY: 1970



As shown on this map, significant concentrations of unsewered urban development in Milwaukee County are found within the Cities of Franklin, Greenfield, and Oak Creek in the southern portion of the county and the former Town of Granville area in the City of Milwaukee in the northwest portion of the county. Such areas are representative of both typical septic tank subdivision development of the 1950s and early 1960s and older, established, unincorporated places, such as the St. Martins area in the City of Franklin. A number of these unsewered urban areas have been provided with sanitary sewer service since 1970. This map also shows the 87 known point sources of wastewater other than sewage treatment plants in the county. Such waste sources occur almost exclusively in the industrial land use concentrations of the major cities in the county.

Source: Wisconsin Department of Natural Resources and SEWRPC.

the county. Seven sewage treatment facilities provide treatment for sewage generated in these 22 public sanitary sewerage systems. Three of these facilities—the Jones Island, South Shore, and Hales Corners sewage treatment plants—are operated by the Milwaukee-Metropolitan Sewerage Commissions and serve, in addition to 18 municipalities within Milwaukee County, six civil divisions lying in areas outside of the county which contract with the Milwaukee-Metropolitan Sewerage District for sewage treatment. The Hales

Table 29

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN MILWAUKEE COUNTY BY MAJOR URBAN CONCENTRATION: 1970

Major Urban Concentration[1]		Estimated Resident Population	Developed Urban Area (Acres)
Number[2]	Name		
1	City of Milwaukee – Northwest	700	135
2	City of Greenfield – West	3,500	927
3	City of Greenfield – South	1,000	125
4	Village of Hales Corners	400	97
5	Village of Greendale	200	89
6	St. Martins Area	2,500	636
7	Mission Hills Area	1,300	219
8	Rawson Homes Area	1,000	292
9	Oakwood Park Area	300	72
10	City of Oak Creek	1,800	289
	Milwaukee County Total	12,700	2,881[3]

[1]*Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*
[2]*See Map 35.*
[3]*Equal to 4.5 square miles.*

Source: SEWRPC.

Corners facility is scheduled to be abandoned in the very near future as trunk sewer service becomes available. Other sewage treatment facilities are operated by the City of South Milwaukee, the City of Oak Creek, the Mission Hills Water and Sewer Trust in the City of Franklin, and the Rawson Homes Sewer and Water Trust in the City of Franklin. Of these latter four facilities, all but the sewage treatment facility operated by the City of South Milwaukee are scheduled to be abandoned as trunk sewers constructed by the local communities and the Milwaukee-Metropolitan Sewerage Commissions become available. In addition to the 22 public sanitary sewerage systems, five sewage treatment facilities were found to exist in the county which primarily serve a single land use. Finally, in 1970 there were an estimated 12,700 persons residing in urban areas in Milwaukee County not served by public sanitary sewer service. Together, these areas totaled about 4.5 square miles.

INVENTORY FINDINGS—OZAUKEE COUNTY

Existing Public Sanitary Sewerage Systems

There are a total of eight existing public sanitary sewerage systems in Ozaukee County which provide centralized sanitary sewer service to subareas of the county.[13] These include the systems

[12]*Small portions of two additional public sanitary sewerage systems extend into Ozaukee County. These include the Village of Bayside system (0.09 square mile in Ozaukee County) described in the Milwaukee County portion of this chapter and the Newburg Sanitary District (less than 0.01) square mile served in Ozaukee County) described in the Washington County portion of this chapter.*

operated by the Cities of Cedarburg, Mequon, and Port Washington; and the Villages of Belgium, Fredonia, Grafton, Saukville, and Thiensville. The City of Mequon system is connected to the larger Milwaukee-Metropolitan sewerage system described earlier in this chapter. Together, these eight systems serve a total area of about 17.3 square miles, or about 7 percent of the total area of the county, and a total population of about 36,300 people, or about 66 percent of the total population of the county. Each of these public sanitary sewerage systems is described in the following paragraphs. Pertinent characteristics of each system are presented in Tables 30 and 31.

Table 30

AREA AND POPULATION SERVED BY EXISTING AND LOCALLY PROPOSED SANITARY SEWERAGE SYSTEMS IN OZAUKEE COUNTY: 1970

Name of Public Sanitary Sewerage System	Estimated Service Area				Population Served[2]	Estimated Treatment of Sewage (See Table 31)
	Existing		Proposed[1]			
	Acres	Square Miles	Acres	Square Miles		
Existing Systems						
City of Cedarburg	1,499	2.34	1,679	2.62	8,000	Operates a Facility
City of Mequon	5,623	8.79	10,600	16.56	6,600	Contracts with Milwaukee-Metropolitan Sewerage Commissions
City of Port Washington	1,289	2.01	4,500	7.02	8,800	Operates a Facility
Village of Belgium	167	0.26	- -	- -	800	Operates a Facility
Village of Fredonia	453	0.71	- -	- -	1,000	Operates a Facility
Village of Grafton	1,200	1.87	1,840	2.87	6,400	Operates a Facility
Village of Saukville	199	0.31	- -	- -	1,100	Operates a Facility
Village of Thiensville	634	0.99	25	0.04	3,600	Operates a Facility
Proposed Systems						
Town of Belgium	- -	- -	4,136	6.46	- -	- -
County Total	11,064	17.28	22,780	35.57	36,300	- -

[1]As identified in locally prepared plans and engineering reports.
[2]Based upon an approximation of the existing sewer service area by U.S. Public Land Survey quarter section.

Source: SEWRPC.

Table 31

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN OZAUKEE COUNTY: 1970

Name of Public Sewage Treatment Facility	Estimated Total Area Served (Square Miles)	Estimated Total Population Served	Date of Original Construction and Major Modification	Type of Treatment Provided	Level of Treatment Provided	Disposal of Effluent	Design Capacity				
							Population[1]	Average Hydraulic (MGD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Population Equivalent[1]
City of Cedarburg	2.34	8,000	1925, 1961	Trickling Filter	Secondary	Cedar Creek	N/A	0.90	1.40	1,500	7,150
City of Port Washington	2.01	8,800	1956	Sedimentation	Primary	Lake Michigan	10,000	1.00	2.55	N/A	N/A
Village of Belgium	0.26	800	1949, 1970	Activated Sludge	Secondary	Unnamed Tributary of the Onion River	1,200	0.07	0.10	N/A	N/A
Village of Fredonia	0.71	1,000	1939, 1962	Activated Sludge	Secondary	Milwaukee River	1,206	0.12	0.25	201	955
Village of Grafton	1.87	6,400	1934, 1959	Activated Sludge	Secondary	Milwaukee River	4,500	0.45	0.65	900	4,300
Village of Saukville	0.31	1,100	1960	Trickling Filter	Secondary	Milwaukee River	N/A	0.32	0.56	267	1,270
Village of Thiensville	0.99	3,600	1951, 1963	Activated Sludge	Secondary	Milwaukee River	3,000	0.24	0.36	N/A	N/A

Name of Public Sewage Treatment Facility	Existing Loading - 1970					Sewage Strength Parameters in Influent Sewage					Industrial Flows		Overall Plant Efficiency Percent Removals			Number of Days in 1970 Plant Flow Exceeded Plant Meter Capacity
	Average Hydraulic (MGD)	Average Per Capita (GPD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Reserve Hydraulic Capacity (MGD)	$CBOD_5$ (mg/1)	Suspended Solids (mg/1)	Total Phosphorus (mg/1)	Organic Nitrogen-N (mg/1)	Ammonia Nitrogen-N (mg/1)	Design Average Daily Flow (MGD)	Estimated Daily Flow 1970 (MGD)	$CBOD_5$ (Percent)	Suspended Solids (Percent)	Total Phosphorus (P) (Percent)	
City of Cedarburg	1.26	158	N/A	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
City of Port Washington	1.05	119	N/A	N/A	None	130[2]	125[2]	15.5[2]	11.2[2]	12.6[2]	N/A	N/A	N/A	40[2]	10[2]	N/A
Village of Belgium	0.06	75	N/A	N/A	0.01	220[3]	160[3]	16.0[3]	14.2[3]	25.6[3]	N/A	N/A	75[3]	57[3]	10[3]	N/A
Village of Fredonia	0.10	100	N/A	N/A	0.02	200[4]	160[4]	9.0[4]	12.9[4]	N/A	N/A	N/A	75[4]	72[4]	5[4]	N/A
Village of Grafton	0.80	125	N/A	N/A	None	46[5]	34[5]	7.2[5]	46[5]	9.6[5]	N/A	N/A	40[5]	20[5]	5[5]	N/A
Village of Saukville	0.25	227	N/A	N/A	0.07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Thiensville	0.70	194	N/A	N/A	None	161[6]	136[6]	N/A	N/A	N/A	N/A	N/A	87[6]	N/A	N/A	N/A

NOTE: N/A indicates data not available.

[1]The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design $CBOD_5$ loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of $CBOD_5$ per day. If the design engineer assumed a different daily per capita contribution of $CBOD_5$, the population equivalent design capacity will differ from the population design capacity shown in the Table.

Source: Wisconsin Department of Natural Resources and SEWRPC.

[2]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in June 1969.
[3]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in September 1969.
[4]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in September 1971.
[5]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in September 1966.
[6]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in September 1966.

City of Cedarburg: The existing service area of the City of Cedarburg sanitary sewerage system is shown on Map 36. This area totals about 2.3 square miles and has a resident population of about 8,000 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Cedarburg is treated at a sewage treatment plant located at the eastern city limits on Cedar Creek, a tributary of the Milwaukee River, to which effluent is discharged (see Figure 35). The plant has a site area of about three acres, all of which are currently utilized. The plant site is bounded by residential development on the northwest and northeast, by cemetery lands on the southwest, and by agricultural and open lands on the southeast. The plant, a trickling filter type, was initially constructed in 1925 and underwent extensive modifications in 1961. The average hydraulic design capacity of the plant is 0.9 mgd, with an estimated peak hydraulic design capacity of 1.4 mgd. The average hydraulic loading on the plant in 1970 was estimated at 1.3 mgd, indicating that the plant did not have adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided by the plant are classified as secondary level. It should be noted that during 1972 the City of Cedarburg placed into operation a significant expansion of its sewage treatment facility, so that the plant now has an average hydraulic design capacity of 3.0 mgd. The new facility is designed to provide for 95 percent removal of $CBOD_5$ and 85 percent removal of phosphorus, as well as disinfection by chlorination, and thus provide an advanced level of waste treatment.

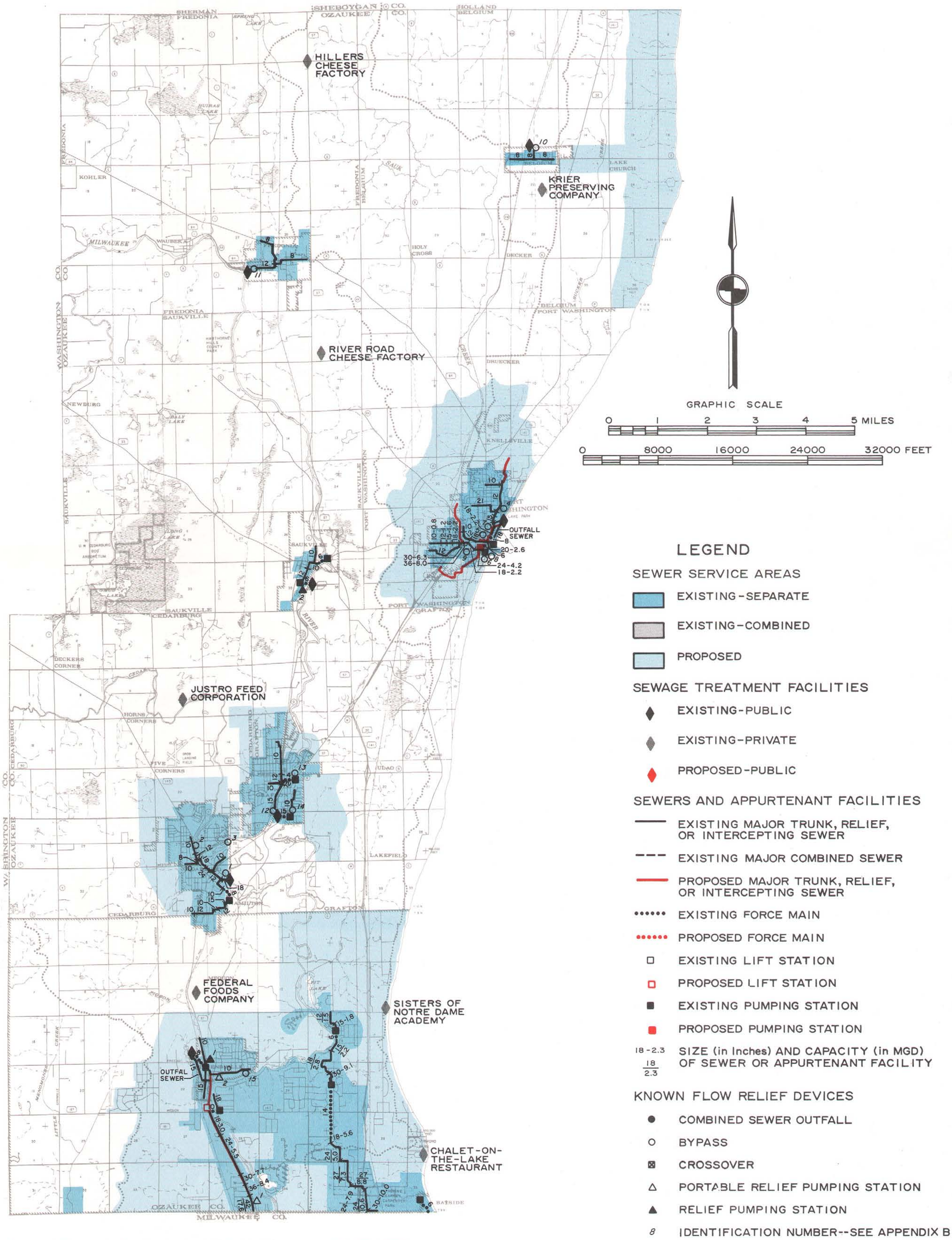
Figure 35

CITY OF CEDARBURG SEWAGE TREATMENT PLANT

Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

Map 36

EXISTING AND LOCALLY PROPOSED PUBLIC SANITARY SEWERAGE SYSTEMS AND OTHER SEWAGE TREATMENT FACILITIES IN OZAUKEE COUNTY 1970



Source: Wisconsin Department of Natural Resources and SEWRPC.

(This page intentionally left blank)

The location and configuration of the major trunk sewers serving the City of Cedarburg are shown on Map 36. There are three known points of sewer overflow or bypassing in the City of Cedarburg sanitary sewerage system, all of which are bypasses including one located at the sewage treatment plant. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional 2.6 square mile area, which area is shown on Map 36. However, no locally proposed trunk sewers were found in the inventory.

Management of the City of Cedarburg sanitary sewerage system is under the direction of a five-member Board of Public Works. Day-to-day administration of the system is provided by the City Engineer. Financing of the system is provided through a sewer service charge equal to the quarterly water charge during the winter quarter. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Cedarburg sanitary sewerage system approximated $62,500, or about $8 per capita. Of this total, $37,500, or about $5 per capita, was expended for operation and maintenance and $25,000, or about $3 per capita, was expended for capital improvements.

City of Mequon: The existing service area of the City of Mequon sanitary sewerage system is shown on Map 36. This area totals about 8.8 square miles and has a resident population of about 6,600 persons. The entire area is served by a separate sanitary sewer system.

The City of Mequon contracts with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment. The sewage from the city is treated in the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The average daily flow from the City of Mequon in 1970 was 0.9 mgd.

The location and configuration of the major trunk sewers serving the City of Mequon are shown on Map 36. There is one known point of sewage flow relief in the City of Mequon sanitary sewerage system—a portable relief pumping station. The planned future service area in the City of Mequon, totaling about 16.5 square miles, is shown on Map 36. No locally proposed trunk sewers were found in the inventory.

Management of the City of Mequon sanitary sewerage system is under the direction of the City Council. Day-to-day administration of this system is provided by the Director of Public Works. Financing of the system is provided through a sewer service charge of $6 per month per connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Mequon sanitary sewerage system approximated $646,057, or about $98 per capita. Of this total, $47,849, or about $7 per capita, was expended for operation and maintenance and $598,208, or about $91 per capita, was expended for capital improvements.

City of Port Washington: The existing service area of the City of Port Washington sanitary sewerage system is shown on Map 36. This area totals about two square miles and has a resident population of about 8,800 persons. The entire area is served by a separate sanitary sewer system.[14]

Sewage from the City of Port Washington is treated in a sewage treatment plant located on the Lake Michigan shoreline just north of the City of Port Washington Harbor (see Figure 36). The plant has a site area of about one acre, all of which is currently utilized. The plant site is bounded on the east by Lake Michigan and on the south, west, and north by park and other municipal lands. Effluent disposal is via an 18-inch outfall sewer to the Port Washington harbor. The plant, which provides only a primary level of treatment, was constructed in 1956. The plant has an average hydraulic design capacity of 1.00 mgd, with a peak hydraulic design capacity of 2.55 mgd. The average hydraulic loading on the plant in 1970 was 1.05 mgd, indicating that the plant is operating over the design capacity. It should be noted that the City of Port Washington has currently under construction additional sewage treatment facilities designed to provide secondary and advanced levels of treatment, with a new average hydraulic design capacity of 1.25 mgd and a peak hydraulic design capacity of 2.55 mgd.

---

[14] *At the time of the inventory for the regional sanitary sewerage system planning program, City of Port Washington officials indicated that the last few remaining combined sewer service areas were in the process of being separated. For the purposes of this report, therefore, the entire city has been classified as a separate sewer service area. City officials expect to complete the separation process in early 1974.*

Figure 36

CITY OF PORT WASHINGTON
SEWAGE TREATMENT PLANT

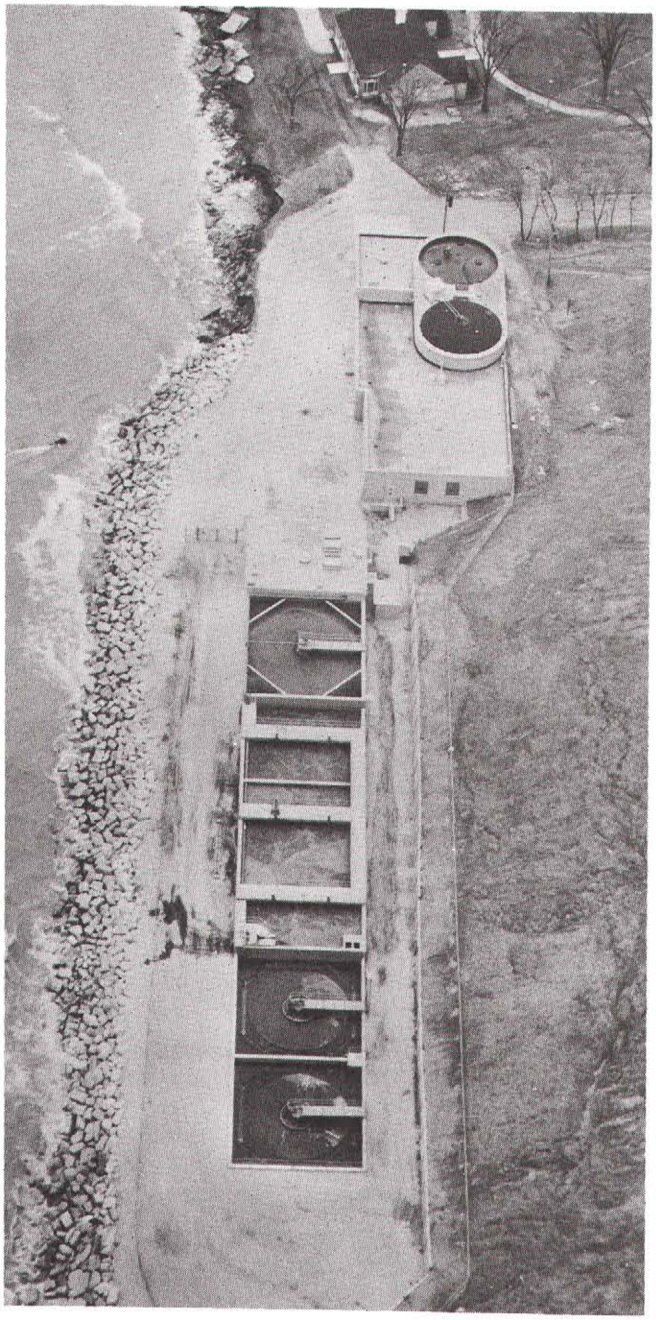


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains comprising the City of Port Washington sanitary sewerage system are shown on Map 36. There are six known points of sewage flow relief in the City of Port Washington sanitary sewerage system, all of which are bypasses, including one at the sewage treatment plant. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional seven square mile area, which area is shown on Map 36. Locally proposed trunk sewers to serve this future service area are also shown on Map 36.

Management of the City of Port Washington sanitary sewerage system is under the direction of the Board of Public Works, a committee of the City Council. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system in 1970 was provided through the general property tax. In July 1972 the city instituted a sewer service charge equal to 80 percent of a consumer's water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Port Washington sanitary sewerage system approximated $182,827, or about $21 per capita. Of this total, $24,952, or about $3 per capita, was expended for operation and maintenance and $157,875, or about $18 per capita, was expended for capital improvements.

Village of Belgium: The existing service area of the Village of Belgium sanitary sewerage system is shown on Map 36. This area totals about 0.26 square mile and has a resident population of about 800 persons. The entire area is served by a separate sanitary sewer system. Sewage from the Village of Belgium is treated in an activated sludge type sewage treatment plant located at the northern village limits on the Onion River, to which effluent is discharged (see Figure 37). The plant has a site area of about 0.5 acre, all of which is currently utilized. The plant site is bounded by commercial land use development on the east and north, a public street on the south, and agricultural land on the west. The plant was constructed in 1949 and has an average hydraulic design capacity of 0.07 mgd, with a peak hydraulic design capacity of 0.10 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.06 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the existing sewer service area. Treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewer serving the Village of Belgium is shown on Map 36. There is one known point of sewage flow

Figure 37

VILLAGE OF BELGIUM SEWAGE TREATMENT PLANT

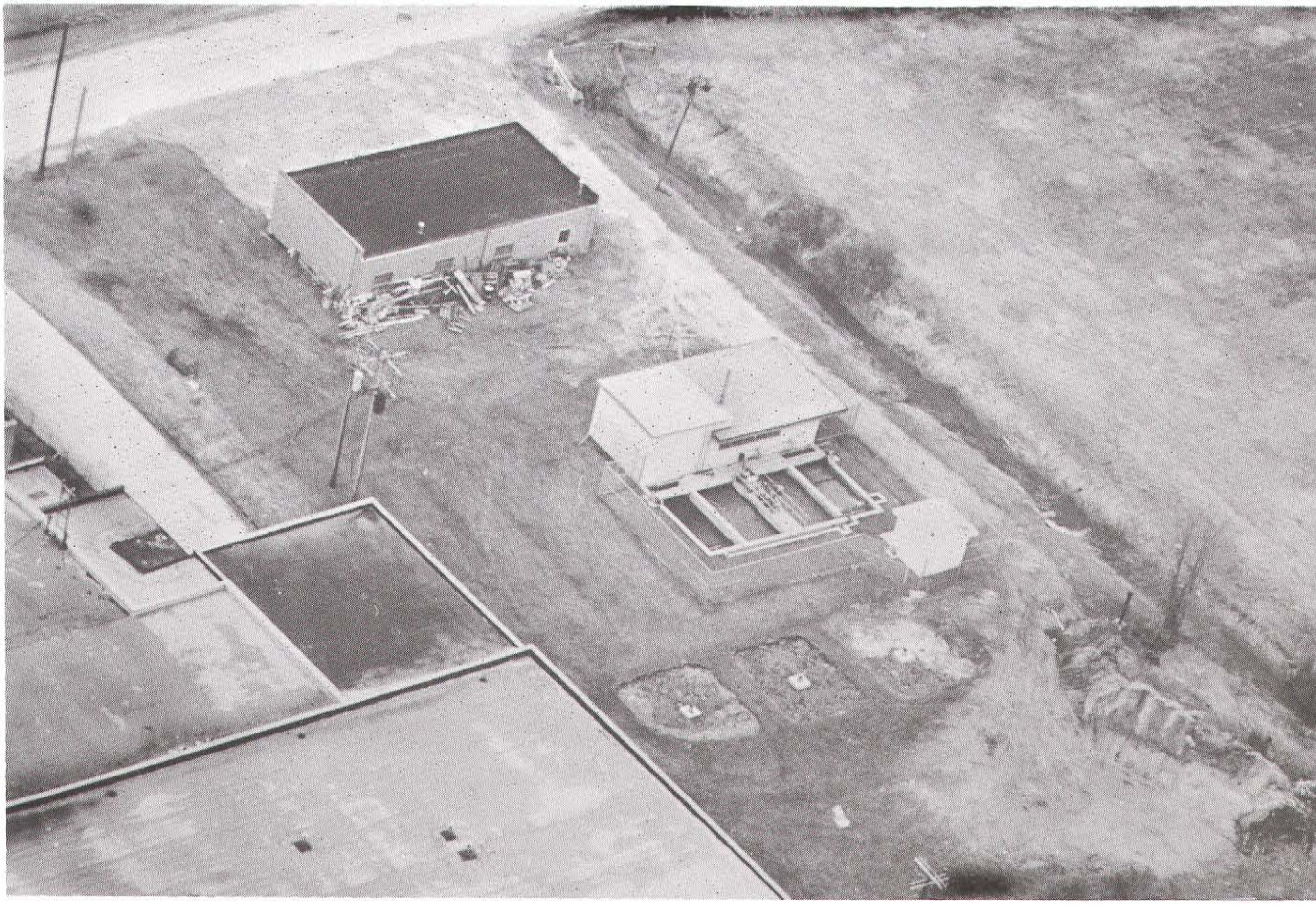


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

relief in the system, a bypass at the sewage treatment plant. The inventory revealed that the village had no documented plan for the expansion of its sewer service area; however, the village has participated in preliminary discussions with the Town of Belgium relative to the provision of sanitary sewer service to existing development located in the Lake Church area and along the Lake Michigan shoreline and to the Harrington Beach State Park. This proposed system in the Town of Belgium is discussed later in this chapter.

Management of the Village of Belgium sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the sewage plant operator. Financing of the system is provided through the general property tax and a sewer service charge of $6 per quarter per connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Belgium sanitary sewerage system approximated $13,120, or about $16 per capita. Of this total, $8,082, or about $10 per capita, was expended for operation and maintenance and $5,038, or about $6 per capita, was expended for capital improvements.

Village of Fredonia: The existing service area of the Village of Fredonia sanitary sewerage system is shown on Map 36. This area totals about 0.71 square mile and has a resident population of about 1,000 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Fredonia is treated in an activated sludge type sewage treatment plant located at the southwesterly village limits on the Milwaukee River, to which effluent is discharged (see Figure 38). The plant has a site area of about

Figure 38

VILLAGE OF FREDONIA SEWAGE TREATMENT PLANT

Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

three acres, of which about one acre is currently utilized, leaving two acres available for future use. The plant site is bounded by agricultural and open lands on all sides. The plant was constructed in 1939 and was extensively modified in 1962. The plant has an average hydraulic design capacity of 0.12 mgd, with a peak hydraulic design capacity of 0.25 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.10 mgd, indicating that the plant is operating near the design capacity. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers serving the Village of Fredonia are shown on Map 36. The only known point of sewage flow relief in the Village of Fredonia sanitary sewerage system is a bypass located at the sewage treatment plant. The inventory revealed that the village had no documented plan for the extension of trunk sewers to provide service to additional areas. Thus, no locally proposed service area or trunk sewers are shown on Map 36.

Management of the Village of Fredonia sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of this system is provided by the Clerk of the Sewer and Water Commission. Financing of the system is provided through the general property tax and a sewer service charge equal to 100 percent of a consumer's water bill. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements for the Village of Fredonia sanitary sewerage system were not made available by the village.

Village of Grafton: The existing service area of the Village of Grafton sanitary sewerage system is shown on Map 36. This area totals about

1.9 square miles and has a resident population of about 6,400 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Grafton is treated in an activated sludge type sewage treatment plant located at the southern village limits on the Milwaukee River, to which effluent is discharged (see Figure 39). The plant has a site area of about two acres, both of which are currently utilized. The plant site is bounded by open and wooded lands on the south, railroad right-of-way on the west, commercial land use on the north, and Green Bay Road on the east. The plant was constructed in 1959 and replaced an earlier plant constructed in 1934. The plant has an average hydraulic design capacity of 0.45 mgd, with a peak hydraulic design capacity of 0.65 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.8 mgd, indicating that the plant was operating over the design capacity. The treatment processes provided at the plant are classified as secondary level. It should be noted that the Village of Grafton placed into operation during 1972 additions to its treatment plant to provide for a total average hydraulic design capacity of 1.0 mgd, a total peak hydraulic capacity of 2.5 mgd, and advanced waste treatment.

The location and configuration of the major trunk sewers serving the Village of Grafton are shown on Map 36. There are three known points of sewage flow relief in the system, all of which are bypasses, including one at the sewage treatment plant. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 2.9 square mile area, which area is shown on Map 36. No locally proposed trunk sewers to serve this area were, however, found in the inventory.

Management of the Village of Grafton sanitary sewerage system is under the direction of a five-member Sewer and Water Commission. Day-to-day administration of this system is provided by the staff of the Commission. Financing of the system is provided through a sewer service charge. Total expenditures during 1970 for opera-

Figure 39

VILLAGE OF GRAFTON SEWAGE TREATMENT PLANT

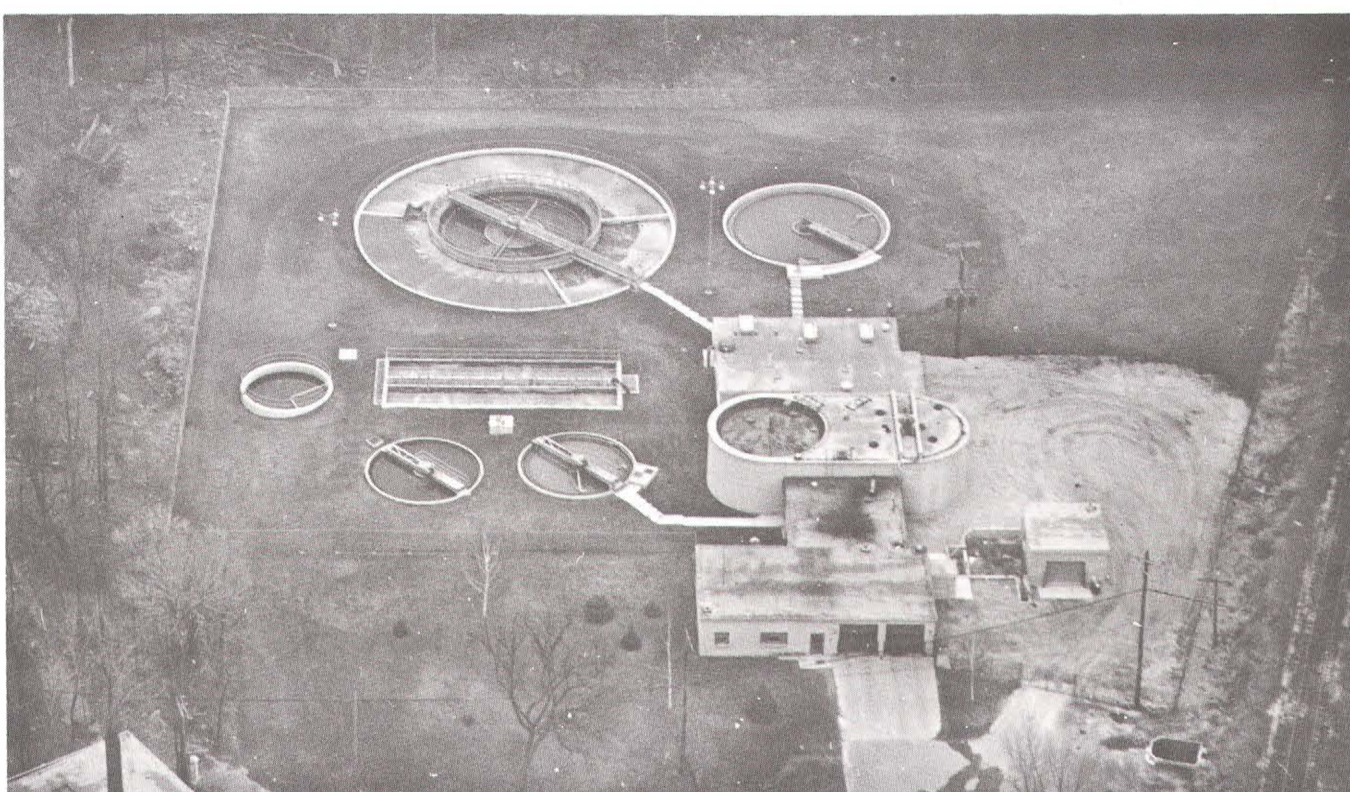


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

tion, maintenance, and capital improvements, including debt retirement, for the Village of Grafton sanitary sewerage system approximated \$136,895, or about \$21 per capita. Of this total, \$15,055, or about \$2 per capita, was expended for operation and maintenance and \$121,840, or about \$19 per capita, was expended for capital improvements.

Village of Saukville: The existing service area of the Village of Saukville sanitary sewerage system is shown on Map 36. This area totals about 0.3 square mile and has a resident population of about 1,100 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Saukville is treated in a trickling filter type sewage treatment plant located at the southeasterly village limits on the Milwaukee River, to which effluent is discharged (see Figure 40). The plant has a site area of about three acres, of which about two acres are currently utilized, leaving about one acre available for future use. The plant site is bounded by the Milwaukee River on the west and by agricultural and open lands on the north, south, and east. The plant was constructed in 1960 and has an average hydraulic design capacity of 0.32 mgd, with a peak hydraulic design capacity of 0.56 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.25 mgd, indicating that the plant was operating near the design capacity. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers serving the Village of Saukville are shown on Map 36. There is one known point of sewage flow relief in the system, a relief pumping station located just ahead of the sewage treatment plant.

Figure 40

VILLAGE OF SAUKVILLE SEWAGE TREATMENT PLANT

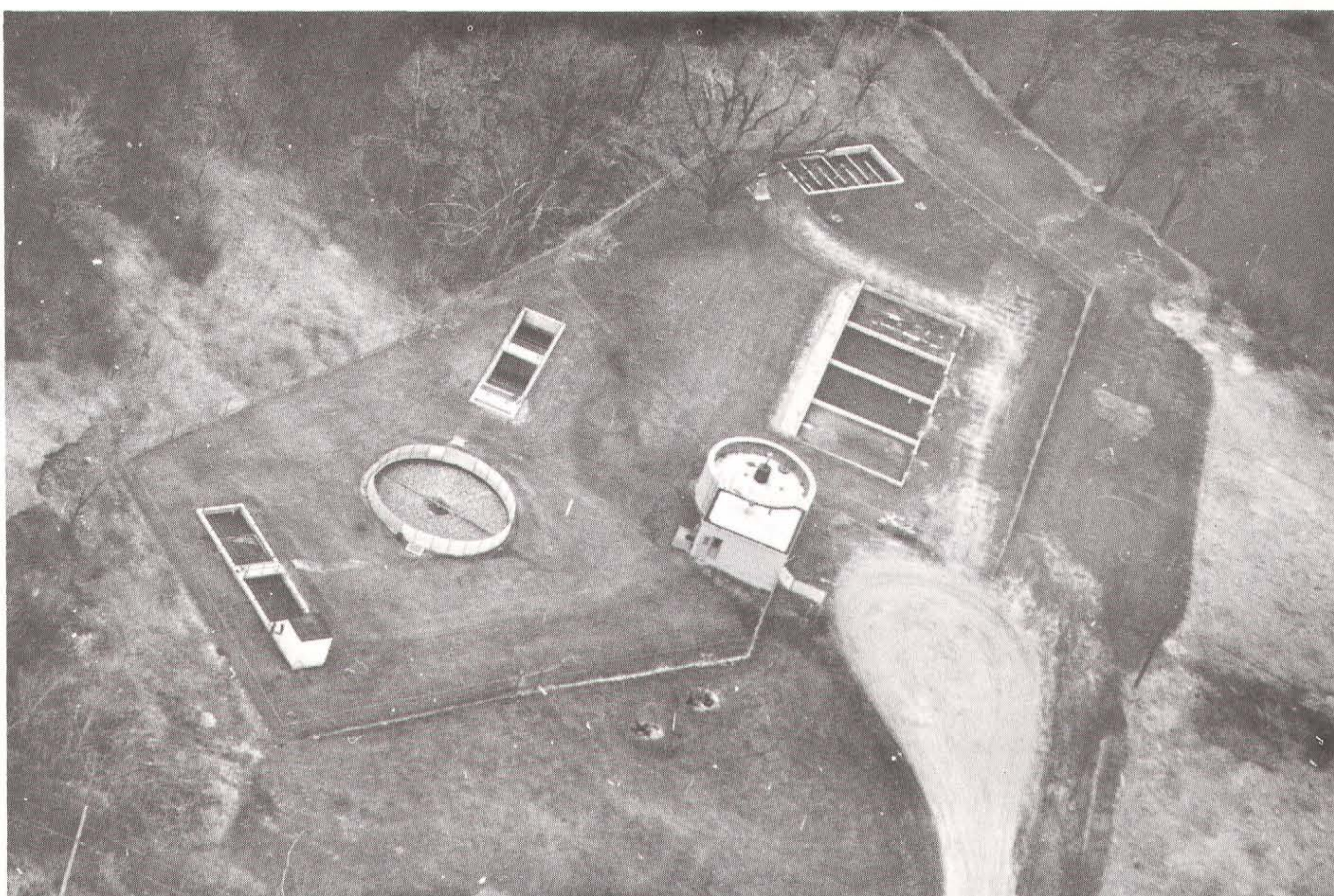


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

The inventory revealed that the village had no documented plan for the extension of trunk sewers to provide service to additional areas. Thus, no locally proposed service area or trunk sewers are shown on Map 36.

Management of the Village of Saukville sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Utility Committee of the Board and the Commissioner of Public Works. Financing of the system is provided through a sewer service charge equal to 80 percent of a consumer's water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Saukville sanitary sewerage system approximated $26,150, or about $24 per capita. Of this total, $17,045, or about $16 per capita, was expended for operation and maintenance and $9,105, or about $8 per capita, was expended for capital improvements.

Village of Thiensville: The existing service area of the Village of Thiensville sanitary sewerage system, which area encompasses nearly the entire village, is shown on Map 36. This area totals about one square mile and has a resident population of about 3,600 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Thiensville is treated in an activated sludge type sewage treatment plant located at the northwesterly village limits on Pigeon Creek, a tributary of the Milwaukee River, into which effluent is discharged (see Figure 41). The plant has a site area of about three acres. The plant was initially constructed in 1951 and was extensively modified in 1963. The plant has an average hydraulic design capacity of 0.24 mgd,

Figure 41

VILLAGE OF THIENSVILLE SEWAGE TREATMENT PLANT

Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

with a peak hydraulic design capacity of 0.36 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.7 mgd, indicating that the plant was operating substantially over the design capacity. Treatment processes provided at the plant are classified as secondary level. The village is experiencing extensive clear water inflow problems in the operation of this system. The Milwaukee River watershed plan, as adopted by the Commission, recommends that this treatment plant be abandoned and its service area connected to the Milwaukee-Metropolitan sewerage system.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Village of Thiensville sanitary sewerage system are shown on Map 36. There are three known points of sewage flow relief in the Village of Thiensville sanitary sewerage system, one bypass, one portable pumping station, and one relief pumping station which permits bypassing of the sewage treatment plant.

Management of the Village of Thiensville sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Administrator. Financing of the system is provided through the general property tax and a sewer service charge of $3 per month per connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Thiensville sanitary sewerage system approximated $99,898, or about $28 per capita. Of this total, $28,778, or about $8 per capita, was expended for operation and maintenance and $71,120, or about $20 per capita, was expended for capital improvements.

Proposed Public Sanitary Sewerage Systems

The inventory revealed that as of 1970 there was one proposed new public sanitary sewerage system to serve urban development in Ozaukee County. This system is currently under consideration by the Town of Belgium and involves the provision of public sanitary sewer service to a 6.5 square mile area of the town. This area, as shown on Map 36, is located along the Lake Michigan shoreline and extends west to include the unincorporated place of Lake Church. The area also includes the newly established Harrington Beach State Park on the Lake Michigan shoreline. At the present time, the Town of Belgium is considering two alternative methods of providing sewage treatment for this area, including the establishment of a new sewage treatment facility which would discharge its effluent to a minor tributary to Lake Michigan and the connection of the area to the existing Village of Belgium sanitary sewerage system with the concomitant expansion of the Village of Belgium sewage treatment plant at a new site.

Other Sewage Treatment Facilities

In addition to the eight public sanitary sewerage systems discussed above, there are a total of seven sewage treatment facilities in Ozaukee County which serve, in most cases, a single isolated land use enclave. These seven sewage treatment facilities serve the Chalet-on-the-Lake Restaurant in the City of Mequon; the Sisters of Notre Dame Academy in the City of Mequon; the Federal Foods Company in the City of Mequon; the Krier Preserving Company in the Town of Belgium; the Justro Feed Corporation in the Town of Cedarburg; the Hillers Cheese Factory in the Town of Fredonia; and the River Road Cheese Factory in the Town of Saukville. Pertinent characteristics pertaining to each of these seven sewage treatment facilities are presented in Table 32.

It should be noted that of the foregoing seven sewage treatment facilities serving single land uses, two—the Chalet-on-the-Lake and the Sisters of Notre Dame Academy—lie within the planned service area of the City of Mequon sanitary sewerage system. The remaining five facilities serve agriculturally-oriented industries in locations beyond existing or planned municipal sewer service areas.

Other Known Point Sources of Waste Water

In addition to identifying all existing public and private sewage treatment plants which discharge treated wastes to streams and watercourses within the Region, and all known sewage overflow points on both the existing sanitary and combined sewerage systems within the Region which discharge untreated wastes to streams and watercourses, an attempt was made in the regional sanitary sewerage system planning program to identify, through existing secondary sources, all other known point sources of waste water discharge. These other point sources of pollution consist primarily of industrial cooling, rinse, and wash waters, which may be discharged directly and without treatment to streams and watercourses or to storm sewers tributary to such streams and watercourses. The secondary sources consulted included river basin survey reports and pollution abatement orders of the Wisconsin Department of Natural Resources and records of municipal public works departments. Four such known point sources of industrial waste water were identified in Ozaukee County. The name, civil division location, type of waste, known pretreatment, and receiving water body of these four waste sources are identified in Table 33. The location of these four point sources is shown on Map 37.

Existing Urban Development Not Served By Public Sanitary Sewers

As noted earlier, public sanitary sewerage systems in Ozaukee County serve a total area of about 17.3 square miles, or about 7 percent of the total area of the county, and a total population of about 36,300, or about 66 percent of the total population of the county. An inventory was conducted in the study to determine the approximate amount of urban development, and the population residing therein, in Ozaukee County not served in 1970 by public sanitary sewer service. Each U. S. Public Land Survey quarter section not having development served by a centralized sanitary sewerage system was examined to determine if a significant amount of urban development was present in 1970. Any quarter section with at least 32 housing units, or an average of one housing unit per five gross acres, was deemed to be urban. The major purpose in identifying such concentrations of urban development was to provide a basis for analyzing the potential of providing public sanitary sewer service to such areas in accordance with recommendations contained in the adopted regional land use plan.

The nonsewered urban development areas identified in Ozaukee County are shown on Map 37. Together these areas total about 2.5 square miles, or 1 percent of the total area of the county, and contain a total population of about 4,900, or 9 percent of the total population of the county. For analysis purposes, the existing nonsewered urban development has been combined into six named

Table 32

SELECTED CHARACTERISTICS OF PRIVATE SEWAGE TREATMENT FACILITIES IN OZAUKEE COUNTY: 1970

Name	Civil Division Location	Type of Land Use Served	Type of Treatment Provided	Average Hydraulic Design Capacity (Gallons/Day)	Disposal of Effluent
Chalet-on-the-Lake Restaurant	City of Mequon	Commercial	Sedimentation	25,000	Lake Michigan
Federal Foods Company	City of Mequon	Industrial	Aerated Lagoon	1,400	Soil Absorption
Hillers Cheese Factory	Town of Fredonia	Industrial	Flow-through Lagoon	N/A	Sauk Creek
Justro Feed Corporation	Town of Cedarburg	Industrial	Seepage Lagoon	N/A	Soil Absorption
Krier Preserving Company	Town of Belgium	Industrial	Flow-through Lagoon and Spray Irrigation	30,000	Soil Absorption
River Road Cheese Factory	Town of Saukville	Industrial	Septic Tank and Seepage Lagoon	N/A	Soil Absorption
Sisters of Notre Dame Academy	City of Mequon	Institutional	Activated Sludge	30,000	Lake Michigan

NOTE: N/A indicates data not available.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 33

KNOWN EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN OZAUKEE COUNTY: 1970

Point Source[1] Number[2]	Point Source[1] Name	Civil Division Location	Type of Waste	Known Pretreatment	Receiving Water Body
1	Kickhaefer Corporation (Western Avenue)	City of Cedarburg	Outboard Engine Testing Wastes	Gravity Oil Separators	Cedar Creek
2	Kickhaefer Corporation (4th Street)	City of Cedarburg	Cooling Water	- -	Cedar Creek
3	Port Washington Water Treatment Plant	City of Port Washington	Waste Water Sludge	Sedimentation	Lake Michigan
4	Wisconsin Electric Power Company	City of Port Washington	Cooling Water	Sedimentation	Lake Michigan

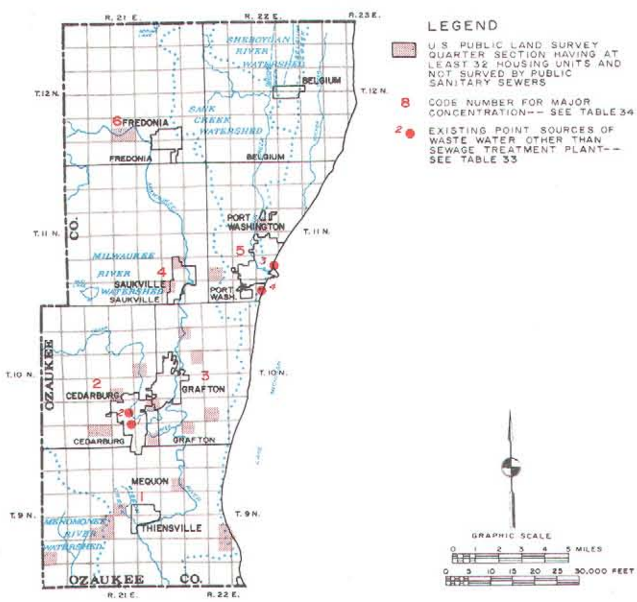
[1]*As identified in Wisconsin Department of Natural Resources river basin survey reports and pollution abatement orders and by selected municipal public works departments; does not include industrial waste sources discharging to municipal sanitary sewerage systems.*

[2]*See Map 37.*

Source: SEWRPC.

Map 37

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS AND EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN OZAUKEE COUNTY: 1970



As shown on this map, significant concentrations of unsewered urban development in Ozaukee County are scattered throughout the City of Mequon and the Towns of Cedarburg, Fredonia, Grafton, Port Washington, and Saukville. While some of this development, particularly in the City of Mequon, occurred in the late 1950s, much of the development in the other towns in the county occurred in the late 1960s and is very typical of the scattered urban development that occurred in eastern Waukesha County in the 1950s--which development is now in the process of being sewered. It is interesting to note that the only town in the county without a significant concentration of unsewered urban development is the Town of Belgium, where town officials have taken local action to prevent urban sprawl through the use of exclusive agricultural zoning. This map also shows the location of the four known point sources of wastewater other than sewage treatment plants in the county, including two each in the Cities of Cedarburg and Port Washington.

Source: Wisconsin Department of Natural Resources and SEWRPC.

major urban concentrations. The estimated population and urban development areas in each of these major concentrations are shown in Table 34.

Concluding Remarks—Ozaukee County

Inventories conducted under the regional sanitary sewerage system planning program revealed that in 1970 there existed in Ozaukee County a total of eight public sanitary sewerage systems which together served a total area of about 17.3 square miles, or 7 percent of the total area of the county, and a total population of about 36,300 persons, or about 66 percent of the total population of the

Table 34

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN OZAUKEE COUNTY BY MAJOR URBAN CONCENTRATION: 1970

Major Urban Concentration[1]		Estimated Resident Population	Developed Urban Area (Acres)
Number[2]	Name		
1	City of Mequon - Scattered Development	2,000	747
2	Town of Cedarburg - Scattered Development	1,200	407
3	Town of Grafton - Scattered Development	600	173
4	Village of Saukville Area	400	65
5	Port Washington Area	300	52
6	Waubeka Area	400	123
	Ozaukee County Total	4,900	1,567[3]

[1]*Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

[2]*See Map 37.*

[3]*Equal to 2.5 square miles.*

Source: SEWRPC.

county. Seven sewage treatment facilities provide treatment for sewage generated in these eight public sanitary sewerage systems. The City of Mequon does not operate a sewage treatment plant but, rather, contracts with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment purposes. In addition to the eight public sanitary sewerage systems, an additional seven sewage treatment facilities serving primarily single land uses, such as restaurants and agriculturally related industries, were found in the inventory. The inventory revealed that as of 1970 there was one proposed public sanitary sewerage system, that to serve existing urban development and the Harrington Beach State Park along the Lake Michigan shoreline in the Town of Belgium. Finally, in 1970 there were an estimated 4,900 persons residing in urban areas of Ozaukee County not served by public sanitary sewer service. Together these areas total about 2.5 square miles.

INVENTORY FINDINGS—RACINE COUNTY

Existing Public Sanitary Sewerage Systems

There are a total of 14 existing public sanitary sewerage systems in Racine County which provide centralized sanitary sewer service to subareas of the county. These include the systems operated by the Cities of Burlington and Racine; the Villages of North Bay, Union Grove, Rochester, Sturtevant, and Waterford; the Caddy Vista Sanitary District in the Town of Caledonia; the Town of Caledonia Sewer Utility District No. 1; the Crestview Sanitary District in the Town of Caledonia; the Town of Mt. Pleasant Sewer Utility District; the North Park Sanitary District in the Village of Wind Point and the Town of Caledonia; the Town of Rochester Sewer Utility District No. 1; and the

Western Racine County Sewerage District, which district provides sewage treatment service for sewage from the Village of Rochester, the Village of Waterford, and the Town of Rochester Utility District No. 1. Together these systems serve a total area of about 29 square miles, or about 9 percent of the total area of the county, and a total population of about 135,900, or about 78 percent of the total population of the county. Each of these public sanitary sewerage systems is described in the following paragraphs. Pertinent characteristics of each system are presented in Tables 35 and 36.

City of Burlington: The existing service area of the City of Burlington sanitary sewerage system is shown on Map 38. This area totals about two square miles and has a resident population of about 7,500 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Burlington is treated at a sewage treatment plant located on the Fox River, to which effluent is discharged (see Figure 42). The plant has a site area of about four acres, of which about two acres are currently utilized, leaving two acres available for future use. The plant site is bounded by railroad right-of-way on the north and west, the Fox River on the east, and open lands on the south. The plant, a trickling filter type, was initially constructed in 1934 and underwent extensive modifications in 1938 and again in 1962. The average hydraulic design capacity of the plant is 1.0 mgd, with an estimated peak hydraulic design capacity of 2.0 mgd. The average hydraulic loading on the plant in 1970 was estimated at 1.2 mgd, indicating that the plant did not have adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided by the plant are classified as secondary level. It should be noted that during 1972 the City of Burlington placed into operation a significant expansion of its sewage treatment facility, so that the plant now has an average hydraulic design capacity of 2.5 mgd. The plant has been modified and converted from the existing trickling filter type to a contact stabilization type sewage treatment plant. The modified treatment facility will also provide a secondary level of treatment. It should further be

Table 35

AREA AND POPULATION SERVED BY EXISTING AND LOCALLY PROPOSED SANITARY SEWERAGE SYSTEMS IN RACINE COUNTY: 1970

Name of Public Sanitary Sewerage System	Estimated Service Area				Estimated Population Served[2]	Treatment of Sewage (See Table 36)
	Existing		Proposed[1]			
	Acres	Square Miles	Acres	Square Miles		
Existing Systems						
City of Burlington	1,333	2.08	2,483	3.88	7,500	Operates a Facility
City of Racine	8,371	13.10	170[3]	0.28[3]	95,400	Operates a Facility
Village of North Bay	69	0.11	- -	- -	1,000	Contracts with City of Racine
Village of Rochester	193	0.30	13,073[4]	20.42[4]	500	Part of Western Racine County Sewerage District
Village of Sturtevant	391	0.61	- -	- -	3,200	Operates a Facility
Village of Union Grove	470	0.74	2,290	3.58	2,800	Operates a Facility
Village of Waterford	345	0.54	- -[4]	- -[4]	1,800	Part of Western Racine County Sewerage District
Caddy Vista Sanitary District	114	0.18	- -	- -	1,200	Operates a Facility
Caledonia Sewer Utility District No. 1	2,381	3.71	1,655	2.58	3,500	Contracts with City of Racine
Crestview Sanitary District	223	0.35	673	1.05	1,500	Contracts with North Park Sanitary District
Mt. Pleasant Sewer Utility District	3,377	5.26	9,875	15.43	10,300	Contracts with City of Racine
North Park Sanitary District[5]	1,466	2.28	4,666	7.28	7,000	Operates a Facility
Town of Rochester Sewer Utility District No. 1	149	0.23	- -[4]	- -[4]	200	Part of Western Racine County Sewerage District
Proposed Systems						
Browns Lake Sanitary District	- -	- -	1,696	2.65	- -	- -
Eagle Lake Sewer Utility District	- -	- -	1,430	2.24	- -	- -
Town of Norway Sanitary District No. 1	- -	- -	2,917	4.56	- -	- -
Tichigan Lake Sanitary District	- -	- -	- -[6]	- -[6]	- -	- -
County Total	18,882	29.49	40,928	63.95	135,900	- -

[1]As identified in locally prepared plans and engineering reports.
[2]Based upon an approximation of the existing sewer service area by U.S. Public Land Survey quarter section.
[3]Includes only that area within the existing (1970) corporate limits of the City of Racine and the Village of Elmwood Park.
[4]Includes the total area proposed for sewer service by the Western Racine County Sewerage District, which District includes the Villages of Rochester and Waterford and the Town of Rochester Sewer Utility District No. 1. This proposed service area also includes the Tichigan Lake Sanitary District in the Town of Waterford.
[5]Includes the Village of Wind Point.
[6]The proposed service area of the Tichigan Lake Sanitary District totals 3,373 acres, or 5.27 square miles. This area has also been included in the proposed service area of the Western Racine County Sewerage District.

Source: SEWRPC.

Table 36

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN RACINE COUNTY: 1970

Name of Public Sewage Treatment Facility	Estimated Total Area Served (Square Miles)	Estimated Total Population Served	Date of Original Construction and Major Modification	Type of Treatment Provided	Level of Treatment Provided	Disposal of Effluent	Design Capacity: Population[1]	Design Capacity: Average Hydraulic (MGD)	Design Capacity: Peak Hydraulic (MGD)	Design Capacity: Average Organic (Pounds $CBOD_5$/Day)	Design Capacity: Population Equivalent[1]
City of Burlington	2.08	7,500	1934, 1938, 1962	Trickling Filter	Secondary	Fox River	6,500	1.00	2.00	N/A	N/A
City of Racine	22.18[3]	110,200[3]	1938, 1967	Activated Sludge	Secondary	Lake Michigan	120,000	23.00	40.00	42,000	200,000
Village of Sturtevant	0.61	3,200	1959	Trickling Filter	Secondary	Minor Tributary of Pike River	3,000	0.30	N/A	N/A	N/A
Village of Union Grove	0.74	2,800	1937, 1962	Activated Sludge	Secondary	West Branch Root River Canal	3,000	0.30	N/A	510	2,400
Caddy Vista Sanitary District	0.18	1,200	1956	Trickling Filter	Secondary	Root River	N/A	0.25	0.40	N/A	N/A
North Park Sanitary District	2.63[7]	8,500[7]	1955, 1965, 1968	Activated Sludge	Secondary	Lake Michigan	9,000	0.90	N/A	1,530	7,300
Western Racine County Sewerage District	1.07[8]	2,500[8]	1968	Activated Sludge	Secondary	Fox River	N/A	0.50	1.00	850	4,000

Name of Public Sewage Treatment Facility	Existing Loading - 1970: Average Hydraulic (MGD)	Average Per Capita (GPD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Reserve Hydraulic Capacity (MGD)	Sewage Strength Parameters in Influent Sewage: $CBOD_5$ (mg/l)	Suspended Solids (mg/l)	Total Phosphorus (mg/l)	Organic Nitrogen-N (mg/l)	Ammonia Nitrogen-N (mg/l)	Industrial Flows: Design Average Daily Flow (MGD)	Estimated Daily Flow 1970 (MGD)	Overall Plant Efficiency Percent Removals: $CBOD_5$ (Percent)	Suspended Solids (Percent)	Total Phosphorus (P) (Percent)	Number of Days in 1970 Plant Flow Exceeded Plant Meter Capacity
City of Burlington	1.20	160	2.0	2,700[2]	None	265[2]	170[2]	N/A	13.0[2]	15.2[2]	N/A	N/A	74[2]	29[2]	N/A	N/A
City of Racine	21.70	197	35.4	15,200	1.30	84	125	N/A	N/A	N/A	N/A	N/A	77	54	N/A	N/A
Village of Sturtevant	0.25	78	N/A	N/A	0.05	193[4]	144[4]	14.2[4]	11.6[4]	31.6[4]	N/A	N/A	78[4]	72[4]	0.1[4]	N/A
Village of Union Grove	0.43	154	N/A	N/A	None	156[5]	116[5]	N/A	N/A	N/A	N/A	N/A	67[5]	53[5]	N/A	N/A
Caddy Vista Sanitary District	0.06	50	0.4	N/A	0.19	171[6]	180[6]	N/A	N/A	N/A	N/A	N/A	59[6]	62[6]	N/A	N/A
North Park Sanitary District	0.80	94	1.8	N/A	0.10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Western Racine County Sewerage District	0.24	96	1.0	N/A	0.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: N/A indicates data not available.

[1]*The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design $CBOD_5$ loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of $CBOD_5$ per day. If the design engineer assumed a different daily per capita contribution of $CBOD_5$, the population equivalent design capacity will differ from the population design capacity shown in the Table.*

[2]*Data obtained from a 24-hour composite sample by Hoganson & Robers, Inc. in October 1968.*

[3]*Includes the City of Racine, the Village of North Bay, the Town of Caledonia Sewer Utility District No. 1, and the Town of Mt. Pleasant Sewer Utility District (see Table 35).*

[4]*Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in October 1966.*

[5]*Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in June 1966.*

[6]*Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in June 1966.*

[7]*Includes the Village of Wind Point, the Crestview Sanitary District, and that portion of the Town of Caledonia within the North Park Sanitary District.*

[8]*Includes the Villages of Rochester and Waterford and the Town of Rochester Sewer Utility District No. 1.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

noted that the City of Burlington in 1971 agreed to provide sewage treatment on a contract basis for sewage generated in the Browns Lake Sanitary District in the Town of Burlington. This proposed public sanitary sewerage system, now (1973) completed, is discussed later in this chapter.

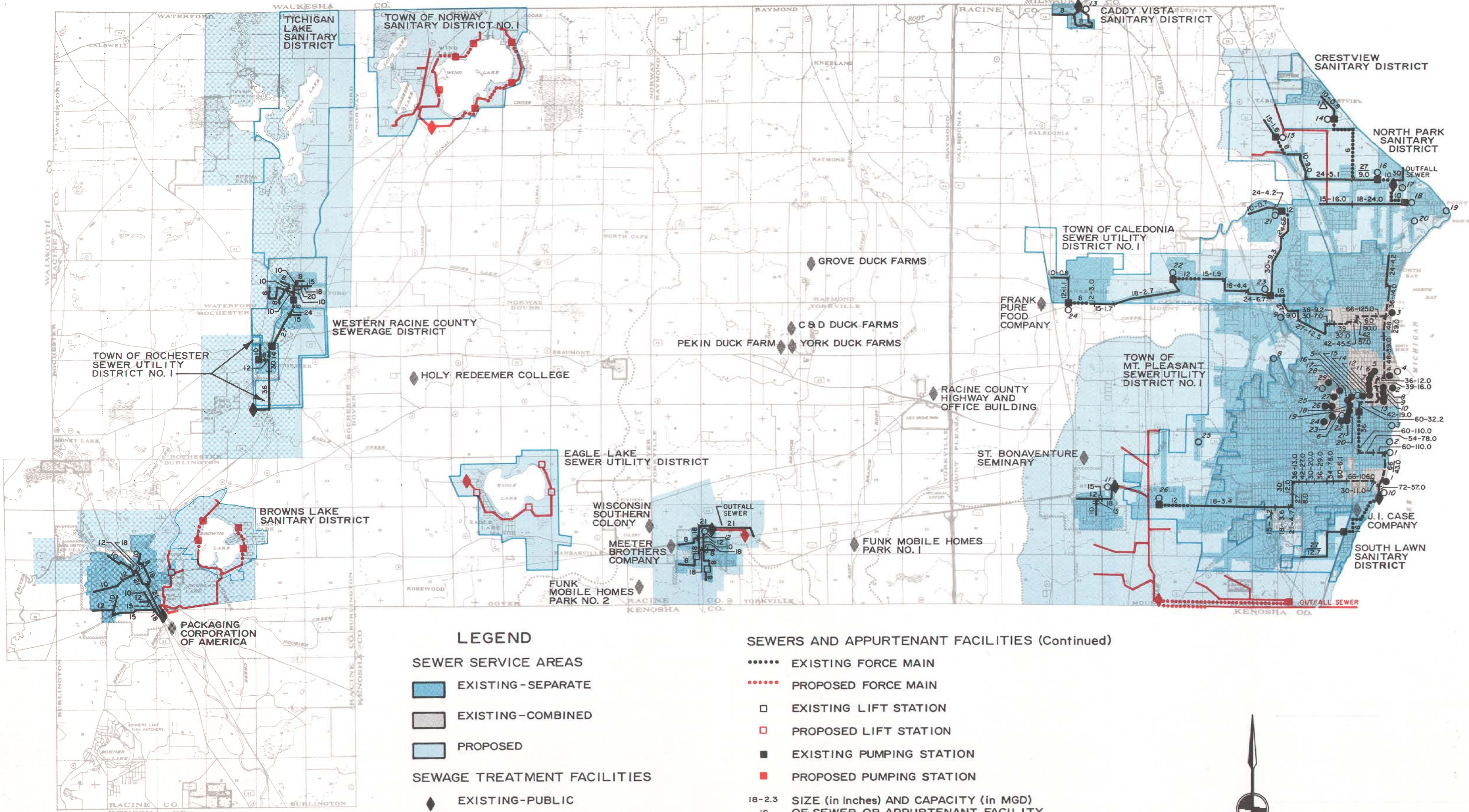
The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the City of Burlington sanitary sewerage system are shown on Map 38. There are no known points of sewer overflow or bypassing in the City of Burlington sanitary sewerage system. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional four square mile area, not including the proposed Browns Lake Sanitary District, which is shown on Map 38. Locally proposed trunk sewers to serve this additional area are also shown on Map 38.

Management of the City of Burlington sanitary sewerage system is under the direction of the Mayor and City Council. Day-to-day administration of the system is provided by the City Engineer. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Burlington sanitary sewerage system approximated $239,014, or about $32 per capita. Of this total, $45,163, or about $6 per capita, was expended for operation and maintenance and $193,851, or about $26 per capita was expended for capital improvements.

City of Racine: The existing service area of the City of Racine sanitary sewerage system is shown on Map 38. This area totals about 13 square miles and has a resident population of about 95,400 persons. In addition, the City of Racine provides on a contract basis treatment for sewage generated in the Village of North Bay, the Town of Caledonia Sewer Utility District No. 1, and the Town of Mt. Pleasant Sewer Utility District. The sewer service area of these contract areas connected to the City of Racine sanitary sewerage system totals about nine square miles and has a total resident population of about 14,800 persons. Thus, the City of Racine sewage treatment facility serves a total sewer service area of about 22 square miles and a total resident population of about 110,200 persons.

Map 38

EXISTING AND LOCALLY PROPOSED PUBLIC SANITARY SEWERAGE SYSTEMS AND OTHER SEWAGE TREATMENT FACILITIES IN RACINE COUNTY 1970



LEGEND

SEWER SERVICE AREAS

- EXISTING-SEPARATE
- EXISTING-COMBINED
- PROPOSED

SEWAGE TREATMENT FACILITIES

- EXISTING-PUBLIC
- EXISTING-PRIVATE
- PROPOSED-PUBLIC

SEWERS AND APPURTENANT FACILITIES

- EXISTING MAJOR TRUNK, RELIEF, OR INTERCEPTING SEWER
- EXISTING MAJOR COMBINED SEWER
- PROPOSED MAJOR TRUNK, RELIEF, OR INTERCEPTING SEWER

SEWERS AND APPURTENANT FACILITIES (Continued)

- EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- EXISTING LIFT STATION
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- PROPOSED PUMPING STATION
- 18-2.3 / $\frac{18}{2.3}$ SIZE (in Inches) AND CAPACITY (in MGD) OF SEWER OR APPURTENANT FACILITY

KNOWN FLOW RELIEF DEVICES

- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION
- *8* IDENTIFICATION NUMBER--SEE APPENDIX B

GRAPHIC SCALE

0 1 2 3 4 5 MILES

0 8000 16000 24000 32000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

(This page intentionally left blank)

Figure 42

CITY OF BURLINGTON SEWAGE TREATMENT PLANT

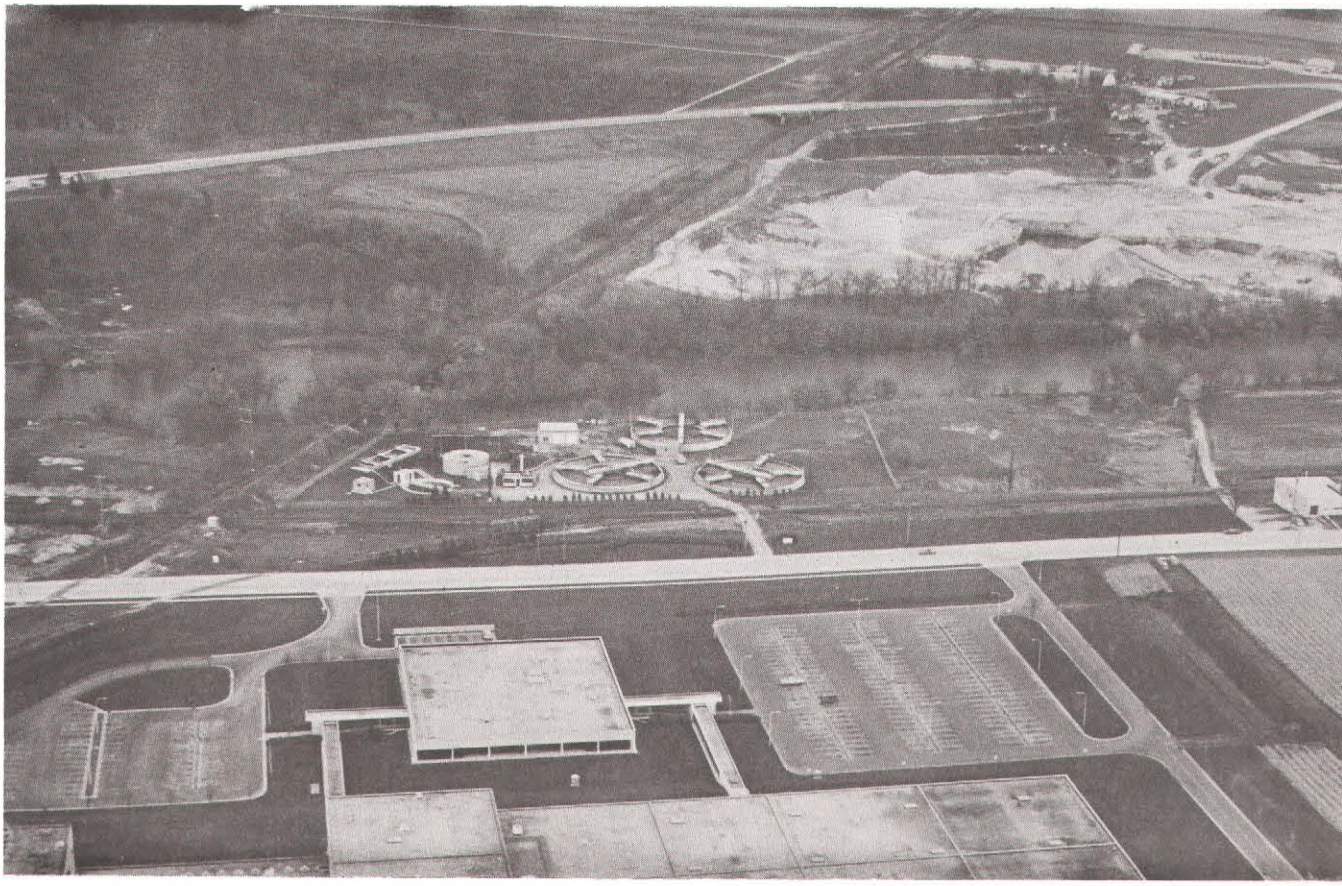


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

As noted above, the sanitary sewerage system within the City of Racine serves an area of about 13 square miles. Of this total, about 11 square miles, or about 85 percent, are served by a separate sewer system and about two square miles, or about 15 percent, are served by a combined sewer system.

Until about the early 1950s, almost all urban development in the Racine area was served by combined sewers, which sewers discharged untreated sewage directly to the Root River or to Lake Michigan. Intercepting sewers were subsequently constructed to intercept the normal dry weather flow of sanitary wastes in combined sewers, as well as a portion of the storm flows, and convey these flows to the City of Racine sewage treatment plant which was constructed in 1938. During periods of heavy rainfall, overflow devices discharge a portion of the combined sanitary-storm water flow, untreated, directly to the Root River or to Lake Michigan. There are 29 known combined sewer outfalls in the Racine area, 26 of which discharge to the Root River and three of which discharge directly to Lake Michigan (see Map 38).

The City of Racine began in 1967 to undertake a sewerage improvement program to effect a greater degree of separation within the combined sewer system. As a possible alternative to complete separation of the combined sewer system, the City of Racine, in cooperation with the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency has embarked upon a demonstration project to study the feasibility of providing sewage treatment plants at the combined sewer outfalls. The project will attempt to demonstrate the feasibility of utilizing a screening-air flotation system of rapid sewage treatment. The demonstration facility, now under construction, will treat combined sewer overflows from seven outfalls along the Root River, as well as treating "pure" storm water from a separate storm sewer outfall. If successful, this demonstration could provide an alternate solution to complete separation of the combined sewer system in the Racine area.

The area committed to future sanitary sewer service in the City of Racine and in the municipalities or special purpose districts which contract with the City of Racine for sewage transmission and treatment is also shown on Map 38.

The Racine sewage treatment facility, an activated sludge type, is located on the Lake Michigan shoreline near the intersection of 21st and Main Streets (see Figure 43). The plant has a site area of about 17 acres, of which about 10 acres are currently utilized, leaving seven acres available for future use, assuming that structural retaining walls would be constructed to retain earthen embankments. The plant site is bounded by Lake Michigan on the east, a city street on the north, a steep embankment on the west, and the Lake Michigan shoreline on the south. The plant was constructed in 1938 with an initial average hydraulic design capacity of 12 mgd and a primary level of sewage treatment. In 1967 the plant was expanded to a capacity of 23 mgd, providing a primary level of treatment. The plant has only 12 mgd, however, of secondary treatment capacity. The expansion in 1967 was the first of a planned three-phase expansion program to provide a total average hydraulic design capacity of 30 mgd by 1972 and 36 mgd by 1980. The current peak hydraulic design capacity of the plant has been rated at about 40 mgd. The influent sewer to the plant is capable of conveying about 70 mgd. Effluent disposal is via an outfall sewer to Lake Michigan which extends 500 feet beyond the breakwater.

In 1970 the average hydraulic loading at the Racine sewage treatment facility was 21.7 mgd, with a peak hydraulic loading of 35.4 mgd and a minimum hydraulic loading of 11.4 mgd. The peak hydraulic loading, however, does not include unmeasured flows bypassed either at the 29 combined sewer outfall locations on the Root River or Lake Michigan or at the sewage treatment plant itself. The 23 mgd of existing primary capacity is sufficient to treat the average hydraulic loading. However, flows frequently exceed 30 mgd.

Figure 43

CITY OF RACINE SEWAGE TREATMENT PLANT

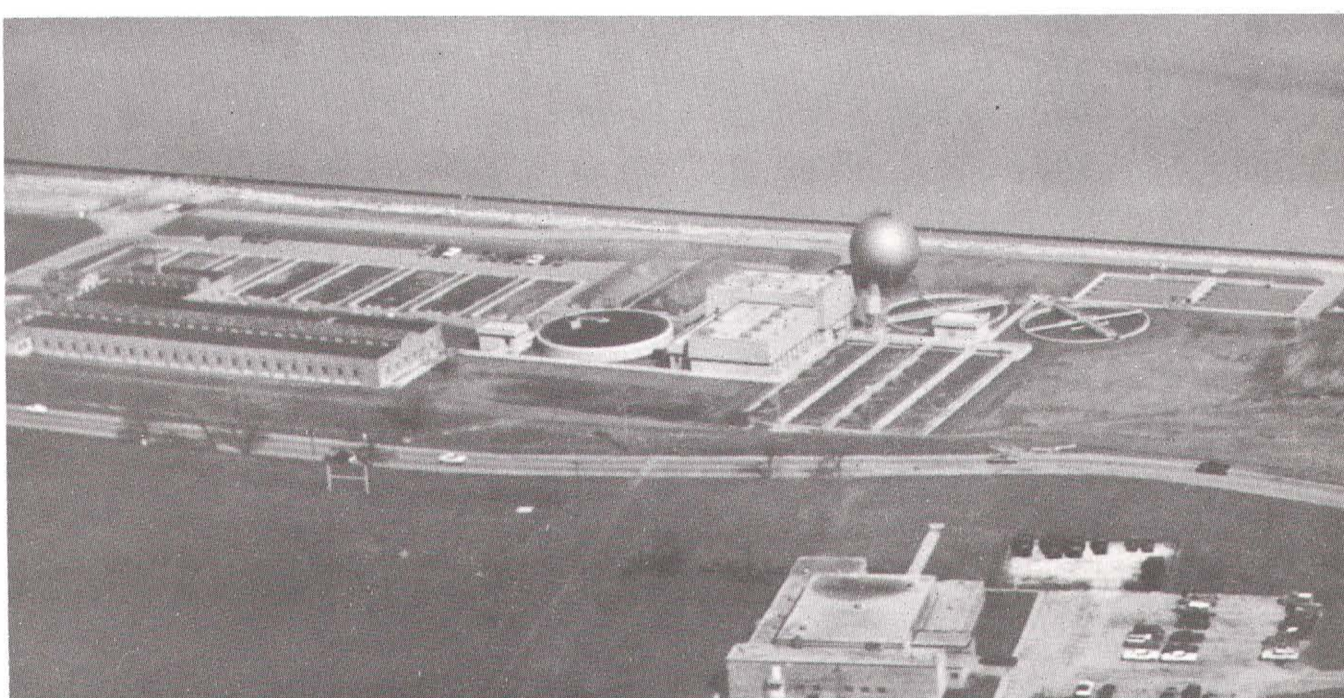


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

Under present conditions, about 12 mgd of sewage are sent from the primary sedimentation tanks to the activated sludge tanks for secondary waste treatment, followed by two hours detention time in final settling tanks. The sewage from the settling tanks is then blended with additional sewage from the primary tanks, chlorinated, and discharged to Lake Michigan. On a normal day, therefore, about 12 million gallons of sewage at the Racine sewage treatment facility receive both primary and secondary treatment and are then mixed with nearly an equal amount of sewage that receives primary treatment. The monthly average biochemical oxygen demand ($CBOD_5$) loadings ranged during 1970 from about 9,200 pounds to about 22,200 pounds per day, with an average loading of about 15,200 pounds per day. Suspended solids loadings averaged about 22,600 pounds per day with a maximum of 29,600 and a minimum of 17,200 pounds per day. During 1970 an average of 54 percent of the suspended solids and 77 percent of the $CBOD_5$ were removed in the treatment process.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Racine sanitary sewerage system are shown on Map 38. In addition to the 29 combined sewer outfalls noted above, there are 10 known points of sewage flow relief in the City of Racine sanitary sewerage system, all of which are bypasses including one at the sewage treatment plant.

Management of the City of Racine sanitary sewerage system is under the direction of the City of Racine Common Council. Day-to-day administration of the system is provided by the staff of the Water Pollution Control Department of the City of Racine, headed by the Commissioner of Public Works.

Local financing of the City of Racine sanitary sewerage system is provided both through the property tax and through funds provided under contractual agreements with other municipalities and special purpose districts. The contractual agreements between the City of Racine and the Town of Mount Pleasant and between the City of Racine and the Town of Caledonia Sewer Utility District No. 1 provide that the town and the district pay to the City of Racine 150 percent of the prorated cost of treating the sewage generated in the contract areas, an additional $40 per million gallons to cover depreciation of the capital facilities already in place, and 100 percent of the cost of additional sewer system components needed to adequately transmit and treat the wastes. The contractual agreement between the City of Racine and the Village of North Bay provides for an annual payment of the actual cost of treating the sewage from the village plus 50 percent. Each of the units of government contracting for sewage treatment with the City of Racine is responsible for the operation and maintenance of the local collection sewer system within the contract area. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Racine sanitary sewerage system approximated $3,596,804, or about $38 per capita. Of this total, $599,920, or about $6 per capita, was expended for operation and maintenance and $2,996,884, or about $32 per capita, was expended for capital improvements.

Village of North Bay: The existing sewer service area of the sanitary sewerage system serving the Village of North Bay is shown on Map 38. As noted above under the discussion of the City of Racine sanitary sewerage system, the Village of North Bay contracts with the City of Racine for sewage treatment. The North Bay service area totals about 0.1 square mile and has a resident population of about 1,000 persons. The average hydraulic loading on the Racine sewage treatment plant from the Village of North Bay in 1970 was estimated at 0.05 mgd. There are no known points of sewer overflow or bypassing in the Village of North Bay sanitary sewerage system.

Management and day-to-day administration of the relatively small Village of North Bay sanitary sewerage system is provided directly by the Village Board. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of North Bay sanitary sewerage system were not made available by the village.

Village of Rochester: The existing service area of the Village of Rochester sanitary sewerage system is shown on Map 38. This area totals about 0.3 square mile and has a resident population of about 500 persons. The entire area is served by a separate sanitary sewer system. Sewage from the Village of Rochester is treated at the sewage treatment facility operated by the Western Racine County Sewerage District, as discussed later in this chapter. The average hydraulic loading on the district plant from the Village of Rochester in 1970 was estimated at 0.04 mgd.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains serving the Village of Rochester are shown on Map 38. There are no known points of sewage flow relief in the Village of Rochester sanitary sewerage system.

Management of the Village of Rochester sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village President. Financing of the system is provided through a sewer service charge of $6.50 per month per connection. This revenue is utilized to operate, maintain, and expand the existing village system, as well as the village's share of operating the sewerage facilities of the Western Racine County Sewerage District. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Rochester sanitary sewerage system approximated $35,100, or about $70 per capita. Of this total, $8,449, or about $17 per capita, was expended for operation and maintenance and $26,651, or about $53 per capita, was expended for capital improvements.

Village of Sturtevant: The existing sewer service area of the Village of Sturtevant sanitary sewerage system is shown on Map 38. This area totals about 0.6 square mile and has a resident population of about 3,200 persons. The entire area is served by a separate sanitary sewerage system.

Sewage from the Village of Sturtevant is treated at a sewage treatment plant located on a minor drainage course leading to the Pike River, to which effluent is discharged (see Figure 44). The plant has a site area of about four acres, of which about two acres are currently utilized, leaving two acres available for future use. The site is bounded by open lands on the north, east, and

Figure 44

VILLAGE OF STURTEVANT SEWAGE TREATMENT PLANT

Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

west and by a railroad right-of-way on the south. The plant, a trickling filter type, was constructed in 1959. The average hydraulic design capacity of the plant is 0.3 mgd. The average hydraulic loading at the plant in 1970 was estimated at 0.25 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. Since 1970, however, the plant has frequently experienced flows exceeding the average hydraulic design capacity. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of all major trunk sewers serving the Village of Sturtevant are shown on Map 38. The only known point of sewage flow relief in the Village of Sturtevant sanitary sewerage system is a bypass at the treatment plant. The inventory revealed that the village had no documented plan for the expansion of its sewerage system.

Management of the Village of Sturtevant sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by a Water and Sewer Committee of the Board together with its staff in the Department of Public Works. Financing of the system is provided through a sewer service charge. There is a minimum charge of $4.50 per quarter for residential and commercial users, to which is added an output charge of 50 percent of the cost of water consumption utilized in excess of 6,000 gallons each quarter. Institutional and industrial users are charged according to separate schedules. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Sturtevant sanitary sewerage system approximated $32,122, or about $10 per capita. Of this total, $20,822, or about $6 per capita, was expended for operation and maintenance and $11,300, or about $4 per capita, was expended for capital improvements.

Village of Union Grove: The existing service area of the Village of Union Grove sanitary sewerage system is shown on Map 38. This area totals about 0.7 square mile and has a resident population of about 2,800 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Union Grove is treated at a sewage treatment plant located on a minor drainage course leading to the west branch of the Root River canal, to which effluent is discharged through a joint outfall sewer also serving the Wisconsin Southern Colony Institution (see Figure 45). The plant has a very small site area of about one-half acre, all of which is currently utilized. The plant site is bounded by industrial development on the north, residential development on the south, USH 45 on the west, and open lands on the east. There is virtually no room for expansion of the plant at its existing site. The plant, an activated sludge type, was initially constructed in 1937 and underwent extensive modifications in 1962. The average hydraulic design capacity of the plant is 0.3 mgd. The average hydraulic loading at the plant in 1970 was estimated at 0.4 mgd, indicating that the plant does not have adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided by the plant are classified as secondary level.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains comprising the Village of Union Grove sanitary sewerage system are shown on Map 38. Except for a bypass located at the sewage treatment plant, there are no known points of sew-

Figure 45

VILLAGE OF UNION GROVE SEWAGE TREATMENT PLANT

Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

age flow relief in the Village of Union Grove sanitary sewerage system. The inventory revealed that the village had a documented plan for the expansion of its sewerage system to an additional 3.6 square mile area and for the replacement of its sewage treatment plant on a new site.

Management of the Village of Union Grove sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided both through the property tax and through a sewer service charge. The charge is based upon water consumption. Water consumers in the village currently pay an annual sewer service charge equal to 50 percent of the annual water charge. Water consumers outside of the village currently pay an annual sewer service charge equal to 70 percent of the annual water charge. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Union Grove sanitary sewerage system approximated \$97,493, or about \$34 per capita. Of this total, \$37,538, or about \$13 per capita, was expended for operation and maintenance and \$59,955, or about \$21 per capita, was expended for capital improvements.

Village of Waterford: The existing service area of the Village of Waterford sanitary sewerage system is shown on Map 38. This area totals about 0.5 square mile and has a resident population of about 1,800 persons. The entire area is served by a separate sanitary sewer system. Sewage from the Village of Waterford is treated at the sewage treatment facility operated by the Western Racine County Sewerage District, as discussed later in this chapter. The average hydraulic loading on the district plant from the Village of Waterford in 1970 was estimated at 0.18 mgd.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Village of Waterford sanitary sewerage system are shown on Map 38. There are no known points of sewage flow relief in the Village of Waterford sanitary sewerage system.

Management of the Village of Waterford sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Clerk. Financing of the system is provided through a sewer service charge equal to 170 percent of the charge for metered water usage during the first quarter of the year. This revenue is utilized to operate, maintain, and expand the existing village system, as well as the village's share of operating the sewerage facilities of the Western Racine County Sewerage District. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Waterford sanitary sewerage system approximated \$53,500, or \$30 per capita, all of which was expended for operation and maintenance.

Caddy Vista Sanitary District: The existing sewer service area of the Caddy Vista Sanitary District in the Town of Caledonia is shown on Map 38. This area, which consists of the Caddy Vista Subdivision, totals about 0.2 square mile and has a resident population of about 1,200 persons. The entire area is served by a separate sanitary sewerage system. It should be noted that the Caddy Vista Sanitary District extends into the City of Oak Creek in Milwaukee County. No development, however, has taken place in this area.

Sewage from the Caddy Vista Sanitary District is treated at a sewage treatment plant located on the Root River, to which effluent is discharged (see Figure 46). The plant has a site area of about six

Figure 46

CADDY VISTA SANITARY DISTRICT
SEWAGE TREATMENT PLANT

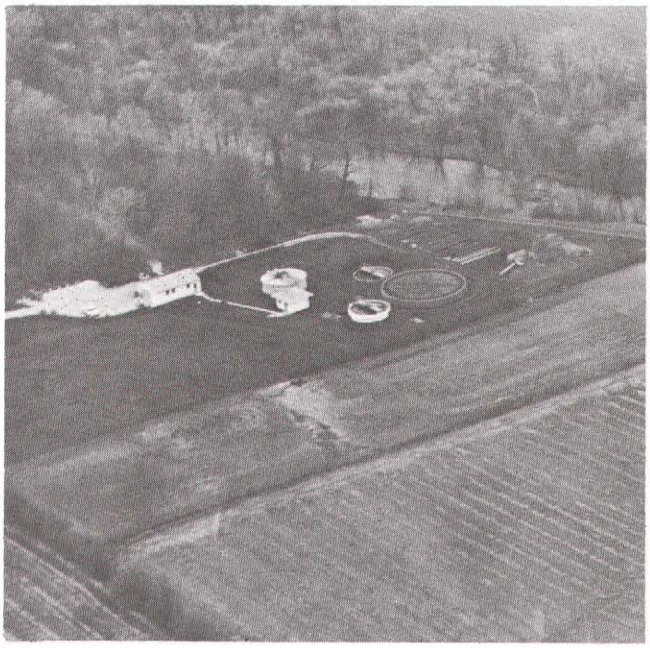


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

acres. The site is bounded by the Root River on the north, and by agricultural, open, and unused lands on the south, east, and west. The plant, a trickling filter type, was constructed in 1956. The average hydraulic design capacity of the plant is 0.25 mgd, with an estimated peak hydraulic design capacity of 0.4 mgd. The average hydraulic loading at the plant in 1970 was estimated at 0.06 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level. The adopted Root River watershed plan recommends abandonment of the Caddy Vista Plant and connection of its service area to the Milwaukee-Metropolitan sewerage system.

The location and configuration of the trunk sewers serving the Caddy Vista Sanitary District are shown on Map 38. The only known point of sewage flow relief in the Caddy Vista Sanitary District sanitary sewerage system is a bypass located at the treatment plant. The inventory revealed that the sanitary district had no documented plan for extension of the sewers into the undeveloped portion of the district located in the City of Oak Creek.

Management of the Caddy Vista Sanitary District sanitary sewerage system is under the direction of a three-member commission. Day-to-day administration of the system is provided by the treatment plant superintendent. Financing of the system is provided both through a sewer service charge of $6 per quarter per sewer connection and through a general property tax levy. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Caddy Vista Sanitary District sanitary sewerage system approximated $20,903, or about $17 per capita. Of this total, $12,465, or about $10 per capita, was expended for operation and maintenance and $8,438, or about $7 per capita, was expended for capital improvements.

Caledonia Sewer Utility District No. 1: The existing sewer service area of the sanitary sewerage system serving the Caledonia Sewer Utility District No. 1 in the Town of Caledonia is shown on Map 38. As noted above under the discussion of the City of Racine sanitary sewerage system, the Caledonia Sewer Utility District No. 1 contracts with the City of Racine for sewage treatment. The Caledonia Sewer Utility District No. 1 service area totals about 3.7 square miles and has a resident population of about 3,500 persons. The average hydraulic loading on the Racine sewage treatment plant from the Caledonia Sewer Utility District No. 1 in 1970 was estimated at 0.5 mgd.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains serving the Caledonia Sewer Utility District No. 1 are shown on Map 38. There are four known points of sewage flow relief in the system, all of which are bypasses. The inventory revealed that the district had a documented plan for the expansion of its sewerage system to an additional 2.58 square mile area within the district boundaries. No locally proposed trunk sewers to serve this additional area were, however, revealed in the inventory.

Management of the Caledonia Sewer Utility District No. 1 sanitary sewerage system is under the direction of a three-member utility board. Day-to-day administration of the system is provided by the Treasurer of the Town of Caledonia. Financing of the system is provided through a sewer service charge of $20 per calendar quarter per sewer connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Caledonia Sewer Utility District No. 1 sanitary sewerage system approximated $130,982, or about $37 per capita. Of this total, $44,480, or about $12 per capita, was expended for operation and maintenance and $86,502, or about $25 per capita, was expended for capital improvements.

Crestview Sanitary District: The existing service area of the Crestview Sanitary District sanitary sewerage system in the Town of Caledonia is shown on Map 38. This area totals about 0.35 square mile and has a resident population of about 1,500 persons. The entire area is served by a separate sanitary sewer system. Sewage from the Crestview Sanitary District is treated at the sewage treatment facility operated by the North Park Sanitary District, as discussed later in this chapter. The average hydraulic loading on the North Park sewage treatment plant from the Crestview Sanitary District in 1970 was estimated at 0.4 mgd.

The location and configuration of the major trunk sewer serving the Crestview Sanitary District is shown on Map 38. There are two known points of sewage flow relief in the Crestview Sanitary District—a bypass and a portable pumping station. The inventory revealed that the district had a documented plan for the extension of sewer service into the undeveloped portions of the district. This additional proposed service area is also shown on Map 38.

Management of the Crestview Sanitary District sanitary sewerage system is under the direction of a three-member commission. Day-to-day administration of the system is provided by the Treasurer of the Town of Caledonia. Financing of the system is provided through a sewer service charge of $22.40 per calendar quarter per sewer connection and a property tax levy. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Crestview Sanitary District sanitary sewerage system approximated $109,518, or about $73 per capita. Of this total, $15,518, or about $10 per capita, was expended for operation and maintenance and $94,000, or about $63 per capita, was expended for capital improvements.

Mt. Pleasant Sewer Utility District: The existing sewer service area of the sanitary sewerage system serving the Mt. Pleasant Sewer Utility District in the Town of Mt. Pleasant is shown on Map 38. As noted above under the discussion of the City of Racine sanitary sewerage system, the Mt. Pleasant Sewer Utility District contracts with the City of Racine for sewage treatment. The Mt. Pleasant Sewer Utility District service area totals about 5.26 square miles and has a resident population of about 10,300 persons. The average hydraulic loading on the Racine sewage treatment plant from the Mt. Pleasant Sewer Utility District in 1970 was estimated at 2.5 mgd.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains serving the Mt. Pleasant Sewer Utility District are also shown on Map 38. There are two known points of sewage flow relief in the Mt. Pleasant Sewer Utility District sanitary sewerage system, both of which are bypasses. The inventory revealed that the Mt. Pleasant Sewer Utility District had documented plans for the expansion of its sewerage system and for the extension of trunk sewers into the proposed service area. In addition, the district has proposed the construction of a new sewage treatment plant on the Pike River near the Racine-Kenosha line to serve a portion of the district and to accommodate anticipated major industrial waste flows primarily from the Waxdale plant of S. C. Johnson and Sons, Inc.

Management of the Mt. Pleasant Sewer Utility District is under the direction of a three-member commission. Day-to-day administration of the system is provided by the Clerk of the Town of Mt. Pleasant. Financing of the system is provided through a sewer service charge of $20 per calendar quarter per sewer connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Mt. Pleasant Sewer Utility District sanitary sewerage system approximated $473,124, or about $46 per capita. Of this total, $199,700, or about $19 per capita, was expended for operation and maintenance and $273,424, or about $27 per capita, was expended for capital improvements.

North Park Sanitary District: The existing sewer service area of the North Park Sanitary District sanitary sewerage system is shown on Map 38. This district consists of all of the Village of Wind Point and a portion of the Town of Caledonia. This area totals about 2.3 square miles and has a resident population of about 7,000 persons. The entire area is served by a separate sanitary sewerage system. As noted earlier in this chapter, the North Park Sanitary District contracts to provide treatment for sewage generated in the Crestview Sanitary District.

Sewage from the North Park and Crestview Sanitary Districts is treated at a sewage treatment plant located near the Lake Michigan shoreline, with an outfall sewer leading directly to the lakeshore (see Figure 47). The plant has a site area of about seven acres, of which about five acres are currently utilized, leaving about two acres available for future use. The site is bounded by agricultural and open lands on the north, south, and east and by residential land use on the west. The North Park plant actually consists of two parallel treatment facilities. The first plant, constructed in 1955 as a trickling filter type plant, was modified and converted in 1968 to a contact stabilization type plant. The second plant, a contact stabilization type plant, was constructed in 1965. The combined average hydraulic design capacity of the two plants is 0.9 mgd, with an estimated combined peak hydraulic design capacity of 1.8 mgd. The average hydraulic loading on the combined plant in 1970 was estimated at 0.8 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the combined plant are classified as secondary level.

Figure 47

NORTH PARK SANITARY DISTRICT
SEWAGE TREATMENT PLANT

Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains serving the North Park Sanitary District are shown on Map 38. There are six known points of sewage flow relief in the North Park Sanitary District sanitary sewerage system, all of which are bypasses. The inventory revealed that the district had documented plans for the expansion of its sewerage system to an additional 7.3 square mile area. Locally proposed trunk sewers to serve this area are shown on Map 38.

Management of the North Park Sanitary District sanitary sewerage system is under the direction of a three-member commission. Day-to-day administration of the system is provided by the plant superintendent. Financing of the system is provided both through a sewer service charge and a general property tax levy. The sewer service charge is currently $7 per calendar quarter per sewer connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the North Park Sanitary District sanitary sewerage system approximated $95,569, or about $14 per capita. Of this total, $39,069, or about $16 per capita, was expended for operation and maintenance and $56,500, or about $8 per capita, was expended for capital improvements.

Town of Rochester Sewer Utility District No. 1: The existing sewer service area of the Town of Rochester Sewer Utility District No. 1 sanitary sewerage system is shown on Map 38. This area totals about 0.23 square mile and has a resident population of about 200 persons. The entire area is served by a separate sanitary sewer system. Sewage from the Town of Rochester Sewer Utility District No. 1 is treated at the sewage treatment facility operated by the Western Racine County Sewerage District, as discussed later in this chapter. The average hydraulic loading on the Western Racine County sewage treatment plant from the Town of Rochester Sewer Utility District No. 1 in 1970 was estimated at 0.02 mgd.

The location and configuration of the major trunk sewer serving the Town of Rochester Sewer Utility District No. 1 is shown on Map 38. There are no known points of sewer overflow or bypassing in the Town of Rochester Sewer Utility District No. 1 sanitary sewerage system.

Management of the Town of Rochester Sewer Utility District No. 1 sanitary sewerage system is under the direction of the Town Board. Day-to-day administration of the system is provided by the staff of the Western Racine County Sewerage District. Financing of the system is provided through a sewer service charge of $7.50 per calendar quarter per connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Town of Rochester Sewer Utility District No. 1 sanitary sewerage system approximated $36,724, or about $184 per capita. Of this total, $4,142, or about $21 per capita, was expended for operation and maintenance and $32,582, or about $163 per capita, was expended for capital improvements.

Western Racine County Sewerage District: As noted earlier in this discussion, the Western Racine County Sewerage District provides trunk sewer conveyance and sewage treatment for sewage originating in the Villages of Rochester and Waterford and the Town of Rochester Sewer Utility District No. 1. It is the only metropolitan sewerage district in the Southeastern Wisconsin Region formed to date under the Wisconsin Statutes, other than the Metropolitan Sewerage District of the County of Milwaukee, which is established under unique legislation.

The existing sewer service area of the Western Racine County Sewerage District is coincident with that of the two villages and town utility district which it serves (see Map 38). This area totals about one square mile and has a resident population of about 2,500 persons. The entire area is served by a separate sanitary sewerage system.

Sewage from the total service area of the Western Racine County Sewerage District is treated at a sewage treatment plant located on the Fox River, to which effluent is discharged (see Figure 48). The plant has a site area of about 20 acres, of which three acres are currently utilized, leaving 17 acres available for future use. The site is bounded by open lands on the north, the Fox River on the west and south, and STH 36 on the east. The plant, an activated sludge type, was constructed in 1968. The average hydraulic design capacity of the plant is 0.5 mgd, with a peak hydraulic design capacity of 1.0 mgd. The average hydraulic loading at the plant in 1970 was estimated at 0.24 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

Figure 48

WESTERN RACINE COUNTY SEWERAGE DISTRICT SEWAGE TREATMENT PLANT

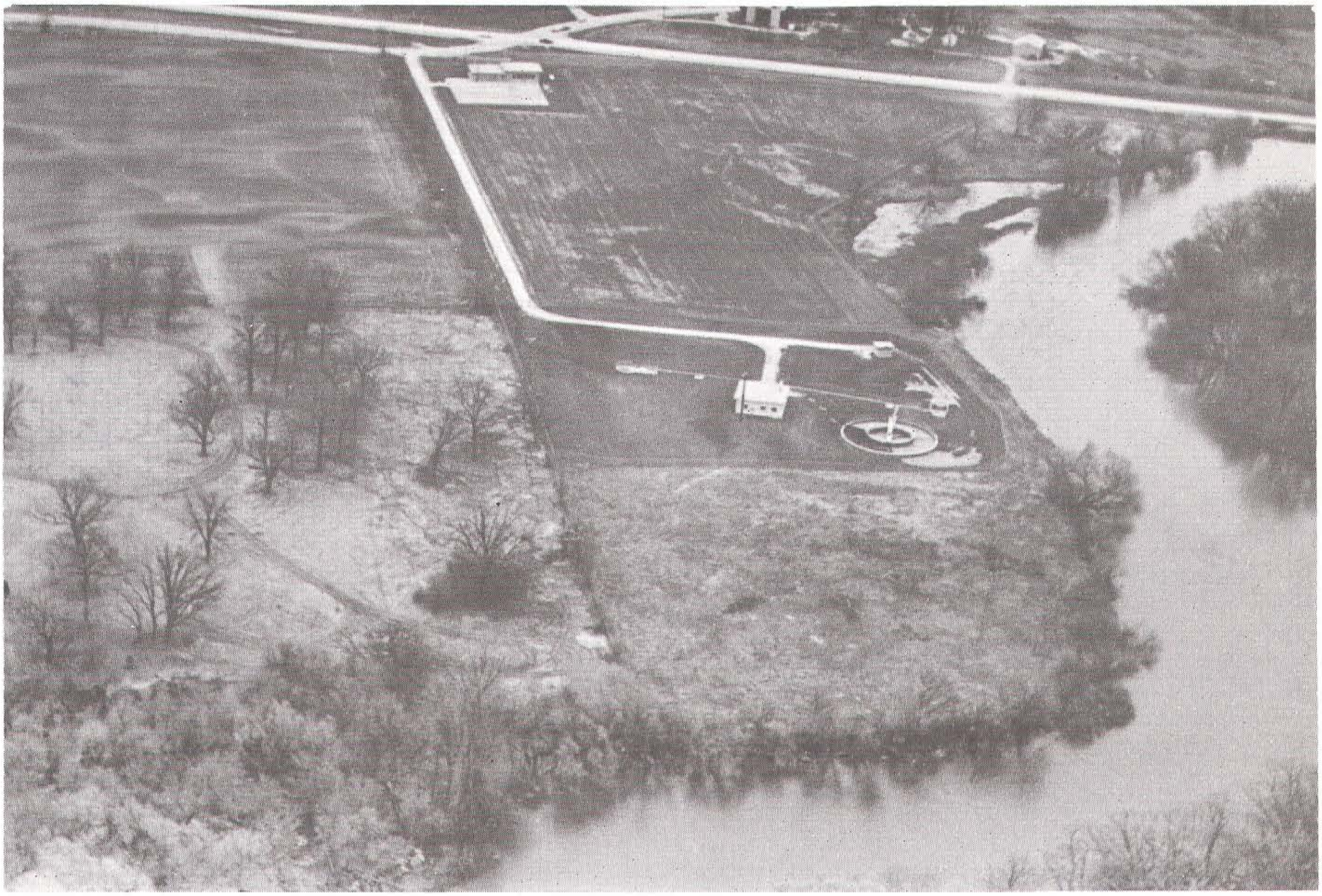


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

The location and configuration of the major trunk sewers and pumping and lift stations and related force mains comprising the Western Racine County Sewerage District sanitary sewerage system are shown on Map 38. There are no known points of sewer overflow or bypassing in the Western Racine County sanitary sewerage system. The inventory revealed that the district had a documented plan for the expansion of its system to include an additional 20 square mile area, including the Tichigan Lake area discussed below.

Management of the Western Racine County sanitary sewerage system is under the direction of a three-member commission. Day-to-day administration of the system is provided by the commission itself. Financing of the system is provided by the two villages and the town utility district which contribute sewage to the district. The metered rate charged by the district to each of its constituent units in 1970 was $90 per million gallons.

Proposed Public Sanitary Sewerage Systems

The inventory revealed that as of 1970 there were four proposed public sanitary sewerage systems in Racine County which would provide centralized sanitary sewer service to subareas of the county. Each of the four proposed systems centers around lake-oriented urban development, with one system each in the Towns of Burlington, Dover, Norway, and Waterford. Together these four proposed systems would serve a total area of about 13.6[15] square miles, or about 4 percent of the total area of the county, and a total existing population of about 11,350, or about 7 percent of the total population of the county. Each of these four proposed public sanitary sewerage systems is described in the following paragraphs.

Browns Lake Sanitary District: The Browns Lake Sanitary District in the Town of Burlington was formed in 1969 to provide sanitary sewer service to existing urban development along the shoreline of Browns Lake. The adopted comprehensive plan for the Fox River watershed recommended that such sewer service be provided and that the district contract with the City of Burlington for sewage treatment. This recommendation has been carried out, and the district has completed construction of the branch and trunk sewers needed to collect sewage and convey it to the City of Burlington sewage treatment plant.

The proposed service area of the Browns Lake Sanitary District is shown on Map 38. This area totals about 2.65 square miles and has a current resident population of about 2,400 persons.

Management of the Browns Lake Sanitary District is under the direction of a three-member commission. Day-to-day administration of the proposed system is to be provided by the commissioners. Operation and maintenance of the system is to be financed through a sewer service charge of about $10 per month per connection.

Eagle Lake Sewer Utility District: The Eagle Lake Sewer Utility District in the Town of Dover was formed in 1970 to provide sanitary sewer service to existing urban development along the shoreline of Eagle Lake and adjacent urban development in the unincorporated place of Kansasville. The adopted comprehensive plan for the Fox River watershed recommended that such sewer service be provided and that the utility district construct a sewage treatment plant near the lake outlet. The district has proceeded to carry out this recommendation and has completed engineering studies for the construction of the needed sewerage system. The district is currently awaiting action on applications for federal and state grants-in-aid for support of construction of such facilities.

The proposed service area of the Eagle Lake Sewer Utility District is shown on Map 38. This area totals about 2.24 square miles and has a current resident population of about 2,050 persons. The district has selected a 15-acre site adjacent to Eagle Creek to which it would discharge sewage effluent. The proposed sewage treatment facility would have an average hydraulic design capacity of 0.40 mgd and a peak hydraulic design capacity of 0.70 mgd, and would be an activated sludge type sewage treatment plant providing a secondary level of treatment.

Management of the Eagle Lake Sewer Utility District is under the direction of a three-member board. Day-to-day administration of the proposed system is to be provided by a certified plant operator. Operation and maintenance of the system are to be financed through a sewer service charge of about $4.50 per month per connection.

[15] *This includes 5.3 square miles also included in the proposed sewer service area of the Western Racine County Sewerage District.*

Town of Norway Sanitary District No. 1: The Town of Norway Sanitary District No. 1 was formed in 1969 to provide sanitary sewer service to existing urban development along the shorelines of Wind, Waubeesee, and Long Lakes in the Town of Norway. The adopted comprehensive plan for the Fox River watershed recommended that sewer service be provided to the Wind Lake area and that the sanitary district construct a sewage treatment plant near the Wind Lake outlet. The district has expanded this recommendation to include nearby development around Waubeesee and Long Lakes. In addition, it has been proposed that the district be further expanded to serve urban development around Denoon Lake in the City of Muskego, Waukesha County. The Town of Norway Sanitary District No. 1 has completed engineering studies for the construction of the needed sewerage system. The district is currently awaiting action on applications for federal and state grants-in-aid in support of the construction of the sewerage facilities.

The proposed service area of the Town of Norway Sanitary District No. 1 is shown on Map 38. This area totals about 4.5 square miles and has a current resident population of about 4,600 persons. The district has proposed a 20-acre sewage treatment plant site adjacent to the Wind Lake canal, to which it would discharge sewage effluent. The proposed sewage treatment facility would have an average hydraulic design capacity of about 0.7 mgd and a peak hydraulic design capacity of 1.0 mgd, and would be an activated sludge type sewage treatment plant providing an advanced level of waste treatment.

Management of the Town of Norway Sanitary District No. 1 is under the direction of a three-member commission. Day-to-day administration of the proposed system is to be provided by a certified plant operator. Operation and maintenance of the system is to be financed through a sewer service charge of about $3 per month per connection.

Tichigan Lake Sanitary District: The Tichigan Lake Sanitary District was formed in 1972 to provide sanitary sewer service to existing urban development in the Tichigan Lake area of the Town of Waterford. The adopted comprehensive plan for the Fox River watershed recommended that sewer service be provided to the immediate area around Tichigan Lake and that a sewage treatment facility be constructed at the southern end of Tichigan Lake and discharge effluent to the Fox River. The adopted plan further recommends that an eventual connection be made for the Tichigan Lake area to the Western Racine County Sewerage District sewage treatment plant located below Rochester. The sanitary district has begun steps toward implementation of the plan recommendation and is currently examining alternative methods of providing sewage treatment to the area. The proposed service area of the Tichigan Lake Sanitary District totals about 5.3 square miles and has a current population of about 2,300 persons. It should be noted that this proposed service area is also included in the proposed service area of the Western Racine County Sewerage District.

Other Sewage Treatment Facilities

In addition to the 14 public sanitary sewerage systems discussed above, there are a total of 14 sewage treatment facilities in Racine County which serve, in most cases, a single isolated land use enclave. These 14 sewage treatment facilities serve the Packaging Corporation of America industrial plant in the Town of Burlington; the Funk Mobile Homes Park No. 2, the Holy Redeemer College, the Meeter Brothers Company plant, and the Wisconsin Southern Colony Institution in the Town of Dover; the Frank Pure Food Company facility, the J. I. Case Company, Clausen Works, and the St. Bonaventure Seminary in the Town of Mt. Pleasant; Grove Duck Farms in the Town of Raymond; and C & D Duck Farms, Funk Mobile Home Park No. 1, Pekin Duck Farms, York Duck Farms, and the Racine County Highway and Office Building in the Town of Yorkville. Pertinent characteristics pertaining to each of these 14 sewage treatment facilities are presented in Table 37. It should be noted that the adopted comprehensive plan for the Root River watershed recommends that the Frank Pure Food Company facility in the Town of Mt. Pleasant be abandoned and connected to the City of Racine sanitary sewerage system.

Other Known Point Sources of Waste Water

In addition to identifying all existing public and private sewage treatment plants which discharge treated wastes to streams and watercourses within the Region, and all known sewage overflow points on both the existing sanitary and combined sewerage systems within the Region which discharge untreated wastes to streams and watercourses, an attempt was made in the regional sanitary sewerage system planning program to identify, through

Table 37

SELECTED CHARACTERISTICS OF PRIVATE SEWAGE TREATMENT FACILITIES IN RACINE COUNTY: 1970

Name	Civil Division Location	Type of Land Use Served	Type of Treatment Provided	Average Hydraulic Design Capacity (Gallons/Day)	Disposal of Effluent
C & D Duck Farms	Town of Yorkville	Industrial	Flow-through Lagoons and Spray Irrigation	N/A	Soil Absorption and West Branch Root River Canal
Fonk Mobile Homes Park No. 1	Town of Yorkville	Residential	Activated Sludge	8,000	East Branch Root River Canal
Fonk Mobile Homes Park No. 2	Town of Dover	Residential	Activated Sludge and Flow-through Lagoon	8,000	Minor Tributary of Des Plaines River
Frank Pure Food Company	Town of Caledonia	Industrial	Flow-through Lagoons	N/A	Hoods Creek
Grove Duck Farms	Town of Raymond	Industrial	Aerated Flow-through Lagoons	N/A	West Branch Root River
Holy Redeemer College	Town of Dover	Institutional	Activated Sludge and Flow-through Lagoon	2,500	Minor Tributary of Wind Lake Canal
J. I. Case Company	Town of Mt. Pleasant	Industrial	Chemical and Sedimentation	3,000,000	Lake Michigan
Meeter Brothers Company	Town of Dover	Industrial	Sedimentation and Flow-through Lagoons	N/A	Minor Tributary to Des Plaines River
Packaging Corporation of America	Town of Burlington	Industrial	Activated Sludge	10,000	Fox River
Pekin Duck Farms	Town of Yorkville	Industrial	Flow-through Lagoons and Spray Irrigation	N/A	Soil Absorption and West Branch Root River Canal
Racine County Highway and Office Building	Town of Yorkville	Governmental	Activated Sludge and Flow-through Lagoon	4,000	East Branch Root River Canal
St. Bonaventure Seminary	Town of Mt. Pleasant	Institutional	Activated Sludge and Flow-through Lagoons	15,000	Minor Tributary of Pike River
Wisconsin Southern Colony	Town of Dover	Institutional	Activated Sludge and Flow-through Lagoons	400,000	West Branch Root River Canal
York Duck Farms	Town of Yorkville	Industrial	Activated Sludge and Flow-through Lagoons	N/A	West Branch Root River Canal

NOTE: N/A indicates data not available.

Source: Wisconsin Department of Natural Resources and SEWRPC.

existing secondary sources, all other known point sources of waste water discharge. These other point sources of pollution consist primarily of industrial cooling, rinse, and wash waters, which may be discharged directly and without treatment to streams and watercourses or to storm sewers tributary to such streams and watercourses. The secondary sources consulted included river basin survey reports and pollution abatement orders of the Wisconsin Department of Natural Resources and records of municipal public works departments. A total of 31 such known point sources of industrial waste water were identified in Racine County. The name, civil division location, type of waste, known pretreatment, and receiving water body of these 31 waste sources are identified in Table 38. The location of these 31 point sources is shown on Map 39.

Existing Urban Development Not Served by Public Sanitary Sewers

As noted earlier, public sanitary sewerage systems in Racine County serve a total area of about 29 square miles, or about 9 percent of the total area of the county, and a total population of about 135,900 persons, or about 78 percent of the total population of the county. An inventory was conducted in the study to determine the approximate amount of urban development, and the population residing therein, in Racine County not served in 1970 by public sanitary sewer service. Each U. S. Public Land Survey quarter section not having development served by a centralized sanitary sewerage system was examined to determine if a significant amount of urban development was present in 1970. Any quarter section with at least 32 housing units, or an average of one housing unit per five gross acres, was deemed to be urban. The major purpose in identifying such concentrations of urban development was to provide the basis for analyzing the potential of providing public sanitary sewer service to such areas in accordance with recommendations contained in the adopted regional land use plan.

The nonsewered urban development areas identified in Racine County are shown on Map 39. Together these areas total about 4.7 square miles, or about 1.4 percent of the total area of the county, and contain a total population of about 11,800 persons, or about 7 percent of the total population of the county. For analysis purposes, the existing nonsewered urban development has been combined into 15 named major urban concentrations. The estimated population and urban development areas of each of these major concentrations are shown in Table 39.

Table 38

KNOWN EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN RACINE COUNTY: 1970

Point Source[1]		Civil Division Location	Type of Waste	Known Pretreatment	Receiving Water Body
Number[2]	Name				
1	Acme Die Casting Corporation	City of Racine	Cooling Waters	--	Lake Michigan
2	Allied Metal Treating Corporation of Wisconsin	City of Racine	Cooling Waters	--	Lake Michigan
3	E. C. Styberg Engineering Company, Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
4	Greene Manufacturing Company	City of Racine	Cooling Waters	--	Lake Michigan
5	Horlicks Corporation	City of Racine	Cooling Waters	--	Lake Michigan
6	In-Sink-Erator Manufacturing Division, Emerson Electric Company	City of Racine	Cooling Waters	--	Lake Michigan
7	Jacobsen Manufacturing Company	City of Racine	Cooling Waters	--	Lake Michigan
8	J. I. Case Company	City of Racine	Cooling Waters	--	Lake Michigan
9	Modine Manufacturing Company	City of Racine	Cooling Waters	--	Lake Michigan
10	Moxness Products, Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
11	Progressive Dairy Products Company	City of Racine	Cooling Waters	--	Lake Michigan
12	City of Racine Water Treatment Plant	City of Racine	Waste Water Sludge	Sedimentation	Lake Michigan
13	Racine Hydraulics, Division of Rex Chainbelt Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
14	Racine Industrial Machinery Company	City of Racine	Cooling Waters	--	Lake Michigan
15	Racine Steel Castings Company	City of Racine	Cooling Waters	--	Lake Michigan
16	Rainfair, Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
17	S. C. Johnson and Son, Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
18	Twin Disc, Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
19	Walker Forge, Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
20	Walker Manufacturing Company	City of Racine	Cooling Waters	--	Lake Michigan
21	Webster Electric Company, Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
22	Western Publishing Company, Incorporated	City of Racine	Cooling Waters	--	Lake Michigan
23	Bardon Rubber Products Company	Village of Union Grove	Cooling Waters	--	Des Plaines River
24	Casey's Locker Plant	Village of Union Grove	Meat Processing Wastes	Septic Tank	West Branch Root River Canal
25	Meeter Brothers and Company	Village of Union Grove	Cooling Waters	--	Des Plaines River
26	Wisconsin Rubber Products Company	Village of Union Grove	Cooling Waters	--	Des Plaines River
27	Young Radiator Company	Town of Caledonia	Cooling Waters	--	Lake Michigan
28	Pure Milk Association	Town of Dover	Process Wastes	Seepage Lagoon	Eagle Lake
29	S. C. Johnson and Son, Incorporated	Town of Mt. Pleasant	Cooling Waters	--	Pike River
30	Fohrs Meat Service	Town of Raymond	Meat Processing Wastes	Septic Tank	Root River Canal
31	Harry Hansen Meat Service	Town of Raymond	Meat Processing Wastes	Septic Tank	West Branch Root River Canal

[1]As identified in Wisconsin Department of Natural Resources river basin survey reports and pollution abatement orders and by selected municipal public works departments; does not include industrial waste sources discharging to municipal sanitary sewerage systems.
[2]See Map 39.

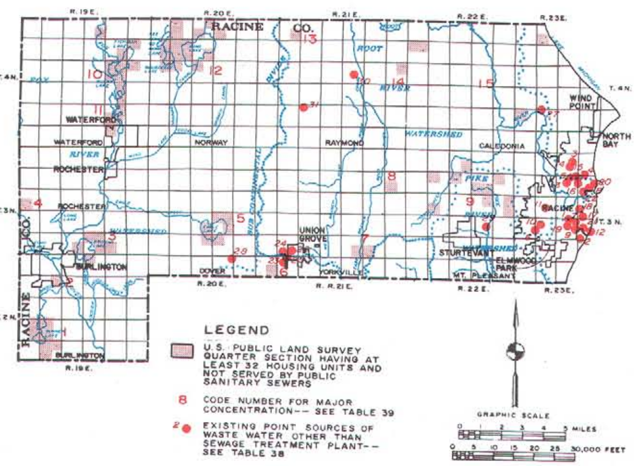
Source: SEWRPC.

Concluding Remarks—Racine County

Inventories conducted under the regional sanitary sewerage system planning program revealed that in 1970 there existed in Racine County a total of 14 public sanitary sewerage systems which together served a total area of about 29 square miles, or about 9 percent of the total area of the county, and a total population of about 135,900 persons, or about 78 percent of the total population of the county. Seven sewage treatment facilities provide treatment for sewage generated in these 14 public sanitary sewerage systems. The Village of North Bay, the Town of Caledonia Sewer Utility District No. 1, and the Town of Mt. Pleasant Sewer Utility District contract with the City of Racine for sewage treatment. The Crestview Sanitary District contracts with the North Park Sanitary District for sewage treatment. Finally, the Villages of Rochester and Waterford and the Town of Rochester Sewer Utility District No. 1 together form the Western Racine County Sewerage District for sewage treatment purposes. In addition to the 14 public sanitary sewerage systems, an additional 14 sewage treatment facilities serving primarily single, isolated land uses were found in the inventory. The inventory revealed that as of 1970 there were four proposed public sanitary sewerage systems, all of which are proposed to serve existing urban development along lake shorelines. Finally, in 1970 there were an estimated 11,800 persons residing in urban areas in Racine County not served by public sanitary sewer service. Together these areas totaled about 4.7 square miles.

Map 39

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS AND EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN RACINE COUNTY: 1970



Significant concentrations of unsewered urban development in Racine County are of two types. The first type consists of unsewered subdivisions in the Towns of Caledonia and Mt. Pleasant in eastern Racine County which represent the remnants of larger unsewered urban areas that developed rapidly in the late 1950s and early 1960s. Sanitary sewer service is in the process of being provided to nearly all of these remaining unsewered areas. The second type consists of lake- and river-oriented development, particularly around Eagle, Bohner, Browns, Tichigan, and Wind Lakes. Centralized sanitary sewer service has been provided to the Browns Lake area since 1970, with additional sewerage systems being planned for the urban development around Eagle, Tichigan, and Wind Lakes. The 31 known point sources of wastewater other than sewage treatment plants in Racine County are also shown on this map. Such sources are primarily concentrated in the Racine and Union Grove areas of the county.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 39

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN RACINE COUNTY BY MAJOR URBAN CONCENTRATION: 1970

Major Urban Concentration[1] Number[2]	Major Urban Concentration[1] Name	Estimated Resident Population	Developed Urban Area (Acres)
1	Bohner Lake Area	1,400	458
2	Burlington Area	100	22
3	Browns Lake Area	1,400	323
4	Honey Lake Area	200	65
5	Eagle Lake Area	800	269
6	Town of Dover - Section 36	200	23
7	Town of Yorkville - Section 27	400	75
8	Ives Grove Area	100	35
9	Town of Mt. Pleasant	1,700	344
10	Tichigan Lake Area	900	252
11	Waterford Area	900	305
12	Wind Lake Area	2,600	597
13	Town of Raymond - Section 6	100	74
14	Town of Raymond - Section 13	200	49
15	Town of Caledonia	800	193
	Racine County Total	11,800	3,034[3]

[1]*Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

[2]*See Map 39.*

[3]*Equal to 4.7 square miles.*

Source: SEWRPC.

INVENTORY FINDINGS—WALWORTH COUNTY

Existing Public Sanitary Sewerage Systems

There are a total of 11 existing public sanitary sewerage systems in Walworth County which provide centralized sanitary sewer service to subareas of the county. These include the systems operated by the Cities of Delavan, Elkhorn, Lake Geneva, and Whitewater; and the Villages of Darien, East Troy, Fontana, Genoa City, Sharon, Walworth, and Williams Bay. Together, these systems serve a total area of about 11.8 square miles, or about 2 percent of the total area of the county, and a total population of about 35,500, or about 56 percent of the total population of the county. Each of these public sanitary sewerage systems is described in the following paragraphs. Pertinent characteristics of each system are presented in Tables 40 and 41.

City of Delavan: The existing service area of the City of Delavan sanitary sewerage system is shown on Map 40. This area totals about 2.4 square miles and has a resident population of about 5,400 persons. The entire area is serviced by a separate sanitary sewer system.

Sewage from the City of Delavan is treated at a sewage treatment plant located on Turtle Creek, to which effluent is discharged (see Figure 49). The plant has a site area of about 10 acres, of which about three acres are currently utilized, leaving seven acres potentially available for future use. The plant site is bounded on all sides by wetlands, floodlands, and other open lands. The plant, a high-rate trickling filter type, was constructed in 1930 and extensively modified in 1949. The average hydraulic design capacity of the plant is 1.0 mgd, with an estimated peak hydraulic design capacity of 1.5 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.7 mgd, indicating that the plant does have adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided by the plant are classified as secondary level.

The location and configuration of all major trunk sewers serving the City of Delavan are shown on

Table 40

AREA AND POPULATION SERVED BY EXISTING AND LOCALLY PROPOSED SANITARY SEWERAGE SYSTEMS IN WALWORTH COUNTY: 1970

Name of Public Sanitary Sewerage System	Estimated Service Area: Existing Acres	Existing Square Miles	Proposed[1] Acres	Proposed[1] Square Miles	Estimated Population Served[2]	Treatment of Sewage (See Table 41)
Existing Systems						
City of Delavan	1,553	2.43	1,834	2.86	5,400	Operates a Facility
City of Elkhorn	1,265	1.98	1,332	2.08	4,000	Operates a Facility
City of Lake Geneva	985	1.54	2,213	3.45	4,700	Operates a Facility
City of Whitewater	1,048	1.64	12,118[3]	18.93[3]	12,000	Operates a Facility
Village of Darien	260	0.41	- -	- -	900	Operates a Facility
Village of East Troy	292	0.46	308	0.48	1,700	Operates a Facility
Village of Fontana	880	1.38	1,589	2.48	1,600	Operates a Facility
Village of Genoa City	131	0.20	211	0.32	900	Operates a Facility
Village of Sharon	274	0.43	111	0.17	1,200	Operates a Facility
Village of Walworth	262	0.41	1,033	1.61	1,600	Operates a Facility
Village of Williams Bay	615	0.96	550	0.86	1,500	Operates a Facility
Proposed Systems						
Town of Lyons Sanitary District No. 2	- -	- -	247	0.39	- -	- -
Delavan Lake Sanitary District	- -	- -	2,475	3.87	- -	- -
Lake Como	- -	- -	922	1.40	- -	- -
Town of East Troy Sanitary District No. 2	- -	- -	270	0.42	- -	- -
County Total	7,565	11.84	25,213	39.32	35,500	- -

[1]*As identified in locally prepared plans and engineering reports.*

[2]*Based upon an approximation of the existing sewer service area by U.S. Public Land Survey quarter section.*

[3]*Includes 960 acres (1.50 square miles) in Rock County and 4,563 acres (7.13 square miles) in Jefferson County.*

Source: SEWRPC.

Table 41

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN WALWORTH COUNTY: 1970

Name of Public Sewage Treatment Facility	Estimated Total Area Served (Square Miles)	Estimated Total Population Served	Date of Original Construction and Major Modification	Type of Treatment Provided	Level of Treatment Provided	Disposal of Effluent	Design Capacity: Population	Average Hydraulic (MGD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Population Equivalent[1]
City of Delavan	2.43	5,400	1930, 1949	Trickling Filter	Secondary	Turtle Creek	10,000	1.0	1.5	N/A	N/A
City of Elkhorn	1.98	4,000	1927, 1949	Trickling Filter	Secondary	Jackson Creek	N/A	0.5	N/A	1,513	7,205
City of Lake Geneva	1.54	4,700	1930, 1966	Trickling Filter	Secondary	White River	9,750	1.1	N/A	1,890	9,000
City of Whitewater	1.64	12,000	1937, 1967	Activated Sludge & Trickling Filter	Secondary	Whitewater Creek	35,750	2.5	3.75	6,080	2,895
Village of Darien[5]	0.41	900	1968	Activated Sludge	Secondary	Seepage Lagoon	N/A	0.14	0.28	245	1,167
Village of East Troy	0.46	1,700	1960	Trickling Filter	Secondary	Honey Creek	2,770	0.32	0.64	417	1,988
Village of Fontana	1.38	1,600	1957	Trickling Filter	Secondary	Seepage Lagoon	4,000	0.40	0.80	680	3,238
Village of Genoa City	0.20	900	1923, 1959	Trickling Filter	Secondary	Nippersink Creek	N/A	0.12	0.24	200	952
Village of Sharon	0.43	1,200	1960	Trickling Filter	Secondary	Sharon Creek	N/A	0.15	0.30	261	1,243
Village of Walworth	0.41	1,600	1952, 1965	Trickling Filter	Tertiary	Piscasaw Creek	N/A	0.15	0.30	1,480	7,048
Village of Williams Bay	0.96	1,500	1931, 1968	Activated Sludge	Secondary	Seepage Lagoon	6,500	0.79	1.2	1,100	5,238

Name of Public Sewage Treatment Facility	Existing Loading - 1970: Average Hydraulic (MGD)	Average Per Capita (GPD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Reserve Hydraulic Capacity (MGD)	Sewage Strength Parameters in Influent Sewage: $CBOD_5$ (mg/1)	Suspended Solids (mg/1)	Total Phosphorus (mg/1)	Organic Nitrogen-N (mg/1)	Ammonia Nitrogen-N (mg/1)	Industrial Flows: Design Average Daily Flow (MGD)	Estimated Daily Flow 1970 (MGD)	Overall Plant Efficiency Percent Removals: $CBOD_5$ (Percent)	Suspended Solids (Percent)	Total Phosphorus (P) (Percent)	Number of Days in 1970 Plant Flow Exceeded Plant Meter Capacity
City of Delavan	0.7	130	N/A	N/A	0.3	58[2]	N/A	8.0[2]	N/A	N/A	N/A	N/A	69[2]	N/A	6[2]	N/A
City of Elkhorn	0.7	175	N/A	N/A	None	152[3]	141[3]	N/A	N/A	N/A	N/A	N/A	97[3]	97[3]	N/A	N/A
City of Lake Geneva	0.64	136	N/A	N/A	0.46	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
City of Whitewater	1.51	126	N/A	N/A	0.99	615[4]	298[4]	16.35[4]	N/A	N/A	N/A	0.58[4]	83[4]	36[4]	7[4]	N/A
Village of Darien[5]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Village of East Troy	0.18	106	N/A	N/A	0.14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Fontana	0.50	312	N/A	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Genoa City	0.076	84	N/A	N/A	0.044	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Sharon	0.045	37	N/A	N/A	0.105	N/A	N/A	6.0	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A
Village of Walworth	0.15	92	N/A	N/A	None	N/A	N/A	13.5	N/A	7.8	N/A	N/A	N/A	N/A	4	N/A
Village of Williams Bay	0.359	239	N/A	N/A	0.431	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: N/A indicates data not available.

[1]*The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design $CBOD_5$ loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of $CBOD_5$ per day. If the design engineer assumed a different daily per capita contribution of $CBOD_5$, the population equivalent design capacity will differ from the population design capacity shown in the Table.*

[2]*Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in July 1969.*

[3]*Data averaged from two 24-hour composite samples by the Wisconsin Department of Natural Resources in August and October 1963.*

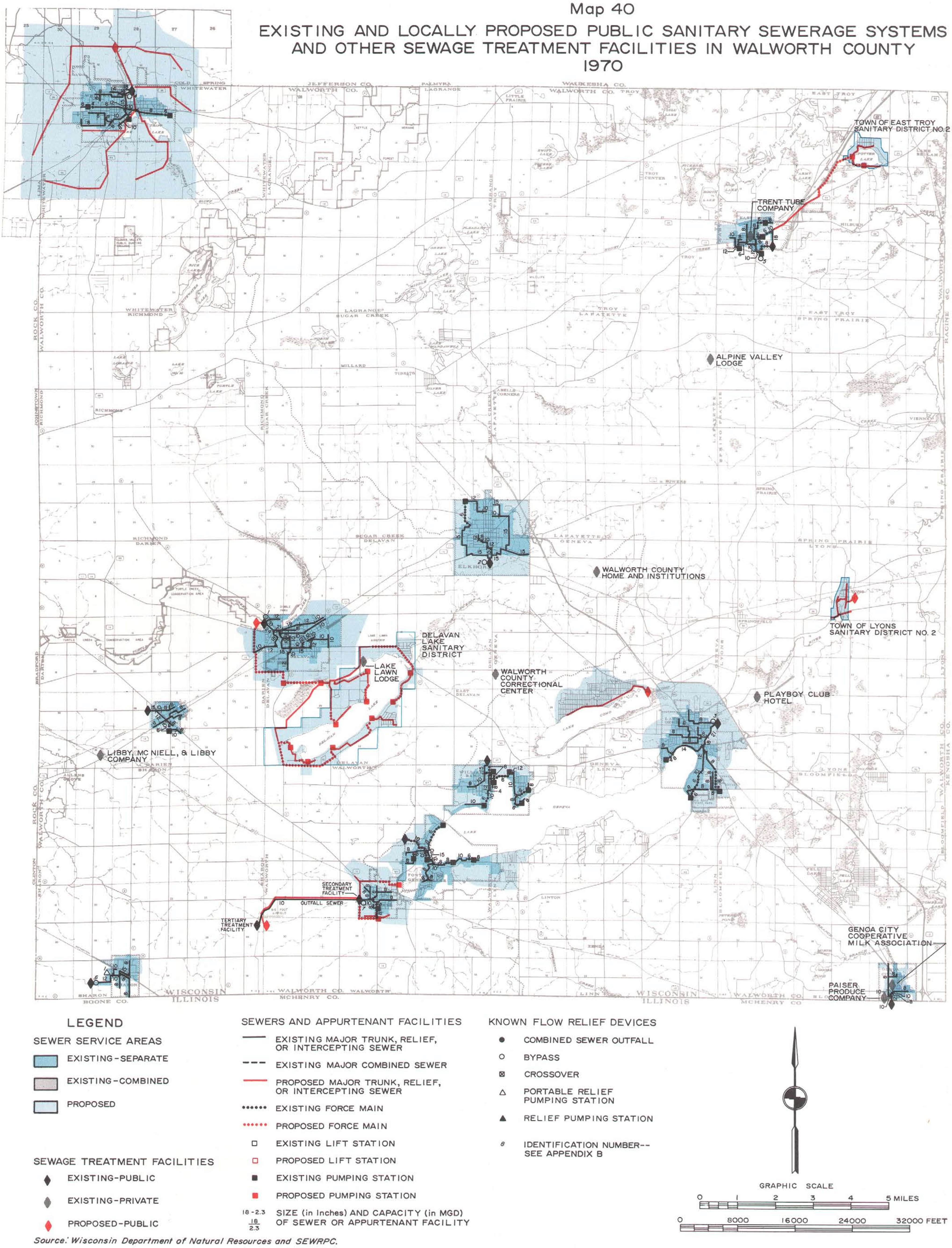
[4]*Data obtained from a 24-hour composite sample by Water Engineering Associates in January 1972.*

[5]*This treatment plant was placed into operation late in 1970; no data pertaining to existing loadings and operational characteristics was, therefore, available.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 40

EXISTING AND LOCALLY PROPOSED PUBLIC SANITARY SEWERAGE SYSTEMS AND OTHER SEWAGE TREATMENT FACILITIES IN WALWORTH COUNTY 1970



Source: Wisconsin Department of Natural Resources and SEWRPC.

(This page intentionally left blank)

Figure 49

CITY OF DELAVAN SEWAGE TREATMENT PLANT

Photo by Roger R. Ross and Joseph C. Ruys.

Map 40. There are no known points of sewer overflow or bypassing in the City of Delavan sanitary sewerage system except for a bypass located at the sewage treatment plant. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional 2.9 square mile area, which area is shown on Map 40. No locally proposed trunk sewers to serve this additional area, however, were found in the inventory.

Management of the City of Delavan sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the City Engineer. Financing of the system is provided through a sewer service charge equal to 50 percent of a consumer's water bill. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Delavan sanitary sewerage system were not made available by the city.

City of Elkhorn: The existing service area of the City of Elkhorn sanitary sewerage system is shown on Map 40. This area totals about two square miles and has a resident population of about 4,000 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Elkhorn is treated at a sewage treatment plant located on a minor tributary to Jackson Creek, to which effluent is discharged (see Figure 50). The plant has a site area of about three acres, all of which are currently utilized. The plant site is bounded by residential land uses on the north and by agricultural and open lands on the east, west, and south. The plant, a trickling filter type, was constructed in 1927 and expanded in 1949. The average hydraulic design capacity of the plant is 0.5 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.7 mgd, indicating that the plant did not have adequate capacity to treat the average daily flow from the existing sewer service area.

Figure 50

CITY OF ELKHORN SEWAGE TREATMENT PLANT

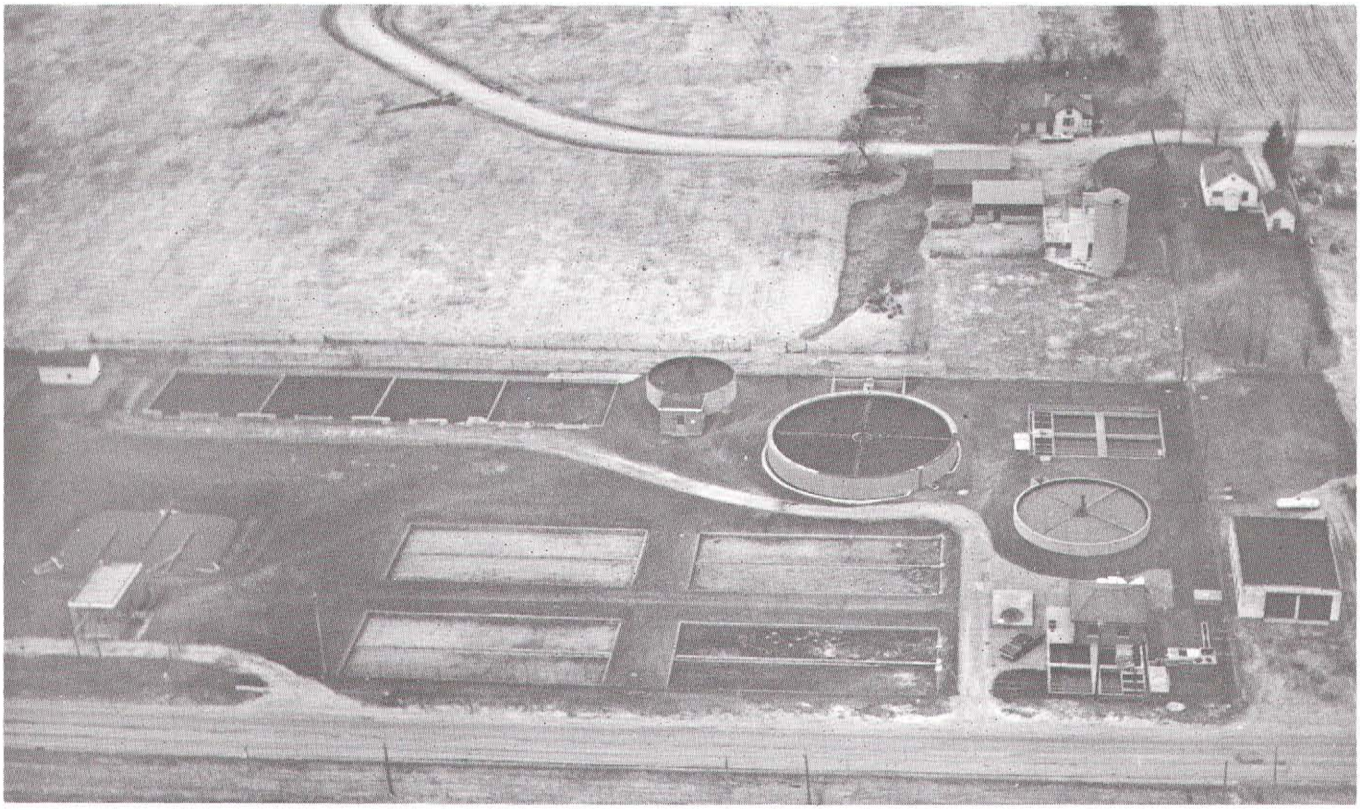


Photo by Roger R. Ross and Joseph C. Ruys.

In addition, it should be noted that the city is experiencing severe problems due to extreme amounts of clear water inflow to the sewerage system. The city is currently under orders from the Wisconsin Department of Natural Resources to take steps to eliminate the extensive clear water inflows in the sewerage system. The treatment processes provided by the plant are classified as secondary level.

The location and configuration of all major trunk sewers serving the City of Elkhorn are shown on Map 40. Other than a bypass at the treatment plant, there are no known points of sewer overflow or bypassing in the City of Elkhorn sanitary sewerage system. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional two square mile area, which area is shown on Map 40. No locally proposed trunk sewers to serve this area, however, were found in the inventory.

Management of the City of Elkhorn sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the Street Commissioner. Financing of the system is provided through a sewer service charge equal to 65 percent of a consumer's water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Elkhorn sanitary sewerage system approximated $250,426, or about $63 per capita. Of this total, $25,843, or about $7 per capita, was expended for operation and maintenance and $224,583, or about $56 per capita, was expended for capital improvements.

City of Lake Geneva: The existing service area of the City of Lake Geneva sanitary sewerage system is shown on Map 40. This area totals about 1.5 square miles and has a resident population of about 4,700 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Lake Geneva is treated at a sewage treatment plant located on the White River, to which effluent is discharged (see Figure 51). The plant has a site area of about 15 acres, of which two acres are currently utilized leaving 13 acres available for future use. The plant site is bounded by residential land use on the west and by open and agricultural lands on the north, south, and east. The plant, a trickling filter type, was originally constructed in 1930 and extensively modified in 1966. The average hydraulic design capacity of the plant is 1.1 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.6 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of all major trunk sewers serving the City of Lake Geneva are shown on Map 40. Except for a bypass at the sewage treatment plant, there are no known points of sewer overflow or bypassing in the City of Lake Geneva sanitary sewerage system. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional 3.5 square mile area, which area is shown on Map 40. No locally proposed trunk sewers to serve this additional area, however, were found in the inventory.

Management of the City of Lake Geneva sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the Sewer and Water Superintendent. Financing of the system is provided through a sewer service charge equal to 100 percent of a consumer's water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Lake Geneva sanitary sewerage system approximated $113,153, or about $24 per capita. Of this total, $65,153, or about $14 per capita, was expended for operation and maintenance and $48,000, or about $10 per capita, was expended for capital improvements.

Figure 51

CITY OF LAKE GENEVA SEWAGE TREATMENT PLANT

Photo by Roger R. Ross and Joseph C. Ruys.

City of Whitewater: The existing service area of the City of Whitewater sanitary sewerage system is shown on Map 40. This area totals about 1.6 square miles and has a resident population of about 12,000 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Whitewater is treated at two parallel sewage treatment facilities located on Whitewater Creek, to which effluent is discharged (see Figure 52). The plant has a site area of about eight acres, of which about six acres are currently utilized, leaving two acres available for future use. The plant site is bounded by residential land use on the south, commercial land use on the north, agricultural land use on the east, and Whitewater Creek on the west. The first plant, a trickling filter type plant, was constructed in 1937. The second plant, an activated sludge type plant, was constructed in 1967. The combined average hydraulic design capacity of the two plants is 2.5 mgd, with an estimated combined peak hydraulic design capacity of 3.75 mgd. The average hydraulic loading on the combined plant in 1970 was estimated at 1.5 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided by both the trickling filter and the activated sludge plants are classified as secondary level. It should be noted that the city is under orders by the Wisconsin Department of Natural Resources to provide a more satisfactory level of sewage treatment at the existing plant. An engineering report has been prepared in response to this order, which report recommends the establishment of a new sewage treatment facility together with plant expansion. Special problems are posed by

Figure 52

CITY OF WHITEWATER SEWAGE TREATMENT PLANT

Photo by Roger R. Ross and Joseph C. Ruys.

the large volumes of waste waters contributed to the sewage treatment facility by the Hawthorne Melody and Foremost Dairy industrial plants. For example, the Hawthorne Melody Dairy contributed about 0.5 mgd to the plant in early 1972.

The location and configuration of all major trunk sewers serving the City of Whitewater are shown on Map 40. There is one known point of sewage flow relief in the City of Whitewater sanitary sewerage system—a gated bypass. The inventory revealed that the city has a documented plan to provide sewer service to an additional 18.9 square mile area, which area is shown on Map 40. The locally proposed trunk sewers to serve the additional area and to relieve existing problems within the existing sewer service area are also shown on Map 40.

Management of the City of Whitewater sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the City Manager. Financing of the system is provided through the general property tax and a sewer service charge equal to 100 percent of a consumer's water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Whitewater sanitary sewerage system approximated $135,919, or about $11 per capita. Of this total, $83,581, or about $7 per capita, was expended for operation and maintenance and $52,338, or about $4 per capita, was expended for capital improvements.

Village of Darien: The existing service area of the Village of Darien sanitary sewerage system is shown on Map 40. This area totals about 0.4 square mile and has a resident population of about 900 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Darien is treated at a sewage treatment plant located on a minor drainage ditch tributary to Turtle Creek, to which overflow effluent from a seepage lagoon could be discharged (see Figure 53); the plant has been designed, however, to result in no discharge to the surface water system. The plant has a site

Figure 53

VILLAGE OF DARIEN SEWAGE TREATMENT PLANT

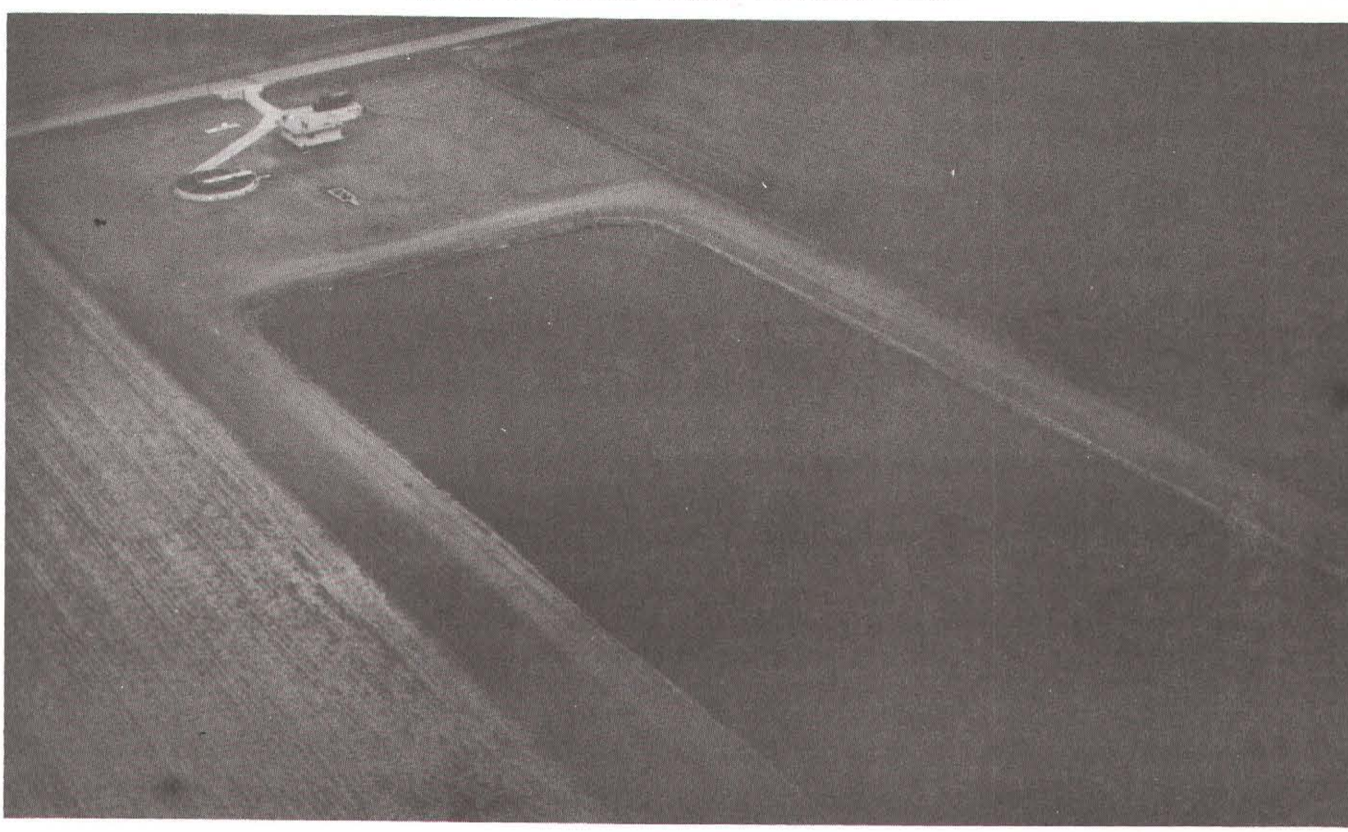


Photo by Roger R. Ross and Joseph C. Ruys.

area of about 9.6 acres, of which about six acres are currently utilized, leaving 3.6 acres available for future use. The plant site is bounded by a county trunk highway on the north and agricultural land uses on the south, west, and east. The plant, an activated sludge type, was constructed in 1968 and placed into operation in late 1970. The average hydraulic design capacity of the plant is 0.14 mgd, with an estimated peak hydraulic design capacity of 0.28 mgd. The average hydraulic loading on the plant in 1970 was negligible, since house connections had not yet been completed. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers serving the Village of Darien are shown on Map 40. There are no known points of sewer overflow or bypassing in the Village of Darien sanitary sewerage system. The inventory revealed that the village did not have a documented plan for expansion of its sewerage system.

Management of the Village of Darien sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Sewer and Water Superintendent. Financing of the system is provided through the general property tax and a sewer service charge of $15 per quarter per connection plus 150 percent of a consumer's water bill for all water used above a specified amount. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Darien sanitary sewerage system were not available.

Village of East Troy: The existing service area of the Village of East Troy sanitary sewerage system is shown on Map 40. This area totals about 0.46 square mile and has a resident population of about 1,700 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of East Troy is treated at a sewage treatment plant located on Honey Creek, to which effluent is discharged (see Figure 54). The plant has a site area of about 5.5 acres, of which two acres are currently utilized leaving 3.5 acres available for future use. The plant site is bounded by open lands on all sides. The plant, a trickling filter type, was constructed in 1960. The average hydraulic design capacity of the plant is 0.32 mgd, with a peak hydraulic design capacity estimated to be 0.6 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.18 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers serving the Village of East Troy are shown on Map 40. There is one known point of sewer overflow or bypassing in the Village of East Troy sanitary sewerage system—a bypass. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 0.5 square mile area, which area is shown on Map 40. No locally proposed trunk sewers to serve this additional area, however, were found in the inventory.

Management of the Village of East Troy sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Superintendent of Public Works. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of East Troy sanitary sewerage system approximated $35,253, or about $21 per capita. Of this total, $11,734, or about $7 per capita, was expended for operation and maintenance and $23,519, or about $14 per capita, was expended for capital improvements.

Figure 54

VILLAGE OF EAST TROY SEWAGE TREATMENT PLANT

Photo by Roger R. Ross and Joseph C. Ruys.

Village of Fontana-on-Geneva Lake: The existing service area of the Village of Fontana sanitary sewerage system is shown on Map 40. This area totals about 1.4 square miles and has a resident population of about 1,600 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Fontana is treated at a sewage treatment plant located near the northwestern corner of the village (see Figure 55). Effluent from the plant is discharged to a seepage lagoon which has no outlet. The plant has a site area of about 55 acres, of which 16 acres are currently utilized, leaving 39 acres available for future use. The plant site is bounded by agricultural lands on all sides. The plant, a high-rate trickling type, was constructed in 1957. The average hydraulic design capacity of the plant is 0.4 mgd, with a peak hydraulic design capacity of 0.8 mgd. The average hydraulic loading of the plant in 1970 was estimated at 0.5 mgd, indicating that the plant does not have adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level. It should be noted that the village placed into operation in January 1973 an addition to the sewage treatment plant so that the plant now has an average hydraulic design capacity of 0.9 mgd and a peak hydraulic design capacity of 1.8 mgd.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Village of Fontana sanitary sewerage system are shown on Map 40. There are no known points of sewer overflow or bypassing in the Village of Fontana sanitary sewerage system. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 2.5 square mile area, which area is shown on Map 40. No locally proposed trunk sewers to serve this additional area, however, were found in the inventory.

Management of the Village of Fontana sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Water and Sewer Superintendent. Financing of the system is provided through a sewer service charge of $9 per quarter per connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Fontana sanitary sewerage system approximated $57,677, or about $36 per capita. Of this total, $20,800, or about $13 per capita, was expended for operation and maintenance and $36,877, or about $23 per capita, was expended for capital improvements.

Village of Genoa City: The existing service area of the Village of Genoa City sanitary sewerage system is shown on Map 40. This area totals about 0.2 square mile and has a resident population of about 900 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Genoa City is treated at a sewage treatment plant located on Nippersink Creek, to which effluent is discharged (see

Figure 55

VILLAGE OF FONTANA SEWAGE TREATMENT PLANT

1970 SEWRPC Photo.

Photo by Roger R. Ross and Joseph C. Ruys.

Figure 56). The plant has a site area of about five acres, of which four acres are currently utilized, leaving one acre available for future use. The plant site is bounded by residential land uses on the north and east, the Wisconsin-Illinois state line on the south, and Nippersink Creek on the west. The plant, a trickling filter type, was initially constructed in 1923 and extensively modified in 1959. The average hydraulic design capacity of the plant is 0.12 mgd, with an estimated peak hydraulic design capacity of 0.24 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.08 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers serving the Village of Genoa City are shown on Map 40. There are no known points of sewer overflow or bypassing in the Village of Genoa City sanitary sewerage system. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 0.3 square mile area, which area is shown

Figure 56

VILLAGE OF GENOA CITY SEWAGE TREATMENT PLANT

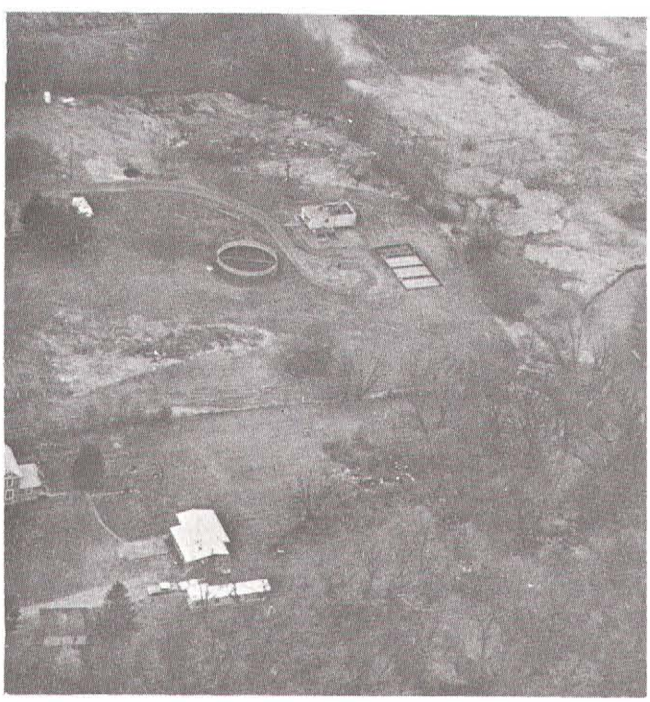


Photo by Roger R. Ross and Joseph C. Ruys.

on Map 40. No locally proposed trunk sewers to serve this additional area, however, were found in the inventory.

Management of the Village of Genoa City sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Water and Sewer Utility Superintendent. Financing of the system is provided through the general property tax and a sewer service charge equal to 55 percent of the consumer's water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Genoa City sanitary sewerage system approximated $33,818, or about $38 per capita. Of this total, $9,457, or about $11 per capita, was expended for operation and maintenance and $24,361, or about $27 per capita, was expended for capital improvements.

Village of Sharon: The existing sewer service area of the Village of Sharon sanitary sewerage system is shown on Map 40. This area totals about 0.4 square mile and has a resident population of about 1,200 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Sharon is treated at a sewage treatment plant located on Sharon Creek, to which effluent is discharged (see Figure 57). The plant has a site area of about two acres, of which 0.5 acre is currently utilized, leaving 1.5 acres available for future use. The plant site is bounded by agricultural land uses on all sides. The plant, a trickling filter type, was constructed in 1960. The average hydraulic design capacity of the plant is 0.15 mgd, with an estimated peak hydraulic design capacity of 0.3 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.05 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers serving the Village of Sharon are shown on Map 40. There are two known points of sewage flow relief in the Village of Sharon sanitary sewerage system—a bypass at the treatment plant and a portable pumping station. The inventory revealed that the village had a documented plan for the extension of its sanitary sewerage system (see Map 40).

Figure 57

VILLAGE OF SHARON SEWAGE TREATMENT PLANT

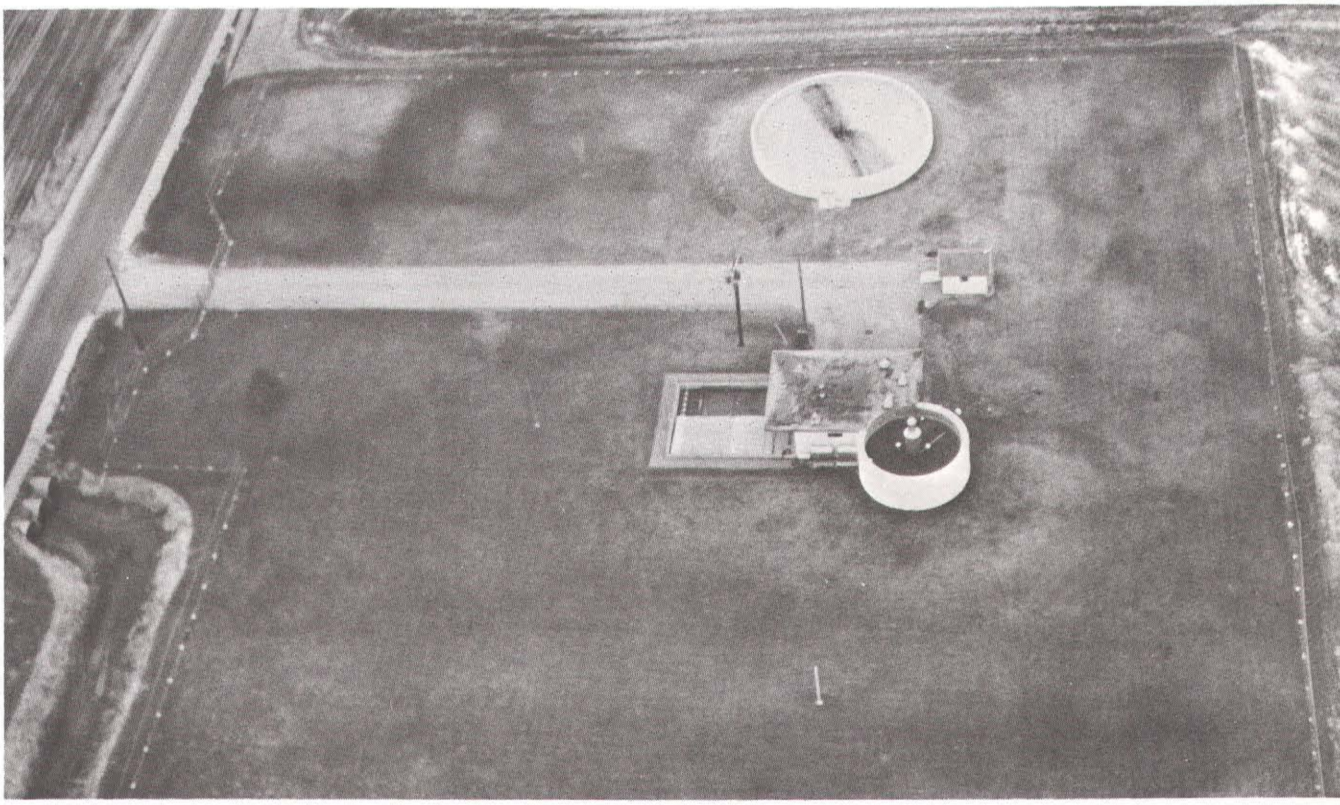


Photo by Roger R. Ross and Joseph C. Ruys.

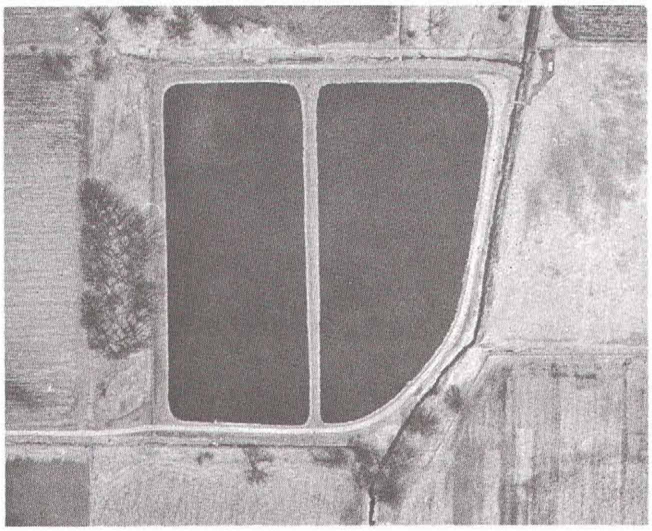
Management of the Village of Sharon sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the treatment plant operator. Financing of the system is provided through a sewer service charge of $12 per quarter per connection plus an amount equal to 75 percent of the consumer's water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Sharon sanitary sewerage system approximated $26,038, or about $22 per capita. Of this total, $12,820, or about $11 per capita, was expended for operation and maintenance and $13,218, or about $11 per capita, was expended for capital improvements.

Village of Walworth: The existing sewer service area of the Village of Walworth sanitary sewerage system is shown on Map 40. This area totals about 0.4 square mile and has a resident population of about 1,600 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Walworth is treated at a sewage treatment plant located at the western village limits, with effluent piped to flow-through lagoons for final effluent treatment located about three miles from the treatment plant on Piscasaw Creek, to which the final effluent is discharged (see Figure 58). In total, the plant has a site area of about 24 acres, of which four acres represent the sewage treatment plant site at the western village limits, and 20 acres represent the effluent lagoon site located on the Piscasaw Creek. Of the 20 acres located on Piscasaw Creek, 10 acres are currently utilized, leaving 10 acres available for future use. The existing plant site is bounded by agricultural land uses on all sides. The Piscasaw Creek site is also bounded by agricultural land uses on all sides. The plant, an Imhoff tank trickling filter type, was initially constructed in 1952 and extensively modified in 1965. The lagoons located on Piscasaw Creek were also added in 1965. The average hydraulic design capacity of the plant is 0.15 mgd, with an estimated peak hydraulic design capacity of 0.3 mgd.

Figure 58

VILLAGE OF WALWORTH SEWAGE TREATMENT PLANT



1970 SEWRPC Photo.

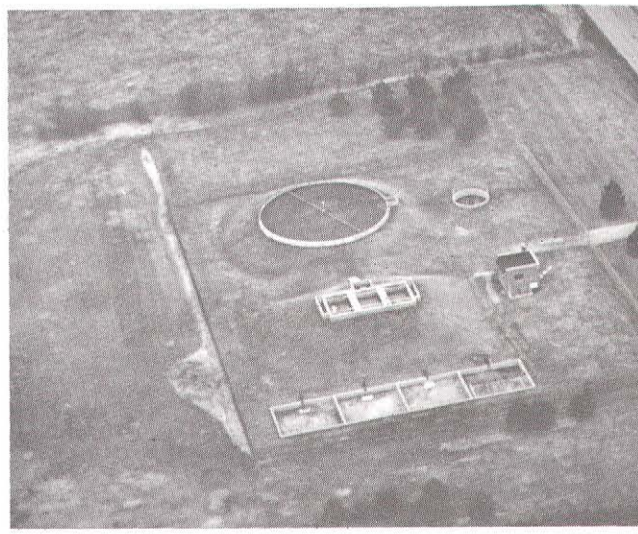


Photo by Roger R. Ross and Joseph C. Ruys.

The average hydraulic loading on the plant in 1970 was estimated at 0.15 mgd, indicating that the plant is operating at the design capacity. The treatment processes provided at the plant are classified as tertiary level.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Village of Walworth sanitary sewerage system are shown on Map 40. Except for a bypass located at the treatment plant, there are no known points of sewer overflow or bypassing in the Village of Walworth sanitary sewerage system. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 1.6 square mile area, which area is shown on Map 40. Locally proposed sewers to serve this additional area are also shown on Map 40. In addition, it should be noted that the village proposed in 1972 the abandonment of the existing sewage treatment plant site at the western limits of the village and the construction of a new activated sludge type advanced sewage treatment plant to be located at the Piscasaw Creek plant site. This proposed plant would have an average hydraulic design capacity of 0.3 mgd, with a peak hydraulic design capacity of 0.48 mgd.

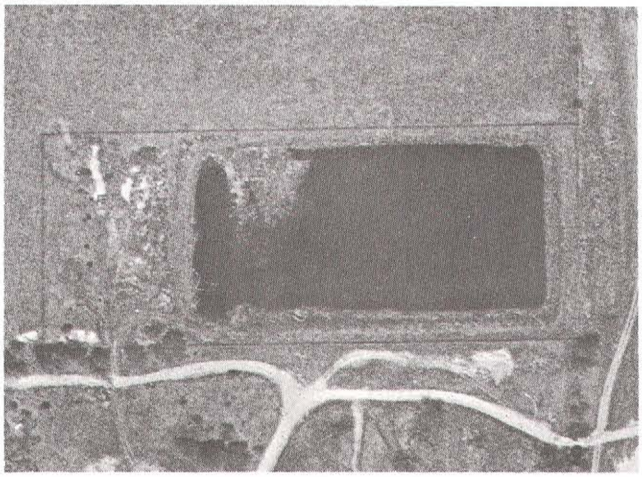
Management of the Village of Walworth sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Water and Sewer Utility Superintendent. Financing of the system is provided through a sewer service charge of $6 per month per connection plus a per gallon charge for all water used in excess of 5,000 gallons per month. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Walworth sanitary sewerage system were not made available by the village.

Village of Williams Bay: The existing service area of the Village of Williams Bay sanitary sewerage system is shown on Map 40. This area totals about one square mile and has a resident population of about 1,500 persons. The entire area is served by a separate sanitary sewerage system.

Sewage from the Village of Williams Bay is treated at a sewage treatment plant located at the northern village limits (see Figure 59). Effluent from the plant is discharged to a seepage lagoon which has no outlet. The plant has a site area of about 34 acres, of which 11 acres are currently utilized, leaving 23 acres available for future use. Since 1970 the village has purchased an additional 80 acres for future sewage treatment use. The plant site is bounded by agricultural land uses on the west and north, residential land uses on the south, and STH 67 on the east. The plant, an activated sludge type, was initially constructed in 1931 and extensively modified in 1968. The average hydraulic design capacity of the plant

Figure 59

VILLAGE OF WILLIAMS BAY SEWAGE TREATMENT PLANT



1970 SEWRPC Photo.

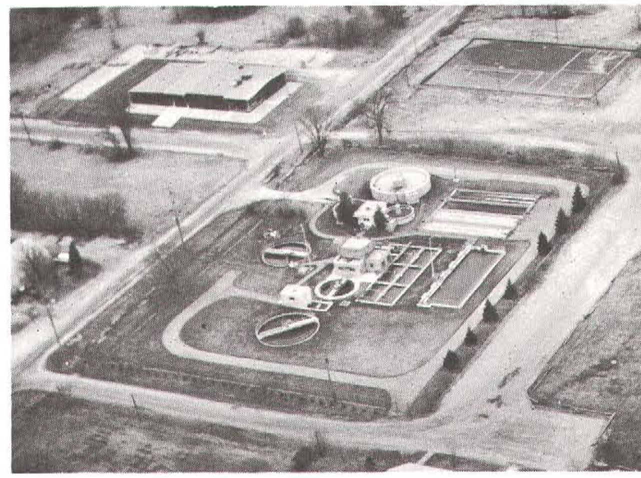


Photo by Roger R. Ross and Joseph C. Ruys.

is 0.8 mgd, with a peak hydraulic design capacity of 1.2 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.4 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Village of Williams Bay sanitary sewerage system are shown on Map 40. There are no known points of sewer overflow or bypassing in the Village of Williams Bay sanitary sewerage system. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 0.9 square mile area, which area is shown on Map 40. No locally proposed trunk sewers to serve this additional area, however, were found in the inventory.

Management of the Village of Williams Bay sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Superintendent of Sewers. Financing of the system is provided through a sewer service charge equal to 100 percent of the quarterly water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Williams Bay sanitary sewerage system approximated $51,900, or about $35 per capita. Of this total, $31,015, or about $21 per capita, was expended for operation and maintenance and $20,885, or about $14 per capita, was expended for capital improvements.

Proposed Public Sanitary Sewerage Systems

The inventory revealed that as of 1970 there were four proposed public sanitary sewerage systems in Walworth County which would provide centralized sanitary sewer service to subareas of the county. These four systems would serve the Town of Lyons Sanitary District No. 2, the Delavan Lake Sanitary District, urban development on the shore of Lake Como, and the Town of East Troy Sanitary District No. 2. Together these four proposed systems would serve a total area of about six square miles, or 1 percent of the county, and a total existing population of about 5,000, or 8 percent of the total population of the county. Each of these four proposed public sanitary sewerage systems is described in the following paragraphs.

Town of Lyons Sanitary District No. 2: The Town of Lyons Sanitary District No. 2 was formed in 1970 to provide sanitary sewer service to existing urban development in the unincorporated place of Lyons, located on the White River about midway between the Cities of Lake Geneva and Burlington. The district was formed in response to a water pollution abatement order issued to the town by the Wisconsin Department of Natural Resources. The district has hired a consulting engineer and is in the process of conducting engineering studies for the provision of sewer service in response to the state orders.

The proposed service area of the Town of Lyons Sanitary District No. 2 is shown on Map 40. This area totals about 0.4 square mile and has a current resident population of about 500 persons.

Management of the Town of Lyons Sanitary District No. 2 is under the direction of a three-member commission. Day-to-day administration of the proposed system is to be provided by a certified treatment plant operator. Operation and maintenance of the system is to be financed through sewer service charges and a general tax levy.

Delavan Lake Sanitary District: The Delavan Lake Sanitary District in the Towns of Delavan and Walworth was formed in 1969 to provide sanitary sewer service to the existing urban development along the shoreline of Delavan Lake. The formation of this district followed several years of effort on the part of local residents concerned with the quality of the water in Delavan Lake and with malfunctioning septic tank systems along its lake shoreline. The district has completed engineering studies for the construction of a sanitary sewerage system, including the construction of a new sewage treatment plant located on a site adjacent to the existing City of Delavan sewage treatment plant on Turtle Creek. The proposed sewage treatment facility would have an average hydraulic design capacity of 2.0 mgd and a peak hydraulic design capacity of 4.0 mgd, and would be an activated sludge type sewage treatment plant providing a secondary level of treatment. The district is currently awaiting action on applications for federal and state grants-in-aid in support of the construction of the needed sewerage facilities.

The proposed service area of the Delavan Lake Sanitary District is shown on Map 40. This area totals about 3.9 square miles and has a current resident population of about 2,600 persons.

Management of the Delavan Lake Sanitary District is under the direction of a three-member commission. Day-to-day administration of the proposed system is to be provided by a certified plant operator and superintendent. Operation and maintenance of the system is to be financed through a sewer service charge of about $10 per month per connection.

Lake Como: A new sanitary sewerage system to serve existing urban development along the shoreline of Lake Como in the Town of Geneva has been proposed in the adopted comprehensive plan for the Fox River watershed and has been informally discussed by the area residents, though no formal action has been taken to date to form a sanitary or a utility district to begin steps toward implementation of the plan recommendation. The proposed service area of the Lake Como sanitary sewerage system is shown on Map 40. This area totals about 1.4 square miles and has a current resident population of about 1,100 persons. The treatment plant for the proposed system, as recommended in the Fox River watershed plan, would be located on a site near Como Creek, to which effluent would be discharged. An alternative method of handling the treatment of sewage from Lake Como would involve transmission of the sewage to the City of Lake Geneva. This interconnection potential should be investigated in the regional sanitary sewerage system planning program.

Town of East Troy Sanitary District No. 2: A new sanitary sewerage system to serve existing urban development along the shoreline of Potters Lake in the Town of East Troy has been proposed by the Town of East Troy Sanitary District No. 2. Local residents living in the district have become increasingly concerned about the quality of water in Potters Lake and the effect upon such quality caused by inoperative onsite soil absorption sewage disposal systems. The district has completed preliminary engineering studies for the construction of a sanitary sewerage system and has proposed that sewage be conveyed to the Village of East Troy for sewage treatment on a contract basis.

The proposed service area of the Town of East Troy Sanitary District No. 2 is shown on Map 40. This area totals about 0.4 square mile and has a current resident population of about 800 persons.

Management of the Town of East Troy Sanitary District No. 2 is under the direction of a three-member commission. Day-to-day administration of the proposed sewerage system will be provided by a plant superintendent. Operation and maintenance of the system is to be financed through sewer service charges.

Other Sewage Treatment Facilities

In addition to the 11 public sanitary sewerage systems discussed above, there are a total of nine sewage treatment facilities in Walworth County which serve, in most cases, a single isolated land use enclave. These nine sewage treatment facilities serve the Trent Tube Company in the Village of East Troy; the Pasier Produce Company and the Genoa City Cooperative Milk Association in the Village of Genoa City; the

Libby, McNeil and Libby, Inc., canning plant in the Town of Darien; the Lake Lawn Lodge in the Town of Delavan; the Walworth County Institutions and the Walworth County Correctional Center in the Town of Geneva; the Alpine Valley Resort in the Town of LaFayette; and the Playboy Club Hotel in the Town of Lyons (see Map 40). Pertinent characteristics pertaining to each of these nine sewage treatment facilities are presented in Table 42. It should be noted that the Lake Lawn Lodge facility would be abandoned upon implementation of the proposed sanitary sewerage system for the Delavan Lake Sanitary District.

Other Known Point Sources of Waste Water

In addition to identifying all existing public and private sewage treatment plants which discharge treated wastes to streams and watercourses within the Region, and all known sewage overflow points on both the existing sanitary and combined sewerage systems within the Region which discharge untreated wastes to streams and watercourses, an attempt was made in the regional sanitary sewerage system planning program to identify, through existing secondary sources, all other known point sources of waste water discharge. These other point sources of pollution consist primarily of industrial cooling, rinse, and wash waters, which may be discharged directly and without treatment to streams and watercourses or to storm sewers tributary to such streams and watercourses. The secondary sources consulted included river basin survey reports and pollution abatement orders of the Wisconsin Department of Natural Resources and records of municipal public works departments. A total of three such known point sources of industrial waste water were identified in Walworth Couny. The name, civil division location, type of waste, known pretreatment, and receiving water body of these three waste sources are identified in Table 43. The location of these three point sources is shown on Map 41.

Table 42

SELECTED CHARACTERISTICS OF PRIVATE SEWAGE TREATMENT FACILITIES IN WALWORTH COUNTY: 1970

Name	Civil Division Location	Type of Land Use Served	Type of Treatment Provided	Average Hydraulic Design Capacity (Gallons/Day)	Disposal of Effluent
Alpine Valley Lodge	Town of LaFayette	Recreational	Activated Sludge and Seepage Lagoon	40,000	Soil Absorption
Genoa City Cooperative Milk Association	Village of Genoa City	Industrial	Aeration Tank	N/A	Nippersink Creek
Lake Lawn Lodge	Town of Delavan	Recreational	Activated Sludge and Sand Filter	100,000	Jackson Creek
Libby, McNeill and Libby, Inc.	Town of Darien	Industrial	Storage Lagoons	N/A	Spray Irrigation
Paiser Produce Company	Village of Genoa City	Industrial	Seepage Lagoons	N/A	Soil Absorption
Playboy Club Hotel	Town of Lyons	Recreational	Activated Sludge	500,000	White River
Trent Tube Company	Village of East Troy	Industrial	Flow-Through Lagoons	N/A	Honey Creek
Walworth County Correctional Center	Town of Geneva	Institutional	Activated Sludge and Seepage Lagoon	34,000	Soil Absorption
Walworth County Institutions	Town of Geneva	Institutional	Activated Sludge and Flow-Through Lagoon	230,000	Minor Tributary to Jackson Creek

NOTE: N/A indicates data not available.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 43

KNOWN EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN WALWORTH COUNTY: 1970

Point Source[1]		Civil Division Location	Type of Waste	Known Pretreatment	Receiving Water Body
Number[2]	Name				
1	Hawthorne Melody Farms Dairy	City of Whitewater	Cooling Water	--	Whitewater Creek
2	Baker Laboratories	Village of East Troy	Cooling Water	--	Honey Creek
3	Sharon Foundry	Village of Sharon	Cooling Water	--	Sharon Creek

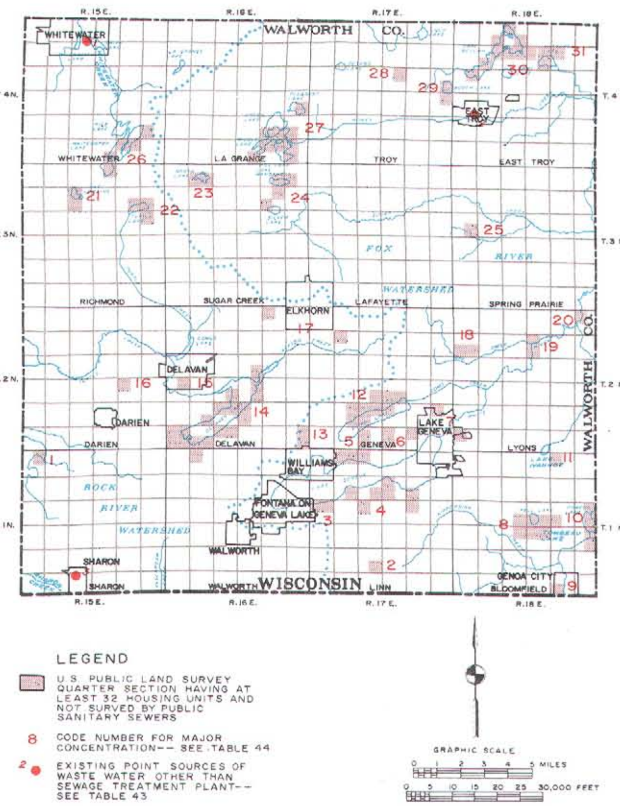
[1]As identified in Wisconsin Department of Natural Resources river basin survey reports and pollution abatement orders and by selected municipal public works departments; does not include industrial waste sources discharging to municipal sanitary sewerage systems.

[2]See Map 41.

Source: SEWRPC.

Map 41

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS AND EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN WALWORTH COUNTY: 1970



Significant concentrations of unsewered urban development in Walworth County consist primarily of two types. The first type consists of lake-oriented urban development--both seasonal and year-round residences--which has occurred around nearly every lake in the county. Centralized sanitary sewerage systems have been proposed for certain of these lake-oriented urban concentrations including those on the shorelines of Como, Delavan, Geneva, and Potters Lakes. The second type consists of the small unincorporated places in the county which historically have served as service centers for the agricultural industry. These include such places as Troy Center, Lyons, and Zenda. This map also shows the location of the three known point sources of wastewater other than sewage treatment plants in the county, one each in the City of Whitewater and the Villages of East Troy and Sharon.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Existing Urban Development Not Served by Public Sanitary Sewers

As noted earlier, public sanitary sewerage systems in Walworth County serve a total area of about 11.8 square miles, or about 2 percent of the total area of the county, and a total population of about 35,500 persons, or about 56 percent of the total population of the county. An inventory was conducted in the study to determine the approximate amount of urban development, and the population residing therein, in Walworth County not served in 1970 by public sanitary sewer service. Each U. S. Public Land Survey quarter section not having development served by a centralized sanitary sewerage system was examined to determine if a significant amount of urban development was present in 1970. Any quarter section with at least 32 housing units, or an average of one housing unit per five gross acres, was deemed to be urban. The major purpose in identifying such concentrations of urban development was to provide the basis for analyzing the potential of providing public sanitary sewer service to such areas in accordance with recommendations contained in the adopted regional land use plan.

The nonsewered urban development areas identified in Walworth County are shown on Map 41. Together these areas total about 9.8 square miles, or 1.7 percent of the total area of the county, and contain a total population of about 13,500 persons, or about 21 percent of the total population of the county. For analysis purposes, the existing nonsewered urban development has been combined into 31 named major urban concentrations. The estimated population and urban development areas of each of these major concentrations are shown in Table 44.

Concluding Remarks—Walworth County

Inventories conducted under the regional sanitary sewerage system planning program revealed that in 1970 there existed in Walworth County a total of 11 public sanitary sewerage systems which together serve a total area of about 11.8 square miles, or about 2 percent of the total area of the county, and a total population of about 35,500 persons, or about 56 percent of the total population of the county. Each of the 11 sanitary sewerage systems operates its own sewage treatment facility. In addition to the 11 public sanitary sewerage systems, an additional nine sewage treatment facilities serving primarily single, isolated land use enclaves were found in the inventory. The inventory revealed that as of 1970 there were four proposed public sanitary sewerage systems in the county. Three of the systems—those for the Delavan Lake Sanitary District, the Town of

East Troy Sanitary District No. 2, and Lake Como—would serve existing urban development along lake shorelines. The fourth proposed new system would serve existing urban development in the unincorporated place of Lyons. Finally, in 1970 there were an estimated 13,500 persons residing in urban areas in Walworth County not served by public sanitary sewer service. Together these areas totaled about 1.7 square miles.

Table 44

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN WALWORTH COUNTY BY MAJOR URBAN CONCENTRATION: 1970

Major Urban Concentration[1] Number[2]	Name	Estimated Resident Population	Developed Urban Area (Acres)
1	Allens Grove	100	33
2	Zenda	100	33
3	Lake Geneva – Fontana Area	200	158
4	Lake Geneva – South	600	474
5	Lake Geneva – Williams Bay Area	500	338
6	Lake Geneva – North	300	201
7	City of Lake Geneva Area	500	144
8	Pell Lake Area	1,200	727
9	Genoa City Area	100	32
10	Powers, Tombeau, Benedict Lake Area	200	201
11	Lake Ivanhoe Area	200	80
12	Lake Como Area	1,100	724
13	Village of Williams Bay Area	200	127
14	Lake Delavan Area	2,300	993
15	City of Delavan Area	100	22
16	Town of Darien – Section 23	200	24
17	City of Elkhorn Area	400	70
18	Springfield Area	300	49
19	Lyons Area	500	95
20	Town of Lyons – Section 1	100	9
21	Lake Loraine Area	300	102
22	Turtle Lake Area	300	111
23	North Lake Area	200	88
24	Lake Wandawega Area	600	259
25	Town of Spring Prairie – Section 18	200	75
26	Whitewater Lake Area	500	172
27	Lauderdale Lakes Area	500	360
28	Troy Center	100	38
29	Booth Lake Area	200	61
30	Lake Beulah Area	700	325
31	Potters Lake Area	700	146
	Walworth County Total	13,500	6,271[3]

[1]*Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

[2]*See Map 41.*

[3]*Equal to 9.8 square miles.*

Source: SEWRPC.

INVENTORY FINDINGS—WASHINGTON COUNTY

Existing Public Sanitary Sewerage Systems

There are a total of eight existing public sanitary sewerage systems in Washington County which provide centralized sanitary sewer service to subareas of the county. These include the systems operated by the Cities of Hartford and West Bend; the Villages of Germantown, Jackson, Kewaskum, and Slinger; the Allenton Sanitary District in the Town of Addison, and the Newburg Sanitary District in the Town of Trenton.[16] Together these systems serve a total area of about 9.4 square miles, or about 2 percent of the total area of the county, and a total population of about 30,200, or about 47 percent of the total population of the county. Each of these public sanitary sewerage systems is described in the following paragraphs. Pertinent characteristics of these systems are presented in Tables 45 and 46.

[16]*The Newburg Sanitary District, while located primarily in the Town of Trenton, also contains a 48-acre area in the Town of Saukville, Ozaukee County. In addition, it should be noted that about 13 acres of the City of Milwaukee are located in the extreme southeastern corner of the former Town of Germantown.*

Table 45

AREA AND POPULATION SERVED BY EXISTING AND LOCALLY PROPOSED SANITARY SEWERAGE SYSTEMS IN WASHINGTON COUNTY: 1970

Name of Public Sanitary Sewerage System	Estimated Service Area: Existing Acres	Existing Square Miles	Proposed[1] Acres	Proposed[1] Square Miles	Estimated Population Served[2]	Treatment of Sewage (See Table 46)
Existing Systems						
City of Hartford	1,075	1.68	4,166	6.50	6,800	Operates a Facility
City of West Bend	3,302	5.17	12,150	19.00	16,400	Operates a Facility
Village of Germantown	359	0.56	7,265	11.35	2,400	Operates Two Facilities
Village of Jackson	407	0.64	2,003	3.13	600	Operates a Facility
Village of Kewaskum	460	0.72	131	0.20	1,900	Operates a Facility
Village of Slinger	201	0.31	- -	- -	1,000	Operates a Facility
Allenton Sanitary District	151	0.24	- -	- -	700	Operates a Facility
Newburg Sanitary District	61	0.10	- -	- -	400	Operates a Facility
Proposed Systems						
Tri-Lakes	- -	- -	- -[3]	- -[3]	- -	- -
Green Lake	- -	- -	19	0.03	- -	- -
Wallace Lake	- -	- -	- -[4]	- -[4]	- -	- -
County Total	6,016	9.42	25,743	40.21	30,200	- -

[1]*As identified in locally prepared plans and engineering reports.*

[2]*Based upon an approximation of the existing sewer service area by U.S. Public Land Survey quarter section.*

[3]*The proposed Tri-Lakes service area totals about 2,240 acres, or 3.5 square miles, and has been included in the proposed service area of the City of West Bend.*

[4]*The proposed Wallace Lake service area totals about 192 acres, or 0.3 square miles, and has been included in the proposed service area of the City of West Bend.*

Source: SEWRPC.

Table 46

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN WASHINGTON COUNTY: 1970

Name of Public Sewage Treatment Facility	Estimated Total Area Served (Square Miles)	Estimated Total Population Served	Date of Original Construction and Major Modification	Type of Treatment Provided	Level of Treatment Provided	Disposal of Effluent	Design Capacity				
							Population[1]	Average Hydraulic (MGD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Population Equivalent[1]
City of Hartford	1.68	6,800	1924, 1931, 1949	Trickling Filter	Secondary	Rubicon River	N/A	0.82	1.50	11,930	56,800
City of West Bend	5.17	16,400	1967	Activated Sludge	Secondary	Milwaukee River	25,000	2.50	5.00	5,500	26,200
Village of Germantown											
Old Village Plant	0.42	1,400	1956, 1969	Activated Sludge	Secondary	Menomonee River	11,000	1.20	2.90	2,385	11,400
County Line Plant	0.14	1,000	1963	Activated Sludge	Secondary	Menomonee River	N/A	0.05	0.10	85	400
Village of Jackson	0.64	600	1939	Trickling Filter	Secondary	Cedar Creek	250	0.025	0.050	N/A	N/A
Village of Kewaskum	0.72	1,900	1955	Activated Sludge	Secondary	Milwaukee River	N/A	0.30	0.60	3,000	14,300
Village of Slinger	0.31	1,000	1950	Trickling Filter & Activated Sludge	Secondary	Marshland Drained by Rubicon River	1,900	0.149	0.30	792	3,800
Allenton Sanitary District	0.24	700	1962	Activated Sludge	Secondary	Rock River East Branch	1,000	0.10	0.20	170	800
Newburg Sanitary District	0.10	400	1965	Activated Sludge	Secondary	Milwaukee River	800	0.08	0.16	136	600

Name of Public Sewage Treatment Facility	Existing Loading - 1970					Sewerage Strength Parameters in Influent Sewage					Industrial Flows		Overall Plant Efficiency Percent Removals			Number of Days in 1970 Plant Flow Exceeded Plant Meter Capacity
	Average Hydraulic (MGD)	Average Per Capita (GPD)	Peak Hydraulic MGD)	Average Organic (Pounds $CBOD_5$/Day)	Reserve Hydraulic Capacity (MGD)	$CBOD_5$ (mg/1)	Suspended Solids (mg/1)	Total Phosphorus (mg/1)	Organic Nitrogen-N (mg/1)	Ammonia Nitrogen-N (mg/1)	Design Average Daily Flow (MGD)	Estimated Daily Flow 1970 (MGD)	$CBOD_5$ (Percent)	Suspended Solids (Percent)	Total Phosphorus (P) (Percent)	
City of Hartford	1.24	180	N/A	N/A	None	910[2]	523[2]	N/A	N/A	N/A	N/A	0.30[2]	N/A	N/A	N/A	N/A
City of West Bend	2.27	138	N/A	N/A	0.23	185[3]	228[3]	16.3[3]	14.0[3]	7.8[3]	N/A	N/A	94[3]	90[3]	38[3]	N/A
Village of Germantown																
Old Village Plant	0.36	257	N/A	N/A	0.84	710[4]	292[4]	13.6[4]	9.7[4]	N/A	N/A	0.03[4]	94[4]	85[4]	N/A	N/A
County Line Plant	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Jackson	0.08	133	N/A	N/A	None	108[5]	112[5]	N/A	N/A	N/A	N/A	N/A	70[5]	60[5]	N/A	N/A
Village of Kewaskum	0.49	258	N/A	N/A	None	265[6]	201[6]	25.0[6]	N/A	N/A	N/A	N/A	40[6]	0[6]	28	N/A
Village of Slinger	0.089	89	N/A	N/A	0.06	117[7]	90[7]	12.5[7]	N/A	N/A	N/A	N/A	49[7]	66[7]	10[7]	N/A
Allenton Sanitary District	0.058	83	N/A	N/A	0.042	200[8]	95[8]	8.0[8]	N/A	N/A	N/A	N/A	59[8]	0[8]	5[8]	N/A
Newburg Sanitary District	0.044	110	N/A	N/A	0.036	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

NOTE: N/A indicates data not available.

[1]The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design $CBOD_5$ loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of $CBOD_5$ per day. If the design engineer assumed a different daily per capita contribution of $CBOD_5$, the population equivalent design capacity will differ from the population design capacity shown in the Table.

[2]Date obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in October 1968.

[3]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in September 1970.

[4]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in October 1967.

[5]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in August 1966.

[6]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in September 1969.

[7]Data obtained from a 24-hour composite sample, by the Wisconsin Department of Natural Resources in September 1969.

[8]Data obtained from a 24-hour composite sample by the Wisconsin Department of Natural Resources in October 1968.

Source: Wisconsin Department of Natural Resources and SEWRPC.

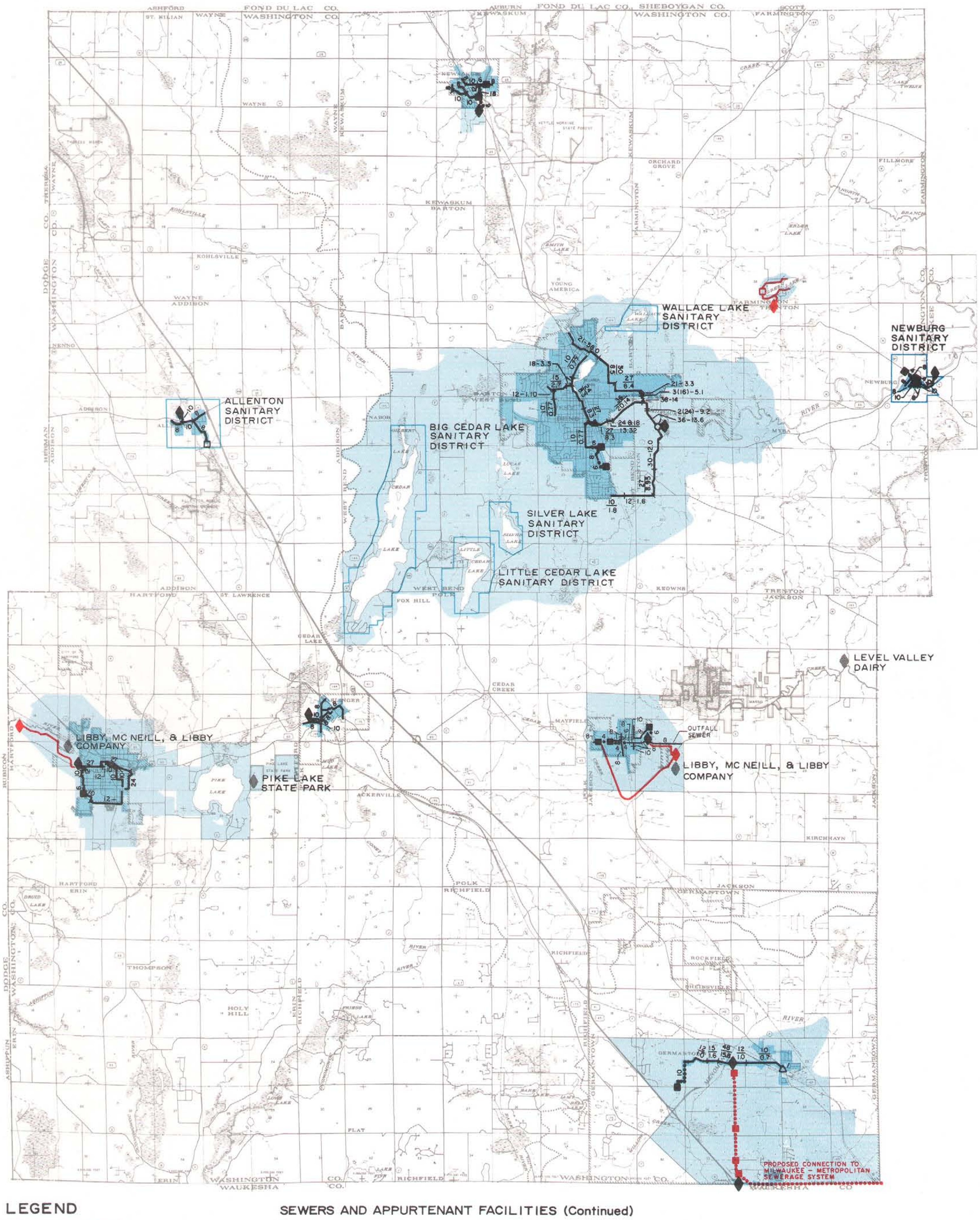
City of Hartford: The existing service area of the City of Hartford sanitary sewerage system is shown on Map 42. This area totals about 1.7 square miles and has a resident population of about 6,800 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Hartford is treated at a sewage treatment plant located on the Rubicon River, to which effluent is discharged (see Figure 60). The existing plant has a site area of about nine acres. The plant site is bounded by industrial land uses on the north, a city street and park area on the east, STH 60 on the south, and agricultural lands on the west. The plant, a high-rate trickling filter type, was initially constructed in 1924 and underwent extensive modifications in 1949. The average hydraulic design capacity of the plant is 0.8 mgd, with a peak hydraulic design capacity of 1.5 mgd. The average hydraulic loading on the plant in 1970 was estimated at 1.2 mgd, indicating that the plant did not have adequate capacity to treat the average daily flow from the existing sewer service area. Treatment processes provided by the plant are classified as secondary level. It should be noted that during 1972 the City of Hartford began construction of a new sewage treatment plant located on a 38-acre site about 0.75 mile downstream from the existing treatment plant site. The new plant, which will also discharge its effluent to the Rubicon River, will have an average hydraulic design capacity of 2.0 mgd and a peak hydraulic design capacity of 4.0 mgd, and will provide an advanced level of waste treatment. In addition, the new plant will treat wastes from the Libby, McNeil and Libby, Inc., canning plant now being treated in aerated flow-through lagoons.

The location and configuration of the major trunk sewers serving the City of Hartford are shown on Map 42. There are no known points of sewer overflow or bypassing in the City of Hartford sanitary sewerage system. The treatment plant has a bypass to a surge lagoon to which raw sewage in excess of the plant capacity is diverted and held for later treatment. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional 6.5 square mile area, which area includes the urban development around Pike Lake and the Pike Lake State Park, as shown on Map 42.

Map 42

EXISTING AND LOCALLY PROPOSED PUBLIC SANITARY SEWERAGE SYSTEMS AND OTHER SEWAGE TREATMENT FACILITIES IN WASHINGTON COUNTY 1970



LEGEND

SEWER SERVICE AREAS

- EXISTING-SEPARATE
- EXISTING-COMBINED
- PROPOSED

SEWAGE TREATMENT FACILITIES

- EXISTING-PUBLIC
- EXISTING-PRIVATE
- PROPOSED-PUBLIC

SEWERS AND APPURTENANT FACILITIES

- EXISTING MAJOR TRUNK, RELIEF, OR INTERCEPTING SEWER
- EXISTING MAJOR COMBINED SEWER
- PROPOSED MAJOR TRUNK, RELIEF, OR INTERCEPTING SEWER

SEWERS AND APPURTENANT FACILITIES (Continued)

- EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- EXISTING LIFT STATION
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- PROPOSED PUMPING STATION
- 18-2.3 / $\frac{18}{2.3}$ SIZE (in Inches) AND CAPACITY (in MGD) OF SEWER OR APPURTENANT FACILITY

KNOWN FLOW RELIEF DEVICES

- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION
- 8 IDENTIFICATION NUMBER--SEE APPENDIX B

GRAPHIC SCALE

0 1 2 3 4 5 MILES

0 8000 16000 24000 32000 FEET

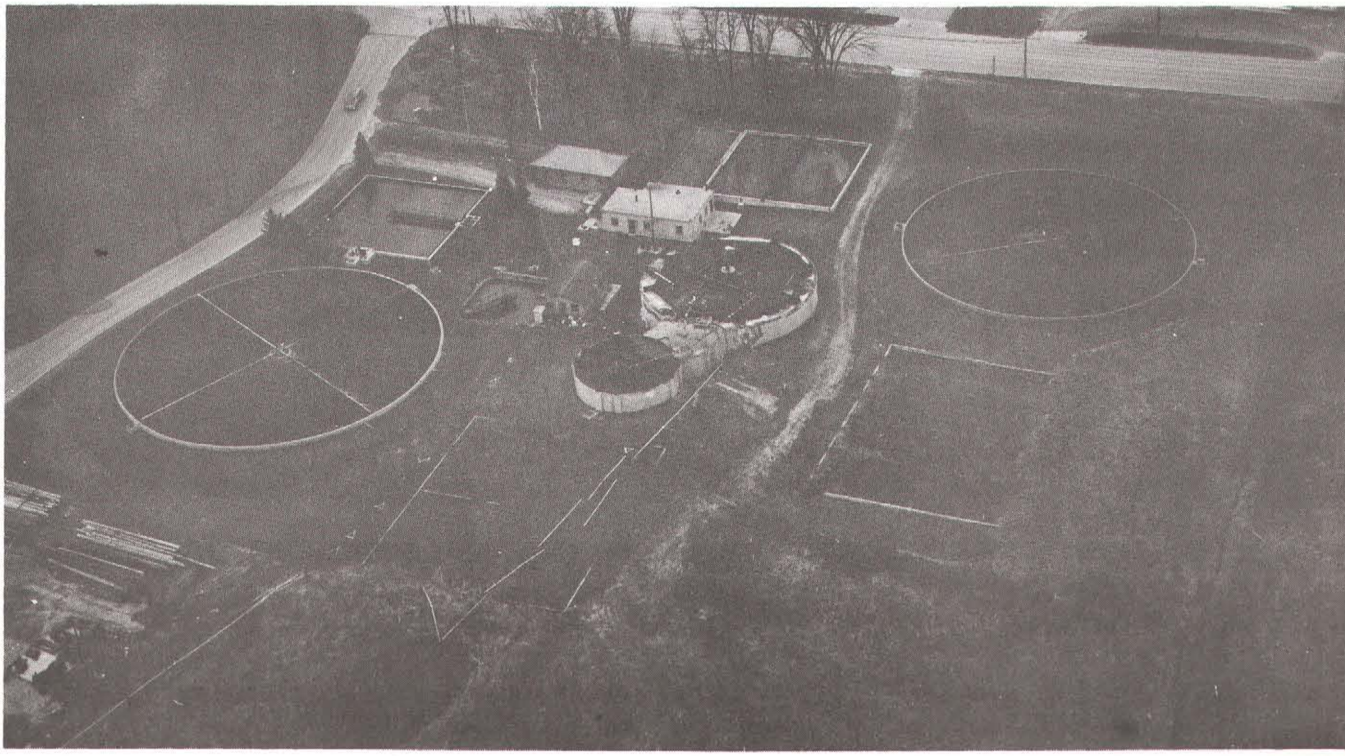
Source: Wisconsin Department of Natural Resources and SEWRPC.

(This page intentionally left blank)

Figure 60

CITY OF HARTFORD SEWAGE TREATMENT PLANT

Existing Facility



Facility Under Construction--1973

Photos by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

Management of the City of Hartford sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided both through a sewer service charge based on water consumption and through a general property tax levy. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Hartford sanitary sewerage system approximated $116,844, or about $17 per capita. Of this total, $51,580, or about $7 per capita, was expended for operation and maintenance and $65,264, or about $10 per capita, was expended for capital improvements.

City of West Bend: The existing service area of the City of West Bend sanitary sewerage system is shown on Map 42. This area totals about 5.2 square miles and has a resident population of about 16,400 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of West Bend is treated at a sewage treatment plant located on the Milwaukee River, to which effluent is discharged (see Figure 61). The plant has a site area of about 38 acres, of which 14 acres are currently utilized, leaving 24 acres available for future use. The plant site, which is partially located in the floodlands of the Milwaukee River, is bounded by agricultural lands on the north and the main stem of the Milwaukee River on the south, west, and east. The plant, an activated sludge type, was constructed in 1967, replacing an older trickling filter type treatment plant constructed in 1936. The average hydraulic design capacity of the plant is 2.5 mgd, with a peak hydraulic design capacity of 5.0 mgd. The average hydraulic loading on the plant in 1970 was

Figure 61

CITY OF WEST BEND SEWAGE TREATMENT PLANT

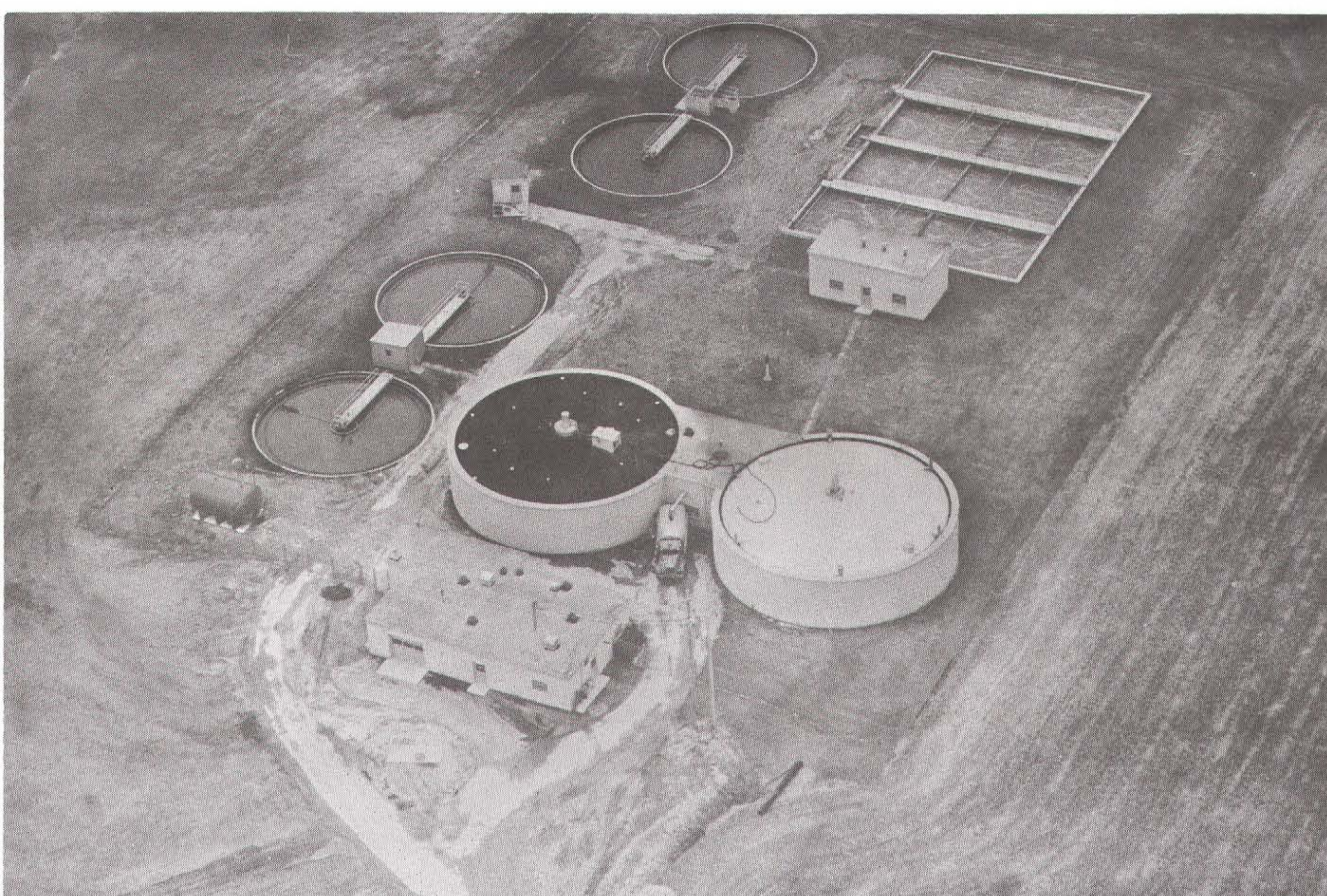


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

estimated at 2.3 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level. It should be noted that during 1972 the City of West Bend completed engineering studies relating to the expansion of the sewage treatment plant so as to provide for future growth in the city, for service to the Tri-Lakes area of Washington County, and for an advanced level of waste treatment. In addition, the city is proposing to remove the treatment plant site from the floodlands of the Milwaukee River through construction of a dike. The proposed new average hydraulic design capacity of the plant is to be 5.85 mgd, with a new peak hydraulic design capacity of 14.6 mgd.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the City of West Bend sanitary sewerage system are shown on Map 42. There is one known point of sewage flow relief in the City of West Bend sanitary sewerage system, a bypass located just ahead of the sewage treatment plant. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional 19 square mile area, which area is shown on Map 42.

Management of the City of West Bend sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the Water and Sewer Department of the city, headed by the City Engineer. Financing of the system is provided through a sewer service charge related to water consumption. Residential water consumers pay a sewer service charge equal to 100 percent of the water consumption charge during the fall, winter, and spring quarters and to 60 percent of the water consumption charge during the summer quarter. A residential sewer service user not supplied by the municipal water system is charged $32 per year for sewer service. All industries pay a sewer service charge equivalent to 100 percent of the water supply charge. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of West Bend sanitary sewerage system approximated $315,622, or about $19 per capita. Of this total, $91,851, or about $5 per capita, was expended for operation and maintenance and $223,771, or about $14 per capita, was expended for capital improvements.

Village of Germantown: The existing service area of the Village of Germantown sanitary sewerage system is shown on Map 42. This area totals about 0.6 square mile and has a resident population of about 2,400 persons. The entire area is served by a separate sanitary sewer system. Of this total, about 0.4 square mile having a resident population of about 1,400 persons is served by the Village of Germantown at a pair of sewage treatment plants located on a minor tributary to the Menomonee River. This area represents the "Old Village" area of the Village of Germantown. About 0.1 square mile having a resident population of about 1,000 persons is served by the village through a small sewage treatment plant serving a single subdivision near the Washington-Waukesha County line.

The two parallel sewage treatment facilities serving the "Old Village" area of the Village of Germantown discharge effluent to the Menomonee River (see Figure 62). This plant has a site area of about five acres. The plant site is bounded by open and unused lands on the south and agricultural lands on the north, east, and west. The first of the two parallel plants, a trickling filter type plant, was constructed in 1956. The second plant, an extended aeration activated sludge type plant, was constructed in 1969. The combined average hydraulic design capacity of the two plants is 1.2 mgd, with an estimated combined peak hydraulic design capacity of 2.9 mgd. The average hydraulic loading on the combined plant in 1970 was estimated at 0.4 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the existing sewer service area. The treatment processes provided by both the trickling filter and activated sludge type plants are classified as secondary level.

The small sewage treatment plant serving the subdivision at the south village limits near the Washington-Waukesha County line also discharges its effluent to the Menomonee River (see Figure 63). This plant has a site area of about one-half acre. The plant site is located inside the STH 41 interchange at CTH Q and G, and is bounded by ramps or freeway lanes on all sides. The plant, an activated sludge type plant, was constructed in 1963. The average hydraulic design capacity of the plant is 0.05 mgd, with an estimated peak hydraulic design capacity of 0.10 mgd. There are no flow records available for this small sewage plant. The treatment processes provided by the plant are classified as secondary level.

Figure 62

VILLAGE OF GERMANTOWN "OLD VILLAGE" SEWAGE TREATMENT PLANT

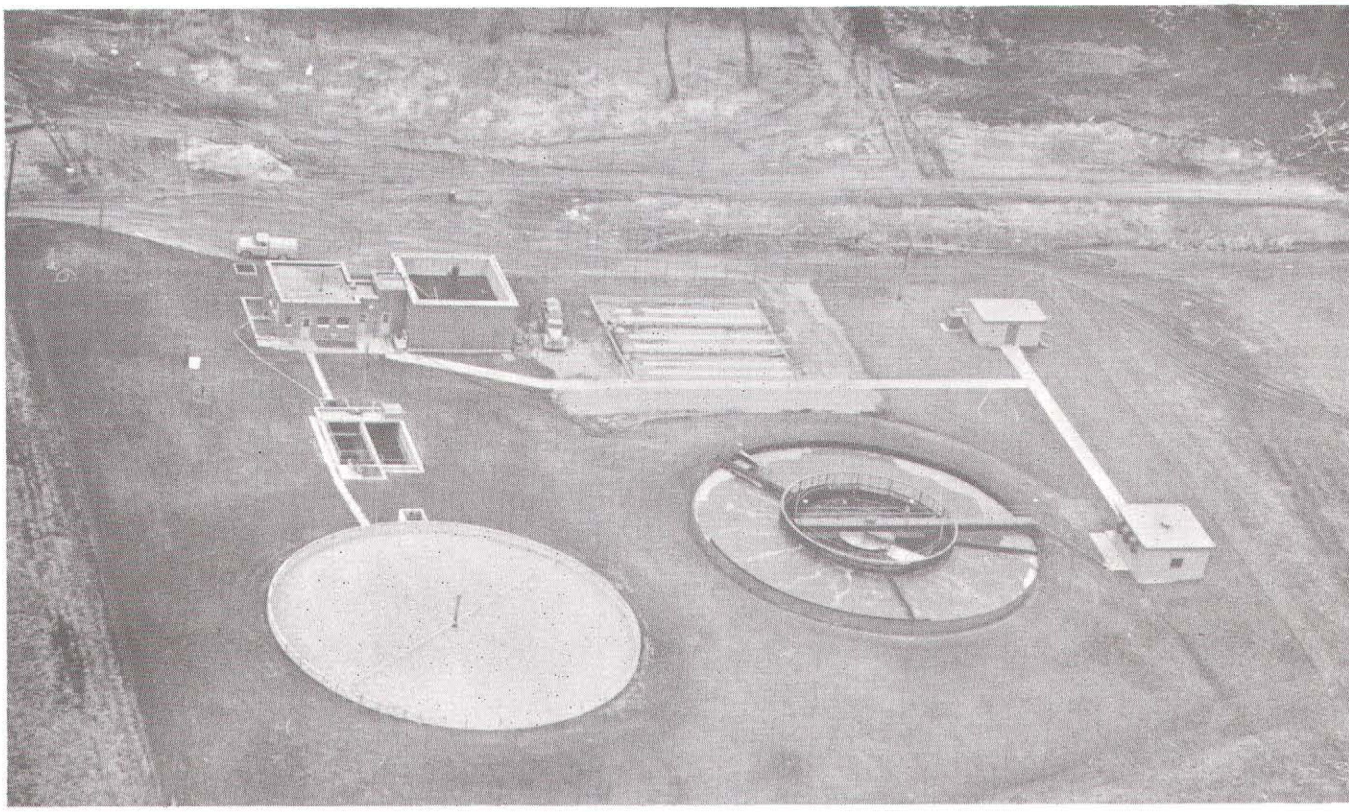


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Village of Germantown sanitary sewerage system are shown on Map 42. The only known point of sewage flow relief in the Village of Germantown sanitary sewerage system is a portable pumping station located near Pilgrim Road and STH 145.

The Village of Germantown and the Milwaukee-Metropolitan Sewerage Commissions have agreed in principle to the future connection of the Germantown sewer service area to the Milwaukee-Metropolitan sewerage system for sewage treatment purposes. At the present time, trunk sewer service to the Village of Germantown is not available. Until such time as trunk sewer service from the Milwaukee-Metropolitan sewerage system becomes available, the Village of Germantown is continuing to operate its treatment facilities and to eliminate the small sewage treatment plant on the Washington-Waukesha County line through a connection to the parallel sewage treatment facilities serving the "Old Village" area. At such time that trunk sewer service becomes available from the Milwaukee-Metropolitan sewerage system, the village intends to construct a series of force mains and pumping stations to connect the "Old Village" area plants to the Milwaukee-Metropolitan system. It is anticipated that this connection will serve the needs of the Village of Germantown through the plan design year of 1990. Eventually, gravity trunk sewers will be extended to serve the Village of Germantown. The proposed force main sewer connection, together with the area proposed in the documented plan of the Village of Germantown for future sanitary sewer service to the year 1990, which area totals about 11 square miles, is shown on Map 42.

Management of the Village of Germantown sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Engineer. Financing of the system is provided through the general property tax and a sewer service charge based on a flat quarterly rate to residences and a volumetric rate to commercial users. Total

Figure 63

VILLAGE OF GERMANTOWN COUNTY LINE SEWAGE TREATMENT PLANT

Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

Figure 64

VILLAGE OF JACKSON SEWAGE TREATMENT PLANT

Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Germantown sanitary sewerage system approximated $496,995, or about $207 per capita. Of this total, $42,981, or about $18 per capita, was expended for operation and maintenance and $454,014, or about $189 per capita, was expended for capital improvements.

Village of Jackson: The existing sewer service area of the Village of Jackson sanitary sewerage system is shown on Map 42. This area totals about 0.6 square mile and has a resident population of about 600 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Jackson is treated at a sewage treatment plant located at the eastern village limits. Effluent is discharged through an outfall sewer to Cedar Creek (see Figure 64). The plant has a site area of about one acre. The plant site is bounded by residential land use on the north, east, and south and agricultural land use on the west. The plant, a trickling filter type plant, was constructed in 1956. The average hydraulic design capacity of the plant is 0.03 mgd, with an estimated peak hydraulic design capacity of 0.05 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.08 mgd, indicating that the plant does not have adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level. It should be noted that the Village of Jackson has completed engineering studies for the construction of a new sewage treatment plant to be located southeast of the village on Cedar Creek, to which effluent would continue to be discharged. The new sewage treatment facility is proposed to have an average hydraulic design capacity of

0.50 mgd and a peak hydraulic design capacity of 0.75 mgd, and would serve, in addition to the Village of Jackson, the Libby, McNeil and Libby, Inc., canning plant located in the Town of Jackson, which will contribute about 50 percent of the total annual $CBOD_5$ loading to the plant. The proposed new plant would be a trickling filter type plant with a flow-through retention lagoon and would provide a tertiary level of waste treatment.

The location and configuration of all major trunk sewers serving the Village of Jackson are shown on Map 42. Data pertaining to known points of sewage flow relief in the Village of Jackson sanitary sewerage system were not available. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 3.1 square mile area, which area is shown on Map 42. Locally proposed trunk sewers to serve this additional area are also shown on Map 42.

Management of the Village of Jackson sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the superintendent of the treatment plant. Financing of the system is provided through the general property tax. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Jackson sanitary sewerage system were not made available by the village.

Village of Kewaskum: The existing sewer service area of the Village of Kewaskum sanitary sewerage system is shown on Map 42. This area totals about 0.7 square mile and has a resident population of about 1,900 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Kewaskum is treated at a sewage treatment plant located on the Milwaukee River, to which effluent is discharged (see Figure 65). The plant has a site area of about six acres, of which two acres are currently utilized, leaving four acres available for future use. The plant site is bounded by open lands on the north, residential land uses on the south, STH 45 on the west, and the Chicago and Northwestern Railroad on the east. The plant, an activated sludge type, was constructed in 1955. The average hydraulic design capacity of the plant is 0.3 mgd, with a peak hydraulic design capacity of 0.6 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.5 mgd, indicating that the plant did not have adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level. It should be noted that in 1971 the Village of Kewaskum placed into operation an addition to the existing sewage treatment plant, bringing the total average hydraulic design capacity of the plant up to 1 mgd, with a new peak hydraulic design capacity estimated to be 2 mgd. The new plant has been designed to handle the significant industrial waste loading in the Village of Kewaskum sewer service area. The treatment processes provided at the plant are classified as advanced level.

The location and configuration of the major trunk sewers serving the Village of Kewaskum are shown on Map 42. There are no known points of sewer overflow or bypassing in the Village of Kewaskum sanitary sewerage system. The inventory revealed that the village had a documented plan for the expansion of its sanitary sewerage system to serve an area lying south of the village.

Management of the Village of Kewaskum sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the superintendent of the treatment plant. Financing of the system is provided through the general property tax and a sewer charge. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Kewaskum sanitary sewerage system approximated $31,604, or about $17 per capita. Of this total, $16,650, or about $9 per capita, was expended for operation and maintenance and $14,954, or about $8 per capita, was expended for capital improvements.

Village of Slinger: The existing service area of the Village of Slinger sanitary sewerage system is shown on Map 42. This area totals about 0.3 square mile and has a resident population of about 1,000 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Slinger is treated at a sewage treatment plant from which effluent is discharged to a minor drainage ditch leading to a marshland which drains into the Rubicon River (see Figure 66). The plant has a site area of about two acres, both of which are currently utilized. The plant site is bounded by open land

Figure 65

VILLAGE OF KEWASKUM SEWAGE TREATMENT PLANT

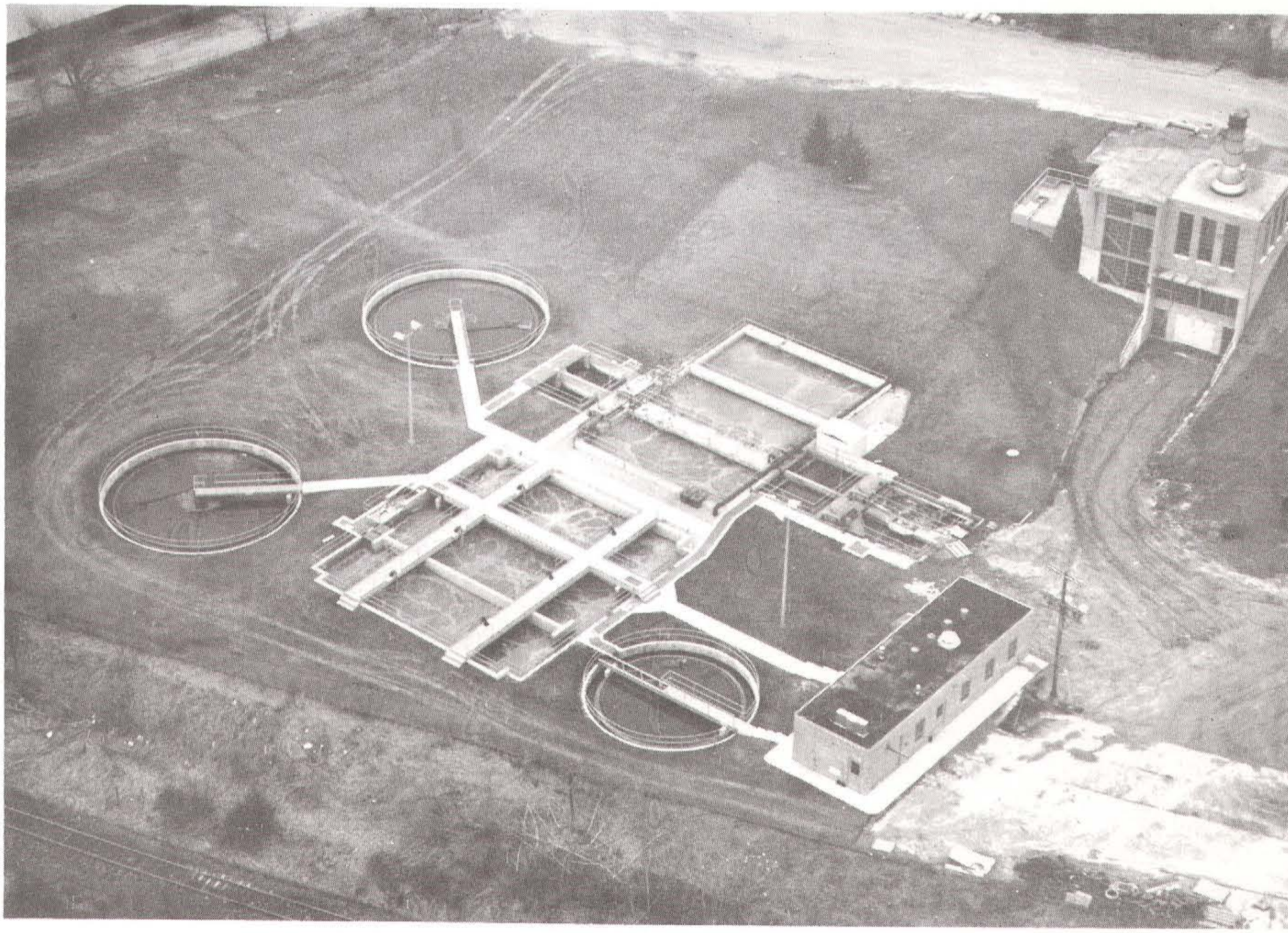


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

uses on the north, the Chicago, Milwaukee, St. Paul and Pacific Railroad on the south, and residential land use on the west and east. The plant, a combined trickling filter and activated sludge type, was constructed in 1950. The average hydraulic design capacity of the plant is 0.15 mgd, with an estimated peak hydraulic design capacity of 0.3 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.09 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers serving the Village of Slinger are shown on Map 42. There are no known points of sewer overflow or bypassing in the Village of Slinger sanitary sewerage system. The inventory revealed that the village had no documented plan for the expansion of its sanitary sewerage system.

Management of the Village of Slinger sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Clerk. Financing of the system is provided through the general property tax and a sewer service charge. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Slinger sanitary sewerage system were not made available by the village.

Allenton Sanitary District: The existing service area of the Allenton Sanitary District sanitary sewerage system in the Town of Addison is shown on Map 42. This area totals about 0.2 square

Figure 66

VILLAGE OF SLINGER SEWAGE TREATMENT PLANT

Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

mile and has a resident population of about 700 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Allenton Sanitary District sanitary sewerage system is treated at a sewage treatment plant located on a minor drainage course leading to the East Branch of the Rock River, to which effluent is discharged (see Figure 67). The plant has a site area of 10 acres, of which less than one acre is currently utilized, leaving nine acres available for future use. The plant site is bounded by open land uses on the north, south, and west and industrial land uses on the east. The plant, an activated sludge type, was constructed in 1962. The average hydraulic design capacity of the plant is 0.1 mgd, with a peak hydraulic design capacity estimated to be 0.2 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.06 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of the major trunk sewers serving the Allenton Sanitary District are shown on Map 42. Data pertaining to known points of sewage flow relief in the Allenton Sanitary District sanitary sewerage system were not available. The inventory revealed that the district had no documented plan for the expansion of its sanitary sewerage system.

Management of the Allenton Sanitary District sanitary sewerage system is under the direction of a three-member commission. Day-to-day administration is provided by a part-time treatment

Figure 67

ALLENTON SANITARY DISTRICT
SEWAGE TREATMENT PLANT

Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

Figure 68

NEWBURG SANITARY DISTRICT
SEWAGE TREATMENT PLANT

Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

plant operator. Financing of the system is provided through the general property tax and a sewer service charge. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Allenton Sanitary District sanitary sewerage system approximated $19,329, or about $28 per capita. Of this total, $10,329, or about $15 per capita, was expended for operation and maintenance and $9,000, or about $13 per capita, was expended for capital improvements.

Newburg Sanitary District: The existing service area of the Newburg Sanitary District sanitary sewerage system, located in the Town of Trenton, Washington County, and the Town of Saukville, Ozaukee County, is shown on Map 42. This area totals about 0.1 square mile and has a resident population of about 400 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Newburg Sanitary District is treated at a sewage treatment plant located on the Milwaukee River, to which effluent is discharged (see Figure 68). The plant site is bounded by open land uses on all sides. The plant, an activated sludge type, was constructed in 1965. The average hydraulic design capacity of the plant is 0.08 mgd, with an estimated peak hydraulic design capacity of about 1.6 mgd. The average hydraulic loading of the plant in 1970 was estimated at 0.04 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of all major trunk sewers serving the Newburg Sanitary District are shown on Map 42. Data pertaining to known points of sewage flow relief in the Newburg Sanitary District sanitary sewerage system were not available. The inventory revealed that the district had no documented plan for the expansion of its sanitary sewerage system.

Management of the Newburg Sanitary District sanitary sewerage system is under the direction of a three-member commission. Day-to-day administration of the system is provided by a part-time certified plant operator and sanitary engineer. Financing of the system is provided through the general property tax and a sewer service charge based on a flat fee of $4 per month per residence. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Newburg Sanitary District sanitary sewerage system approximated $18,767, or about $47 per capita. Of this total, $7,871, or about $20 per capita, was expended for operation and maintenance and $10,896, or about $27 per capita, was expended for capital improvements.

Proposed Public Sanitary Sewerage Systems

The inventory revealed that as of 1970 there were three proposed public sanitary sewerage systems in Washington County which would provide centralized sanitary sewer service to subareas of the county. These three systems would serve the Tri-Lakes area in Washington County, consisting of urban development along the shorelines of Big Cedar Lake, Little Cedar Lake, and Silver Lake, located southwest of the City of West Bend; urban development along the shoreline of Green Lake in the Town of Farmington; and urban development along the shoreline of Wallace Lake in the Towns of Barton and Trenton. All of these proposed sanitary sewerage systems were recommended in the adopted comprehensive plan for the Milwaukee River watershed. Together these three proposed systems would serve a total area of about four square miles, or about 1 percent of the county, and a total seasonal resident population of about 4,300. Each of these three proposed public sanitary sewer systems is described in the following paragraphs.

Tri-Lakes Sanitary Sewerage System: As noted above, the Tri-Lakes sanitary sewerage system would serve existing urban development along Big Cedar, Little Cedar, and Silver Lakes. After careful consideration of alternative ways of providing centralized sanitary sewer service to this major lakes area, the comprehensive plan for the Milwaukee River watershed recommended that service be provided through the City of West Bend sanitary sewerage system. To date, the Common Council of the City of West Bend has agreed in principle to the provision of such service and has authorized the conduct of engineering studies designed to expand the existing West Bend sewage treatment plant in part to accommodate the anticipated sewage flow from the Tri-Lakes area. The individual sanitary districts already formed around the three lake areas have not acted to date to adopt the plan recommendations. The proposed service area of the Tri-Lakes sanitary sewerage system is shown on Map 42. This area totals about 3.5 square miles and has a current seasonal resident population of about 3,700 persons.

Green Lake Sanitary Sewerage System: The proposed sanitary sewerage system to serve existing urban development along the shoreline of Green Lake in the Town of Farmington is recommended in the Milwaukee River watershed plan as an aid in maintaining good lake water quality for recreational uses by eliminating any potential health hazards due to malfunctioning septic tank sewage disposal systems and by reducing the total nutrient input to the lake. The plan recommends that the sewage treatment facility to serve the lake be constructed on a site southwest of the lake and discharge its effluent to a wetland area eventually leading to a tributary of the main stem of the Milwaukee River. To date, no action has been taken to implement this plan recommendation. The proposed service area of the Green Lake sanitary sewerage system is shown on Map 42. This area totals about 0.03 square mile and has a current seasonal resident population of about 300 persons.

Wallace Lake Sanitary Sewerage System: The proposed sanitary sewerage system for Wallace Lake, which lake is located adjacent to the northeast limits of the City of West Bend, is recommended to be connected to the City of West Bend sanitary sewerage system for sewage treatment purposes. The Wallace Lake area is included in the future planned service area of the City of West Bend. The proposed service area, as shown on Map 42, totals about 0.3 square mile and has a current resident population of about 300 persons.

Other Sewage Treatment Facilities

In addition to the eight public sanitary sewerage systems discussed above, there are a total of four sewage treatment facilities in Washington County which serve single isolated land use enclaves. These four treatment facilities serve the Pike Lake State Park in the Town of Hartford; the Libby, McNeil and Libby, Inc., canning plant in the City of Hartford; the Level Valley Dairy in the Town of Jackson; and the Libby, McNeil and Libby, Inc., canning plant in the Town of Jackson. Pertinent characteristics pertaining to each of these four sewage treatment facilities are presented in Table 47. It should be noted that of these four facilities, three are proposed to be connected to centralized public sanitary sewerage systems in locally proposed sewerage plans. The Pike Lake State Park facility and the Libby, McNeil and Libby, Inc., facility in the City of Hartford would both eventually be connected to the City of Hartford sanitary sewerage system. The Libby, McNeil and Libby, Inc., plant in the Town of Jackson is proposed to be connected to the new Village of Jackson sewage treatment facility.

Other Known Point Sources of Waste Water

In addition to identifying all existing public and private sewage treatment plants which discharge treated wastes to streams and watercourses within the Region, and all known sewage overflow points on both the existing sanitary and combined sewerage systems within the Region which discharge untreated wastes to streams and watercourses, an attempt was made in the regional sanitary sewerage system planning program to identify, through existing secondary sources, all other known point sources of waste water discharge. These other point sources of pollution consist primarily of industrial cooling, rinse, and wash waters, which may be discharged directly and without treatment to streams and watercourses or to storm sewers tributary to such streams and watercourses. The secondary sources consulted included river basin survey reports and pollution abatement orders of the Wisconsin Department of Natural Resources and records of municipal public works departments. A total of eight such known point sources of industrial waste water were identified in Washington County. The name, civil division location, type of waste, known pretreatment, and receiving water body of these eight waste sources are identified in Table 48. The location of these eight point sources is shown on Map 43.

Existing Urban Development Not Served by Public Sanitary Sewers

As noted earlier, public sanitary sewerage systems in Washington County serve a total area of about 9.4 square miles, or 2 percent of the total area of the county, and a total population of about 30,200, or about 47 percent of the total population of the county. An inventory was conducted in the study to determine the approximate amount of urban development, and the population residing therein, in Washington County not served in 1970 by public sanitary sewer service. Each U. S. Pub-

Table 47

SELECTED CHARACTERISTICS OF PRIVATE SEWAGE TREATMENT FACILITIES IN WASHINGTON COUNTY: 1970

Name	Civil Division Location	Type of Land Use Served	Type of Treatment Provided	Average Hydraulic Design Capacity (Gallons/Day)	Disposal of Effluent
Level Valley Dairy	Town of Jackson	Industrial	Flow-Through Lagoon	50,000	North Branch Cedar Creek
Libby, McNeill, and Libby, Inc.	City of Hartford	Industrial	Aerated Lagoons	170,000	Rubicon River
Libby, McNeill, and Libby, Inc.	Town of Jackson	Industrial	Flow-Through Lagoons and Spray Irrigation	N/A	Soil Absorption and Cedar Creek
Pike Lake State Park	Town of Hartford	Recreational	Seepage Lagoons	N/A	Soil Absorption

NOTE: N/A indicates data not available.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 48

KNOWN EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN WASHINGTON COUNTY: 1970

Point Source[1]		Civil Division Location	Type of Waste	Known Pretreatment	Receiving Water Body
Number[2]	Name				
1	Broan Mfg. Co., Incorporated	City of Hartford	Cooling Waters	--	Rubicon River
2	Chrysler Outboard Corporation	City of Hartford	Cooling Waters	Oil Separation	Rubicon River
3	International Stamping Co., Inc.	City of Hartford	Cooling Waters	Ponding	Rubicon River
4	Amity Leather Products Company	City of West Bend	Cooling Waters	--	Milwaukee River
5	Line Materials Division of McGraw-Edison Co.[3]	City of West Bend	Industrial Wastes	--	Milwaukee River
6	The West Bend Company[3]	City of West Bend	Wash Waters	--	Milwaukee River
7	Gehl Guernsey Farms, Incorporated	Village of Germantown	Cooling Waters	Ponding	Menomonee River
8	Regal Ware, Incorporated	Village of Kewaskum	Cooling Waters	--	Milwaukee River

[1]As identified in Wisconsin Department of Natural Resources river basin survey reports and pollution abatement orders and by selected municipal public works departments; does not include industrial waste sources discharging to municipal sanitary sewerage systems.

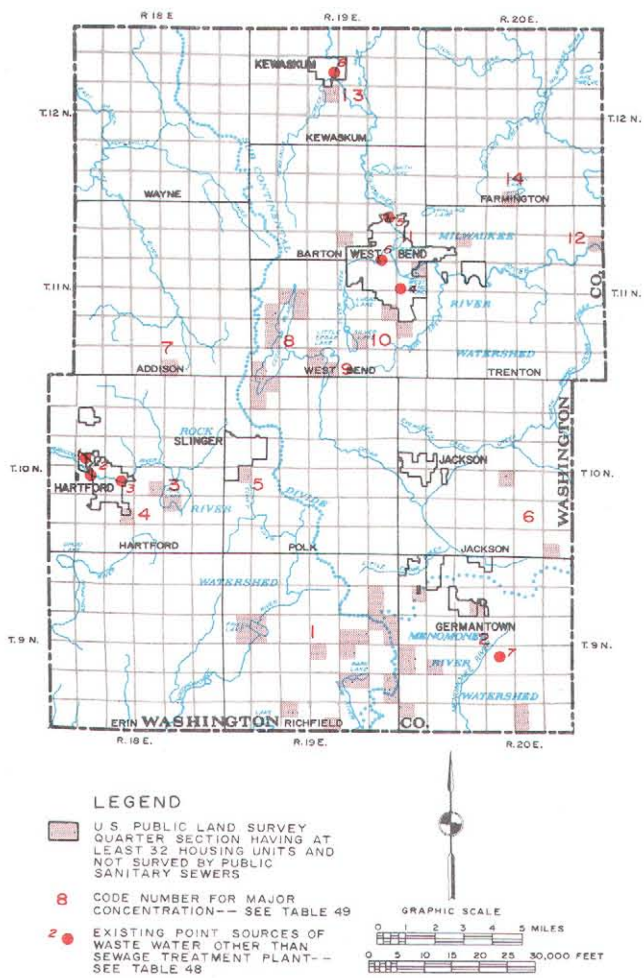
[2]See Map 43.

[3]Connected to City of West Bend sanitary sewerage system since 1970.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 43

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS AND EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN WASHINGTON COUNTY: 1970



Significant concentrations of unsewered urban development in Washington County are found both in older, established lake-oriented development, primarily along the shorelines of Big Cedar, Little Cedar, Friess, Green, Pike, and Silver Lakes and in relatively new urban subdivisions located throughout the Village of Germantown and the Towns of Jackson and Richfield. Centralized sanitary sewer service has been proposed for several of the lake-oriented urban communities, including those along the shorelines of Big Cedar, Little Cedar, Green, Pike, and Silver Lakes. The location of the eight known point sources of wastewater other than sewage treatment plants in Washington County is also shown on this map. Such sources are concentrated in the Hartford and West Bend areas of the county.

Source: Wisconsin Department of Natural Resources and SEWRPC.

lic Land Survey quarter section not having development served by a centralized sanitary sewerage system was examined to determine if a significant amount of urban development was present in 1970. Any quarter section with at least 32 housing units, or an average of one housing unit per five gross acres, was deemed to be urban. The major purpose of identifying such concentrations of urban development was to provide the basis for analyzing the potential of providing public sanitary sewerage service to such areas in accordance with recommendations contained in the adopted regional land use plan.

The nonsewered urban development areas identified in Washington County are shown on Map 43. Together these areas total about four square miles, or 1 percent of the total area of the county, and contain a total population of about 9,600, or 15 percent of the total population of the county. For analysis purposes, the existing nonsewered urban development has been combined into 14 named major urban concentrations. The estimated population and urban development areas of each of these major concentrations are shown in Table 49.

Concluding Remarks—Washington County

Inventories conducted under the regional sanitary sewerage system planning program revealed that in 1970 there existed in Washington County a total of eight public sanitary sewerage systems, which together served a total area of about 9.4 square miles, or about 2 percent of the total area of the county, and a total population of about 30,200 per-

Table 49

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SEWERS IN WASHINGTON COUNTY BY MAJOR URBAN CONCENTRATION: 1970

Major Urban Concentration[1]		Estimated Resident Population	Developed Urban Area (Acres)
Number[2]	Name		
1	Town of Richfield	3,400	1,047
2	Village of Germantown	1,500	385
3	Pike Lake Area	400	83
4	City of Hartford Area	100	5
5	Village of Slinger Area	200	24
6	Town of Jackson	600	130
7	Town of Addison	200	27
8	Big Cedar Lake Area	1,400	396
9	Little Cedar Lake Area	400	137
10	Silver Lake Area	100	33
11	City of West Bend Area	900	146
12	Newburg Area	100	27
13	Village of Kewaskum Area	200	59
14	Green Lake Area	100	23
	Washington County Total	9,600	2,522[3]

[1]*Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*
[2]*See Map 43.*
[3]*Equal to 4 square miles.*

Source: SEWRPC.

sons, or about 47 percent of the total population of the county. Each of the eight sanitary sewerage systems operates its own sewage treatment facility. In addition to the eight public sanitary sewerage systems, four sewage treatment facilities serving single isolated land use enclaves were found in the inventory. The inventory revealed that as of 1970 there were three proposed public sanitary sewerage systems in the county, all of which would serve existing urban development along lake shorelines. Finally, in 1970 there were an estimated 9,600 persons residing in urban areas in Washington County not served by public sanitary sewer service. Together these areas totaled about four square miles.

INVENTORY FINDINGS—WAUKESHA COUNTY

Existing Public Sanitary Sewerage Systems

There are a total of 13 existing public sanitary sewerage systems in Waukesha County which provide centralized sanitary sewer service to subareas of the county. These include the systems operated by the Cities of Brookfield, Muskego, New Berlin, Oconomowoc, and Waukesha; and the Villages of Butler, Dousman, Elm Grove, Hartland, Menomonee Falls, Mukwonago, Pewaukee, and Sussex. Together these systems serve a total area of about 39 square miles, or about 6 percent of the total area of the county, and a total population of about 122,000, or about 53 percent of the total population of the county. Each of these public sanitary sewerage systems is described in the following paragraphs. Pertinent characteristics of these systems are presented in Tables 50 and 51.

City of Brookfield: The City of Brookfield sanitary sewerage system consists of two separate parts, one to serve urban development located in the city east of the subcontinental divide which traverses the Southeastern Wisconsin Region and the other

Table 50

AREA AND POPULATION SERVED BY EXISTING AND LOCALLY PROPOSED SANITARY SEWERAGE SYSTEMS IN WAUKESHA COUNTY: 1970

Name of Public Sanitary Sewerage System	Estimated Service Area: Existing Acres	Existing Square Miles	Proposed[1] Acres	Proposed[1] Square Miles	Estimated Population Served[2]	Treatment of Sewage (See Table 20)
Existing Systems						
City of Brookfield						
Menomonee River Watershed System	2,368	3.70	6,720	10.50	8,500	Contracts with Milwaukee-Metropolitan Sewerage Commissions
Fox River Watershed System	3,954	5.62	8,506	13.29	12,300	Operates Two Facilities
City of Muskego	1,150	1.80	9,314	14.55	4,500	Operates a Temporary Facility — Contracts with Milwaukee-Metropolitan Sewerage Commissions
City of New Berlin						
Area Connected to Milwaukee-Metropolitan System	2,796	4.38	13,262	20.71	7,900	Contracts with Milwaukee-Metropolitan Sewerage Commissions
Greenridge Subdivision	76	0.12	- -	- -	800	Operates a Temporary Facility
Regal Manors Subdivision	58	0.09	- -	- -	- -	Operates a Temporary Facility
City of Oconomowoc	1,368	2.14	33,500	52.34	9,500	Operates a Facility
City of Waukesha	5,719	8.92	3,934	6.15	40,700	Operates a Facility
Village of Butler	499	0.78	- -	- -	2,100	Contracts with Milwaukee-Metropolitan Sewerage Commissions[3]
Village of Dousman	232	0.36	- -	- -	600	Operates a Facility
Village of Elm Grove						
Sanitary District No. 1	1,140	1.78	- -	- -	3,900	Contracts with Milwaukee-Metropolitan Sewerage Commissions
Sanitary District No. 2	940	1.47	- -	- -	2,700	Contracts with Milwaukee-Metropolitan Sewerage Commissions
Village of Hartland	515	0.81	- -[4]	- -[4]	2,900	Operates a Facility
Village of Menomonee Falls	2,413	3.77	9,300	14.53	17,400	Operates Temporary Facilities — Contracts with Milwaukee-Metropolitan Sewerage Commissions
Village of Mukwonago	689	1.07	1,152	1.80	2,600	Operates a Facility
Village of Pewaukee	518	0.81	2,268	3.50	2,900	Operates a Facility
Village of Sussex	570	0.89	316	0.49	2,800	Operates a Facility
Proposed Systems						
Hartland-Delafield	- -	- -	8,588	13.42	- -	- -
Pewaukee Lake Sanitary District	- -	- -	4,032	6.30	- -	- -
Village of North Prairie	- -	- -	847	1.32	- -	- -
County Total	24,645	38.51	101,739	158.90	122,100	- -

[1]*As identified in locally prepared plans and engineering reports.*
[2]*Based upon an approximation of the existing sewer service area by U.S. Public Land Survey quarter section.*
[3]*Pending completion of trunk sewer construction, sewage flow from the Village of Butler to the Milwaukee-Metropolitan sewerage system is limited to 400,000 gallons per day. Any flow in excess of this amount is bypassed through a chlorination tank and discharged to the Menomonee River.*
[4]*The locally proposed sewer service area for the Village of Hartland is included in the proposed service area of the Hartland-Delafield Water Pollution Control Commission.*

Source: SEWRPC.

Table 51

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT FACILITIES IN WAUKESHA COUNTY: 1970

Name of Public Sewage Treatment Facility	Estimated Total Area Served (Square Miles)	Estimated Total Population Served	Date of Original Construction and Major Modification	Type of Treatment Provided	Level of Treatment Provided	Disposal of Effluent	Design Capacity: Population[1]	Design Capacity: Average Hydraulic (MGD)	Design Capacity: Peak Hydraulic (MGD)	Design Capacity: Average Organic (Pounds $CBOD_5$/Day)	Design Capacity: Population Equivalent[1]
City of Brookfield											
Fox River Plant	5.62	12,300	1960	Activated Sludge	Secondary	Fox River	10,000	1.0	2.0	2,000	9,540
Poplar Creek Lagoons			1968	Aerated Lagoons	Secondary	Fox River	N/A	N/A	N/A	N/A	N/A
City of Muskego	1.80	4,500	1967, 1970	Aerated Flow-Through Lagoons	Secondary	Big Muskego Lake	2,600	0.70	0.90	1,400	6,660
City of New Berlin											
Greenridge Plant	0.12	800	1966	Activated Sludge	Secondary	Root River	1,000	0.10	N/A	200	955
Regal Manors Plant	0.09	--[3]	1970	Activated Sludge	Secondary	Deer Creek	N/A	0.35	N/A	515	2,450
City of Oconomowoc	2.14	9,500	1936	Trickling Filter	Secondary	Oconomowoc River	N/A	1.50	3.0	N/A	N/A
City of Waukesha	8.92	40,700	1949, 1967	Trickling Filter	Secondary	Fox River	N/A	8.50	11.50	11,500	54,700
Village of Dousman	0.36	600	1961	Activated Sludge	Secondary	Bark River	N/A	0.12	0.30	200	955
Village of Hartland	0.81	2,900	1933, 1962	Activated Sludge	Secondary	Bark River	3,500	0.35	0.70	700	3,330
Village of Menomonee Falls											
Pilgrim Road Plant	3.77	17,400	1954, 1962	Trickling Filter & Activated Sludge	Secondary	Menomonee River	N/A	1.9	2.5	935	4,450
Lilly Road Plant			1969	Activated Sludge & Flow-Through Lagoon	Tertiary	Menomonee River	N/A	1.0	2.0	1,700	8,100
Village of Mukwonago	1.07	2,600	1950	Trickling Filter	Secondary	Mukwonago River	1,500	0.244	0.30	585	2,800
Village of Pewaukee	0.81	2,900	1950	Trickling Filter	Secondary	Pewaukee River	N/A	0.30	0.60	625	2,980
Village of Sussex	0.89	2,800	1958	Trickling Filter	Secondary	Sussex Creek	3,000	0.30	1.50	500	2,380

Name of Public Sewage Treatment Facility	Existing Loading - 1970: Average Hydraulic (MGD)	Average Per Capita (GPD)	Peak Hydraulic (MGD)	Average Organic (Pounds $CBOD_5$/Day)	Reserve Hydraulic Capacity (MGD)	Sewage Strength Parameters in Influent Sewage: $CBOD_5$ (mg/1)	Suspended Solids (mg/1)	Total Phosphorus (mg/1)	Organic Nitrogen-N (mg/1)	Ammonia Nitrogen-N (mg/1)	Industrial Flows: Design Average Daily Flow (MGD)	Estimated Daily Flow 1970 (MGD)	Overall Plant Efficiency Percent Removals: $CBOD_5$ (Percent)	Suspended Solids (Percent)	Total Phosphorus (P) (Percent)	Number of Days in 1970 Plant Flow Exceeded Plant Meter Capacity
City of Brookfield																
Fox River Plant	1.66	140	7.0	1,803	None	105	163	N/A	N/A	N/A	N/A	N/A	72[2]	83[2]	N/A	249
Poplar Creek Lagoons	0.06		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
City of Muskego	0.40	89	N/A	N/A	0.30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
City of New Berlin																
Greenridge Plant	0.065	81	N/A	N/A	0.035	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Regal Manors Plant	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
City of Oconomowoc	1.618	170	1.9	1,850	None	140[4]	165[4]	6.5[4]	9.0[4]	8.8[4]	N/A	N/A	85[4]	64[4]	0[4]	0
City of Waukesha	8.28	203	12.0	12,000	0.22	180[5]	144[5]	N/A	N/A	N/A	N/A	N/A	95[5]	88[5]	N/A	N/A
Village of Dousman	0.084	140	0.12	60	0.036	90[6]	100[6]	8.0[6]	5.4[6]	8.4[6]	N/A	N/A	67[6]	83[6]	0[6]	N/A
Village of Hartland	0.27	93	N/A	316	0.08	140[7]	170[7]	17.0[7]	14.4[7]	27. [7]	N/A	N/A	82[7]	83[7]	10[7]	0
Village of Menomonee Falls																
Pilgrim Road Plant	1.70	138	N/A	N/A	0.20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lilly Road Plant	0.70		N/A	N/A	0.30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Mukwonago	0.30	115	N/A	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Pewaukee	0.40	138	N/A	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Village of Sussex	0.294	105	0.52	223	0.006	92[8]	120[8]	8.6[8]	10.2[8]	16.2[8]	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: N/A indicates data not available.

[1]The population design capacity for a given sewage treatment facility was obtained directly from engineering reports prepared by or for the local unit of government operating the facility and reflects assumptions made by the design engineer. The population equivalent design capacity was estimated by the Commission staff by dividing the design $CBOD_5$ loading in pounds per day, as set forth in the engineering reports, by an estimated per capita contribution of 0.21 pound of $CBOD_5$ per day. If the design engineer assumed a different daily per capita contribution of $CBOD_5$, the population equivalent design capacity will differ from the population design capacity shown in the Table.

Source: Wisconsin Department of Natural Resources and SEWRPC.

[2]When both treated and bypassed flows are included, about 53 percent of the $CBOD_5$ and 45 percent of the suspended solids were removed (data from 1969 City of Brookfield annual report).

[3]During 1970 this plant served only the New Berlin Eisenhower High School.

[4]Data obtained from 24-hour composite sample by the Wisconsin Department of Natural Resources in July 1970.

[5]Data obtained from the 1970 Annual Report of the City of Waukesha Public Works Department.

[6]Data obtained from 24-hour composite sample by the Wisconsin Department of Natural Resources in August 1969.

[7]Data obtained from 24-hour composite sample by the Wisconsin Department of Natural Resources in June 1969.

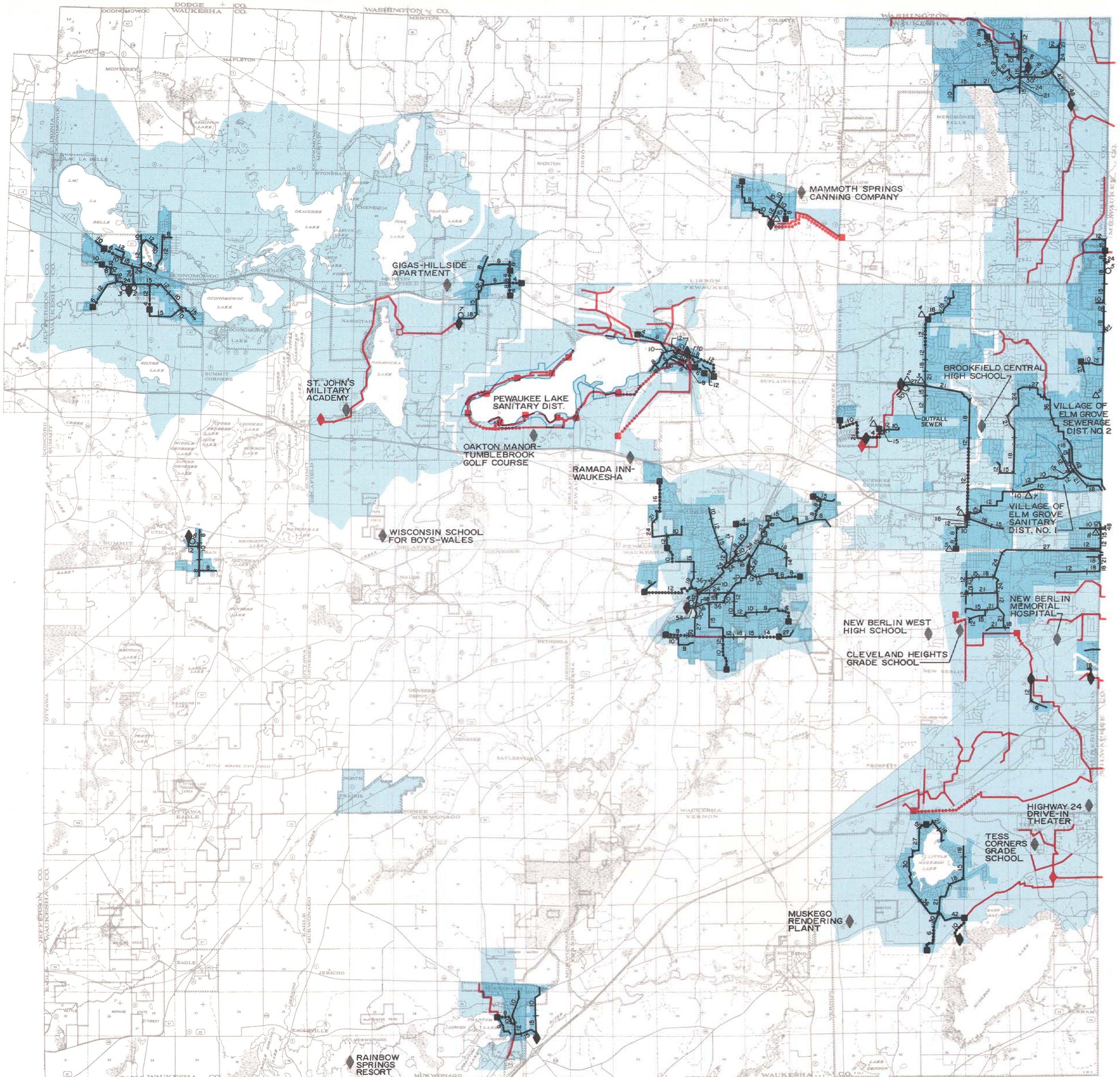
[8]Data obtained from 24-hour composite sample by the Wisconsin Department of Natural Resources in July 1970.

to serve urban development located in the Fox River watershed west of the subcontinental divide. The existing service areas of each of these sanitary sewerage systems are shown on Map 44. Together, these areas total about 9.3 square miles and have a resident population of about 20,800 persons. Both areas are served by separate sanitary sewer systems.

The City of Brookfield contracts with the Milwaukee-Metropolitan Sewerage Commissions for treatment of sewage generated in the area east of the subcontinental divide. This area totals about 3.7 square miles and has a resident population of about 8,500 persons. The average hydraulic loading on the Milwaukee-Metropolitan sewerage system from the City of Brookfield in 1970 was estimated at 0.9 mgd.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the City of Brookfield sanitary sewerage system east of the subcontinental divide is shown on Map 44. There are three known points of sewage flow relief in this portion of the City of Brookfield sanitary sewerage system, all of which are portable pumping stations. The planned future service area in this portion of the City of Brookfield, which includes all of the city east of the subcontinental divide and which totals about 10.5 square miles, together with locally proposed trunk sewers to serve this land area, are also shown on Map 44.

The existing service area of the City of Brookfield sanitary sewerage system in the Fox River watershed west of the subcontinental divide is shown



Map 44

EXISTING AND LOCALLY PROPOSED PUBLIC SANITARY SEWERAGE SYSTEMS AND OTHER SEWAGE TREATMENT FACILITIES IN WAUKESHA COUNTY 1970

LEGEND

SEWER SERVICE AREAS

- EXISTING-SEPARATE
- EXISTING-COMBINED
- PROPOSED

SEWAGE TREATMENT FACILITIES

- EXISTING-PUBLIC
- EXISTING-PRIVATE
- PROPOSED-PUBLIC

SEWERS AND APPURTENANT FACILITIES

- EXISTING MAJOR TRUNK, RELIEF, OR INTERCEPTING SEWER
- EXISTING MAJOR COMBINED SEWER
- PROPOSED MAJOR TRUNK, RELIEF, OR INTERCEPTING SEWER
- EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- EXISTING LIFT STATION
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- PROPOSED PUMPING STATION
- 18-2.3 $\frac{18}{2.3}$ SIZE (in Inches) AND CAPACITY (in MGD) OF SEWER OR APPURTENANT FACILITY

KNOWN FLOW RELIEF DEVICES

- COMBINED SEWER OUTFALL
- BYPASS
- CROSSOVER
- PORTABLE RELIEF PUMPING STATION
- RELIEF PUMPING STATION
- 8 IDENTIFICATION NUMBER--SEE APPENDIX B

GRAPHIC SCALE

0 1 2 3 4 5 MILES

0 8000 16000 24000 32000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

(This page intentionally left blank)

on Map 44. This area totals about 5.6 square miles and has a resident population of about 12,300 persons. Sewage from this portion of the City of Brookfield is treated at two sewage treatment facilities. The first facility is located on a 50-acre site on the Fox River, to which effluent is discharged (see Figure 69). The plant site is bounded by the Chicago, Milwaukee, St. Paul and Pacific Railroad on the north and south, industrial land uses on the east, and the Fox River and its floodplains on the west. The plant, an activated sludge type, was constructed in 1960. The average hydraulic design capacity of the plant is 1.0 mgd, with a peak hydraulic design capacity of 2.0 mgd. The average hydraulic loading on the plant in 1970 was estimated at 1.7 mgd, indicating that the plant did not have adequate capacity to treat the average daily flow from the existing sewer service area. Treatment processes provided by the plant are classified as secondary level. The second facility is a two-stage temporary lagoon treatment facility located on a 90-acre industrial park site near the confluence of Poplar Creek and the Fox River (see Figure 70). This plant site is bounded by the Fox River on the north, Poplar Creek on the east, unused and open lands on the south, and a new 77-acre sewage treatment plant site on the west. The lagoons were placed into operation in 1968 and serve exclusively the Camelot Forest Subdivision and the Elmbrook Memorial Hospital. The average hydraulic loading on the facility in 1970 was estimated at 0.06 mgd. Treatment processes provided by the lagoons are classified as secondary level.

Figure 69

CITY OF BROOKFIELD FOX RIVER SEWAGE TREATMENT PLANT

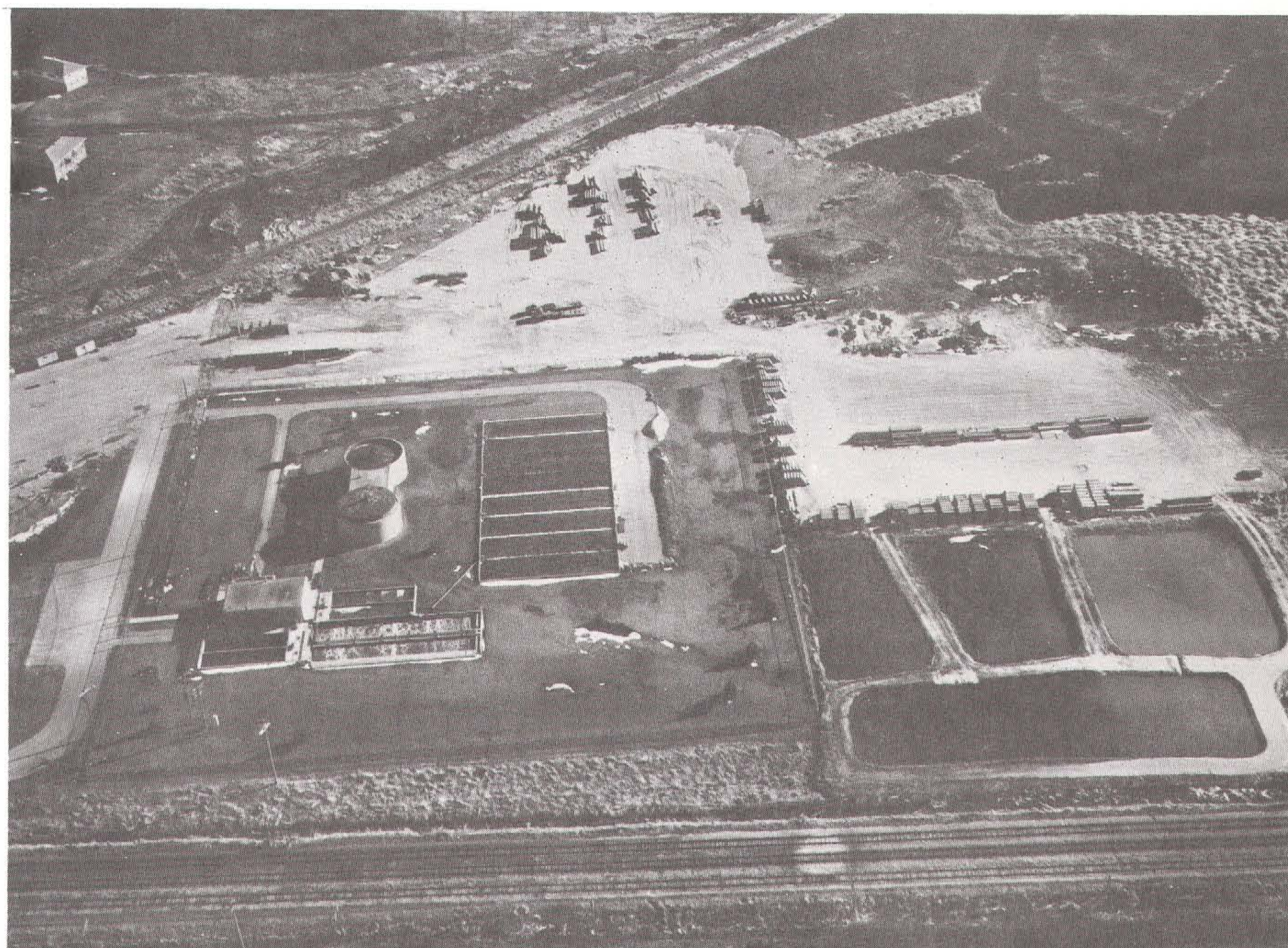


Photo by Karl W. Emrich and Ching-Chi Wu.

Figure 70

CITY OF BROOKFIELD POPLAR CREEK SEWAGE TREATMENT PLANT

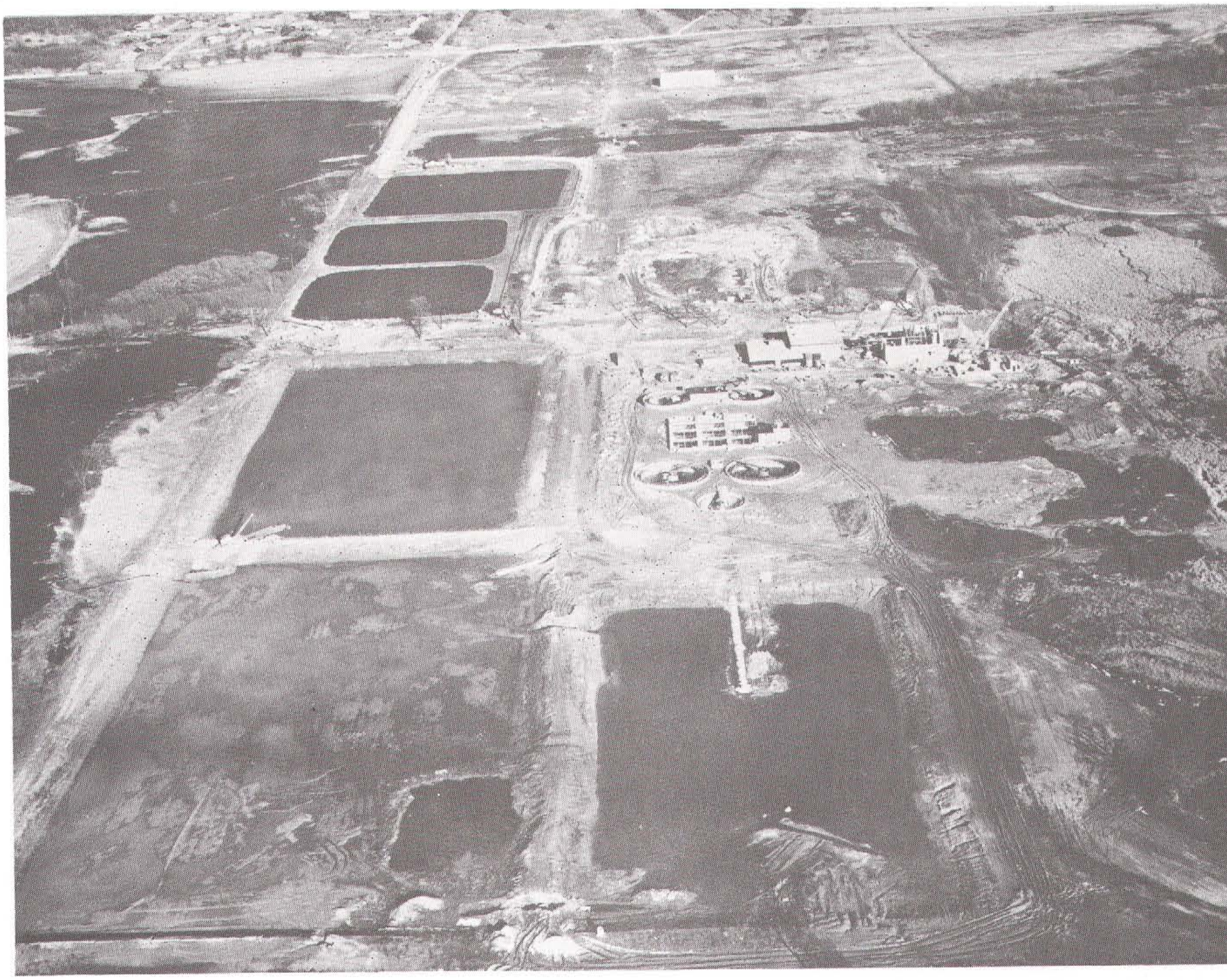


Photo by Karl W. Emrich and Ching-Chi Wu.

It should be noted that during 1972 the City of Brookfield had under construction a new sewage treatment plant located on the 77-acre site adjacent to the site of the existing sewage treatment lagoons near the confluence of Poplar Creek and the Fox River. The new plant, which will also discharge its effluent to the Fox River, will have an average hydraulic design capacity of 5.0 mgd and a peak hydraulic design capacity of 12.0 mgd, and will provide a secondary level of waste treatment. The existing City of Brookfield sewage treatment plant and the existing City of Brookfield sewage lagoons will be abandoned upon completion of the new treatment facility, which is expected in 1973. The new Brookfield sewage treatment plant was approved as an interim treatment facility pending full implementation of the recommended upper Fox River watershed sanitary sewerage system as contained in the adopted Fox River watershed plan. Ultimately, the plan recommends that all sewage originating in the City of Brookfield west of the subcontinental divide be treated at a new 36 mgd advanced waste treatment facility proposed to be located south of Waukesha. Sewage from the City of Brookfield, the Village of Menomonee Falls, the Village of Lannon, the Village of Sussex, the Village of Pewaukee, the Pewaukee Lake Sanitary District, the City of New Berlin, and the City of Waukesha, together with adjacent urban development in several towns in the upper Fox River watershed area, would be treated at the proposed new major areawide sewage treatment facility.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the City of Brookfield sanitary sewerage system in the Fox River watershed are shown on Map 44. There are seven known points of sewage flow relief in this portion of the City of Brookfield sanitary sewerage system, including six portable pumping stations and one bypass located at the old sewage treatment plant. The inventory revealed that the City of Brookfield had a locally proposed sewerage system plan to serve all of the City of Brookfield in the Fox River watershed and portions of the Town of Brookfield. This area totals about 13 square miles.

Management of the City of Brookfield sanitary sewerage system is under the direction of a five-member sewer utility board including the Mayor and Public Works Director, along with a four-member Underwood Creek Sewer Commission, a joint commission with the Village of Elm Grove. Day-to-day administration of the system is provided by the Director of Public Works and the utility superintendent. Financing of the system is provided through both a sewer service charge and a general property tax levy. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Brookfield sanitary sewerage system, approximated $666,574, or about $32 per capita. Of this total, $220,758, or about $11 per capita, was expended for operation and maintenance and $445,816, or about $21 per capita, was expended for capital improvements.

City of Muskego: The existing service area of the City of Muskego sanitary sewerage system is shown on Map 44. This area totals about 1.8 square miles and has a resident population of about 4,500 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Muskego is temporarily being treated at a sewage treatment lagoon located near Big Muskego Lake, to which effluent is discharged (see Figure 71). The existing lagoon site accommodates three lagoons and is about 21 acres in size. It is bounded by agricultural land uses on all sides. The treatment facility, a flow-through stabilization lagoon type, was constructed in 1967 and reconstructed in 1970 as an aerated stabilization lagoon type. The average hydraulic design capacity of the lagoon is 0.7 mgd, with a peak hydraulic design capacity of 0.9 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.4 mgd, indicating that the facility did have adequate capacity to treat the average daily flow from the existing sewer service area. Treatment processes provided by the plant are classified as secondary level.

It should be noted that the City of Muskego constructed in 1971 and placed into operation in 1972 an additional sewage treatment facility to serve the northeast area of the city. This facility consists of an activated sludge type sewage treatment plant discharging to a seepage lagoon (see Figure 72). The lagoon has emergency overflow gates that would allow discharge of effluent to the Tess Corners Creek, a tributary of the Root River. The average hydraulic design capacity of the northeast district sewage treatment plant in the City of Muskego is 0.5 mgd, with a peak hydraulic design capacity of 1.3 mgd.

Both of the City of Muskego sewage treatment facilities are scheduled to be abandoned upon completion of a major trunk sewer by the Milwaukee-Metropolitan Sewerage Commissions to the Milwaukee-Waukesha County line. The City of Muskego is committed by contract to abandon its

Figure 71

CITY OF MUSKEGO BIG MUSKEGO LAKE SEWAGE TREATMENT PLANT

Photo by Karl W. Emrich and Ching-Chi Wu.

Figure 72

CITY OF MUSKEGO NORTHEAST DISTRICT SEWAGE TREATMENT PLANT

Photo by Karl W. Emrich and Ching-Chi Wu.

temporary sewage treatment facilities and connect to the Milwaukee-Metropolitan sewerage system as soon as the trunk sewer capacity becomes available. At the present time it is anticipated that this trunk sewer will be in place in 1977.

Although nearly the entire City of Muskego lies within the contract service area of the Milwaukee-Metropolitan Sewerage Commissions, the locally proposed plans of the City of Muskego are to serve a 14.5 square mile area, as shown on Map 44. Locally proposed trunk sewers to serve this area and to enable abandonment of the existing sewage treatment plants are also shown on Map 44.

The location and configuration of all existing major trunk sewers and pumping and lift stations and related force mains in the City of Muskego sanitary sewerage system are shown on Map 44. There are no known points of sewer overflow or bypassing in the City of Muskego sanitary sewerage system.

Management of the City of Muskego sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the City Engineer. Financing of the system is provided through the general property tax and a sewer service charge. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Muskego sanitary sewerage system approximated \$1.24 million, or about \$276 per capita. Of this total, \$6,908, or about \$1 per capita, was expended for operation and maintenance and \$1,233,340, or \$275 per capita, was expended for capital improvements.

City of New Berlin: The existing service area of the City of New Berlin sanitary sewerage system is shown on Map 44. This area totals about 4.6 square miles and has a resident population of about 8,700 persons. The entire area is served by a separate sanitary sewer system. All of the area lies east of the subcontinental divide traversing the Southeastern Wisconsin Region. Of the total area served, about 4.4 square miles having a resident population of about 7,900 persons are served directly through the Milwaukee-Metropolitan sewerage system, and about 0.1 square mile having a resident population of about 800 persons is served directly by the City of New Berlin through a small sewage treatment plant located near the eastern city limits (see Figure 73).

The City of New Berlin has a contract with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment for sewage generated in all of the area of the city east of the subcontinental divide. The average hydraulic loading on the Milwaukee-Metropolitan sewerage system from the City of New Berlin in 1970 was estimated at 1.5 mgd.

The small sewage treatment plant serving the Greenridge Subdivision at the eastern city limits is located on about a four-acre site, and is a temporary sewage treatment plant scheduled to be abandoned as trunk sewer service from the Milwaukee-Metropolitan Sewerage Commissions becomes available. The average hydraulic design capacity of the plant is 0.1 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.07 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The City of New Berlin placed into operation during 1970 on a limited use basis a new sewage treatment plant designed to serve the Eisenhower High School and the Regal Manors Subdivision (see Figure 74). During 1970 only the Eisenhower High School was served by this new plant, which is also a temporary sewage treatment facility designed to be abandoned upon extension of trunk sewer service from the Milwaukee-Metropolitan sewerage system. The area served during 1970 by the plant totaled about 0.1 square mile. The plant, an activated sludge type, has an average hydraulic design capacity of 0.3 mgd. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the City of New Berlin sanitary sewerage system are shown on Map 44.

Figure 73

CITY OF NEW BERLIN GREENRIDGE SEWAGE TREATMENT PLANT

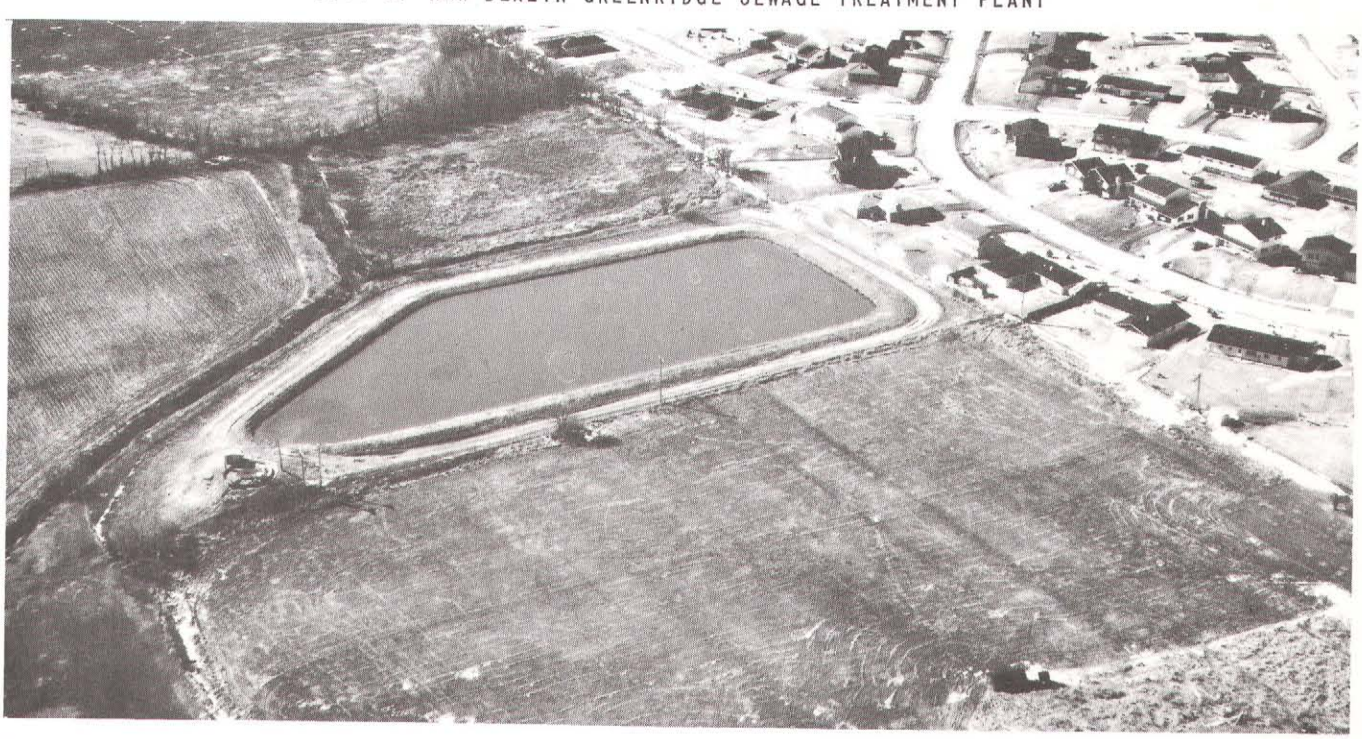


Photo by Karl W. Emrich and Ching-Chi Wu.

Figure 74

CITY OF NEW BERLIN REGAL MANORS SEWAGE TREATMENT PLANT

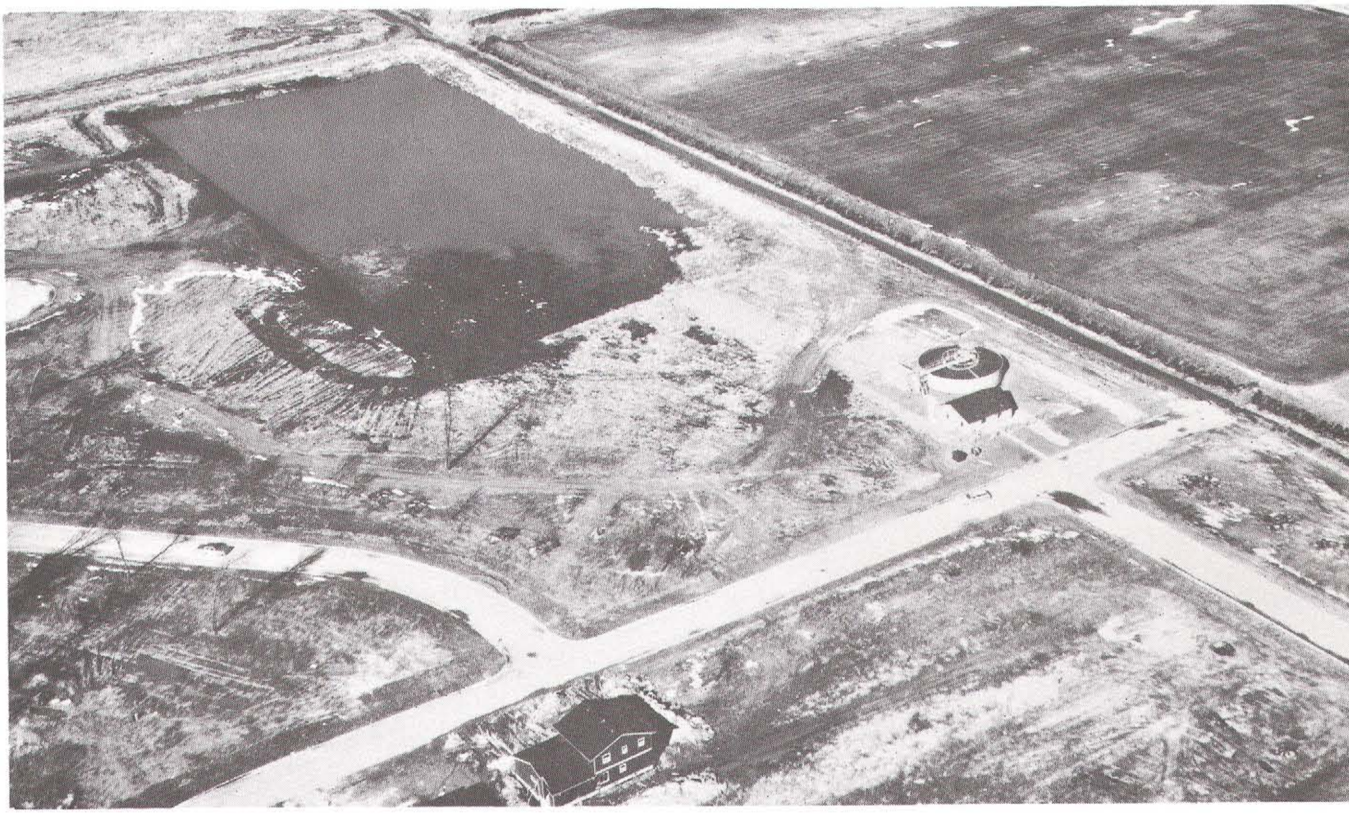


Photo by Karl W. Emrich and Ching-Chi Wu.

There are no known points of sewer overflow or bypassing in the City of New Berlin sanitary sewerage system. The inventory revealed that the city had a documented plan to provide sewer service to all of the area of the city within the contract limits of the Milwaukee-Metropolitan Sewerage Commissions, which area generally corresponds to the area lying east of the subcontinental divide. This proposed future sewer service area, which approximates 20.7 square miles, is shown on Map 44. Locally proposed trunk sewers to serve this area are also shown on Map 44.

Management of the City of New Berlin sanitary sewerage system is under the direction of the Common Council. Day-to-day administration of this system is provided by the Director of Public Works. Financing of the system is provided through a sewer service charge of $18 per quarter per residential connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of New Berlin sanitary sewerage system approximated $228,469, or about $26 per capita. Of this total, $206,869, or about $24 per capita, was expended for operation and maintenance and $21,600, or about $2 per capita, was expended for capital improvements.

City of Oconomowoc: The existing service area of the City of Oconomowoc sanitary sewerage system is shown on Map 44. This area totals about 2.1 square miles and has a resident population of about 9,500 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Oconomowoc is treated at a sewage treatment plant located on the Oconomowoc River, to which effluent is discharged (see Figure 75). The plant has a site area of about 25 acres, of which 10 acres are currently utilized, leaving 15 acres available for future use. The plant site is bounded by residential land use on the north and open land uses on the south, west, and east. The plant, a trickling filter type, was constructed in 1936. The average hydraulic design capacity of the plant is 1.5 mgd, with an estimated

Figure 75

CITY OF OCONOMOWOC SEWAGE TREATMENT PLANT

Photo by Karl W. Emrich and Ching-Chi Wu.

peak hydraulic design capacity of 3.0 mgd. The average hydraulic loading on the plant in 1970 was estimated at 1.6 mgd, indicating that the plant does not have adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level. It should be noted that the City of Oconomowoc has completed engineering studies relating to the construction of a new sewage treatment plant, which plant is proposed to serve as an areawide sewage treatment facility for existing and proposed urban development in several adjacent communities lying in the Oconomowoc River basin. The proposed average hydraulic design capacity of the new plant is to be 4.0 mgd, with a peak hydraulic design capacity of 9.0 mgd. The plant would be located downstream of and immediately adjacent to the site of the existing sewage treatment facility on the remaining land area.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the City of Oconomowoc sanitary sewerage system are shown on Map 44. There are two known points of sewage flow relief in the City of Oconomowoc sanitary sewerage system, both of which are manually operated bypasses. Neither bypass has been used since 1966. The proposed future sewer service area, as documented in engineering reports prepared for the proposed new sewage treatment facility for the City of Oconomowoc, which area approximates 52 square miles, is shown on Map 44.

Management of the City of Oconomowoc sanitary sewerage system is under the direction of the Mayor and Common Council. Day-to-day administration of the system is provided by the Director of Public Works. Financing of the system is provided through the general property tax and a sewer service charge equal to 100 percent of the winter quarter water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Oconomowoc sanitary sewerage system approximated $124,708, or about $13 per capita. Of this total, $50,000, or about $5 per capita, was expended for operation and maintenance and $74,708, or about $8 per capita, was expended for capital improvements.

City of Waukesha: The existing service area of the City of Waukesha sanitary sewerage system is shown on Map 44. This area totals about 8.9 square miles and has a resident population of about 40,700 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the City of Waukesha is treated at a sewage treatment plant located on the Fox River, to which effluent is discharged (see Figure 76). The plant has a site area of about 40 acres, of which about 28 acres are currently utilized. The plant site is bounded by the city public works garage on the north, the municipal incinerator on the south, the Fox River and its floodplains on the west, and Sentry Drive on the east. The plant, a high-rate two-stage trickling filter type, was initially constructed in 1949 and was extensively modified and expanded in 1967. The average hydraulic design capacity of the plant is 8.5 mgd, with a peak hydraulic design capacity of 11.5 mgd. The average hydraulic loading on the plant in 1970 was estimated at 8.3 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. Examination of sewage flow records reveals, however, that the peak hydraulic design capacity of the plant is occasionally exceeded. It should be noted that the City of Waukesha during 1972 authorized the conduct of engineering studies to examine the expansion potential of the existing plant, together with the recommendation contained in the adopted Fox River watershed plan that the plant be ultimately abandoned and that a new 36 mgd areawide sewage treatment facility be constructed on a new site below the existing City of Waukesha plant.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the City of Waukesha sanitary sewerage system are shown on Map 44. The only known point of sewage flow relief in the City of Waukesha sanitary sewerage system is a bypass at the sewage treatment plant. The inventory revealed that the city had a documented plan for the provision of sewer service to an additional 6.1 square mile area, which area is shown on Map 44. No locally proposed trunk sewers to serve this additional area were, however, found in the inventory.

Management of the City of Waukesha sanitary sewerage system is under the direction of the Mayor and Common Council, advised by the Board of Public Works. Day-to-day administra-

Figure 76

CITY OF WAUKESHA SEWAGE TREATMENT PLANT

Photo by Karl W. Emrich and Ching-Chi Wu.

tion of the system is provided by the Director of Public Works and the Sewage Plant Superintendent. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the City of Waukesha sanitary sewerage system approximated $1,133,038, or about $28 per capita. Of this total, $221,905, or about $5 per capita, was expended for operation and maintenance and $911,133, or about $23 per capita, was expended for capital improvements.

Village of Butler: The existing service area of the Village of Butler sanitary sewerage system, which encompasses the entire village, is shown on Map 44. This area totals about 0.8 square mile and has a resident population of about 2,100 persons. The entire area is served by a separate sanitary sewer system.

The Village of Butler contracts with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment. The average hydraulic loading on the Milwaukee-Metropolitan sewerage system from the Village of Butler in 1970 was estimated at 0.4 mgd. Pending completion of trunk sewer construction, sewage flow from the village of the Milwaukee-Metropolitan sewerage system is limited to 400,000 gallons per day. Any flow in excess of this amount is bypassed through a chlorination tank and discharged to the Menomonee River. The location and configuration of the major trunk sewers serving the Village of Butler are shown on Map 44.

Management of the Village of Butler sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Water and Sewer Superintendent. Financing of the system is provided through a sewer service charge based upon the quarterly water billings. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Butler sanitary sewerage system approximated $60,805, or about $29 per capita. Of this total, $39,922, or about $19 per capita, was expended for operation and maintenance and $20,883, or about $10 per capita, was expended for capital improvements.

Village of Dousman: The existing service area of the Village of Dousman sanitary sewerage system is shown on Map 44. This area totals about 0.4 square mile and has a resident population of about 600 persons. The entire area is served by a separate sanitary sewerage system.

VILLAGE OF BUTLER SEWAGE OVERFLOW CHLORINATION FACILITY

Photo by Karl W. Emrich and Ching-Chi Wu.

Sewage from the Village of Dousman is treated at a sewage treatment plant located on the Bark River, to which effluent is discharged (see Figure 77). The plant has a site area of about 10 acres, of which one acre is currently utilized, leaving nine acres available for future use. The plant site is bounded by the Bark River on the north, and unused vegetated land areas on the south, west, and east. The plant, an activated sludge type, was constructed in 1961. The average hydraulic design capacity of the plant is 0.12 mgd, with a peak hydraulic design capacity of 0.3 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.08 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

Figure 77

VILLAGE OF DOUSMAN SEWAGE TREATMENT PLANT

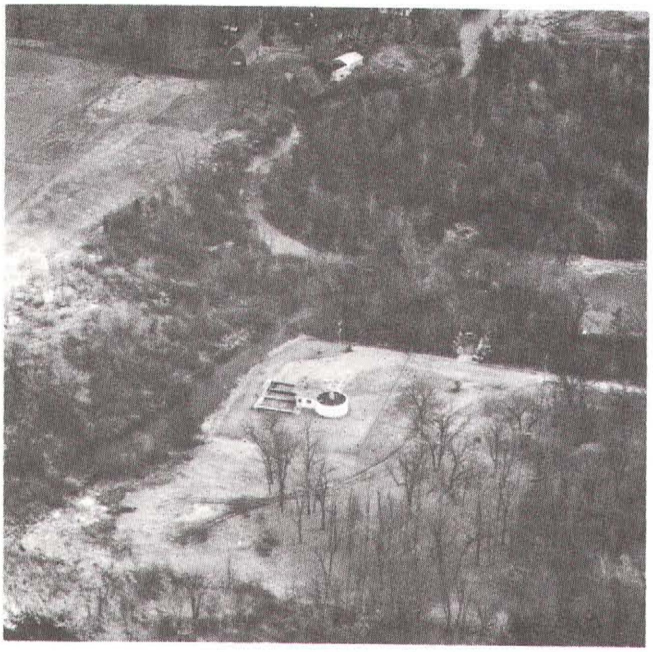


Photo by Karl W. Emrich and Ching-Chi Wu.

The location and configuration of the major trunk sewers serving the Village of Dousman are shown on Map 44. There is one known point of sewage flow relief in the Village of Dousman sanitary sewerage system—a bypass located in a manhole at the sewage treatment plant. The inventory revealed that the village had no documented plan for the extension of its sanitary sewerage system.

Management of the Village of Dousman sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the plant superintendent. Financing of the system is provided through the general property tax and a sewer service charge of $15 per quarter per connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Dousman sanitary sewerage system approximated $34,108, or about $57 per capita. Of this total, $26,834, or about $45 per capita, was expended for operation and maintenance and $7,274, or about $12 per capita, was expended for capital improvements.

Village of Elm Grove: The existing service area of the Village of Elm Grove sanitary sewerage system is shown on Map 44. This area, which encompasses the entire village, totals about 3.3 square miles and has a resident population of about 6,600 persons. Of this total, about 1.8 square miles with a resident population of about 3,900 persons consist of the Village of Elm Grove Sanitary District No. 1. The remaining 1.5 square miles with a resident population of about 2,700 persons consist of the Village of Elm Grove Sewerage District No. 2. The entire village is served by a separate sanitary sewer system.

The Village of Elm Grove contracts with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment. The average hydraulic loading on the Milwaukee-Metropolitan sewerage system from the Village of Elm Grove in 1970 was estimated at 0.9 mgd.

The location and configuration of the major trunk sewers serving the Village of Elm Grove are shown on Map 44. There are no known points of sewage flow relief in the Village of Elm Grove sewerage system. Management of the Village of Elm Grove Sanitary District No. 1 sewerage system is under the direction of a three-member commission. Management of the Village of Elm Grove Sewerage District No. 2 sanitary sewerage system is also under the direction of a three-member commission. Day-to-day administration of both systems is provided by the Village Manager. Financing of both systems is provided through the general property tax and a sewer service charge of $42 per year per connection. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Elm Grove Sanitary District No. 1 sanitary sewerage system approximated $82,791, or about $21 per capita. Of this total, $49,151, or about $13 per capita, was expended for operation and maintenance and $33,640, or about $8 per capita, was expended for capital improvements. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Elm Grove Sewerage District No. 2 sanitary sewerage system approximated $221,171, or about $82 per capita. Of this total, $21,498, or about $8 per capita, was expended for operation and maintenance and $199,673, or about $74 per capita, was expended for capital improvements.

Village of Hartland: The existing service area of the Village of Hartland sanitary sewerage system is shown on Map 44. This area totals about 0.8 square mile and has a resident population of about 2,900 persons. The entire area is served by a separate sanitary sewerage system.

Sewage from the Village of Hartland is treated at a sewage treatment plant located upstream from Nagawicka Lake on the Bark River, to which effluent is discharged (see Figure 78). The existing plant has a site area of about 37 acres, of which five acres are currently utilized, leaving 32 acres available for future use. The plant site is bounded by agricultural land uses on all sides. The plant, an activated sludge type, was constructed in 1933 and extensively modified in 1962. The average hydraulic design capacity of the plant is 0.35 mgd, with an estimated peak hydraulic design capacity of 0.7 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.3 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of all major trunk sewers and pumping and lift stations and related force mains comprising the Village of Hartland sanitary sewerage system are shown on Map 44. The only known point of sewage flow relief in the Village of Hartland sanitary sewerage system is a bypass located at the sewage treatment plant.

The Village of Hartland is currently under orders from the Wisconsin Department of Natural Resources to either provide additional waste treatment facilities in order to remove at least 85 percent of the annual average total phosphorus received at the existing sewage treatment plant and install emergency holding lagoons for waste that might bypass the treatment process, or completely eliminate any waste discharges to the Bark River and its tributaries upstream from

Figure 78

VILLAGE OF HARTLAND SEWAGE TREATMENT PLANT

Photo by Karl W. Emrich and Ching-Chi Wu.

Nagawicka Lake. In response to this order, the Village of Hartland began negotiations in 1970 with the City of Delafield to consider the construction and joint operation and maintenance of a metropolitan sewerage system that would eliminate any sewage discharge to Nagawicka Lake. Preliminary engineering studies for the establishment of this system have been completed and a joint Delafield-Hartland Water Pollution Control Commission has been established to provide for implementation of the proposed new areawide waste treatment system. This proposed new system is more specifically discussed later in this chapter.

Management of the Village of Hartland sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Engineer. Financing of the system is provided through the general property tax and a sewer service charge equal to 100 percent of the winter quarter water bill. Data pertaining to expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Hartland sanitary sewerage system were not made available by the village.

Village of Menomonee Falls: The existing service area of the Village of Menomonee Falls sanitary sewerage system is shown on Map 44. This area totals about 3.8 square miles and has a resident population of about 17,400 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Menomonee Falls is currently treated at two temporary sewage treatment facilities located on the Menomonee River, to which effluent is discharged (see Figures 79 and 80). The first plant, located near the Pilgrim Road crossing of the Menomonee River, has a site

Figure 79

VILLAGE OF MENOMONEE FALLS PILGRIM ROAD SEWAGE TREATMENT PLANT

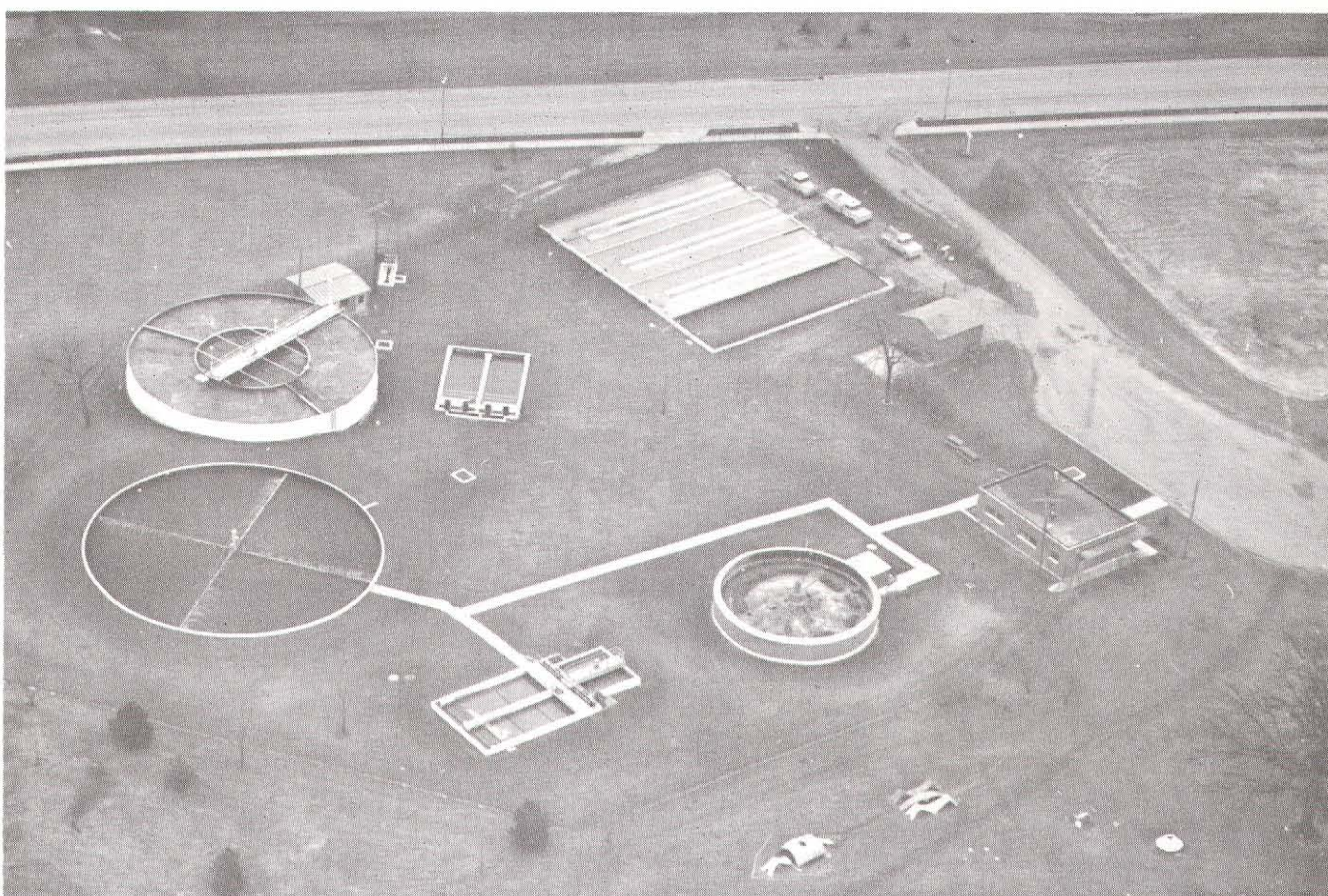


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

Figure 80

VILLAGE OF MENOMONEE FALLS LILLY ROAD SEWAGE TREATMENT PLANT

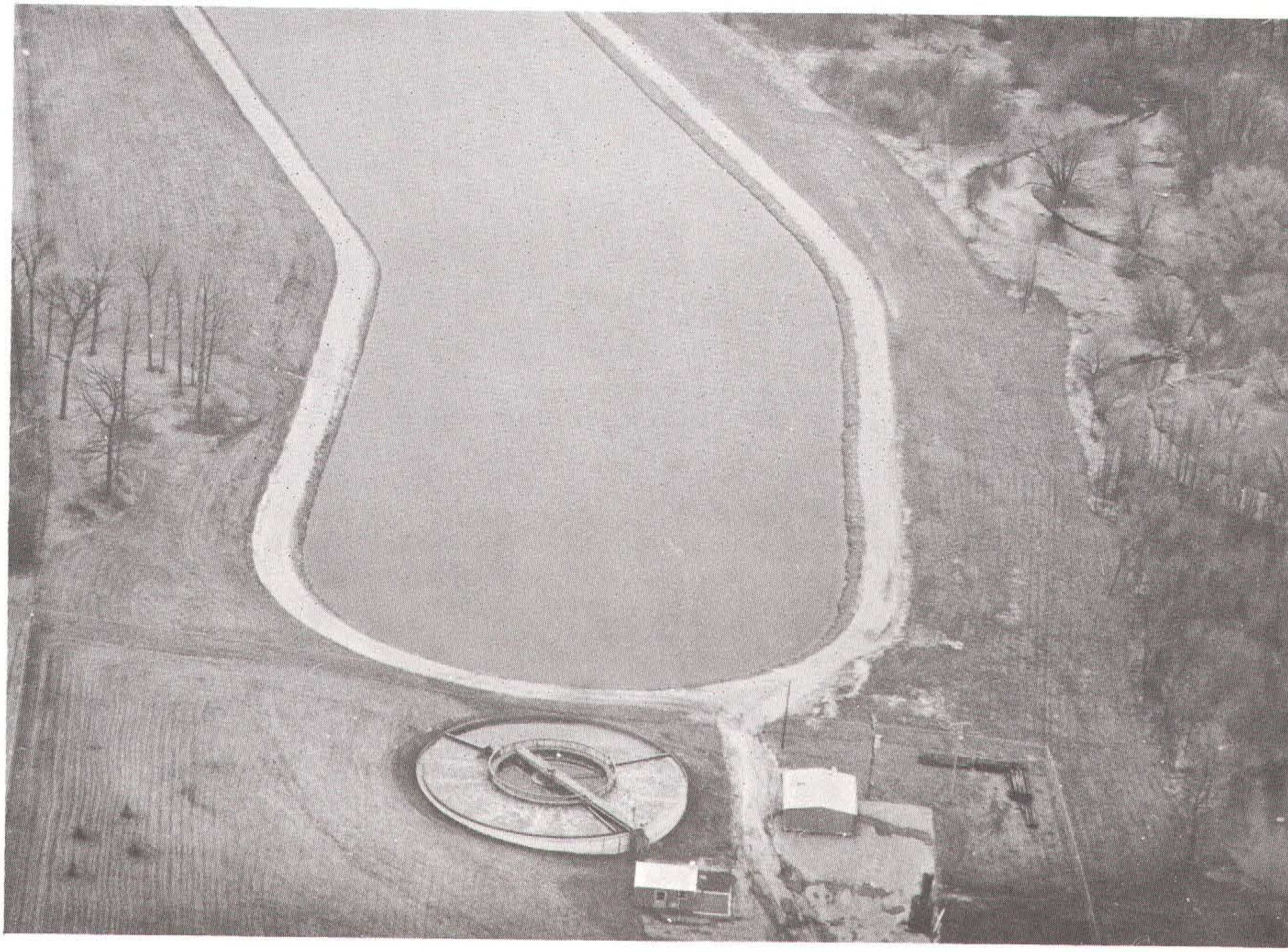


Photo by Melissa D. Creamer, Michael G. Dorn, Jean A. Hervert, and Kenneth E. Johnson.

area of about four acres. The plant site is bounded by village streets on the east and south and by commercial and other urban land uses on the west and north. The original plant, a trickling filter type, was constructed in 1954. In 1962 a new activated sludge plant was constructed to operate in parallel with the trickling filter plant. The average hydraulic design capacity of this combined plant is 1.9 mgd, with a peak hydraulic design capacity of about 2.5 mgd. The average hydraulic loading on the plant in 1970 was estimated at 1.7 mgd, indicating that the plant has adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level. The second plant, located about one mile downstream from the first plant, has a site area of about 25 acres. The plant site is bounded by residential land uses on three sides and a golf course on the east. The plant, an activated sludge type, was constructed in 1969. The average hydraulic design capacity of the plant is 1.0 mgd, with a peak hydraulic design capacity estimated to be 2 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.7 mgd, indicating that the plant has adequate capacity to treat the average daily flow from its sewer service area. The treatment processes provided at the plant are classified as tertiary level. It should be noted that the Menomonee Falls sewer system can be controlled to divide the flows between the plants.

Both of the Village of Menomonee Falls sewage treatment facilities are scheduled to be abandoned upon completion of a major trunk sewer by the

Milwaukee-Metropolitan Sewerage Commissions to the Milwaukee-Waukesha County line at STH 45. The Village of Menomonee Falls is committed by contract to abandon its temporary sewage treatment facilities and connect to the Milwaukee-Metropolitan sewerage system as soon as the trunk sewer capacity becomes available. At the present time it is anticipated that this trunk sewer will be in place in 1973.

All of the Village of Menomonee Falls lying east of the subcontinental divide which traverses the Southeastern Wisconsin Region lies within the contract service area of the Milwaukee-Metropolitan Sewerage Commissions. This future sewer service area approximated 14.5 square miles and is in addition to the area already served at the temporary sewage treatment facilities. Locally proposed trunk sewers to serve this area and to enable abandonment of the existing sewage treatment plants are shown on Map 44.

The location and configuration of all existing major trunk sewers serving the Village of Menomonee Falls are shown on Map 44. The only known point of sewage flow relief in the Village of Menomonee Falls sanitary sewerage system is a bypass located at the Pilgrim Road sewage treatment plant.

Management of the Village of Menomonee Falls sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Public Works Director. Financing of the system is provided through the general property tax, a special property tax levy of $0.50 per $1,000 of assessed evaluation specifically for trunk sewer construction, and a sewer service charge equal to 70 percent of the water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Menomonee Falls sanitary sewerage system approximated $659,421, or about $38 per capita. Of this total, $141,869, or about $8 per capita, was expended for operation and maintenance and $517,552, or about $30 per capita, was expended for capital improvements.

Village of Mukwonago: The existing service area of the Village of Mukwonago sanitary sewerage system is shown on Map 44. This area totals about one square mile and has a resident population of about 2,600 persons. The entire area is served by a separate sanitary sewer system. Sewage from the Village of Mukwonago is treated at a sewage treatment plant located on the Mukwonago River, to which effluent is discharged (see Figure 81). The plant has a site area of about two acres, of which one acre is currently utilized, leaving about an acre available for future use. The plant site is bounded by agricultural or unused lands on all sides. The plant, a high-rate trickling filter type, was constructed in 1950. The average hydraulic design capacity of the plant is 0.20 mgd, with a peak hydraulic design capacity estimated to be 0.3 mgd. The average hydraulic loading on the plant in 1970 was estimated to be 0.30 mgd, indicating that the plant does not have adequate capacity to treat the average daily flow from the sewer service area. The treatment processes provided at the plant are classified as secondary level.

The location and configuration of all major trunk sewers serving the Village of Mukwonago are shown on Map 44. There are no known points of sewer overflow or bypassing in the Village of Mukwonago sanitary sewerage system. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 1.8 square mile area, which area is shown on Map 44. Locally proposed trunk sewers to serve this additional area are also shown on Map 44.

Figure 81

VILLAGE OF MUKWONAGO SEWAGE TREATMENT PLANT

Photo by Roger R. Ross and Joseph C. Ruys.

Management of the Village of Mukwonago sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Engineer and the plant superintendent. Financing of the system is provided through the general property tax. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Mukwonago sanitary sewerage system approximated $9,356, or about $4 per capita. Of this total, $8,123, or about $3 per capita, was expended for operation and maintenance and $1,233, or about $1 per capita, was expended for capital improvements.

Village of Pewaukee: The existing service area of the Village of Pewaukee sanitary sewerage system is shown on Map 44. This area totals about 0.8 square mile and has a resident population of about 2,900 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Pewaukee is treated at a sewage treatment plant located on the Pewaukee River, to which effluent is discharged (see Figure 82). The plant has a site area of about three acres. The plant site is bounded by a city street on the north, the Pewaukee River on the south, industrial land uses on the west, and open land uses and STH 16 on the east. The plant, a trickling filter type, was constructed in 1950. The average hydraulic design capacity of the plant is 0.3 mgd, with an estimated peak hydraulic design capacity of 0.6 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.4 mgd, indicating that the plant did not have adequate capacity to treat the average daily flow from the existing sewer service area. In response to an order from the Wisconsin Department of Natural Resources, the Village of Pewaukee placed into operation in March 1972 an addition to its existing sewage treatment plant. This addition consists of a new experimental bio-disc filter type sewage

Figure 82

VILLAGE OF PEWAUKEE SEWAGE TREATMENT PLANT

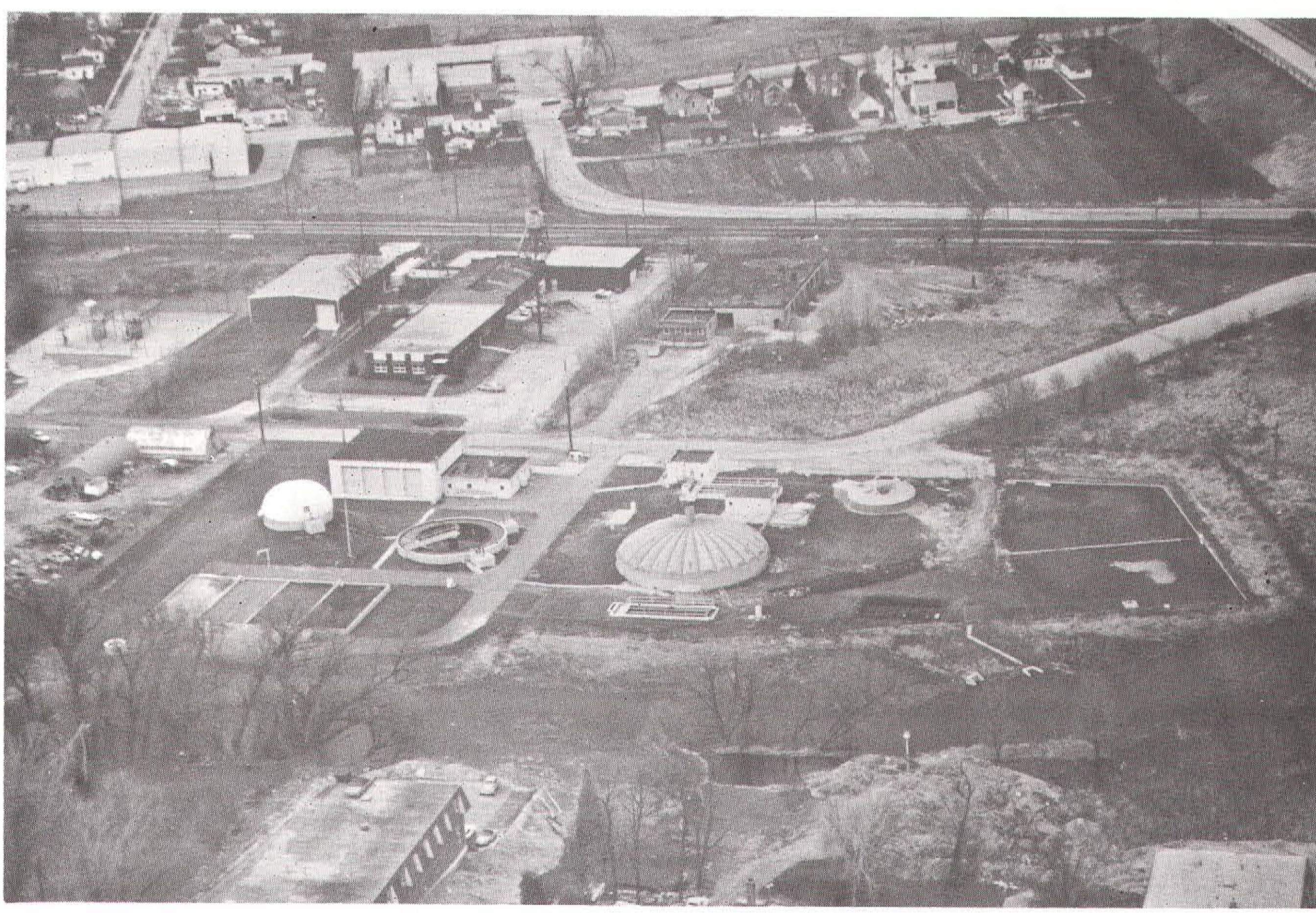


Photo by Michael G. Dorn, Charles L. Hamilton, and Mark W. Sheets.

treatment facility. The new combined hydraulic design capacity of the plant is 0.76 mgd, with a combined peak hydraulic design capacity estimated to be 1.3 mgd. With this new addition, the plant has adequate capacity to treat the existing average daily flow from the sewer service area. The treatment processes provided by the trickling filter and bio-disc type sewage treatment plants are classified as secondary level. It should be noted that the adopted Fox River watershed plan recommends the ultimate abandonment of the existing sewage treatment facility serving the Village of Pewaukee and the connection of the Pewaukee sewer service area to a new 36 mgd areawide sewage treatment facility to be constructed on a new site below the existing City of Waukesha sewage treatment plant.

The location and configuration of all major trunk sewers serving the Village of Pewaukee are shown on Map 44. There are no known points of sewer overflow or bypassing in the Village of Pewaukee sanitary sewerage system. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 3.50 square mile area, which area is shown on Map 44. Locally proposed trunk sewers to serve this additional area are also shown on Map 44.

Management of the Village of Pewaukee sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Administrative Engineer. Financing of the system is provided through a sewer service charge which is equal to 100 percent of the quarterly water bill. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Pewaukee sanitary sewerage system approximated $79,643, or about $27 per capita. Of this total, $35,977, or about $12 per capita, was expended for operation and maintenance and $43,666, or about $15 per capita, was expended for capital improvements.

Village of Sussex: The existing service area of the Village of Sussex sanitary sewerage system is shown on Map 44. This area totals about 0.9 square mile and has a resident population of about 2,800 persons. The entire area is served by a separate sanitary sewer system.

Sewage from the Village of Sussex is treated at a sewage treatment plant located on Sussex Creek, a tributary of the Fox River, to which effluent is discharged (see Figure 83). The plant has a site area of about 12 acres, and is bounded by agricultural land uses on all sides. The plant, a trickling filter type, was constructed in 1958. The average hydraulic design capacity of the plant is 0.3 mgd, with a peak hydraulic design capacity of 1.5 mgd. The average hydraulic loading on the plant in 1970 was estimated at 0.3 mgd, indicating that the plant is presently operating at its design capacity, treating the average daily flow from the present sewer service area.

The adopted Fox River watershed plan recommends that the Village of Sussex sewage treatment facility be ultimately abandoned and its sewer service area connected to the proposed upper Fox River watershed sanitary sewerage system, with treatment to be provided at a new 36 mgd sewage treatment facility to be located on a site downstream from the existing City of Waukesha sewage treatment plant. Since adoption of the Fox River watershed plan, the Village of Sussex has agreed in principle to the establishment of the upper Fox River watershed sanitary sewerage system and has requested that it be allowed to construct an addition to its existing sewage treatment facility to provide for interim growth until the proposed upper Fox River watershed system is fully implemented. The proposed addition to the Village of Sussex sewage treatment plant would result in a total average hydraulic design capacity of 0.8 mgd with a total peak hydraulic design capacity of 2.1 mgd.

Figure 83

VILLAGE OF SUSSEX SEWAGE TREATMENT PLANT

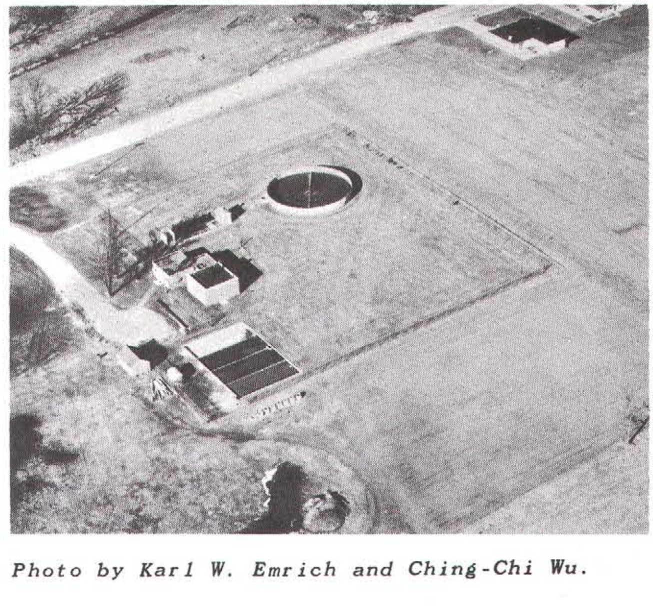


Photo by Karl W. Emrich and Ching-Chi Wu.

The location and configuration of all major trunk sewers serving the Village of Sussex are shown on Map 44. There is one known point of sewage flow relief in the Village of Sussex sanitary sewerage system—a portable pumping station at a manhole near the sewage treatment plant. The inventory revealed that the village had a documented plan for the provision of sewer service to an additional 0.5 square mile area (see Map 44).

Management of the Village of Sussex sanitary sewerage system is under the direction of the Village Board. Day-to-day administration of the system is provided by the Village Engineer. Financing of the system is provided through the general property tax and a sewer service charge. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the Village of Sussex sanitary sewerage system approximated $45,805, or about $16 per capita. Of this total, $24,086, or about $8 per capita, was expended for operation and maintenance and $21,719, or about $8 per capita, was expended for capital improvements.

Proposed Public Sanitary Sewerage Systems

The inventory revealed that as of 1970 there were three proposed sanitary sewerage systems in Waukesha County which would provide centralized sanitary sewer service to subareas of the county. These three systems would serve the Hartland-Delafield area; urban development along the shoreline of Pewaukee Lake in the Towns of Delafield and Pewaukee; and the Village of North Prairie. Together these three proposed systems would serve a total area of about 21 square miles, or 4 percent of the total area of the county, and a total existing population of about 11,700, or 5 percent of the total population of the county. Each of these three proposed sanitary sewerage systems is described in the following paragraphs.

Hartland-Delafield Sanitary Sewerage System: As noted earlier in this chapter under the discussion of the existing sanitary sewerage system in the Village of Hartland, a proposed new areawide sanitary sewerage system to serve the City of Delafield, the Village of Nashotah, and the Village of Hartland has developed out of a pollution abatement order by the Wisconsin Department of Natural Resources to the Village of Hartland. In addition, the deteriorating lake water quality of Nagawicka Lake has prompted concern on the part of many residents of the City of Delafield over the need to provide centralized sanitary sewer service.

The proposed service area of the Hartland-Delafield sanitary sewerage system is shown on Map 44. This area totals about 13 square miles and has a current resident population of about 6,000 persons, not including that area and population now served in the Village of Hartland. Sewage from this area is proposed to be treated at a new sewage treatment plant located either downstream from the Crooked Lake outlet on the Bark River or at the west city limits of the City of Delafield. The average hydraulic design capacity of the proposed plant would be 2 mgd, with a proposed peak hydraulic design capacity of about 5 mgd. The proposed plant would provide an advanced level of sewage treatment, including nutrient removal.

An institutional structure—the Hartland-Delafield Water Pollution Control Commission—has been formed by the Village of Hartland and the City of Delafield to construct, operate, and maintain the necessary components of the areawide sanitary sewerage system. The joint commission would build and operate the treatment plant and the necessary trunk sewer to interconnect the communities that are to be served (see Map 44).

Pewaukee Lake Sanitary Sewerage System: The adopted Fox River watershed plan recommends that urban development along and adjacent to the shoreline of Pewaukee Lake in the Towns of Pewaukee and Delafield be served with centralized sanitary sewer service. The plan recommends that trunk sewers be constructed along the lake shorelines and, together with sewage from the Village of Pewaukee, be conveyed through a new major trunk sewer along the Pewaukee River, connecting with another major new trunk sewer along the Fox River serving the Villages of Sussex, Lannon, and Menomonee Falls and the Cities of Brookfield and New Berlin. Sewage would ultimately be conveyed to a new areawide sewage treatment facility proposed to be located on a new site below the existing City of Waukesha sewage treatment plant.

The Pewaukee Lake Sanitary District, formed in 1947 and governed by a three-member commission, has completed preliminary engineering studies for the provision of centralized sewer service to urban development within the district. The area proposed to be served in the district is shown on Map 44. The preliminary engineering studies for the Pewaukee Lake Sanitary District examined both a connection to the Village of Pewaukee sewage treatment plant, as recommended in the Fox River watershed plan, and a potential connection to the existing City of Waukesha sewage treatment facility through sewers serving the northwest area of the City of Waukesha. The locally proposed service area of the Pewaukee Lake Sanitary District, totaling about 6.3 square miles, and the locally proposed trunk sewer system to serve this area are shown on Map 44. This locally proposed service area has a current resident population of about 5,000 persons.

Village of North Prairie: The Village of North Prairie is considering the establishment of a centralized public sanitary sewerage system. The proposed service area of this system is shown on Map 44. This area totals about 1.3 square miles and has a current resident population of about 700 persons. Sewage from this area is proposed to be treated at a sewage treatment plant located on a tributary to Jericho Creek, to which sewage effluent would be discharged.

Other Sewage Treatment Facilities

In addition to the 13 public sanitary sewerage systems discussed above, there are a total of 14 sewage treatment facilities in Waukesha County which serve single isolated land use enclaves. These 14 sewage treatment facilities serve the Brookfield Central High School in the City of Brookfield; St. John's Military Academy in the City of Delafield; the Cleveland Heights Grade School, the Highway 24 Drive-in Theater, the New Berlin West High School, and the New Berlin Memorial Hospital in the City of New Berlin; the Gigas-Hillside Apartments, Oakton Manor—Tumblebrook Country Club, and the Wisconsin School for Boys-Wales in the Town of Delafield; the Mammoth Springs Canning Company in the Town of Lisbon; the Rainbow Springs Resort in the Town of Mukwonago; the Muskego Rendering Plant and the Tess Corners Grade School in the City of Muskego; and the Ramada Inn-Waukesha in the Town of Pewaukee (see Map 44). Pertinent characteristics pertaining to each of these 14 sewage treatment facilities are presented in Table 52. It should be noted that all but three of these facilities—the Wisconsin School for Boys-Wales, the Mammoth Springs Canning Company, and the Rainbow Springs Resort—are proposed to be connected to centralized public sanitary sewerage systems in locally proposed sewerage plans.

Other Known Point Sources of Waste Water

In addition to identifying all existing public and private sewage treatment plants which discharge treated wastes to streams and watercourses within the Region, and all known sewage overflow points on both the existing sanitary and combined sewerage systems within the Region which discharge untreated wastes to streams and watercourses, an attempt was made in the regional sanitary sewerage system planning program to identify, through existing secondary sources, all other known point sources of waste water discharge. These other point sources of pollution consist primarily of industrial cooling, rinse, and wash waters, which may be discharged directly and without treatment to streams and watercourses or to storm sewers

Table 52

SELECTED CHARACTERISTICS OF PRIVATE SEWAGE TREATMENT FACILITIES IN WAUKESHA COUNTY: 1970

Name	Civil Division Location	Type of Land Use Served	Type of Treatment Provided	Average Hydraulic Design Capacity (Gallons/Day)	Disposal of Effluent
Brookfield Central High School	City of Brookfield	Institutional	Septic Tank, Sand Filter, and Seepage Lagoon	N/A	Soil Absorption
Cleveland Heights Grade School	City of New Berlin	Institutional	Septic Tank, Sand Filter, and Flow-through Lagoon	N/A	Tributary to Poplar Creek
Gigas-Hillside Apartments	Town of Delafield	Residential	Activated Sludge and Seepage Lagoon	20,000	Soil Absorption
Highway 24 Drive-In Theater	City of New Berlin	Commercial	Sedimentation	N/A	Soil Absorption
Mammoth Springs Canning Company	Town of Lisbon	Industrial	Screening and Spray Irrigation	N/A	Soil Absorption
Muskego Rendering Plant	City of Muskego	Industrial	Aerated Seepage Lagoon	N/A	Soil Absorption
New Berlin West High School	City of New Berlin	Institutional	Sedimentation, Sand Filter, and Flow-through Lagoon	24,000	Tributary to Poplar Creek
New Berlin Memorial Hospital	City of New Berlin	Institutional	Activated Sludge	19,000	Tributary to Root River
Oakton Manor-Tumblebrook Golf Course	Town of Delafield	Recreational	Activated Sludge and Flow-through Lagoon	36,000	Pewaukee Lake
Rainbow Springs Resort[1]	Town of Mukwonago	Recreational	Activated Sludge	160,000	Tributary to Mukwonago River
Ramada Inn-Waukesha[2]	Town of Pewaukee	Commercial	Contact Stabilization, Seepage Lagoon, and Spray Irrigation	25,000	Soil Absorption
St. John's Military Academy	City of Delafield	Institutional	Septic Tank and Flow-through Lagoon	75,000	Bark River
Tess Corners Grade School	City of Muskego	Institutional	Septic Tank and Sand Filter	11,000	Tributary to Root River
Wisconsin School for Boys-Wales	Town of Delafield	Institutional	Activated Sludge and Seepage Lagoon	165,000	Soil Absorption

NOTE: N/A indicates data not available.

[1]This facility has not yet been placed into operation.
[2]This facility constructed since 1970.

Source: Wisconsin Department of Natural Resources and SEWRPC.

tributary to such streams and watercourses. The secondary sources consulted included river basin survey reports and pollution abatement orders of the Wisconsin Department of Natural Resources and records of municipal public works departments. A total of 20 such known point sources of industrial waste water were identified in Waukesha County. The name, civil division location, type of waste, known pretreatment, and receiving water body of these 20 waste sources are identified in Table 53. The location of these 20 point sources is shown on Map 45.

Existing Urban Development Not Served by Public Sanitary Sewers

As noted earlier, public sanitary sewerage systems in Waukesha County serve a total area of about 39 square miles, or 6 percent of the total area of the county, and a total population of about 122,100 persons, or about 53 percent of the total population of the county. An inventory was conducted in the study to determine the approximate amount of urban development, and the population residing therein, in Waukesha County not served in 1970 by public sanitary sewer service. Each U. S. Public Land Survey quarter section not having development served by a centralized sanitary sewerage system was examined to determine if a significant amount of urban development was present in 1970. Any quarter section with at least 32 housing units, or an average of one housing unit per five gross acres, was deemed to be urban. The major purpose of identifying such concentrations of urban development was to provide a basis for analyzing the potential of providing public sanitary sewerage service to such areas in accordance with the recommendations contained in the adopted regional land use plan.

The nonsewered urban development areas identified in Waukesha County are shown on Map 45. Together these areas total about 32 square miles, or about 5 percent of the total area of the county, and contain a total population of about 75,000 persons, or about 32 percent of the total population of the county. For analysis purposes, the existing nonsewered urban development has been combined in 33 named major urban concentrations. The

Table 53

KNOWN EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN WAUKESHA COUNTY: 1970

Point Source[1]		Civil Division Location	Type of Waste	Known Pretreatment	Receiving Water Body
Number[2]	Name				
1	Vitamin Products Company	City of Brookfield	Process Water	--	Spray Irrigation - Soil Absorption
2	Boldt, Incorporated	City of Muskego	Process Water	--	Tess Corners Creek
3	Alloy Products Corporation	City of Waukesha	Cooling Water and Industrial Wastes	Seepage Lagoon	Soil Absorption
4	Borden Food Company	City of Waukesha	Cooling Water	--	Fox River
5	Butler Bin Company	City of Waukesha	Paint Spray Booth Wash Water	Settling and Skimming	Fox River
6	Fredricks Readi-Mix Company	City of Waukesha	Concrete Plant Wash Wastes	--	Marsh Tributary to the Fox River
7	General Castings Corporation	City of Waukesha	Cooling Water	--	Fox River
8	G.T.E. Automatic Electric Company, Incorporated	City of Waukesha	Cooling Water	--	Fox River
9	International Harvester Company	City of Waukesha	Cooling Water	--	Fox River
10	Oconomowoc Electro-Plating Co.[3]	City of Waukesha	Industrial Wastes	--	Fox River
11	Payne and Dolan Company	City of Waukesha	Waste Wash Water	Settling Pond	Fox River
12	RTE Corporation	City of Waukesha	Oily Yard Runoff	--	Fox River
13	Waukesha Foundry[3]	City of Waukesha	Cooling Water	--	Fox River
14	Waukesha Motor Company Division of Bangor-Punta, Incorporated	City of Waukesha	Cooling Water and Industrial Wastes	Oil Separation	Marsh Tributary to the Fox River
15	Sealtite Insulation Manufacturing Corporation	Village of Merton	Industrial Wastes	Screening	Bark River
16	Brookhill Farms	Town of Genesee	Cattle Yard Drainage	--	Genesee Creek
17	Keystone Farms	Town of Genesee	Dairy Waste Water	Septic Tank and Stabilization Pond	Pebble Creek
18	Pleasant Valley Farms	Town of Genesee	Chicken Yard Drainage	--	Genesee Creek
19	Halquist Stone Co., Inc.	Town of Lisbon	Stone Cutting Waste Water	Settling Pond	Sussex Creek
20	Waukesha Lime & Stone Company	Town of Pewaukee	Quarry Water	--	Fox River

[1]As identified in Wisconsin Department of Natural Resources river basin survey reports and pollution abatement orders and by selected municipal public works departments; does not include industrial waste sources discharging to municipal sanitary sewerage systems.

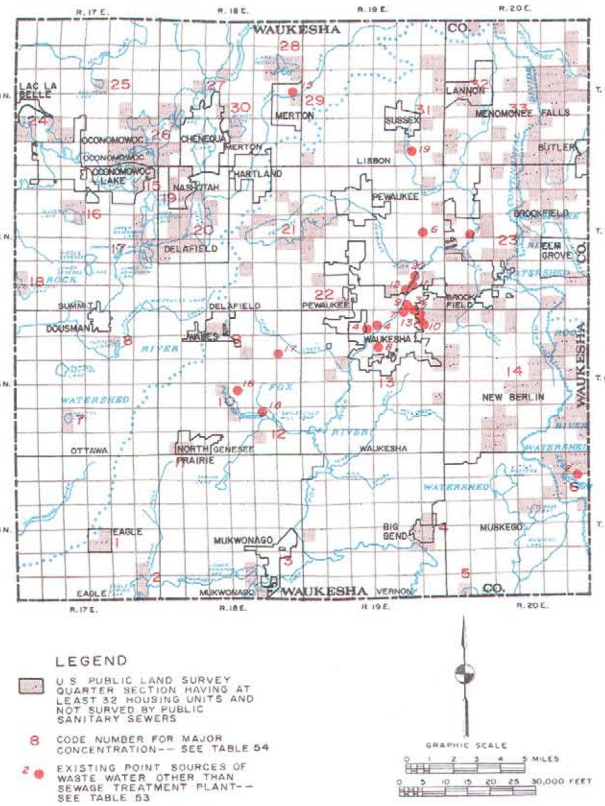
[2]See Map 45.

[3]This source now connected to City of Waukesha sanitary sewerage system.

Source: SEWRPC.

Map 45

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS AND EXISTING POINT SOURCES OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANTS IN WAUKESHA COUNTY: 1970



Significant concentrations of unsewered urban development in Waukesha County may be characterized in four types. The first consists of remaining unsewered remnants of urban development in the eastern tier of townships in the county, which development occurred primarily in the 1950s and early 1960s. Such development is rapidly being provided with centralized sanitary sewer service. The second type consists of unsewered older, established incorporated villages, including Big Bend, Eagle, Merton, North Prairie, and Wales. The third type consists of lake-oriented urban development in the western portion of the county. Most of this development is relatively old. Finally, the fourth type consists of new "leapfrog sprawl" subdivisions which have occurred throughout nearly every town in the county since the mid-1960s. This map also identifies the location of the 20 known point sources of wastewater other than sewage treatment plants in Waukesha County.

Source: Wisconsin Department of Natural Resources and SEWRPC.

estimated population and urban development areas of each of these major concentrations are shown in Table 54.

Table 54

EXISTING URBAN DEVELOPMENT NOT SERVED BY SANITARY SEWERS IN WAUKESHA COUNTY BY MAJOR URBAN CONCENTRATION: 1970

Major Urban Concentration[1]		Estimated Resident Population	Developed Urban Area (Acres)
Number[2]	Name		
1	Village of Eagle	700	178
2	Eagle Spring Lake Area	400	129
3	Village of Mukwonago Area	500	213
4	Village of Big Bend	1,450	330
5	City of Muskego - Lake Denoon Area	150	24
6	City of Muskego - North East Area	4,100	939
7	Pretty Lake Area	400	86
8	Hunters Lake Area	100	16
9	Village of Wales	800	315
10	Genesee - Genesee Depot Area	400	90
11	Village of North Prairie	700	144
12	Saylesville Area	100	61
13	Town of Waukesha - Scattered Development	1,300	432
14	City of New Berlin	15,400	4,390
15	Village of Oconomowoc Lake	200	107
16	Silver Lake Area	400	148
17	Nemahbin Lakes Area	1,100	368
18	Golden Lake Area	200	53
19	Village of Nashotah	400	97
20	City of Delafield	2,400	710
21	Pewaukee Lake Area	4,600	1,168
22	Town of Pewaukee - Scattered Development	2,400	575
23	City of Brookfield	14,600	3,726
24	Lac LaBelle Area	900	404
25	Ashippun Lake Area	200	69
26	Okauchee Lake Area	3,800	1,540
27	North Lake Area	200	57
28	Lake Keesus Area	500	155
29	Village of Merton	300	37
30	Beaver Lake Area	300	123
31	Town of Lisbon - Scattered Development	1,900	620
32	Village of Lannon Area	1,200	228
33	Village of Menomonee Falls	12,700	2,706
	Waukesha County Total	74,800	20,238[3]

[1]*Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

[2]*See Map 45.*

[3]*Equal to 31.6 square miles.*

Source: SEWRPC.

Concluding Remarks—Waukesha County

Inventories conducted under the regional sanitary sewerage system planning program revealed that in 1970 there existed in Waukesha County a total of 13 public sanitary sewerage systems which together serve a total area of about 39 square miles, or about 6 percent of the total area of the county, and a total population of about 122,100 persons, or about 53 percent of the total population of the county. Fourteen sewage treatment facilities provide treatment for sewage generated in these 13 public sanitary sewerage systems. The Village of Menomonee Falls, the Village of Butler, the City of Brookfield, the Village of Elm Grove, the City of New Berlin, and the City of Muskego all contract with the Milwaukee-Metropolitan Sewerage Commissions to provide for sewage treatment in those areas generally lying east of the subcontinental divide traversing the Southeastern Wisconsin Region. Ultimately, all sewage treatment plants operated by these communities in this area will be abandoned. In addition to the 13 public sanitary sewerage systems, 14 sewage treatment facilities serving generally single isolated land use enclaves were found in the inventory. Of these 14, all but three would be abandoned upon implementation of locally proposed sanitary sewerage system plans. The inventory revealed that as of 1970 there were three proposed public sanitary sewerage systems in the county, one to serve the Hartland-Delafield area, one to serve urban development along the shoreline of Pewaukee Lake, and one to serve the Village of North Prairie. Finally, in 1970 there were an estimated 75,000 persons residing in urban areas in Waukesha County not served by public sanitary sewer service. Together these areas totaled about 30 square miles.

SUMMARY

One of the initial steps in the regional sanitary sewerage system planning program was an inventory of all existing sanitary and combined sewerage systems within the Region, whether publicly or privately owned. Such an inventory is essential to an evaluation of the adequacy of the existing network of sanitary sewers presently serving urban land use development within the Region; to an analysis of the deficiencies in the existing systems in meeting present needs; and to a determination of the capabilities of the existing systems to be expanded to meet probable future needs. Also included under the inventory of the existing sanitary sewerage systems was an inventory of all locally prepared sanitary sewerage system plans and engineering reports.

The inventory found that there are a total of 91 existing public sanitary sewerage systems in the Southeastern Wisconsin Region which provide public sanitary sewer service to various subareas of the Region. Together these 91 systems serve a total area of about 309 square miles, or about 11 percent of the total area of the Region, and a total population of about 1.5 million, or nearly 85 percent of the total population of the Region (see Map 46). The area and population served by public sanitary sewerage systems in each county in the Region are summarized in Table 55. The percent of the total area of a county served by sewers ranges from a high of 74 percent in highly urbanized Milwaukee County to a low of 2 percent in largely rural Walworth County. The percent of total county population served ranges from a high of 98 percent in Milwaukee County to a low of 47 percent in Washington County.

Comparable data relating to sanitary sewer service area and population served by sanitary sewers for the year 1963—the year when the Commission first inventoried sanitary sewerage systems as a part of the initial regional land use-transportation study—are also presented in Table 55. Interestingly, the proportion of the total regional population served has remained nearly constant over the seven-year period, despite significant gains in both the number and proportion of the total population served in several counties. For example, the proportion of the total population served in rapidly urbanizing Ozaukee County, which was about 49 percent in 1963, rose to nearly 67 percent by 1970, while the proportion of the total population served in rapidly urbanizing Waukesha County, which was about 43 percent in 1963, rose to 53 percent by 1970. That these and other similar significant gains in the proportion of the total population served in the outlying counties of the Region did not materially increase the proportion of the total regional population served can

Table 55

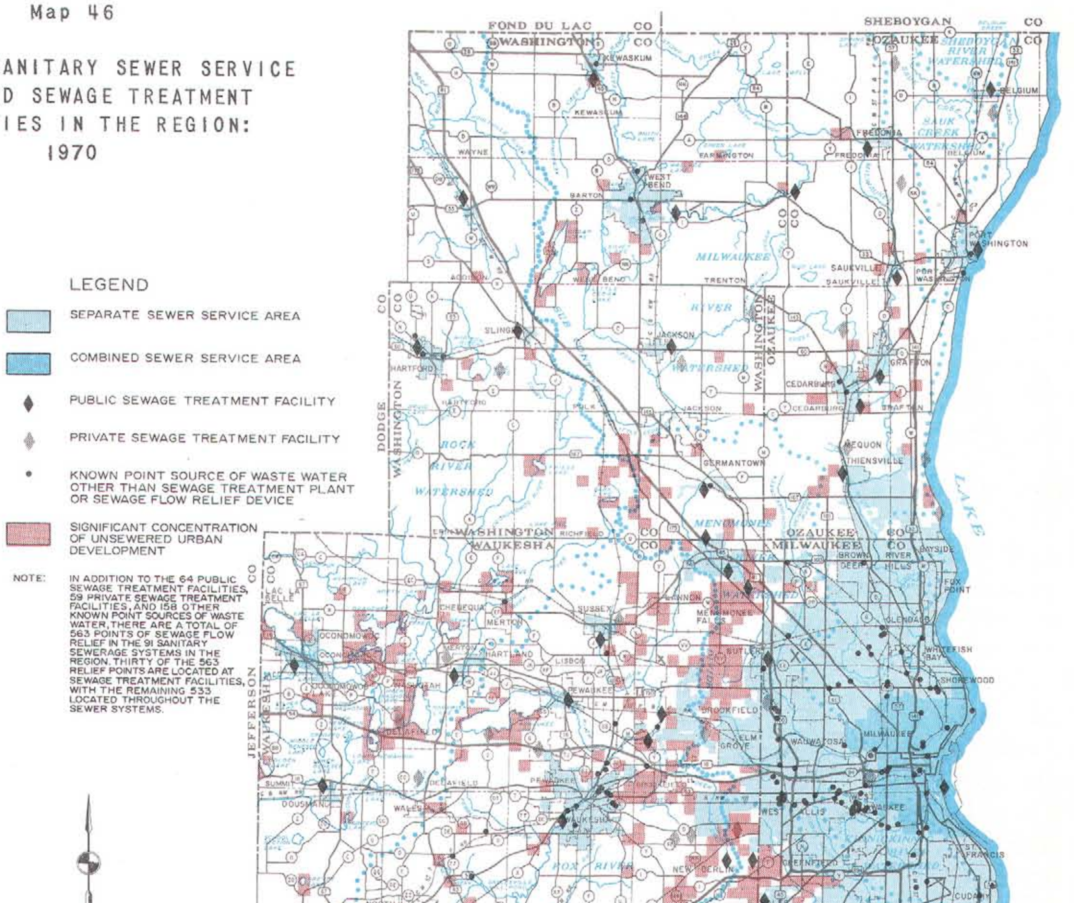
EXISTING AREA AND POPULATION SERVED BY CENTRALIZED SANITARY SEWERS IN THE REGION BY COUNTY: 1963 and 1970

County	Sanitary Sewer Service Area				Population Served			
	1963		1970		1963		1970	
	Square Miles	Percent of County	Square Miles	Percent of County	Number	Percent of County	Number	Percent of County
Kenosha	14.0	5.0	23.83	8.6	79,160	74.2	94,000	79.7
Milwaukee	142.3	58.8	179.00	73.9	1,075,000	99.0	1,034,700	98.2
Ozaukee	6.2	2.6	17.28	7.4	20,340	48.9	36,300	66.7
Racine	19.1	5.6	29.49	8.7	112,600	74.8	135,900	79.6
Walworth	8.6	1.5	11.84	2.1	28,925	52.1	35,500	56.0
Washington	6.1	1.4	9.42	2.2	23,050	46.6	30,200	47.3
Waukesha	20.7	3.6	38.51	6.6	79,950	43.4	122,100	52.8
Region	217.0	8.1	309.37	11.5	1,419,025	84.8	1,488,700	84.8

Source: SEWRPC.

Map 46

EXISTING SANITARY SEWER SERVICE AREAS AND SEWAGE TREATMENT FACILITIES IN THE REGION: 1970



Centralized public sanitary sewer service in the Region is currently provided by 91 public sewerage systems to an area of about 309 square miles, or 11 percent of the total area of the Region. These 91 systems serve nearly 1.5 million persons, or about 85 percent of the total population of the Region. About 31 square miles, primarily located in the central cities of Kenosha, Milwaukee, and Racine, are served by combined storm and sanitary sewers. Treatment for sewage generated in the Region is provided at 64 public sewage treatment facilities, which collectively discharge about 265 million gallons of sewage effluent per day. Of this total, 233 mgd, or nearly 88 percent, are discharged directly to Lake Michigan. There are also 59 sewage treatment facilities serving isolated enclaves of urban land use development, as well as 158 known point sources of wastewater other than sewage treatment plants, which sources consist primarily of industrial cooling, rinse, and wash waters discharged directly to storm sewers or streams. While not shown on this map, there are an additional 533 known points of sewage flow relief in the Region, consisting of combined sewer overflows, relief pumping stations, crossovers from the sanitary to the storm sewer system, and gravity bypasses directly to the streams of the Region. In total, then, there are over 800 point sources of raw sewage, sewage effluent, and industrial waste discharge throughout the Region.

Source: SEWRPC.

be attributed to the fact that the actual number of people served in highly urbanized Milwaukee County actually declined by about 40,000 persons, from about 1,075,000 in 1963 to about 1,034,700 in 1970. This decline in the population served in Milwaukee County is due to the actual loss of population experienced by the central City of Milwaukee over this time period, and concomitant declines in central city population densities.

Despite the fact that the total population served by sanitary sewers in Milwaukee County declined from 1963 to 1970, total average daily sewage flow from within Milwaukee County increased from about 175 mgd in 1963 to about 187 mgd in 1970. On a per capita basis, this represents an increase in flow from 163 gallons per day in 1963 to 181 gallons per day in 1970. That part of the total sewage flow made up of infiltration and storm water inflow in the separate and combined sewer service areas of Milwaukee County should not vary significantly with population declines in the central area of the City of Milwaukee, since such flows are directly related to rainfall. Thus, the decline in the population has not reduced the need for completion of programmed relief trunk sewers nor the need to resolve the combined sewer overflow problem in the manner recommended in the adopted comprehensive plan for the Milwaukee River watershed. The increase in per capita sewage flows can largely be attributed to increasing per capita water consumption in homes and, perhaps, increased industrial water consumption.

Of the total 309 square miles of area served by public sanitary sewers in the Region, about 31 square miles, or nearly 10 percent, consist of combined sewer service area where, by design, sanitary sewage and storm water are collected and conveyed in a single sewer system (see Map 46). About 26 of the 30 square miles of combined sewer service area are in the City of Milwaukee, about one square mile in the Village of Shorewood, and about two square miles each in the Cities of Kenosha and Racine.

Treatment for sewage generated in the 91 centralized sanitary sewerage systems is provided at 64 sewage treatment facilities throughout the Region, indicating that many of the systems are actually subsystems of larger systems that provide sewage treatment on an intergovernmental contract or special purpose district basis (see Map 46). All but three of these 64 sewage treatment facilities discharge treated wastes to the surface water of the Region. The remaining three treatment plants—those serving the Villages of Darien, Fontana, and Williams Bay—discharge treated wastes to the groundwater reservoir through seepage lagoons. The sewage treatment facilities range in size, as measured by average hydraulic design capacity, from 0.03 mgd at the sewage treatment facilities serving the Town of Somers Sanitary District No. 2 in Kenosha County and the Village of Jackson in Washington County to 200 mgd at the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. Of the 64 sewage treatment facilities, three, as of 1970, were equipped to provide only a primary level of waste treatment; 58 were equipped to provide a secondary level of waste treatment; two were equipped to provide a tertiary level of waste treatment; and one was equipped to provide an advanced level of waste treatment. The three facilities providing only a primary level of waste treatment include the City of Port Washington sewage treatment plant in Ozaukee County; the South Shore sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commission in Milwaukee County; and the City of South Milwaukee sewage treatment facility also in Milwaukee County. All three of these facilities discharge effluent to Lake Michigan. It should be noted in this respect that construction of facilities to provide secondary and advanced levels of waste treatment has begun at the three sewage treatment facilities providing only a primary level of waste treatment.

The two sewage treatment facilities equipped to provide a tertiary level of waste treatment are operated by the Village of Walworth in Walworth County and the Village of Menomonee Falls in Waukesha County. The single facility equipped to provide an advanced level of waste treatment is the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions in the City of Milwaukee. It should be noted that a number of communities discharging effluent to watercourses in the Lake Michigan basin have taken steps since 1970 to provide for advanced levels of waste treatment in order to meet state pollution abatement orders reflecting the recommendations of the Lake Michigan Enforcement Conference.

As shown in Table 56, the total effluent discharged from municipal sewage treatment plant in the Region during 1970 was about 265 mgd. Of this total, 233 mgd, or nearly 88 percent, were dis-

Table 56

DISTRIBUTION OF PUBLIC SEWAGE TREATMENT PLANT EFFLUENT DISCHARGE AND POPULATION SERVED BY PUBLIC SANITARY SEWERAGE SYSTEMS BY RECEIVING WATER SYSTEM IN THE REGION: 1970

Receiving Water System	Sewage Treatment Plant Effluent Discharge		Estimated Population Served	
	MGD	Percent of Total	Number	Percent of Total
Lake Michigan - St. Lawrence River Drainage System				
Lake Michigan	232.56	87.83	1,272,600	85.48
Milwaukee River Watershed	5.99	2.26	39,400	2.65
Menomonee River Watershed	2.76	1.04	19,800	1.33
Root River Watershed	1.39	0.52	13,200	0.89
Pike River Watershed	0.28	0.11	3,600	0.24
Sheboygan River Watershed	0.06	0.02	800	0.05
Subtotal	243.04	91.78	1,349,400	90.64
Mississippi River Drainage System				
Des Plaines River Watershed	0.35	0.13	3,600	0.24
Fox River Watershed	14.09	5.32	86,000	5.78
Rock River Watershed	6.46	2.44	45,700	3.07
Subtotal	20.90	7.89	135,300	9.09
Total Discharge to Surface Water System	263.94	99.67	1,484,700	99.73
Discharge to Groundwater Reservoir	0.86	0.33	4,000	0.27
Total Discharge	264.80	100.00	1,488,700	100.00

Source: SEWRPC.

Table 57

DISTRIBUTION OF SEWAGE TREATMENT FACILITIES IN THE REGION BY COUNTY: 1970

County	Number of Sewage Treatment Facilities		Total
	Serving Public Sanitary Sewerage Systems	Serving Isolated Urban Land Use Enclaves	
Kenosha	9	6	15
Milwaukee	7	5	12
Ozaukee	7	7	14
Racine	7	14	21
Walworth	11	9	20
Washington	9	4	13
Waukesha	14	14	28
Region	64	59	123

Source: SEWRPC.

charged directly to Lake Michigan, while an additional 10 mgd, or an additional 4 percent, were discharged to streams draining directly to Lake Michigan. Clearly, the waters in the Lake Michigan basin bear the greatest burden of waste water assimilation in the Region. The total sewage treatment plant effluent discharged to streams west of the subcontinental divide and, therefore, in the Mississippi River basin, was about 21 mgd, or only about 8 percent of the total sewage effluent discharged in 1970 in the Region. The remaining 1 mgd, or less than 1 percent, were discharged to the groundwater reservoir.

In addition to the 64 facilities providing treatment for wastes generated in the 91 centralized sanitary sewerage systems in the Region, there are a total of 59 sewage treatment facilities generally serving isolated enclaves of urban land use development (see Map 46). Of these 59 small treatment plants, 30 are located in the Lake Michigan basin and 29 in the Mississippi River basin. The distribution of these sewage treatment facilities by county is summarized in Table 57. Thus, there are in all a total of 123 sewage treatment facilities in the Southeastern Wisconsin Region, of which all but 22 discharge wastes to the surface waters of the Region.

Of the 64 sewage treatment facilities serving the centralized sanitary sewerage systems in the Region, 20 were found to be operating at or over their average hydraulic design capacities in 1970. These 20 facilities are listed in Table 58. It should be noted that in all but one instance the communities operating the 20 sewage treatment facilities have acted since 1970 to either begin construction of new or expanded treatment facilities to handle the current and anticipated waste loadings or to begin the engineering studies necessary to provide such new or expanded treatment facilities. The single exception is the facility operated by the Town of Somers Sanitary District No. 2, which facility is recommended to be abandoned in the comprehensive plan for the Kenosha Planning District at such time as trunk sewer service is extended to the area from the City of Kenosha sanitary sewerage system.

While a comparison between the average hydraulic loading and the average hydraulic design capacity provides one indication of possible existing or potential problems associated with sewage treatment facilities, it is important to note that a number of other facilities in the Region, while not overloaded when the average hydraulic loading is compared with the average hydraulic design capacity, are experiencing serious overloading problems during peak flow periods, resulting in temporary bypassing of influent sewage and in greatly reduced efficiencies of sewage treatment. Clear water infiltration and storm water inflow into separate sanitary sewer systems are the primary causes of such peak flow bypassing and are a significant problem in many communities throughout the Region.

Table 58

PUBLIC SEWAGE TREATMENT FACILITIES OPERATING AT OR OVER AVERAGE HYDRAULIC DESIGN CAPACITIES IN THE REGION BY COUNTY: 1970

County	Name of Public Sewage Treatment Facility	Average Hydraulic Design Capacity	Average Hydraulic Loading	Percent Loading Over Design Capacity
Kenosha	Town of Bristol Utility District No. 1[1]	0.06	0.06	At Design Capacity
	Town of Somers Sanitary District No. 2	0.03	0.03	At Design Capacity
Milwaukee	City of South Milwaukee[1]	3.00	3.80	26
Ozaukee	City of Cedarburg[1]	0.90	1.26	40
	City of Port Washington[1]	1.00	1.05	5
	Village of Grafton[1]	0.45	0.80	75
	Village of Thiensville[2]	0.24	0.70	192
Racine	City of Burlington[1]	1.00	1.20	20
	Village of Union Grove[2]	0.30	0.43	35
Walworth	City of Elkhorn[2]	0.50	0.70	40
	Village of Fontana[1]	0.40	0.50	25
	Village of Walworth[2]	0.15	0.15	At Design Capacity
Washington	City of Hartford[1]	0.82	1.24	50
	Village of Jackson[2]	0.03	0.08	160
	Village of Kewaskum[1]	0.30	0.49	66
Waukesha	City of Brookfield - Fox River Plant[1]	1.00	1.66	66
	City of Oconomowoc[2]	150	1.62	8
	Village of Mukwonago[2]	0.30	0.30	At Design Capacity
	Village of Pewaukee[1]	0.30	0.40	33
	Village of Sussex[2]	0.30	0.30	At Design Capacity

[1]New or expanded treatment facilities under construction in 1972.
[2]New or expanded treatment facilities under design in 1972.
Source: SEWRPC.

It was not possible under the study to determine the number of times during 1970 that sewage treatment facilities within the Region bypassed influent sewage to the surface waters, nor was it possible to determine the number of days in the year when the average hydraulic design capacity was exceeded, thereby reducing the efficiency of treatment. Such information is rarely provided in published records of the utility systems. Furthermore, it is important to note that even where documented records are available, such as the daily sewage treatment plant flow charts, such records generally do not fully reflect total peak sewage flow because of bypassing of sewage from upstream points of overloading in the sanitary sewerage system to surface waters, which action is essential to avoid the environmental health hazards and related undesirable effects of sewage backup and storage in basements; because of bypassing at the sewage treatment plants ahead of the meter; and because of limited meter capacity. Thus, given the current status of sanitary sewerage system development and of sewage flow record keeping, it is simply not feasible to determine in a precise manner total sewage flows generated within the Region during periods of high, as opposed to average, flow. Clearly, if complete control of sewage flow is to be an objective in water quality control efforts in the coming years, changes will be needed in the way in which sewage flow is monitored, recorded, and publicly reported.

During the inventory process, appropriate officials from each community having public sanitary sewerage systems were asked to identify all known sewage overflow, or relief, points located on either the separate or combined sewerage systems in order to determine the number of points at which raw sewage is presently discharged to surface waters in the Region, particularly during periods of wet weather and peak sewage flows. The results of that inventory are presented by sewerage system and summarized by county in Table 59. Thirty of the 64 public sewage treatment facilities serving the Region had a flow relief device located at the sewage treatment plant that would allow for direct bypass of raw sewage at any time the plant capacity is exceeded or the plant is not operable for some reason. There are 536 additional known flow relief devices in the sanitary sewer systems tributary to the sewage treatment plants within the Region. Of this total, 428 have been identified in Milwaukee County.

Table 59

DISTRIBUTION OF KNOWN SEWAGE FLOW RELIEF DEVICES IN THE REGION BY SANITARY SEWERAGE SYSTEM: 1970

Sanitary Sewerage System	Sewage Treatment Plant Flow Relief Device (Yes or No and Type)	Sewage Flow Relief Devices in Sewer System: Crossovers	Bypasses	Relief Pumping Stations	Portable Pumping Stations	Combined Sewer Outfalls	Total	SEWRPC Staff Judgement of Data Reliability
Kenosha County								
City of Kenosha	Yes – Bypass	20	--	--	--	6	26	Highly Reliable
Village of Paddock Lake	Yes – Bypass	--	1	--	--	--	1	Reliable
Village of Silver Lake	No	--	--	--	--	--	--	Reliable
Village of Twin Lakes	Yes – Bypass	--	--	--	--	--	--	Reliable
Town of Bristol Utility District No. 1	Yes – Bypass	--	--	--	--	--	--	Reliable
Town of Pleasant Prairie								
Sewer Utility District No. 1	No Plant	--	--	--	--	--	--	Reliable
Sewer Utility District No. 2	No Plant	--	--	--	--	--	--	Reliable
Sewer Utility District A	No Plant	--	--	--	--	--	--	Reliable
Sewer Utility District B	No Plant	--	--	--	--	--	--	Reliable
Sewer Utility District C	No Plant	--	--	--	--	--	--	Reliable
Sewer Utility District D	Yes – Bypass	--	--	--	--	--	--	Reliable
Pleasant Park Utility Company, Inc.	Unknown	--	--	--	--	--	--	--
Town of Salem Sewer Utility District No. 1	No	--	--	--	--	--	--	Reliable
Town of Somers								
Sanitary District No. 1	No Plant	--	--	--	--	--	--	Reliable
Sanitary District No. 2	Yes – Bypass	--	--	--	--	--	--	Reliable
Subtotal	6 Bypasses	20	1	--	--	6	27	--
Milwaukee County								
Milwaukee-Metropolitan Sewerage Commissions	Jones Island Plant – No South Shore Plant – No Hales Corners Plant – Yes – Bypass	15	22	10	--	--	47	Highly Reliable
City of Cudahy	No Plant	13	5	--	--	--	18	Reliable
City of Franklin	No Plant	--	--	--	--	--	--	Highly Reliable
City of Glendale	No Plant	--	--	--	--	--	--	Highly Reliable
City of Greenfield	No Plant	--	--	1	--	--	1	Reliable
City of Milwaukee	No Plant	90	--	--	37	112	239	Highly Reliable
City of Oak Creek	No	1	--	--	--	--	1	Reliable
City of South Milwaukee	No	--	4	--	2	--	6	Reliable
City of St. Francis	No Plant	--	--	--	--	--	--	Reliable
City of Wauwatosa	No Plant	34	--	--	--	--	34	Highly Reliable
City of West Allis	No Plant	9	--	4	4	--	17	Highly Reliable
Village of Bayside	No Plant	--	1	--	--	--	1	Reliable
Village of Brown Deer	No Plant	--	--	--	2	--	2	Highly Reliable
Village of Fox Point	No Plant	8	1	2	--	--	11	Reliable
Village of Greendale	No Plant	--	--	--	--	--	--	Reliable
Village of Hales Corners	No Plant	--	4	--	1	--	5	Reliable
Village of River Hills	No Plant	--	--	--	--	--	--	Highly Reliable
Village of Shorewood	No Plant	10	--	--	--	1	11	Reliable
Village of West Milwaukee	No Plant	--	--	--	--	--	--	Reliable
Village of Whitefish Bay	No Plant	35	--	--	--	--	35	Reliable
Mission Hills Water and Sewer Trust	No	--	--	--	--	--	--	Reliable
Rawson Homes Sewer and Water Trust	Yes – Bypass	--	--	--	--	--	--	Reliable
Subtotal	2 Bypasses	215	37	17	46	113	428	--
Ozaukee County								
City of Cedarburg	Yes – Bypass	--	2	--	--	--	2	Reliable
City of Mequon	No Plant	--	--	--	1	--	1	Highly Reliable
City of Port Washington	Yes – Bypass	--	5	--	--	--	5	Highly Reliable
Village of Belgium	Yes – Bypass	--	--	--	--	--	--	Reliable
Village of Fredonia	Yes – Bypass	--	--	--	--	--	--	Reliable
Village of Grafton	Yes – Bypass	--	2	--	--	--	2	Highly Reliable
Village of Saukville	Yes – Relief Pumping Station	--	--	--	--	--	--	Highly Reliable
Village of Thiensville	No	--	1	1	1	--	3	Highly Reliable
Subtotal	1 Relief Pumping Station 5 Bypasses	--	10	1	2	--	13	--
Racine County								
City of Burlington	No	--	--	--	--	--	--	Reliable
City of Racine	Yes – Bypass	--	9	--	--	29	38	Highly Reliable
Village of North Bay	No Plant	--	--	--	--	--	--	Reliable
Village of Rochester	No Plant	--	--	--	--	--	--	Reliable
Village of Sturtevant	Yes – Bypass	--	--	--	--	--	--	Reliable
Village of Union Grove	Yes – Bypass	--	--	--	--	--	--	Reliable
Village of Waterford	No Plant	--	--	--	--	--	--	Reliable
Caddy Vista Sanitary District	Yes – Bypass	--	--	--	--	--	--	Reliable
Town of Caledonia Sewer Utility District No. 1	No Plant	--	4	--	--	--	3	Reliable
Crestview Sanitary District	No Plant	--	1	--	1	--	2	Reliable
Town of Mt. Pleasant Sewer Utility District	No Plant	--	2	--	--	--	3	Reliable
North Park Sanitary District	No	--	6	--	--	--	6	Reliable
Town of Rochester Sewer Utility District No. 1	No Plant	--	--	--	--	--	--	Reliable
Western Racine County Metropolitan Sewerage District	No	--	--	--	--	--	--	Reliable
Subtotal	4 Bypasses	--	22	--	1	29	52	--

Table 59 (continued)

Sanitary Sewerage System	Sewage Treatment Plant Flow Relief Device (Yes or No and Type)	Sewage Flow Relief Devices in Sewer System: Crossovers	Bypasses	Relief Pumping Stations	Portable Pumping Stations	Combined Sewer Outfalls	Total	SEWRPC Staff Judgement of Data Reliability
Walworth County								
City of Delavan	Yes - Bypass	--	--	--	--	--	--	Reliable
City of Elkhorn	Yes - Bypass	--	--	--	--	--	--	Reliable
City of Lake Geneva	Yes - Bypass	--	--	--	--	--	--	Reliable
City of Whitewater	No	--	1	--	--	--	1	Reliable
Village of Darien	No	--	--	--	--	--	--	Reliable
Village of East Troy	No	--	1	--	--	--	1	Reliable
Village of Fontana	No	--	--	--	--	--	--	Reliable
Village of Genoa City	No	--	--	--	--	--	--	Reliable
Village of Sharon	Yes - Bypass	--	--	--	1	--	1	Reliable
Village of Williams Bay	No	--	--	--	--	--	--	Reliable
Subtotal	5 Bypasses	--	2	--	1	--	3	--
Washington County								
City of Hartford	No	--	--	--	--	--	--	Reliable
City of West Bend	Yes - Bypass	--	--	--	--	--	--	Reliable
Village of Germantown	Old Village Plant - No County Line Plant - No	--	--	--	1	--	1	Reliable
Village of Jackson	Unknown	--	--	--	--	--	--	--
Village of Kewaskum	No	--	--	--	--	--	--	Reliable
Village of Slinger	No	--	--	--	--	--	--	Reliable
Allenton Sanitary District	Unknown	--	--	--	--	--	--	--
Newburg Sanitary District	Unknown	--	--	--	--	--	--	--
Subtotal	1 Bypass	--	--	--	1	--	1	--
Waukesha County								
City of Brookfield	Fox River Plant - Yes - Bypass Poplar Creek Lagoons - No	--	--	--	9	--	9	Highly Reliable
City of Muskego	No	--	--	--	--	--	--	Reliable
City of New Berlin	Greenridge Plant - No Regal Manors Plant - No	--	--	--	--	--	--	Reliable
City of Oconomowoc	No	--	2	--	--	--	2	Highly Reliable
City of Waukesha	Yes - Bypass	--	--	--	--	--	--	Reliable
Village of Butler	No Plant	--	1	--	--	--	1	Reliable
Village of Dousman	Yes - Bypass	--	--	--	--	--	--	Reliable
Village of Elm Grove	No Plant	--	--	--	--	--	--	Highly Reliable
Village of Menomonee Falls	Pilgrim Road Plant - Yes - Bypass Lilly Road Plant - No	--	--	--	--	--	--	Reliable
Village of Mukwonago	No	--	--	--	--	--	--	Reliable
Village of Pewaukee	No	--	--	--	--	--	--	Reliable
Village of Sussex	Yes - Portable Pumping Station	--	--	--	--	--	--	Reliable
Subtotal	1 Portable Pumping Station 5 Bypasses	--	3	--	9	--	12	--
Region Total	1 Relief Pumping Station 1 Portable Pumping Station 28 Bypasses	235	75	18	60	148	536	--

Source: SEWRPC.

It should be stressed that several problems were encountered in the conduct of this inventory which affect the findings as presented in Table 59. Appropriate officials in charge of each system were asked to list all known overflow points. In some instances such officials diligently responded to the request and reported accurately the existence of such devices where they were known. Other officials reluctantly reported limited information. Still other officials did not know if any flow relief devices existed. Consequently, the data presented in Table 59 varies in reliability and, therefore, the number of sewage flow relief devices reported in Table 59 cannot be assumed to be a reliable and accurate inventory of all such devices within the Region. Rather, the data presented represents only an approximation of the total number of such devices. To assist the reader in interpreting the data, the Commission staff has assigned one of two reliability ratings to each data entry in the table, either "highly reliable," indicating that such data have resulted from link-by-link sewer system surveys, or "reliable," indicating that, in the staff judgment, local officials have reported all known data, although no specific effort to survey sewer systems on a link-by-link was made. No reliability rating has been entered in those few instances where local officials indicated a lack of knowledge concerning flow relief devices.

Particularly good records of the existence of such devices were found in several municipalities within Milwaukee County and may account, therefore, for the preponderance of such devices allocated to Milwaukee County in Table 59. It should be recognized, however, that the sewer service area in Milwaukee County approximates 57 percent of the total area served in the Region, that the Milwaukee County sewerage systems are among the oldest in the Region, and that, therefore, it is to be expected that the majority of sewage flow relief devices would be found to occur in Milwaukee County. Of the 536 such devices in the Region, not including bypasses or relief pumping stations at sewage treatment plants, 148 are combined sewer outfalls located in the Cities of Kenosha, Milwaukee, and Racine and the Village of Shorewood; 235 are gravity crossovers from the separate sanitary sewer system to a storm sewer system; 75 are gravity bypasses from the separate sewer system directly to surface watercourses; 18 are relief pumping stations, pumping sewage from the separate sanitary sewer system directly to surface watercourses; and 60 are portable pumping stations also utilized to pump sewage from the separate sewer system directly to surface watercourses. Ideally, all sewage flow relief points on the separate sanitary sewer system would be eliminated through the construction of relief sewers and, as necessary, the provision of additional treatment plant capacity. The combined sewer outfalls pose a special problem in that combined sewer overflows need to be either collected at the outfall points and conveyed, either directly or after temporary storage, to either one or more special treatment facilities, or eliminated through a sewer separation program.

In addition to identifying all existing public and private sewage treatment plants which discharge treated wastes to streams and watercourses within the Region, and all known sewage overflow points on both the existing sanitary and combined sewerage systems within the Region which discharge untreated wastes to streams and watercourses, an attempt was made in the regional sanitary sewerage system planning program to identify, through existing secondary sources, all other known point sources of waste water discharge. These other point sources of pollution consist primarily of industrial cooling, rinse, and wash waters, which may be discharged directly and without treatment to streams and watercourses or to storm sewers tributary to such streams and watercourses. The secondary sources consulted included river basin survey reports and pollution abatement orders of the Wisconsin Department of Natural Resources and records of municipal public works departments. A total of 158 such known point sources of industrial waste water were identified in the Region, of which five are located in Kenosha County, 87 in Milwaukee County, four in Ozaukee County, 31 in Racine County, three in Walworth County, eight in Washington County, and 20 in Waukesha County (see Map 46).

An important aspect of the inventory of existing sanitary sewerage systems in the Region relates to sewerage system expenditures. It was initially intended to develop a time series of such expenditures utilizing the uniform audit reports required by the Wisconsin Department of Administration, Bureau of Municipal Audit. A review of these reports revealed, however, obvious nonuniformity of reporting, including in some cases nonreporting, particularly with respect to capital versus operating and maintenance expenditures. The audit reports were not considered, therefore, to be reliable for the purpose of tabulating accurately expenditures made over a period of years in each of the 97 centralized sanitary sewerage systems in the Region. Accordingly, it was determined to pursue an alternate means of obtaining accurate and reliable data for one year directly from the local public officials responsible for management of each sanitary sewerage system. The results of that inventory are presented in summary form in Table 60.

Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the sanitary sewerage systems in the Region approximated $43.1 million, or about $29 per capita, such per capita cost based upon the estimated total population within the Region served by sanitary sewers. Of this total, about $9.4 million, or about $6 per capita, was expended for operation and maintenance and about $33.7 million, or about $23 per capita, was expended for capital improvements. Total expenditures during 1970 on a per capita basis ranged from a low of $4 per capita in the Village of Mukwonago to a high of $463 per capita in the City of Franklin. Capital expenditures during 1970 on a per capita basis ranged from a low of $1 per capita in the Village of Mukwonago to a high of $462 per capita in the City of Franklin. Operation and maintenance expenditures during 1970 on a per capita basis ranged from a low of $1 per capita in the Cities of Franklin and Muskego to a high of $45 per capita in the Village of Dousman.

Table 60

ESTIMATED SANITARY SEWERAGE EXPENDITURES IN THE REGION BY PUBLIC SANITARY SEWERAGE SYSTEM: 1970

Public Sanitary Sewerage System	Estimated Population Served	Sanitary Sewerage Expenditures: Operation and Maintenance		Capital Improvements Including Debt Retirement		Total		Code Number on Figure 84
		Dollars	Dollars Per Capita	Dollars	Dollars Per Capita	Dollars	Dollars Per Capita	
Kenosha County								
City of Kenosha	80,900	378,494	5	588,174	7	966,668	12	1
Village of Paddock Lake	1,500	N/A	N/A	N/A	N/A	N/A	N/A	- -
Village of Silver Lake	1,200	14,944	12	65,756	55	80,700	67	2
Village of Twin Lakes	1,700	15,651	9	29,000	17	44,651	26	3
Town of Bristol Utility District No. 1	500	4,744	9	61,337	123	66,081	132	4
Town of Pleasant Prairie								
Sewer Utility District No. 1	1,400	15,975	11	8,062	6	24,037	17	5
Sewer Utility District No. 2	600	11,485	19	23,395	39	34,880	58	6
Sewer Utility District A	400	1,850	5	7,365	18	9,215	23	7
Sewer Utility District B	900	2,904	3	6,285	7	9,189	10	8
Sewer Utility District C	400	2,204	5	6,658	17	8,862	22	9
Sewer Utility District D	800	10,071	13	35,244	44	45,315	57	10
Pleasant Park Utility Company, Inc.	800	2,230	3	1,635	2	3,865	5	11
Town of Salem Sewer Utility District No. 1	800	N/A	N/A	N/A	N/A	N/A	N/A	- -
Town of Somers								
Sanitary District No. 1	1,700	22,894	13	36,363	22	59,257	35	12
Sanitary District No. 2	400	3,318	8	5,776	15	9,094	23	13
Subtotal	94,000[1]	486,764	5	875,050	10	1,361,814	15	- -
Milwaukee County[1]								
City of Cudahy	22,000	183,161	8	353,093	16	536,254	24	14
City of Franklin	2,600	2,402	1	1,201,189	462	1,203,591	463	15
City of Glendale	18,700	96,322	5	388,891	21	485,213	26	16
City of Greenfield	21,800	138,913	6	1,984,291	91	2,123,204	97	17
City of Milwaukee	703,700	4,350,628	6	12,442,192	18	16,792,820	24	18
City of Oak Creek	10,600	103,061	10	2,553,786	241	2,656,847	251	19
City of South Milwaukee	23,300	92,883	4	213,869	9	306,752	13	20
City of St. Francis	11,200	61,734	5	63,402	6	125,136	11	21
City of Wauwatosa	59,500	234,524	4	811,456	14	1,045,980	18	22
City of West Allis	78,200	303,037	4	1,750,270	22	2,053,307	26	23
Village of Bayside	3,900	28,601	7	61,284	16	89,885	23	24
Village of Brown Deer	12,500	43,496	3	260,204	21	303,700	24	25
Village of Fox Point	8,600	34,869	4	125,895	15	160,764	19	26
Village of Greendale	14,700	92,323	6	214,280	15	306,603	21	27
Village of Hales Corners	7,300	59,395	8	180,411	25	239,806	33	28
Village of River Hills	1,900	17,620	9	55,998	30	73,618	39	29
Village of Shorewood	12,600	61,629	5	152,247	12	213,876	17	30
Village of West Milwaukee	5,600	124,915	22	209,345	38	334,260	60	31
Village of Whitefish Bay	14,900	71,556	5	187,004	12	258,560	17	32
Mission Hills Water and Sewer Trust	500	3,829	8	6,600	13	10,429	21	33
Rawson Homes Sewer and Water Trust	600	3,550	6	- -	- -	3,550	6	34
Subtotal	1,034,700	6,108,448	6	23,215,707	22	29,324,155	28	- -
Ozaukee County								
City of Cedarburg	8,000	37,500	5	25,000	3	62,500	8	35
City of Mequon	6,600	47,849	7	598,208	91	646,057	98	36
City of Port Washington	8,800	24,952	3	157,875	18	182,827	21	37
Village of Belgium	800	8,082	10	5,038	6	13,120	16	38
Village of Fredonia	1,000	N/A	N/A	N/A	N/A	N/A	N/A	- -
Village of Grafton	6,400	15,055	2	121,840	19	136,895	21	39
Village of Saukville	1,100	17,045	16	9,105	8	26,150	24	40
Village of Thiensville	3,600	28,778	8	71,120	20	99,898	28	41
Subtotal	36,300[1]	179,261	5	988,186	28	1,167,447	33	- -
Racine County								
City of Burlington	7,500	45,163	6	193,851	26	239,014	32	42
City of Racine	95,400	599,920	6	2,996,884	32	3,596,804	38	43
Village of North Bay	1,000	N/A	N/A	N/A	N/A	N/A	N/A	- -
Village of Rochester[3]	500	8,449	17	26,651	53	35,100	70	44
Village of Sturtevant	3,200	20,822	6	11,300	4	32,122	10	45
Village of Union Grove	2,800	37,538	13	59,955	21	97,493	34	46
Village of Waterford[3]	1,800	53,500	30	N/A	N/A	53,500	30	47
Caddy Vista Sanitary District	1,200	12,465	10	8,438	7	20,903	17	48
Caledonia Sewer Utility District No. 1	3,500	44,480	12	86,502	25	130,982	37	49
Crestview Sanitary District	1,500	15,518	10	94,000	63	109,518	73	50
Mt. Pleasant Sewer Utility District	10,300	199,700	19	273,424	27	473,124	46	51
North Park Sanitary District	7,000	39,069	6	56,500	8	95,569	14	52
Town of Rochester Sewer Utility District No. 1[3]	200	4,142	21	32,582	163	36,724	184	53
Subtotal	135,900[1]	1,080,766	8	3,840,087	28	4,920,853	36	- -

Table 60 (continued)

Public Sanitary Sewerage System	Estimated Population Served	Sanitary Sewerage Expenditures: Operation and Maintenance: Dollars	Operation and Maintenance: Dollars Per Capita	Capital Improvements Including Debt Retirement: Dollars	Capital Improvements Including Debt Retirement: Dollars Per Capita	Total: Dollars	Total: Dollars Per Capita	Code Number on Figure 84
Walworth County								
City of Delavan	5,400	N/A	N/A	N/A	N/A	N/A	N/A	- -
City of Elkhorn	4,000	25,843	7	224,583	56	250,426	63	54
City of Lake Geneva	4,700	65,153	14	48,000	10	113,153	24	55
City of Whitewater	12,000	83,581	7	52,338	4	135,919	11	56
Village of Darien	900	N/A	N/A	N/A	N/A	N/A	N/A	- -
Village of East Troy	1,700	11,734	7	23,519	14	35,253	21	57
Village of Fontana	1,600	20,800	13	36,877	23	57,677	36	58
Village of Genoa City	900	9,457	11	24,361	27	33,818	38	59
Village of Sharon	1,200	12,820	11	13,218	11	26,038	22	60
Village of Walworth	1,600	N/A	N/A	N/A	N/A	N/A	N/A	- -
Village of Williams Bay	1,500	31,015	21	20,885	14	51,900	35	61
Subtotal	35,500[1]	260,403	9	443,781	16	704,184	25	- -
Washington County								
City of Hartford	6,800	51,580	7	65,264	10	116,844	17	62
City of West Bend	16,400	91,851	5	223,771	14	315,622	19	63
Village of Germantown	2,400	42,981	18	454,014	189	496,995	207	64
Village of Jackson	600	N/A	N/A	N/A	N/A	N/A	N/A	- -
Village of Kewaskum	1,900	16,650	9	14,954	8	31,604	17	65
Village of Slinger	1,000	N/A	N/A	N/A	N/A	N/A	N/A	- -
Allenton Sanitary District	700	10,329	15	9,000	13	19,329	28	66
Newburg Sanitary District	400	7,871	20	10,896	27	18,767	47	67
Subtotal	30,200[1]	221,262	8	777,899	26	999,161	34	- -
Waukesha County								
City of Brookfield	20,800	220,758	11	445,816	21	666,574	32	68
City of Muskego	4,500	6,908	1	1,233,340	275	1,240,248	276	69
City of New Berlin	8,700	206,869	24	21,600	2	228,469	26	70
City of Oconomowoc	9,500	50,000	5	74,708	8	124,708	13	71
City of Waukesha	40,700	221,905	5	911,133	23	1,133,038	28	72
Village of Butler	2,100	39,922	19	20,883	10	60,805	29	73
Village of Dousman	600	26,834	45	7,274	12	34,108	57	74
Village of Elm Grove								
Sanitary District No. 1	3,900	49,151	13	33,640	8	82,791	21	75
Sewerage District No. 2	2,700	21,498	8	199,673	74	221,171	82	76
Village of Hartland	2,900	N/A	N/A	N/A	N/A	N/A	N/A	- -
Village of Menomonee Falls	17,400	141,869	8	517,552	30	659,421	38	77
Village of Mukwonago	2,600	8,123	3	1,233	1	9,356	4	78
Village of Pewaukee	2,900	35,977	12	43,666	15	79,643	27	79
Village of Sussex	2,800	24,086	8	21,719	8	45,805	16	80
Subtotal	122,100[1]	1,053,900	9	3,532,237	29	4,586,137	38	- -
Region Total	1,488,700	9,390,804	6	33,672,947	23	43,063,751	29	- -

NOTE: N/A indicates data not available.

[1]In calculating the per capita costs on a county basis, only that aggregate population in those communities providing expenditure data was included.

[2]The expenditures noted for each of the communities included in the Metropolitan Sewerage District of the County of Milwaukee, which includes all municipalities in Milwaukee County except the City of South Milwaukee, include expenditures for the Milwaukee-metropolitan sanitary sewerage system apportioned back to the municipalities in the District. Capital improvement costs for the metropolitan system were prorated back to the communities based upon equalized assessed valuation. Operation and maintenance costs for the metropolitan system were prorated back to the communities based upon sewage flow.

[3]Includes expenditures related to operation, maintenance, and capital improvements for the Western Racine County Sewerage District.

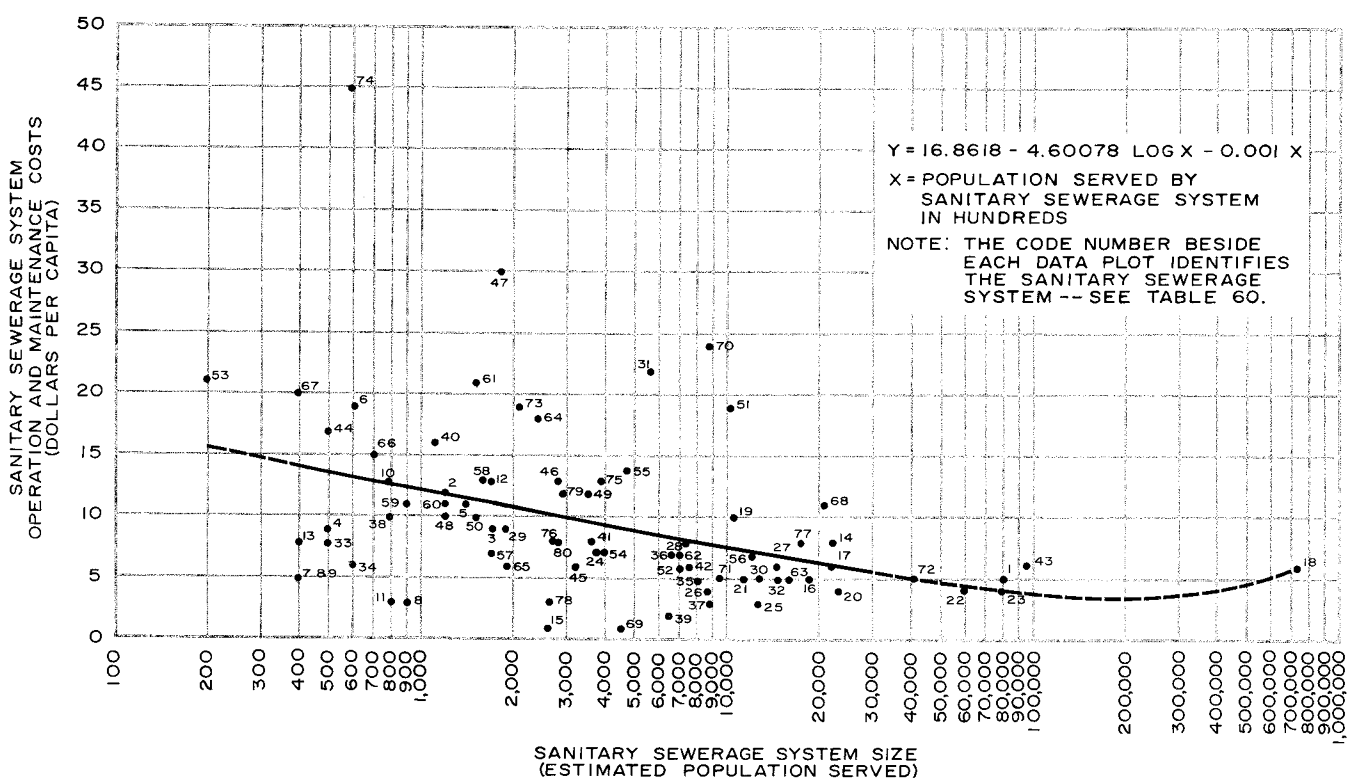
Source: SEWRPC.

The data presented in Table 60 represent the cost records as maintained by each municipality and reported directly to the Commission. Caution should be exercised in utilizing the data to make comparisons on a community-by-community basis. There is no assurance that the data have been reported on a strictly uniform basis. For example, different criteria may have been used locally to determine whether to report a given expenditure as a capital expenditure or as an operation and maintenance cost; hence, similar expenditures in two communities may be reported as a capital cost in one community and an operation and maintenance cost in the other community. Also, in some cases communities may have included in their reports operation, maintenance, and/or capital costs directly related to storm sewerage systems. In addition to these problems of nonuniformity of reporting, it must be realized that the data presented in no way reflect the level of the sewerage service being provided, particularly with respect to the level of treatment provided. It also should be recognized that those communities currently undergoing rapid development or redevelopment may be experiencing disproportionately high expenditures for capital improvements. For example, the very high per capita capital improvement costs noted in 1970 in the Cities of Franklin and Oak Creek include contract expenditures during calendar year 1970 for very large sewerage projects. It may well be that while such expenditures were made during the year, actual payments for such improvements will be extended over a period of time through bonding procedures. Similarly, it should be noted that the distribution of land uses within communities affects per capita costs. For example, there is a relatively high per capita operation and maintenance cost for the Village of West Milwaukee. This is to be expected since the village experiences high sewage flows due to the large amount of industrial and commercial land use development within the community, coupled with a relatively low resident population.

While the data presented in Table 60 relate only to one year and, therefore, with respect to data for any given individual sanitary sewerage system are subject to the aforementioned qualifications in utilization of the data in making comparisons of variations in sewerage costs between communities, it is reasonable to assume that, because they include both average and extreme situations, the county and regional averages represent valid per capita costs for a typical year. This would be particularly true with respect to the operation and maintenance costs. As noted above, the average per capita cost for operation and maintenance of sanitary sewerage systems during 1970 in the Region was $6. On a county basis such per capita costs ranged from $5 in Kenosha and Ozaukee Counties to $9 in Walworth and Waukesha Counties. The per capita operation and maintenance costs for each reporting system in the Region during 1970 are depicted in a scatter diagram reproduced as Figure 84. From this it may be concluded that, in general, operation and maintenance costs for sanitary sewerage systems decrease with increasing system size.

Figure 84

RELATIONSHIP BETWEEN SANITARY SEWERAGE OPERATION AND MAINTENANCE EXPENDITURES AND SEWERAGE SYSTEM SIZE IN THE REGION: 1970



Source: SEWRPC.

The foregoing per capita costs developed for the Region as a whole may be compared with the national average per capita costs developed for the U. S. Environmental Protection Agency (EPA). In a recent report published by the EPA[17] the average annual per capita cost for operation and maintenance of centralized sanitary sewerage systems was estimated, in 1968 dollars, at $4.50. Given the effects of inflation since 1968 and the precision with which the data were collected for the national and regional studies, this figure is comparable to the regional average of $6 per capita for operation and maintenance of centralized sanitary sewerage systems for the year 1970. Similarly, the regional average of $23 per capita for capital improvements during 1970 may be compared with a national average of about $15.30 per capita for the year 1968.

As noted earlier, centralized sanitary sewerage systems in the Region serve a total area of about 309 square miles, or about 11 percent of the total area of the Region, and a total population of nearly 1.5 million, or nearly 85 percent of the total population of the Region. The remaining 15 percent of the total Region population, or about 268,000 persons, rely on septic tank sewage disposal systems for domestic sewage disposal. About 27,000 of these persons are reported in the U. S. Census of Population as living on farms. The remaining 241,000 persons constitute urban dwellers generally living in scattered fashion throughout the rural and rural-urban fringe areas of the Region. Of this total, about 139,000 persons, or about 8 percent of the total regional population, reside in significant concentrations of urban development (see Table 61). These scattered urban concentrations total about 61 square miles of urban land use, or slightly over one-fifth of the area of the Region (see Map 46).

As already noted, an inventory was also conducted of all local plans and engineering reports relating to the future provision of sanitary sewer service in the Region. As shown in Table 62, local units of government in the Region have proposed the extension of sanitary sewer service to about an additional 447 square miles of land throughout the Region. This can be compared to the approximately 309 square miles of area in the Region now served by centralized sanitary sewers. If it is assumed that urban development would take place throughout the locally proposed sewer service area at an average overall population density equal to 5,000 persons per square mile, the average population density for new development as

[17] *Cost to the Consumer for Collection and Treatment of Wastewater*, Water Pollution Control Research Series, U. S. Environmental Protection Agency, July 1970.

Table 61

EXISTING POPULATION NOT SERVED BY CENTRALIZED PUBLIC SANITARY SEWERS IN THE REGION BY COUNTY: 1970

County	Unsewered Urban Development[1]					Rural Population[2]			
	Population			Square Miles		Farm		Non-Farm	
	Number	Percent of Total Urban Population	Percent of Total Population	Number	Percent of Total Urban Area	Number	Percent of Total Population	Number	Percent of Total Population
Kenosha	11,800	11.2	10.0	5.6	18.7	3,297	2.8	9,220	7.8
Milwaukee	12,700	1.2	1.2	4.5	2.5	- -	- -	7,349	0.7
Ozaukee	4,900	11.9	9.0	2.5	12.6	3,124	5.7	10,137	18.0
Racine	11,800	7.9	7.0	4.7	13.3	4,613	2.6	18,525	10.8
Walworth	13,500	27.6	21.0	9.8	45.3	5,779	9.1	8,765	13.6
Washington	9,600	24.0	15.0	4.0	30.0	6,677	10.5	17,262	27.0
Waukesha	74,800	38.0	31.6	30.0	47.0	3,930	1.5	30,508	13.0
Region	139,100	8.5	7.5	61.1	16.6	27,420	1.6	101,766	5.8

[1]*Urban development is defined in this context as concentrations of urban land uses within any given U.S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

[2]*For the purposes of this study, rural population has been divided into "farm" and "non-farm." The rural farm population includes all those persons enumerated as such by the U.S. Bureau of the Census and includes all persons living on actively operating farms. The rural non-farm population shown in this Table is less than the rural non-farm population as enumerated by the Bureau of the Census, since many persons classified as rural non-farm by the Bureau live in the urban development areas as defined in footnote above. The rural non-farm population shown in this Table is a residual number derived in the following manner: A = B - (C + D + E)*

where: A = Rural non-farm population
B = Total population
C = Population served by public sanitary sewers
D = Population attributed to "unsewered urban development"
E = U.S. Census rural farm population

Source: SEWRPC.

Table 62

LOCALLY PROPOSED ADDITIONAL SANITARY SEWER SERVICE AREAS IN THE REGION BY COUNTY: 1970

County	Proposed Sewer Service Area	
	Square Miles	Percent of County
Kenosha	51.96	18.7
Milwaukee	56.72	23.4
Ozaukee	35.57	15.2
Racine	63.95	18.8
Walworth	39.32	6.8
Washington	40.21	9.2
Waukesha	158.90	27.4
Region	446.63	16.6

Source: SEWRPC.

recommended in the adopted regional land use plan, the locally proposed sewer service area could be expected to accommodate a future population increment of about 2.2 million persons. Thus, locally proposed sewer service areas in the Region already contain enough area to more than double the population of the Region. Even the most optimistic population forecasts indicate an increase in the population of the Region over the next 20-year period of no more than one million persons. Clearly, there is a need to better coordinate land use development with sewer service. The most appropriate vehicle for providing such coordination is the adopted regional land use plan.

(This page intentionally left blank)

Chapter VI

SEWAGE CHARACTERISTICS

INTRODUCTION

The planning and design of sanitary sewerage systems involve careful consideration of many factors, including existing and probable future service areas; existing and probable future land use development patterns; existing and probable future population levels, densities, characteristics, and distributions; and the anticipated physical life of the various components of the total system. Of particular importance among these considerations are the characteristics of the sewage to be collected and treated, including the rate and volume of flow and the concentrations of contaminants. Since municipal sewage is commonly a mixture of domestic and industrial wastes, sewage flows and strengths vary with the land use pattern and population characteristics of the service area. The presence of certain types of industrial land uses particularly may affect sewage flows and strengths. The characteristics of the sewerage system itself may also affect sewage flows and strengths.

Sewage flow rates are used to determine the size of sewers, lift and pumping stations, and sewage treatment plants. Flow volumes and sewage strengths are used to establish the type and level of treatment required to meet established stream and lake water use objectives and supporting water quality standards. For sanitary sewerage system planning purposes, flow rates are normally expressed in gallons per minute (gpm), million gallons per day (mgd), or cubic feet per second (cfs). Flow volumes are normally expressed in millions of gallons (mg).

Sewage strength is also a factor in the determination of the size of sewage treatment plants and of the type and level of treatment to be provided. Such strength is a measure of the concentration of contaminants present in the sewage, and is usually expressed in milligrams per liter (mg/l) or parts per million (ppm) of selected measures of the pollutants or contaminants present, such as of oxygen-demanding organic matter, suspended solids, or various nutrients. The total amount of any pollutant or contaminant present in sewage can be calculated once the concentration of the pollutants or contaminants and the volume of sewage have been established.

The cost of sewage treatment will be determined, in part, by sewage strength characteristics and the degree of treatment required before discharge to the receiving environment. High-strength or low-strength sewage may require the use of different types of treatment processes than those normally used for treating more common medium-strength sewage. Unless the sewage effluent is to be discharged to the land either through seepage ponds or irrigation, the type and degree of treatment is largely determined by the volume and quality of the receiving waters, the desired or prescribed use of the receiving waters, and the volume and strength of the raw sewage. Thus, the costs of sewage treatment will be determined by both sewage flow and strength characteristics, while the costs of sewage conveyance facilities will be largely determined by flow characteristics together with the land use, topographic, and soil conditions in the service area.

This chapter describes the results of investigations that were made under the regional sanitary sewerage system planning program to determine the flow and strength characteristics of sewage generated within the Region for regional sanitary sewerage system planning purposes. Such characteristics were then utilized together with accepted engineering standards as the basis for the selection of the sewerage system design criteria discussed in Chapter IX of this report.

SEWAGE FLOW COMPONENTS

The principal sources of sanitary sewage are spent municipal water supply, groundwater infiltration, and storm water inflow. Sanitary sewage flow rates for design purposes must, therefore, include allowances for the nonwaste components which inevitably become a part of the total sewage flow, as well as for the waste component of the total flow. Within the Region, the quantity of sewage derived from spent municipal water supplied to residential, commercial, industrial, institutional, and other consumers usually corresponds closely to the quantity of water supplied. The one major exception occurs during the summer season when relatively large volumes of water may be used for lawn sprinkling and cooling purposes.

Clear water enters the sewerage system both as groundwater infiltration through cracked pipes, defective joints and faulty manholes, and as storm and flood waters which may enter the sewerage system directly through submerged manhole covers or through illegally connected roof and foundation drains which the operating agency has been unable, or unwilling, to eliminate. Storm water soaking into the soil may also accelerate the rate of infiltration at sewer and manhole joints. The only other significant source of clear water entering the sanitary sewerage system is storm water in areas served by combined rather than separate storm water and sanitary sewers. Combined sewer systems presently exist within and serve parts of only five communities within the Region—the Cities of Kenosha, Milwaukee, Port Washington, and Racine, and the Village of Shorewood—and, therefore, cannot be considered typically a part of the existing sewerage systems within the Region.[1] No new combined sewer systems are being constructed within the Region. In addition, in urban renewal areas where clearance and replacement of the existing buildings and related land use activities are involved, new separate storm and sanitary sewers are generally installed. Therefore, flow data from sewerage systems having combined sewer service areas, although investigated in the regional sanitary sewerage system planning program, were considered atypical in the determination of sewage flow and strength characteristics for system planning purposes.

In order to permit the ready and convenient derivation of sewage flows from adopted regional and subregional land use plans, it was decided to establish design criteria which relate annual average sewage flows to the major land use categories used in the adopted land use plans. This required the establishment of unit design flow criteria for five major land use categories: high-density general urban development, medium-density general urban development, low-density general urban development, major commercial concentrations, and major industrial concentrations. It should be noted that these land use categories are gross in nature, in that they also contain, as appropriate, related supporting land uses such as streets and highways, railroads, parks and open spaces, institutions, and minor commercial and industrial establishments. The establishment of these unit design flow criteria, in turn, required investigation and analyses of the sewage flows generated by comparable existing land uses.

In order to permit individual consideration in the development of the design criteria of the major factors involved, the amount of sewage flow presently generated from the following sources was investigated:

1. The amount of sewage flow contributed by all general urban land uses except major commercial and industrial concentrations. These land uses would include all residential, minor commercial, institutional, governmental, minor industrial, and other land uses within the sewer service area. Flows from such land uses vary with the resident population level, and the relationship between land use and sewage flow was, therefore, expressed on a per capita basis; that is, in terms of gallons per capita per day. It should be noted that this approach incorporates consideration of population density as well as population level.

2. The amount of sewage flow contributed by major commercial concentrations. Since such flows are not related to resident population levels, but to the amount and type of commercial activity, the desired relationship was expressed on an areal basis; that is, in terms of gallons per acre per day.

3. The amount of sewage flow contributed by major industrial concentrations. Such flows, like commercial flows, being related to the amount and type of industrial activity, were also expressed on an areal basis, in terms of gallons per acre per day.

---

[1] *The characteristics of each of the five combined sewer systems in the Region, as well as planning and engineering studies and demonstration programs completed or underway as integral parts of local efforts to abate water pollution caused by combined sewer overflows, are described in Chapter V of this report.*

4. The amount of sewage flow contributed by clear water infiltration through manholes, sewer joints, and cracks. Since the length of sewer and, therefore, the number of joints and manholes varies approximately with the area served, this desired relationship was expressed on an areal basis, in terms of gallons per minute per acre.

5. The amount of sewage flow contributed by storm water inflow both through manholes and connected building roof and foundation drains. This relationship was also expressed on an areal basis in terms of gallons per minute per acre.

The first three of the foregoing sewage flow contributions were first analyzed on an annual average daily basis. Then peak-to-average flow rates were investigated, the flow contributions by infiltration and storm water inflows being separately analyzed on a dry weather-wet weather basis, respectively.

To provide a basis for the selection of the design criteria, inventories were conducted of water consumption and sewage flow at selected communities within the Region. These data were then analyzed to determine the amount of sewage flow that is currently contributed by each of the five major land use and flow categories noted above, as well as to determine the peak-to-average flow ratios. The results of these inventories are presented in the following discussion. The actual design criteria selected for use in the regional sanitary sewerage system planning program, which criteria are based upon not only the data presented in this chapter, but upon widely accepted engineering standards as revealed by a careful review of the literature, and upon experienced local engineering judgement incorporated through the careful review of the preliminary criteria by the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning, are presented in Chapter IX of this report. It should be noted that the design criteria were specifically developed for regional sewerage system planning purposes. The design of local sanitary sewerage facilities and systems may require more detailed sewage flow analyses based upon consideration of specific industrial, institutional, commercial, and other land uses to be served, as well as of the varying local infiltration and storm water inflow conditions.

As already noted with the exceptions previously discussed, virtually all of the water delivered by municipal water supply systems becomes sanitary sewage. For analytical purposes, therefore, it was assumed that sewage flow would exceed water delivery by an amount equal to the sum of groundwater infiltration and storm water inflows. Water use and sewage flow data from the seven county seats in the Region—from the Cities of Elkhorn, Kenosha, Milwaukee, Port Washington, Racine, Waukesha, and West Bend—were selected for use in the analyses in order to provide data representing a broad but representative range of community size, type, and geographic location. The selected communities range in population from about 4,000 to more than 700,000 persons and have well-established municipal water supply and sanitary sewerage systems with fairly complete records of water delivery and sewage flow. The water consumption and sewage flow data for the year 1970 for each of the selected communities are presented in Table 63. Water consumption and sewage flow data for the 11-year period from 1960 through 1970 are presented in Tables 64 and 65, respectively. It is apparent from these data that water consumption and sewage flow in 1970 conform reasonably well to the pattern established in the 11-year time series, and that, therefore, 1970 was not an atypical year and can be appropriately used for analytical purposes.

Domestic Sewage Flows

For convenience in data presentation and analysis, water use, and sewage flow data in Table 63 have been separated into two categories, namely "industrial" and "domestic." The domestic flows include water consumption by and estimated sewage received from all residential, commercial, institutional, and governmental land uses within the sewer service area. The industrial category includes all municipal water supply delivered to industrial land uses. This assumption that industrial sewage flow is approximately equal to municipal water supply delivered is generally true within the Region and is the result of a historic policy of the state, which required all industrial waste flows and industrial cooling waters in urban areas to be discharged to the municipal sewerage system. Major exceptions to this assumption, as revealed by the inventories conducted under the study, are noted in Table 63 and were accounted for in the analyses. The data presented in Table 63 generally show that there is a relatively constant ratio of water delivered to sewage received, and that water consumption

Table 63

WATER CONSUMPTION AND SEWAGE FLOW RELATIONSHIPS IN SELECTED COMMUNITIES IN THE REGION: 1970

Selected Community	Water Consumption: Water Delivered[1] Total (mgd)	Water Delivered[1] Metered Industrial (mgd)	Water Delivered[1] Domestic[2] (mgd)	Estimated Service Area Population[3]	Per Capita Relationship: Total Water Delivered (gpcd)	Per Capita Relationship: Domestic Water Delivered (gpcd)	Sewage Flow: Sewage Received Total (mgd)	Sewage Received Estimated Industrial[4] (mgd)	Sewage Received Domestic (mgd)	Estimated Service Area Population[3]	Per Capita Relationship: Total Sewage Received (gpcd)	Per Capita Relationship: Domestic Sewage Received (gpcd)	Ratio of Water Delivered to Sewage Received (Based on Per Capita Relationships): Total Flow	Ratio: Domestic Flow
City of Elkhorn	0.39	0.08	0.31	3,992	98	78	0.70[5]	0.08	0.62	4,000	175	155	0.560	0.503
City of Kenosha[6]	12.69[7]	5.63	7.06	81,300[8]	156	87	16.26[9]	4.50	11.76	86,300[10]	188	136	0.830	0.640
City of Milwaukee[6]	127.52	54.01	73.51	717,372	178	103	134.00[11]	54.01	79.95	703,700	190	114	0.937	0.904
City of Port Washington[6]	0.96	0.28	0.68	8,752	110	78	1.05[12]	0.28	0.77	8,800	119	88	0.924	0.886
City of Racine[6]	14.48	5.82	8.66	95,162	152	91	21.70[13]	9.10	12.60	110,200[14]	197	114	0.772	0.798
City of Waukesha	7.72	4.21	3.51	40,274	192	87	8.28[11]	4.21	4.07	40,700	203	100	0.946	0.870
City of West Bend	2.70	1.19	1.51	16,555	163	91	2.27[11]	0.91	1.36	16,400	138	83	1.181	1.096
Average	—	—	—	—	150	88	—	—	—	—	173	113	—	—

[1]From 1970 annual reports submitted by the water utilities to the Wisconsin Public Service Commission. Includes only the water consumed in the indicated civil division; all water sold "for resale" or "wholesale" or sold retail outside the civil division has been excluded.

[2]Includes residential, commercial, and public authority water users.

[3]1970 U. S. Census of Population.

[4]Industrial sewage flow was assumed to be equal to the metered industrial water consumption except in the Cities of Kenosha, Racine, and West Bend. In West Bend an estimated 280,000 gallons per day of metered industrial water was discharged directly to the Milwaukee River as spent cooling water by Line Material Industries-McGraw Edison Company and the West Bend Company (estimates based on data provided by Mr. R. McQuiggin, Safety Director, Line Material Industries, and Mr. L. W. Hillman, Director of Industrial and Plant Engineering, West Bend Company). In Kenosha industrial waste flows were estimated at 4.50 mgd in a Report on Kenosha Water Pollution Control Plant—Phosphorus Removal and Oil, Grease, and Sludge Removal, Alvord, Burdick, and Howson, Chicago, Illinois, 1971. In Racine industrial waste flows were estimated at 9.10 mgd in an Engineering Report on Wastewater Treatment Facilities - Racine, Wisconsin, Consoer, Townsend and Associates, Chicago, Illinois, 1970.

[5]Data provided by sewage treatment plant operator.

[6]Portion of community is served by a combined sewer system.

[7]Includes the City of Kenosha and a portion of the Town of Pleasant Prairie served on a retail basis by the City of Kenosha.

[8]Includes an estimated 2,500 persons residing in water service contract areas in the Town of Pleasant Prairie.

[9]From the 1970 Annual Report of the Kenosha Water Utility.

[10]Includes 5,400 persons residing in sewer service contract areas in the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C and in the Town of Somers Sanitary District No. 1.

[11]Data provided by operating staff of the Sewerage Commission of the City of Milwaukee.

[12]From the 1970 Annual Report submitted by the sewage treatment plant operator to the Wisconsin Department of Natural Resources.

[13]From the 1970 Annual Report of the City of Racine Water Pollution Control Division.

[14]Includes 14,800 persons residing in sewer service contract areas in the Village of North Bay, the Town of Caledonia Sewer Utility District No. 1, and the Town of Mt. Pleasant Sewer Utility District.

Source: SEWRPC.

can be assumed to be roughly equivalent to sewage flow in the estimation of design criteria for areawide sanitary sewerage system planning.

The water delivered for domestic consumption can most conveniently be expressed in gallons per capita per day (gpcd). As shown in Table 63, domestic water consumption at the selected communities in the Region ranged from 78 gpcd in the Cities of Elkhorn and Port Washington to 103 gpcd in the City of Milwaukee. Domestic water consumption in the Region, based on an average of the consumption rates in the seven selected communities, is 88 gpcd. If the total amount of water consumed for domestic purposes in the selected communities is summed and the result divided by the total population in the selected communities, an estimated domestic water consumption rate of 99 gpcd is obtained. This latter estimate reflects the higher per capita water consumption rates found in the larger urban communities in the Region. As shown in Table 64, the average domestic water consumption rate in 1960 is estimated at 67 gpcd, thus indicating an increasing per capita domestic water consumption in the Region over the past 10 years. Domestic sewage flows are also shown in Table 63 for each of the selected communities. The total flows represent gaged flows at the treatment plants. Domestic flows were estimated by subtracting industrial waste flows—generally assumed to be equal to metered industrial water consumption—from total flows. The domestic flows so estimated then provided the basis for computing the per capita domestic flows. It should be noted that the per capita flows so computed include varying amounts of infiltration, storm water inflow, and the addition of any spent water originally supplied by private water systems.

Industrial Sewage Flows

Table 66 presents the relationship between the estimated total industrial sewage flow, as determined from Table 63, and the total amount of industrial land use in the selected communities. The estimated industrial sewage flow rates range from 1,430 gallons per acre per day in the City of Elkhorn to 24,660 gallons per acre per day in the City of Racine. In general, the larger and older the community, the greater the estimated industrial sewage flow rate in terms of gallons per acre per day. Industrial sewage flow in the

Table 64

WATER CONSUMPTION IN SELECTED COMMUNITIES IN THE REGION: 1960-1970

Selected Community	Year											
	1960			1961			1962			1963		
	Water Delivered[1]			Water Delivered[1]			Water Delivered[1]			Water Delivered[1]		
	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)
City of Elkhorn	0.29	0.06	0.23	0.31	0.07	0.24	0.35	0.08	0.27	0.39	0.08	0.31
City of Kenosha	9.33[5]	4.31	5.02	9.71[5]	4.20	5.51	10.73[5]	4.63	6.10	11.08[5]	4.90	6.18
City of Milwaukee	107.83	50.05	57.78	109.72	48.16	61.56	113.38	49.81	63.57	115.28	50.06	65.22
City of Port Washington	0.47	0.09	0.38	0.56	0.10	0.46	0.56	0.08	0.48	0.59	0.09	0.50
City of Racine	11.92[8]	5.40	6.52	12.03[8]	5.38	6.65	12.69[8]	5.97	6.72	13.84[8]	6.63	7.21
City of Waukesha	3.55	1.89	1.66	3.79	1.98	1.81	4.12	2.24	1.88	4.48	2.46	2.02
City of West Bend	1.21	0.54	0.67	1.20	0.44	0.76	1.41	0.50	0.91	1.51	0.52	0.99
Average	—	—	—	—	—	—	—	—	—	—	—	—

	Year											
	1964			1965			1966			1967		
	Water Delivered[1]			Water Delivered[1]			Water Delivered[1]			Water Delivered[1]		
	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)
City of Elkhorn	0.36	0.09	0.27	0.36	0.08	0.28	0.43	0.09	0.34	0.37	0.09	0.28
City of Kenosha	11.47[5]	5.21	6.26	11.80[5]	5.33	6.47	11.85[5]	5.35	6.50	11.40[5]	4.75	6.65
City of Milwaukee	117.26	52.56	64.70	117.77	52.66	65.11	124.58	55.00	69.58	120.30	52.96	67.34
City of Port Washington	0.64	0.12	0.52	0.68	0.13	0.55	0.77	0.14	0.63	0.86	0.21	0.65
City of Racine	14.99[8]	7.58	7.41	15.11[8]	7.65	7.46	16.10	8.18	7.92	15.51	7.80	7.71
City of Waukesha	7.11	2.67	4.44	5.06	2.94	2.12	6.03	3.13	2.90	6.46	3.49	2.97
City of West Bend	1.60	0.54	1.06	1.72	0.69	1.03	1.90	0.76	1.14	1.97	0.77	1.20
Average	—	—	—	—	—	—	—	—	—	—	—	—

Selected Community	Year									Per Capita Relationship			
	1968			1969			1970			1960		1970	
	Water Delivered[1]			Water Delivered[1]			Water Delivered[1]						
	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Total (mgd)	Metered Industrial (mgd)	Domestic[2] (mgd)	Service Area Population[3]	Domestic Water Delivered (gpcd)	Service Area Population[4]	Domestic Water Delivered (gpcd)
City of Elkhorn	0.37	0.08	0.29	0.42	0.08	0.34	0.39	0.08	0.31	3,586	64	3,992	78
City of Kenosha	11.65	4.92	6.73	11.63	4.98	6.65	12.69	5.63	7.06	68,900[6]	73	81,300[7]	87
City of Milwaukee	120.01	54.17	65.84	122.06	55.61	66.45	127.52	54.01	73.51	741,324	78	717,372	103
City of Port Washington	0.86	0.16	0.70	0.93	0.18	0.75	0.96	0.28	0.68	5,984	64	8,752	78
City of Racine	15.01	6.97	8.14	14.77	6.77	8.00	14.48	5.82	8.66	89,144	73	95,162	91
City of Waukesha	7.15	3.98	3.17	7.53	4.26	3.27	7.72	4.21	3.51	30,004	55	40,274	87
City of West Bend	2.36	1.03	1.33	2.56	1.17	1.39	2.70	1.19	1.51	11,538	58	16,555	91
Average	—	—	—	—	—	—	—	—	—	—	67	—	88

[1]*From annual reports submitted by the water utilities to the Wisconsin Public Service Commission.*
[2]*Includes residential, commercial, and public authority water users.*
[3]*1960 U. S. Census of Population.*
[4]*1970 U. S. Census of Population.*
[5]*Includes the City of Kenosha and a portion of the Town of Pleasant Prairie served on a retail basis by the City of Kenosha.*
[6]*Includes the City of Kenosha and an estimated 1,000 persons served in the Town of Pleasant Prairie.*
[7]*Includes the City of Kenosha and an estimated 2,500 persons served in the Town of Pleasant Prairie.*
[8]*Estimated consumption within the City of Racine derived through the application of a regression equation to the historic measured water consumption in the City of Racine for the years 1966 through 1970.*

Source: SEWRPC.

Region, based on an average of the flow rates in the seven selected communities, is estimated at about 12,300 gallons per acre per day. If the total amount of industrial sewage flow in the selected communities is summed and the result divided by the total amount of industrial land use in the selected communities, an estimated industrial sewage flow rate of about 18,500 gallons per acre per day is obtained. This latter estimate reflects the higher per acre industrial sewage flow rates found in the larger urban communities in the Region.

Table 65

SEWAGE FLOW IN SELECTED COMMUNITIES IN THE REGION: 1960-1970

Selected Community	Metered Sewage Flow (mgd)											Per Capita Relationship			
												1960		1970	
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Estimated Service Area Population	Metered Sewage Flow (gpcd)	Estimated Service Area Population	Metered Sewage Flow (gpcd)
City of Elkhorn	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.70	3,600	N/A	4,000	175
City of Kenosha	15.40	14.60	14.50	14.20	15.60	20.00	18.50	18.20	16.00	15.90	16.26	67,900	227	86,300	188
City of Milwaukee	141.00	129.00	128.00	121.00	128.00	140.00	140.00	140.00	138.00	140.00	134.00	741,300	190	703,700	190
City of Port Washington	0.89	0.76	0.78	0.65	0.68	0.75	0.69	0.96	0.88	0.94	1.05	6,000	148	8,800	119
City of Racine	19.20	17.30	17.50	16.90	18.60	22.00	20.50	21.50	21.00	23.90	21.70	89,100	216	110,200	197
City of Waukesha	5.00	4.60	4.70	5.40	5.70	6.30	4.00	N/A	8.10	8.80	8.28	30,000	167	40,700	203
City of West Bend	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.60	1.80	2.10	2.27	11,500	N/A	16,400	138
Average	--	--	--	--	--	--	--	--	--	--	--	--	190	--	173

NOTE: N/A indicates data not available.

Source: SEWRPC.

Table 66

ESTIMATED SEWAGE FLOW FROM INDUSTRIAL LAND USES IN SELECTED COMMUNITIES IN THE REGION: 1970

Selected Community	Sewage Flow			Total Industrial Land Use[3] (Acres)	Industrial Sewage Flow Rate (gallons/ acre/day)
		Estimated Industrial[2]			
	Total[1] (mgd)	(mgd)	Percent of Total		
City of Elkhorn	0.70	0.08	11.4	56	1,430
City of Kenosha	16.26	4.50	27.7	490	9,180
City of Milwaukee	134.00	54.01	40.3	2,621	20,610
City of Port Washington	1.05	0.28	26.7	62	4,520
City of Racine	21.70	9.10	41.9	369	24,660
City of Waukesha	8.28	4.21	50.9	219	19,220
City of West Bend	2.27	0.91	40.1	145	6,280
Average	—	—	—	—	12,270

[1]*See Table 63 for references to sources of data.*

[2]*Industrial sewage flow was assumed to be equal to the metered industrial water consumption except in the Cities of Kenosha, Racine, and West Bend. In West Bend an estimated 280,000 gallons per day of metered industrial water was discharged directly to the Milwaukee River as spent cooling water by Line Material Industries-McGraw Edison Company and the West Bend Company (estimates based on data provided by Mr. R. McQuiggin, Safety Director, Line Material Industries and Mr. L. W. Hillman, Director of Industrial and Plant Engineering, West Bend Company). In Kenosha industrial waste flows were estimated at 4.50 mgd in a Report on Kenosha Water Pollution Control Plant - Phosphorus Removal and Oil, Grease, and Sludge Removal, Alvord, Burdick, and Howson, Chicago, Illinois, 1971. In Racine industrial waste flows were estimated at 9.10 mgd in an Engineering Report on Wastewater Treatment Facilities - Racine, Wisconsin, Consoer, Townsend and Associates, Chicago, Illinois, 1970.*

[3]*Data obtained from SEWRPC 1970 regional land use inventory. These data represent net land usage; as such, the areas include only land actually devoted to industrial operations and do not include supporting land uses, such as streets and highways, railroad trackage, parking facilities, and appurtenant vacant site areas held for future expansion.*

[4]*As noted in footnote [2] above, an estimated 280,000 gallons per day of metered industrial water is discharged directly to the Milwaukee River as spent cooling water. If this amount were included in the calculation of the industrial sewage flow rate, the result would be 8,210 gallons per acre per day.*

Source: SEWRPC.

Table 66 also indicates that industrial wastes presently comprise from a low of about 11 to a high of nearly 51 percent of the total sewage flow in the selected communities. It is considered unlikely that industry will continue to utilize water in the future at the same relatively high rates presently experienced. Surface water quality problems and the attendant need for higher levels of waste treatment, together with the attendant increased cost of treating industrial waste waters in municipal plants and the potential for recycling industrial wastes in order to recover economically valuable raw materials, products, or byproducts, may be expected to lead increasingly to industrial water conservation and reuse within major industrial plants.

Commercial Sewage Flows

Table 67 presents the relationship between the estimated total commercial sewage flow, which was assumed to be equal to metered commercial water supply, and the total amount of commercial land use in 1970 in the selected communities. The estimated commercial sewage flow rates range from 2,580 gallons per acre per day in the City of Elkhorn to 13,620 gallons per acre per day in the City of Milwaukee. In general the larger and older the community the greater the estimated commercial sewage flow rate in terms of gallons per acre per day. Commercial sewage flow in the Region, based on an average of the flow rates in the seven selected communities, is 7,640 gallons per acre per day. If the total amount of commercial sewage flow in the selected communities is

Table 67

ESTIMATED SEWAGE FLOW FROM COMMERCIAL LAND USES IN SELECTED COMMUNITIES IN THE REGION: 1970

Selected Community	Sewage Flow			Total Commercial Land Use[3] (Acres)	Commercial Sewage Flow Rate (gallons/ acre/day)
	Total[1] (mgd)	Estimated Commercial[2] (mgd)	Estimated Commercial[2] Percent of Total		
City of Elkhorn	0.70	0.08	11.4	31	2,580
City of Kenosha	16.26	1.68	10.3	242	6,940
City of Milwaukee	134.00	21.05	15.7	1,545	13,620
City of Port Washington	1.05	0.17	16.2	22	7,730
City of Racine	21.70	2.30	10.6	230	10,000
City of Waukesha	8.28	0.76	9.2	122	6,230
City of West Bend	2.27	0.39	17.2	61	6,390
Average	—	—	—	—	7,640

[1]*See Table 63 for references to sources of data.*
[2]*Commercial sewage flow was assumed to be equal to the metered commercial water consumption as determined from 1970 annual reports submitted by the water utilities in each of the selected communities to the Wisconsin Public Service Commission.*
[3]*Data obtained from SEWRPC 1970 regional land use inventory. These data represent net land usage; as such, the areas include only land actually devoted to commercial operations and do not include supporting land uses, such as streets and highways, parking facilities, and appurtenant vacant site areas held for future expansion.*

Source: SEWRPC.

summed and the result divided by the total amount of commercial land use in the selected communities, an estimated commercial sewage flow rate of 11,730 gallons per acre per day is obtained. This latter estimate reflects the higher per acre commercial sewage flow rates found in the larger urban communities in the Region. Table 67 also indicates that commercial wastes presently comprise from a low of about 9 to a high of about 16 percent of the total sewage flow.

Infiltration

Groundwater infiltration through joints in sewer pipes and manholes can result in appreciable contributions to total sewage flow. National data indicate that old sewerage systems may show infiltration rates as high as 60,000 gallons per day per mile of sewer.[2] New methods of joining sewers and building manholes should, however, result in future decreases in infiltration. Although state requirements mandate the use of joints and construction procedures that minimize infiltration, sanitary sewerage system planning and design must recognize that some settlement and subsequent increases in infiltration may occur. Allowances for infiltration should, therefore, be somewhat greater than those anticipated at the time of initial construction. Infiltration rates commonly used for system planning purposes range nationally from 10,000 to 40,000 gallons per day per mile, depending on sewer size and soil and groundwater conditions.[3] Sewers which are located below the water table will obviously be subject to greater rates of infiltration than those located above the water table in well-drained soils. For sewer design and construction purposes, the infiltration allowances are usually expressed in gallons per inch of sewer diameter per mile of sewer, and range nationally from 100 to 1,000. For system planning purposes, however, it is more convenient to express the infiltration allowances in terms of gallons per minute per acre.

In order to provide a basis for the selection of a design parameter for infiltration as a component of total sewage flow in the regional sanitary sewerage system planning program, an analysis was made of flow records from eight selected sanitary sewerage systems within the Region in an effort to estimate existing groundwater infiltration rates. Five of the eight systems selected were systems used in the per capita and per acre sewage flow analyses described above. In addition, gaged flow records were obtained for three subareas of the Region served by relatively new sanitary sewerage systems. These subareas were located in the Cities of Brookfield, Mequon, and New Berlin—which contract with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment and, hence, all sewage flow from these subareas is metered in order to determine total flow for billing purposes. Since each of these three systems was constructed within the last 10 years, the resulting infiltration data, when compared to that obtained from the communities having substantially older sanitary sewerage systems, indicates the extent to which more recent sewer and manhole construction practices may be expected to result in lowering infiltration rates. For analytical purposes, it was assumed that the sewage flow during the period from 12 midnight to 4 a.m. on Sundays in February consists entirely of groundwater infiltration. At this time of the day, week, and year, temperatures may be expected to be low and the ground frozen, thus substantially eliminating storm or snowmelt water inflows. In addition, domestic and industrial flows would be at a minimum. The flow rates for each of the four

[2]*Design and Construction of Sanitary and Storm Sewers; ASCE Manual of Engineering Practice No. 37, 1969; page 30.*

[3]*Ibid, page 31.*

Sunday mornings (February 1970) were averaged and apportioned over the tributary service area of each sewage treatment plant, or in the cases of Brookfield, Mequon, and New Berlin, the service area of each metering station, to determine the unit infiltration rate.

The results of this analysis are presented in Table 68. Typical sewage flow charts for each of the sewage treatment plants and metering stations used in the analysis are shown in Figures 85 through 92. As expected, the infiltration rates for the three communities having newly developed systems were below the 10-community average, with Mequon exhibiting the lowest rate, 0.09 gpm/acre. The rates ranged from this low to a high of 0.73 gallons per minute per acre in the City of Waukesha. The average of the estimated infiltration rates is 0.24 gallons per minute per acre. It is important to note that these estimated infiltration values are derived from dry weather, winter flow data and as such represent absolute minimal values. Infiltration may be expected to increase substantially in the spring when the ground is saturated.

Table 68

ESTIMATED SEWAGE FLOW CONTRIBUTED BY GROUNDWATER INFILTRATION IN SELECTED SANITARY SEWERAGE SYSTEMS IN THE REGION: 1970

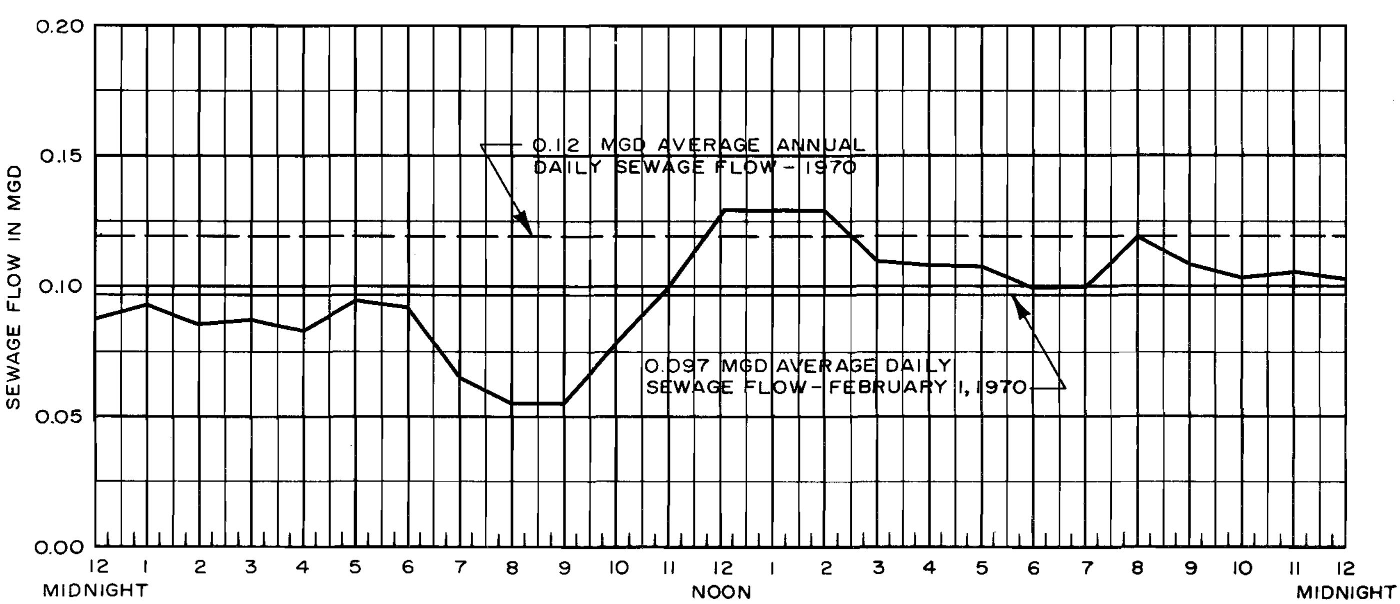
Selected Sanitary Sewerage System	Minimum Flow Rate[1] (gpm)	Estimated Sewer Service Area (Acres)	Estimated Infiltration Rate (gpm/acre)
City of Brookfield[2]	38	174	0.22
City of Elkhorn	153	1,265	0.12
City of Kenosha	4,120	12,986[3]	0.32
City of Mequon[4]	179	1,896	0.09
City of New Berlin[5]	17	137	0.13
City of Port Washington	174	1,289	0.14
City of Waukesha	4,170	5,719	0.73
City of West Bend	600	3,302	0.18
Average	—	—	0.24

[1]*Average of total sewage flow from 12:00 a.m. to 4:00 a.m. on four consecutive Sunday mornings during the month of February 1970.*
[2]*Represents a subarea of the City of Brookfield from which sewage flow is recorded at a metering station located at Pilgrim Parkway and Luther Lane extended.*
[3]*Includes contract service areas in the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C and the Town of Somers Sanitary District No. 1.*
[4]*Represents a subarea of the City of Mequon from which sewage flow is recorded at a metering station located at Cedarburg Road and the Milwaukee-Ozaukee County line.*
[5]*Represents a subarea of the City of New Berlin from which sewage flow is recorded at a metering station located at Ohio Avenue and the Milwaukee-Waukesha County line.*

Source: SEWRPC.

Figure 85

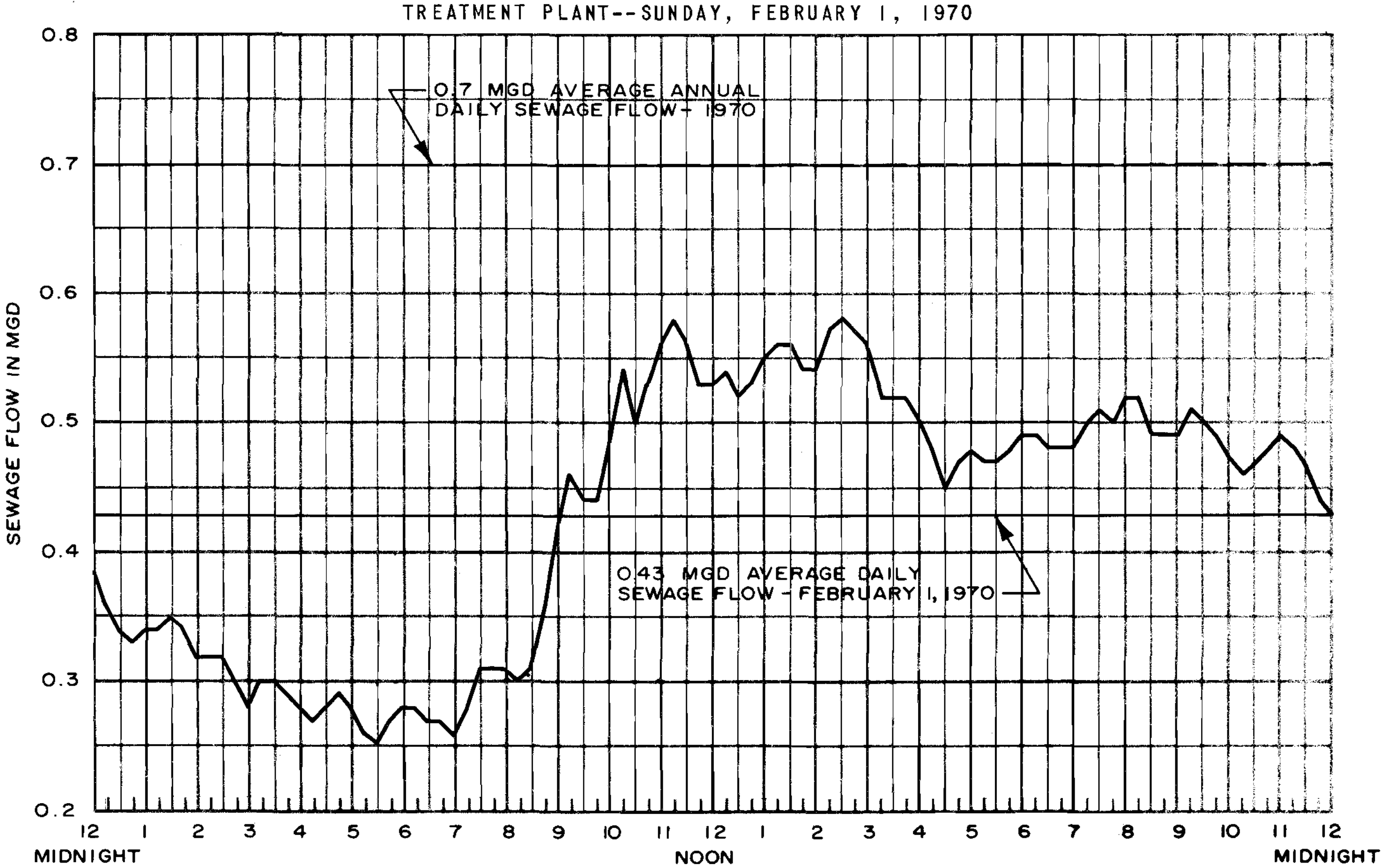
METERED SEWAGE FLOW AT THE CITY OF BROOKFIELD PILGRIM PARKWAY AND LUTHER LANE METERING STATION--SUNDAY, FEBRUARY 1, 1970



Source: City of Brookfield and SEWRPC.

Figure 86

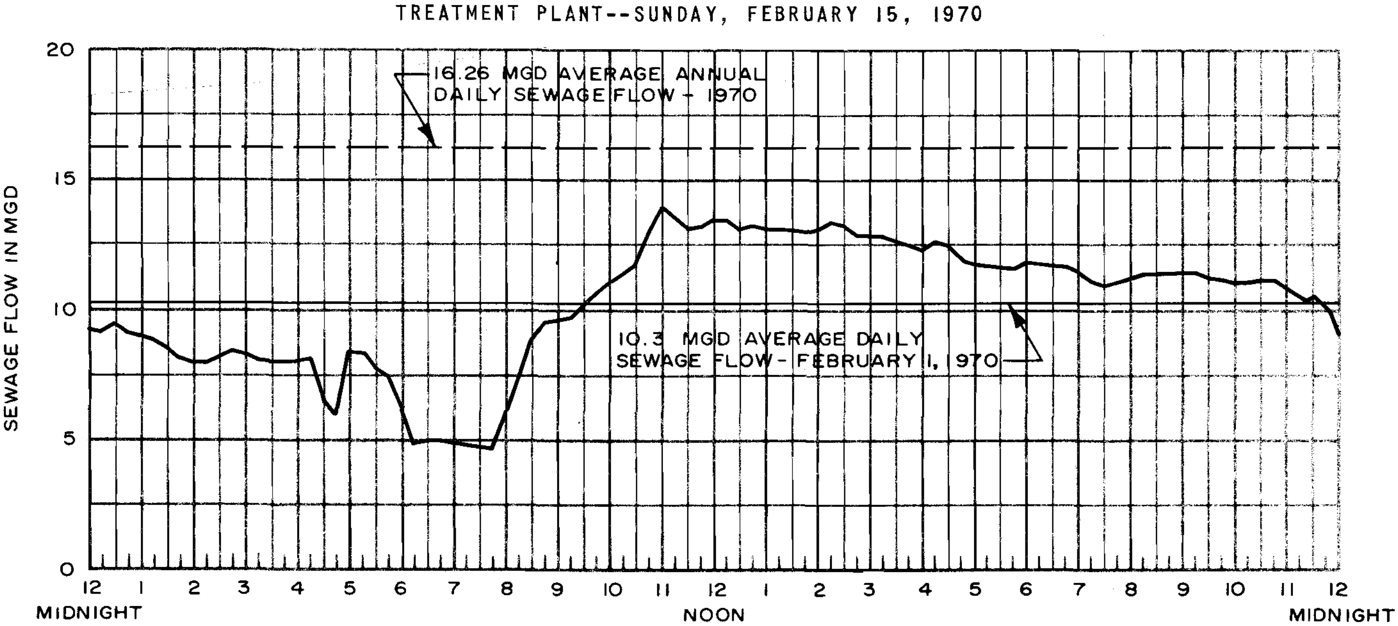
METERED SEWAGE FLOW AT THE CITY OF ELKHORN SEWAGE TREATMENT PLANT--SUNDAY, FEBRUARY 1, 1970



Source: City of Elkhorn and SEWRPC.

Figure 87

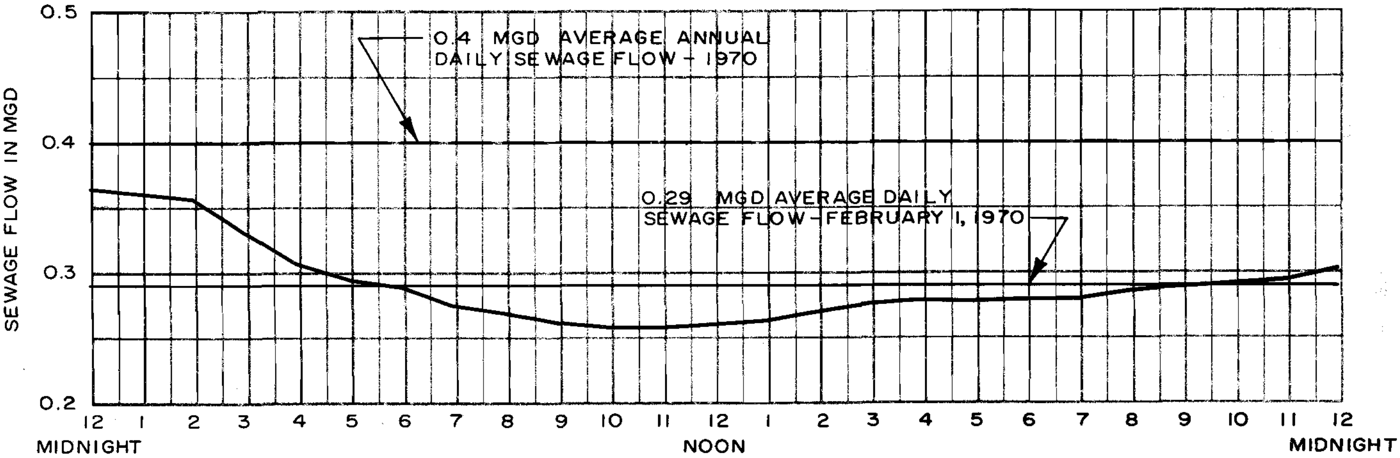
METERED SEWAGE FLOW AT THE CITY OF KENOSHA SEWAGE TREATMENT PLANT--SUNDAY, FEBRUARY 15, 1970



Source: City of Kenosha and SEWRPC.

Figure 88

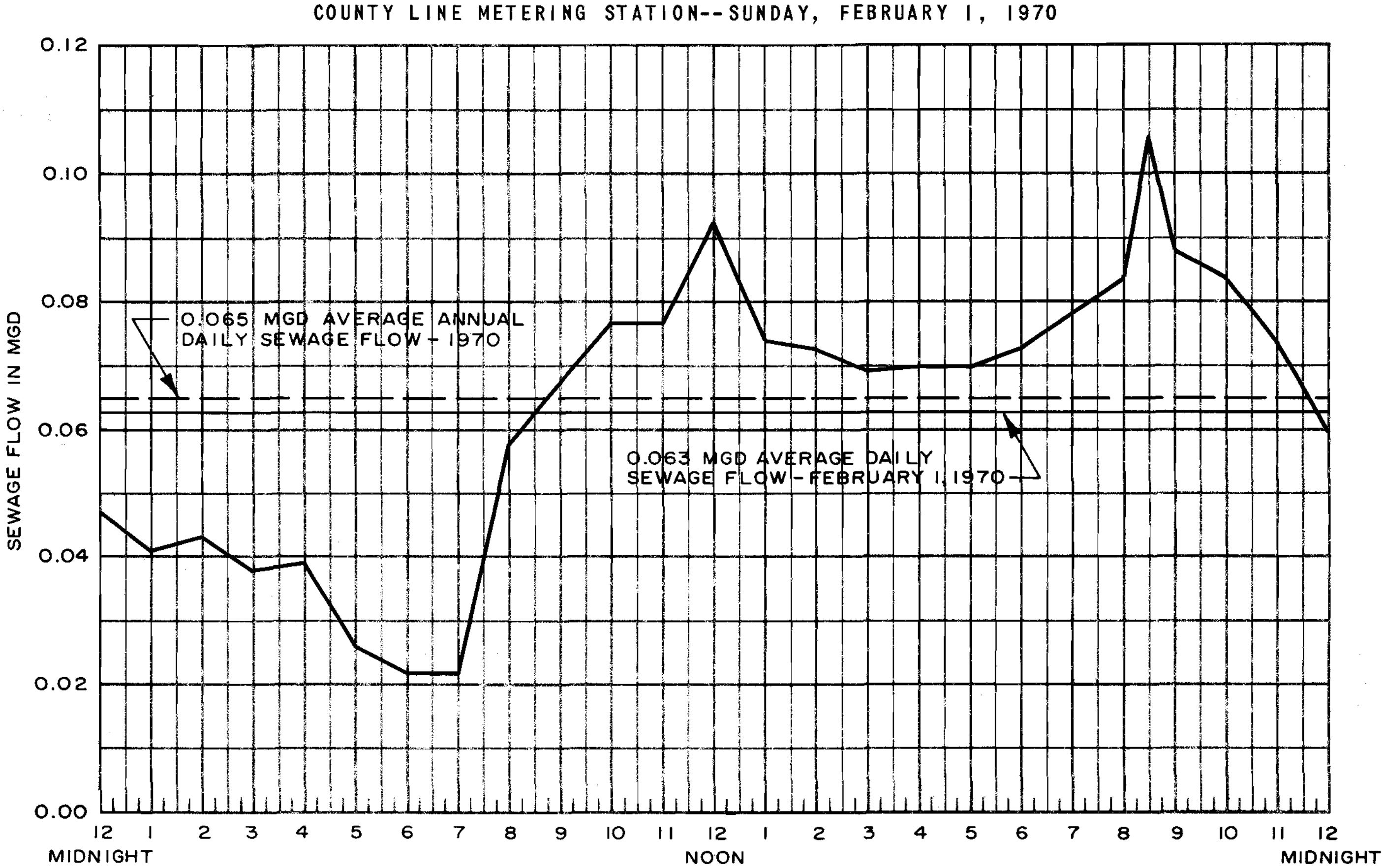
METERED SEWAGE FLOW AT THE CITY OF MEQUON CEDARBURG ROAD AND MILWAUKEE-OZAUKEE COUNTY LINE METERING STATION--SUNDAY, FEBRUARY 1, 1970



Source: *City of Mequon and SEWRPC.*

Figure 89

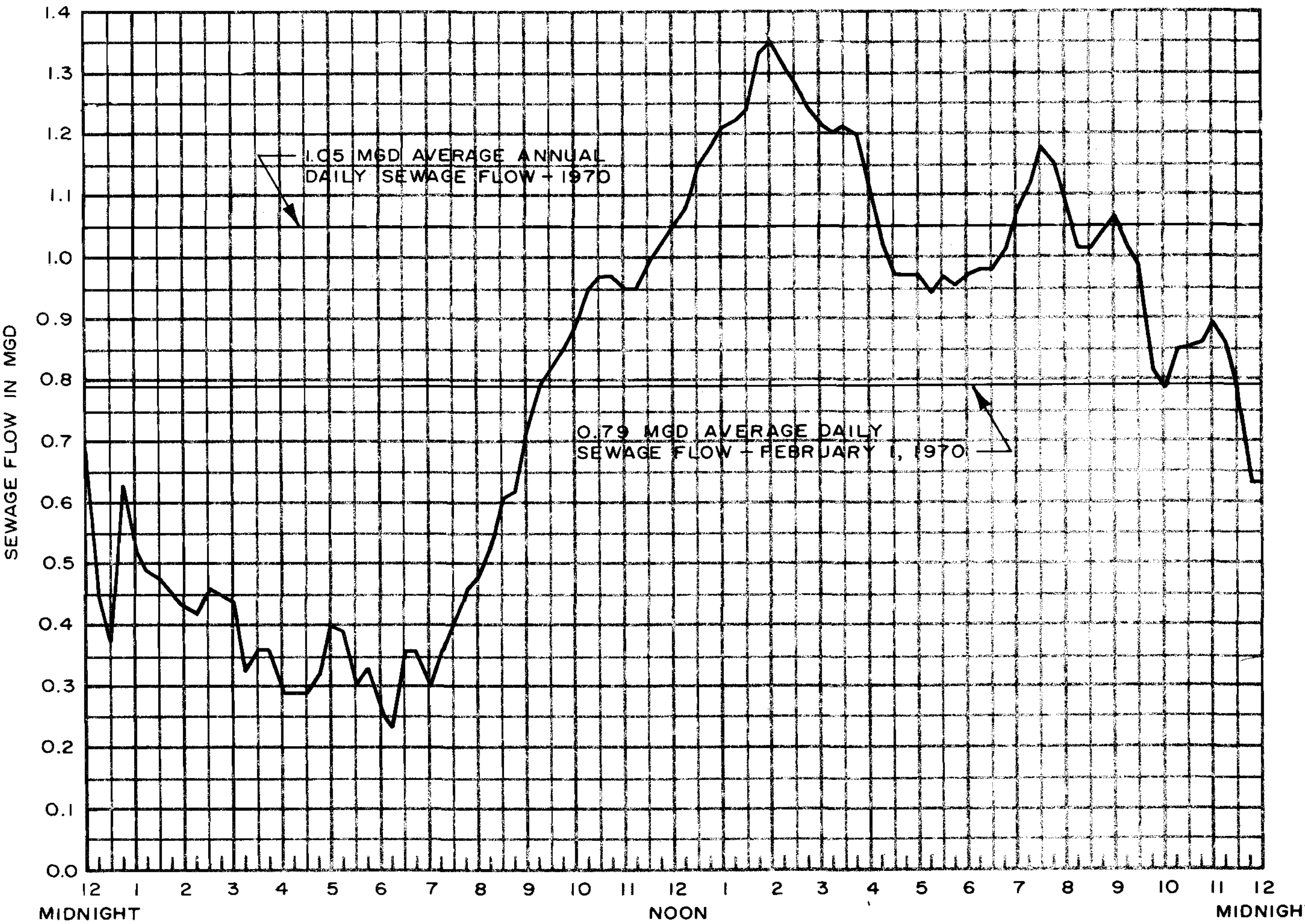
METERED SEWAGE FLOW AT THE CITY OF NEW BERLIN OHIO AVENUE AND MILWAUKEE-WAUKESHA COUNTY LINE METERING STATION--SUNDAY, FEBRUARY 1, 1970



Source: *City of New Berlin and SEWRPC.*

Figure 90

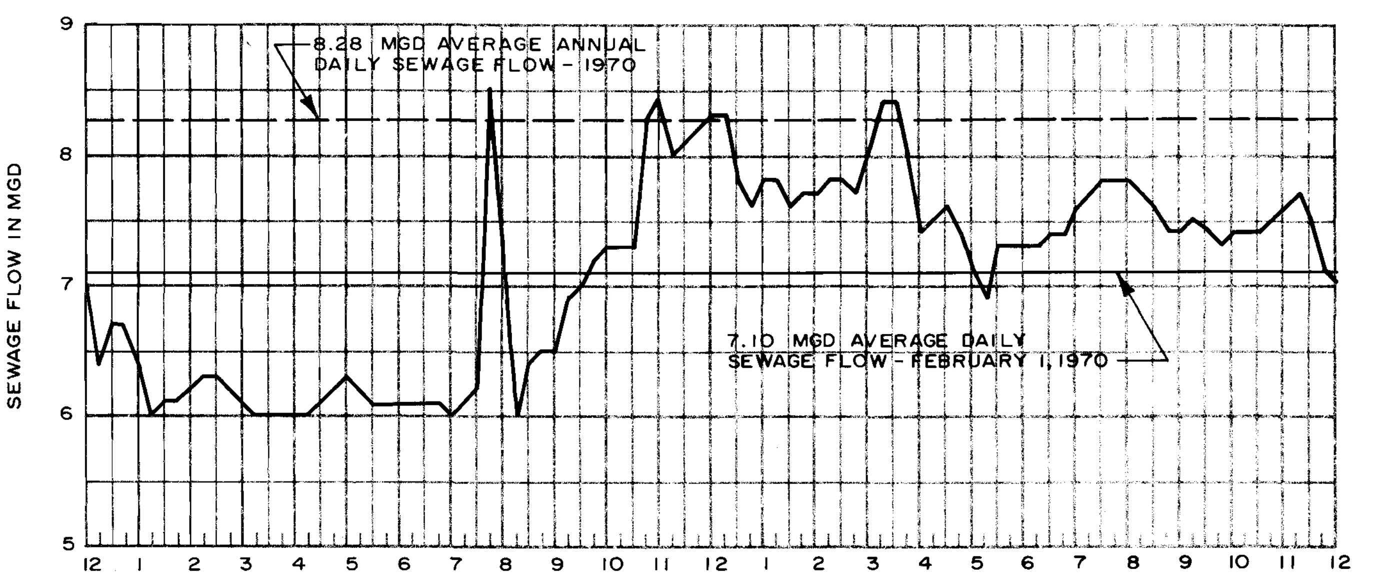
METERED SEWAGE FLOW AT THE CITY OF PORT WASHINGTON SEWAGE TREATMENT PLANT--SUNDAY, FEBRUARY 1, 1970



Source: City of Port Washington and SEWRPC.

Figure 91

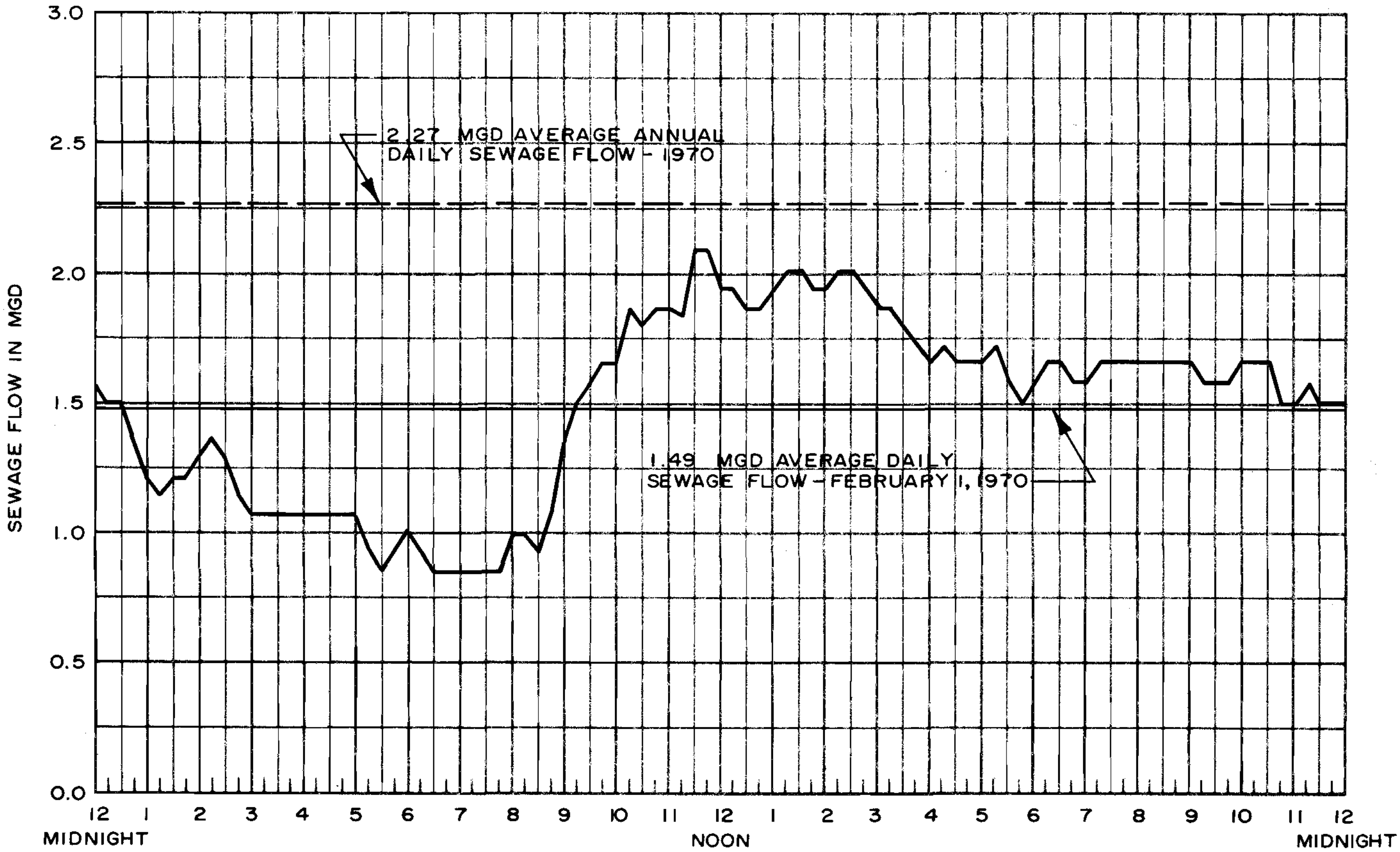
METERED SEWAGE FLOW AT THE CITY OF WAUKESHA SEWAGE TREATMENT PLANT--SUNDAY, FEBRUARY 1, 1970



Source: City of Waukesha and SEWRPC.

Figure 92

METERED SEWAGE FLOW AT THE CITY OF WEST BEND SEWAGE TREATMENT PLANT--SUNDAY, FEBRUARY 1, 1970



Source: City of West Bend and SEWRPC.

Storm Water Inflow

Storm water inflow during periods of intense rainfall or surface flooding can also result in appreciable contributions to total sewage flow. The storm water inflow occurs as increased sewer joint leakage (infiltration) and as water entering the sewerage system through manhole covers. State and local regulations prohibit the discharge of storm water from roof or foundation drains to sanitary sewers. It is common construction practice in southeastern Wisconsin to provide gravity drainage for basements. Foundation and roof drains can, therefore, be readily connected to the sanitary sewers, thereby avoiding the need to operate—if not to install—a sump pump for clear water discharge to the surface storm water drainage system. An allowance should, therefore, be included for water that is added to the sanitary sewer system by such connections of roof or foundation drains that are made illegally and remain undetected.

It should be noted that the actual peak wet weather flows within sanitary sewerage systems in the Region are not subject to complete measurement both because of the effect of the operation of bypasses, cross-overs, and relief pumping stations and because peak flows exceed installed metering capacities at the sewage treatment plants. The peak wet weather flow as indicated by metering facilities at a sewage treatment plant is, therefore, subject to inaccuracies and will always be less than the actual peak flow.

In order to provide a basis for the selection of a design parameter for storm water inflow as a component of total sewage flow in the regional sanitary sewerage system planning program, a further analysis was made of flow records from selected sanitary sewerage systems within the Region. Seven of the eight systems used for the infiltration analyses were used in the analysis relating to storm water inflow. The City of

Kenosha system was excluded from the storm water inflow analyses since a portion of that system consists of combined sewers. The wet weather flow in this system was, therefore, considered to be atypical of not only most of the existing sanitary sewerage systems in the Region but of systems which would be proposed to be constructed in the future. For analytical purposes, it was assumed that the total sewage flow during the period from 12 midnight to 4 a.m. on June 1, 2, and 3, 1970, consisted of infiltration and storm water inflow. These data were selected because weather records indicate that heavy 24-hour rainfalls totaling 1 inch each occurred on June 1 and 2, and these rainfalls could be expected to produce distinct increases in sewage flow over the base infiltration rate. The base infiltration inflows previously determined were then subtracted from the total flows to approximate the incremental wet weather storm water inflows. The estimated incremental wet weather flow rates were then apportioned over the appropriate service areas to determine unit storm water inflow rates.

The results of this storm water inflow analysis are presented in Table 69. Typical sewage flow charts for each of the sewage treatment plants and metering stations used in the analysis are shown in Figures 93 through 99. The rates so calculated ranged from a low of 0.23 gallons per minute per acre in the City of West Bend to a high of 1.68 gallons per minute per acre in the City of Brookfield. The average estimated storm water inflow rate is 0.57 gallons per minute per acre.

Peak-to-Average Flow Ratios

Sewage flows normally vary greatly, exhibiting seasonal, daily, and hourly ebbs and floods which must be recognized in sewerage system planning and design. Although annual average flow rates normally provide the basis for the sizing of sewerage systems, certain important components of the system must be designed to provide adequate capacity for peak flows, while functioning at minimum flows both initially and finally without nuisance. Estimates of peak flow rates are therefore required to determine the hydraulic capacity of sewers and of some treatment plant and lift and pump station components. For design purposes, the peak rate of flow is defined as the mean rate of flow during the maximum 15-minute period in any 12-month period. For system planning and design purposes, however, peak flow rates are normally estimated by factoring annual average flow rates. Therefore, the ratio of peak-to-average flow must be established.

As already noted, sanitary sewerage flows are generally comprised of spent domestic and industrial water supplies, such groundwater as may enter the sewers through leaking joints and manholes, and such storm water as may enter the sewers through connected building roof and foundation drains. In addition, in older sewerage systems which incorporate combined sewers, storm water may be admitted to the sewers by design. Each of these components of the total sewage flow has individual time patterns, which together determine the overall time pattern of the total sewage flow. The flow of spent domestic and industrial water supplies will vary with the day of the week and with the hour of the day. Extreme low flows usually occur between midnight and 6 a.m. on Sundays, with a daily peak flow occurring in a regular pattern during the midday daylight hours. The ground and surface water components of the total flow, on the other hand, remain practically constant throughout any one day but vary widely with the season and weather, with flows peaking immediately during and after periods of rainfall.

The ratio of the peak-to-average flow will also vary with the size of the tributary drainage area served, being lower for relatively large sewers serving relatively large tributary drainage areas and higher for relatively small sewers serving relatively small tributary drainage areas. The ratio of peak-to-average flow will also vary with the type of land use in the service area and with changes in land use over time.

Table 69

ESTIMATED SEWAGE FLOW CONTRIBUTED BY STORM WATER INFLOW IN SELECTED SANITARY SEWERAGE SYSTEMS IN THE REGION: 1970

Selected Sanitary Sewerage System	Incremental Wet Weather Flow Rate[1] (gpm)	Estimated Sewer Service Area (Acres)	Estimated Storm Water Inflow Rate (gpm/acre)
City of Brookfield[2]	292	174	1.68
City of Elkhorn	506	1,265	0.40
City of Mequon[3]	681	1,896	0.36
City of New Berlin[4]	57	137	0.42
City of Port Washington	555	1,289	0.43
City of Waukesha	2,820	5,719	0.49
City of West Bend	750	3,302	0.23
Average	—	—	0.57

[1]Determined as the difference between the maximum early morning flow rate in June 1970 and the maximum early morning flow rate in February 1970.

[2]Represents a subarea of the City of Brookfield from which sewage flow is recorded at a metering station located at Pilgrim Parkway and Luther Lane extended.

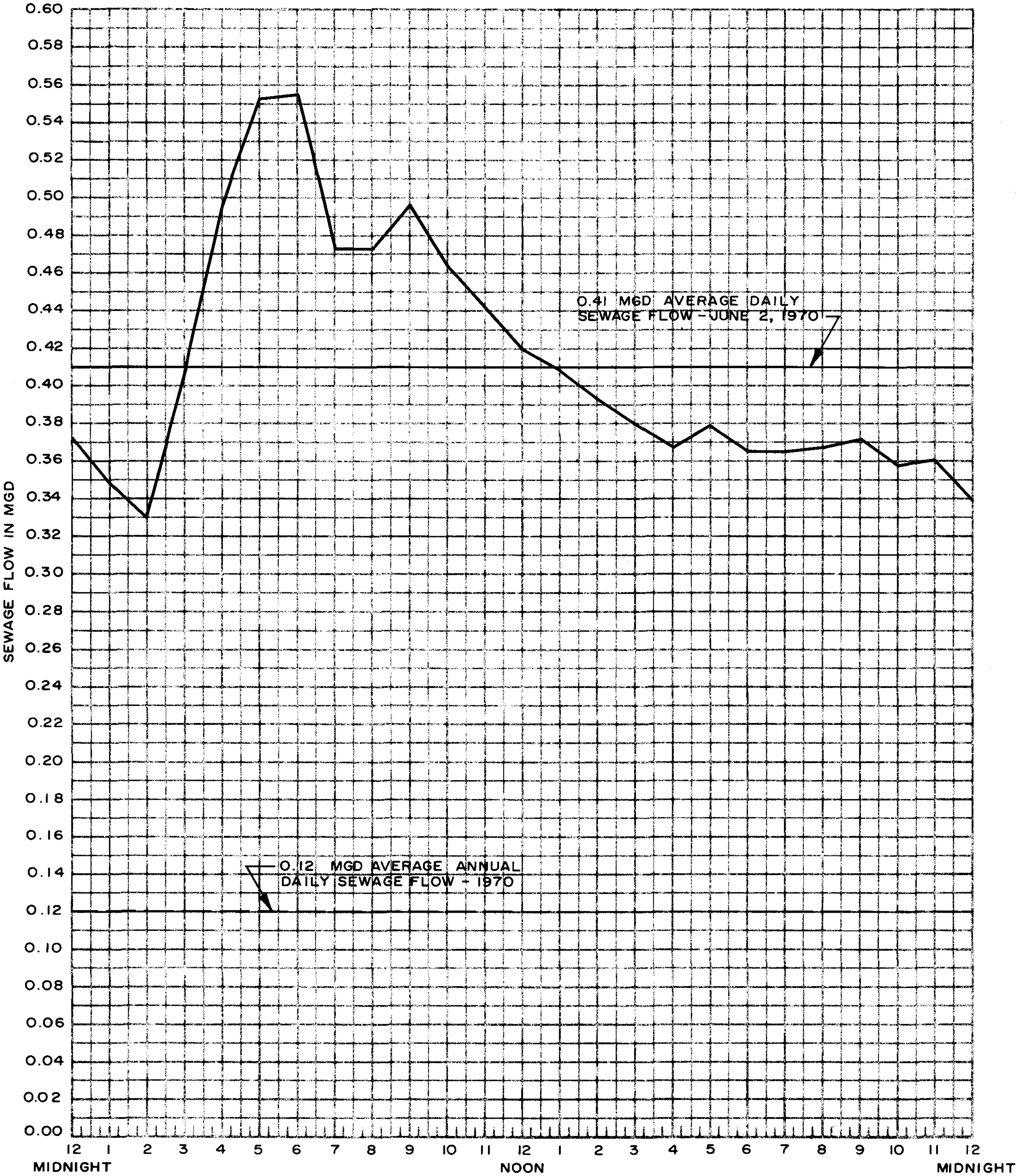
[3]Represents a subarea of the City of Mequon from which sewage flow is recorded at a metering station located at Cedarburg Road and the Milwaukee-Ozaukee County line.

[4]Represents a subarea of the City of New Berlin from which sewage flow is recorded at a metering station located at Ohio Avenue and the Milwaukee-Waukesha County line.

Source: SEWRPC.

Figure 93

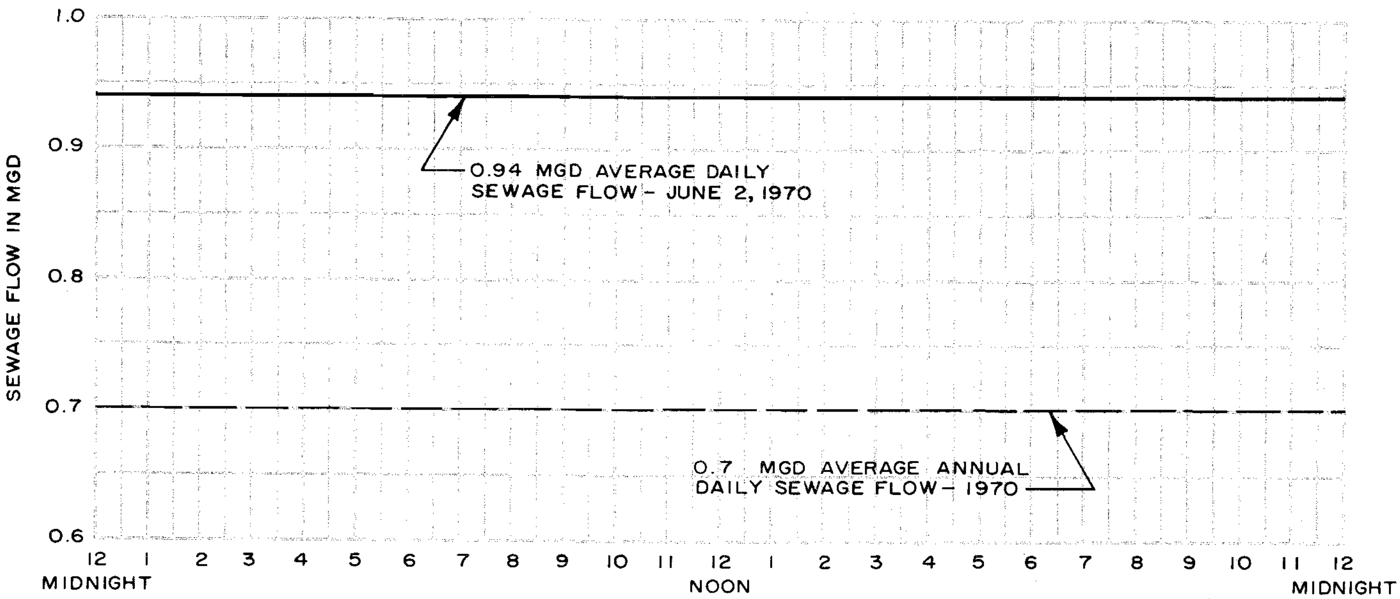
METERED SEWAGE FLOW AT THE CITY OF BROOKFIELD PILGRIM PARKWAY AND LUTHER LANE METERING STATION--JUNE 2, 1970



Source: City of Brookfield and SEWRPC.

Figure 94

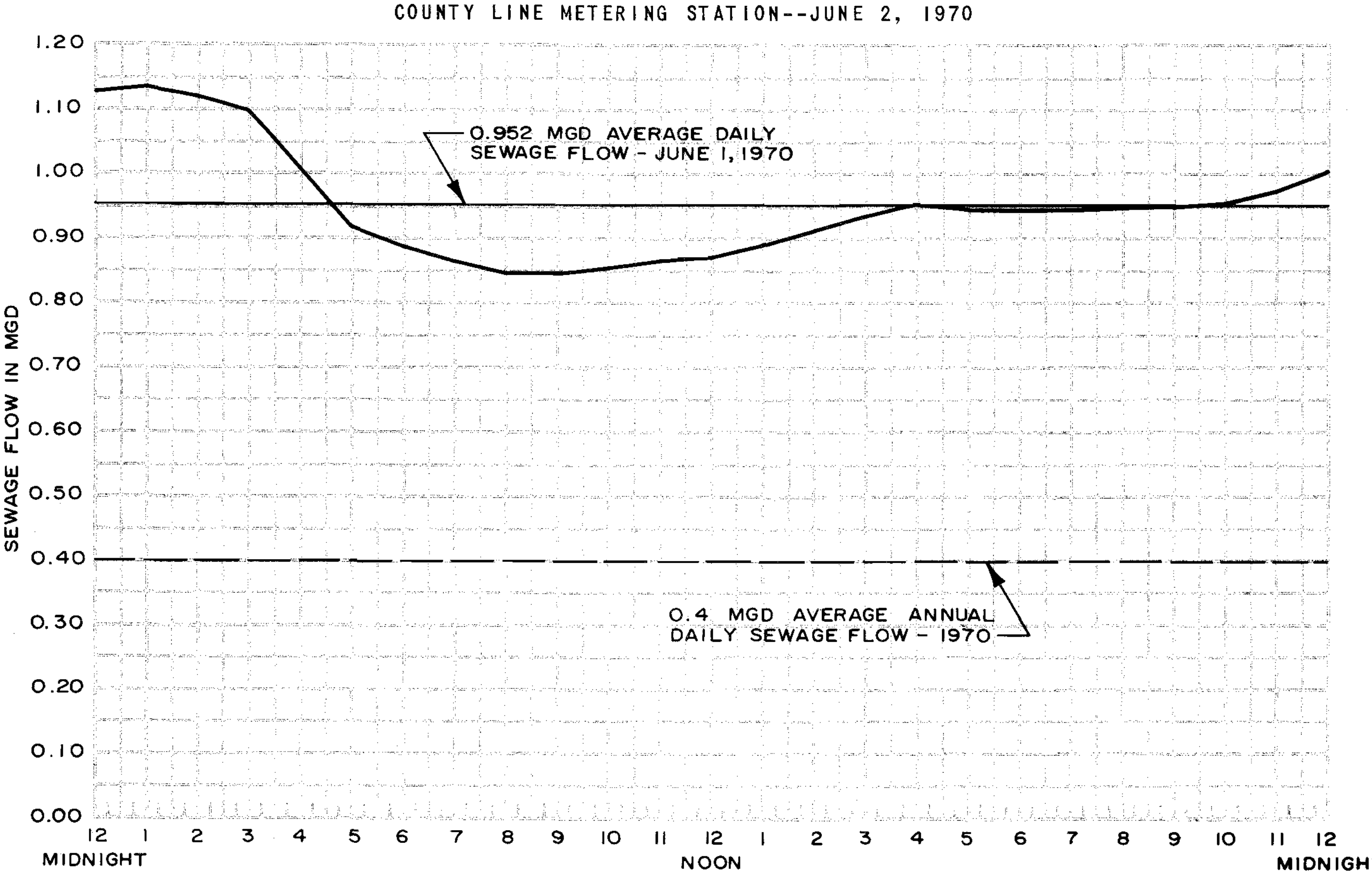
METERED SEWAGE FLOW AT THE CITY OF ELKHORN SEWAGE TREATMENT PLANT--JUNE 2, 1970



Source: City of Elkhorn and SEWRPC.

Figure 95

METERED SEWAGE FLOW AT THE CITY OF MEQUON CEDARBURG ROAD AND MILWAUKEE-OZAUKEE COUNTY LINE METERING STATION--JUNE 2, 1970



Source: City of Mequon and SEWRPC.

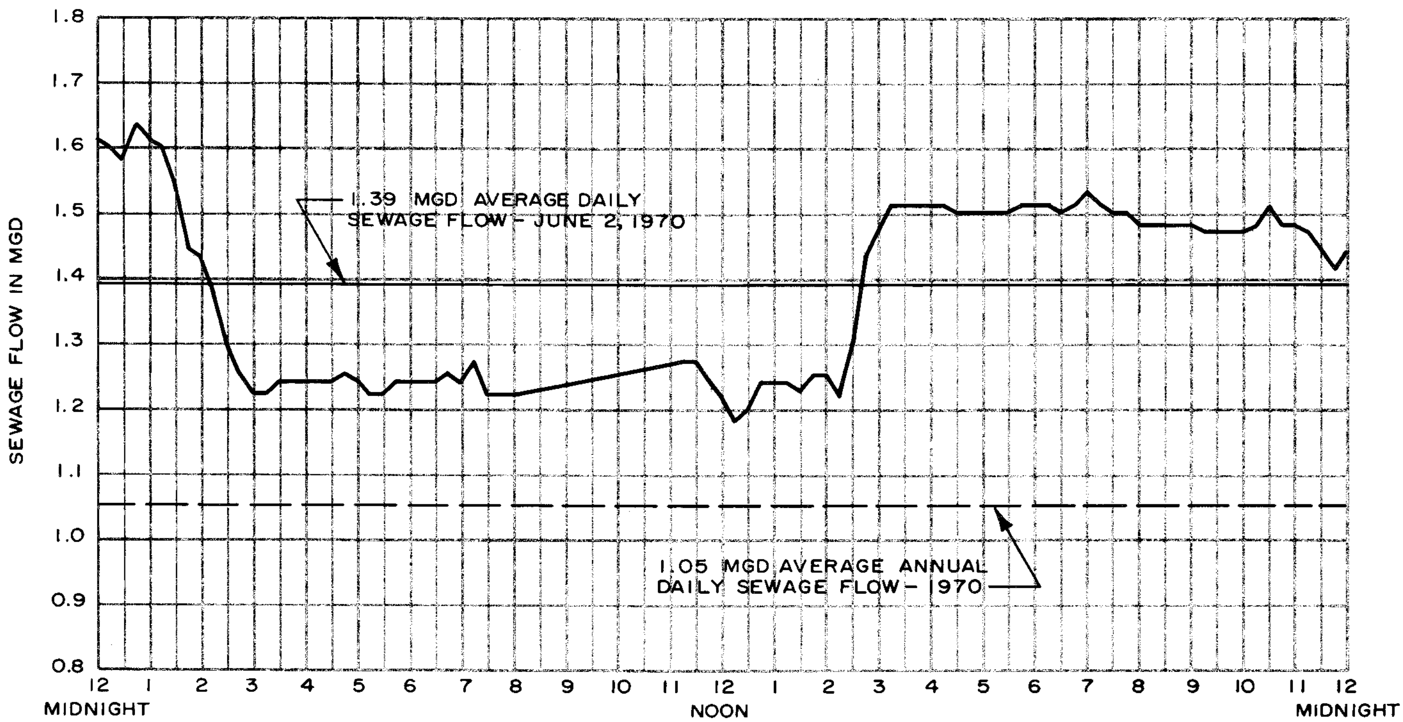
Figure 96

METERED SEWAGE FLOW AT THE CITY OF NEW BERLIN OHIO AVENUE AND MILWAUKEE-WAUKESHA COUNTY LINE METERING STATION--JUNE 2, 1970

Source: City of New Berlin and SEWRPC.

Figure 97

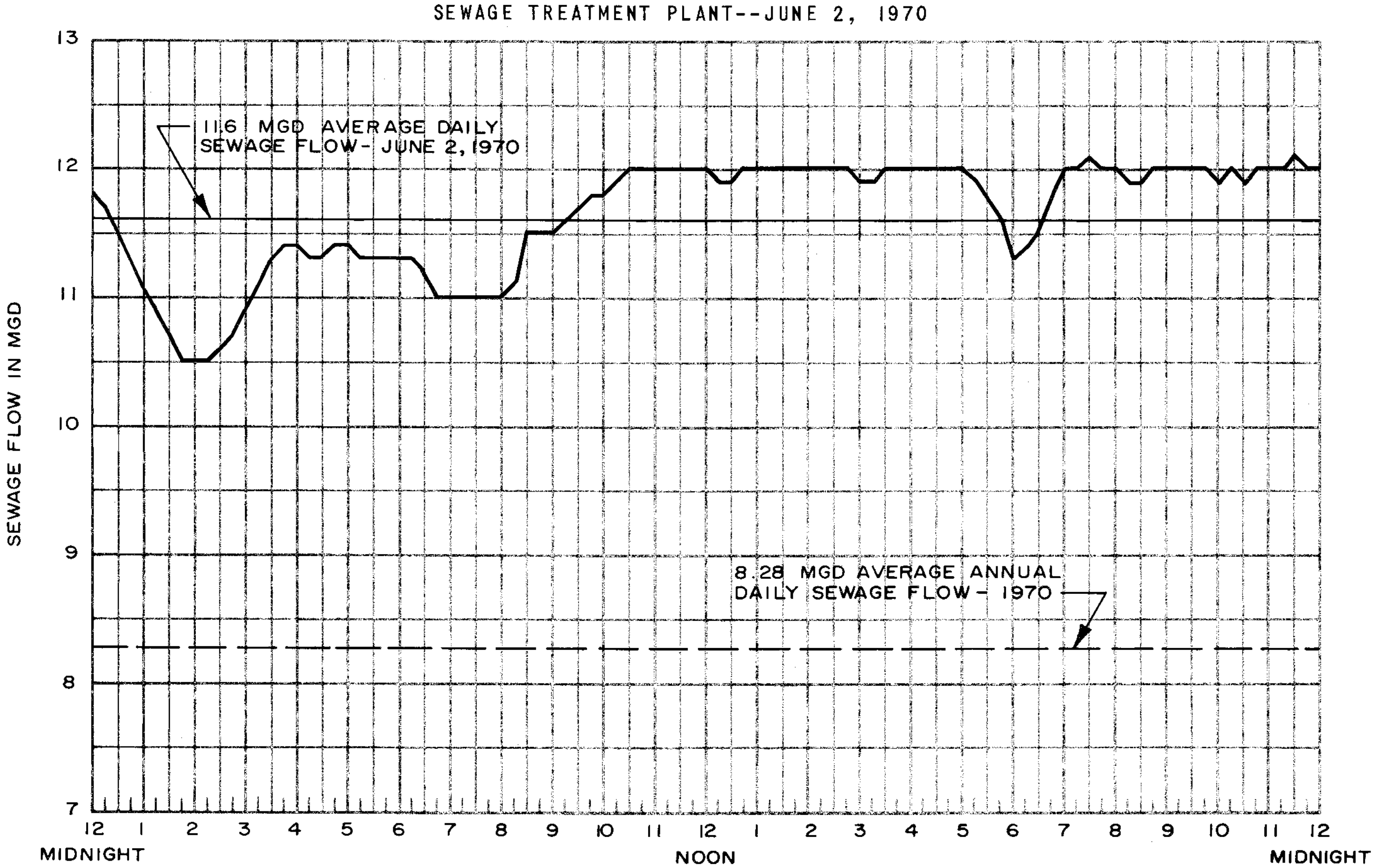
METERED SEWAGE FLOW AT THE CITY OF PORT WASHINGTON
SEWAGE TREATMENT PLANT--JUNE 2, 1970



Source: City of Port Washington and SEWRPC.

Figure 98

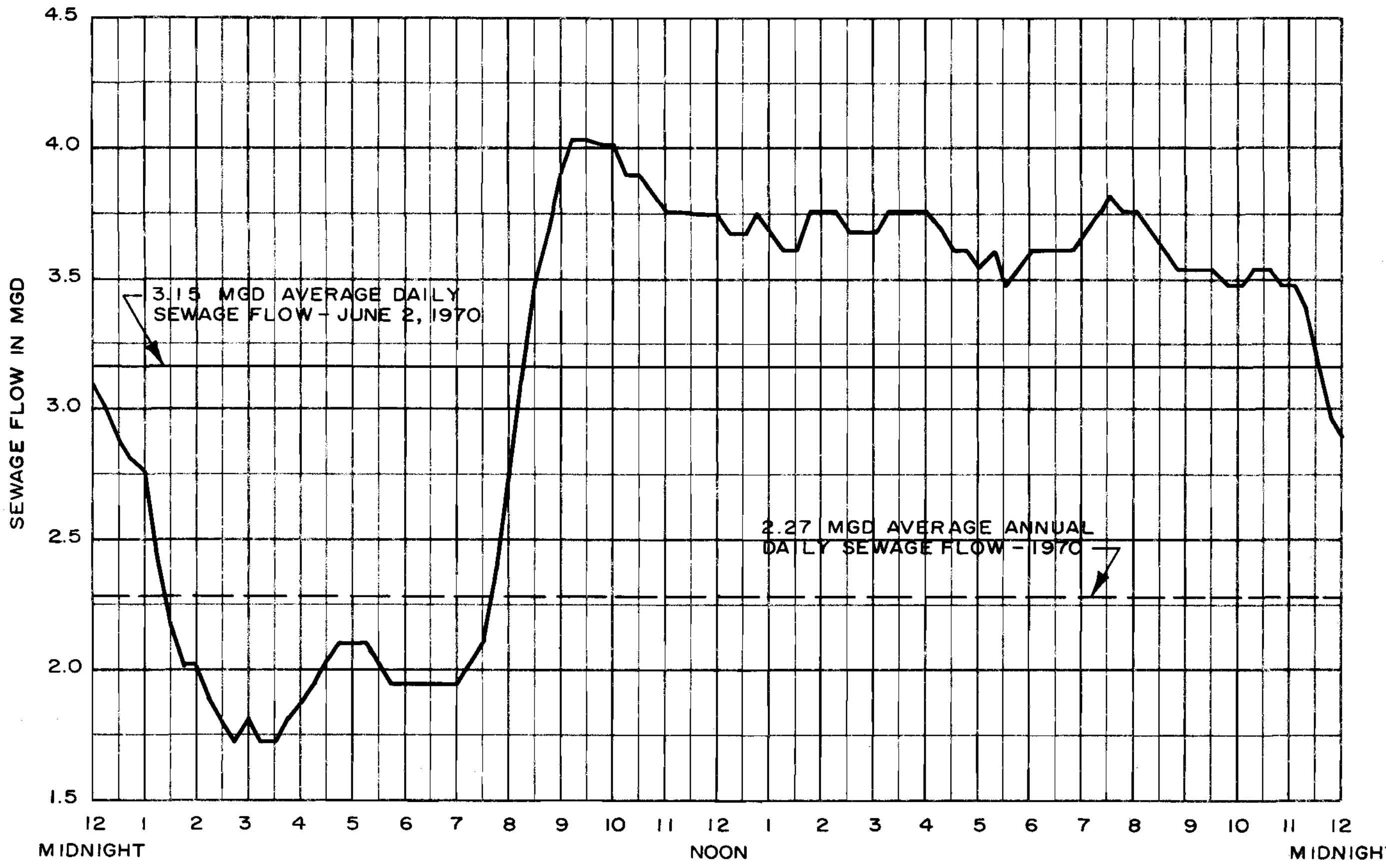
METERED SEWAGE FLOW AT THE CITY OF WAUKESHA
SEWAGE TREATMENT PLANT--JUNE 2, 1970



Source: City of Waukesha and SEWRPC.

Figure 99

METERED SEWAGE FLOW AT THE CITY OF WEST BEND SEWAGE TREATMENT PLANT--JUNE 2, 1970



Source: City of West Bend and SEWRPC.

In order to provide a basis for the selection of design criteria relating to peak-to-average flows for regional sanitary sewerage system planning purposes, an analysis was made of the variations in flow which occur within selected sewerage systems serving the Region. Four of the seven sewerage systems used in the analysis of average sewage flows described above were used in the peak-to-average flow analysis. The Kenosha, Milwaukee, and Racine sewerage systems were not used in this analysis since such systems contain substantial areas served by combined sewers. The flow records of the four systems analyzed—Elkhorn, Port Washington, Waukesha, and West Bend—were first examined in order to determine the peak 15-minute flow rate during the year. The annual average daily flow was then computed, and the ratio of the peak-to-average flow rate established. The inventory revealed that such peak-to-average flow ratios, defined as the ratio of the peak 15-minute flow rate during the year to the average annual daily flow rate, ranged from a low of 1.34 to 1 at the Elkhorn sewage treatment plant to a high of 2.66 to 1 at the Port Washington sewage treatment plant.

As noted earlier, actual peak flows during wet weather periods can never fully be determined because of the bypassing of sewage that occurs at crossovers, bypasses, and relief pumping stations located throughout the sewerage systems and the bypasses located at the treatment plants. In addition, the metering devices available at many sewage treatment plants are not capable of recording extreme peak flows. For example, the peak-to-average flow ratio computed for the City of Elkhorn based upon metering records during 1970 was only 1.34 to 1. During 1971 the City of Elkhorn installed a new flow meter on the influent sewer to the plant upstream of the plant bypass. Sewage flow records for 1971 and 1972 document actual peak-to-average flow ratios at the Elkhorn plant of as high as 10 to 1, thus indicating that substantial plant bypassing occurred during 1970, bypassing which resulted in a grossly understated peak-to-average flow ratio for the plant. It may be concluded, therefore, that the peak-to-average flow ratios revealed in the foregoing analysis represent low approximations of actual peak-to-average flow ratios in sewerage systems throughout the Region, and should be so recognized in the selection of a peak-to-average flow ratio design criterion for sewage treatment plants in Chapter IX of this report.

Data were also collected concerning peak-to-average ratios for three relatively new sanitary sewerage systems serving subareas of the Cities of Brookfield, Mequon, and New Berlin in order to obtain peak-to-average ratios for trunk sewers serving tributary areas varying in size from about 160 to about 2,000 acres. The peak-to-average flow ratios for the trunk sewers serving these three systems were found to range from a low of 2.83 to 1 in the City of Mequon to a high of 4.61 to 1 in the City of Brookfield. It may be expected that these estimates of peak-to-average flow ratios in trunk sewers more closely approximate actual peak-to-average flow ratios than do the foregoing estimates of peak-to-average flow ratios for sewage treatment plants, since very little or no bypassing of sewage may be found to exist in the relatively new sanitary sewerage systems.

The preceding discussion concerned itself with only the ratio of the peak 15-minute flow rate during the year to the average annual daily flow. It should be recognized, however, that other peak-to-average flow ratios, while not of concern in system planning, may be of concern in sewage treatment plant design and operation. Daily fluctuations in flow experienced at sewage treatment plants throughout a normal dry weather operating day must be accommodated by means of flexibility incorporated in the design of the various treatment units in the plant and in adjustments in the mode of operation by the plant operator in order to compensate for the flow variations. In the sewage treatment plants studied in the foregoing analysis, two to three peak flow periods were found to occur during an average dry weather day. These peak periods usually occurred in the early morning, early afternoon, and late evening, with the largest dry weather daily peak generally occurring in the early afternoon period. The daily fluctuation inflow at the sewage treatment plants analyzed varied from a low dry weather daily peak-to-average flow ratio from 1.20 to 1 at the Waukesha sewage treatment plant to a high of 1.67 to 1 at the Port Washington sewage treatment plant. Thus, even during dry weather periods, variations in daily flow reaching nearly a ratio of 2 to 1 may be expected.

SEWAGE STRENGTHS

Variation in sewage strengths is not as critical a consideration in regional sanitary sewerage system planning as variation in sewage flow rates, since treatment plant construction costs are primarily a function of the volume of the sewage flow. A knowledge of sewage strength characteristics is required, however, to determine the required type and level of treatment and the potential effects of effluent discharges on the quality of the receiving stream. Concentrations of pollutants or contaminants in sewage treatment plant effluent are neither constant nor directly proportional to raw inflow sewage strengths, varying throughout the day and from season to season. Common indicators used to measure the strength of sewage are the concentrations of oxygen demanding materials, nutrients, suspended solids, and the relative acidity or alkalinity of the sewage. These commonly used indicators of sewage strength are the same as the commonly used indicators of stream water quality, and are discussed, together with their importance in the design of sewage treatment works, in some detail in Appendix C of this report.

Survey Findings

In order to provide a basis for selecting sewage strength design criteria for use in regional sanitary sewerage system planning, analyses were made of available data pertaining to carbonaceous biochemical oxygen demand, suspended solids, and nutrient concentrations from selected sewage treatment plants within the Region. In addition to data available for the sewerage systems serving the seven county seats within the Region, which systems were used in the flow analyses presented earlier in this chapter, sample strength data from selected additional communities where surveys have recently been completed were also utilized in order to provide a broader basis for the estimation of average values for sewage strength parameters within the Region. The data utilized in this analysis are presented in Table 70, along with the estimated regional averages for the various sewage strength parameters.

Table 70

SEWAGE STRENGTH PARAMETERS IN SELECTED SANITARY SEWERAGE SYSTEMS IN THE REGION

Selected Sewage Treatment Plant	Type of Treatment Provided	Average Hydraulic Design Capacity (mgd)	Estimated Population Served (1970)	Source of Sample or Record Data	Date of Sample or Record Flow	Flow on Sample Date Maximum (mgd)	Flow on Sample Date Minimum (mgd)
Allenton Sanitary District	Activated Sludge	0.100	700	DNR – 24-hour sewage treatment plant survey report	10/68	N/A	N/A
Village of Belgium	Activated Sludge	0.070	800	DNR – 24-hour sewage treatment plant survey report	9/17/69	N/A	N/A
City of Brookfield Fox River Plant	Activated Sludge	0.100	12,300	Annual Report by the Superintendent of the Brookfield Sewer Utility	1969	N/A	N/A
City of Burlington	Trickling Filter	1.000	7,500	Engineering Study for Revising Existing Sewage Treatment Plant – City of Burlington, Hoganson and Robers, Inc., Burlington, Wisconsin	1968	N/A	N/A
Caddy Vista Sanitary District	Trickling Filter	0.250	1,200	DNR – 24-hour sewage treatment plant survey report	5/66-6/66	0.110	0.020
City of Delavan	Trickling Filter	1.000	5,400	DNR – 24-hour sewage treatment plant survey report	7/69	N/A	N/A
Village of Dousman	Activated Sludge	0.120	600	DNR – 24-hour sewage treatment plant survey report	8/69	0.166	N/A
Village of Fredonia	Activated Sludge	0.120	1,000	DNR – 24-hour sewage treatment plant survey report	9/15/71	N/A	N/A
Village of Germantown Old Village Plant	Activated Sludge	1.200	1,400	DNR – 24-hour sewage treatment plant survey report	10/12/67	N/A	N/A
Village of Grafton	Activated Sludge	0.450	6,400	Sewage Treatment Report Village of Grafton, Wisconsin, Donohue & Associates, Inc., Sheboygan, Wisconsin	1968	N/A	N/A
City of Hartford	Trickling Filter	0.820	6,800	DNR – 24-hour sewage treatment plant survey report	10/68	N/A	N/A
Village of Hartland	Activated Sludge	0.350	2,900	DNR – 24-hour sewage treatment plant survey report	6/69	0.250	0.110
Village of Jackson	Trickling Filter	0.025	600	DNR – 24-hour sewage treatment plant survey report	8/24/66	N/A	N/A
City of Kenosha	Activated Sludge	18.000	86,300	1970 Annual Report – Kenosha Water Utility and Report on Kenosha Water Pollution Control Plant Phosphorus Removal and Oil, Grease, and Sludge Disposal, 1971, Alvord, Burdick, and Howson, Chicago, Illinois	1970	29,200	9,800
Village of Kewaskum	Activated Sludge	0.300	1,900	DNR – 24-hour sewage treatment plant survey report	9/10/69	N/A	N/A

Table 70 (continued)

Selected Sewage Treatment Plant	Average Hydraulic Loading (1970)		Sewage Strength Parameters in Influent Sewage									
			CBOD$_5$		Suspended Solids		Total Phosphorus (P)		Organic Nitrigen (N)		Ammonia Nitrogen (N)	
	Total (mgd)	Per Capita (gpcd)	mg/1	Pounds Per Capita Per Day[1]	mg/1	Pounds Per Capita Per Day[1]	mg/1	Pounds Per Capita Per Day[1]	mg/1	Pounds Per Capita Per Day[1]	mg/1	Pounds Per Capita Per Day[1]
Allenton Sanitary District	0.058	83	200	0.1382	95	0.0656	8.0	0.0055	N/A	--	N/A	
Village of Belgium	0.060	75	220	0.1376	160	0.1001	16.0	0.0100	14.2	0.0089	25.6	0.0160
City of Brookfield												
Fox River Plant	1.660	140	105[2]	0.1182	163[2]	0.1835	--	--	--	--	--	--
City of Burlington	1.200	160	265	0.3536	170	0.2269	N/A	--	13.0	0.0175	15.2	0.0203
Caddy Vista Sanitary District	0.060	50	171	0.0713	180	0.0751	N/A	--	N/A	--	N/A	--
City of Delavan	0.700	130	58	0.0627	N/A	--	8.0	0.0087	5.8	0.0063	6.4	0.0069
Village of Dousman	0.084	140	90	0.1051	100	0.1168	8.0	0.0094	5.4	0.0063	8.4	0.0098
Village of Fredonia	0.100	100	200	0.1668	160	0.1334	9.0	0.0075	12.9	0.0108	N/A	--
Village of Germantown												
Old Village Plant	0.360	257	710	1.5226	292	0.6262	13.6	0.0292	9.7	0.0208	N/A	--
Village of Grafton	0.800	125	155	0.1616	130	0.1355	14.0	0.0146	N/A	--	N/A	--
City of Hartford	1.240	182	150	0.2281	145	0.2205	9.0	0.0137	N/A	--	N/A	--
Village of Hartland	0.270	93	140	0.1087	170	0.1320	1.7	0.0132	14.4	0.0112	2.7	0.0210
Village of Jackson	0.080	133	108	0.1201	112	0.1246	N/A	--	N/A	--	N/A	--
City of Kenosha	16.300	188	94[3]	0.1481	123[3]	0.1938	6.4[4]	0.0101	N/A	--	N/A	--
Village of Kewaskum	0.490	258	265	0.5700	201	0.4323	24.88	0.0535	N/A	--	N/A	--

Table 70 (continued)

Selected Sewage Treatment Plant	Type of Treatment Provided	Average Hydraulic Design Capacity (mgd)	Estimated Population Served (1970)	Source of Sample or Record Data	Date of Sample or Record Flow	Flow on Sample Date Maximum (mgd)	Flow on Sample Date Minimum (mgd)
Milwaukee-Metropolitan Sewerage Commissions – Jones Island Plant	Activated Sludge	200.00	916,068[5]	Phosphorus Removal With Pickle Liquor in an Activated Sludge Plant by the Sewerage Commission of the City of Milwaukee for the EPA	1970	115,600	22.300
Milwaukee-Metropolitan Sewerage Commissions – South Shore Plant	Sedimentation	120.000	117,632[5]	Milwaukee-Metropolitan Sewerage Commissions staff	1970	25.000	15.000
City of Oconomowoc	Trickling Filter	1.500	9,500	Report on Wastewater Treatment Facilities for the City of Oconomowoc, Wisconsin, Donohue & Associates, Inc., Sheboygan, Wisconsin	7/70	N/A	N/A
City of Port Washington	Sedimentation	1.000	8,800	DNR – 24-hour sewage treatment plant survey report	1/8/69	N/A	N/A
City of Racine	Activated Sludge	23.000	110,200	Engineering Report on Wastewater Treatment Facilities, Racine, Wisconsin, Consoer, Townsen, and Associates and 33rd Annual Report, 1970, City of Racine Water Pollution Control Division.	1970	N/A	N/A
Village of Saukville	Trickling Filter	0.320	1,100	DNR – 24-hour sewage treatment plant survey report	11/22/66	N/A	N/A
Village of Slinger	Trickling Filter and Activated Sludge	0.149	1,000	DNR – 24-hour sewage treatment plant survey report	9/68	N/A	N/A
Village of Sturtevant	Trickling Filter	0.300	3,200	DNR – 24-hour sewage treatment plant survey report	10/19/56	N/A	N/A
Village of Sussex	Trickling Filter	0.300	2,800	DNR – 24-hour sewage treatment plant survey report	7/28/70	N/A	N/A
Village of Thiensville	Activated Sludge	0.240	3,200	DNR – 24-hour sewage treatment plant survey report	10/6/66	N/A	N/A
Village of Union Grove	Activated Sludge	0.300	2,800	DNR – 24-hour sewage treatment plant survey report	6/2/66	0.47	0.29
Village of Walworth	Trickling Filter	0.150	1,600	DNR – 24-hour sewage treatment plant survey report	1969	N/A	N/A
City of Waukesha	Trickling Filter	8.500	40,700	Sewage treatment plant operator	1970	N/A	N/A
City of West Bend	Activated Sludge	2.500	16,400	DNR – 24-hour sewage treatment plant survey report	9/4/70	N/A	N/A
City of Whitewater	Activated Sludge and Trickling Filter	2.500	12,000	Whitewater, Wisconsin Preliminary Report Wastewater Interceptor and Treatment System, Stone & Robinson Assoc., Inc., Brookfield, Wisconsin	1/72	N/A	N/A

Selected Sewage Treatment Plant	Average Hydraulic Loading (1970)		Sewage Strength Parameters in Influent Sewage									
			$CBOD_5$		Suspended Solids		Total Phosphorus (P)		Organic Nitrigen (N)		Ammonia Nitrogen (N)	
	Total (mgd)	Per Capita (gpcd)	mg/1	Pounds Per Capita Per Day[1]	mg/1	Pounds Per Capita Per Day[1]	mg/1	Pounds Per Capita Per Day[1]	mg/1	Pounds Per Capita Per Day[1]	mg/1	Pounds Per Capita Per Day[1]
Milwaukee-Metropolitan Sewerage Commissions – Jones Island Plant	169.600	185	209[3]	0.3227	207[3]	0.3196	8.2[3]	0.0127	N/A	--	N/A	--
Milwaukee-Metropolitan Sewerage Commissions – South Shore Plant	19.300	164	362[3]	0.4953	494[3]	0.6760	N/A	--	N/A	--	N/A	--
City of Oconomowoc	1.620	170	140	0.1991	165	0.2347	6.5	0.0092	9.0	0.0128	8.8	0.0125
City of Port Washington	1.050	83	130	0.1294	125	0.1244	15.5	0.0154	11.2	0.0112	12.6	0.0125
City of Racine	21.700	197	84[3]	0.1380	125[3]	0.2053	7.8[6]	0.0128	N/A	--	N/A	--
Village of Saukville	0.250	180	237	0.4492	172	0.3260	N/A	--	N/A	--	N/A	--
Village of Slinger	0.089	89	117	0.0868	90	0.0668	12.5	0.0093	N/A	--	N/A	--
Village of Sturtevant	0.250	78	193	0.1258	144	0.0938	14.2	0.0093	11.6	0.0076	31.6	0.0206
Village of Sussex	0.294	105	92	0.0806	120	0.1051	8.6	0.0031	10.2	0.0089	16.2	0.0142
Village of Thiensville	0.700	220	161	0.2611	136	0.2206	N/A	--	N/A	--	N/A	--
Village of Union Grove	0.430	154	156	0.1998	116	0.1486	N/A	--	11.9	0.0152	18.2	0.0233
Village of Walworth	0.150	92	N/A	--	N/A	--	13.5	0.0106	7.8	0.0061	8.0	0.0063
City of Waukesha	8.280	203	145[3]	0.2460	165[3]	0.2800	N/A	--	N/A	--	N/A	--
City of West Bend	2.270	138	110	0.1270	228	0.2632	13.0	0.0150	9.8	0.0113	6.6	0.0076
City of Whitewater	1.510	126	615	0.6454	298	0.3127	16.35	0.0172	N/A	--	N/A	--
Average	--	--	--	--	--	0.2194	11.91	0.0138	10.5	0.0111	15.4	0.0143

NOTE: N/A indicates information not available.

[1]The estimated per capita loading of each sewage strength parameter was computed by multiplying the measured sewage strength parameter concentration at the time of sampling by the volumetric per capita sewage flow rate by the appropriate conversion factor.

Example:

Where $CBOD_5$ = 200 mg/1, Average Hydraulic Loading (1970) = 0.058 MGD, and the Estimated Population Served (1970) = 700 Persons

Average Raw Sewage $CBOD_5$ Load in Pounds Per Capita Per Day = $COBD_5$ in mg/1 X Average Hydraulic Loading (1970) in MGD X 8.34 (Conversion Factor for #/MG/mg/1) ÷ Estimated Population Served (1970)

Average Raw Sewage $CBOD_5$ = 200 mg/1 X 0.058 MGD X 8.34 #/MG/mg/1 ÷ 700 Persons = 0.1382 #/Capita/Day

[2]Data based on an average of 107 tests for $CBOD_5$ and 125 tests for Suspended Solids.

[3]Data based on an average of 24-hour composite samples collected daily for 1970.

[4]Data based on an average of 18 samples during the months of February through July.

[5]The estimation of the population served for the Jones Island plant and the South Shore plant is proportioned on the basis of the average annual flow into each plant.

[6]Data based on an average of the six samples collected on April 20, through April 21, 1970.

Source: SEWRPC.

The average five-day carbonaceous biochemical oxygen demand value is 0.259 pound per capita per day. This average was based upon sample values from 11 sewerage systems. The average suspended solid value is 0.219 pound per capita per day, based upon sample values from 28 sewerage systems. The average total phosphorus value is 0.0138 pound per capita per day, based upon sample values from 21 sewerage systems. The average organic nitrogen value is 0.0111 pound per capita per day, based upon sample values from 14 sewerage systems. The average ammonia nitrogen value is 0.0143 pound per capita per day, based upon sample values from 12 sewerage systems. It is important to note that the number of samples on which the foregoing average values are based greatly exceed the number of sewerage systems from which the samples were collected, since multiple samples were obtained in most cases.

COMPARISON OF SEWAGE FLOW AND STRENGTH SURVEY FINDINGS WITH OTHER RESEARCH FINDINGS IN THE REGION

The foregoing survey findings relating to sewage flow and strength based upon analyses of selected sanitary sewerage systems in the Region may be compared against other recent research within the Region. Because of the scarcity of recent field data pertaining to per capita hydraulic and pollution loadings attributable to domestic sewage, a study was recently conducted in the City of Cudahy, Milwaukee County, to provide such field data.[4] The study area in the City of Cudahy consisted of approximately 160 acres of' residential land served by separate sanitary sewers. About 1,200 people resided in the study area at the time of the survey and were housed in 270 dwelling units composed of 226 single family homes, two duplexes, and a five-building apartment complex. Most of the houses were built between 1961 and 1967 and, as of 1972, had market values ranging from $24,000 to $27,000.

The separate sanitary sewerage system serving this area was relatively new having been built during the period 1961-1967. Except for house connections, the system utilizes concrete pipe with rubber gasket joints in order to minimize infiltration. The pipe slopes were designed to achieve adequate flow velocities and minimize deposition of solids.

Flow measurements and water quality samples were obtained at a point just upstream of a connection of the sewer system serving the study area to a Milwaukee-Metropolitan Sewerage Commissions trunk sewer. About 10,000 feet of branch and lateral sanitary sewers were tributary to the sampling point. The field work was conducted between November 1969 and May 1970 during which time twenty 24-hour composite and two 12-hour composite samples were obtained.

The study revealed that in this strictly residential, or domestic, study area, hydraulic loadings ranged from 41 to 80 gallons per capita per day, with an average of about 58 gallons per capita per day. Per capita five-day carbonaceous biochemical oxygen demand values ranged from 0.05 to 0.17 pound per capita per day, with an average value of about 0.10 pound per capita per day. Per capita suspended solids contributions ranged from 0.04 to 0.22 pound per capita per day, with an average of about 0.08 pound per capita per day.

Comparisons of the foregoing research findings with the data presented earlier in this chapter indicate that the average hydraulic loading of 58 gallons per capita per day from the study area in the City of Cudahy is below the lower end of the range of estimated per capita domestic sewage flow contributions of 78 to 102 gallons per capita per day determined for the sewerage systems serving the seven county seats in the Region. Since the area studied in the City of Cudahy is considerably smaller than the sewered area of any of the seven county seats in the Region, and since the technique utilized to estimate per capita domestic sewage flow contribution in the seven county seats was based upon metered water delivery, it would be expected that the Cudahy research findings would indicate somewhat lower flow contributions than those derived from flow data for the seven county seat communities. The average values for per capita five-day carbonaceous biochemical oxygen demand and per capita suspended solids contributions found in the Cudahy research fall within the range of values for these sewage strength criteria provided by the data presented earlier in this chapter. Thus, it may be concluded that the recent research findings on

[4] *E. B. Zanoni and R. J. Rutkowski "Per Capita Loadings of Domestic Wastewater," Journal Water Pollution Control Federation, Volume 44, No. 9, September 1972, pages 1756-1762.*

sewage flow and strength for strictly domestic sewage for an area in the City of Cudahy are generally consistent with the sewage flow and strength data presented in this chapter and utilized in the selection of the sewerage system design criteria presented in Chapter IX of this report.

SUMMARY

Of particular importance in the planning and design of sanitary sewerage systems are the characteristics of the sewage to be collected and treated, including the rate and volume of flow and the concentration of contaminants. Several investigations were made under the regional sanitary sewerage system planning program to determine the flow and strength characteristics of sewage generated within the Region. Such characteristics were utilized, together with widely accepted engineering standards and experienced engineering judgement, as a basis for the selection of sewerage system design criteria presented in Chapter IX of this report.

The principal sources of sanitary sewage are spent municipal water supply, groundwater infiltration, and storm water inflow. Analyses conducted under the regional sanitary sewerage system planning program indicated the following average conditions for the Region with respect to sewage flow components:

1. Average amount of domestic sewage flow contributed by all urban land uses except major industrial and commercial concentrations and based upon water delivery records: 88 gallons per capita per day, ranging from a low of 78 to a high of 103 gpcd.

2. Average amount of sewage flow contributed by major concentrations of industrial land uses: 12,270 gallons per acre per day, ranging from a low of 1,430 to a high of 24,660 gpad.

3. Average amount of sewage flow contributed by major concentrations of commercial land uses: 7,640 gallons per acre per day, ranging from a low of 2,580 to a high of 13,620 gpad.

4. Average infiltration rate: 0.24 gallons per minute per gross developed acre, ranging from a low of 0.09 to a high of 0.73 gpad.

5. Average storm water inflow rate: 0.57 gallons per minute per gross developed acre, ranging from a low of 0.26 to a high of 1.68 gpad.

6. Peak-to-average flow rates: 3.72 to 1 for trunk sewers, ranging from a low of 2.83 to 1 to a high of 4.61 to 1; and 1.87 to 1 for sewage treatment plants, ranging from a low of 1.34 to 1 to a high of 2.66 to 1.

While variation in sewage strengths is not as critical a consideration in regional sanitary sewerage system planning as variations in sewage flow rates, a knowledge of sewage strength characteristics is required to determine the necessary type and level of treatment to be provided and the potential effects of effluent discharges on the quality of the receiving stream. Indicators commonly used today, but not necessarily historically, to measure the strength of sewage are concentrations of oxygen demanding materials, nutrients, suspended solids, and the pH—that is, the relative acidity and alkalinity—of the sewage. Analyses conducted under the regional sanitary sewerage system planning program indicated the following average conditions for the Region with respect to sewage strength characteristics:

1. Average five-day carbonaceous biochemical oxygen demand value: 0.259 pound per capita per day, ranging from a low of 0.0627 to a high of 1.523 pounds per capita per day.

2. Average suspended solids value: 0.219 pound per capita per day, ranging from a low of 0.0656 to a high of 0.676 pound per capita per day.

3. Average total phosphorus value: 0.0138 pound per capita per day, ranging from a low of 0.0055 to a high of 0.0535 pound per capita per day.

4. Average organic nitrogen value: 0.0111 pound per capita per day, ranging from a low of 0.0061 to a high of 0.0208 pound per capita per day.

5. Average ammonia nitrogen value: 0.0143 pound per capita per day, ranging from a low of 0.0063 to a high of 0.0233 pound per capita per day.

As noted above, the foregoing survey data pertaining to sewage flow and sewage strength characteristics from throughout the Region were utilized in the regional sanitary sewerage system planning program as a partial basis for the selection of design criteria for the sanitary sewerage system components to be included in the regional sanitary sewerage system plan. In addition, however, an extensive literature search was conducted to provide an additional basis for the selection of the design criteria. This literature search and the design criteria selected for use in the study, as well as the relationship of the selected design criteria to the foregoing average values for sewage flow and strengths in the Region, are discussed in Chapter IX of this report.

Chapter VII

LEGAL CONSIDERATIONS IN SANITARY SEWERAGE SYSTEM DEVELOPMENT

INTRODUCTION

In any sound planning and engineering effort, it is necessary to investigate the legal, as well as the physical and economic, factors affecting the problem under consideration. In areawide sanitary sewerage system planning the law can be as important as the technical feasibility and cost of proposed facilities in determining the ultimate practicality of a given sewerage system plan. If legal constraints bearing on the planning problem are ignored during plan formulation, serious obstacles may be encountered during plan implementation.

In recognition of the importance of legal aspects in comprehensive planning, the Southeastern Wisconsin Regional Planning Commission previously completed two companion analyses of existing law in southeastern Wisconsin. The first of these analyses related to the existing body of water law in southeastern Wisconsin and included a survey of the legal framework of public and private water rights affecting water resources management, planning, and engineering. The findings of this survey and analysis were set forth in published form in SEWRPC Technical Report No. 2, Water Law in Southeastern Wisconsin, January 1966. This analysis, conducted as an integral part of the Root River watershed planning program, was carried out under the direction of the late Professor J. H. Beuscher, University of Wisconsin Law School, and included an inventory of the existing powers and responsibilities of the various levels and agencies of government involved in water resource management, as well as of the structure of public and private water rights, which must necessarily be considered in the formulation of a comprehensive watershed plan. In subsequent planning programs for the Fox and Milwaukee River watersheds, the Commission summarized the legal factors bearing upon the water-related problems of the respective watersheds, updating as necessary the pertinent aspects of statutory and administrative law presented in the original water law report. These summaries are set forth in Chapter XIV, SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume One, Inventory Findings and Forecasts, April 1969, and Chapter XV, SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume One, Inventory Findings and Forecasts, December 1970. In general, the analysis of basic water law as presented in summary form in SEWRPC Technical Report No. 2 remains valid today. Those aspects of the report which deal with the statutory and administrative provisions of federal and state law governing water resource protection, however, have changed substantially since the publication of SEWRPC Technical Report No. 2 and, accordingly, need revision. One of the primary objectives of this chapter is, then, to provide such a revision pertaining to the legal provisions for water pollution control.

The second report dealing with the legal aspects of planning and plan implementation in southeastern Wisconsin was a survey of existing planning law also conducted for the Commission by Professor Beuscher and published in SEWRPC Report No. 6, Planning Law in Southeastern Wisconsin, October 1966. This report deals with the specific powers for local and areawide planning and plan implementation primarily with respect to land use planning. As such, it has a less direct bearing upon a regional sanitary sewerage system plan than does the companion water law survey and analysis. The importance of sound land use development, and, therefore, of sound public land use controls to sanitary sewerage system planning and development should not, however, be overlooked. Areawide—or local—plans for the provision of public utility systems, such as sanitary sewerage systems, can only be properly prepared within the framework of a land use plan. Moreover, public policies that provide for the extension of sanitary sewer service on the basis of an agreed-upon areawide sanitary sewerage system plan can contribute significantly toward implementation of an agreed-upon areawide land use plan. Thus, the various kinds of comprehensive plan implementation powers discussed in Technical Report No. 6 deserve the careful attention of agencies and units of government assigned implementing responsibilities under the regional sanitary sewerage system plan. No attempt is made in this chapter, however, to repeat the salient findings of the analyses presented in SEWRPC Technical Report No. 6. Rather, the reader is referred directly to that report.

The law relating directly to the development of sanitary sewerage systems consists largely of statutes, ordinances, and administrative rules enacted at the federal, state, and local levels of government. These statutes, ordinances, and rules relate primarily to water pollution prevention and abatement—and particularly to the regulation of design, construction, and operation of sewage treatment plants—since sewage treatment plants constitute the most significant category of identifiable point sources of water pollution. In addition, particularly with respect to the state level, there are legal considerations which relate to the various institutional structures which may be created at the local level of government to provide for areawide sewage collection, conveyance, and treatment facilities in urban and urbanizing areas. Finally, also with respect to the state level, there are numerous administrative rules governing the design, construction, operation, and maintenance of sanitary sewerage facilities.

This chapter, then, is intended to provide a brief overview of the legal considerations relating to sanitary sewerage system planning and development at the federal, state, and local levels of government. It should be stressed that this area of the law is rapidly changing as new statutes and administrative rules are enacted to provide for greater protection of the natural environment. For this reason, attention is focused more on the broad policy evolving in federal and state law as opposed to the specific means of implementation of that policy. Attention in this chapter is first directed at evolving federal water pollution control machinery; next at the state level water pollution control machinery which is rapidly changing to meet new federal requirements; then at local water pollution control machinery, with particular emphasis upon alternative institutional structures for the implementation of areawide sanitary sewerage system plans; and finally at private steps for water pollution control.

FEDERAL WATER POLLUTION CONTROL MACHINERY

The federal government has long been involved in water pollution control efforts, although it is only in relatively recent years that the United States Congress has acted to secure the establishment of water use objectives and supporting standards for navigable waters. The 1899 Refuse Act prohibited the discharge of any refuse matter of any kind, other than that flowing from streets and sewers, into any navigable waters of the United States, or tributaries thereto, without first obtaining a permit from the Secretary of the Army. The Secretary was directed to make a specific finding that the discharge of any refuse matter would not adversely affect anchorage and navigation; no finding on water quality was, however, required. This Act and the permits issued thereunder were largely ignored until enactment of the Environmental Policy Act of 1969, which required all federal agencies to consider the environmental impact in the administration of all public laws, and the Water Quality Improvement Act of 1970, which required applicants for federal permits to file a certification from the appropriate state that the proposed discharge would not violate any applicable state adopted water quality standard. The enactment of these two new laws in relatively recent years made it necessary for the Secretary of the Army to assess the affects of proposed discharges on water quality in the processing of any 1899 Refuse Act permit.

A broader federal approach to water pollution control began with passage of the Federal Water Pollution Control Act on June 30, 1948. With the passage of this Act, the federal government began to take effective steps toward controlling and preventing pollution of the navigable waters of the United States. Initially, the Act was primarily directed at establishing a federal grant-in-aid program for the construction of publicly owned waste treatment facilities. In the mid-1960's, requirements were added relating to the establishment of interstate water quality standards. The Act was substantially revised by the Federal Water Pollution Control Act amendments of 1972, enacted into law on October 18, 1972 over a Presidential veto. In general, the revised Act provides for an increased emphasis on the enhancement of the quality of all of the navigable waters of the United States, whether interstate or intrastate, and further places an increased emphasis on planning and the examination of alternative courses of action to meet stated water use objectives and supporting water quality standards. The Act declares it to be a national goal to eliminate the discharge of pollutants into the navigable waters of the United States by 1985; that, wherever obtainable, an interim goal of water quality which provides for the protection and propagation of fish and natural wildlife and for human recreation in and on the water be achieved by 1983; that substantial federal financial assistance be provided to construct publicly owned waste treatment works; and that areawide waste treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants within each state.

The Federal Water Pollution Control Act is divided into five broad titles. Title I deals with research and related programs and includes Congressional declaration of goals and policy for water quality. Title II of the Act contains provisions relating to federal grants-in-aid for the construction of publicly owned waste treatment works, including the need for areawide waste treatment planning and management. Title III of the Act deals broadly with water quality standards and enforcement provisions, including effluent limitations, water use objectives and supporting water quality standards, water quality inventories, and inspection and monitoring programs. Title IV of the Act deals with permits and licenses, including the establishment of a national pollutant discharge elimination system. Finally, Title V of the Act includes general provisions relating to administration of the Act. The following sections attempt to summarize in the very briefest fashion the requirements of the current Federal Water Pollution Control Act as these requirements affect sanitary sewerage system planning and development. These requirements may be categorized under the following headings: water quality standards and effluent limitations, pollutant discharge permit system, continuing statewide water quality management planning process, areawide waste treatment planning and management, and federal grants for waste treatment works construction. A summary timetable of the key actions required under the current Act, together with appropriate references to the Act and the Code of Federal Regulations, is set forth in Table 71. Following discussion of these relevant portions of the Federal Water Pollution Control Act, attention is given to the requirements of the National Environmental Policy Act of 1969, the Lake Michigan Enforcement Conference recommendations (although this conference has been dissolved) and the question of interbasin water diversion.

Water Quality Standards and Effluent Limitations

Since 1965 the Federal Water Pollution Control Act has required states to adopt water use objectives and supporting water quality standards for all interstate waters. The Act as revised in 1972 incorporates by reference in Section 303(a) all existing interstate water quality standards that have been approved by the Administrator of the Environmental Protection Agency (EPA). In addition, the Act requires for the first time the adoption and submittal to EPA for approval of intrastate water use objectives and supporting water quality standards. Wisconsin, through the Natural Resources Board and the Department of Natural Resources, has adopted the required interstate and intrastate water use objectives and supporting water quality standards. These objectives and standards as related to the streams and watercourses of southeastern Wisconsin are presented in detail later in this chapter. Under the new federal law, state governors are required to hold public hearings at least every three years for the purpose of reviewing the adopted water use objectives and supporting water quality standards and, in light of such hearings, appropriately modify and readopt such objectives and standards.

In addition, Sections 301 and 302 of the Act require the establishment of, respectively, effluent limitations and water quality related effluent limitations. Section 301 establishes a deadline of July 1, 1977, for the enactment of specific effluent limitations for all point sources of water pollution other than publicly owned treatment works. Such limitations must require the application of the best practical water pollution control technology currently available, as defined by the EPA Administrator. In addition, any waste source which discharges into a publicly owned treatment works must comply with applicable pretreatment requirements also to be established by the EPA Administrator. All publicly owned treatment works in existence on July 1, 1977, must meet effluent limitations based upon a secondary level of treatment, as defined by the EPA Administrator, and must apply the best practicable waste treatment technology. In addition, Section 301 provides that any waste source must meet any more stringent effluent limitation as required to implement any applicable water use objective and supporting standard established pursuant to any state law or regulation or any other federal law or regulation. Section 301 further provides that no later than July 1, 1983, effluent limitations for point sources of water pollution other than publicly owned treatment works must require the application of the best available technology that will result in further progress toward the national goal of eliminating the discharge of all pollutants. The EPA Adminis-

Table 71

SUMMARY OF KEY ACTIONS REQUIRED BY THE FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972 RELATED TO WATER QUALITY MANAGEMENT PLANNING AND SEWERAGE FACILITY CONSTRUCTION GRANTS

Specified Time Period Provided for Action to be Completed	Target Date[1]	Action Required[2]	Federal Water Pollution Control Act Reference	Code of Federal Regulations Reference (If Applicable and Known)
60 days	December 17, 1972	EPA Publishes Information on the Degree of Effluent Reduction Attainable Through Secondary Treatment	Sec. 304(d)(1)	- -
90 days	January 16, 1973	EPA Publishes Guidelines for Identification of Areas of Urban-Industrial Concentrations with Substantial Water Quality Control Problems	Sec. 208(a)(1)	40 CFR Part 126
90 days	January 16, 1973	EPA Publishes Lists of Categories of Sources Subject to National Standards of Performance	Sec. 306(b)(1)(A)	- -
90 days	January 16, 1973	EPA Publishes List of Toxic Pollutants Subject to Regulation of Discharges	Sec. 307(a)(1)	- -
120 days	February 15, 1973	EPA Promulgates Rules and Regulations for Construction Grants	Sec. 201(g)(4)	40 CFR Part 35
120 days	February 15, 1973	State Submits Proposed Continuing Planning Process	Sec. 303(e)(2)	40 CFR Part 130
120 days	February 15, 1973	EPA Publishes Guidelines for Pretreatment of Pollutants Not Susceptible to Treatment by Publicly Owned Treatment Works	Sec. 304(f)(1)	- -
150 days	March 17, 1973	Governor Identifies Areas with Substantial Water Pollution Control Problems	Sec. 208(a)(2)	40 CFR Part 126
150 days	March 17, 1973	EPA Administrator Approves State Continuing Planning Process	Sec. 303(e)(2)	40 CFR Part 130
180 days	April 16, 1973	EPA Issues Guidelines for Payment of Costs by Industry	Sec. 204(b)(2)	- -
180 days	April 16, 1973	EPA Issues Guidelines for Evaluation of Methods of Treatment, Including Cost-Effectiveness Analyses	Sec. 212(2)(C)	- -
180 days	April 16, 1973	EPA Issues Guidelines for Establishing Test Procedures for the Analysis of Pollutants	Sec. 304(g)	- -
180 days	April 16, 1973	EPA Proposes Pretreatment Standards for Introduction of Pollutants into Publicly Owned Treatment Works Which are Determined Not to be Susceptible to Treatment or Which Would Interfere with the Operation of the Treatment Works	Sec. 307(b)(1)	- -
270 days	July 15, 1973	Governor Designates Boundaries and Organizations for Areawide Waste Treatment Management Planning	Sec. 208(a)(2)	40 CFR Part 126
270 days	July 15, 1973	EPA Issues Information on Processes and Operating Methods for Elimination or Reduction of Discharge of Pollutants to Implement Standards of Performance	Sec. 304(c)	- -
270 days	July 15, 1973	EPA Issues Information on Methods, Procedures, and Processes to Restore and Enhance the Quality of Publicly Owned Fresh Water Lakes	Sec. 304(i)	- -
270 days	July 15, 1973	EPA Publishes Proposed Effluent Standards for Toxic Pollutants	Sec. 307(a)(2)	- -
270 days	July 15, 1973	EPA, After Public Hearing, Issues Regulations Establishing Pretreatment Standards	Sec. 307(b)(1)	- -
9 months	July 18, 1973	EPA Issues Information on Available Alternative Waste Treatment Management Techniques	Sec. 304(d)(2)	- -
1 year	October 18, 1973	EPA Publishes Criteria for Water Quality	Sec. 304(a)(1)	- -
1 year	October 18, 1973	EPA Publishes Information on Factors Necessary to Restore and Maintain Integrity of Waters	Sec. 304(a)(2)	- -
1 year	October 18, 1973	EPA Publishes Regulations Providing Guidelines for Effluent Limitations	Sec. 304(b)	- -
1 year	October 18, 1973	EPA Publishes Guidelines for Identifying and Evaluating Non-Point Sources of Pollutants	Sec. 304(e)(c)	- -
450 days	January 11, 1974	EPA Proposes Regulations Establishing National Standards of Performance for New Waste Sources in all Categories	Sec. 306(h)(1)(B)	- -
450 days	January 11, 1974	EPA, After Public Hearing, Promulgates Effluent Standards	Sec. 307(a)(2)	- -
1 year, 7 months	May 18, 1974	EPA, After Giving Opportunity for Comment, Promulgates Regulations Establishing National Standards of Performance	Sec. 306(b)(1)(B)	- -
1 year, 9 months	July 18, 1974	Areawide Waste Treatment Management Planning Process Must Be In Operation	Sec. 208(b)(1)	40 CFR Part 126
3 years, 9 months	July 18, 1976	Initial Areawide Plan Certified by Governor to EPA – Governor Designates Waste Treatment Management Agency	Sec. 208(b)(1)	40 CFR Part 126
3 years, 9 months	July 18, 1976	Compliance With Pretreatment Standards Required	Sec. 307(b)(1)	- -
4 years	October 18, 1976	EPA Approves Waste Treatment Management Agency	Sec. 208(c)(2)	40 CFR Part 126

[1]*Based upon the time period allotted for action to be completed after enactment of the Federal Water Pollution Control Act Amendments of 1972 on October 18, 1972. It should be noted that considerable slippage in meeting the target dates has already (May 1973) been evident.*

[2]*In addition to the listed actions required by the Federal Water Pollution Control Act, the following dates are of significance to water quality management planning and sewerage facility construction grants:*

a. *After March 1, 1973, no construction grant may be approved without the establishment of user charges in the local sewerage system; the repayment of applicable share of federal grant by industries contributing sewage; and the approval of the applicant's legal, institutional, managerial, and financial capability for the construction, operation, and maintenance of treatment facilities (Sec. 204(b)(1)).*

b. *After July 1, 1973, no construction grant may be approved unless the applicant satisfies the EPA Administrator that the sewer system tributary to the treatment plant is not subject to excessive infiltration (Sec. 201 (g)(3)).*

c. *After June 30, 1974, no construction grant may be approved unless alternative waste management techniques have been evaluated. In addition, all waste treatment works must provide for application of technology at a later date for the recycling and reclaiming of water (Sec. 201(g)(2)).*

Source: U. S. Environmental Protection Agency and SEWRPC.

trator is required to formulate findings, if possible, that the elimination of point sources of pollution by category and class is technologically and economically achievable. Also by July 1, 1983, all publicly owned treatment works must comply with all requirements specified under Section 201 of the Act pertaining to the evaluation of alternative waste management techniques, including, as appropriate, the reclaiming or recycling of water in order to eliminate the discharge of pollutants. Finally, Section 301 provides that any effluent limitation established to meet the July 1, 1983, goals must be reviewed at least every five years and, if appropriate, revised to implement the national goal of eliminating the discharge of all pollutants.

Section 302 of the Act provides authority for the EPA Administrator to set even more stringent effluent limitations for point sources or groups of point sources of water pollution upon a specific finding that the effluent limitations established under Section 301 relating to the 1983 goals would not result in the attainment or maintenance of that water quality in a specific portion of the navigable waters which would protect public water supplies, accommodate agricultural and industrial uses and the protection and propagation of a balanced fish and wildlife population, and allow human recreational activities in and on the water. No authority is given in this section to the states, indicating that upon specific findings, the EPA Administrator can apply direct federal action to assure the achievement of water use objectives and supporting water quality standards. Before such direct federal effluent limitations can be set, however, the balance between the economic and social benefits and costs of such a limitation is required to be determined at an administrative hearing.

As part of the continuing state planning process discussed below, each state is required by Section 303(d) of the Act to identify any waters within its boundary for which effluent limitations required under Section 301 are not stringent enough to achieve applicable adopted water use objectives and supporting water quality standards. The state is then required to establish a priority ranking for such waters taking into account the severity of the pollution and the uses proposed to be made of the waters. For each such identified water, the state is then to establish a total maximum daily load for appropriate pollutants. Such a daily load is to be established at a level necessary to implement the water quality standards. Any loadings for such waters, as approved by the EPA Administrator, are required to be incorporated into the state water resources plan required under Section 303(e) of the Act.

Section 306 of the Act provides for the first time national standards of performance with respect to the discharge of pollutants. The EPA Administrator is required to publish a list of categories of pollution sources and regulations establishing federal standards of performance for newly established sources of pollution within each industrial category. The term "standard of performance" is defined to mean a standard for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated water pollution control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants. In essence, then, this section requires the establishment of national levels of performance with respect to new sources of water pollution within industrial categories, new sources being defined as any new facility constructed after the national standards of performance have been promulgated. Thus, for example, any newly established firm processing dairy products would be required to meet the same standard of performance with respect to the discharge of water pollutants anywhere in the United States irrespective of the assimilative capacity of the receiving water body. The practical effect of this section is to eliminate "shopping around" on the part of industries for specific locations in the country which may be able to require less stringent water pollution control standards than other areas because of the availability of a large dilution potential. Under the new law the Administrator may delegate to each state authority for applying and enforcing the national standards of performance.

Section 307 of the new Act requires the EPA Administrator to establish toxic and pretreatment effluent standards. The Administrator must publish a list of pollutants that are determined to be toxic and subsequently publish proposed effluent limitations, which may include a discharge prohibition, for such pollutants. In addition, the Administrator is required to establish national pretreatment standards for the discharge of pollutants into publicly owned treatment works. The standards must cover pollutants that are not susceptible to treatment at the public facility or that would interfere with the proper operation of the public facility. Any state or local pretreatment requirements that are not in conflict with any national pretreatment standards are allowed to remain in effect. This section also specifies that individual industrial users of municipal waste treatment plants are not to be required to obtain a discharge permit under Section 402 of the Act, as discussed below. Any such discharge permit issued to a municipal waste treatment plant must, however, identify any industrial contributors and the quality and quantity of effluent introduced by them. This section of the Act further provides that any violation of pretreatment standards may be enforced directly against the contributor by the EPA Administrator. Finally, industrial users must give notice of any change in the quality or quantity of the effluent discharged into a municipal sewerage system to the state or federal agency issuing a permit for a publicly owned treatment works, so that that agency will have an opportunity to examine the impact of the proposed discharge so as to determine whether there might be a violation of the municipal waste discharge permit.

Section 308 of the Act requires the EPA Administrator, or a state upon approval of the Administrator, to establish an effective monitoring system related to all point sources of pollution. Owners or operators of any point sources, whether discharging directly to surface waters or into a municipal sanitary sewerage system, must establish and maintain records; make reports; install, maintain, and use monitoring equipment or methods; provide sampling of effluents in a manner prescribed by the EPA or the state; and provide any other relevant information that may be required. It should be noted that, as discussed in more detail below, the State of Wisconsin has recently established a point source monitoring system.

Finally, with respect to water quality standards and effluent limitations, Section 304 of the Act grants to the EPA Administrator the authority to develop appropriate guidelines applicable to the establishment of the aforementioned water quality standards and effluent limitations (see Table 71). These guidelines include the following:

1. The development and publication of criteria for water quality accurately reflecting the latest scientific knowledge on the kind and extent of identifiable effects on health and welfare which may be expected from the presence of pollutants in any body of water; on the concentration and dispersal of pollutants through biological, physical, and chemical processes; and on the effects of pollutants on biological community diversity, productivity, and stability.

2. The development and publication of information on factors necessary to restore and maintain the chemical, physical, and biological integrity of all navigable waters; on the factors necessary for the protection and propagation of fish life for classes and categories of receiving waters and to allow recreational activities in and on the waters; on the measurement and classification of water quality; and on the identification of pollutants suitable for maximum daily load measurement correlated with the achievement of water quality objectives.

3. The preparation and publication of regulations providing guidelines for adopting or revising effluent limitations.

4. The development and publication of information relating to the degree of effluent reduction attainable through the application of secondary waste treatment; information on alternative waste treatment management techniques and systems; and information for identifying and evaluating the nature and extent of nonpoint sources of pollution and the processes, procedures, and methods needed to control pollution from such sources.

5. The preparation and publication of guidelines for the pretreatment of pollutants determined not susceptible to treatment by publicly owned treatment works.

6. The preparation and publication of guidelines for establishing test procedures for the analysis of pollutants.

7. The preparation and publication of guidelines for the establishment of uniform application forms and other minimum requirements for the acquisition of information from owners and operators of point sources of pollution.

8. The preparation and publication of guidelines establishing the minimum procedural and related elements of any state permit program for waste discharges including monitoring requirements, reporting requirements, and enforcement provisions.

It is clearly the intent of Congress that any effluent limitations applicable to individual point sources within a given category or class not only be as uniform as possible, but be uniformly applied nationwide. The EPA Administrator is expected to be precise in his guidelines in order to assure that similar point sources with similar characteristics, regardless of their location in the nation or the nature of the water into which the discharge is made, will be required to meet similar effluent limitations.

Pollutant Discharge Permit System

As noted earlier Title IV of the Federal Water Pollution Control Act, as revised in 1972, deals with permits and licenses. Section 402 establishes a national pollutant discharge elimination system. Under this system, the EPA Administrator, or a state upon approval of the EPA Administrator, may issue permits for the discharge of any pollutant, or combination of pollutants, upon condition that the discharge will either meet all applicable effluent limitations or, prior to the taking of necessary implementing actions relating to effluent limitations, such additional conditions as the Administrator determines are necessary to carry out the provisions of the Act. In effect, this section supersedes the permit system established, but little utilized for water quality purposes under the Refuse Act of 1899. All such permits are now to be issued under the Federal Water Pollution Control Act, and none are to be issued from this time on under the Refuse Act. All such permits must contain conditions to assure compliance with all the requirements of the Act, including conditions on data and information collection and reporting. In essence, this section provides that all waste discharges into navigable waters must obtain a federal permit or, in the cases where a state is authorized to issue permits, a state permit.

In order for the EPA Administrator to authorize a state to issue permits, the state must show that it has the necessary capability and must submit a proposed permit program. The EPA Administrator must approve a state permit program unless he finds that the state does not have authority to adequately carry out all requirements of the Federal Water Pollution Control Act. The intent of the permit system is to include in the permit, where appropriate, a schedule of compliance which will set forth the dates by which various stages of the requirements imposed in the permit shall be achieved.

The new pollutant discharge permit system thus becomes the primary vehicle for implementation of the basic goals of the Federal Water Pollution Control Act and any plans prepared pursuant to provisions of the Act. Because of its comprehensiveness in terms of scope and depth and its direct relationship to water quality standards and effluent limitations, the permit system in Wisconsin will likely have the effect of superseding the existing system of the issuance of pollution abatement orders to the operators of individual point sources of pollution. This change is likely to be one both of mechanics and of substance. While state pollution abatement orders often specified actions to be taken much like conditions to be met under a permit system, such orders rarely, if ever, were directly related to comprehensive water resource management plans and to the water use objectives and supporting water quality standards underlying such plans.

Section 401 of the Act provides that any applicant for a federal license or a permit to conduct any activity relating to the construction or operation of facilities which may result in any discharge into navigable waters provide the federal licensing or permit agency with a certification from the appropriate state that the discharge will comply with all provisions of the new Act. In addition, such state certification must set forth any effluent limitations or monitoring requirements necessary to assure compliance with the Act, as well as any additional state requirements. All such limitations or requirements set forth in the state certification automatically become conditions on any federal license or permit.

Section 405 of the Federal Water Pollution Control Act prohibits the disposal of sewage sludge from the operation of a sewage treatment plant in any manner which would result in any pollutant from such sludge entering the navigable waters of the United States, except in accordance with a special permit issued by the EPA Administrator. The Administrator is required to promulgate regulations governing the issuance of permits for sewage sludge disposal. Any state may administer its own permit program for the disposal of sewage sludge upon approval of the EPA Administrator.

Continuing Statewide Water Quality Management Planning Process

The new Federal Water Pollution Control Act provides in Section 303(e) that each state must have a continuing planning process consistent with the objectives of the Act. States are required to submit a proposed continuing planning process to the EPA Administrator for his approval. The Administrator is prohibited from approving any state discharge permit program under Title IV of the Act for any state which does not have an approved continuing planning process under Section 303(e).

The state continuing planning process must result in water quality management plans for the navigable waters within the state which include at least the following items:

1. Effluent limitations and schedules of compliance to meet applicable water use objectives and supporting water quality standards.

2. The incorporation of all elements of any applicable areawide waste management plan prepared for metropolitan areas under Section 208 of the Act.

3. The total maximum daily load for pollutants for all waters identified by the state where the effluent limitations required by Section 301 of the Act are not stringent enough to implement water use objectives and supporting water quality standards, together with the total maximum daily load of pollutants for all other waters, taking into account seasonal variations and margins of safety.

4. Adequate procedures for revision of plans.

5. Adequate authority for intergovernmental cooperation.

6. Adequate steps for implementation, including schedules of compliance, of any water use objectives and supporting water quality standards.

7. Adequate control over the disposition of all residual waste from any water treatment processing.

8. An inventory and ranking in order of priority of needs for the construction of waste treatment works within the state.

In effect, the Section 303(e) state planning process is designed to result in the preparation of comprehensive water quality management plans for natural drainage basins or watersheds. Such basin plans, however, are likely to be less comprehensive in scope than the comprehensive plans prepared for the Root, Fox, and Milwaukee River watersheds by the Regional Planning Commission. The basin plans are to incorporate, as appropriate, any metropolitan or regional plans or specific facility development, such as a regional sanitary sewerage system plan described in this report. In addition, such basin plans should reflect appropriate findings and recommendations of any comprehensive basin plan (Level B) prepared by the Water Resources Council under the federal Water Resources Planning Act. Thus, the statewide planning process in Section 303(e) is envisioned as one largely of synthesizing the various basin, watershed, and regional planning elements prepared throughout the state by federal, state, regional, and local units and agencies of government. This state planning process should also become the vehicle for coordinating all state and local activities directed at securing compliance with the requirements of the Federal Water Pollution Control Act.

Areawide Waste Treatment Planning and Management

Title II of the Federal Water Pollution Control Act, as revised in 1972, deals broadly with federal grants for the construction of waste treatment works. One of the major provisions in this title is found in Section 208 and deals with the development and implementation of areawide waste treatment management plans. Such plans are intended to become the basis upon which the EPA approves grants to local units of government for the construction of waste treatment works.

The first step in the Section 208 planning process is the preparation and publication by the EPA Administrator of guidelines for the identification of areas which, as a result of urban and industrial concentrations or other development factors, have substantial water quality control problems. Upon formal publication of these EPA guidelines, the state governor has 60 days to identify each area within a state which has a substantial water quality control problem. Upon such identification, the governor then has an additional 120 days to consult with appropriate elected and other officials of local governments within the area concerning the nature of the water quality control problems and the designation of an appropriate planning region.

Following such consultation, the governor is then required to designate the official boundaries of all Section 208 planning areas within the state, and to further designate for each area a single representative planning organization capable of developing an effective areawide waste treatment management plan. If the governor does not act either by designating—or affirmatively determining not to designate—Section 208 planning areas, the chief elected officials of local governments within a metropolitan area may take the initiative and by agreement designate boundaries for a Section 208 planning area and further designate an appropriate planning agency. In either case the EPA Administrator must approve all designations of Section 208 planning areas and planning agencies. The state is required to act as the planning agency for any portion of a state not designated as a Section 208 planning region. It should be noted that the foregoing time schedule will likely not be met, since the first step in the process—the publication of EPA guidelines implementing Section 208—has already (May 1973) been delayed. The statutory time schedule for the Section 208 planning process is included in Table 71.

Within one year after the date of designation of any planning organization to conduct Section 208 areawide waste treatment planning, the planning agency must have in operation an approved continuing, areawide waste treatment management planning process consistent with the objectives of the federal grant program for waste treatment works construction. The agency must prepare an areawide waste treatment management plan for the region and submit such plan to the governor. The governor must then certify the plan and submit it to the EPA Administrator no longer then two years after the planning process is placed into operation. Any areawide plan prepared under the Section 208 planning process must include at least the following elements:

1. The identification of waste treatment works necessary to meet the anticipated municipal and industrial waste treatment needs for the area for a 20-year period. This identification must include an analysis of alternative waste treatment systems, an identification of any requirements for the acquisition of land for treatment purposes, the identification of any necessary waste water collection and urban storm water drainage systems, and the development of a program to provide the necessary financial arrangements for the development of any treatment works.

2. The establishment of construction priorities and time schedules for all treatment works included in the plan.

3. The establishment of a regulatory program to provide for the location, modification, and construction of any facilities within the planning area which may result in pollutant discharges and to ensure that any industrial or commercial wastes discharged into any treatment works meet applicable pretreatment requirements.

4. The identification of all agencies necessary to construct, operate, and maintain the facilities included in the plan and to otherwise carry out the recommendations in the plan.

5. The identification of the measures necessary to carry out the plan, including financing; period of time necessary to carry out the plan; the cost of carrying out the plan; and the economic, social, and environmental impact of carrying out the plan.

6. The identification of agriculturally and silviculturally related nonpoint sources of pollution and the procedures and methods, including land use controls, necessary to control, to the maximum extent feasible, such pollution sources.

7. The identification, as appropriate, of all mine-related sources of pollution, construction-related sources of pollution, and salt water intrusion, and the methods and procedures to control, to the maximum extent feasible, such pollution point sources.

8. Recommendations for the control of the disposition of all residual wastes generated in the planning area which may affect water quality, such as sludge.

9. The establishment of a process to control the disposal of pollutants on land or in subsurface excavations.

All areawide waste treatment management plans must be updated annually and certified annually by the governor to the EPA Administrator as being consistent with any applicable basin plans as prepared under Section 303(e) of the Act.

It should be understood that areawide plans prepared to meet requirements set forth under Section 208 of the Federal Water Pollution Control Act need not consist of a single planning effort culminating in a single document. This is particularly true in areas such as the Southeastern Wisconsin Region where truly areawide comprehensive planning efforts have been carried on for over a decade. In such cases it would be reasonable to expect that the Section 208 planning requirements would all be met in the comprehensive planning process, and that, therefore, documentation for such a plan would be set forth in several publications. As discussed in more detail in Chapter II of this report, the Commission's comprehensive watershed planning programs may be thought of as natural resource conservation oriented planning efforts which provide a broad approach to water control facility and related land and water use planning and development. The Commission's sanitary sewerage system planning program, on the other hand, may be thought of as an urban development oriented planning effort which seeks to provide the facilities necessary to permit sound urban development within the Region while protecting the underlying and sustaining natural resource base. The watershed, sanitary sewerage, and ultimately, water supply plan elements, together with the underlying land use plan, must be carefully coordinated and must comprise integrated elements of a single comprehensive, areawide development plan.

More specifically, with respect to the Section 208 planning requirements, the regional sanitary sewerage system plan will identify the waste treatment works necessary in the Region to meet municipal waste treatment needs for a 20-year period, will include an analysis of alternative waste treatment systems, will identify land requirements necessary for sewage treatment purposes, and will further identify the necessary waste water collection systems. Furthermore, the regional sanitary sewerage system plan will estimate the costs of carrying out the plan; the overall economic, social, and environmental impact of carrying out the plan; set forth a general timetable for plan implementation; and identify all agencies with plan implementation responsibilities. The Commission's watershed studies are intended to identify all nonpoint sources of pollution and the procedures and methods necessary to control pollution from such sources to the maximum extent feasible. Such watershed studies are also intended to result in preparation of the basic areawide storm water drainage plan element for the Region since, with the exception of a very few of the oldest and largest communities in the Region, the storm water drainage facilities of areawide significance are the streams and water courses of the Region. The Commission has identified all existing urban type, piped storm water drainage systems in the Region, as reported in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin, July 1963. In general the development of these piped storm water drainage facilities in the Region has been nonsystematic and highly localized in nature, with reliance upon the streams and watercourses in either a natural or "improved" state as the principal outlet. Specific plan elements relating to storm water drainage and flood control are provided in each of the Commission comprehensive watershed plans and are documented in the watershed reports.

Other Commission planning efforts also relate to the Section 208 planning requirements. For example, the Commission has published SEWRPC Planning Guide No. 6, Soils Development Guide, August 1969, which sets forth recommended measures and procedures to control soil erosion and sediment pollution during the land development process. In addition, the Commission's ongoing regional land use planning effort provides the basic land use data and the areawide land use plan so essential to the preparation of areawide water quality management plans.

Certain of the specific planning requirements under Section 208 can best be met through additional planning and preliminary engineering efforts accomplished once the basic water quality management plan has been adopted. For example, in situations where a comprehensive watershed development plan or a regional sanitary sewerage system plan has recommended that an areawide sanitary sewerage system affecting several municipalities be established, there are a number of alternative ways in which such communities, acting pursuant to state law, could proceed to implement the basic plan recommendation. These would include the formation of a metropolitan sewerage district, the establishment of a joint sewerage system upon approval of the Department of Natural Resources, or the establishment of a joint sewerage system under the general grant of intergovernmental cooperation power. Furthermore, with respect to specific implementation schedules related to the timing and staging of the various subelements of an areawide system plan and with respect to the need for interim facilities, it would appear to be poor practice to spend time and effort in analyzing such matters until basic agreement upon a general plan is achieved among all units and agencies of government concerned. Accordingly, questions dealing with specific institutional measures for carrying out a plan and with the specific scheduling of plan implementation projects are best dealt with as part of a continuing planning effort involving, in metropolitan areas, very close working relationships between the areawide planning agency and the local units and agencies of government designated as management agencies to carry out the plan. Detailed implementation plans, very similar in concept to the jurisdictional highway system plans prepared by the Commission as an implementation tool with respect to the adopted regional transportation plan, should follow, where appropriate, the preparation and adoption of basic areawide water quality management plan elements. Thus, the basic areawide plan would identify, for example, the functional sewerage systems needed to serve existing and anticipated future needs. The jurisdictional planning effort would recommend a specific institutional structure for constructing, operating, and maintaining an areawide functional sewerage system; would examine alternatives with respect to staging and construction of the system, including the identification of and justification for interim facilities not included in the initial plan; would recommend a specific timetable for construction of the system; would identify the total costs necessary to carry out the plan and recommend a method for appropriate cost sharing between the municipalities involved; would examine alternative waste management techniques and processes with respect to the waste treatment facilities needed for the areawide system; and would recommend specific means for all residual waste disposal.

In essence, then, the Commission views the requirements of the Section 208 planning process as being met through a series of interrelated planning efforts conducted within the framework of comprehensive, areawide planning for the Region. It is likely that such requirements will only be fully met within the context of a number of interrelated regional plan elements.

At the time an areawide waste treatment management plan is submitted by the governor to the EPA Administrator, the governor must designate, after consultation with the appropriate areawide planning agency, one or more waste treatment management agencies to carry out the plan. Once a waste treatment management agency having appropriate authority has been so designated, and once a Section 208 areawide waste treatment management plan has been approved by the EPA Administrator, the Administrator is prohibited from making any federal grant for the construction of a publicly owned treatment works except to the designated management agency and for treatment works found to be in conformity with the areawide plan. In addition, no permit may be issued under Section 402 of the Act for any point source of water pollution found to be in conflict with any approved Section 208 plan.

Federal Grants for Waste Treatment Works Construction

One of the basic goals of the Federal Water Pollution Control Act is to provide for federal funding of publicly owned waste treatment works. As noted above, the Act requires that such funding be based upon an approved areawide waste treatment management plan designed to provide for control of all point and nonpoint sources of water pollution. The Act further encourages waste treatment management at specific treatment works which provides for the recycling of potential pollutants through the production of agriculture, silviculture, or aquaculture products for revenue; the confined and contained disposal of any pollutants not recycled; the reclamation of wastewater; and the ultimate disposal of sludge in an environmentally safe manner.

Section 201 of the Act provides that the EPA Administrator cannot approve any grant after July 1, 1973, unless the applicant demonstrates that the sewage collection system discharging into the sewage treatment facility is not subject to excessive infiltration or clear water inflow. Special grants for the evaluation of clear water problems in sewer collection systems are to be made available under new guidelines to be published by the Administrator.

Section 201 also prohibits the Administrator from making any grant for a sewage treatment facility unless he determines that alternative waste management techniques for a particular facility have been studied and evaluated and that the specific works proposed for federal grant assistance will provide for the application of the best practicable waste treatment technology over the life of the works, and that, as appropriate, the works proposed for assistance will take into account and allow to the extent practicable the application of technology at a later date that will provide for the reclaiming or recycling of water or otherwise eliminate the discharge of pollutants.

Federal funding for any grant for waste treatment works has been set at 75 percent of the construction costs. In an important departure from previous regulations, the new Federal Water Pollution Control Act authorizes contract authority in that the Administrator has the power to commit the federal government to payment of its portion of the treatment facility at the time he approves an applicant's plans, specifications, and estimates. In previous years the first payment of a federal grant to a municipality occurred when 25 percent of the actual construction of the facility was completed. Under the new program, which is modeled after the Federal Highway Act, each stage in the construction of a waste treatment facility may be considered as a separate project. An applicant for a grant may stage in any manner the overall project and prepare plans, specifications, and estimates for each stage. Actual payment may be based upon approval of such plans, specifications, and estimates for each stage.

Various limitations and conditions on any federal waste treatment work grant are set forth in Section 204 of the Act. As already noted, any treatment works proposed to be funded must be included in any Section 208 areawide waste treatment management plan and must be found in conformity with any applicable state plan developed under Section 303(e). Furthermore, the state must certify that the works to be funded are entitled to priority over other works in the state. In addition, the size and capacity of the works must relate directly to the specific needs to be served by the works, accounting for sufficient reserve capacity. Finally, the applicant must adopt a system of charges to assure that each recipient of waste treatment services within the applicant's jurisdiction will pay its proportionate share of the operation and maintenance costs, including replacement costs, of any waste treatment services provided; and that industrial users of the treatment works will pay to the applicant that portion of the cost of construction of the works which is allocable to the treatment of industrial wastes, at least with respect to the federal share of the cost of construction. The EPA Administrator is required to publish guidelines to be used by local governments in setting up schedules of service charges for industrial and other users of waste treatment works. Such guidelines must establish classes of users of such services, including categories of industrial users; criteria against which to determine the adequacy of charges imposed on all classes and categories of users reflecting all factors that influence the cost of waste treatment, including strength, volume, and delivery flow rate characteristics; and model systems and rates of user charges typical of various treatment works serving communities. All industrial charges are to be retained by the grant applicant in an amount equal to the non-federal cost of the project plus an amount necessary for future expansion and reconstruction. Any revenues in excess of 50 percent of all revenues derived from industrial users, however, are to be returned to the U. S. Treasury.

It should be noted that potential conflicts exist between several of the foregoing objectives of the Act relating to waste treatment works. For example, the imposition of industrial charges for capital recovery as well as operation and maintenance costs may well lead to decisions in the private sector to recycle wastewater and substantially reduce the flows discharged to the public sewerage system. While this is generally considered to be a desirable objective, undesirable side effects relating to other objectives of the Act, for example recycling, may occur. Elimination of substantial amounts of brewery wastes in the Milwaukee-Metropolitan sewerage system could, for example, adversely affect the production of Milorganite, a commercial fertilizer, at the Jones Island sewage treatment plant. Consequently, the objectives of the federal act clearly can be achieved only within the context of areawide planning efforts.

National Environmental Policy Act

One of the significant pieces of national legislation in recent years is the National Environmental Policy Act of 1969. This Act broadly declares a national policy to encourage a productive and enjoyable relationship between man and his environment; to promote efforts which will prevent or eliminate damage to the environment; and to enrich the understanding of the ecological systems and natural resources important to the nation. This Act has broad application to all projects in any way related to federal action, including the construction of sewerage facilities aided by federal grants. The mechanism by which the intent of the Environmental Policy Act of 1969 is carried out is the preparation of an environmental impact statement for each project. Such statement must include documentation of the environmental impact of the proposed project; any adverse environmental effects which cannot be avoided should the project be constructed; any alternatives to the proposed project; the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. Draft copies of all environmental impact statements must be made available for review by appropriate federal, state, and local agencies. Such environmental impact statements are required for all municipal waste water transmission and treatment projects. As discussed later in this chapter, the State of Wisconsin has a similar environmental policy act covering governmental action of all kinds within the state, whether or not it is federally aided.

The Federal Water Pollution Control Act, as amended in 1972, specifically relates the provisions of that Act to the National Environmental Policy Act of 1969. Section 511 of the Federal Water Pollution Control Act specifically excepts all actions of the EPA Administrator from the requirements of the National Environmental Policy Act of 1969, except federal grants for publicly owned treatment works and the issuance of any permit under Section 402 for the discharge of any pollutant by a newly established source as defined in Section 306. The Senate Conference Report (92-1236) submitted in support of the enactment of the Federal Water Pollution Control Act amendments of 1972 notes that in the administration of the Act virtually every action of the EPA Administrator can be construed to involve a balancing of factors which affect the environment, and that if all of the actions of the Administrator were subject to the requirements of the National Environmental Policy Act, the administration of the Act would be greatly impeded.

Thus, with but two exceptions—construction grants for sewerage facilities, including sewage treatment plants, and discharge permits for new sources of pollution—all actions taken by the EPA Administrator under this Act are exempt from the preparation of environmental impact statements. Specific guidelines and procedures for the preparation of environmental impact statements for sewerage facilities and plans associated with such facilities are set forth in Title 40, Part 6, of the Code of Federal Regulations (40 CFR Part 6). These guidelines clearly distinguish between an environmental assessment, an environmental review, an environmental impact statement, a negative declaration of environmental impact, and an environmental impact appraisal.

An "environmental assessment" is defined by the EPA as a written analysis submitted to the EPA describing the environmental impacts of actions undertaken or proposed to be undertaken with the financial support of the EPA. An "environmental review" is defined by the EPA as a formal evaluation by the EPA to determine whether a proposed EPA action—such as approving an areawide sewerage system plan or a federal grant-in-aid of the construction of sewerage facilities—may have a significant impact on the environment. An "environmental impact statement" is defined by the EPA as a report prepared by the EPA which identifies and analyzes in detail the environmental impacts of a proposed EPA action. A "negative declaration of environmental impact" is defined by the EPA as a written announcement prepared subsequent to the environmental review which states that the EPA has decided that the preparation of an environmental impact statement will not be necessary because the review determined that the proposed action will not significantly affect the environment. An "environmental impact appraisal" is defined by the EPA as an abbreviated document supporting a position of negative declaration of environmental impact by setting forth a basis for the conclusion by EPA that no significant environmental impact of an EPA action is anticipated.

Since the regional sanitary sewerage system plan set forth in this report is intended to be adopted by the Regional Planning Commission, certified by the Commission to and approved by the Wisconsin Natural Resources Board, and in turn certified by the Board to the EPA as the state's official water quality management plan for the seven-county Region, and since the plan deals with sewerage facilities the construction of which is likely to be aided through EPA administered federal grants, the guidelines set forth in 40 CFR Part 6 pertaining to the preparation of an environmental impact statement apply directly to the plan. The environmental assessment required as the first step in the process is included in Chapters XI and XII of this report setting forth the alternative plans and the recommended plan, respectively. Based upon this assessment, the

EPA will be able to conduct an environmental review and make a determination as to whether or not an environmental impact statement is required. Should such a statement be required, the EPA itself is responsible for its preparation and circulation in draft and final forms, it being anticipated that such statements would be based in large part upon the environmental assessments provided to the EPA.

The federal regulations clearly state that a major objective is to prepare an environmental impact statement for an areawide sewerage facility construction program at the system planning stage. In the case of the regional sanitary sewerage system plan for southeastern Wisconsin, the necessary environmental impact statement could be prepared immediately upon certification of the plan by the Natural Resources Board to the EPA. Once such a statement is completed and approved, the federal regulations provide that individual environmental impact statements will not be required for specific sewerage facilities unless such facilities deviate substantially from the previously approved areawide plan or unless the original plan does not provide sufficient detail to fully assess significant impacts of individual projects. Thus, approval of the regional sanitary sewerage system plan by the EPA, coupled with the early preparation of an environmental impact statement by EPA, would obviate the need for local units of government in the Region to prepare environmental impact statements for sewerage facility projects that substantially conform to the areawide plan.

Lake Michigan Enforcement Conference Recommendations

Before the Federal Water Pollution Control Act was amended in 1972, steps had been taken to establish enforcement measures against the pollution of Lake Michigan. Such steps were manifested in the continuing Lake Michigan Enforcement Conference established under Section 10 of the old Act. While the precise legal status of such enforcement measures is not clear at this time, since the new Act did not incorporate such measures by reference nor provide for the continuance of such enforcement conferences, the enforcement measures promulgated by the Lake Michigan Enforcement Conference have been fully integrated into the state's water pollution control efforts and must be considered, therefore, in the preparation of the regional sanitary sewerage system plan.

The Lake Michigan Enforcement Conference was initially convened in 1968 by the then Secretary of the U. S. Department of the Interior to explore the abatement of pollution of Lake Michigan and its tributary waters. The conferees included official representatives of the states of Illinois, Indiana, Michigan, and Wisconsin as well as of the federal government. The Conference was called by the Secretary at the request of the governor of the State of Illinois and upon the basis of studies conducted by the federal government on the matter of the pollution of Lake Michigan. At the initial Conference, 26 recommendations dealing with water pollution control efforts in the Lake Michigen basin were formulated and agreed to by the conferees. Of particular significance to that portion of the regional sanitary sewerage system planning program directed at the Lake Michigan Basin are the following recommendations:

1. Waste treatment is to be provided by all municipalities to achieve at least 80 percent reduction of total phosphorus. This action was to be substantially accomplished by December 1972.

2. Industries not connected to municipal sewerage systems are to provide sewage treatment so as to meet the water quality standards for Lake Michigan as approved by the Secretary of the Interior. This action was also to be substantially accomplished by 1972.

3. Continuous disinfection is to be provided throughout the year for all municipal waste treatment plant effluent. This action was to have been accomplished not later than May 1969.

4. Unified sewage collection systems serving contiguous urban areas are to be encouraged.

5. Combined storm and sanitary sewers are to be separated in coordination with all urban reconstruction projects and prohibited in all new developments, except where other techniques can be applied to control pollution from combined sewer overflows. Pollution from combined sewers is to be controlled by July 1977.

6. Discharge of treatable industrial wastes to municipal sewerage systems, following needed preliminary treatment, is to be encouraged.

7. Prohibition of the dumping of polluted material into Lake Michigan is to be accomplished as soon as possible.

8. State water pollution control agencies are to accelerate programs to provide for the maximum use of areawide sewerage facilities, to discourage the proliferation of small treatment plants in contiguous urbanized areas, and to foster the replacement of septic tanks with adequate collection and treatment.

Pursuant to the recommendations of the Conference, the Wisconsin Department of Natural Resources has issued pollution abatement orders to effect the recommendations to all communities discharging directly to Lake Michigan or tributaries to Lake Michigan.

Subsequent sessions of the Lake Michigan Enforcement Conference were held in 1969, 1970, and 1972. At the 1969 session the recommendation noted above to remove 80 percent phosphorus from all municipal sewage treatment plants was modified to provide for a basinwide approach to phosphorus reduction. Thus, so long as at least 80 percent of the total phosphorus contribution from municipal sewage treatment plants in the basin was removed, it did not matter whether each municipal plant mounted a phosphorus reduction program. The practical effect of this policy modification is to exempt small sewage treatment plants from phosphorus reduction orders. At the 1972 session, the phosphorus removal recommendation was supplemented so as to also require a maximum effluent total phosphorus concentration of 1.0 mg/l.

As noted earlier, the Conference was dissolved upon enactment of the Federal Water Pollution Control Act Amendments of 1972. The last meeting of the Conference was held in September and continued in November 1972. Presumably, because all of the states have already taken steps to effectuate the Conference recommendations, and have done so utilizing state water quality control authority, such recommendations will constitute an input to all water quality management plans and become reflected in all pollutant discharge permits.

Interbasin Water Diversion

Although not directly a part of the federal water pollution control machinery, one of the more important legal problems in water resources and sewerage system planning concerns interbasin diversion of water. The traditional common law riparian doctrine, which for the most part is still in effect today, forbade the transfer of substantial amounts of water between watersheds. It must be recognized, however, that states, by legislative action, can and have created exceptions to this general doctrine and that major interwatershed diversions, such as the so-called Chicago diversion of water from the Lake Michigan-St. Lawrence River drainage basin to the Mississippi River drainage basin, have on occasion taken place.

The problem of interbasin water diversion was of significance in the Commission watershed studies for the Root and Fox River watersheds and, hence, is of significance to the regional sanitary sewerage system planning program. Many factors militate against interbasin stream diversions and such diversions are generally accomplished only with great legal difficulty. Riparians along the stream from which the diversion is made may be in a position, depending upon the quantity of water involved and the duration of the diversion, to assert their private property rights against the public agencies carrying out the diversion. Similarly, those individuals whose lands abut the water body into which the diversion is made may be able to claim damages caused by unnatural increased flow. In either case the riparians involved have rights under common water law.

Another problem arises in Wisconsin with regard to interbasin navigable stream diversions. It would appear that the consent of the state as guardian "in trust" of public rights in all navigable waters of the state is necessary. Section 30.18 of the Wisconsin Statutes, dealing with water diversions, stipulates that "...no water shall be so diverted to the injury of public rights in the stream...." This certainly seems to preclude the diversion of the total flow of a stream because that would not just injure but would actually terminate public rights in that stream. In other words, consent for such a diversion could not legally be given. The diversion of less than the total flow would seemingly present a question of fact as to whether or not public rights had been injured—a question to be resolved by the courts in each individual instance. Section 30.18 of the Wisconsin Statutes furthermore seems to preclude interbasin diversion of any but surplus waters as defined in the statute.[1] Once again, the diversion of any major quantity of water must be considered unlikely under the provisions of this statute.

A last but important factor militating against interbasin stream diversions which in any way affect interstate or international waters, as might well be the case in southeastern Wisconsin, is the longstanding litigation between Wisconsin and Illinois in the Supreme Court of the United States concerning the Chicago diversion and developments arising therefrom. The most recent decree[2] entered by the U. S. Supreme Court in this litigation occurred in 1967 when the State of Illinois and its political subdivisions were enjoined from diverting from the Great Lakes-St. Lawrence River drainage basin to the Mississippi River drainage basin more than 3,200 cubic feet per second for domestic use. The Court, however, indicated that the State of Illinois could make application for a modification of the decree to permit further diversion upon a showing that the reasonable needs of the northeastern Illinois metropolitan region for water for domestic use cannot be met from the surface water and groundwater resources of the region and from the current permitted diversion. Wisconsin has long argued in this litigation that interbasin diversions which reduce or alter the level or flow of waters in one state or country in favor of another state or country are illegal. The tactical position of Wisconsin, in light of its long-held position in this litigation, would be seriously weakened if it permitted a stream diversion within the Region which altered in favor of Wisconsin the natural flow of waters between Wisconsin and Illinois. The advantages that such a diversion would have to the Region and to the state as a whole would thus have to be weighed against the longstanding and apparently deeply felt issues involved in this past and probable future U. S. Supreme Court litigation.

Based upon the foregoing it is apparent that interbasin water diversion in any substantial amount poses a significant constraint on the development of a sanitary sewerage system plan for the Southeastern Wisconsin Region. Hence, in the formulation of alternative arrangements for the provision of areawide sanitary sewerage service, attention in this study will be focused on those reasonable alternatives which do not involve substantial diversion of water across the subcontinental divide traversing the Southeastern Wisconsin Region.

STATE WATER POLLUTION CONTROL MACHINERY

Responsibility for water pollution control in Wisconsin is centered in the Department of Natural Resources. Pursuant to the State Water Resources Act of 1965,[3] the Department of Natural Resources acts as the central unit of state government to protect, maintain, and improve the quality and management of the ground and surface waters of the state. Previous to this Act, responsibility for state water resource management was diffused among the State Committee on Water Pollution, the State Board of Health (now renamed the State Division of Health), the Wisconsin Public Service Commission, and the Wisconsin Conservation Commission. All of the water pollution control related functions of these agencies were merged into the new Wisconsin Department of Natural Resources, except regulation of private septic tank sewage disposal systems which remains centralized, along with the general plumbing supervision function, in the Department of Health and Social Services, Division of Health. Attention in this section of the chapter will be focused on those specific functions of the Department of Natural Resources which directly bear upon water pollution control and, hence, upon the preparation of the regional sanitary sewerage system plan. Attention first will be focused upon the general pollution abatement powers and responsibilities of the Department of Natural Resources, including regulations governing the design, construction, operation, and maintenance of sanitary sewerage facilities, and subsequently upon the water use objectives and supporting water quality standards, the municipal waste water treatment policies, and the effluent reporting and monitoring system established by the Department. Finally, attention will also be given to the regulation of septic tank installations in the state and the relatively recent state legislation which requires the preparation of environmental impact statements for all significant state actions.

---

[1] *Wisconsin Statutes 30.18(2). Surplus water as used in this section means any water of a stream which is not being beneficially used. The Department of Natural Resources may determine how much of the flowing water at any point in a stream is surplus.*

[2] *Wisconsin, et al v. Illinois, et al, 388 U. S. 426 (1967).*

[3] *Chapter 614, Laws of Wisconsin, 1965.*

General Pollution Abatement Responsibilities of the Department of Natural Resources

The basic authority and accompanying responsibilities relating to the water pollution control function of the Department of Natural Resources are set forth in Chapter 144 of the Wisconsin Statutes. In accordance with its basic purpose of serving as the central unit of state government to protect, maintain, and improve the quality and management of the waters of the state, Section 144.025(2)(a) provides that the Department formulate a long-range comprehensive state water resources plan for each region in the state. The seven-county Southeastern Wisconsin Planning Region coincides with one of the water resource planning districts established by the Department. This section of the statutes also provides that the Department formulate plans and programs for the prevention and abatement of water pollution and for the maintenance and improvement of water quality. Such plans are generally prepared on a watershed or basin basis. The Department is further given authority under Section 144.025(2)(b) to adopt rules setting standards of water quality applicable to all of the waters of the state, which standards must be related to the different uses to which the waters may be put. These specific water use objectives and supporting water quality standards established by the state pursuant to this authority are discussed in more detail below.

Pursuant to Section 144.025(2)(c), the Department is given authority to issue general orders applicable throughout the state for the construction, installation, use, and operation of systems, methods, and means for preventing and abating water pollution. This section also provides that the Department may adopt specific rules relating to the installation of water pollution abatement systems. Pursuant to this authority, the Department has adopted requirements for sewage disposal in Chapter NR 108 of the Wisconsin Administrative Code and for the design and operation of sewerage systems in Chapter NR 110 of the Wisconsin Administrative Code. These rules require the submission, review, and approval of all plans and specifications for components of sanitary sewerage systems. At the present time, Chapter NR 110 deals in a rather general manner with the plans and engineering reports required to be submitted in support of applications for approval of the design and operation of sewerage facilities. The Department is currently revising these rules in an attempt to be more specific and complete in identifying the applicable regulations governing sewerage facilities. Specific policies with respect to waste water treatment are discussed in more detail below.

Special pollution abatement orders directing particular polluters to secure appropriate operating results at sewage treatment facilities in order to control water pollution are authorized to be issued by the Department in Section 144.025(2)(d). Such orders may prescribe a specified time for compliance with provisions of the order. This provision of the statutes is widely utilized by the Department to secure the proper operation and maintenance of sanitary sewerage systems, including in particular sewage treatment facilities. Such orders are directed not only at municipal units of government that operate sewage treatment plants but also at private corporations and individuals who in any way discharge wastes to the surface or groundwaters of the state. Because these orders are timely and are subject to change, revision, and updating through daily implementation action, or perhaps the lack of implementation action, no attempt has been made in this report to review all of the specific pollution abatement orders currently outstanding in the Southeastern Wisconsin Region, which are estimated at the present time (March 1973) to number about 100. The Department has the power to make such investigations and inspections as are necessary to assure compliance with any pollution abatement orders which it issues. In cases of noncompliance with any pollution abatement order, the Department has the authority, under Section 144.025(2)(s), to take any action directed by the order and to collect the costs thereof from the owner to whom the order was directed. Such charges become a lien against the property involved.

The Department is also authorized to conduct research and demonstration projects on sewerage and waste treatment matters. It is also authorized to establish pilot sewage treatment plants and other facilities and to purchase land or equipment in connection therewith. Furthermore, the Department is required upon request and without charge to consult with and advise owners of waste sources as to the most appropriate method of waste disposal. The Department is given the authority under Section 144.025(2)(j) to enter into agreements with other states, subject to approval by the governor, relative to pollution control on any interstate waters and to carry out such agreement by appropriate orders to owners of waste sources. Such authority becomes important in the Southeastern Wisconsin Region where many interstate waters are involved, including Lake Michigan and the waters of the Fox and Rock River watersheds.

In Section 144.025(2)(1) of the Wisconsin Statutes, the Department is given the authority to establish an examining program for the certification of sewage treatment plant operators. Pursuant to this authority the Department has adopted Chapter NR 144 of the Wisconsin Administrative Code which provides for a Board of Certification for sewage treatment plant operators and examinations for such operators. All sewage treatment plants in the state are classified by size and type. In general, the larger the sewage treatment plant, the greater the educational and experience requirements and the more complex the examination for the sewage treatment plant operator. All persons operating sewage treatment plants must hold valid certificates issued pursuant to this Code.

Under Section 144.025(2)(r) the Department is given specific authority to order the installation of a sanitary sewerage system within a specified time upon a finding that the absence of a municipal sanitary sewerage system or treatment plant tends to create a nuisance or menace to public health. The Department has used this general authority in the Region particularly where widespread failure of private septic tank sewage disposal systems has occurred. One of the most recent cases occurred in the Town of Lyons in Walworth County where the Department ordered the town to establish a sanitary or utility district and submit plans for the installation of a centralized sanitary sewerage system in the unincorporated place of Lyons. Similarly, the Department is authorized to require a sewerage system, including a sewage disposal plant, of any governmental unit to be so planned and constructed that it may be connected with that of any other governmental unit and may, after appropriate public hearing, order the proper connections to be made. This power was modified by the enactment of Chapter 89 of the Wisconsin Laws of 1971, whereby any such order cannot become effective for 30 days following its issuance. Within that time period the governing body of a city or village subject to such an order may commence an annexation proceeding to annex the unincorporated territory that may be subject to the order. If the result of the referendum for annexation is in favor of annexation, the territory involved is annexed to the city or village and sewer service is to be extended in compliance with the order. If the result of the referendum is against the annexation, the connection order is deemed to be null and void. If a city or village does not commence an annexation proceeding within the 30-day period, the order becomes effective at the end of that time.

Finally, in Section 144.21 of the Wisconsin Statutes, the Department is authorized to administer a financial assistance program for the construction of pollution prevention and abatement facilities. This program is administered by the Department pursuant to rules set forth in Chapter NR 125 of the Wisconsin Administrative Code.

Based upon the foregoing general pollution control authority, the Wisconsin Department of Natural Resources, following the procedures established by its predecessor agencies, has established a pollution control program that involves the examination and survey of entire river basins or major sectors thereof, rather than attacking pollution solely on a case-by-case basis as problems arise. This procedure, though sound, is time consuming in order to be competent and thorough. The basic studies conducted by the Department involve a water quality sampling program; physical, chemical, and biological analyses of the samplings; an inventory of all significant sources of water pollution within the basin; and a preliminary assessment of the results. All probable polluters—private, industrial, and municipal—who utilize a particular watercourse for waste disposal are given notice that such a study is under way and will be followed by public hearings at which time the preliminary findings are presented and at which owners of waste sources can appear and submit statements in refutation, defense, or mitigation. Following the study and subsequent hearing, the findings are summarized in a basin survey report wherein the extent of each stream user's contribution to the total pollution load and individual efforts to minimize or control the polluting qualities of effluents are documented. After all analyses have been completed, the hearing of testimony ended, and the basic pollution report prepared, specific orders addressed to each polluter on the stream are then issued directing such action as the Department deems necessary to reduce or eliminate water pollution within the basin. The unique substances of each polluter are thus known and can be taken into account in framing these orders, and a reasonable time limit in which to comply can be established.

With the enactment of the Federal Water Pollution Control Act Amendments of 1972, as discussed earlier in this chapter, it is likely that the foregoing basic procedures for water pollution control in Wisconsin will change somewhat. While the details of this change are not clear at this time and remain to be worked out, it is likely that the state will establish a pollution discharge permit system that will supplant the issuance of specific pollution abatement orders. Such permits must reflect findings and recommendations of long-range plans prepared under either Section 208 or 303(e) of the Federal Water Pollution Control Act. It is likely that the basin survey processes discussed above consisting of inventory, analyses, and public hearing steps will be fully integrated into the areawide and statewide planning programs and thus become reflected in the pollution discharge permits.

Water Use Objectives and Water Quality Standards

As noted earlier, the Wisconsin Department of Natural Resources (DNR) is required under Section 144.025(2)(b) of the Wisconsin Statutes to adopt rules relating to water use objectives and supporting water quality standards to be applicable to all of the surface waters of the state. In addition, the Federal Water Pollution Control Act requires the establishment of such use objectives and standards for all navigable waters in the United States. Such water use objectives and water quality standards were initially adopted by the Wisconsin Resource Development Board (now the Wisconsin Natural Resources Board) for interstate and intrastate water on June 1, 1967, and September 1, 1968, respectively, and were set forth in Chapters NR 102, NR 103, and NR 104 of the Wisconsin Administrative Code.

Effective October 1, 1973, the Wisconsin Natural Resources Board adopted revised water use objectives and supporting standards which are set forth in revised Chapters NR 102, NR 103, and NR 104 of the Wisconsin Administrative Code. The new objectives and standards are generally more stringent than the old, both with respect to the water use objectives established for the streams and lakes of the Region and with respect to the supporting water quality standards.

An understanding of both the water use objectives and supporting water quality standards adopted by DNR in 1967 and 1968—hereinafter referred to as the initial DNR objectives and standards—as well as the new water use objectives and supporting water quality standards adopted by the Department in 1973—hereinafter referred to as the revised DNR objectives and standards—is required for a proper understanding of the recommended sanitary sewerage system development objectives. An understanding of the initial DNR objectives and standards is required in order to relate the adopted comprehensive watershed plans, the water quality management elements of which plans were based in part upon these initial objectives and standards, to the regional sewerage system plan. An understanding of the revised DNR objectives and standards is required, since these objectives and standards served as the point of departure in formulating the long-range water use objectives and supporting standards for southeastern Wisconsin under the regional sanitary sewerage system planning program.

Initial DNR Water Use Objectives and Water Quality Standards: The initial DNR water quality standards applicable to surface waters were formulated for the following seven major water uses: protection of fish reproduction, maintenance of a warm water fishery, whole-body contact recreation, partial-body contact recreation, public water supply, and industrial and cooling water. The seventh water use relates to aesthetic considerations and provides minimum standards for all waters. The initial state standards are set forth in Table 72. Such standards are statements of the physical, chemical, and biological characteristics of the water that must be maintained if it is to be suitable for the specified use.[4]

Minimum Standards for All Waters: The initial state minimum standards applied to all surface waters at all locations within the state. Essentially, these minimum standards were designed to maintain all state waters in an aesthetically pleasant condition and to protect the public health. These also served as the standards for determining suitability for livestock and wildlife watering, irrigation, navigation, and waste assimilation.

Public Water Supply: Quality standards for raw water to be used for public water supply should be such that the water, after appropriate treatment, will be suitable for human consumption. The factors used in formulating these criteria in the initial DNR water quality standards were that the

[4]*See Appendix C for a discussion of water quality indicators applicable to the initial DNR water use objectives.*

Table 72

ADOPTED WATER QUALITY STANDARDS FOR MAJOR WATER USES IN WISCONSIN: 1972

Water Quality Parameters	Water Use Objectives						
	Preservation and Enhancement Of Fish Life		Municipal (Public) Water Supply	Recreation		Industrial And Cooling Water	Minimum Standards For All Waters
	Fish Reproduction Of Primary Importance	Warm-Water Fishery		Whole Body Contact[3]	Partial Body Contact[4]		
Dissolved Oxygen (mg/1)	5.0M[5]	4.0M[6]	--[7]	--[8]	--[8]	1.0M[9]	Substances in concentrations or combinations which are toxic or harmful to human beings shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which, by appropriate test, indicate acute or chronic levels harmful to animals, plants, or aquatic life. Substances that will cause objectionable deposits on the shore or in the bed of a water body, floating or submerged debris, oil, or other material, and material producing color, odor, taste, or unsightliness shall not be present in such amounts as to cause a nuisance.
Coliform Count (MFCC/100ML)	--[7]	--[7]	5,000[10]	1,000[11]	5,000[12]	--[7]	
Temperature (°F)	84[13]	89[13]	--[7]	--[7]	--[7]	89	
pH (Units)	--[7]	--[7]	6.0-9.0[14]	--[7]	--[7]	6.0-9.0[14]	
Dissolved Solids (mg/1)	--[7]	--[7]	500[15]	--[7]	--[7]	750.0[16]	
Other Parameters	--[17, 18, 19]	--[18, 19]	--[20]	--[8]	--[8]	--[18]	

[1]Limits are maximum permissible values, except minimum limits, which are denoted by the suffix M. Standards for pH have a range of limiting values.

[2]Interstate and intrastate standards adopted by the Wisconsin Resource Development Board effective June 1, 1967, and September 1, 1968, respectively. The Wisconsin Resource Development Board has since been succeeded by the Wisconsin Natural Resources Board.

[3]Whole-body-contact recreation refers to swimming, water skiing, and skin diving.

[4]Partial-body-contact recreation refers to fishing, boating, and hunting.

[5]Also, not less than 80 percent saturation and no abrupt change in background by more than 1 mg/1 at any time.

[6]Also, not less than 5 mg/1 during at least 16 hours of any 24-hour period.

[7]No standard established.

[8]Qualitative criteria listed under minimum standards and esthetics apply.

[9]Also, not less than 2.0 mg/1 as a daily average value.

[10]Coliform number not to exceed 5,000 per 100 ML as a monthly arithmetic average value, nor exceed this value in more than 20 percent of the samples examined during any month, nor exceed 20,000 per 100 ML in more than 5 percent of the samples.

[11]Arithmetic average of 1,000 MFCC/100 ML or less and a maximum not exceeding 2,500 MFCC/100 ML during recreation season. A sanitary survey and/or evaluation to assure protection from fecal pollution is the chief criterion in determining recreational suitability.

[12]Arithmetic average of 5,000 MFCC/100 ML or less and no more than 1 of the last 5 samples exceeding 20,000 MFCC/100 ML during recreation season.

[13]Also, no change from background by more than 5°F at any time nor at a rate in excess of 2°F per hour. Authorization must be obtained for proposed installations where discharge of a thermal pollutant may increase the natural maximum temperature of a stream by more than 3°F.

[14]Except in natural waters having a pH of less than 6.5 or greater than 8.5 where effluent discharges may not reduce the low value or raise the high value more than 0.5 pH units.

[15]Monthly average value not to exceed 500 mg/1, and a maximum not to exceed 750 mg/1 at any time.

[16]The monthly average value not to exceed 750 mg/1, and a maximum not exceeding 1,000 mg/1 at any time.

[17]Streams classified by law as trout waters shall not be altered from a natural background by effluents that affect the stream environment to such an extent that the trout population is adversely affected in any manner.

Source: Wisconsin Department of Natural Resources.

[18]Lake Michigan thermal discharge standards became effective as of February 1972 and are intended to protect aquatic biota. These standards apply to facilities discharging heated water directly to Lake Michigan, excluding municipal water and wastewater treatment plants and vessels or ships. Such discharges shall not raise the temperature of Lake Michigan at the boundary of the mixing zone established by the Wisconsin Department of Natural Resources by more than 3°F and, except for the Milwaukee and Port Washington Harbors, thermal discharges shall not increase the temperature of Lake Michigan at the boundary of the established mixing zones during the following months above the the following limits:

January, February, March	45°F
April	55°F
May	60°F
June	70°F
July, August, September	80°F
October	65°F
November	60°F
December	50°F

All owners utilizing or maintaining thermal discharge sources exceeding a daily average of 500 million BTU per hour shall, commencing April 1, 1972, submit monthly temperature and flow data reports to the Department of Natural Resources and shall, by February 1, 1974, submit to the Department a report on the environmental effect of such thermal discharges after approval of which the Department will establish mixing zones. Furthermore, parties responsible for thermal discharges exceeding a daily average of 500 million BTU per hour shall, by August 1, 1972, submit to the Department detailed chemical analyses of blowdown waters discharged to Lake Michigan and its tributaries and a preliminary engineering report for alternative cooling systems. Thermal discharge facilities, the construction of which commenced after February 1, 1972, shall be designed so as to avoid significant thermal discharges to Lake Michigan. If environmental damage to Lake Michigan exists or appears imminent, the Department of Natural Resources may order reductions in thermal discharges regardless of interim measures that may have been undertaken by owners of thermal discharge facilities.

[19]Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life.

[20]Concentrations of other constituents must not be hazardous to health, also, the intake water supply must be such that, by appropriate treatment and safeguards, it will meet the Public Health Service drinking water standards, 1962.

finished water should be physiologically harmless, palatable, odorless, and aesthetically desirable. Because of the effectiveness of present treatment methods, such standards are applied to the finished water rather than to the raw water supply.

Preservation and Enhancement of Fish and Other Aquatic Life: Standards for water to be used for the preservation and enhancement of fish and other aquatic life are generally specified in terms of parameters that affect the physiologic condition of the fish, the food chain that sustains the fish, and the aquatic environment. Two subcategories of water use related to aquatic life with differing standards were established—fish reproduction and maintenance of a warm water fishery. Dissolved oxygen concentration and temperature are the most frequently used parameters, since the reproduction and survival of fish and their susceptibility to toxic substances are highly dependent upon these factors. In addition, there are many substances, particularly insecticides, herbicides, and heavy metals, that are highly toxic to aquatic life in very small amounts. The initial DNR adopted standards for the preservation and enhancement of fish and other aquatic life are set forth in Table 72, and include Lake Michigan thermal discharge standards which became effective in February 1972. Lake Michigan thermal discharge standards were applicable only to those facilities discharging heated water directly to Lake Michigan. The initial DNR standards excluded municipal water and sewage treatment plants, as well as vessels or ships, and also excluded facilities discharging heated water to streams tributary to the lake.

Recreation: Two subcategories of water use related to recreation with differing standards are established—full- and partial-body contact. Waters to be used for recreational purposes were to conform to the following general conditions: 1) absence of obnoxious floating or suspended substances, objectionable color, and foul odors; 2) absence of substances that are toxic upon ingestion or irritating to the skin of human beings; and 3) absence of pathogenic organisms. The first two conditions were satisfied if the water met the minimum standards for all waters as previously described. The third condition, however, required that a standard be set to ensure the safety of a water from the standpoint of health. The concentration of total coliform bacteria was the parameter used for this purpose. Since the total coliform count is only a general, rather than a specific, indicator of fecal contamination, the initial Wisconsin standards, as set forth in Table 72, recommended that the primary criterion for determining the suitability of a water for recreational use should be a thorough sanitary survey to assure protection from fecal contamination, with the coliform concentrations serving only as guidelines in evaluating this suitability.

Industrial and Cooling Water: The ideal water quality for industrial and cooling uses varies widely for the many industrial uses to which water is put. The initial DNR standards, as set forth in Table 72, were intended to assure that the water would be suitable for most industrial uses after proper treatment and to minimize adverse effects of thermal discharges on aquatic biota. The required treatment would vary depending on the final water quality necessary for each industrial operation. One requirement common to all industries, however, was that the concentration of various constituents of the water should remain relatively constant. The quality of groundwater and of Lake Michigan water is more constant, in a temporal sense, than the quality of streams and inland lakes. Since most industries depend on groundwater and Lake Michigan as sources of water supply, either directly or by way of a municipal distribution system, the standards for industrial and cooling water use and discharge were meaningful only in those few areas of the Region where surface water was used as a source of supply or where spent cooling water was discharged either directly to Lake Michigan or to one of its tributaries.

Application of Initial Water Use Objectives to the Region: It is important to note that the particular standards to be applied to a given stream reach depend upon the existing or potential water uses in that reach; that is, the initial DNR standards, as listed in Table 72, could not be applied without knowledge of existing water uses and designation of water use objectives. Also, the capacity of a stream to receive and assimilate discharges with potential pollutants was determined by the flow and quality of water in the stream which would be available for dilution. The evaluation of compliance with water use objectives and supporting standards was to be based on estimates of water available for dilution, with a stream-flow equivalent to the lowest average for any period of seven consecutive days in the most recent 10 years.

The initial water use objectives stated that all surface waters within the Region should meet the standards for whole-body-contact recreational uses and for the preservation of fish and other aquatic life, with any exceptions and additions as shown on Map 47. It should be noted that initial water use objectives and supporting standards were to be subject to revision as either additional data were accumulated bearing on the continued validity of the water use objectives or as new data or techniques were developed which permitted the standards to be expressed in more precise, quantitative, and statistically valid terms.

As already noted, the foregoing water use objectives and supporting water quality standards adopted by the Natural Resources Board were utilized as a point of departure for the selection of recommended water use objectives and for plan preparation in the Commission's comprehensive planning programs for the Fox and Milwaukee River watersheds. With respect to all surface waters in the Milwaukee River watershed and the streams in the Fox River watershed, the plan recommends the water use objectives exactly as initially set forth in the Wisconsin Administrative Code. With respect to certain lakes within the

Map 47

INITIAL WISCONSIN DEPARTMENT OF NATURAL RESOURCES WATER USE OBJECTIVES FOR SURFACE WATERS IN THE REGION AS ADOPTED IN 1967-68

LEGEND

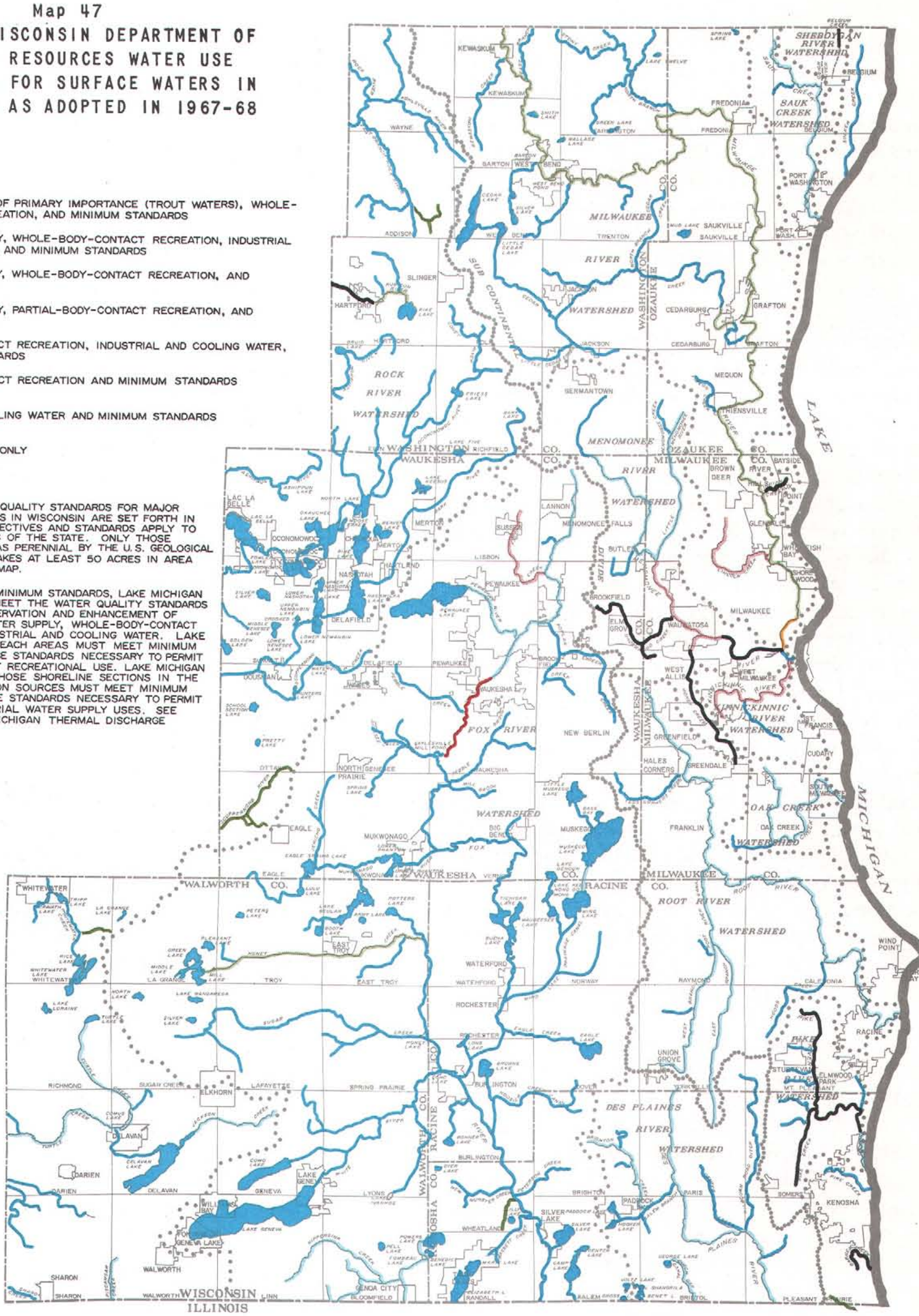
WATER USE OBJECTIVES

- FISH REPRODUCTION OF PRIMARY IMPORTANCE (TROUT WATERS), WHOLE-BODY-CONTACT RECREATION, AND MINIMUM STANDARDS
- WARM WATER FISHERY, WHOLE-BODY-CONTACT RECREATION, INDUSTRIAL AND COOLING WATER, AND MINIMUM STANDARDS
- WARM WATER FISHERY, WHOLE-BODY-CONTACT RECREATION, AND MINIMUM STANDARDS
- WARM WATER FISHERY, PARTIAL-BODY-CONTACT RECREATION, AND MINIMUM STANDARDS
- PARTIAL-BODY-CONTACT RECREATION, INDUSTRIAL AND COOLING WATER, AND MINIMUM STANDARDS
- PARTIAL-BODY-CONTACT RECREATION AND MINIMUM STANDARDS
- INDUSTRIAL AND COOLING WATER AND MINIMUM STANDARDS
- MINIMUM STANDARDS ONLY

NOTES:

1. THE ADOPTED WATER QUALITY STANDARDS FOR MAJOR WATER USE OBJECTIVES IN WISCONSIN ARE SET FORTH IN TABLE 72. SUCH OBJECTIVES AND STANDARDS APPLY TO ALL SURFACE WATERS OF THE STATE. ONLY THOSE STREAMS IDENTIFIED AS PERENNIAL BY THE U. S. GEOLOGICAL SURVEY AND THOSE LAKES AT LEAST 50 ACRES IN AREA ARE SHOWN ON THIS MAP.

2. IN ADDITION TO THE MINIMUM STANDARDS, LAKE MICHIGAN OPEN WATERS MUST MEET THE WATER QUALITY STANDARDS FOR ALL USES--PRESERVATION AND ENHANCEMENT OF FISH LIFE, PUBLIC WATER SUPPLY, WHOLE-BODY-CONTACT RECREATION, AND INDUSTRIAL AND COOLING WATER. LAKE MICHIGAN SWIMMING BEACH AREAS MUST MEET MINIMUM STANDARDS AND THOSE STANDARDS NECESSARY TO PERMIT WHOLE-BODY-CONTACT RECREATIONAL USE. LAKE MICHIGAN HARBOR AREAS AND THOSE SHORELINE SECTIONS IN THE VICINITY OF POLLUTION SOURCES MUST MEET MINIMUM STANDARDS AND THOSE STANDARDS NECESSARY TO PERMIT COOLING AND INDUSTRIAL WATER SUPPLY USES. SEE TABLE 72 FOR LAKE MICHIGAN THERMAL DISCHARGE STANDARDS.



The initial water use objectives for all surface waters in the Region were adopted by the Wisconsin Resource Development Board in 1967 and 1968. In most cases, such objectives provided for water quality standards sufficient to permit a warm water fishery and whole-body-contact recreational uses. In some cases, however, lesser water quality standards were prescribed. For example, as shown on the above map, the Pike River, Underwood Creek, Honey Creek, a portion of the Menomonee River, Barnes Creek, a portion of the Rubicon River, and a portion of Belgium Creek were to meet only minimum water quality standards. In light of the new national goal to attain water quality levels in all streams providing for a warm water fishery and for total recreational use by 1983, these water use objectives and supporting standards were upgraded effective October 1, 1973 (see Map 48).

Source: Wisconsin Department of Natural Resources and SEWRPC.

Fox River watershed, however, the plan recommends that the use objectives be changed from full-body-contact recreational use to partial-body-contact recreational use because the characteristics of the lake other than water quality, in particular, physical features such as shallow depths and small size, limit their practical utility for swimming. These lakes are North, Silver, and Peters Lakes in Walworth County and Echo and Long Lakes in Racine County.

Revised DNR Water Use Objectives and Water Quality Standards: The revised DNR water quality standards have been formulated for the following seven major water uses: restricted use, public water supply, maintenance of a trout fishery, maintenance of salmon spawning, maintenance of a warm water fishery, and recreational use. The seventh water use relates to aesthetic considerations and provides minimum standards for all waters. The revised state standards are set forth in Table 73. These standards are statements of the physical, chemical, and biological characteristics of the water that must be maintained if the water is to be suitable for the specified uses.[5]

Minimum Standards for All Waters: The revised state minimum standards apply to all surface waters at all locations within the state. Like the original minimum standards, these minimum standards are intended to protect the public health, to maintain all state waters in an aesthetically acceptable condition, and to protect domestic animals as well as wildlife.

Restricted Use: As indicated in Table 73, the restricted use category is intended to result in water quality a level above minimum standards. The most significant characteristics of the restricted use category are the inclusion of a requirement for minimum dissolved oxygen concentration and an upper limit on fecal coliform bacteria.

Public Water Supply: The principal consideration with respect to quality standards for raw water to be used for public water supply is that the water be such that, after appropriate treatment, it will meet the U. S. Public Health Service Drinking Water Standards established in 1962. The DNR standards of raw water to be used for water supply include an allowable pH range and maximum limits on temperature, dissolved solids, and fecal coliform.

Fish and Aquatic Life: Standards for water to be used for the preservation and enhancement of fish and aquatic life are generally specified in terms of parameters that affect the physiologic condition of the fish, the food chain that sustains the fish, and the aquatic environment. The DNR standards for fish and aquatic life, including the special subcategories of salmon spawning and trout fishery, are set forth in Table 73, and it is apparent that key factors include temperature, dissolved oxygen, and pH, in addition to other substances that may be harmful to the aquatic ecosystem. The adopted standards for the preservation and enhancement of fish and aquatic life include Lake Michigan thermal discharge standards which are only applicable to those facilities discharging heated water directly to Lake Michigan. The standards exclude municipal water and sewage treatment plants, as well as vessels or ships.

Recreation: As noted earlier, waters to be used for recreational purposes should be aesthetically attractive, free of substances that are toxic upon ingestion or irritating to the skin upon contact, and void of pathogenic organisms. The first two conditions are satisfied if the water meets the minimum standards for all waters as previously described, whereas the third condition requires that a standard be set to ensure the safety of a water from the standpoint of health. The concentration of fecal coliform bacteria is the parameter now used for this purpose. Since the fecal coliform count is only an indicator of a potential public health hazard, the Wisconsin standards, as set forth in Table 73, specify that a thorough sanitary survey to assure protection from fecal contamination be the chief criterion for determining recreational suitability.

Application of Revised Water Use Objectives to the Region: The application of the aforementioned six basic categories of water use objectives to the Region requires specification of a design low flow at or above which the water quality standards commensurate with each water use objective are to be met. The revised DNR water use objectives state that compliance with the supporting standards is to be evaluated on the basis of streamflows as low as the 7 day-10 year low flow,

---

[5] *See Appendix C for a discussion of water quality indicators applicable to the revised DNR water use objectives.*

Table 73

REVISED WISCONSIN DEPARTMENT OF NATURAL RESOURCES WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS FOR SURFACE WATERS: AS ADOPTED IN 1973

Water Quality Parameters	Water Use Objectives [1, 2, 3, 4]						Combinations of Water Use Objectives Applicable to Southeastern Wisconsin Inland Lakes and Streams		
	Restricted Use	Recreational Use	Public Water Supply	Fish and Aquatic Life: Fishery	Fish and Aquatic Life: Salmon Spawning	Fish and Aquatic Life: Trout Fishery	Recreational Use and Fish and Aquatic Life	Recreational Use and Salmon Spawning	Recreational Use and Trout Fishery
Temperature (°F)	--[5]	--[5]	--[5]	--[5, 6]	--[5]	--[5, 7]	--[5, 7]	--[5]	--[5, 7]
Total Dissolved Solids (mg/l)	--	--	500 and[8] 750	--	--	--	--	--	--
Dissolved Oxygen (mg/l)	2.0 min	--	--	5.0 min	5.0 min[9]	6.0 min[10]	5.0 min	5.0 min[9]	6.0 min[10]
pH (Units)	6.0-9.0[11]	--	6.0-9.0[11]	6.0-9.0[11]	6.0-9.0[11]	6.0-9.0[11]	6.0-9.0[11]	6.0-9.0[11]	6.0-9.0[11]
Fecal Coliforms (MFFCC/100ml)	1,000 and 2,000[12]	200 and 400[13]	200 and 400[13]	--	--	--	200 and 400[13]	200 and 400[13]	200 and 400[13]
Miscellaneous Parameters[14]	--[15]	--[15, 16]	--[15, 17]	--[15]	--[15]	--[15, 18]	--[15, 16]	--[15, 16]	--[15, 16, 18]

[1]*Includes all basic water use categories established by the Wisconsin Department of Natural Resources plus those combinations of water use categories applicable to the Southeastern Wisconsin Region.*

[2]*Standards are expressed in mg/l except as indicated. Single numbers are maximum permissible values, except where minimum limits are denoted by the subscript Min.*

[3]*All waters shall meet the following conditions at all times and under all flow conditions: Substances that will cause objectionable deposits on the shore or in the bed of a body of water, shall not be present in such amounts as to interfere with public rights in waters of the state. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the state. Materials producing color, odor, taste or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life.*

[4]*Water quality standards have not been formulated for commercial shipping and navigation since suitability for these uses depends primarily on quantity, depth, and elevation.*

[5]*There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the existing natural temperature shall not exceed 5°F for streams and 3°F for lakes.*

[6]*The temperature shall not exceed 89°F for warm water fish.*

[7]*There shall be no significant artificial increases in temperature where natural trout reproduction is to be protected.*

[8]*Not to exceed 500 mg/l as a monthly average nor 750 mg/l at any time.*

[9]*The dissolved oxygen in the Great Lakes tributaries used by stocked salmonids for spawning runs shall not be lowered below natural background during the period of habitation.*

[10]*Dissolved oxygen shall not be lowered to less than 7.0 mg/l during the spawning season.*

[11]*The pH shall be within the range of 6.0 to 9.0 with no change greater than 0.5 units outside the estimated natural seasonal maximum and minimum.*

[12]*Shall not exceed a monthly geometric mean of 1,000 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 2,000 per 100 ml in more than 10 percent of all samples during any month.*

[13]*Shall not exceed a monthly geometric mean of 200 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 400 per 100 ml in more than 10 percent of all samples during any month.*

[14]*Lake Michigan thermal discharge standards, which are intended to minimize the effects on aquatic biota, apply to facilities discharging heated water directly to Lake Michigan, excluding that from municipal waste and water treatment plants and vessels or ships. Such discharges shall not raise the temperature of Lake Michigan at the boundary of the mixing zone established by the Wisconsin Department of Natural Resources by more than 3°F and, except for the Milwaukee and Port Washington Harbors, thermal discharges shall not increase the temperature of Lake Michigan at the boundary of the established mixing zones during the following months above the following limits:*

January, February, March	*45°F*
April	*55°F*
May	*60°F*
June	*70°F*
July, August, September	*80°F*
October	*65°F*
November	*60°F*
December	*50°F*

All owners utilizing, maintaining, or presently constructing thermal discharge sources exceeding a daily average of 500 million BTU per hour shall submit monthly temperature and flow data on forms prescribed by the Department of Natural Resources and shall, on or before February 1, 1974, submit to the Department a report on the environmental and ecological impact of such thermal discharges in a manner approved by the Department. After a review of the ecological and environmental impact of the discharge, mixing zones shall be established by the department. New thermal discharge facilities (construction commenced after February 1, 1972 and prior to August 1, 1974) shall be so designed as to avoid significant thermal discharges to Lake Michigan. Any plant or facility, the construction of which is commenced on or after August 1, 1974, shall be so designed that the thermal discharges therefrom to Lake Michigan comply with mixing zones established by the Department. In establishing a mixing zone, the Department will consider ecological and environmental information obtained from studies conducted pursuant to February 1, 1974 and any requirements of the Federal Water Pollution Control Act Amendments of 1972.

[15]*Unauthorized concentrations of substances are not permitted that alone or in combination of, with other materials present, are toxic to fish or other aquatic life. Questions concerning the permissible levels, or changes in the same, of a substance, or combination of substances, of undefined toxicity to fish and other biota shall be resolved in accordance with the methods specified in "Water Quality Criteria," Report of the National Technical Advisory Committee to the Secretary of the Interior, April 1, 1968. The committee's recommendations will also be used as guidelines in other aspects where recommendations may be applicable.*

[16]*A sanitary survey and/or evaluation to assure protection from fecal contamination is the chief criterion in determining the suitability of a surface water for recreational use.*

[17]*The intake water supply shall be such that by appropriate treatment and adequate safeguards it will meet the Public Health Service Drinking Water Standards established in 1962.*

[18]*Streams classified as trout waters by the DNR (Wisconsin Trout Streams, publication 213-72) shall not be altered from natural background by effluents that influence the stream environment to such an extent that trout populations are adversely affected.*

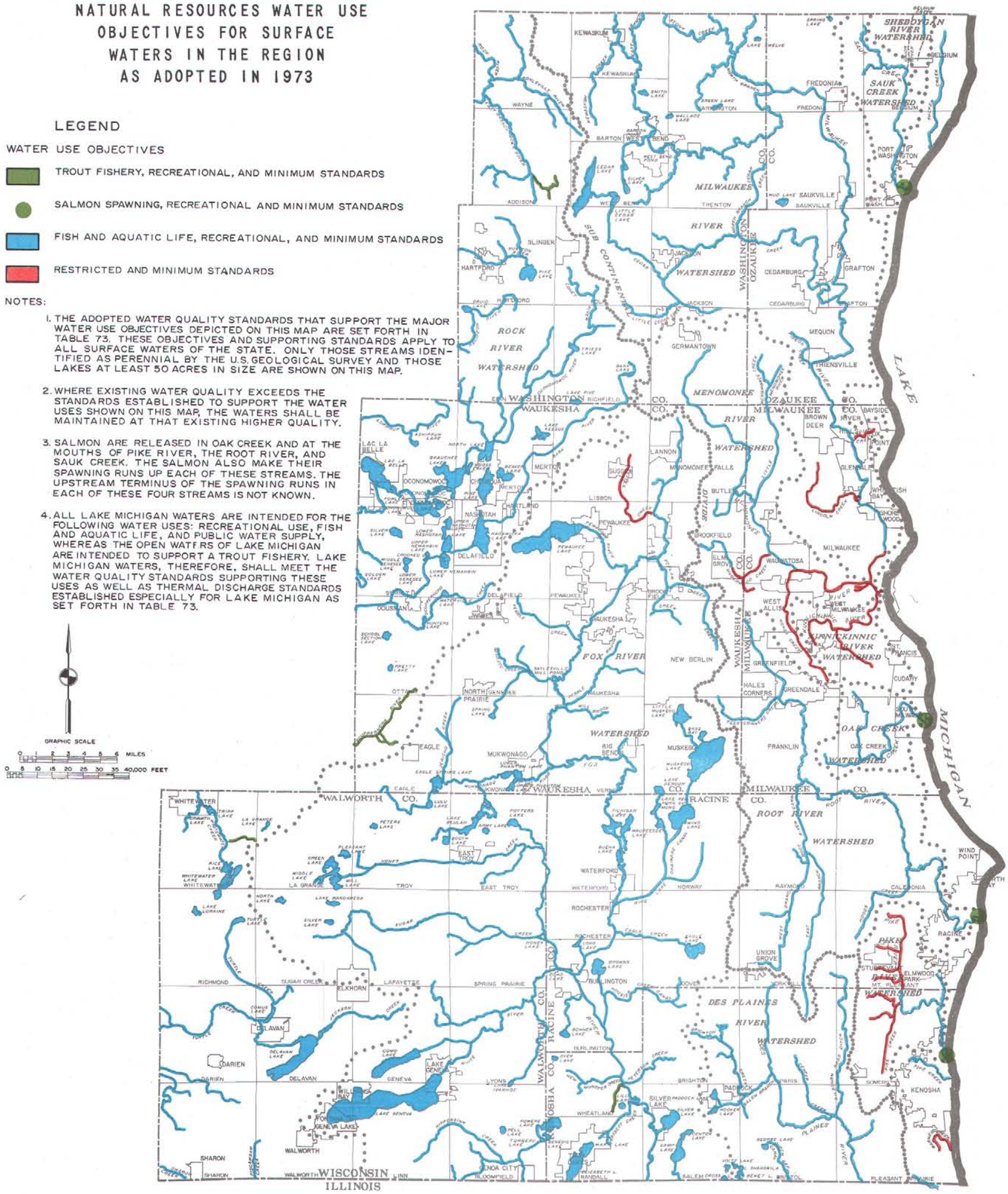
Source: Wisconsin Department of Natural Resources and SEWRPC.

which is defined as the minimum 7-day mean low flow expected to occur once on the average of every 10 years. That is, for a given water use objective, the stream water quality is to be such as to satisfy the supporting standards for all streamflow conditions at or above the 7 day-10 year low flow.

The revised, more stringent interstate and intrastate water use objectives for surface waters in the Region were adopted by the Wisconsin Natural Resources Board so as to become effective on October 1, 1973. These objectives, as shown on Map 48, specify that most of the surface waters within the Region should meet the standards for

Map 48

REVISED WISCONSIN DEPARTMENT OF NATURAL RESOURCES WATER USE OBJECTIVES FOR SURFACE WATERS IN THE REGION AS ADOPTED IN 1973



Revised water use objectives for all surface waters in the Region, as well as for Lake Michigan, were adopted by the Wisconsin Natural Resources Board effective October 1, 1973. Most of the surface waters of Southeastern Wisconsin are now designated for a combination of recreational and fishery use under these recently adopted objectives. These relatively short-range DNR water use objectives served as a point of departure for the long-range water use objectives adopted under the regional sanitary sewerage system planning program.

Source: Wisconsin Department of Natural Resources and SEWRPC.

recreational use and preservation of fish and aquatic life. The restricted use category is evident in a few locations in the Region—primarily in the Menomonee and Pike River watersheds and the Milwaukee estuary—where it is applied to streams flowing through areas that are basically aesthetically unattractive and, because of the nature or concentration of riverine development, actually inhibit access to the streams by potential users.

While the revised DNR objectives for the Region include—either singularly or in combinations—the recreational use, fish and aquatic life use, and the restricted use categories, the minimum standards category is not individually applied anywhere and the public water supply category is specified only for Lake Michigan. It should be noted—as demonstrated by the recent upgrading of water use objectives and supporting standards—that the new water use objectives and standards adopted by the State of Wisconsin are, like the initial objectives and standards, subject to revision as either additional data are accumulated that bear on the continued validity of the water use objectives, or as new data or techniques are developed that permit the standards to be expressed in more precise, quantitative, and statistically valid terms.

The foregoing revised water use objectives and supporting water quality standards recently adopted by the Natural Resources Board have been utilized as a point of departure for preparation of the long-range water use objectives and standards under the regional sanitary sewerage system planning program. The recommended sanitary sewerage system development objectives and standards, including those specifically pertaining to surface water quality, are presented in Chapter VIII of this report.

Comparison of Initial and Revised DNR Water Use Objectives and Supporting Standards: The initial and revised DNR water use objectives and supporting standards are contrasted below in order to demonstrate that the latter are, in fact, more stringent than the initial DNR water use objectives and standards. This comparison is limited to the major differences in the initial and revised DNR water use objectives and standards, and is not intended to be an exhaustive analysis. A detailed comparison may be made by contrasting the entries in Table 72 with analogous entries in Table 73, and by comparing stream reaches on Map 47 with the same reaches on Map 48, or by comparing the initial and revised versions of Chapters NR 102, NR 103, and NR 104 of the Wisconsin Administrative Code.

Water Use Objectives: Both the initial and revised DNR water use objectives include seven basic water use categories. One of the initial water use objectives—industrial and cooling water—has no equivalent in the revised set of water use objectives. All of the six remaining initial water use objectives have approximate equivalents in the new set of objectives. The initial whole-body-contact recreational objective is equivalent to the new recreational use objective. The initial public water supply objective is equivalent to the new public water supply objective. The initial warm water fishery objective is equivalent to the new warm water fishery objective. The initial fish reproduction objective is equivalent to the new salmon spawning and trout fishery objectives. The initial partial-body-contact recreational objective is equivalent to the new restricted use objective. Finally, the initial minimum standards objective is equivalent to the new minimum standards objective.

The comparison of the initial and revised DNR water use objectives as applied to the surface waters in southeastern Wisconsin indicates, as shown on Maps 47 and 48, that the revised DNR water use objectives do set a goal of significantly improved water quality in the seven-county Region. Nearly all of the surface waters in southeastern Wisconsin are now intended for a combination recreational and warm water fishery use.

Supporting Water Quality Standards: Water quality levels required to satisfy both the initial and revised DNR water use objectives are set forth in Tables 72 and 73, respectively. The newer standards include more stringent coliform and dissolved oxygen requirements, and also incorporate a means of resolving questions concerning the many water quality indicators not explicitly identified in the standards.

Whereas total coliform maximums were used in the initial water quality standards, the revised standards utilize fecal coliform counts since the latter are considered a better indicator of the probable presence of disease-producing organisms. More stringent dissolved oxygen criteria have been incorporated into the recently adopted water quality standards. The initial standard in support of the fishery objectives permitted nighttime dissolved oxygen levels as low as 4.0 mg per liter, while the revised standards require at least 5.0 mg per liter.

Unlike the initial DNR water quality standards, the recently adopted standards incorporate, by reference, "Water Quality Criteria," the 1968 report of the National Technical Advisory Committee to the Secretary of the Interior. Questions concerning the permissible levels, or changes in same of a substance, or combination of substances, of undefined toxicity to fish and other biota are to be resolved in accordance with the methods specified in that report. That Committee's recommendations are also to be used as guidelines in other areas of water quality standards where those recommendations may be applicable. One aspect of the aforementioned report is particularly significant to the regional sanitary sewerage system planning program, namely the emphasis on the toxic effect of ammonia on fish and aquatic life. Rather than specify a universal maximum in-stream ammonia level, the federal report recommends that precise determinations of maximum allowable in-stream ammonia concentrations be determined by flow-through bio-assay tests under controlled pH, dissolved oxygen, and temperature levels.

Municipal Waste Water Treatment Policy

As noted above, the Wisconsin Department of Natural Resources, pursuant to statutory authority set forth in Sections 144.025(2)(b)(c) and 144.04 of the Wisconsin Statutes and Chapters NR 108 and NR 110 of the Wisconsin Administrative Code, is responsible for reviewing and approving plans and specifications for all sanitary sewerage facilities, including new sewage treatment plants and additions or alterations to existing sewage treatment facilities if such additions or alterations significantly affect the quality or quantity of the effluent or the location of the outfall. This review procedure provides the mechanism whereby the Department can assure that all sewage treatment plants, whether municipal or industrial, are designed to implement the adopted water use objectives. Of particular importance in this respect to the regional sanitary sewerage system planning program are secondary treatment requirements; phosphorus removal requirements; and departmental policies with respect to the proliferation of waste treatment plants, the location of waste stabilization lagoons, and the examination of alternatives in areawide sewerage system planning.

Secondary Treatment Requirements: The Wisconsin Department of Natural Resources requires that all municipal sewage treatment plants in the Region provide at least secondary treatment and that the effluents be disinfected before discharge to the surface waters. Secondary waste treatment has been defined by the Wisconsin Department of Natural Resources[6] utilizing two separate sets of criteria—one for treatment facilities designed to operate continuously in daily service and one for treatment facilities designed to operate intermittently following periods of high rainfall and runoff. For sewage treatment plants in daily service, secondary treatment must provide 90 percent removal of five-day carbonaceous biochemical oxygen demand (CBOD) and total suspended solids determined as a monthly average of samples analyzed daily, with the monthly average five-day CBOD of the effluent not to exceed 35 mg/l. For sewage treatment plants in intermittent service, secondary treatment must provide 85 percent removal of five-day CBOD and total suspended solids determined as a "monthly average" of samples composited and analyzed daily during the periods of operation.

In addition to providing CBOD removal consistent with secondary waste treatment as described above, sewage treatment plants must achieve a CBOD reduction such that the effluent will not exert a CBOD in excess of that which can be assimilated by the stream at low flow conditions while meeting the established water use objectives. If the effluent from a municipal sewage treatment plant is to be discharged to a perennial stream for which the actual waste assimilative capacity is not known, the Department generally uses as a guide a maximum of 26 pounds of five-day 20°C CBOD per cfs of low streamflow at the discharge point. It should be emphasized that this is only a guide subject to adjustment as local conditions may require and is invoked only in the absence of a determination of the streams actual waste assimilative capacity.

Low streamflow at the outfall site is defined by the Department as the lowest average streamflow for any period of seven consecutive days in the most recent 10 years. In those instances where

[6] *See letter from Thomas G. Frangos, Administrator, Division of Environmental Protection, Wisconsin Department of Natural Resources, to Kurt W. Bauer, Executive Director, SEWRPC, dated March 31, 1971.*

an acceptable estimate of the seven day-10 year low flow is not available, the Department may use, as the low streamflow at the outfall site, that streamflow which will be reached or exceeded 95 percent of the time.

In the event that a new or modified municipal sewage treatment plant is to discharge its effluent to an intermittent stream or to a ditch constructed to convey the treatment plant effluent to a perennial stream, the Department applies a different review procedure with regard to minimum CBOD removal. Sewage treatment plant plans must include, in such cases, evidence that an effluent discharge right-of-way in the form of a land purchase, an easement, or other agreement has been obtained from land owners across or through whose lands the effluent will be conveyed. The Department may then allow discharge to an intermittent stream or to a specially constructed conveyance channel provided that the CBOD loading on both the intermittent stream and the perennial stream to which the intermittent stream ultimately discharges does not exceed that established by the Department on examination of local stream conditions.

As noted above, the Wisconsin Department of Natural Resources requires that municipal sewage treatment plant effluents be disinfected before discharge to surface waters. Disinfection is to be accomplished in such a manner so as to provide a minimum contact time, between the sewage and disinfecting agent, of 15 minutes and, if chlorine is used, to produce a total chlorine excess by the orthotolidin test of at least 0.5 mg/l in the effluent as it is discharged to the receiving waters.

Phosphorus Removal Requirements: In its review of new or modified municipal and industrial sewage treatment facilities, the Wisconsin Department of Natural Resources applies minimum phosphorus removal criteria if the treated waste is to be discharged to a stream tributary to Lake Michigan, that is, east of the subcontinental divide. These criteria represent Wisconsin's response to the pollution abatement recommendations made by the Federal Lake Michigan Enforcement Conference, which recommendations, as noted earlier, include a stipulation that municipal and industrial effluents in areas tributary to Lake Michigan achieve an overall reduction of at least 80 percent of the total phosphorus.[7] Department phosphorus removal requirements are intended to achieve this overall 80 percent phosphorus removal by requiring at least 85 percent removal at larger treatment plants and not requiring phosphorus removals at smaller plants. Thus, municipal sewage treatment plants serving communities with populations of 2,500 people or more are required to remove at least 85 percent of the influent phosphorus, whereas special phosphorus removal facilities are not generally required at treatment plants serving smaller populations.

New or modified waste treatment plants receiving exclusively industrial waste containing phosphorus in a concentration exceeding 2.0 milligrams per liter and having an annual phosphorus population equivalent of 2,500 or more are also required to remove at least 85 percent of the influent phosphorus. The population equivalent of influent phosphorus is determined on the basis of 3.5 pounds of phosphorus per person per year and, thus, an annual phosphorus population equivalent of 2,500 or more represents an annual influent phosphorus loading of 8,750 pounds or more.

Some municipal sewage treatment plants serving less than 2,500 people receive phosphorus from industrial as well as domestic sources, and therefore the Department has adopted a policy to determine phosphorus removal requirements for sewage treatment plants in this category. Municipal sewage treatment facilities serving less than 2,500 people and receiving more than one-half of their annual phosphorus loadings from industrial resources are required to remove 85 percent of the influent phsophorus if the sum of the actual population served plus the phosphorus equivalent of the industrial waste is equal to or greater than 2,500.

The above criteria with regard to phosphorus removal at municipal and industrial sewage treatment plants are minimum requirements and do not preclude the Department of Natural Resources from requiring waste dischargers to remove addi-

[7] *It should be noted that the Lake Michigan Enforcement Conference in November 1972 supplemented its phosphorus removal recommendations so as to also require a minimum effluent total phosphorus concentration of 1.0 mg/l.*

tional phosphorus if conditions, such as potential over-fertilization of surface waters, warrant such removals. It should also be emphasized that the Department phosphorus removal criteria are strictly applicable to municipal and industrial sewage treatment plants located east of the subcontinental divide and that similar criteria are not in effect for that portion of the seven-county planning Region west of the subcontinental divide. This does not mean, however, that phosphorus removal is not required to protect the water resources of the latter portion of the Region, but instead indicates that a formal policy with regard to phosphorus removal in that portion of the Region has yet to be formulated by the Department of Natural Resources. The Department may require special phosphorus removal facilities for municipal and industrial sewage treatment plants located west of the subcontinental divide where such removals are deemed necessary for achievement of water use objectives.

Proliferation of Waste Treatment Plants: In conjunction with efforts at the federal level to encourage areawide concepts of pollution control as expressed in the recommendations of the Lake Michigan Enforcement Conference and in the Federal Water Pollution Control Act, the Department of Natural Resources adopted in 1969 a policy statement relating to the proliferation of waste treatment plants. This policy statement seeks to promote the use of unified sewage collection systems serving contiguous areas and the connection of newly developing areas to existing treatment facilities where such action is feasible and clearly in the public interest. Concomitantly, the statement discourages the proliferation of small sewage treatment facilities in contiguous areas together with the abandonment of multiple plants in favor of joint treatment where technically and economically feasible and desirable. The policy would also discourage the construction of sewage treatment facilities not designed in accordance with an adopted areawide plan and would seek to withhold state grants-in-aid for the construction of nonconforming treatment plants. It must be recognized, however, that to the extent that the regional land use plan is not implemented, resulting in a more highly diffused and lower density land use pattern, greater proliferation of small sewage treatment facilities may occur. The nonproliferation policy is, therefore, very closely related to implementation of the adopted regional land use plan.

Location of Waste Stabilization Lagoons: The Department of Natural Resources has initiated an administrative policy in regulating the location of waste stabilization lagoons. All proposed waste stabilization lagoon sites that are not to be aerated must be located a minimum of 2,000 feet from all existing occupied dwellings. This distance can be reduced to 1,600 feet if the dwelling in question is upwind (prevailing) of the lagoon site and the owner consents to having the lagoon closer than the prescribed 2,000 feet. Once constructed, however, there is no way that the Department can prohibit landowners from building residences within the 2,000-foot limit. The bottom elevation of the lagoon must be at least 3 feet above the groundwater table and 8 feet above the bedrock strata. Requirements are similar for aerated lagoon sites except that the distance from occupied dwellings is reduced to a minimum of 1,000 feet, or 800 feet if the dwelling in question is upwind of the site and the owners consent is obtained.

Guidelines for Areawide Sewerage System Planning: In response to federal requirements for areawide sewerage system planning in effect prior to the Federal Water Pollution Control Act Amendments of 1972, the Wisconsin Department of Natural Resources in 1971 prepared and distributed guidelines to be utilized by planners and engineers in selecting and evaluating alternatives for the provision of joint sewage treatment facilities. These guidelines seek to ensure that all reasonable alternatives for the provision of joint sewage treatment are considered and that time and money are not unnecessarily expended in considering alternatives that would clearly not be feasible from an economic point of view. The guidelines define the situations which must be evaluated for joint treatment purposes; however, they do not in any way prejudge the results of the analysis which may or may not recommend joint treatment.

The guidelines are based upon the population of the urban area "sending" sewage, the population of the urban area "receiving" sewage from the "sending" area, and the distance in miles between the two urban areas. In determining the population of the "sending" or "receiving" communities, consideration must be given to the industrial contribution to the waste water and, if the industrial contribution is significant, a population equivalent factor must be utilized as opposed to a simple population expressed in number of persons in the community. Table 74 presents the guidelines as

Table 74

WISCONSIN DEPARTMENT OF NATURAL RESOURCES MILEAGE GUIDELINES
FOR AREAWIDE SEWERAGE SYSTEM PLANNING

TRANSMITTING CITY POPULATION EQUIVALENT	RECEIVING CITY POPULATION EQUIVALENT														
	750	1,000	1,500	2,000	2,500	3,000	4,000	5,000	7,500	10,000	20,000	30,000	40,000	50,000	75,000
500	1.2	1.3	1.4	1.5	1.6	1.6	1.7	1.7	1.8	1.9	2.0	2.1	2.1	2.2	2.2
750	1.3	1.5	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.6	2.7	2.8	2.8	2.9
1,000	1.5	1.6	1.9	2.0	2.1	2.2	2.4	2.5	2.7	2.8	3.1	3.2	3.3	3.3	3.4
1,500	1.6	1.8	2.1	2.3	2.5	2.6	2.8	3.0	3.2	3.4	3.8	4.0	4.1	4.2	4.3
2,000	1.8	2.0	2.3	2.6	2.8	2.9	3.2	3.4	3.7	3.9	4.4	4.7	4.8	4.9	5.1
2,500	1.8	2.1	2.4	2.7	3.0	3.1	3.4	3.6	4.0	4.3	4.9	5.2	5.4	5.5	5.7
3,000	1.9	2.1	2.5	2.8	3.1	3.3	3.6	3.9	4.3	4.6	5.3	5.6	5.8	6.0	6.3
4,000	1.9	2.2	2.7	3.0	3.3	3.5	3.9	4.2	4.8	5.1	6.0	6.4	6.7	6.9	7.3
5,000	2.0	2.3	2.8	3.1	3.5	3.7	4.2	4.5	5.1	5.6	6.6	7.1	7.4	7.7	8.1
7,500	2.0	2.4	2.9	3.3	3.7	4.0	4.5	4.9	5.7	6.3	7.6	8.4	8.8	9.2	9.8
10,000	2.1	2.4	3.0	3.5	3.9	4.2	4.8	5.3	6.2	6.9	8.5	9.4	10.0	10.5	11.2
20,000	1.6	1.9	2.4	2.8	3.2	3.5	4.0	4.5	5.4	6.1	7.9	9.0	9.8	10.4	11.4
30,000	1.4	1.7	2.1	2.5	2.8	3.1	3.6	4.1	4.9	5.6	7.5	8.7	9.6	10.3	11.4
40,000	1.2	1.5	1.9	2.2	2.5	2.8	3.2	3.7	4.5	5.2	7.0	8.2	9.1	9.8	11.1
50,000	1.1	1.4	1.7	2.1	2.3	2.6	3.1	3.4	4.3	4.9	6.8	8.0	9.0	9.7	11.0
75,000	1.0	1.2	1.5	1.8	2.0	2.2	2.6	3.0	3.7	4.4	6.1	7.4	8.3	9.1	10.5

NOTE: In areawide sewerage system planning, an interconnection alternative must be examined for sewage treatment purposes if the distance between the "transmitting" and "receiving" communities is less than the distance specified in miles; conversely, if the distance between the "transmitting" and "receiving" communities is greater than that indicated in miles, there is no need to consider interconnection potential.

Source: Wisconsin Department of Natural Resources.

promulgated by the Department. In utilizing these guidelines, an interconnection alternative must be examined for treatment purposes if the distance between the "sending" and "receiving" communities is less than the distance specified; conversely, if the distance between the "sending" and "receiving" communities is greater than that indicated in the guidelines, there is no need to consider interconnection potential. These guidelines were utilized in the construction of alternatives in the regional sanitary sewerage system planning program as discussed in Chapter XI of this report.

Effluent Reporting and Monitoring System

Section 144.54 of the Wisconsin Statutes, created by Chapter 125 of the Wisconsin Laws of 1971, directs the Department of Natural Resources to require by rule that persons discharging industrial wastes, toxic and hazardous substances, or air contaminants submit a report on such discharges to the Department. The law further specifically exempts municipalities from the rules and establishes an annual monitoring fee to provide for the cost of administering the program. In response to this statutory mandate, the Department prepared and adopted in January 1973 Chapter NR 101 of the Wisconsin Administrative Code setting forth the specific rules by which the reporting and monitoring program is to be conducted. Of particular importance to water quality control are the effluent reports required in this chapter.

The rules require that every person, except a municipality, discharging industrial wastes or toxic and hazardous substances is required to file an effluent report with the Department if: 1) treated or untreated effluent is discharged directly to surface waters; 2) a minimum of 10,000 gallons of effluent per day, one or more days a year, is discharged to a land disposal system or to a municipal sewerage system; 3) less than 10,000 gallons of effluent per day is discharged to a land disposal system or a municipal sewerage system if the Department specifically finds that reporting is necessary to protect the environment; and 4) more than one million British thermal units are contributed per day, one or more days during the year, to the effluent discharged to surface waters. Certain discharges are exempted from reporting, however, primarily if the discharge contributes none of the particular industrial wastes or toxic and hazardous substances specified in the code. In addition, agricultural land runoff from land used exclusively for crop production need not be reported. Generally, the reports required by the Department must provide specific locations where effluent is being discharged into either surface waters, a sanitary sewerage system, or a land disposal system; estimates of the annual and average daily quantity of effluent discharged; concentrations and quantities of industrial wastes or toxic and hazardous substances contributed to the effluent in excess of required reporting levels; temperatures and volumes of thermal discharges; pH range of effluent; and a brief description of the manner and amount of raw materials used to produce the wastes being reported.

It should be noted that this new reporting and monitoring system will provide a first step in establishing the effective monitoring system required in Section 308 of the Federal Water Pollution Control Act, although it may be necessary to reconcile the fee schedule established to cover the cost of administering the program with any new reporting and permitting systems and associated fee schedules that may be established to implement the new federal legislation. It must be understood, however, that this reporting and monitoring system does not constitute a licensing or permit system, but rather establishes a means for providing for the first time ever the data necessary to prepare truly comprehensive water quality management plans that become the basis upon which effluent discharge permits eventually will be issued.

Septic Tank Regulation

In performing its functions relating to the maintenance and promotion of public health, the Wisconsin Division of Health is charged with the responsibility for regulating the installation of private septic tank sewage disposal systems. Such systems often contribute to the pollution of surface and ground waters. Pursuant to Chapter 236 of the Wisconsin Statutes, the Division of Health reviews plats of all land subdivisions not served by public sanitary sewerage systems and may object to such plats if sanitary waste disposal facilities are not properly provided for in the layout of the plat. The Division has promulgated regulations governing lot size and elevation in Chapter H65 of the Wisconsin Administrative Code. Basic regulations governing the installation of septic tank systems are set forth in Chapter H62 of the Wisconsin Administrative Code. It should be noted further that the Wisconsin Department of Natural Resources must approve the provisions of the state plumbing code which set specifications for septic tank systems and their installation. The Department may also prohibit the installation or use of septic tanks in any area of the state where the Department finds that the use of septic tanks would impair water quality.

All septic tanks in the state must be registered by permits pursuant to Section 144.03 of the Wisconsin Statutes.

State Environmental Policy Act

The Wisconsin Legislature in April 1972 created Section 1.11 of the Wisconsin Statutes relating to governmental consideration of environmental impact. In many ways this state legislation parallels the National Environmental Policy Act of 1969 discussed earlier in this chapter. Under this state legislation, all agencies of the state must include a detailed environmental impact statement in every recommendation or report on proposals for legislation or other major actions which would significantly affect the quality of the human environment. The contents of this statement parallel the contents required in the federal environmental impact statements. The effect of this state legislation is, therefore, to extend the environmental impact statement concept to all state action not already covered under the federal legislation.

LOCAL WATER POLLUTION CONTROL MACHINERY

In general, local units of government in Wisconsin have, as part of the broad grant of authority by which they exist, sufficient police power to regulate by ordinance any conditions or set or circumstances bearing upon the health, safety, and welfare of the community. Presumably, the water quality of a receiving stream or the polluting capability of effluent generated within the municipal unit falls within the regulative sphere by virtue of its potential danger to health and welfare. Because of the significant amount of statutory regulation in this area by the federal and state levels of government, however, the most significant action on the part of local units of government with respect to the regional sanitary sewerage system plan involves the powers of local governments to provide sanitary sewer service and, in particular, to organize institutions for the provision of such service. Accordingly, the following discussion will largely focus on the specific powers of each type of local government to provide sewer service and the specific methods by which local units of government can join together to provide sewerage service.

General Powers of Local Governments to Provide Sewer Service

In Wisconsin, general-purpose local units of government consist of counties, cities, villages, and towns. In one manner or another, each of these types of local units of government may become involved in the provision of sanitary sewer service.

There are only three methods by which county units of government in Wisconsin may provide sanitary sewerage service, other than providing service to county-owned institutions. Two of these three methods involve county participation in metropolitan sewerage districts and are discussed in detail below. The third method is set forth in Section 59.083 of the Wisconsin Statutes. This statute is a limited grant of home rule power to the county board of any county with a population of 250,000 or more. The statute was initially directed only at Milwaukee County and, as of the 1970 U. S. Census of Population, would still apply only to Milwaukee County. However, the statute has potential application within the Southeastern Wisconsin Region in Waukesha County which had a 1970 population of about 240,000. Under this statute such a county board may provide many municipal services, including sewer service, and may carry out these powers in districts which it may create for such a purpose. Such powers may be exercised by the county board in any town, city, or village or any part thereof within the county upon the request of the town, city, or village as evidenced by a resolution adopted by a majority vote of the governing body. Thus, although this statute has little meaning in Milwaukee County with respect to sanitary sewer service because of the creation of the Metropolitan Sewerage District of the County of Milwaukee, this statute could prospectively be utilized in Waukesha County at the time it reaches the 250,000 population level. It would at that time provide one alternative method of organizing and carrying out any proposed areawide sanitary sewerage system plan within the county.

In addition to its general grant of home rule power, cities have specific authority under Section 62.18 of the Wisconsin Statutes to provide for sewer service and to construct, operate, and maintain an entire sanitary sewerage system. Under this statute, cities are allowed to establish within the city limits special sewerage districts and levy special sewerage district taxes therein for improvements. By direct reference in Section 61.39, villages are given identical powers as cities with respect to establishing sanitary sewerage systems and special sewerage districts.

Towns generally do not have specific authority to provide for sanitary sewerage systems except through the establishment of either town sanitary districts or town utility districts. Under Section 60.29(16), however, towns may grant permission to adjacent municipalities to lay and maintain sewers within towns and, in counties having a population of 150,000 or more, town boards may, pursuant to Section 60.29(19), build and construct sewers along streets upon petition of two-thirds of abutting property owners and to so assess the property benefited. In addition, under Section 60.29(30) town boards are authorized, if village powers are granted at an annual town meeting, to provide municipal improvements—presumably including sanitary sewer service—in any properly designated unincorporated village in the town.

Special Units of Government
That Can Provide Sewer Service

The Wisconsin Statutes provide several methods by which special-purpose districts may be formed to provide sewer service and several ways in which local units of government may jointly provide sewer service. These include metropolitan sewerage districts, sanitary districts, utility districts, joint sewerage systems, and a general grant of intergovernmental cooperation.

Metropolitan Sewerage District of the County of Milwaukee: The Metropolitan Sewerage District of the County of Milwaukee was established and operates under the provisions of Section 59.96 of the Wisconsin Statutes. It operates through the agency of the Sewerage Commission of the City of Milwaukee, which was established pursuant to Chapter 608, Laws of Wisconsin 1913, and the Metropolitan Sewerage Commission of the County of Milwaukee, which operates and exists pursuant to the provisions of Section 59.96 of the Wisconsin Statutes. The Metropolitan Sewerage Commission has the power to project, plan, and construct main sewers; pumping and temporary disposal works for the collection and transmission of house, industrial, and other sanitary sewage to and into the intercepting sewerage systems of such District; and may improve any watercourse within the District by deepening, widening, or otherwise changing the same where, in the judgment of the Commission, it may be necessary in order to carry off surface or drainage waters. The Metropolitan Sewerage Commission, however, may only exercise its powers outside the City of Milwaukee. The Sewerage Commission of the City of Milwaukee, on the other hand, may build treatment plants and build main and intercepting sewers and may improve watercourses within its area of operation, which is within the City of Milwaukee.

In order to coordinate the activities of the two Commissions, the statute provides that the Metropolitan Sewerage Commission must secure the approval of the Sewerage Commission of the City of Milwaukee before it is empowered to engage in any work and, when it has completed the work it proposes to do, it then turns over all of these facilities to the Sewerage Commission of the City of Milwaukee for operation and maintenance. Rules and regulations adopted by the Sewerage Commissions pursuant to the statute further provide for coordination of the sewer improvement programs in the District by requiring that all cities and villages lying within the District and in contract service areas adjacent to the District must submit their sewerage system and construction plans for approval before they can connect to the main and intercepting system owned by the District. The two Commissions have the power to promulgate and enforce reasonable rules for the supervision, protection, management, and use of the entire sewerage system.

The District at the present time includes all of the cities and villages within the County of Milwaukee, except for the City of South Milwaukee, which elected not to become part of the District. In addition, the District, through its two Commissions, may enter into contracts with areas in the same general drainage area and adjacent to the District to furnish sewer service to those municipalities. The two Commissions have the power to inspect all sewers and sewerage systems which drain into the main or intercepting system and further have the power to require any town, city, or village or the occupant of any premises engaged in discharging sewage effluent from sewage plants, sewage refuse, factory waste, or other materials into any river or canal within such county and within the drainage area to so change or rebuild any such outlet drain or sewer as to discharge said sewage waste or trade waste into the sewers of said town, city, or village or into the main or intercepting sewers owned by the District.

With regard to watercourse improvements, the District, through its two Commissions, has engaged in a broad program of improving watercourses by widening, deepening, or otherwise changing said watercourses so as to accommodate the expected flow of storm and surface drainage waters from the area within the District and from the areas surrounding the District. In connection with this work, many unauthorized waste discharges to watercourses were uncovered and eliminated, thus reducing the discharge of objectionable materials into the rivers and streams in Milwaukee County, as well as providing greater capacity for such streams and rivers and providing for more rapid and efficient runoff of storm and drain waters.

The term "same general drainage area" has been defined by the two Commissions to include all of the Kinnickinnic, Menomonee, and Milwaukee Rivers and Oak Creek watersheds and those portions of the Root River watershed draining into Milwaukee County. In theory the Metropolitan Sewerage District of the County of Milwaukee could, under existing legislation, contract to transmit, treat, and dispose of sewage originating throughout the entire Milwaukee River watershed. The present northerly terminus of the contract service limits of the Metropolitan Sewerage District in the Milwaukee River watershed, however, is the northerly corporate limits line of the City of Mequon, excluding therefrom, however, the Village of Thiensville.

Metropolitan Sewerage Districts Outside of Milwaukee County: One metropolitan sewerage district outside of the County of Milwaukee has been formed in the Region, namely, the Western Racine County Sewerage District serving the Villages of Rochester and Waterford and the Town of Rochester Sewer Utility District No. 1. This District was formed in the mid-1960's under enabling legislation struck down by the Wisconsin Supreme Court in 1969 as an unconstitutional delegation of legislative power. In response to this Supreme Court action, the Wisconsin Legislature enacted into law in 1972[8] new enabling legislation for the creation of metropolitan sewerage districts. Such legislation is set forth in the Wisconsin Statutes in Sections 66.20 to 66.26. This legislation provides that proceedings to create a metropolitan sewerage district may be initiated by resolution of the governing body of any municipality. Such resolution, which must set forth a description of the territory proposed to be included in the district and a description of the functions proposed to be performed by the district, is directed at the Wisconsin Department of Natural Resources. Upon receipt of the resolution, the Department is required to schedule a public hearing for the purpose of permitting any persons to present any information relating to the matter of the proposed metropolitan sewerage district. Within 90 days of the hearing, the Department must either order or deny the creation of the proposed district. The Department must order the creation of the district if it finds that the district consists of at least one municipality in its entirety and all or part of other municipalities; the district is determined to be conducive to management of a unified system of sewage collection and treatment; the formation of the district will promote sound sewerage management policies and operation and is consistent with adopted plans of municipal, regional, and state agencies; and if the formation of the district will promote the public health and welfare and effect efficiency and economy in sewerage management. No territory of a city or village jointly or separately owning or operating a sewage collection or disposal system may be included in the district, however, unless it has filed with the Department of Natural Resources a certified copy of a resolution of its governing body consenting to the inclusion of its territory within the proposed district.

Once formed, a district is to be governed by a five-member commission appointed for staggered five-year terms. All commissioners are appointed by the county board of the county in which the district is located. Such commissioners must be residents of the district.

The Commission is directed by statute to prepare and by resolution to adopt plans and standards for the planning, design, and operation for all projects and facilities to be operated by the district. The commission's plans must be consistent with any duly adopted plans of a regional planning commission recognized under Section 66.945. The commission may adopt rules for the supervision, protection, management, and use of the systems and facilities operated by the District. Such rules may restrict or deny the provision of utility services to lands not recommended for urban development in adopted plans. The commission has the power to plan, project, construct, and maintain within the district intercepting and other main sewers for the collection and transmission of sewage. The commission may require any person or municipality within the district to provide for the discharge of sewage into the district's collection and disposal system where reasonable opportunity to do so is provided. The commission may order that the district shall assume ownership of any existing sewerage works and facilities in the district as are needed to carry out the purposes of the commission. Upon assuming ownership of any works the commission becomes obligated to pay to the municipality amounts sufficient to pay, when due, all remaining principal of and interest

[8] *Chapter 276 of the Wisconsin Laws of 1971.*

on bonds issued by the municipality for the acquisition or improvement of the works taken over. Such commissions may also provide for storm water drainage facilities.

Territory not originally included within a metropolitan sewerage district and which becomes annexed for municipal purposes to a city or village that was included in its entirety within the original district automatically becomes added to the metropolitan district. Any other territory may be added to a district upon petition of a municipal governing body or upon motion of the commission itself. Upon receipt of the petition or upon adoption of its own motion, the commission is required to hold a public hearing and may approve the annexation thereafter upon determination that the resulting annexation will promote unified sewerage management policies and operation and will be consistent with adopted plans of municipal, regional, and state agencies and that the addition of the area would promote the public health and welfare and effect efficiencies and economies in sewerage management.

To date (March 1973) one such petition for the formation of a metropolitan sewerage district in southeastern Wisconsin has been received by the Wisconsin Department of Natural Resources. This petition was filed by the Village of Lac La Belle requesting the creation of a Lac La Belle Metropolitan Sewerage District. It would include all of the Village of Lac La Belle and portions of the Town of Oconomowoc, Waukesha County, and the Town of Ixonia, Jefferson County. It is proposed that this metropolitan district contract with the City of Oconomowoc for sewage treatment purposes. Although a public hearing concerning this matter has been held, the Wisconsin Department of Natural Resources has not as yet (May 1973) acted upon the petition.

<u>Town Sanitary Districts</u>: Town sanitary districts may be created, pursuant to Section 60.30 of the Wisconsin Statutes, to plan, construct, and maintain sanitary and storm sewers and sewage treatment and disposal systems. A town sanitary district may offer its services outside its jurisdictional area on a reimbursable basis. In addition, the Wisconsin Legislature, in Section 60.30(2) of the Wisconsin Statutes, evidenced an intent that town sanitary districts be created to provide auxiliary sewer construction in unincorporated areas of metropolitan sewerage districts. Town sanitary districts are usually created by the town board upon petition of 51 percent of the property owners or the owners of 51 percent of the property within the proposed district. The Wisconsin Department of Natural Resources may, however, upon finding that private sewage disposal or water supply systems constitute a public health menace and that there is no local action evident to correct the situation, order the creation of such districts.

As discussed in Chapter III of this report, there are a total of 27 town sanitary districts existing in the Region. Nine of these 27 sanitary districts currently provide sanitary sewer service, with five owning and operating a sewage treatment facility and the remaining four contracting with adjacent municipalities for sewage treatment purposes. The location and service areas of these sanitary districts are shown on Map 2.

<u>Utility Districts</u>: Section 66.072 of the Wisconsin Statutes permits towns, villages, and cities of the third and fourth class to establish utility districts for a number of municipal improvement functions, including the provision of sanitary sewer service. Funds for the provision of services within the district are provided by levying a tax upon all property within the district. The establishment of utility districts requires a majority vote in towns and a three-fourths vote in cities and villages. Prior to establishing such a district, the local governing bodies are also required to hold a formal public hearing.

Utility districts within the Region have been formed primarily within towns. There are a total of 14 such town utility districts within the Region. Of this total all but three currently provide sanitary sewer service, with three owning and operating sewage treatment plants and eight contracting with adjacent municipalities for sewage treatment purposes. The location and service area of these town utility districts are shown on Map 2.

<u>Joint Sewerage Systems</u>: Section 144.07 of the Wisconsin Statutes provides authority for a group of governmental units, including cities, villages, and town sanitary or utility districts, to construct and operate a joint sewerage system following hearing and approval by the Wisconsin Department of Natural Resources. The statute provides that when one governmental unit renders service to another under this section, such as sewage conveyance and treatment, reasonable compensation is to be paid. Such reasonable charges are to be

determined by the governmental unit furnishing the service. If the governmental unit receiving the service deems the charge unreasonable, the statutes provide for either binding arbitration by a panel of three reputable and experienced engineers or for judicial review in the circuit court of the county of the governmental unit furnishing the service. In the alternative, the jointly acting governmental units may create a sewerage commission to project, plan, construct, and maintain in the area sewerage facilities for the collection, transmission, and treatment of sewage. Such a sewerage commission becomes a municipal corporation and has all the powers of a common council and board of public works in carrying out its duties. However, all bond issues and appropriations made by such a sewerage commission are subject to approval by the governing bodies of the units of government which initially formed the commission. The statutes provide that each governmental unit must pay its proportionate share of constructing, operating, and maintaining the joint, sewerage system. Grievances concerning same may be taken to the circuit court of the county in which the aggrieved governmental unit is located.

In effect, then, such a joint sewerage commission created under Section 144.07 of the Wisconsin Statutes can operate much like a metropolitan sewerage commission created under Sections 66.20 to 66.26 of the Wisconsin Statutes. To date no such joint sewerage commissions have been created in the Southeastern Wisconsin Region. Such commissions exist in two other areas of the state, however, the Neenah-Menasha and Sauk City-Prairie du Sac areas.

<u>Cooperative Action by Contract</u>: Section 66.30 of the Wisconsin Statures permits the joint exercise by municipalities, broadly defined to include the state or any department or agency thereof or any city, village, town, county, school district, public library system, sanitary district, or regional planning commission, of any power or duty required of, or authorized to, such municipality by statute. To jointly exercise any such power, such as the transmission, treatment, and disposal of sanitary sewage, municipalities would have to create a commission by contract. Appendix A to SEWRPC Technical Report No. 6, <u>Planning Law in Southeastern Wisconsin</u>, contains a model agreement creating such a cooperative contract commission.

Three such contract commissions have been created under this statute in the Southeastern Wisconsin Region for sewerage purposes. The first of these is the Underwood Sewer Commission jointly created by contract between the City of Brookfield and the Village of Elm Grove. The purpose of this cooperative action was to provide for the construction, operation, and maintenance of a major trunk sewer along Underwood Creek which provides conveyance for sewage from both communities to the Milwaukee-Metropolitan sewerage system for sewage treatment purposes. The second of these is the Menomonee South Sewerage Commission jointly created by contract between the City of Brookfield and the Village of Menomonee Falls to provide for the construction, operation, and maintenance of a major trunk sewer along Butler Ditch. The third such cooperative commission is the Delafield-Hartland Water Pollution Control Commission recently formed to provide sewage conveyance and treatment in the two communities. As discussed in Chapter V of this report, this Commission has developed a plan for the construction of a major new sewage treatment facility discharging its effluent to the Bark River below the Nemahbin Lakes in the Town of Summit, together with a major trunk sewer ultimately planned to serve the City of Delafield and the Villages of Nashotah and Hartland. This system could also be expanded to serve a portion of the Town of Summit.

In addition to the formal contract commissions noted above that have been created to construct, operate, and maintain joint sewerage facilities, there are a number of intergovernmental contracts within the Region that provide for the conveyance and treatment of sewage by one community for sewage generated in another community. The City of Kenosha provides treatment for sewage generated in the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C and the Town of Somers Sanitary District No. 1. The City of Racine provides treatment for sewage generated in the Village of North Bay, the Town of Caledonia Sewer Utility District No. 1, and the Town of Mt. Pleasant Sewer Utility District. The North Park Sanitary District, which serves the Village of Wind Point and a portion of the Town of Caledonia, provides treatment for sewage generated in the Crestview Sanitary District. Finally, the Metropolitan Sewerage District of the County of Milwaukee provides treatment for sewage generated in all or portions of the Cities of Brookfield, Mequon, Muskego, and New

Berlin and the Villages of Butler, Elm Grove, and Menomonee Falls.

Sewer Service Charges

Section 66.076 of the Wisconsin Statutes provides that, in addition to all other methods of financing sewerage system development, operation, and maintenance, municipalities may establish sewer service charges. The revenue from such charges may be pledged as security for mortgage bonds or mortgage certificates. For the purpose of making equitable charges for all services rendered by the sewerage system, the property benefited may be classified taking into consideration the volume of water, the character of the sewage or waste disposed, and the nature of the use made of the sewerage system. The Wisconsin Public Service Commission is required to investigate any complaint by any user of such a sewer service that the rates, rules, and practices are unreasonable or unjustly discriminatory.

While Section 66.076 of the Wisconsin Statutes does provide clear authority for municipalities to establish sewer service charges, an apparently conflicting provision in Section 59.96 of the Statutes should be noted. This section provides, with respect only to those municipalities within the Metropolitan Sewerage District of the County of Milwaukee, that the clerk must place all operating and maintenance expenditures apportioned by the District to each municipality on the local property tax roll. The Wisconsin Public Service Commission has taken the position, in a case involving the City of Oak Creek, that the City may not utilize a local sewer service charge to pay for the District operation and maintenance expenditures apportioned to the City because of the mandatory property tax provision found in Section 59.96. Remedial legislation has been introduced into the Wisconsin Legislature (1973 Senate Bill 104) to amend Section 59.96 to make it clear that municipalities within the Metropolitan Sewerage District may, if they choose, utilize sewer service charges to pay for all expenses associated with belonging to the District.

House Connections

In Section 144.06 of the Wisconsin Statutes, any city or village or any town having a population of over 7,500 owning and operating a sewerage system is authorized by ordinance to require buildings used for human habitation and located adjacent to a sewer to be connected with such sewer in the manner prescribed. Should the owner fail to so comply with such ordinance, the municipality is authorized to cause the connection to be made and to charge the expense thereof as a special tax assessment against the property benefited.

Authority of Municipalities to Accept Aids

In Section 66.33 of the Wisconsin Statutes any municipality, defined as any city, village, town, town sanitary district, or metropolitan sewerage district, is authorized to apply for and accept grants-in-aid from the U. S. Government in aid of the prevention or abatement of water pollution. Municipalities are further authorized to accept contributions and other aid from commercial, industrial, or other establishments for the purpose of aiding in the prevention or abatement of water pollution. In furtherance of such purpose, municipalities are authorized to enter into contracts and agreements with such commercial, industrial, or other establishments covering all aspects of sewage collection, conveyance, treatment, and disposal.

PRIVATE STEPS FOR WATER POLLUTION CONTROL

The foregoing discussion in this chapter deals exclusively with the water pollution control machinery, as it relates to sanitary sewerage system development, available to units and agencies of government. Direct action may also be taken, however, by private individuals or organizations to effectively abate water pollution. In seeking direct action for water pollution control there are two legal categories of private individuals: riparians, or owners of land along a natural body of water, and nonriparians.

Riparians

It is not enough for a riparian proprietor seeking an injunction to show simply that an upper riparian is polluting the stream and thus he, the lower riparian, is being damaged. Courts will often inquire as to the nature and the extent of the defendant's activity; its worth to the community; its suitability to the area; and his present attempts, if any, to treat wastes. The utility of the defendant's activity is weighed against the extent of the plaintiff's damage within the framework of reasonable alternatives open to both. On the plaintiff's side, the court may inquire into the size and scope of his operations, the degree of water purity that he actually requires, and the extent of his actual damages. This approach may cause the court to conclude that the plaintiff is entitled to a judicial remedy. Whether this remedy will be an injunction or merely an award of damages depends on the balance which the court strikes after reviewing all the evidence. For example, where a municipal treatment plant or industry is involved, the court, recognizing equities on both sides, might not grant an injunction stopping the defendant's activity but might compensate the plaintiff in damages. In addition, the court may order the defendant to install certain equipment or to take certain measures designed to minimize the future polluting effects of his waste disposal. It is not correct to characterize this balancing as simply a test of economic strengths. If it were simply a weighing of dollars and cents, the rights of small riparians would never receive protection. The balance that is struck is one of reasonable action under the circumstances, and small riparians can be and have been adequately protected by the courts.

Riparians along water bodies in the Southeastern Wisconsin Region are not foreclosed by the existence of federal, state, or local pollution control efforts from attempting to assert their common law rights in courts. The court may ask the Wisconsin Department of Natural Resources to act as its master in chancery, especially where unbiased technical evidence is necessary to determine the rights of litigants. The important point, however, is that nothing in the Wisconsin Statutes can be found which expressly states that, in an effort to control pollution, all administrative remedies must first be exhausted before an appeal to the courts may be had or that any derogation of common law judicial remedies was intended. Thus, the courts are not prevented from entertaining an original action brought by a riparian owner to abate pollution.

Nonriparians

The rights of nonriparians to take direct action through the courts are less well defined than in the case of riparians. The Wisconsin Supreme Court set forth a potentially far-reaching conclusion in Muench v. Public Service Commission[9] when it concluded that:

> The rights of the citizens of the state to enjoy our navigable streams for recreational purposes, including the enjoyment of scenic beauty, is a legal right that is entitled to all the protection which is given financial rights.

This language, however, was somewhat broader than necessary to meet the particular situation at hand, since the case involved an appeal from a state agency ruling. The case has not yet arisen where a private nonriparian citizen is directly suing to enforce his public rights in a stream. Only when such a case does arise can it be determined if the Court will stand behind the broad language quoted above or draw back from its implications. The more traditional view would be that a nonriparian citizen must show special damages in a suit to enforce his public rights.

It should be noted that Section 144.537 of the Wisconsin Statutes presently enables six or more citizens, whether riparian or not, to file a complaint leading to a full-scale public hearing by the Department of Natural Resources on alleged or potential acts of pollution. In addition, a review of Department orders may be had pursuant to Section 144.56 of the Wisconsin Statutes by "any owner or other person in interest." This review contemplates eventual court determination under Chapter 227 of the Wisconsin Statutes when necessary. The phrase "of other persons" makes it clear that nonriparians may ask such judicial review.

The Federal Water Pollution Control Act provides for citizen suits in Section 505. Under this section, any citizen, meaning a person or persons having an interest which is or may be adversely affected, may commence a civil action on his own behalf against any person, including any governmental agency, alleged to be in violation of any effluent standard, limitation, or prohibition or any pollution discharge permit or condition thereof; or against the EPA Administrator when there is alleged failure by the Administrator to duly carry out any nondiscretionary duty or act under the Federal Water Pollution Control Act. Prior to bringing such action, however, the citizen commencing the action must give notice of the alleged violation to the EPA Administrator, to the state in which the alleged violation occurs, and to the alleged violator. The courts when issuing final orders in any action under this section may award costs of litigation to any party.

---

[9] *261 Wis. 492, 53 N.W. 2d 514 (1952).*

SUMMARY

This chapter has described in summary form the basic legal framework within which sanitary sewerage system planning and plan implementation must take place in southeastern Wisconsin. Such legal framework consists primarily of water pollution control legislation and administrative machinery at the federal, state, and local levels of government.

With the passage of the Federal Water Pollution Control Act Amendments of 1972, the U. S. Congress set in motion a series of actions which will have many ramifications for sewerage system planning and development within the Region. Water use objectives and supporting water quality standards are now required for all navigable waters in the United States. Such standards must be reviewed and, as appropriate, revised at least every three years. It is a national goal to eliminate the discharge of pollutants into the navigable waters of the United States by 1985 and to obtain an interim goal of suitable water quality for the maintenance of fish life and for use by human recreational activities in and on the water by 1983. To meet these goals the Act requires, in addition to water use objectives and water quality standards, the enactment of specific effluent limitations for all point sources of water pollution. If economically and technically feasible, such effluent limitations could include a complete discharge prohibition. For certain categories of pollutors, national standards of performance with respect to the discharge of pollutants are to be formulated and applied to any newly established source within the categories. Thus, no matter what the assimilative capacity may be of a receiving water body, a newly established industrial firm anywhere in the nation will have to meet the national standards.

The new Act also establishes a pollutant discharge permit system under which the EPA, or a state upon approval of the EPA, is to issue permits for the discharge of any pollutants subject to conditions that the discharge will meet all applicable effluent limitations and contribute toward achieving the established water use objectives and supporting water quality standards. This new system supercedes the established but little utilized discharge permit system under the Refuse Act of 1899.

Each state must have a continuing planning process designed to achieve the overall water quality objectives of the Act. This state planning process is to be designed to result in the preparation of comprehensive development plans for natural basins and watersheds and must incorporate metropolitan or regional sanitary sewerage system plans. In order to provide a basis upon which to expend federal monies in metropolitan areas for public waste treatment works construction, the new Act requires the development and implementation of areawide waste treatment management plants. The regional sanitary sewerage system plan for southeastern Wisconsin is intended to be the first step in meeting this requirement. Upon completion of areawide waste treatment management plans, management agencies must be designated to carry out the plans. The EPA Administrator can only make federal grants for waste treatment works construction to such management agencies and for treatment works found to be in accordance with the officially adopted plan. In addition, no permits may be issued for any point source of water pollution found to be in conflict with an adopted areawide waste treatment management plan.

Federal funding for waste treatment works construction has been set at 75 percent of construction costs. In addition to meeting planning requirements, any federal grant recipient must establish a system of sewer service charges to assure that each recipient of waste treatment services pays its proportionate share of the operation, maintenance, and replacement costs of waste treatment services provided.

Responsibility for water pollution control in Wisconsin is centered in the Wisconsin Department of Natural Resources. The Department is given authority to prepare long-range water resources plans, to establish water use objectives—with supporting water quality standards—applicable to all waters of the state, to issue pollution abatement orders, to certify sewage treatment plant operators, to review and approve plans for sewerage facilities, to order the installation of sanitary sewerage systems, and to administer financial assistance programs for the construction of water pollution abatement facilities. Water use objectives and supporting water quality standards applicable to all of the surface waters of the state were initially established by the Wisconsin Resource Development Board in 1967-68. A revised, more stringent version of these water use objectives and supporting water quality standards was adopted by the Wisconsin Natural Resources Board effec-

Local water pollution control machinery generally centers around specific methods of organizing to provide for sanitary sewer service. Cities and villages under the home rule power can take all steps necessary to effectively establish, operate, and maintain sanitary sewerage systems, including the adoption of rules regulating the discharge of substances into such systems. Counties and towns do not have such broad authority. Towns may form sanitary or utility districts to provide such sewerage service to portions of the town.

Several ways exist to provide for areawide sanitary sewerage systems. In addition to the long-established Metropolitan Sewerage District of the County of Milwaukee which serves, in addition to nearly all Milwaukee County, portions of Ozaukee, Washington, and Waukesha Counties, other metropolitan sewerage districts may be established under state law. Such districts must include at least one city or village in its entirety. In addition, adjacent communities can establish joint sewerage commissions to operate areawide facilities upon approval of the Department of Natural Resources. The general grant of intergovernmental cooperation power set forth in Section 66.30 of the Wisconsin Statutes also is available to establish areawide sewerage systems. Three commissions have to date been established in the Region under this section, including the Underwood Sewer Commission created by the City of Brookfield and the Village of Elm Grove, the Menomonee South Sewerage Commission created by the City of Brookfield and the Village of Menomonee Falls, and the Delafield–Hartland Water Pollution Control Commission created by the City of Delafield and the Village of Hartland.

Private citizens may take steps to abate existing water pollution and prevent potential pollution. Riparians have a common law right to enjoin another riparian from polluting the stream, providing significant damages can be shown. Non-riparians also have certain rights to enjoy the navigable waters for recreational and other purposes. The statutes in Wisconsin permit six citizens, whether riparian or not, to file a complaint leading to a public hearing by the Department of Natural Resources on alleged or potential acts of water pollution. Private citizens may also file suit in U. S. Courts to enjoin violations of the Federal Water Pollution Act and to force federal officials to properly carry out their nondiscretionary activity under the Act.

Chapter VIII

SANITARY SEWERAGE SYSTEM DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

As noted in Chapter II of this report, planning is a rational process for formulating and meeting objectives. The formulation of objectives is, therefore, an essential task which must be undertaken before plans can be prepared. The formulation of objectives for organizations whose functions are directed primarily at a single purpose or interest and, therefore, are direct and clear-cut is a relatively easy task. The seven-county southeastern Wisconsin planning region is, however, composed of many diverse and often divergent interests; consequently, the formulation of objectives for the preparation of advisory comprehensive regional development plans is a very difficult task.

Soundly conceived regional development objectives should incorporate the combined knowledge of many people who are informed about the Region and should be established by duly elected or appointed representatives legally assigned this task, assisted by planning technicians and engineers. This is particularly important because of the value system implications inherent in any set of development objectives. The act of participation by duly elected or appointed public officials and by citizen leaders in the overall regional planning program is implicit in the structure and organization of the Southeastern Wisconsin Regional Planning Commission itself. Moreover, the Commission very early in its existence recognized that the task of guiding the broad spectrum of related public and private development programs which would influence and be influenced by a comprehensive regional planning program would require an even broader opportunity for the active participation of public officials and private interest groups in the regional planning process. In light of this recognition, the Commission has provided for the establishment of a number of advisory committees to assist the Commission and its staff in the conduct of the regional planning program. The Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning is only one of many advisory committees which have contributed to the formulation of objectives toward which the advisory structure of regional plan elements has been directed. Others include the Intergovernmental Coordinating Committee on Regional Land Use-Transportation Planning and the Technical Coordinating and Advisory Committee on Regional Land Use-Transportation Planning, which jointly contributed to the formulation of the land use and transportation development objectives; and the Root River Watershed Committee, the Fox River Watershed Committee, and the Milwaukee River Watershed Committee, which contributed to the formulation of water use and water control facility objectives for their respective watersheds.

This chapter sets forth the relevant regional planning objectives, principles, and standards which have been adopted by the Commission under related regional planning programs after careful review and recommendation by the advisory committees concerned. In addition, a series of new objectives, principles, and standards relating directly to the development of sanitary sewerage systems is presented.

BASIC CONCEPTS AND DEFINITIONS

The term "objective" is subject to a wide range of interpretation and application, and is closely linked to other terms often used in planning work which are equally subject to a wide range of interpretation and application. The following definitions have, therefore, been adopted in order to provide a common frame of reference:

1. Objective: a goal or end toward the attainment of which plans and policies are directed.

2. Principle: a fundamental, primary, or generally accepted tenet used to support objectives and prepare standards and plans.

3. Standard: a criterion used as a basis of comparison to determine the adequacy of plan proposals to attain objectives.

4. Plan: a design which seeks to achieve the agreed-upon objectives.

5. Policy: a rule or course of action used to ensure plan implementation.

6. Program: a coordinated series of policies and actions to carry out a plan.

Although this chapter deals with the first three of these terms, an understanding of the interrelationship of the foregoing definitions and the basic concepts which they represent is essential to the following discussion of development objectives, principles, and standards.

DEVELOPMENT OBJECTIVES

Objectives, in order to be useful in the comprehensive regional planning process, must be sound logically and related in a demonstrable and measurable way to alternative physical development proposals. This is necessary because it is the legal duty and function of the Commission to prepare a comprehensive plan for the physical development of the Region and, more particularly, because it is the purpose of the regional sanitary sewerage system planning program to prepare one of the key elements of such a plan: a regional sanitary sewerage system plan. Only if the objectives are clearly relatable to physical development, and only if they are subject to objective test, can an intelligent choice be made from alternative plans in order to select the one plan or combination of plans which best meets the agreed-upon objectives.

Recognizing that various public and private interest groups within a Region as large and diverse as southeastern Wisconsin may have varying and at times conflicting objectives; that many of these objectives are of a qualitative nature, and therefore, difficult to quantify; and that many objectives which may be held to be important by the various interest groups within the Region may not be related in a demonstrable manner to physical development plans, the Commission has identified two basic types of objectives. These are general development objectives, which are by their very nature either qualitative or difficult to relate directly to development plans; and specific development objectives, which can be directly related to physical development plans and at least crudely quantified.

General Objectives

After careful review and recommendation by advisory and intergovernmental coordinating committees under the regional land use-transportation study, which was the first planning program conducted by the Commission designed to prepare the regional plan elements, the Commission adopted nine general development objectives for the Region. These are:

1. Economic growth at a rate consistent with regional resources and primary dependence on free enterprise, in order to provide maximum employment opportunities for the expanding labor force of the Region.

2. A wide range of employment opportunities through a broad, diversified economic base.

3. Conservation and protection of desirable existing residential, commercial, industrial, and agricultural development in order to maintain desirable social and economic values; renewal of obsolete and deteriorating residential, commercial, and industrial areas in the rural as well as in the urban areas of the Region; and prevention of slums and blight.

4. A broad range of choice among housing designs, types, and costs, recognizing changing trends in age group composition, income, and family living habits.

5. An adequate and balanced level of community services and facilities.

6. An efficient and equitable allocation of fiscal resources within the public sector of the economy.

7. An attractive and healthful physical and social environment with ample opportunities for education, cultural activities, and outdoor recreation.

8. Protection, wise use, and sound development of the natural resource base.

9. Development of communities having distinctive individual character, based on physical conditions, historical factors, and local desires.

The foregoing development objectives are proposed as goals which public policy within the Region should promote. They are all necessarily general but, nevertheless, provide the broad framework within which regional planning can take place and the more specific goals of the various functional elements and component parts of the regional plan can be stated and pursued. The statement of these objectives is concerned entirely with ends and not with means, and the principal emphasis of these general development objectives is on those aspects of regional development which relate either to the expenditure of public funds or to the effects of government actions and regulations. With respect to these development objectives, it is deemed sufficient to arrive at a consensus among advisory committees and the Commission itself that plan proposals do not conflict with the objectives. Such a consensus represents the most practical evaluation of the ability of alternative plan proposals to meet the general development objectives.

Specific Development Objectives

In the framework established by the general development objectives, a secondary set of more specific alternatives can be postulated which will be directly relatable to physical development plans and can be at least crudely quantified. The quantification is facilitated by complementing each specific objective with a set of quantifiable planning standards which are, in turn, directly relatable to a planning principle which supports the chosen objective. Planning principles thus augment each specific objective by asserting its inherent validity as an objective.

In its planning efforts to date, the Commission has adopted, after careful review and recommendation by advisory and coordinating committees, nine specific regional land use development objectives, seven specific regional transportation system development objectives, and four specific water control facility development objectives. These specific development objectives, together with their supporting principles and standards, are set forth in full in previous Commission planning reports.[1]

[1] *See SEWRPC Planning Report No. 7, Land Use-Transportation Study, Forecasts and Alternative Plans--1990, Volume II, and SEWRPC Planning Reports Nos. 9, 12, and 13, Comprehensive Plans for the Root, Fox, and Milwaukee River Watersheds, respectively*

Land Use Development Objectives: The nine specific regional land use development objectives already adopted by the Commission under previous planning programs are applicable to the regional sanitary sewerage system planning effort, and are hereby recommended for reaffirmation as development objectives under the regional sanitary sewerage system planning program. These are:

1. A balanced allocation of space to the various land use categories which meets the social, physical, and economic needs of the regional population.

2. A spatial distribution of the various land uses which will result in a compatible arrangement of land uses.

3. A spatial distribution of the various land uses which will result in the protection, wise use, and development of the natural resources of the Region.

4. A spatial distribution of the various land uses which is properly related to the supporting transportation and public utility systems in order to assure the economic provision of utility and municipal services.

5. The development and conservation of residential areas within a physical environment that is healthy, safe, convenient, and attractive.

6. The preservation and provision of a variety of suitable industrial and commercial sites both in terms of physical characteristics and location.

7. The preservation and provision of open space to enhance the total quality of the regional environment, maximize essential natural resource availability, give form and structure to urban development, and facilitate the ultimate attainment of a balanced year-round outdoor recreation program providing a full range of facilities for all age groups.

8. The preservation of land areas for agricultural uses in order to provide for certain special types of agriculture, provide a reserve for future needs, and ensure the preservation of those unique rural areas

which provide wildlife habitat and which are essential to shape and order urban development.

9. The attainment of good soil and water conservation practices in order to reduce storm water runoff; soil erosion; and stream and lake sedimentation, pollution, and eutrophication.

Water Control Facility Development Objectives: Two of the four water control facility development objectives already adopted by the Commission under its comprehensive watershed planning programs are applicable to the regional sanitary sewerage system planning effort and are hereby recommended for reaffirmation as specific development objectives for the regional sanitary sewerage system planning program. These are:

1. An integrated system of drainage and flood control facilities which will effectively reduce flood damage under the existing land use pattern in the watersheds of the Region and promote the implementation of the watershed land use plans, meeting the anticipated runoff loadings generated by the existing and proposed land uses.

2. Attainment of sound groundwater resource development and protective practices to minimize the possibility of pollution and depletion of the groundwater resources.

Two additional objectives formulated under the watershed programs deal with stream and lake water quality for each particular watershed. These objectives have been implicitly recognized in the development of similar objectives for the Region as a whole under the regional sanitary sewerage system planning program.

Sanitary Sewerage System Development Objectives: The following four specific development objectives for regional sanitary sewerage system planning have been developed under this program and are recommended for adoption as additional development objectives for the Region:

1. The development of sanitary sewerage systems which will effectively serve the existing regional urban development pattern and promote implementation of the regional land use plan, meeting the anticipated sanitary waste disposal demand generated by the existing and proposed land uses.

2. The development of sanitary systems so as to meet established water use objectives and supporting water quality standards (see Map 49).[2]

3. The development of sanitary sewerage systems that are properly related to and will enhance the overall quality of the natural and manmade environments.

4. The development of sanitary sewerage systems that are both economical and efficient, meeting all other objectives at the lowest cost possible.

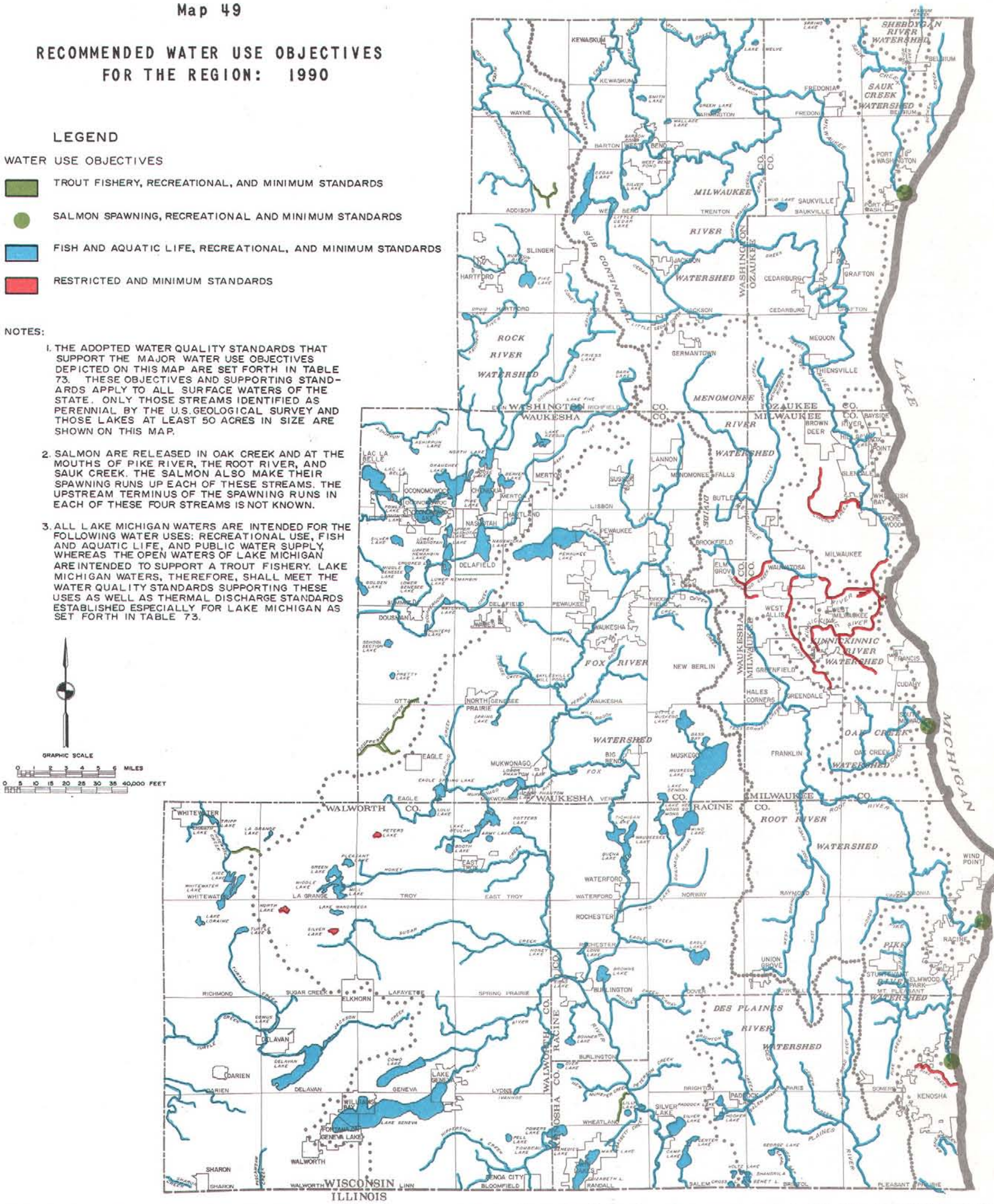
Principles and Standards

Complementing each of the foregoing specific land use, water control, and sanitary sewerage system development objectives is a planning principle and a set of planning standards. These, as they apply

[2] *It is important to note that the recommended water use objectives differ in certain locations from the current (1973) water use objectives adopted by the Wisconsin Natural Resources Board and set forth in Chapter NR 104 of the Wisconsin Administrative Code. In four locations--three lakes and one stream--the recommended water use objectives are lower than the currently adopted water use objectives: Peters, North, and Long Lakes in Walworth County, where the physical characteristics of the lake, and in particular the extremely shallow depths, severely inhibit use for recreational and fishery purposes and the lakes are recommended, therefore, to be placed in the restricted use category rather than in the recreational use category; and the Pike Creek tributary to the Kenosha harbor in Kenosha County which has essentially been converted to a closed urban storm sewer and, therefore, is recommended to be placed in the restricted category rather than in the recreational and fish and aquatic life use categories. In six locations the recommended water use objectives are higher than those currently adopted by the state: Barnes Creek in Kenosha County, Pike Creek tributary to Pike River in Kenosha County, Pike River in Racine County, Sussex Creek in Waukesha County, Indian Creek in Milwaukee County, and the Menomonee River between Honey Creek and Hawley Road in Milwaukee County. In each instance the surface water involved is recommended to be placed in the recreational and fish and aquatic life use categories rather than the restricted use category. Since these streams have been placed in the restricted use category because of current waste sources, namely temporary sewage treatment facilities, sanitary sewer overflows, and malfunctioning septic tank systems, and since it is expected that these waste sources will be eliminated as sources of pollution over time as centralized sanitary sewerage systems are extended and relief sewers constructed, it is recommended as a long-term objective that the recreational and fish and aquatic life use categories be applied.*

Map 49

RECOMMENDED WATER USE OBJECTIVES FOR THE REGION: 1990



The 1990 water use objectives shown on this map provide an important basis for regional sanitary sewerage system plan design, test, and evaluation. Since sewage effluent from treatment plants is one of the most significant sources of pollution of the lakes and streams of the Region, it is essential that the regional sanitary sewerage system plan include recommended performance standards with respect to each sewage treatment facility so as to assure that the designated water use objectives for a particular stream or lake are ultimately reached. Generally the surface waters of the Region are recommended to be maintained in a condition suitable for both recreational use and for the preservation and enhancement of fish and aquatic life. The attainment of these objectives will require the provision of levels of waste treatment beyond those normally found in the Region today.

Source: SEWRPC.

Table 75

LAND USE PLANNING OBJECTIVES, PRINCIPLES, AND STANDARDS

OBJECTIVE NO. 1

A balanced allocation of space to the various land use categories which meets the social, physical, and economic needs of the regional population.

PRINCIPLE

The planned supply of land set aside for any given use should approximate the known and anticipated demand for that use.

STANDARDS

1. For each additional 1,000 persons to be accommodated within the Region at each density, the following minimum amounts of land should be set aside:

Residential Land	Net Area[1]	Gross Area[2]
Low density	250 acres/1,000 persons	312 acres/1,000 persons
Medium density	70 acres/1,000 persons	98 acres/1,000 persons
High density	25 acres/1,000 persons	38 acres/1,000 persons

Governmental and Institutional Land	Gross Area[3]
Regional[4]	3 acres/1,000 persons
Local[5]	6 acres/1,000 persons

Park and Recreation Land[6]	Gross Area[7]
Regional[8]	4 acres/1,000 persons
Local[9]	10 acres/1,000 persons

2. For each additional 100 commercial and industrial employees to be accommodated within the Region, the following minimum amounts of land should be set aside.

	Gross Area[10]
Commercial land[11]	5 acres/100 employees
Industrial land[12]	7 acres/100 employees

OBJECTIVE NO. 2

A spatial distribution of the various land uses which will result in a compatible arrangement of land uses.

PRINCIPLE

The proper allocation of uses to land can avoid or minimize hazards and dangers to health, safety, and welfare and maximize amenity and convenience in terms of accessibility to supporting land uses.

STANDARDS

1. Residential uses should be located within planning units which contain, within a reasonable walking distance, necessary supporting local service uses such as neighborhood park, local commercial, and elementary school facilities; and should have reasonable access, through the appropriate component of the transportation system, to employment, commercial and cultural centers, and secondary school facilities.

2. Regional commercial uses should be located in centers of concentrated activity on only one side of an arterial street and should be afforded direct access[13] to the arterial street system.

3. Industrial uses should be located to have direct access to highway facilities and reasonable access through the appropriate component of the transportation system to residential areas and railway and airport facilities, and should not be intermixed with commercial, residential, governmental, recreational, or institutional land uses.

OBJECTIVE NO. 3

A spatial distribution of the various land uses which will result in the protection, wise use, and development of the natural resource of the Region.

PRINCIPLE

The proper allocation of uses to land can assist in maintaining an ecological balance between the activities of man and the natural environment which supports him.

A. Soils

Principle

The proper relation of urban and rural land use development to soils can serve to avoid many environmental problems, aid in the establishment of better regional settlement patterns, and promote the wise use of an irreplaceable resource.

STANDARDS

1. Urban development, particularly for residential use, shall be located only in those areas which do not contain significant concentrations of soils rated in the regional detailed operational soil survey as poor, questionable, or very poor for such development. Significant concentrations are defined as follows:

   a. In areas[14] to be developed for low-density residential use, no more than 2.5 percent of the gross area should consist of soils rated in the regional soil survey as poor, questionable, or very poor for such development.

b. In areas to be developed for medium-density residential use, no more than 3.5 percent of the gross area should consist of soils rated in the regional soil survey as poor, questionable, or very poor for such development.

c. In areas to be developed for high-density residential use, no more than 5.0 percent of the gross area should consist of soils rated in the regional soil survey as poor, questionable, or very poor for such development.

2. Rural development, principally agricultural land use, shall be allocated primarily to those areas covered by soils rated in the regional soil survey as very good, good, or fair for such use.

3. Land developed or proposed to be developed without public sanitary sewer service should be located only on areas covered by soils rated in the regional soil survey as very good, good, or fair for such development.

B. Inland Lakes and Streams

Principle

Inland lakes and streams contribute to the atmospheric water supply through evaporation; provide a suitable environment for desirable and sometimes unique plant and animal life; provide the population with opportunities for certain scientific, cultural, and educational pursuits; constitute prime recreational areas; provide a desirable aesthetic setting for certain types of land use development; serve to store and convey floodwaters; and provide certain water withdrawal requirements.

STANDARDS

1. A minimum of 25 percent of the perimeter or shoreline frontage of lakes having a surface area in excess of 50 acres and of both banks of all perennial streams should be maintained in a natural state.

2. A minimum of 10 percent of the shoreline of each inland lake having a surface area in excess of 50 acres should be maintained for public use, such as a beach area, pleasure craft marina, or park.

3. Not more than 50 percent of the shoreline length of inland lakes having a surface area in excess of 50 acres and of perennial streams should be allocated to urban development except for park and outdoor recreational use.

4. In addition, it is desirable that 25 percent of the shoreline of each inland lake having a surface area less than 50 acres be maintained in either a natural state or some low-intensity public use, such as park land.

5. Floodplain lands[15] should not be allocated to any urban development[16] which would cause or be subject to flood damage.

6. No unauthorized structure or fill should be allowed to encroach upon and obstruct the flow of water in the perennial stream channels[17] and floodways.[18]

C. Wetlands

Principle

Wetlands support a wide variety of desirable and sometimes unique plant and animal life; assist in the stabilization of lake levels and streamflows; trap, store, and release plant nutrients in runoff with a net improvement in the quality of runoff, thus reducing enrichment of surface waters and obnoxious weed and algae growth; contribute to the atmospheric oxygen supply, reduce storm water runoff by providing area for floodwater impoundment and storage; reduce stream sedimentation; and provide the population with opportunities for certain scientific, educational, and recreational pursuits.

STANDARDS

All wetland areas[19] adjacent to streams or lakes, all wetlands within areas having special wildlife values, and all wetlands having an area in excess of 50 acres should not be allocated to any urban development except limited recreation and should not be drained or filled. Adjacent surrounding areas should be kept in open-space use, such as agriculture or limited recreation.

D. Woodlands[20]

Principle

Woodlands assist in maintaining unique natural relationships between plants and animals; reduce storm water runoff; contribute to the atmospheric oxygen supply; contribute to the atmospheric water supply through transpiration; aid in reducing soil erosion and stream sedimentation; provide the resource base for the forest product industries; provide the population with opportunities for certain scientific, educational, and recreational pursuits; and provide a desirable aesthetic setting for certain types of land use development.

STANDARDS

1. A minimum of 10 percent of the land area of each watershed[21] within the Region should be devoted to woodlands.

2. For demonstration and educational purposes, the woodland cover within each county should include a minimum of 40 acres devoted to each major forest type: oak-hickory, northern hardwood, pine species, and lowland forest.

3. A minimum regional aggregate of 5 acres of woodland per 1,000 population should be maintained for recreational pursuits.

E. Wildlife[22]

Principle

Wildlife, when provided with a suitable habitat, will provide the population with opportunities for certain scientific, educational, and recreational pursuits; provide a food source; aid significantly in controlling harmful insects and other noxious pests; and provide an economic resource for the fur and fishing industries.

STANDARDS

The most suitable habitat for wildlife, that is – the area wherein fish and game can best be fed, sheltered, and reproduced – is a natural habitat. Since the natural habitat for fish and game can best be obtained by preserving or maintaining other resources, such as soil, air, water, wetlands, and woodlands, in a wholesome state, the standards for each of these other resources, if met, would ensure the preservation of a suitable wildlife habitat and population.

OBJECTIVE NO. 4

A spatial distribution of the various land uses which is properly related to the supporting transportation and public utility systems in order to assure the economical provision of utility and municipal services.

PRINCIPLE

The transportation and public utility facilities and the land use pattern which these facilities serve and support are mutually interdependent in that the land use pattern determines the demand for, and loadings upon, transportation and utility facilities and these facilities, in turn, are essential to, and form a basic framework for, land use development.

STANDARDS

1. The transportation system should be located and designed to avoid the penetration of residential planning units by through traffic.

2. The transportation system should be located and designed to avoid the penetration of prime natural resource areas by through traffic.

3. The transportation system should be located and designed to provide access not only to all land presently devoted to urban development but to all land well-suited for urban development.

4. Transportation terminal facilities, such as off-street parking, should be located in close proximity to the principal land uses to which they are accessory.

5. Land developed or proposed to be developed for medium- and high-density residential use should be located in a gravity drainage area tributary to an existing or proposed public sanitary sewerage system.

6. Land developed or proposed to be developed for medium- and high-density residential use should be located in areas serviceable by an existing or proposed public water supply system.

7. Urban development should be located so as to maximize the use of existing transportation and utility systems.

OBJECTIVE NO. 5

The development and conservation of residential areas within a physical environment that is healthy, safe, convenient, and attractive.

PRINCIPLE

Residential areas developed in designed planning units can assist in stabilizing community property values, preserving residential amenities, and promoting efficiency in the provision of public and community service facilities; can best provide a desirable environment for family life; and can provide the population with improved levels of safety and convenience.

STANDARDS

1. Residential planning units should be physically self-contained within clearly defined and relatively permanent isolating boundaries, such as arterial streets and highways, major park and open-space reservations, or significant natural features, such as rivers, streams, or hills.

2. Residential planning units should contain enough area to provide housing for the population served by one elementary school and one neighborhood park; an internal street system which discourages penetration of the unit by through traffic; and all of the community and commercial facilities necessary to meet the day-to-day living requirements of the family within the immediate vicinity of its dwelling unit. To meet these requirements at varied residential densities, the following specific standards should be met:[23]

Land Use	Low-Density Development (2 miles square) Percent of Area	Medium-Density Development (1 mile square) Percent of Area	High-Density Development (½ mile square) Percent of Area
Residential	80.0	71.0	66.0
Streets & Utilities	16.5	23.0	25.0
Parks & Playgrounds	1.5	2.5	3.5
Public Elementary School	0.5	1.5	2.5
Other Governmental & Institutional	1.0	1.0	1.5
Commercial	0.5	1.0	1.5
Total	100.0	100.0	100.0

3. Each residential planning unit should be designed to include a wide range of housing types, designs, and costs.

OBJECTIVE NO. 6

The preservation and provision of a variety of suitable industrial and commercial sites both in terms of physical characteristics and location.

PRINCIPLE

The production and sale of goods and services are among the principal determinants of the level of economic vitality in any society, and the important activities related to these functions require areas and locations suitable to their purpose.

STANDARDS

1. New industrial development should be located in planned industrial districts which meet the following standards:
   a. Direct access to high-speed, all-weather highway facilities.
   b. Reasonable access to railroad facilities.
   c. Reasonable access to airport facilities for the movement of both passengers and freight.
   d. Available adequate water supply.
   e. Available adequate sanitary sewer service.
   f. Available adequate storm water drainage facilities.
   g. Available adequate power supply.
   h. Soils rated in the regional soil survey as very good, good, or fair for such development.

2. New local commercial development, which includes activities primarily associated with the sale of convenience goods and services, should be contained within the residential planning units, the total area devoted to the commercial use varying with the residential density:
   a. In low-density areas, land devoted to local commercial centers should comprise at least 0.5 percent of the total gross residential area or about 3.2 acres per square mile of gross residential land use.
   b. In medium-density areas, land devoted to local commercial centers should comprise at least 1.0 percent of the total gross residential area or about 6.4 acres per square mile of gross residential land use.
   c. In high-density areas, land devoted to local commercial centers should comprise at least 1.5 percent of the total gross residential area or about 9.6 acres per square mile of gross residential land use.

3. New regional commercial development, which would include activities primarily associated with the sale of shopper's goods, should be concentrated in regional commercial centers which meet the following minimum standards:
   a. Accessibility to a population of between 75,000 and 150,000 persons located within either a 20-minute one-way travel period or a ten-mile radius.
   b. Direct access to the arterial street system.
   c. Available adequate water supply.
   d. Available adequate sanitary sewer service.
   e. Available adequate storm water drainage facilities.
   f. Available adequate power supply.
   g. A minimum site area of 60 acres.
   h. Soils rated in the regional soil survey as very good, good, or fair for such development.

In addition to the above minimum standards, the following site development standards are desirable:
   i. Provision of off-street parking for at least 5,000 cars.
   j. Provision of adequate off-street loading facilities.
   k. Provision of well-located points of ingress and egress which are controlled to prevent traffic congestion on adjacent arterial streets.
   l. Provision of adequate screening to serve as a buffer between the commercial use and adjacent noncommercial uses.
   m. Provision of adequate building setbacks from major streets.

OBJECTIVE NO. 7

The preservation and provision of open space[24] to enhance the total quality of the regional environment, maximize essential natural resource availability, give form and structure to urban development, and facilitate the ultimate attainment of a balanced year-round outdoor recreational program providing a full range of facilities for all age groups.

PRINCIPLE

Open space is the fundamental element required for the preservation, wise use, and development of such natural resources as soil, water, woodlands, wetlands, and wildlife; it provides the opportunity to add to the physical, intellectual, and spiritual growth of the population; it enhances the economic and aesthetic value of certain types of development; and is essential to outdoor recreational pursuits.

STANDARDS[25]

1. Local park and recreation open spaces should be provided within a maximum service radius of one-half mile of every dwelling unit in an urban area, and each site should be of sufficient size to accommodate the maximum tributary service area population at a use intensity of 675 persons per acre.

2. Regional park and recreation open spaces should be provided within an approximately one-hour travel time of every dwelling unit in the Region and should have a minimum site area of 250 acres.

3. Areas having unique scientific, cultural, scenic, or educational value should not be allocated to any urban or agricultural land uses; and adjacent surrounding areas should be retained in open-space use, such as agriculture or limited recreation.

OBJECTIVE NO. 8

The preservation of land areas for agricultural uses in order to provide for certain special types of agriculture, provide a reserve for future needs, and ensure the preservation of those unique rural areas which provide wildlife habitat and which are essential to shape and order urban development.

PRINCIPLE

Agricultural areas, in addition to providing food and fibre, contribute significantly to maintaining the ecological balance between plants and animals; provide locations proximal to urban centers for the production of certain food commodities which may require nearby population concentrations for an efficient production-distribution relationship; and provide open spaces which give form and structure to urban development.

STANDARDS

1. All prime agricultural areas[26] should be preserved.

2. All agricultural lands surrounding adjacent high-value scientific, educational, or recreational resources and covered by soils rated in the regional detailed operational soil survey as very good, good, or fair for agricultural use should be preserved.

In addition to the above, attempts should be made to preserve agricultural areas which are covered by soils rated in the regional detailed operational soil survey as fair if these soils: a) occur in concentrations greater than five square miles and surround or lie adjacent to areas which qualify under either of the above standards, or b) occur in areas which may be designated as desirable open spaces for shaping urban development.

OBJECTIVE NO. 9

The attainment of good soil and water conservation practices in order to reduce storm water runoff; soil erosion; and stream and lake sedimentation, pollution, and eutrophication.

PRINCIPLE

Good soil and water conservation practices, including mulch tillage, terracing, grass in waterways, contour strip cropping, and suitable crop rotation in rural areas; seeding; sodding; erosion control structures for drainageways; erosion control structures at storm sewer outlets; and proper land development and construction methods and practices, particularly in urban areas, including maximum possible delay in stripping of vegetation, construction of sediment basins, and mulching and revegetating as soon as possible, can assist in reducing storm water runoff; soil erosion; and stream and lake siltation, pollution, and eutrophication.

STANDARDS

1. The area of the watershed in cultivated agricultural use, which has general land slopes greater than 2 percent, should be under district cooperative soil and water conservation agreements and planned conservation treatment.

2. Drainageways should be controlled to eliminate channel erosion both through stabilization of bank and bed materials and by reduction of the channel gradient.

3. All urban and structural plans and developments, where soil and vegetative cover is removed, should include soil and water conservation practices to control erosion on critical areas.

4. Runoff through and from areas with exposed soil should be trapped and stored or retarded to less than critical erosive velocities.

---

[1]*Net land use area is defined as the actual site area devoted to a given use and consists of the ground floor site area occupied by any buildings plus the required yards and open spaces.*

[2]*Gross residential land use area is defined as the net area devoted to this use plus the area devoted to all supporting land uses including streets, neighborhood parks and playgrounds, elementary schools, and neighborhood institutional and commercial uses, but not including freeways and expressways.*

[3]*Gross governmental and institutional area is defined as the net area devoted to this use plus the area devoted to supporting land uses, including streets and off-street parking.*

[4]*Includes federal, state, and county governmental uses; hospitals; cemeteries; colleges and universities; and large region-serving, semipublic institutional uses, such as central YMCA facilities.*

[5]*Includes schools and churches. Approximately one-half of this standard is met implicitly if the gross acreage standard for residential use is met.*

[6]*This category does not include regional or local open spaces other than those actively used for public park or outdoor recreational purposes. Such uses as boulevards, parkways, stadia, environmental corridors, arboreta, zoological gardens, and botanical gardens are not included unless they are a part of or adjacent to an active recreation area.*

[7]*Gross park and recreation area is defined as equal to net area.*

[8]*Brighton Dale County Park; Cliffside County Park; Harrington Beach State Park; Minooka County Park; Oakwood County Park; Ottawa Lake State Recreation Area; Pike Lake State Park; Racine County Park, Ela Site; and Whitewater Lake State Recreation Area.*

[9]*A portion of this standard is met implicitly if the gross acreage standard for residential use is met. This implicite portion totals 1.3 acres per 1,000 persons in a one-half mile square high-density neighborhood; 2.5 acres per 1,000 persons in a one mile square medium-density neighborhood; and 4.5 acres per 1,000 persons in a two mile square low-density neighborhood.*

[10]*Gross commercial and industrial area is defined as the net area devoted to this use plus the area devoted to supporting land uses, including streets and off-street parking.*

[11]*Includes all regional, local, and highway-oriented commercial activities plus adjacent streets and onsite parking.*

[12]*Includes all manufacturing and wholesaling activities plus adjacent streets and onsite parking.*

[13]*Direct access implies adjacency or immediate proximity.*

[14]*Areas, as used in this context, refer to any land unit, 160 acres or more in areal extent, which is subject to development.*

[15]*Floodplain lands are herein defined as those lands inundated by a flood having a recurrence interval of 100 years where hydrologic and hydraulic engineering data are available, and as those lands inundated by the maximum flood of record where such data are not available.*

[16]*Urban development, as used herein, refers to all land uses except agriculture, water, woodlands, wetlands, and open lands.*

[17]*A stream channel is herein defined as that area of the floodplain lying either within legally established bulkhead lines or within sharp and pronounced banks marked by an identifiable change in flora and normally occupied by the stream under average annual high-flow conditions.*

[18]*Floodway lands are herein defined as those lands inundated by a flood having a recurrence interval of 10 years and require hydrologic and hydraulic engineering data for delineation.*

[19]*Wetland areas are defined as those lands which are partially covered by marshland flora and generally covered with shallow standing water, open lands intermittently covered with water, or lands which are wet and spongy due to a high water table or character of the soil.*

[20]*The term woodlands, as used herein, is defined as a dense, concentrated stand of trees and underbrush covering a minimum area of 20 acres.*

[21]*A watershed, as used herein, is defined as a portion of the surface of the earth occupied by a surface drainage system discharging all surface water runoff to a common outlet and which is 25 square miles or larger in areal extent.*

[22]*Includes all fish and game.*

[23]*For a more detailed description of development densities, population, and dwelling units, see Appendix Table A-1 and A-2, SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans — 1990.*

[24]*Open space is defined as land or water areas which are generally undeveloped for residential, commercial, or industrial uses and are or can be considered relatively permanent in character. It includes areas devoted to park and recreation uses and to large land-consuming institutional uses, as well as areas devoted to agricultural use and to resource conservation whether publicly or privately owned.*

[25]*It was thought impractical to establish spatial distribution standards for open space, per se; therefore, only the park and recreation component of the open-space land use category is listed in the standards according to its local or regional orientation. These local park and recreation spaces may include playlots, playgrounds, playfields, and neighborhood parks. Regional park and recreation spaces include large county or state parks. Other open spaces which are not included in the spatial distribution standard are forest preserves and arboreta; major river valleys; lakes; zoological and botanical gardens; stadia; woodland, wetland, and wildlife areas; scientific areas; and agricultural lands whose location must be related to, and determined by, the natural resource base.*

[26]*Prime agricultural areas are defined as those areas which contain soils rated in the regional detailed operational soil survey as very good or good for agriculture, and occur in concentrated areas over five square miles in extent which have been designated as exceptionally good for agricultural production by agricultural specialists.*

Source: SEWRPC.

Table 76

WATER CONTROL FACILITY DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

OBJECTIVE NO. 1

An integrated system of drainage and flood control facilities which will effectively reduce flood damage under the existing land use pattern in the watersheds of the Region and promote the implementation of the watershed land use plans, meeting the anticipated runoff loadings generated by the existing and proposed land uses.

PRINCIPLE

Reliable local municipal storm water drainage facilities cannot be properly planned, designed, or constructed except as integral parts of an areawide system of floodwater conveyance and storage facilities centered on major drainageways and perennial waterways designed so that the hydraulic capacity of each waterway opening and channel reach abets the common aim of providing for the storage, as well as the movement, of floodwaters. Not only does the land use pattern of the tributary drainage area affect the required hydraulic capacity, but the effectiveness of the floodwater conveyance and storage facilities affects the uses to which land within the tributary watershed, and particularly within the riverine areas of the watershed, may properly be put.

STANDARDS

1. All new and replacement bridges and culverts over perennial waterways shall be designed so as to accommodate, according to the categories listed below, the designated flood events without overtopping of the related roadway or railroad track and resultant disruption of traffic by floodwaters.

   a. Minor and collector streets used or intended to be used primarily for access to abutting properties: a 10-year recurrence interval flood discharge.

   b. Arterial streets and highways, other than freeways and expressways, used or intended to be used primarily to carry heavy volumes of fast, through traffic: a 50-year recurrence interval flood discharge.

   c. Freeways and expressways: a 100-year recurrence interval flood discharge.

   d. Railroads: a 100-year recurrence interval flood discharge.

2. All new and replacement bridges and culverts over perennial waterways, including pedestrian and other minor bridges, in addition to meeting the applicable above-specified requirements, shall be designed so as to accommodate the 100-year recurrence interval flood event without raising the peak stage, either upstream or downstream, more than 0.5 foot above the peak stage for the 100-year recurrence interval flood, as established in the adopted comprehensive watershed plan. Larger permissible flood stage increases may be acceptable for reaches having topographic or land use conditions which could accommodate the increased stage without creating additional flood damage potential upstream or downstream of the proposed structure.

3. The waterway opening of all new and replacement bridges shall be designed so as to readily facilitate the passage of ice floes and other floating debris and thereby avoid blockages often associated with bridge failure and with unpredictable backwater effects and flood damages. In this respect it should be recognized that clear spans and rectangular openings are more efficient than interrupted spans and curvilinear openings in allowing the passage of ice floes and other floating debris.

4. Certain new or replacement bridges and culverts over perennial waterways, including pedestrian and other minor bridges, so located with respect to the stream system that the accumulation of floating ice or other debris may cause significant backwater effects with attendant danger to life, public health, or safety, or attendant serious damage to homes, industrial and commercial buildings, and important public utilities, shall be designed so as to pass the 100-year recurrence interval flood with at least 2.0 feet of freeboard between the peak stage and the low concrete or steel in the bridge span.

5. Standards 1, 3, and 4 shall also be used as the criteria for assessment of the adequacy of the hydraulic capacity and structural safety of existing bridges or culverts over perennial waterways and thereby serve, within the context of the adopted comprehensive watershed plan, as the basis for crossing modification or replacement recommendations designed to alleviate flooding and other problems.

6. Channel improvements, levees, and floodwalls should be restricted to the minimum number and extent absolutely necessary for the protection of existing and proposed land use development, which development is consistent with the land use element of the comprehensive watershed plan; and any such improvements which may significantly increase upstream or downstream peak flood discharges should be used only in conjunction with complementary facilities for the storage and movement of the incremental floodwaters through downstream reaches. The height of levees and floodwalls shall be based on the high water surface profiles for the 100-year recurrence interval flood prepared under the comprehensive watershed study, and shall be capable of passing the 100-year recurrence interval flood with a freeboard of at least two feet. Channel improvements, levees, or floodwalls shall not increase the height of the 100-year recurrence interval flood by more than one-half foot in any unprotected upstream or downstream stream reaches. Increases in flood stages in excess of one-half foot resulting from any channel, levee, or floodwall improvement shall be contained within the upstream or downstream extent of the channel, levee, or floodwall improvement, except where topographic or land use conditions could accommodate the increased stage without creating additional flood damage potential.

The construction of channel improvements, levees, or floodwalls shall be deemed to change the limits and extent of the associated floodways and floodplains. However, no such change in the extent of the associated floodways and floodplains shall become effective for the purposes of land use regulation until such time as the channel improvements, levees, or floodwalls are actually constructed and operative. Any development in a former floodway or floodplain located to the landward side of any levee or floodwall shall be provided with adequate drainage so as to avoid ponding and associated damages.

7. All water control facilities other than bridges and culverts, such as dams and diversion channels, so located on the stream system that failure would damage only agricultural lands and isolated farm buildings, shall be designed to accommodate at least the hydraulic loadings resulting from a 100-year recurrence interval flood. Water control facilities so located on the stream system that failure could jeopardize public health and safety; cause loss of life; seriously damage homes, industrial and commercial buildings, and important public utilities; or result in closure of principal transportation routes shall be designed to accommodate a flood that approximates the standard project flood or the more severe probable maximum flood, depending on the ultimate probable consequences of failure.[1]

8. Reduced regulatory flood protection elevations and accompanying reduced floodway or floodplain areas resulting from any proposed dams or diversion channels shall not become effective for the purposes of land use regulation until the reservoirs or channels are actually constructed and operative.

9. All public land acquisitions intended to eliminate the need for water control facilities shall, in all areas not already in intensive urban use, encompass at least all of the riverine areas lying within the 100-year recurrence interval flood inundation line.

OBJECTIVE NO. 2

The attainment of sound groundwater resource development and protective practices to minimize the possibility for pollution and depletion of the groundwater resources.

PRINCIPLE

Sound practices in the location, installation, and operation of water supply wells and waste treatment and disposal facilities can reasonably assure a continuing supply of good quality groundwater at reasonable cost.

STANDARDS

1. Groundwater withdrawals should be made so as to prevent undue interference with adjacent withdrawal points, and the capacities and withdrawal rates should be related to potential yield and total demand on the aquifers penetrated.

2. Wells should be constructed so as not to permit contamination of the aquifer through the well during construction or during subsequent operation.

3. Waste conveyance, treatment, and disposal facilities, located above or below ground surface, both public and private, should be designed, constructed, and operated in a manner to prevent migration or infiltration of contaminants into sources of usable groundwater. These facilities include pipes, tunnels, spetic tanks, leaching areas, sanitary landfills, and injection wells.

[1]*These flood events, which have been formulated and used by the U. S. Army Corps of Engineers, are defined and discussed in Chapter VII, SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, November 1968.*

Source: SEWRPC.

Table 77

SANITARY SEWERAGE SYSTEM PLANNING OBJECTIVES, PRINCIPLES, AND STANDARDS

OBJECTIVE NO. 1

The development of sanitary sewerage systems which will effectively serve the existing regional urban development pattern and promote implementation of the regional land use plan, meeting the anticipated sanitary waste disposal demand generated by the existing and proposed land uses.

PRINCIPLE

Sanitary sewerage systems are essential to the development and maintenance of a safe, healthy, and attractive urban environment, and the extension of existing sanitary sewerage systems and the creation of new systems can be effectively used to guide and shape urban development both spatially and temporally.

STANDARDS

1. Sanitary sewer service should be provided to all existing areas of medium-[1] or high-density[2] urban development and to all areas proposed for such development in the regional land use plan.

2. Sanitary sewer service should be provided to all existing areas of low-density[3] urban development and to all areas proposed for such development in the regional land use plan, where such areas are contiguous to areas of medium- or high-density urban development. Where noncontiguous low-density development already exists, the provision of sanitary sewer service should be contingent upon the inability of the underlying soil resource base to properly support onsite absorption waste disposal systems.

3. Where public health authorities declare that public health hazards exist because of the inability of the soil resource base to properly support onsite soil absorption waste disposal systems, sanitary sewer service should be provided.

4. Lands designated as primary environmental corridors on the regional land use plan should not be served by sanitary sewers, except that development incidental to the preservation and protection of the corridors, such as parks and related outdoor recreation areas, and existing clusters of urban development in such corridors, may be provided with sanitary sewer service. Engineering analyses relating to the sizing of sanitary sewerage facilities should assume the permanent preservation of all undeveloped primary environmental corridor lands in natural open-space uses.

5. Floodlands[4] should not be served by sanitary sewers, except that development incidental to the preservation in open-space uses of floodlands, such as parks and related outdoor recreation areas, and existing urban development in floodlands not recommended for eventual removal in comprehensive watershed plans, may be provided with sanitary sewer service. Engineering analyses relating to the sizing of sewerage facilities should not assume ultimate development of floodlands for urban use.

6. Significant concentrations[5] of lands covered by soils found in the regional soil survey to have very severe limitations for urban development even with the provision of sanitary sewer service should not be provided with such service. Engineering analyses relating to the sizing of sewerage facilities should not assume ultimate urban development of such lands for urban use.

7. The timing of the extension of sanitary sewerage facilities should, insofar as possible, seek to promote urban development in a series of complete neighborhood planning units, with service being withheld from any new units in a given municipal sewer service area until previously served units are substantially developed and until existing units not now served are provided with service.

8. The sizing of sewerage facility components should be based upon an assumption that future land use development will occur in general accordance with the land use pattern recommended in the regional land use plan.

9. To the extent feasible, industrial wastes except clear cooling waters, as well as the sanitary wastes generated at industrial plants, should be discharged to municipal sanitary sewerage systems for ultimate treatment and disposal. The necessity to provide pretreatment for industrial wastes should be determined on an individual case by case basis.

OBJECTIVE NO. 2

The development of sanitary sewerage systems so as to meet established water use objectives and supporting water quality standards (see Map 49).

PRINCIPLE

Sewage treatment plant effluent is a major pollutant of the streams and lakes of the Region; the location, design, construction, operation, and maintenance of sewage treatment plants and the quality and quantity of the effluent of such plants has a major effect on stream and lake water quality and the ability of that water quality to support the established water uses.

STANDARDS

1. The level of treatment to be provided at each sewage treatment plant should be determined by water quality analyses directly related to the established water use objectives for the receiving surface water body. These analyses should demonstrate that the proposed treatment level will aid in achieving the water quality standards supporting each major water use objective as set forth in Table 73 of this report.

2. The discharge of sewage treatment plant effluent directly to inland lakes should be avoided and sewage treatment plant discharges to streams flowing into inland lakes should be located and treated so as to contribute to the achievement of the established water use objectives and standards for those lakes.

3. The specific standards for sewage treatment at all sewage treatment plants discharging effluent to surface waters in the Lake Michigan drainage basin shall be those established by the Federal Lake Michigan Enforcement Conference (see pages 302-303 of this report).

4. Existing sewage treatment plants scheduled to be abandoned within the plan design period should provide only secondary waste treatment and disinfection of effluent, unless a further degree of treatment is determined to be required to meet the established water use objectives and standards for the receiving surface water body.

5. Interim sewage treatment plants deemed necessary to be constructed prior to implementation of the long-range plan should also provide levels of treatment determined by water quality analyses directly related to the established water use objectives and standards for the receiving surface water body.

6. Bypassing of sewage to storm sewer systems, open channel drainage courses, and streams should be prohibited.

7. Combined sewer overflows should be eliminated or adequately treated to meet the established water use objectives and standards for the receiving body of surface water.

8. Sewage treatment plants should be designed to perform their intended function to provide their specified level of treatment under adverse conditions of inflow, should be of modular design with sufficient standby capacity to allow maintenance to be performed without bypassing influent sewage, and should not be designed to bypass any flow delivered by the inflowing sewers.

OBJECTIVE NO. 3

The development of sanitary sewerage systems that are properly related to, and that will enhance the overall quality of, the natural and man-made environments.

PRINCIPLE

The improper location, design, construction, operation, and maintenance of sewerage system components can adversely affect the natural and man-made environments; therefore, every effort should be made in such actions to properly relate to these environments and minimize any disruption or harm thereto.

STANDARDS

1. New and replacement sewage treatment plants, as well as additions to existing plants, should, wherever possible, be located on sites lying outside of the 100-year recurrence interval floodplain. When it is necessary to use floodplain lands for sewage treatment plants, the facilities should be located outside of the floodway so as to not increase the 100-year recurrence interval flood stage, and should be floodproofed to a flood protection elevation of two feet above the 100-year recurrence interval flood stage so as to assure adequate protection against flood damage and avoid disruption of treatment and consequent bypassing of sewage during flood periods. In the event that a floodway has not been established, or if it is necessary to encroach upon an approved floodway, the hydraulic effect of such encroachment should be evaluated on the basis of an equal degree of encroachment for a significant reach on both sides of the stream, and the degree of encroachment should be limited so as not to raise the peak stage of the 100-year recurrence interval flood by more than 0.5 feet.

2. Existing sewage treatment plants located in the 100-year recurrence interval floodplain should be floodproofed to a flood protection elevation of two feet above the 100-year recurrence interval flood stage so as to assure adequate protection against flood damage and avoid disruption of treatment and consequent bypassing of sewage during flood periods.

3. The location of new and replacement sewage treatment plants should be properly related to the existing and proposed future urban development pattern, as reflected in the regional land use plan and any community or neighborhood unit development plans prepared pursuant to, and consistent with, the regional land use plan.

4. New and replacement sewage treatment plants, as well as additions to existing plants, should be located on sites large enough to provide for adequate open space between the plant and existing or planned future urban land uses; should provide adequate area for expansion to ultimate capacity as determined in the regional sanitary sewerage system plan; and should be located, oriented, and architecturally designed so as to complement their environs and to present an attractive appearance consistent with their status as public works.

5. The disposal of sludge from sewage treatment plants should be accomplished in the most efficient manner possible, consistent, however, with any adopted rules and regulations pertaining to air quality control and solid waste disposal.

OBJECTIVE NO. 4

The development of sanitary sewerage systems that are both economical and efficient, meeting all other objectives at the lowest cost possible.

PRINCIPLE

The total resources of the Region are limited, and any undue investment in sanitary sewage systems must occur at the expense of other public and private investment; total sewerage system costs, therefore, should be minimized while meeting and achieving all water quality standards and objectives.

STANDARDS

1. The sum of sanitary sewerage system operating and capital investment costs should be minimized.

2. The total number of sanitary sewerage systems and sewage treatment facilities should be minimized in order to effect economies of scale and concentrate responsibility for water quality management. Where physical consolidation of sanitary sewer systems is uneconomical, administrative and operational consolidation should be considered in order to obtain economies in manpower utilization and minimize duplication of administrative, laboratory, storage, sludge disposal, and other necessary appurtenant facilities and equipment.

3. Maximum feasible use should be made of all existing and committed sanitary sewage facilities. Such facilities should be supplemented with additional facilities only as necessary to serve the anticipated sanitary waste demand generated by substantial implementation of the regional land use plan, while meeting pertinent water quality use objectives and standards.

4. The use of new or improved materials and management practices should be allowed and encouraged if such materials and practices offer economies in materials or construction cost, or if by their superior performance lead to the achievement of water quality objectives at lesser costs.

5. Sewer systems and sewage treatment facilities should be designed for staged or incremental construction where feasible and economical so as to limit total investment in sewerage facilities and permit maximum flexibility to accommodate changing situations, such as changes in the rate of growth of population and economic activity or changes in water use objectives and standards, and changing technology, such as changes in the technology of sewage conveyance and treatment.

6. When technically feasible and otherwise acceptable, alignments for new sewer construction should coincide with existing public rights-of-way in order to minimize land acquisition or easement costs and disruption to the natural resource base.

7. Clear water inflows to the sanitary sewerage system should be eliminated and infiltration should be minimized.

8. Sanitary sewerage systems and storm water drainage systems should be designed and developed concurrently in order to effect engineering and construction economies as well as to assure the separate function and integrity of each of the two systems; to immediately achieve pollution abatement and drainage benefits of the integrated design; and to minimize disruption of the natural resource base and existing urban development.

---

[1]*Medium-density residential development is defined as that development having an average gross population density of 10.2 persons per acre and a net lot ranging from 6,333 to 19,819 square feet.*

[2]*High-density residential development is defined as that development having an average gross population density of 26.1 persons per acre and a net lot area per dwelling unit ranging from 6,333 to 2,430 square feet.*

[3]*Low-density residential development is defined as that development having an average gross population density of 3.2 persons per acre and a net lot area per dwelling unit ranging from 19,820 to 209,090 square feet.*

[4]*Floodlands are defined as those lands, including the floodplains, floodways, and channels subject to inundation by the one hundred (100)-year recurrence interval flood or, where such data is not available, the maximum flood of record.*

[5]*Areas over 160 acres in extent.*

Source: SEWRPC.

to land use and sanitary sewerage system planning and development, are set forth in Tables 75, 76, and 77, and serve to facilitate quantitative application of the objectives in plan design, test, and evaluation.

It should be noted that the planning standards herein recommended fall into two groups: comparative and absolute. The comparative standards, by their very nature, can be applied only through a comparison of alternative plan proposals. Absolute standards can be applied individually to each alternative plan proposal since they are expressed in terms of maximum, minimum, or desirable values. Standards should not only aid in the development, testing, and evaluation of sanitary sewerage system plans but also in development, testing, and evaluation of local land use and public utility plans and in the development of plan implementation policies and programs.

SUMMARY

The task of formulating objectives and standards to be used in plan design and evaluation is a difficult but necessary part of the planning process. It is readily conceded that regional plan elements must advance development proposals which are physically feasible, economically sound, aesthetically pleasing, and conducive to the promotion of public health and safety. The agreement on development objectives beyond such generalities, however, becomes more difficult to achieve because the definition of specific development objectives and supporting standards inevitably involves value judgements. Nevertheless, it is essential to state such objectives for the development of regional sanitary sewerage systems and to quantify them insofar as possible through standards in order to provide the framework through which the regional sanitary sewerage system plan can be prepared. Moreover, so that the regional sanitary sewerage system plan will form an integral part of the overall framework of long-range plans for the development of the Region, the regional sanitary sewerage system objectives must be compatible with, and dependent upon, other regional development objectives. Therefore, the regional sanitary sewerage system development objectives and supporting principles and standards as set forth in this chapter are based upon previously adopted regional development objectives, supplementing these only as required to meet the specific needs of the regional sanitary sewerage system planning program.

Four new development objectives, together with supporting principles and standards, were formulated under the regional sanitary sewerage system planning program. Together with the land use and related water control facility objectives previously established under related Commission work programs, these development objectives, principles, and standards provided the basic framework within which alternative regional sanitary sewerage systems were formulated and a recommended regional sanitary sewerage system plan synthesized.

(This page intentionally left blank)

Chapter IX

ENGINEERING DESIGN CRITERIA AND ANALYTIC PROCEDURES[1]

INTRODUCTION

In addition to the objectives, principles, and standards set forth in the preceding chapter of this report, certain engineering design criteria and analytic procedures were utilized in the regional sanitary sewerage system planning program to prepare alternative plan elements and the recommended sanitary sewerage system plan. These engineering design criteria and analytic procedures include all of the engineering techniques used to design alternative plan elements, test the physical feasibility of those elements, and make necessary economic comparisons between alternative plan elements. Although many of these criteria are widely accepted and firmly based in current civil and sanitary engineering practice, it was nevertheless believed important to document these criteria in this report. The criteria and procedures described herein were used to size the principal components of the various alternative plan elements, such as sanitary sewers, pumping and lift stations, and sewage treatment plants, as well as to estimate the cost of those alternatives.

The description of these criteria and procedures in this chapter is intended to document the degree of detail and level of sophistication employed in the preparation of the recommended regional sanitary sewerage system plan and thereby to provide a better understanding of the plan and of the need for refinements in that plan prior to implementation. It should be understood that the design criteria and analytic procedures described herein were developed specifically for system planning purposes. Consequently, refinements in these criteria and procedures and in the recommendations based on these criteria and procedures should be expected as projects envisioned in the adopted system plan are advanced from the planning to the engineering design phase during plan implementation. Such refinements may include both modifications in the design criteria to reflect local conditions and changes in the analytic procedures to reflect both additional information and improvements in methodology.

It should be noted that, while the design criteria and analytic procedures described in this chapter were used in the preparation of the regional sanitary sewerage system plan, these criteria and procedures do not comprise standards as defined and discussed in the preceding chapter of this report. The criteria and procedures discussed in this chapter relate to the technical methods used in the inventory, analyses, and plan design, test, and evaluation rather than to relating alternative plans to specific development objectives. Nevertheless, an understanding of these criteria and procedures is important since they were used not only to size and cost the various components of the alternative sanitary sewerage system plans considered but also to establish the type and level of sewage treatment required to meet the established water use objectives and supporting surface water quality standards. Before the design criteria and analytic procedures are presented, it is appropriate to review the state of the art of sanitary engineering in order to provide a better understanding of the reasons for selecting the specific criteria and procedures used in the planning program.

STATE OF THE ART OF SANITARY SEWERAGE

Technological advancement in sewage collection, conveyance, and treatment has undergone acceleration in recent years. Public concern for maintaining and restoring environmental quality has stimulated substantial increases in state and federal government funding of research in waste water management and water pollution abatement. As a result of this surge in research activity, many new or refined concepts, materials, processes, and procedures have been propounded in the technical literature. Substantiation of the feasibility of these proposed advances in the art of waste water management ranges from laboratory experiment to full-scale operational experience.

[1] *For definitions of water quality parameters used in this chapter and for discussions of the significance of each, refer to Appendix C of this report, "Water Quality Parameters--Definitions and Significance."*

It is important that the regional sanitary sewerage system plan be based upon and incorporate the best current technology. However, it is even more important that the technological recommendations in the plan have reasonable assurance of meeting expected performance at the costs used in plan formulation and selection. Therefore, it is necessary in the planning process to review the "state of the art" to assure that the plan is consistent with current advances in practice and to distinguish between tested and proven technology and unproven concepts which have risk of failure in performance or cost. Accordingly, following a discussion of basic sewerage concepts, the state of the art in the following three subject areas pertinent to regional sewerage system planning is explored: the planning process itself, sewage collection and conveyance, and sewage treatment.

Basic Sewerage Concepts

Water carriage of domestic wastes to central locations for treatment and return to the land and water environment is universally practiced in urban areas of the United States and in other developed countries of the world, and is expected to remain the practice for at least the next several decades. This conclusion is fundamental to regional sanitary sewerage system planning, and is based on consideration of the technical, economic, and sociological factors discussed below.

The question is often raised of the suitability and desirability of continuing to utilize the water carriage system to convey sanitary sewage to a central location. In residential or domestic sewerage systems, from 15 to 30 gallons per capita per day, a considerable quantity of water, are used solely for conveyance of human wastes. These wastes must then be separated from the water by costly treatment processes. The capital cost of the sewer piping system is substantial and must be publicly financed, often before the ultimate land use and tax base have been fully developed to contribute to the cost. Furthermore, sewerage systems serve to concentrate the wastes from a large area and, even after treatment, impose a heavy waste load at a single point in the receiving environment.

It must, nevertheless, be concluded that the water carriage system of sewage disposal has fewer and less serious disadvantages than available and foreseeable alternatives. The disadvantages of the alternatives, which necessarily consist of various onsite disposal systems, include one or more of the following: higher unit costs, inability to dispose of kitchen wastes and wash waters, maintenance problems, and lack of demonstrated technical feasibility.

Except for septic tanks, currently available alternatives to the water carriage system do not appear likely to present any economic advantage over centralized waste collection and treatment. Given suitable soil resource conditions and assuming proper design, operation, and maintenance, the septic tank alternative would appear to have an economic advantage over centralized sewerage systems. In widespread application, however, septic tanks could be utilized only for very low density urban development, an urban development pattern that would not only make the provision of other public facilities and services more costly, but which entails heavy social costs. Because of the area needed to properly dispose of wastes, septic tanks as an alternative waste handling system are simply not feasible for areas developed for urban use at medium and high population densities. Moreover, even at low population densities, septic tank sewage disposal does not represent a viable alternative throughout much of the Southeastern Wisconsin Region, since the soil resource base simply is not well-suited for the safe absorption of the volume of sewage effluent that would be generated.

Even if human and kitchen wastes could be adequately disposed of without the use of water, large quantities of water will continue to be used in residences for bathing, clothes washing, and dish washing. In areas of low residential density located on suitable soils, this water, approximately 40 to 70 gallons per capita per day, most probably can be returned on site to the environment with minimal damage. In medium- and high-density residential areas, however, even this reduced amount of water probably would overtax the receiving capability of the soil, resulting in the hazard of groundwater pollution or surface seepage and runoff. In addition, any requirement of two onsite waste disposal systems, one for sanitary wastes and one for wash water wastes instead of the present single offsite system, would compound problems of maintenance and public acceptance.

A number of onsite residential waste disposal systems have been developed, some of which use incineration and need small water volumes and others which utilize water but provide onsite treatment before disposal to the soil or to surface waters. All onsite waste disposal alternatives, including septic tanks, require conscientious maintenance in order to properly perform the primary functions of protecting the public health and environment. With septic tanks, however, maintenance is often not performed until after gross malfunction has occurred. There is little reason to expect the attitudes of residents toward preventive maintenance of more complicated alternatives would be significantly different. When wastes are collected and treated in a publicly operated system, it is possible to exercise competent professional supervision over operation and maintenance. Effective public supervision of operation and maintenance of individual residential onsite waste disposal systems is, as a practical matter, very difficult if not impossible in present society.

Public acceptance of conventional sanitary sewerage systems is high, primarily because little or no involvement on the part of the user is required. Public acceptance of alternative devices which treat or dispose of wastes on site and, therefore, require careful attention by the user may be expected to be quite low. No change from the present practice of water-borne waste collection and disposal is discernible, nor does there appear to be any significant expression of public desire to motivate a change.

Contrary to the above-stated forecasted continuance of present practice in domestic waste management, it is likely that water carriage of industrial wastes will decline, with a definite trend in this direction already having been established. The reasons which may be advanced that no change may be expected in the management of domestic wastes generally do not apply to industrial wastes. Many industrial wastes are produced in sufficient quantity to justify recovery and recycling or onsite treatment. Moreover, adequate supervision and maintenance are more apt to be provided for facilities serving industrial plants than for facilities serving small, isolated enclaves of residential development. In addition, water conservation and waste recovery are often economically advantageous to the industrial firm. Finally, there is strong public pressure on industries to reduce the volume of waste water discharged.

The Sewerage System Planning Process

The use of planning procedures that are accepted as best current practice is equally as important in the preparation of a sound regional sanitary sewerage system plan as is the incorporation of best current technology in the physical aspects of the plan. The plan not only establishes the physical nature of the recommended sewerage system, but also can exert substantial influence on the development of land use and on the environmental characteristics of the Region. Furthermore, the U. S. Environmental Protection Agency, the U. S. Department of Housing and Urban Development, and the U. S. Farmers Home Administration require the regional sewerage system planning be completed as a prerequisite for federal grants-in-aid for the construction of sanitary sewerage facilities.

Aspects of the planning process that represent recent advances in sewerage planning include the extension of planning boundaries to the regional or areawide scale; the increased participation by public officials, citizens, and representatives of interest groups in the planning process; the setting of objectives, principles, and standards; coordination with an areawide land use plan; and the formulation of alternatives from which a recommended plan can be selected. These planning advances have all been incorporated in the overall planning strategy and procedures used in preparation of the regional sanitary sewerage system plan, which strategy and procedures are fully described in Chapter II of this report.

Sewage Collection and Conveyance

Technological factors relating to the sewage collection and conveyance system and affecting system planning include system type, sanitary sewage flow characteristics, separation of sanitary and storm flows, extraneous flow contributions, and sewer materials and construction practices. A brief discussion of the state of the art concerning each of these factors is presented in the following sections.

System Type: Sanitary sewers are currently designed principally as single pipe gravity flow systems. Several innovative alternative system types have been suggested in the recent past. These include pressurized and vacuum transport systems, some of which are conceived as dual pipe arrangements to allow for at-source separation of high strength and low strength sewage. Other proposals involve segmented or compartmentalized sewers for separate conveyance, in a single unit, of both sanitary and storm water flows. None of the innovations has gained wide acceptance because they do not offer the simplicity in construction and operation nor the reliability afforded by the conventional gravity flow system. In view of this fact, and considering the extensive existing utilization of conventional gravity flow systems within the Region, it may be expected that sanitary sewers will continue to be designed and constructed as single pipe gravity flow systems to and beyond the design year of the regional sanitary sewerage system plan.

Sanitary Flows: Average and peak sanitary sewage flows are an important basis for the determination of collection and conveyance system capacity. Currently, the discharge of waste waters from homes averages 60 to over 100 gallons per capita, though human consumption of water is only about one and one-half gallons per capita per day. Toilet flushing accounts for about one-third of the daily domestic sanitary discharge, with bathing, clothes washing, and dish washing each comprising additional significant amounts (see Table 78). Accordingly, attention has been given to possible reuse of washing waters for toilet flushing in order to reduce sewage flow volumes. The present system of gravity flush tanks using few moving parts is simple, highly reliable, and relatively maintenance free; and it is unlikely that homeowners will forego the existing system to install a more complicated and expensive system. Significant reductions in per capita discharge of domestic sewage is not envisioned over the planning period. Rather, a continuation of the trend of increasing per capita domestic water use and subsequent increased discharges of domestic sewage may be expected. This trend may be compensated for to some extent by decreased industrial waste flows in public sewerage systems as noted earlier. Current practices in capacity determination to allow for peak-to-average flow ratios for sewers serving various tributary areas are also assumed to be valid for the planning period.

Table 78

ESTIMATED DOMESTIC WASTEWATER FLOWS PER CAPITA BY TYPE OF WATER USE

Water Use	Utilization Range (Gallons per Day)
Bathing	20 - 30
Toilets	15 - 30
Clothes Washing Machine	10 - 20
Dishwashing, Automatic	10 - 20
Garbage Grinder	2 - 5
Handwashing	3 - 6
Miscellaneous Washing	1 - 3
Total	61-114

Source: Harza Engineering Company.

Separation of Sanitary and Storm Flows: The first sewer systems developed in urban areas were combined sewers designed to carry both sanitary and storm water flows to the nearest water course for disposal without treatment. Intercepting sewers were subsequently built to collect the dry weather sanitary sewage from these combined sewers and convey it to sewage treatment facilities. Storm flows mixed with sanitary sewage were, and in most cases still are, bypassed to the receiving waterways. Present practice in sewering new areas is to provide separate sewer systems for storm water and for sanitary sewage. These separate systems avoid the mixing of sanitary sewage with storm discharges to the receiving waterways, and also minimize the storm water dilution of sanitary sewage, thereby minimizing the quantity of water requiring treatment. Recently, however, it has been determined that storm water runoff from urban areas is significantly polluted in terms of microorganisms, carbonaceous biochemical oxygen demand (CBOD), suspended solids, and phosphorus compounds.[2] Consequently, in some situations urban storm water runoff may be a significant source of pollution to streams and lakes. There is a strong possibility that treatment of such storm water runoff may be required in the future, and if it is, the validity of the continued reliance upon separate sewer systems may be questioned. It is concluded, however, that although treatment of storm water runoff may eventually be required, the continued use of separate sewer systems will be technologically and economically desirable.

Technologically, the combination of storm flows and sanitary flows is undesirable for a number of reasons. Since pipe size would necessarily have to be based on storm flows, which can exceed sanitary flows by a ratio of 500 to 1, flow depths and velocities of sanitary sewage during periods of dry weather flow in these large pipes would be very low. Unless special pipe shapes are used, incorporating cunettes, such low velocities of flow could lead to the undesirable deposition of sewage solids in the pipe system. Sewage treat-

[2] *e.g., See E. H. Bryan, "Quality of Stormwater Drainage from Urban Land," Water Resources Bulletin, June 1972.*

ment plants designed for high levels of waste removal from sanitary sewage may be expected to experience some difficulty in handling the large fluctuations in flow volume and sewage strength which would result from combined flows in which the daily flow volume of storm water might frequently exceed the sanitary flow volume by factors exceeding 10 to 1.

It is more likely that the concepts for treatment of storm water will diverge from the concepts of treatment of sanitary sewage. Also, it is unlikely that storm water treatment will be required to provide as high a level of treatment as will be required for sanitary sewage. The present direction of development in the treatment of storm water, as well as the treatment of combined sewer overflow, is toward the use of relatively small, intermittently operating treatment plants located at the individual sewer outfalls; plants using mechanical and chemical treatment processes for removal of solids, including chemically coagulated phosphorus compounds; and chlorination, rather than biological treatment processes. These facilities are inherently unable to remove dissolved oxygen-demanding organic substances, but these constituents present minor problems when associated with high receiving stream flows. Present facilities capable of treatment of storm water are considerably cheaper than sanitary sewage treatment plants, and it is likely that costs will diverge even more in the future.

Currently, most regulatory agencies either forbid or discourage extensions of combined sewer systems or construction of new combined sewer systems. Moreover, no relaxation of the ban on construction of new combined systems is foreseen. Until recently, separation of existing combined sewer systems has been regarded as a solution to water pollution problems occurring from combined sewer overflows. It was, however, concluded by the Commission in its Milwaukee River watershed study that, generally, separation of existing combined sewers is not economical in comparison to the alternative means available for the abatement of water pollution from combined sewer overflows.

Extraneous (Clear Water) Flows: Clear water flows result from infiltration of groundwater and discharge of roof and foundation drainage into the sanitary sewage collection and conveyance system. Current technology addresses the problem of infiltration through improvement of sewer jointing systems, a topic which is discussed along with sewer pipe materials in detail in the subsequent section of this chapter. Roof and foundation drainage can only be prevented from entering the conveyance system by implementation of programs of rigorous code enforcement and inspection relative to building connections.

The elimination of most extraneous water from the sewer system is possible with current technology. Many communities are undertaking programs with this objective as the costs to provide additional sewer and treatment capacity increase. Such programs should actually be initiated during home and other building construction in order to eliminate rainwater and footing drain connections to the sanitary sewer system, and to ensure that only tightly joined building sewers in well-backfilled and compacted trenches are accepted for connection to common sewers. In addition to proper inspection of all new building sewer construction, communities should also provide means for checking connections to common sewers after homes and other buildings have been constructed and connected. One such means is by providing a riser pipe at the point where each house lateral is connected to the street sewer. By inserting a plug at this point, and at appropriate points within the building basement, air or water leakage tests will show whether the building lateral has tight connections and whether footing drains have been connected into the sewer system.

Several techniques are available to reduce infiltration of street sewers. Estimates of infiltration volume and repair or replacement costs to eliminate the infiltration sources can be made using television inspection to locate cracked or broken sections of line or illegal connections.

Building sewers typically account for 40 to 50 percent of the total sewer footage of sanitary sewerage systems, and it is estimated that a disproportionate and substantial percentage—well in excess of 50 percent—of the total system infiltration is contributed by building sewers. Thus, it is critical that the attainment of low infiltration should be an important objective in the design of new sanitary sewerage systems. Infiltration criteria used in the regional sewerage system planning program are discussed later in this chapter. Joint materials and methods are available for reducing infiltration to less than 200 gallons per inch diameter per mile. However, the institutional means to fully implement the technology are generally lacking. For this study, therefore, relatively high values of infiltration have been used in sizing required facilities. The attendant cost estimates are therefore also high, and the attendant economic analyses conservative. The comparison of alternative development plans, which involve trade-offs between conveyance and treatment capacities, should be only slightly affected by any future reductions in extraneous flow volumes because both sewer size and treatment capacity requirements would be similarly reduced.

Sewer Materials and Construction Practices: There are several requirements that must be met by sewer materials and construction practices. These include:

a. Durability—The sewer must not corrode or erode during its anticipated life.

b. Strength—The sewer must be capable of supporting soil and traffic loads.

c. Flow capacity—The sewer must be of a material that is smooth to minimize frictional losses and of sufficient size and slope to reduce blockages.

d. Tightness—The sewer should be capable of being joined tightly to reduce to an absolute minimum the infiltration of groundwater.

e. Installed cost—The sewer must not be of a prohibitively expensive material or be difficult to install, since these features raise costs.

There are numerous materials presently available to meet all the above requirements. Vitrified clay tile, concrete, asbestos-cement concrete, cast iron lined with cement mortar, and plastic pipe all excel in one or more of the particular requirements listed above.

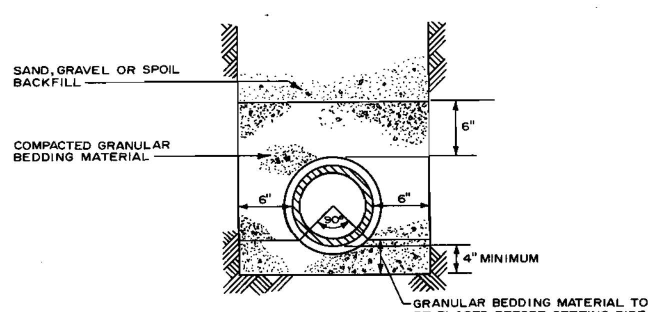
Clay tile has been used for conveying sewage since sewers were first installed. With the development of portland cement, concrete pipes were developed, and when steel-reinforced, could be made structurally stronger than clay tile. Clay tile is inert while concrete can be corroded by the acid formed from gases generated by septic sewage and by acids discharged into the sewerage system. In southeastern Wisconsin there is little evidence of concrete sewer corrosion except in sewers serving industrial areas. Asbestos cement, concrete, or clay tile sewers have been successfully used for domestic sewers. With the development of plastics, numerous new pipe materials have been proposed combining various desirable features of the listed sewer requirements. For smaller diameter pipes, plastic compounds such as polyvinyl chlorides (PVC), acrylonitrile butadiene styrene (ABS), and polyethylene (PE) solid wall pipes are competitive on an installed cost basis with concrete and tile because of their ease in handling. Due to their relatively light weight, the plastic pipes are usually available in longer laying lengths, thus reducing the number of joints and, consequently, the possibilities for infiltration. Two major considerations have slowed acceptance of plastic pipe for sewers. These are the concern over the structural strength and the concern over the durability of the materials with regard to abrasion, high temperature, and chemical resistance.

When the manufacturer can guarantee that the plastic pipe will perform according to the standards of proven sewer materials, such as clay tile and concrete, and where the municipality is confident that the contractor will install plastic pipe to the manufacturer's specifications, the plastic pipe is often selected.

Several features of sewer system construction have significant impact on sewerage system costs. These include pipe bedding, joints, and backfill of sewer trenches. Good bedding is essential to develop pipe strength and thus insure structural strength and stability, Class B bedding using a granular bedding material up to the midpoint of the pipe would be used for construction in well suited soils. This method of bedding is illustrated in Figure 100. Proper utilization of this type of bedding, with a well-compacted base and backfill, will minimize joint opening and reduce infiltration. In soils poorly suited to sewer construction, concrete bedding or envelopes may have to be used.

Figure 100

CLASS B SEWER PIPE BEDDING



Source: National Clay Pipe Institute, Clay Pipe Engineering Manual, 1968, p. 53.

The joints of common pipe material today are far better, and generally less costly to install, than materials used in older systems. Previously, cement mortar or jute and an asphaltic compound were common joint-sealing materials. Today, inert, resilient, synthetic materials are used for joints that are tight enough in many cases to qualify for use in water distribution systems. These joints include solvent welded plastic pipe to compression fittings, either premolded on the bell and spigot of the pipe (typical clay tile joint), or rubber "O" rings (typical on asbestos—cement and concrete pipe); or flexible, compressible neoprene gaskets typical on tongue and groove concrete pipe. A recent administrative decision by the Wisconsin Department of Natural Resources[3] requires that all new sanitary sewers be constructed with joints that do not exceed a leakage of 200 gallons per inch-diameter-mile per day.

Sewage Treatment Levels

Sewage treatment may be defined as a process to which sewage is subjected in order to remove or alter its objectionable constituents so as to render it less offensive and dangerous and less damaging to the receiving environment. Such treatment may be broadly categorized as to level or degree of treatment by means of the terms primary, secondary, tertiary, advanced, and auxiliary treatment. These levels of treatment are illustrated in Figure 101. The following definitions of treatment levels were adopted for use in the regional sanitary sewerage system planning program.

[3]*Letter dated December 3, 1971 from Mr. R. M. Krill, Chief, Municipal Wastewater Section, Wisconsin Department of Natural Resources, to all consulting and municipal agencies in Wisconsin on subject of infiltration limits into sanitary sewers. The letter indicates that the Sewage Works Committee of the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers had acted to change Section 25.8 of the Recommended Standards for Sewage Works, commonly referred to as the "Ten States Standards," reducing the allowable infiltration for "any section of the system" from 500 gallons per inch diameter per mile per day to 200 gallons per inch diameter per mile per day. The allowable rate is intended to apply to total sanitary sewer construction projects. The new standard recognizes that there may be certain sections of a system where the 200 gallon limit may be impractical to attain, and provide that the limit between adjacent manholes on sections of a total project may exceed the 200 gallon limit up to 500 gallons per inch diameter per mile per day, provided that the total project does not exceed the 200 gallon limit.*

Primary Treatment: This may be defined as physical treatment of raw sewage in which the coarser floating and settleable solids are removed by screening and sedimentation. Primary treatment normally provides 50 to 60 percent reduction of the influent suspended matter and 25 to 35 percent reduction of the influent ultimate carbonaceous biochemical oxygen-demanding organic matter ($CBOD_{ult}$). It removes little or no colloidal and dissolved matter.

Secondary Treatment: This may be defined as biological treatment of the effluent from primary treatment, in which additional oxygen-demanding organic matter is removed by trickling filters or activated sludge tanks and additional sedimentation. Secondary treatment normally provides up to 90 percent removal of the raw influent suspended matter and 75 to 95 percent removal of the raw influent $CBOD_{ult}$. Secondary treatment facilities can be designed and operated to also remove 30 to 50 percent of the raw influent ultimate nitrogenous biochemical oxygen demand ($NBOD_{ult}$) and 30 to 40 percent of the raw influent phosphorus content of the influent sewage.

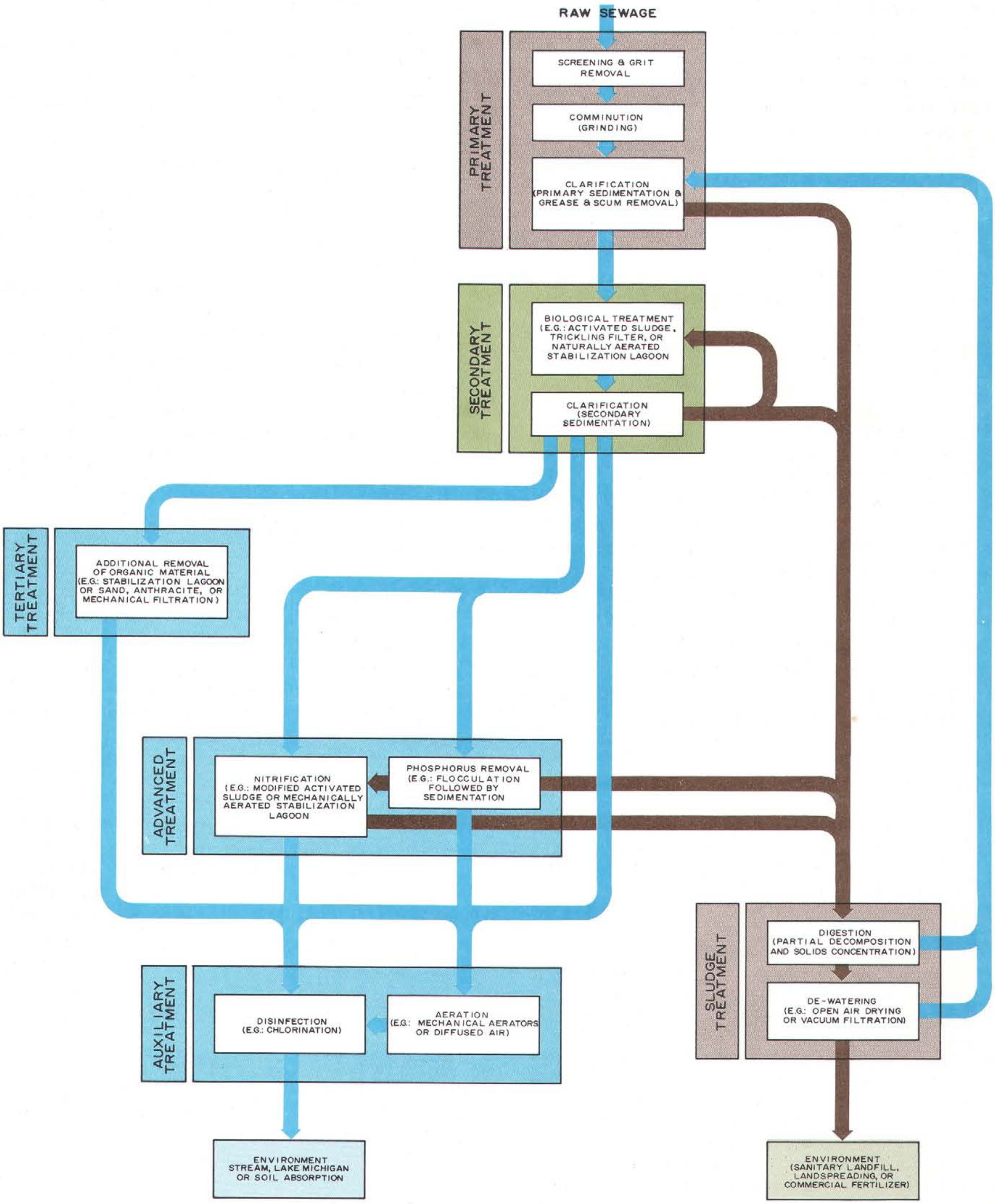
Tertiary Treatment: This may be defined as physical and biological treatment of the effluent from secondary treatment, in which additional oxygen-demanding matter is removed by use of shallow detention ponds to provide additional biochemical treatment and settling of solids or filtration using sand or mechanical filters. Tertiary treatment normally provides up to 99 percent removal of the raw influent suspended matter and 95 to 97 percent of the raw influent $CBOD_{ult}$.

Advanced Treatment: This may be defined as additional physical and chemical treatment to provide removal of additional constituents, particularly phosphorus and nitrogen compounds, by such means as chemical coagulation, sedimentation, charcoal filtration, and aeration. Although advanced treatment is traditionally conceived of as following secondary treatment or as combined with tertiary treatment, it can be performed following primary treatment or as an integral part of secondary treatment. Advanced treatment may remove 90 percent or more of the raw influent phosphorus and may remove up to 90 percent of the raw influent nitrogen or effect up to 95 percent reduction in the oxygen demand of ammonia in the sewage treatment plant influent by converting the ammonia compounds to nitrates.

Auxiliary Treatment: This may be defined as a treatment measure used in combination with

Figure 101

SEWAGE TREATMENT PROCESSES



Source: SEWRPC.

all other treatment methods, and includes, for example, effluent aeration and disinfection by chlorination.

Sewage Treatment Processes

A number of processes occurring in a variety of treatment units are currently employed in municipal sewage treatment plants, as shown in Figure 101, to achieve the previously discussed levels of treatment. Some of these processes rely primarily on biological phenomena while others are predominantly physical-chemical in nature.

Current design practice in municipal sewage treatment involves principally the removal of some of the oxygen-demanding wastes present in the sewage and disinfection of the effluent prior to discharge to receiving waterways. Recent research, development, and demonstration have been oriented toward processes capable of removing additional oxygen-demanding wastes, principally ammonia, and removal of phosphorus compounds. Of concern currently is concentration of heavy metals in sewage effluent, the precise determination of which has only just begun. Another current trend in research is land disposal of both sewage sludge and effluent. Though this disposal method had been practiced for some time on a limited scale, examination of the technique for application on a greatly expanded scale is underway. All of the preceding are factors of the state of the art of sewage treatment processes and are developed in more detail in the following sections.

Biological Treatment: Removal of oxygen-demanding wastes from sewage is accomplished most efficiently, within the framework of today's state of the art, by biological treatment processes. Of these processes, two are currently relied upon for the majority of sewage treatment: the trickling filter process and the activated sludge process. To accomplish more nearly uniform treatment efficiency throughout the year by the trickling filter process, the State of Wisconsin now requires that the filters be provided with covers when originally constructed, or when modified or enlarged if plants are already built under older regulations. Within the past 10 years, synthetic media have been developed for trickling filters which allow higher surface loadings. These media have not been used extensively to replace existing stone filter media because major changes in plant components are required to attain the higher hydraulic loadings. For new plants, however, the synthetic media offer significant advantages over stone. The trickling filter biological treatment process does not generally provide as high a level of $CBOD_{ult}$ removal as the activated sludge treatment process. For this reason, new plants are generally using the activated sludge process. The activated sludge process may be employed in three basic variations: extended aeration, conventional, or contact stabilization. A plant may be designed to progress from one variation to the next, since the major difference between variations consists of modification of sewage residence time in the aeration tanks.

Activated sludge plants can be designed to achieve high quality treatment with increased loading produced by a growing population. If the process is initially designed as an extended aeration process, primary clarifiers may not be necessary to reduce the $CBOD_{ult}$ loading, and sludge production is minimized. Consequently, the initial facilities may require only sludge-holding facilities and intermittent, interim disposal facilities. As population increases, the process may be modified to a conventional activated sludge unit with a higher sludge protection, requiring some method of concentrating the sludge. The system can again be modified to the contact stabilization process as growth continues. This modification can be accomplished without additional aeration tank construction. However, additional clarifier surface area must be provided as the flow to the plant increases. Finally, a primary clarifier must be added to reduce the $CBOD_{ult}$ loading to the activated sludge process to bring the entire system to full capacity.

Another recent modification of the activated sludge process that has been demonstrated as practical is the use of pure oxygen instead of air to supply the oxygen requirements of the bacteria in the system. Based on recent research results,[4] the use of pure oxygen in the process can produce significant cost savings in plant construction and operation. Size of structures can be reduced, less land area is required, and smaller volumes of sludge are produced using the pure oxygen system. The resulting savings are greatest when oxygen is generated at the treatment plant site. To date, however, there has not been enough variety of experience with pure oxygen-activated sludge plants to conclusively establish their cost relationship with conventional activated sludge

---

[4] *Investigation of the Use of High Purity Oxygen Aeration in the Conventional Activated Sludge Process*, FWQA.

plants. For this report, it was assumed that activated sludge plants would use the conventional aeration.

New equipment is available to introduce and diffuse compressed air throughout the activated sludge tank. The most common methods of diffusing air are by use of permeable synthetic stone or coarse bubble devices. Surface aerators or submerged turbine aerators, however, are being used with increasing frequency in municipal waste treatment, although some freezing problems have been experienced with the former in colder climates. Submerged turbine aerators develop currents throughout the tank with air introduced at the turbine blade by blower and piping equipment. In overloaded plants, turbine aerators may be added to activated sludge tanks using diffused air to increase the oxygen input to the system.

Conventional activated sludge plants are capable of achieving about 90 percent removal of influent $CBOD_{ult}$. The $CBOD_{ult}$ can be further reduced by filtration following final sedimentation. Such filtration can be done with rapid sand filters similar to the filters used in water treatment plants. It has been recently demonstrated that performance comparable to rapid sand filtration can be obtained from rotating microstrainers. The microstrainers utilize extremely fine mesh stainless steel or nylon fabrics that are continuously backwashed. The microstrainers require less maintenance than rapid sand filters and only a fraction of the space.[5]

A major consideration in currently developing sewage treatment technology is the further reduction of oxygen-demanding substances. Ammonia is important among these substances inasmuch as it may initiate the NBOD process. $NBOD_{ult}$ levels in influent sewage can comprise as much as 40 percent of the total influent oxygen demand levels. Since conventional sewage treatment plants remove only about 30 percent of the influent $NBOD_{ult}$ but 90 percent of the $CBOD_{ult}$, the effluent generally contains a higher level of $NBOC_{ult}$ than of $CBOD_{ult}$.

Ammonia is toxic to fish in concentrations as low as 2.0 mg/l, as ammonia, at an alkalinity of 80 mg/l and a pH of 8.0 or less. The allowable ammonia concentration increases with increasing alkalinity, but decreases with increasing pH. Toxicity is also increased as dissolved oxygen levels decrease.

Until the 1930's, sewage treatment plants in the United States were designed to produce a nitrified effluent with ammonia compounds converted to nitrate. Because treatment facilities required to produce nitrified effluents were more costly than plants required only to reduce $CBOD_{ult}$ to acceptable levels, the practice of nitrification declined. With the trend toward more rigorous evaluation of pollution effects on receiving waters, the oxygen demand of ammonia is again being considered in the planning and design of sewage treatment plants.

Physical-Chemical Treatment: Physical-chemical treatment is the application of a series of unit processes that do not incorporate biological processes to reduce the $CBOD_{ult}$ and $NBOD_{ult}$ of the sewage. The processes include chemical addition, flocculation, sedimentation, adsorption, and filtration. The physical-chemical process concept is not new, having been developed prior to the biological processes. Current development of the process is associated with improvement of the adsorption and filtration steps.

The processes of chemical addition for coagulation and sedimentation are the same as used in numerous water treatment plants throughout the world. Similarly, the filtration step can be by gravity, through sand and anthracite filters, or by pressure filtration. Generally, pressure filters are only used in small installations. The filtration process is also a typical water treatment plant process.

The major change in the process is the inclusion of activated carbon for adsorption of organics. Organic adsorption is nonspecific; that is, both biodegradable and refractory organics are adsorbed in the media surface. This nonspecificity is advantageous where toxic organics might inhibit normal biological treatment processes. Activated carbon is the media most commonly used in pilot and full-scale operation of physical-chemical treatment. The adsorbing capability of the carbon can be restored by intensive heating.

The physical-chemical process requires only about 30 percent of the land area of a conventional biological treatment plant. Test results to date indicate that the costs of operation of a physical-chemical system are competitive with biological treatment plants when high removal percentages

---

[5] *Process Design Manual for Suspended Solids Removal for Environmental Protection Agency Technology Transfer*, Burns and Roe, Inc., October 1971.

are required.[6,7] As mentioned previously, the activated carbon treatment removes organic materials that would not be removed even in a sophisticated biological treatment plant, unless the plant incorporated activated carbon filtration of effluent as a treatment step.

Currently, the primary disadvantage of the physical-chemical process is its considerably higher cost for levels of treatment comparable to conventional biological treatment plants. Another disadvantage of the physical-chemical process is the complexity of the system and the lack of experienced operators to cope with this complexity.

Current full-scale demonstration plant operational and economic performance has not established the superiority of the physical-chemical process for general application. The use of physical-chemical processes was not assumed as the typical treatment for the regional sanitary sewerage system. As more construction and operating experience with these plants is acquired, however, and as stream water quality requirements, especially with regard to trace organics and heavy metals, become more stringent, the use of the physical-chemical processes will become more common in the Region.[8]

Sludge Treatment and Disposal: The disposal of sewage sludge continues to be one of the most difficult and costly problems associated with sewage treatment. Sewage sludge may be classified as raw or digested. Raw sludge is the mixture of water, inert minerals, and organic matter that is settled and subsequently collected from the sewage stream at various points in the treatment process. Raw sludge is unstable, and the uncontrolled decomposition of the volatile compounds in such sludge creates obnoxious odors. Raw sludge may be stabilized by anaerobic or aerobic biologic decomposition of the volatile organic compounds. The resulting product, which is commonly called digested sludge, is also more readily handled and dewatered than raw sludge because of the concentration of solids that occurs in the digestion process. After digestion, the sludge is commonly dewatered by air drying on sand beds, by vacuum filtering, centrifuging, or heat drying, producing an inert product. Sludge digestion is normally accomplished anaerobically in a heated tank. The resultant gases are sometimes utilized to fuel engines of the treatment plant or to heat the digester. In addition to biochemical methods, undigested sludge can be incinerated by either high temperature burning or by the wet oxidation process. In the latter process, sludge is burned at a temperature of about $500^{\circ}F$ under pressures of from 150 to 3000 psi. Some odor remains in the wet oxidized sludge.

In the midwestern United States, sewage sludge is commonly ultimately disposed of on land. The U. S. Environmental Protection Agency design guidelines,[9] however, prohibit the disposal of raw sludge to land. Digested sludge with varying amounts of moisture or heat-dried sludge may be applied to the land, usually with no detrimental effects, if the sludge application is controlled to prevent ground or surface water contamination. Land disposal of digested or heat-treated sludge is frequently beneficial on sandy soils which are low in natural nutrients, improving crop yields because of the nutrients and water present in the sludge. The Sewerage Commission of the City of Milwaukee has successfully marketed heat-dried sludge as a fertilizer under the name Milorganite for about 50 years. Because of the uniquely high nitrogen content of sludge from Milwaukee's Jones Island plant, a high quality fertilizer and, therefore, an adequate economic return could be obtained to justify the cost of heat-drying and marketing.

It is likely that utilization of wet-digested sludge as a fertilizer and soil conditioner will increase. An intensive three-year testing program carried out by the University of Illinois has established that agricultural utilization of wet-digested sludge has minimal hazard to crops and public health.[10]

---

[6] *R. V. Villiers, E. L. Berg, C. A. Brunner, and A. N. Marse, "Municipal Wastewater Treatment by Physical Chemical Methods," Water and Sewage Works, 1971 Reference Edition.*

[7] *W. G. Weber, C. B. Hopkins, and R. J. Bloom, "Physicochemical Treatment of Wastewater," Journal of the Water Pollution Control Federation, 42:83, January 1970.*

[8] *The physical-chemical process is proposed by a local engineering consultant for a new sewage treatment plant recommended in the Delafield-Hartland subarea of the Region.*

[9] *Federal Guidelines, "Design, Operation and Maintenance of Wastewater Treatment Facilities," FWQA (now EPA), September 1970, p. 12.*

[10] *T. D. Hinesly, O. C. Braids, and J. E. Molina, "Agricultural Benefits and Environmental Changes Resulting from the Use of Digested Sludge on Field Crops," University of Illinois, 1971.*

The Metropolitan Sanitary District of Greater Chicago has purchased 6,000 acres of strip-mined land for reclamation using wet-digested sludge and is considering transportation by rail, barge, and pipeline.

The U. S. Environmental Protection Agency recently investigated the economic aspects of the various methods for sludge management and drew the following general conclusions:[11]

1. Anaerobic digestion of sewage sludges for all small cities and cities located near the coasts is justified. It allows relatively inexpensive final disposal methods, such as ocean dilution, lagooning, and spreading liquid sludge on land as a soil conditioner.

2. Lagooning industrial sludges is an inexpensive disposal technique.

3. Pipeline transportation of sludge to desirable disposal areas should be considered because it is relatively inexpensive.

4. If heat-dried sludge can be sold as a fertilizer for about $15 a ton, only then should the process be considered.

5. Digesting sludge before incineration cannot be justified on the basis of economics.

6. Water plant sludges are normally disposed of very inexpensively in sewerage systems, lagoons, or directly to surface waters, although the latter form of disposal is no longer accepted in Wisconsin.

Sludge treatment costs will vary greatly. Costs of sludge disposal from smaller plants located close to the acceptable land disposal sites may be relatively low. However, for large facilities located in intensively developed metropolitan areas, transport of sludge to distant land disposal sites may make disposal very costly. The high cost of transportation favors the use of sludge concentration processes to reduce the volume of water in the sludge transported to disposal sites. For this reason, design engineers should make comparative studies and cost estimates for alternative sludge disposal methods. The fact that sludge handling and disposal represent 25 to 30 percent of the total treatment plant capital and operating cost justifies a thorough economic evaluation of alternatives.

Nutrient Removal: The adverse effect of excessive aquatic plant growth on rivers and lakes is causing sewage treatment plants to be designed to remove or treat compounds that stimulate these growths. In addition to being unsightly, heavy algae and weed growths produce large fluctuations in the concentration of dissolved oxygen in receiving waters. During sunlight periods algae growths create supersaturated concentrations, while during the nighttime hours the algae withdraw oxygen from the water. This withdrawal can depress oxygen levels to as low as one or two parts per million, well below the minimum standards necessary to maintain fish life. For these reasons, control of nutrients is proposed to limit algae growths.

The three primary nutrients important to algae and weed growth are carbon, nitrogen, and phosphorus. The average ratio of the nutrient elements carbon (C), nitrogen (N), and phosphorus (P) is 100:20:1 in the cellular structure of aquatic plants. It is generally accepted that the growth of algae and other aquatic plants will be in proportion to the quantity of the nutrient element in most limited supply. In the surface waters of southeastern Wisconsin, carbon and nitrogen generally are available in excess of plant needs as compared to the availability of phosphorus. Therefore, phosphorus is considered to be the limiting nutrient. Fortunately, it is the nutrient most susceptible to control. Both carbon and nitrogen are available from the atmosphere and other natural sources, while most sources of excessive phosphorus are attributable to activities of man.

There are numerous forms in which carbon is available as a nutrient source both to bacteria and algae. However, of concern to the development of a sewerage system plan are the oxygen depression effects of discharges to the receiving waters of carbon compounds as measured by the CBOD test.

Nitrogen in effluent is of concern in two forms. When in the ammonia form, instream nitrification may occur in the receiving waters, thereby seriously depleting oxygen levels in the stream. In the nitrate form, the nitrogen is available as a direct algal nutrient source entering streams. Some algae species are capable of fixing nitrogen from

[11] *A Study of Sludge Handling and Disposal*, USFWPCA, Publication WP-20-4, May 1968, p. 320.

the atmosphere directly into their cell structure. Therefore, it is unlikely that control of aquatic plant growth can be accomplished solely by nitrogen removal from sewage sources.

It is possible to remove nitrogen from the waste waters by several processes. One involves ammonia stripping in aeration towers or nitrification-denitrification steps in stabilization processes. But ammonia stripping in towers has certain major disadvantages. To date, lime has been used to raise the pH of the sewage to the level required for effective stripping. This use of lime produces large volumes of sludge. In addition, effluent pH level reduction is necessary before discharge. Aeration tower efficiency is seriously impaired during periods of below freezing weather.

Because of these drawbacks, other methods of removing nitrogen are being explored. The research results currently indicate that a two-stage process of nitrification-denitrification will produce effective nitrogen removals of up to 90 percent. In this process, a nitrifying activated sludge system is developed in series with the typical activated sludge system. The nitrified effluent from the second activated sludge system is then passed through a deep bed filter or an anaerobic tank reactor which contains denitrifying bacteria. These bacteria reduce the nitrate to nitrogen gas. The process is complicated and expensive, and results in an oxygen deficient effluent. For these reasons it is concluded that nitrogen removal should not be anticipated as a future sewage treatment requirement except in special instances. The primary concern in this study is the oxygen demand exerted by the ammonia.

Ammonia nitrogen and its oxygen demand should be of greatest concern in sewerage system planning in southeastern Wisconsin on the basis of the foregoing discussion. There are two methods currently utilized to convert ammonia nitrogen to nitrate nitrogen: raising the levels of active solids in the activated sludge process, or creating a separate nitrification system, the latter being operated as a second stage system following a first stage system designed primarily for CBOD removal. The required design detention time is a function of sewage temperature, the reaction proceeding more rapidly with increasing temperature. For this study it was assumed that nitrification tank capacity should be designed assuming a three-hour detention period. This period of aeration should provide adequate nitrification during the summer when normally the need is greatest to remove oxygen demands on the stream. During the winter months it may be unnecessary to provide nitrification because of reduced algae activity, greater streamflow, and lower water temperatures. These factors all tend to reduce the probability of decreases in dissolved oxygen concentrations to values less than required by established standards. Ice cover, however, may limit natural reaeration and cause winter decreases in dissolved oxygen concentrations.

Phosphorus removal can be accomplished by precipitating phosphorus at one or more of several points in the treatment process. Addition of metal salts to aeration tanks requires minimal additional facilities construction. Alternatively, chemicals may be added in a separate flocculation-sedimentation tank following the secondary clarifier. Processes for removal are now well established, and the principal efforts in continuing research are toward reduction of cost. For this study, it was assumed that chemicals to precipitate phosphorus would be added in the aeration tanks.[12]

Waste Stabilization Lagoons: In addition to the conventional sewage treatment processes previously discussed, waste stabilization lagoons are becoming increasingly popular as a method of treating sewage from small urban communities. Stabilization lagoons are a means of providing complete treatment and should not be confused with final effluent polishing ponds sometimes used in connection with conventional sewage treatment plants. Waste stabilization lagoons may be either naturally aerated or mechanically aerated. Both types, if properly designed and operated, can produce effluents comparable in quality to effluent from conventional secondary treatment plants. The provision of both effluent aeration and instream aeration may be necessary to maintain required dissolved oxygen levels in small watercourses with relatively little dilution capacity receiving effluent from stabilization lagoons.

Naturally Aerated Waste Stabilization Lagoons: Stabilization lagoons consist of impervious earthen dikes, with manual control structures and flow metering equipment which can be used to maintain

[12] *"Phosphorus Removal with Pickle Liquor in an Activated Sludge Plant," Sewerage Commission of the City of Milwaukee for the U. S. Environmental Protection Agency, March 1971.*

the depth of the lagoon at from 3 to 5 feet. Single or multiple-cell lagoons may be used although only multiple cell lagoons are approved by the state for use in Wisconsin. For treatment of domestic wastes, the primary cell or cells are normally sized on the basis of one acre of liquid surface area per 100 persons, or from 16 to 20 pounds of $CBOD_5$ per acre of liquid surface per day and an average detention period of 180 days. The secondary cell or cells are sized at about one-fourth to one-third the size of the primary cell or cells. Naturally aerated waste stabilization lagoons can be utilized to treat many, but not all, kinds of industrial wastes.

Naturally aerated waste stabilization lagoons use natural processes to decompose and stabilize the organic matter in raw sewage. Sunlight, natural aeration, and evaporation over an extended detention time all work together to reduce the raw sewage to a safe and stable effluent. Because of their relatively fail-safe operation and independence from human operator error, naturally aerated waste stabilization lagoons have proven to be a particularly efficient method of treatment for smaller communities. The advantages of naturally aerated waste stabilization lagoons, as compared to conventional biological forms of treatment, include the fact that no chlorination equipment, and only a minimal amount of laboratory testing equipment, is presently required by state regulations. Highly skilled operators are not required; no power is required for operation; the process is well-suited to shock loadings and to treatment of the highly fluctuating flows commonly associated with small sewerage systems; there is very little depreciation; overall operating costs are low; and overall treatment levels are relatively high in terms of CBOD removal, ranging up to 90 percent $CBOD_5$ removal. Sludge disposal problems are minimized because sludge deposits normally form slowly in the basins, at rates ranging from one-quarter to 2.5 inches per year. Rates approaching or exceeding the latter indicate that excessive amounts of sand or silt may be entering the tributary sewerage systems.

The major disadvantages of a naturally aerated waste stabilization lagoon include little actual phosphorus removal; an effluent which may frequently be relatively high in ammonia content and, as such, toxic to fish life in the receiving stream; development of algae during warm summer months with resultant potential suspended solids carry-over to receiving streams; and significantly reduced biological activity during cold weather months resulting in nuisance odors during the spring thaw. Stabilization ponds provide no grease removal facilities, relying instead on bacterial decomposition of the greases, on depth control of releases to avoid carrying grease over into the effluent, and occasionally on baffles.

In addition, there are several requirements which make the lagoons unsuitable for certain applications. The State of Wisconsin requires that all proposed stabilization lagoon sites be located at a minimum distance of 2,000 feet from all existing dwellings. This distance can be reduced to 1,600 feet if the dwellings in question are located upwind (prevailing) of the lagoon site and the owners consent to having the lagoon located closer than the prescribed 2,000 feet. Once a lagoon is constructed, adjacent landowners can build as close to the lagoon as they wish. The lagoons are unsuitable for the treatment of certain industrial wastes, such as those from cheese factories. Excessive land costs may make this method of treatment uneconomical. Finally, state regulations require that the bottom of the lagoon be located at an elevation at least 3 feet above the groundwater table and at least 8 feet above bedrock strata.

Mechanically Aerated Waste Stabilization Lagoons: Aerated lagoons are similar to natural stabilization lagoons with the following major differences: liquid depths may be increased, ranging from 10 to 14 feet; shorter detention times may be used, ranging from 30 to 50 days; and mechanical aeration and chlorination are required. For treatment of domestic wastes, aerated lagoons are normally sized on the basis of one acre of liquid surface area per 600 to 800 persons. The exact sizing is dependent upon sewage volumes, $CBOD_5$ loadings, and oxygen transfer efficiency of the aerators. Many industrial wastes can be treated by aerated lagoons.

Aeration may be accomplished by surface aerators, floating or fixed; agitators; or by subsurface aerators (diffusers). In the climate of the Region surface aerators are subject to freezing problems. Consequently, the trend is toward use of the subsurface aerators which are not subject to freezing, although both initial and operating costs are somewhat higher.

Aerated lagoons possess all of the advantages of natural stabilization lagoons as compared to conventional biological forms of treatment. In addition, aerated lagoons may provide a reduction in ammonia concentration of up to 90 percent,[13] a major advantage over natural stabilization lagoons, particularly when the effluent is to be discharged to streams with very low flows.

In addition, the State of Wisconsin requires that all proposed aerated lagoon sites be located at a minimum distance of 1,000 feet from all existing dwellings. This distance can be reduced to 800 feet if the dwellings in question are located upwind (prevailing) of the lagoon site and the owners consent to having the lagoon located closer than the prescribed 1,000 feet. Once an aerated lagoon is constructed, adjacent landowners can build as close to the lagoon as they wish. As for naturally aerated stabilization lagoons, state regulations require that the bottom elevation of the lagoon be at an elevation of at least 3 feet above the groundwater table and 8 feet above the bedrock strata.

Effluent Disposal Methods: Seepage lagoons and direct discharge to land are two alternatives which avoid final effluent disposal directly to streams. Under both methods of disposal, effluent percolates through the soil, eventually reaching the shallow aquifer system.

Seepage lagoons should only be used after careful study of the soils and groundwater movements indicates suitability at the specific site. If there is a potential for groundwater contamination of nearby public or private wells, the direction of groundwater flow in the area must be determined to avoid or eliminate a buildup of dissolved minerals and organic compounds in water supplies.

Effluent disposal by land application is considered by some as an ideal solution to the problem of stream pollution. The feasibility of this scheme, however, is strongly dependent on numerous factors, such as proximity of available land; land value; climate; topography; depth to groundwater; and perhaps most importantly, soil type. Unfortunately, land application appears to be suitable within the Region only for rather small, isolated urban communities located in rural, agricultural areas. In such areas, land costs are relatively low and crop and pasture land with soils and topography suitable for effluent discharge are located nearby.

[13] See "*Nutrient Removal from Sewage Effluents by Algal Activity*," Advances in Water Pollution Research, Pergamon Press, 1969, pp. 701-715.

Climate and soils are the most significant factors influencing the development of land disposal schemes in southeastern Wisconsin. Effluent is most effectively applied to land by spraying, although flood irrigation (ridge and furrow) is also practiced. A spray disposal operation requires piping systems, reservoirs, pumps, and large irrigation system sprayers. These sprayers are usually designed to serve a 60-foot radius, but models are available which can serve up to a 250-foot radius. The long period of potential below-freezing temperatures in southeastern Wisconsin, extending from about November 1 to April 1, precludes the possibility of designing spray irrigation systems without large storage reservoirs. These reservoirs could be considered as stabilization ponds, with discharge to a stream during the spring when streamflow is high. Alternatively, the holding basin effluent could be sprayed on the disposal fields when they are dry enough to allow for percolation. Of the remaining factors, climate and groundwater require further discussion.

The second major problem with land disposal in the Region is the generally low permeability of the soil. It is estimated by Pennsylvania State University researchers that to sustain a stable land disposal operation the application rate should not exceed one inch per week. This loading is about 28,000 gallons per acre per week. With this application rate, approximately 300 acres are required for each 1 mgd of sewage. In addition to this land, an additional 50 acres would be required for construction of the necessary holding basins. Another potential problem related to soils is the possible production of toxic conditions in the soil or groundwater. The acidity or alkalinity of the soils affects this potential. Wastewater elements which are harmless in basic soils may be toxic in acidic soils. The soils within the Region, however, are predominantly neutral or mildly alkaline and should, therefore, create a serious problem in this respect.

The advantages of land disposal of effluent are numerous. They include elimination of effluent discharges to surface waters, resulting in a simpler and cheaper plant operation, since the removal of nitrogen and phosphorus from the effluent is not necessary. Problems with stream-dissolved oxygen deficits caused by addition of sewage effluent are eliminated. The sewage adds nitrogen, phosphorus, trace elements, and moisture to the soils which can increase crop yields. This would especially benefit higher portions of the croplands where loss of moisture and nutrient usually result in poorer yields. In addition, sludge could be added to the flood irrigation system increasing the concentration of nutrient applied.

Land disposal of effluent by spraying, flooding, or seepage all have the common problem of groundwater contamination. Experience indicates that bacteria are normally quite effectively removed by passage through five feet of soil. Less is known, however, about the removal of viruses by passage through soil. Dissolved minerals in the effluent may create concentrations in the groundwater that exceed the values established by U. S. Public Health Service. The most troublesome element in this regard would probably be nitrogen, whose compounds are quite soluble. The maximum allowable concentration of nitrate nitrogen is 10 mg/l, or 45 mg/l as nitrate. A study of the crop nitrogen balance must be conducted to support recommendations for land disposal. In addition, the continued practice of land disposal might eventually require either construction of a new water supply system or installation of deeper wells for all potentially affected supplies. The development of biodegradable detergents has eliminated the problem of foaming, an obvious indicator of pollution in contaminated supplies. Therefore the presence of pollutants is likely to go unnoticed until illnesses or routine testing programs indicate that groundwater is polluted.

Instream Aeration: As already noted, there is little natural reaeration during cold winter months when streams may have heavy ice covers. This can cause dissolved oxygen concentrations to fall below critical limits. There are two potential solutions, or at least partial solutions, to this problem: to provide a high quality treatment plant effluent or to provide instream aeration at selected stream stations. For the latter solution, a diffused air system appears to be the most practical approach, since a clear waterway will be maintained. Turbine aerators are subject to damage from ice and debris and would require a flexible anchoring system to allow the units to float during flood or high flow conditions. Instream aerators would be of most use if installed in impoundments where the diurnal fluctuation in oxygen concentration is likely to affect the largest fish population.

In streams that are essentially comprised of sewage treatment plant effluent during low flow, a small residual of oxygen-demanding substances in the sewage treatment plant effluent may still cause a dissolved oxygen depression. Methods of dealing with this problem include the provision of higher levels of effluent treatment, mechanical aeration to increase the dissolved oxygen concentration in the sewage treatment plant effluent, or instream aeration to raise the dissolved oxygen level in the critical oxygen area of the stream. If one or the other of these methods is insufficient, a combination of methods can be utilized. Because shallow water depths and relatively high temperature reduce the oxygen transfer efficiency, operating costs for this solution may be more expensive than for increased removal of oxygen-demanding substances. The capital costs for the installation of these devices are low compared with the costs of additional treatment units, however, and depending on the specific situation, intermittent use of instream aeration may be the most economical alternative.

SEWER DESIGN CRITERIA AND ANALYTIC PROCEDURES

Numerous hydraulic factors are involved in the design of sewers and sewerage systems including design sewage flows, hydraulic friction, pipe capacity, flow velocities, depths of flow, and minimum sewer slopes. In addition to these hydraulic factors, consideration must be given to building and sewer construction practices which may determine minimum and maximum sewer depths. The following discussion describes the sewer design criteria selected for use in the regional sanitary sewerage system planning program, and sets forth the methods and procedures by which cost estimates were prepared for all sewers included in the regional sanitary sewerage system plan.

Sewage Flow

Sewage flow consists basically of domestic, commercial, and industrial waste water; storm water inflow; and groundwater infiltration. One of the most important criteria used in the design of sewers is that used to determine the amount of sewage flow contributed to a given sewer from its tributary drainage area. Normally, sewage flow is estimated in terms of gallons per capita per day (gpcd) or cubic feet per second per acre cfs/acre). Several sets of design criteria have been used within the Region to estimate sewage flow, including those formulated under the Commission's Fox and Milwaukee River watershed studies, those utilized by the Milwaukee-Metropolitan Sewerage Commission, and those contained in the Recommended Standards for Sewage Works,[14] popularly called the "Ten-States Standards." Each of these sets of sewage design flow criteria is discussed below.

In both the Fox and Milwaukee River watershed studies, design sewage flows were based on relationships between population size and average daily sewage flow established from empirical data collected from communities of varying size throughout the two watersheds. In the Fox River watershed study, design sewage flows were based on an average daily flow contribution of 120 gpcd in communities with populations under 5,000, and an average flow contribution of 180 gpcd in communities with 5,000 or more population. Trunk sewers were sized on a peak-to-average flow ratio of 2 to 1, resulting in design flows of 240 gpcd and 360 gpcd respectively for the smaller and larger communities. The average daily and peak design sewage flows were assumed to include normal storm water inflow and groundwater infiltration, as well as domestic, commercial, and industrial waste water flows.

In the Milwaukee River watershed study, average daily design sewage flows were based on a contribution which varied from 120 gpcd for communities with under 1,000 population to 210 gpcd for communities of more than 30,000 population. Trunk sewers were sized on a peak-to-average flow ratio of 2 to 1, resulting in peak design flows ranging from 240 gpcd to 420 gpcd. As in the Fox River watershed study, the average daily and peak design flows were assumed to include normal storm water inflow and groundwater infiltration, as well as domestic and industrial waste water flows.

The rules of the Milwaukee-Metropolitan Sewerage Commissions specify that sanitary sewers built by municipalities and connected to the Sewerage Commission's trunk or interceptor sewers be sized on the basis of a peak flow contribution of 0.015 cfs/acre in areas where the population ranges from 10 to 14 persons per gross residential acre, and on the basis of a contribution of 0.020 cfs/acre in areas where the population ranges from 15 to 20 persons per gross residential acre. These design flow rates are equivalent to a peak contribution ranging from 970 gpcd to 650 gpcd, and include allowances for storm water inflow and groundwater infiltration. Where the population is less than 10 or more than 20 persons per gross residential acre, special studies are required to be made to determine the peak design flow criteria to be used. Trunk and interceptor sewers under the jurisdiction of the Milwaukee-Metropolitan Sewerage Commissions are designed on the basis of a 450 gpcd instantaneous peak flow.

The Ten-States Standards recommend that sanitary sewers be sized using a minimum average daily design flow of 100 gpcd and a peak design flow of at least 250 gpcd. Design criteria used in the Fox and Milwaukee River watershed studies closely approximate the Ten-States Standards recommendations.

In the regional sanitary sewerage system planning program, criteria were developed relating average daily and instantaneous peak sewage flows to the major land use categories identified on the adopted regional land use plan. Criteria were also developed pertaining to allowances for normal groundwater infiltration and storm water inflow. With respect to the regional land use plan, sewage flow criteria were developed for low, medium, and high density urban land use areas, for major retail and service centers, and for major industrial centers, the urban areas and urban activity centers identified and spatially located on the adopted regional land use plan. Since the low, medium, and high density urban land use categories of the plan include by definition minor commercial, industrial, and institutional land uses generally found throughout otherwise predominantly residential land use areas, the criteria developed were intended to account for all sewage flow from the urban land use categories used in the plan.

Based upon an analysis of sewage treatment plant flow and water supply system pumpage records for selected communities throughout the Region (see Chapter VI of this report), it was determined that an average daily sewage flow contribution of 125 gpcd would be utilized in the regional study for sizing sewerage system components. This base flow was intended to include all domestic, commercial, and industrial sewage contributions exclusive of storm water inflow or groundwater infiltration. This per capita base flow was then used in combination with groundwater infiltration

---

[14] *Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, Recommended Standards for Sewage Works, Public Health Education Service, 1971 Revised Edition.*

and storm water inflow allowances to develop design sewage flows from the low, medium, and high density urban local use areas, which areas, as already noted, include commercial, industrial, and institutional, as well as residential, land uses. For certain designated major retail and service and industrial concentrations, shown as such on the land use plan, a peak daily sewage flow contribution of 7,500 gallons per acre was also established.

Because of existing legal prohibitions against the diversion of storm and groundwater from roof downspouts and foundation drains into the sanitary sewerage system, the sewage flow design criteria did not include extraordinary allowances for contributions from these two sources. An additional allowance was made, however, for the normal groundwater infiltration and storm water inflow which could be reasonably expected to occur in new, well-constructed systems,[15] in addition to the per capita sewage flow contributions. Thus, the design criteria are intended to be applied primarily to the design of new sewerage facilities. Older existing sewerage systems may experience peak wet weather flows considerably higher than indicated by the design criteria.

It was determined that a variable peak-to-average ratio for sanitary sewage, excluding infiltration and storm water inflow, would be utilized to design trunk sewers, with the ratio varying from a low of 2.5 to 1 to a high of 5.0 to 1 depending upon the population of the service area tributary to the given sewer. Table 79 presents the peak-to-average daily flow ratios adapted from data presented in ASCE Manual of Engineering Practice No. 37, Design and Construction of Sanitary and Storm Sewers, and utilized in the regional sanitary sewerage system planning program. Where minimum flow velocities required investigation, the ratio of average daily to minimum flow was assumed to be the same as the ratio of peak flow to average daily flow.

As previously noted, in addition to the sewage flow from residential, commercial, institutional, and industrial land uses, allowances were made in the design criteria for normal storm water inflow and groundwater infiltration. To determine the criteria to be used for storm water inflows and groundwater infiltration, analyses were made of hypothetical sewerage systems to serve typical low-, medium-, and high-density residential neighborhoods. A sewer layout, including building, lateral, branch, and trunk sewers ranging in size from 4" to 15" in diameter, was prepared for each typical neighborhood. The allowable infiltration for new sewer construction, as set by the Wisconsin Department of Natural Resources, is 200 gallons per inch-diameter-mile per day. The infiltration rate indicated in a construction specification, however, is not necessarily the same infiltration rate which should be used in establishing the required capacity of sewers. To be conservative and account for possible settlement of sewers and opening of sewer joints with age, an infiltration allowance of 1,500 gallons per inch-diameter-mile per day was used for all common sewers. For building sewers, which are seldom constructed with the same inspection standards as common sewers, an infiltration allowance of 3,000 gallons per inch-diameter-mile per day was used. Table 80 presents the calculations utilized to determine the infiltration allowance in the regional sanitary sewerage system planning program for a typical medium-density residential neighborhood in the Region. From this table, it

Table 79

RATIO OF PEAK FLOW TO AVERAGE DAILY FLOW UTILIZED TO DETERMINE TRUNK SEWER DESIGN FLOW IN THE REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM

Population Range	Ratio of Peak Flow to Average Daily Flow[1]
0- 2,000	5.0
2,000-10,000	4.0
10,000-20,000	3.0
More than 20,000	2.5

[1]*This ratio applies to sanitary sewage flow but not to infiltration and stormwater inflow.*

Source: Adapted by Harza Engineering Company from ASCE Manual No. 37, "Design and Construction of Sanitary and Storm Sewers," 1969, p. 33.

[15]*It should be noted that the groundwater infiltration and storm water inflow allowances set forth in this chapter were selected by the Technical Advisory Committee on Regional Sanitary Sewerage System Planning after very lengthy and careful deliberation. In this deliberation, the Committee substantially increased the infiltration and storm water inflow allowances initially recommended by the staff. In making this decision, the Committee relied on the experienced judgement of sanitary engineers actively engaged in constructing, operating, and maintaining sewerage systems throughout the Region. Thus, the criteria selected reflect the best engineering judgement available within the Region on the amount of infiltration and storm water inflow which can reasonably be expected in new sewerage systems currently being installed in the Region.*

was determined that a total of about 511,000 gallons per day of infiltration can be expected from a typical medium-density residential neighborhood. This flow converts to a total infiltration allowance of about 0.6 gpm per acre, which allowance was intended to represent a peak infiltration flow and as such to be added to the peak flow rate derived by factoring the base flow of 125 gpcd.

Storm water enters truly separate sanitary sewers primarily through submerged manhole covers. Tests made on manhole covers submerged in only one inch of water indicated that the inflow of water may range from 20 to 75 gpm per manhole. Additional storm water may enter the sanitary sewerage system through illegally connected building foundation and roof drains and illegally connected area drains. The design engineer, therefore, must evaluate the situation and make allowance for such amounts of storm water as experienced judgement indicates may be unworkable, under probable enforcement conditions for the area under design. Because of a lack of detailed data in the Region relating to actual storm water additions to the total sewage flow, it was conservatively assumed that storm water inflow would be equivalent to infiltration. Thus the total flow for infiltration and the storm water inflow for a typical medium-density residential neighborhood in southeastern Wisconsin would be 1.2 gpm per acre. This allowance, like the infiltration allowance, was intended to represent a peak storm water inflow and as such to be added to the peak flow rate derived by factoring the base flow of 125 gpcd.

Table 80

CALCULATION OF INFILTRATION ALLOWANCE FOR A TYPICAL MEDIUM DENSITY RESIDENTIAL NEIGHBORHOOD IN THE REGION

Sewer Diameter (Inches)	Sewer Lengtn (Feet)	Sewer Length (Miles)	Infiltration Allowance[1]	Infiltration (gals/day/mi)	Infiltration per Day (gals)
4	130,000	24.60	3,000	12,000	295,000
6	8,000	1.52	1,500	9,000	13,670
8	74,400	14.08	1,500	12,000	169,000
10	6,900	1.31	1,500	15,000	19,600
12	1,700	0.32	1,500	18,000	5,750
15	1,800	0.34	1,500	22,500	7,650
				Total	510,670[2]

NOTE: A medium density residential neighborhood is defined as a one square mile area with an average population density of 10.2 persons per gross acre. (See Appendix D of SEWRPC Planning Report No. 7, Volume 3.)

[1]*Gallons per day per inch-diameter-mile.*

[2]*Equivalent to 356 gpm and, therefore, infiltration may be expressed on an areal basis as 356 gpm/640 acres = 0.56 gpm/acre or about 0.6 gpm/acre.*

Source: Harza Engineering Company.

Because of fewer building, lateral, and branch sewers, the allowance for infiltration and storm water inflow for low-density residential neighborhoods was determined to be somewhat less than for medium-density neighborhoods. Similarly, in high-density neighborhoods the open space is significantly reduced, thus decreasing infiltration. Table 81 presents the infiltration and storm water contributions estimated for low-, medium-, and high-density residential development.

The above sewage flow design criteria were utilized to prepare a series of trunk sewer design curves for each of the three residential density ranges utilized in the regional land use plan—low, medium, and high density. The curves which are shown in Figures 102, 103, and 104 are recommended for refined and detailed trunk sewer design during the plan implementation phase of the regional sanitary sewerage system planning program.

Each figure contains three sets of curves. The first set in each figure shows the relationship between tributary area in acres and gallons per capita per day for the low, middle, and upper ends of the appropriate density range. The second set in each figure shows the relationship between tributary area in acres and a flow rate expressed in cfs per acre. The third set in each figure shows the tributary area in acres and the flow rate expressed in million gallons per day. Thus, a total of nine sets of curves are presented in Figures 102 through 104, three each for the low-, medium-, and high-density residential land use development categories.

In lieu of using the above design curves, a somewhat more generalized procedure was used to size trunk sewers under the regional sanitary sewer-

Table 81

INFILTRATION AND STORM WATER INFLOW ALLOWANCES UTILIZED IN THE REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM

Type of Residential Development	Infiltration and Storm Water Inflow Contributions (gpm/acre)
Low Density (0.5 to 5.5 persons/acre)	1.0
Medium Density (5.6 to 15.6 persons/acre)	1.2
High Density (15.7 to 39.1 persons/acre)	1.0

Source: Harza Engineering Company.

Figure 102

TRUNK SEWER DESIGN CURVES/LOW DENSITY URBAN DEVELOPMENT

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Gallons Per Capita Per Day

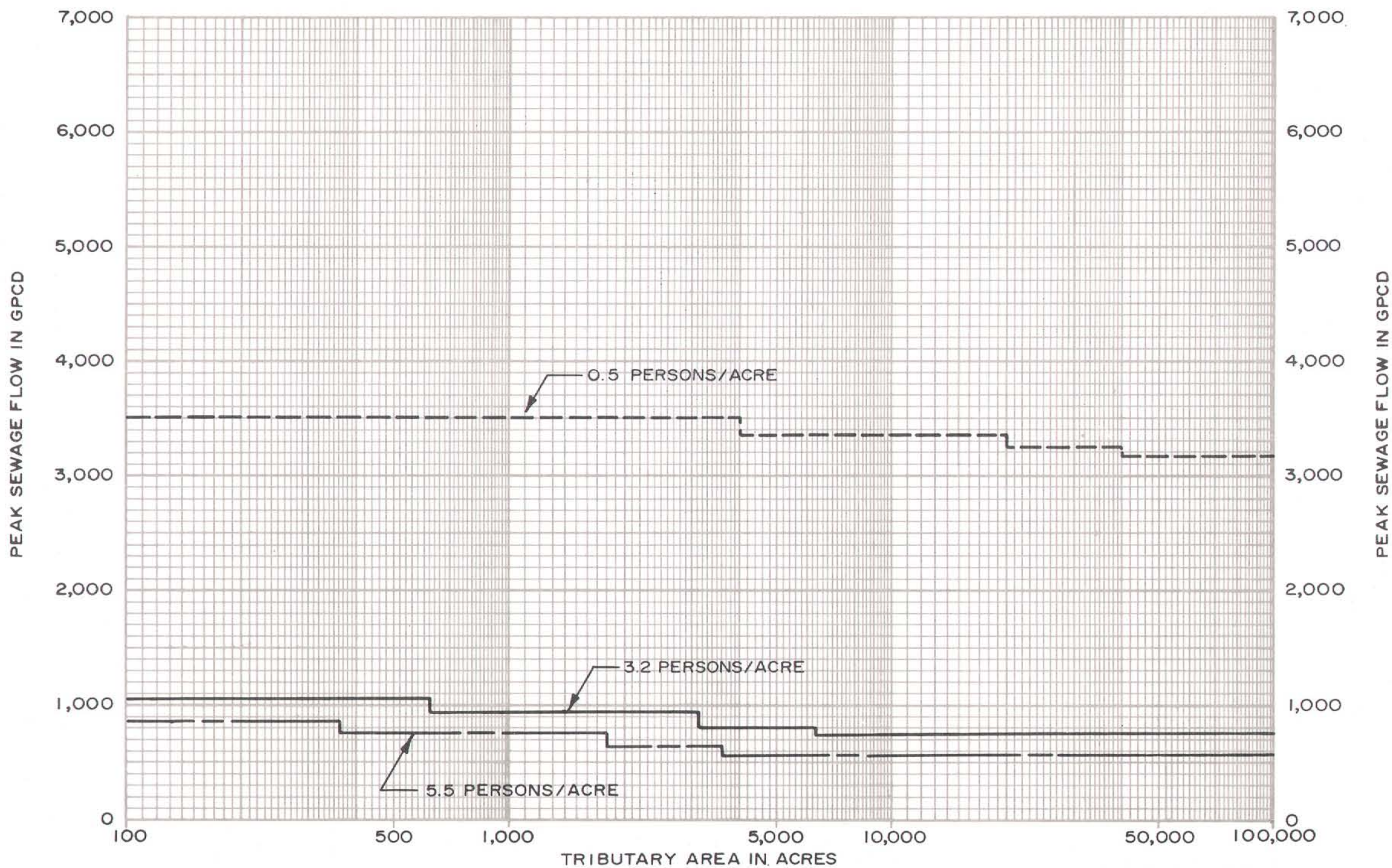


Figure 102--continued

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Cubic Feet Per Second Per Acre

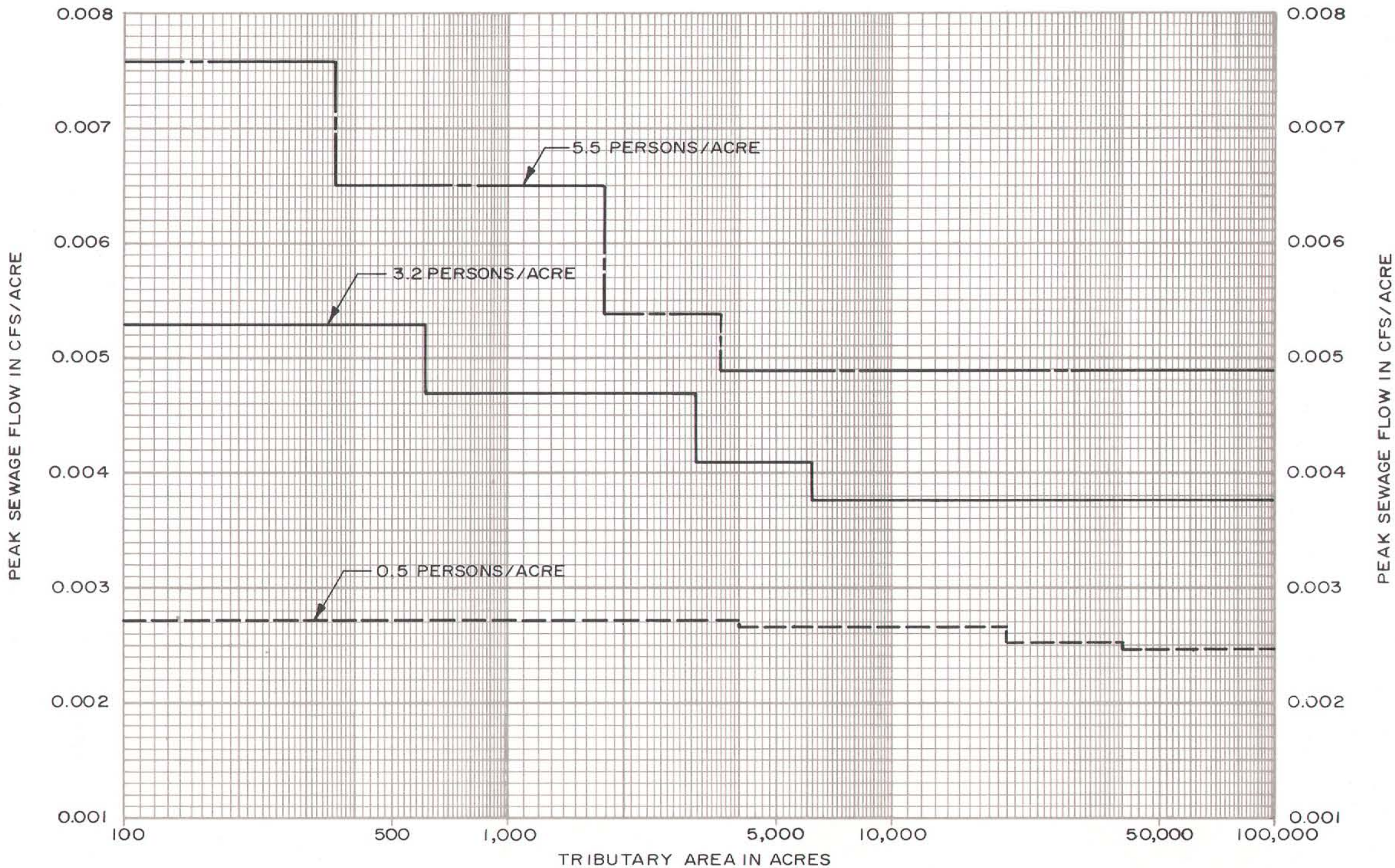
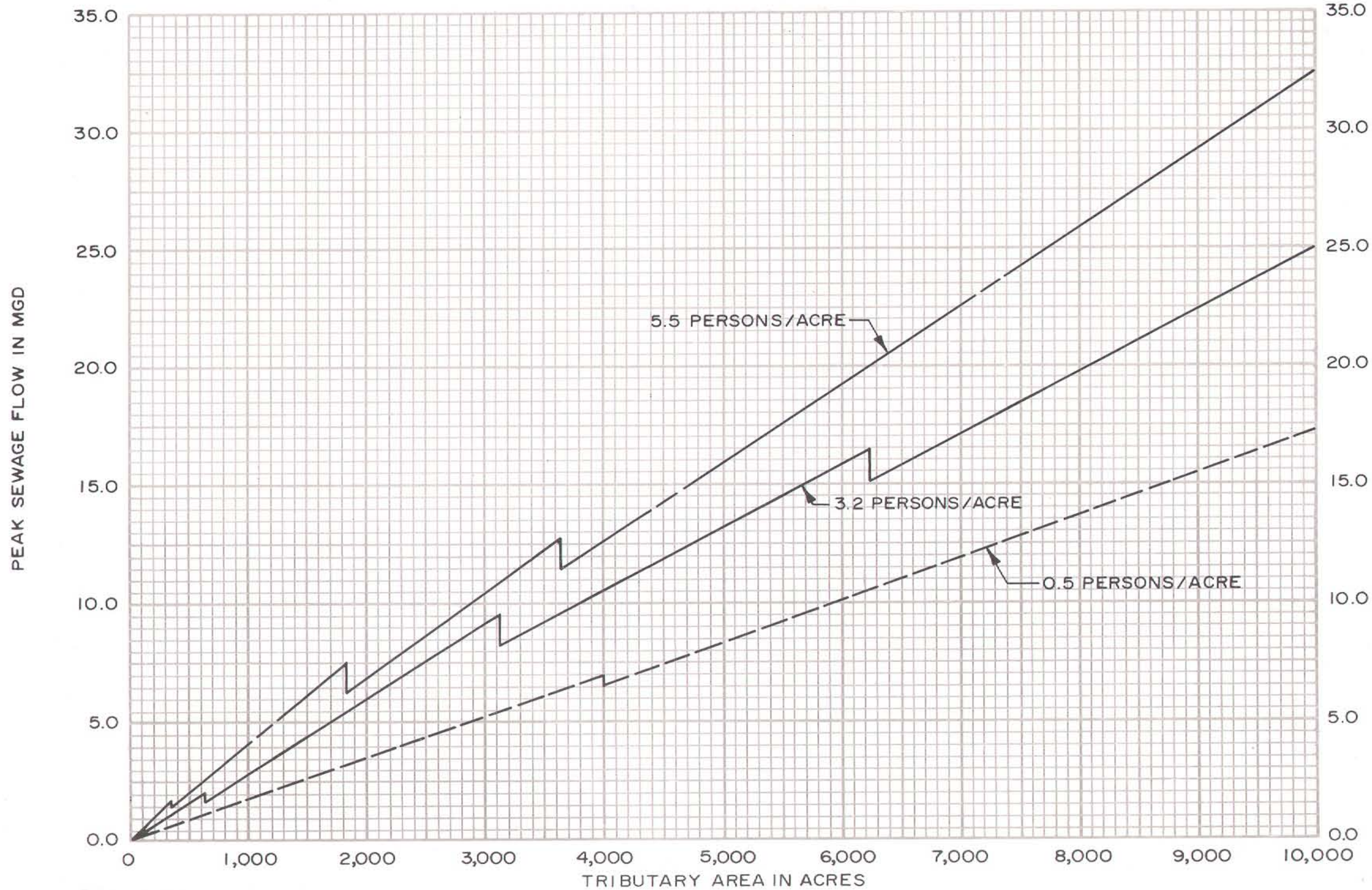


Figure 102--continued

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Millions of Gallons Per Day



NOTES:

(1) PEAK SEWAGE FLOW RATES ASSUME THE FOLLOWING:

a. AVERAGE DAILY SEWAGE FLOW: 125 gpcd

b. PEAK-TO-AVERAGE RATIOS:

POPULATION RANGE	PEAK-TO-AVERAGE RATIO
0– 1,999	5.0
2,000– 9,999	4.0
10,000–19,999	3.0
20,000 OR MORE	2.5

c. INFILTRATION: 0.5 gpm/ACRE

d. STORM WATER INFLOW: 0.5 gpm/ACRE

(2) 0.5 PERSONS PER ACRE, 3.2 PERSONS PER ACRE, AND 5.5 PERSONS PER ACRE CORRESPOND TO THE LOWER END, MIDDLE, AND UPPER END, RESPECTIVELY, OF THE SEWRPC LOW DENSITY URBAN DEVELOPMENT RANGE.

Source: Harza Engineering Company and SEWRPC.

Figure 103

TRUNK SEWER DESIGN CURVES/MEDIUM DENSITY URBAN DEVELOPMENT

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Gallons Per Capita Per Day

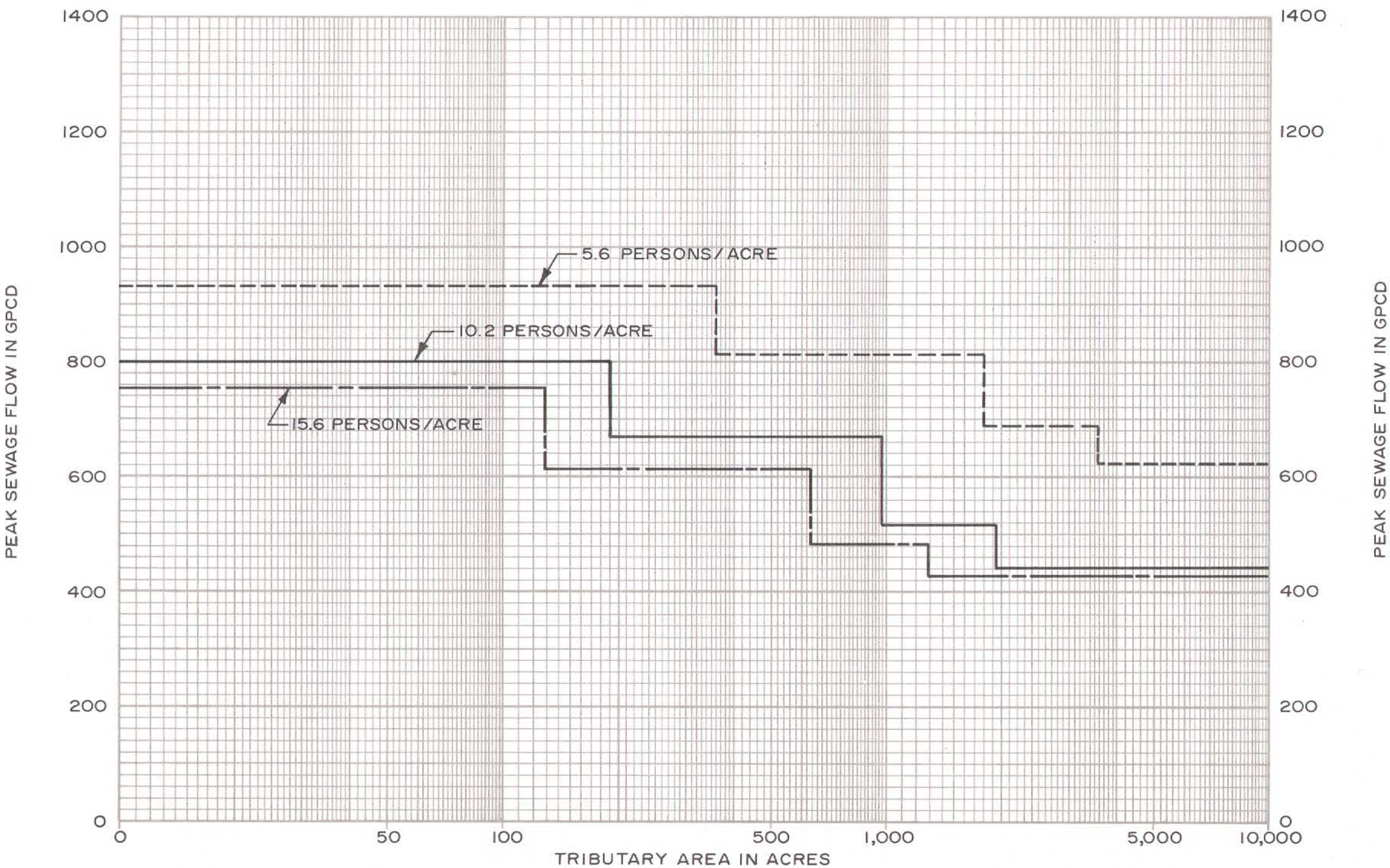


Figure 103--continued

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Cubic Feet Per Second Per Acre

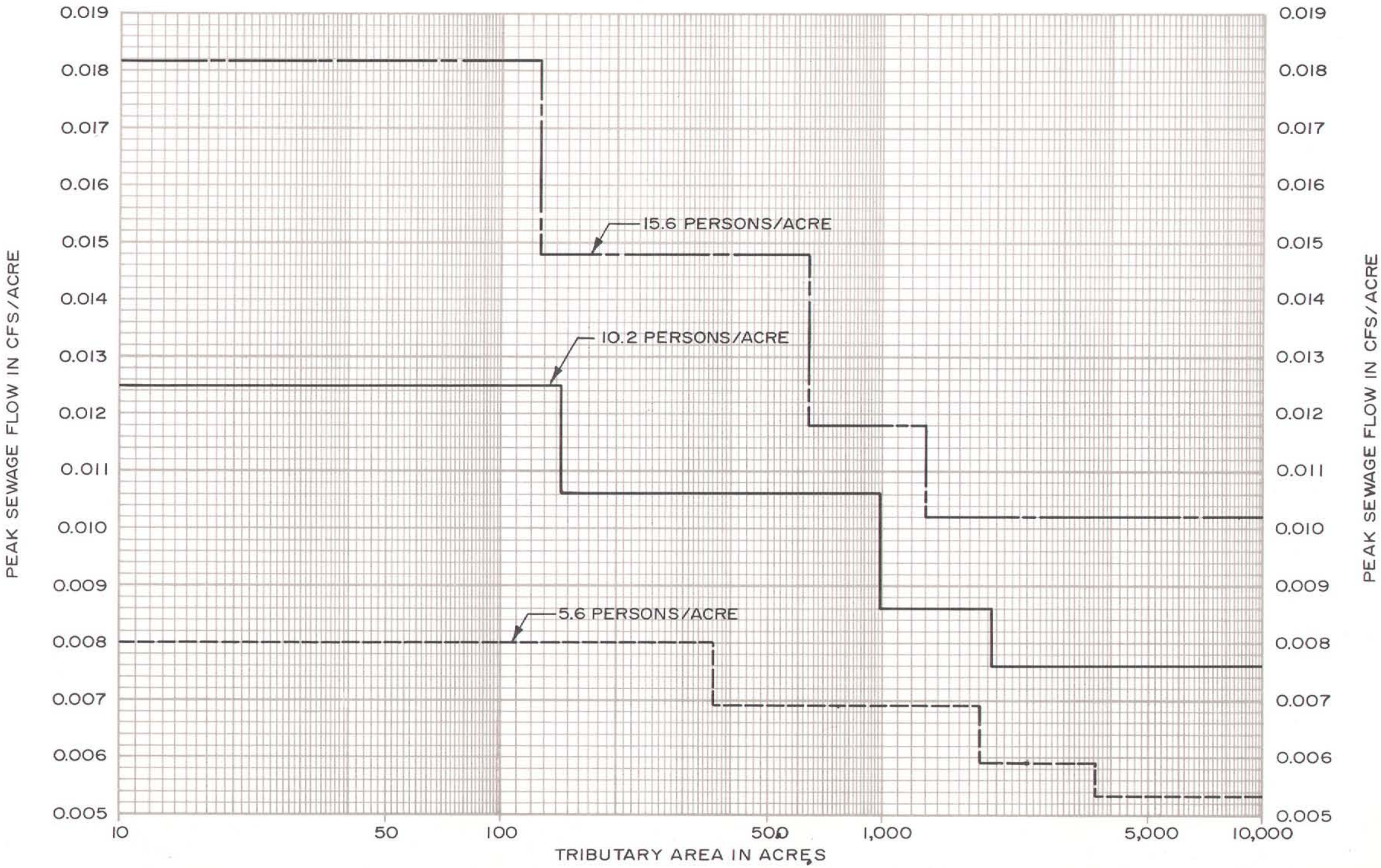
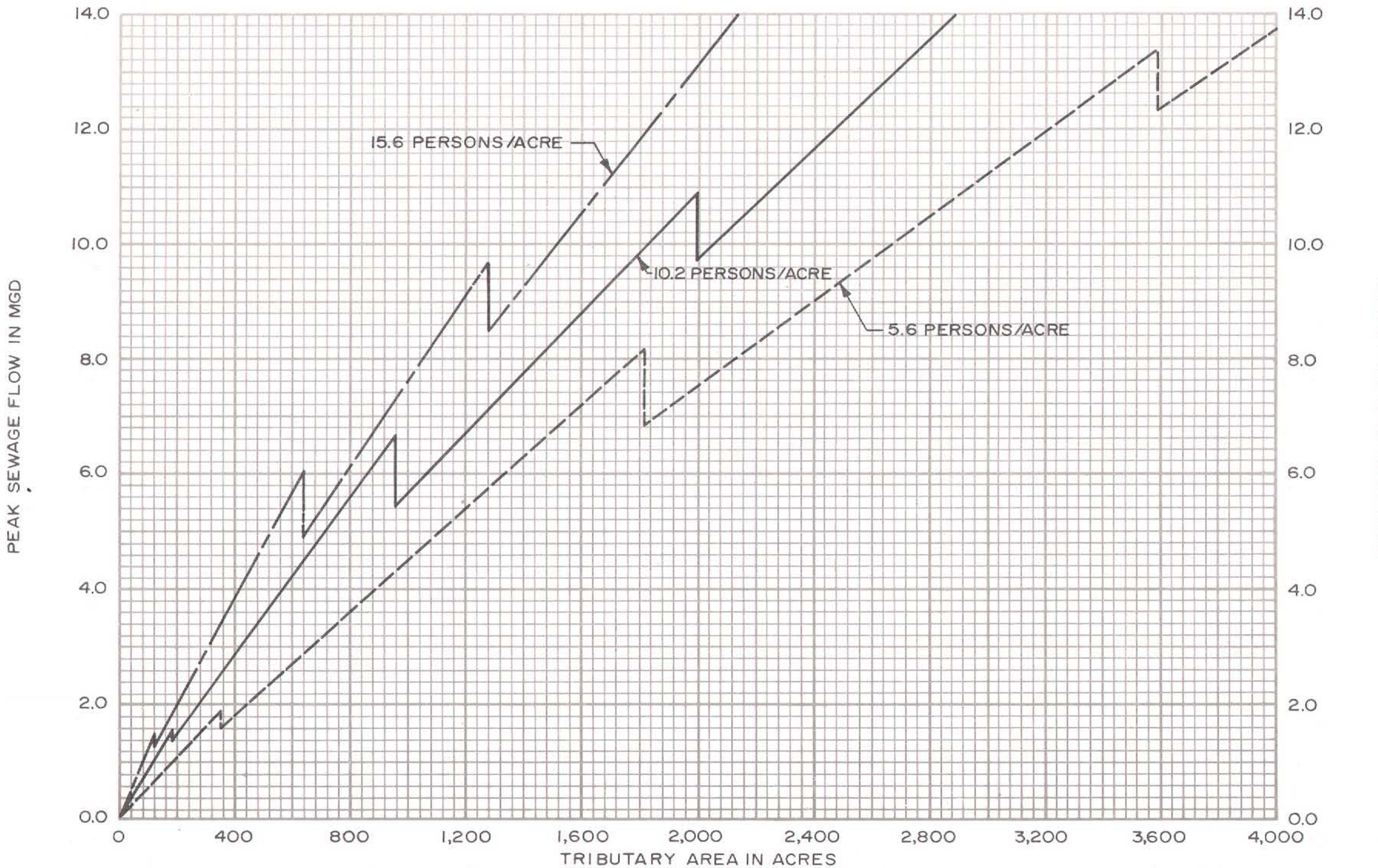


Figure 103--continued

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Millions of Gallons Per Day



NOTES:

(1) PEAK SEWAGE FLOW RATES ASSUME THE FOLLOWING:

a. AVERAGE DAILY SEWAGE FLOW: 125 gpcd

b. PEAK-TO-AVERAGE RATIOS:

POPULATION RANGE	PEAK-TO-AVERAGE RATIO
0 – 1,999	5.0
2,000 – 9,999	4.0
10,000 – 19,999	3.0
20,000 OR MORE	2.5

c. INFILTRATION: 0.6 gpm/ACRE

d. STORM WATER INFLOW: 0.6 gpm/ACRE

(2) 5.6 PERSONS PER ACRE, 10.2 PERSONS PER ACRE, AND 15.6 PERSONS PER ACRE CORRESPOND TO THE LOWER END, MIDDLE, AND UPPER END, RESPECTIVELY, OF THE SEWRPC MEDIUM DENSITY URBAN DEVELOPMENT RANGE.

Source: Harza Engineering Company and SEWRPC.

Figure 104

TRUNK SEWER DESIGN CURVES/HIGH DENSITY URBAN DEVELOPMENT

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Gallons Per Capita Per Day

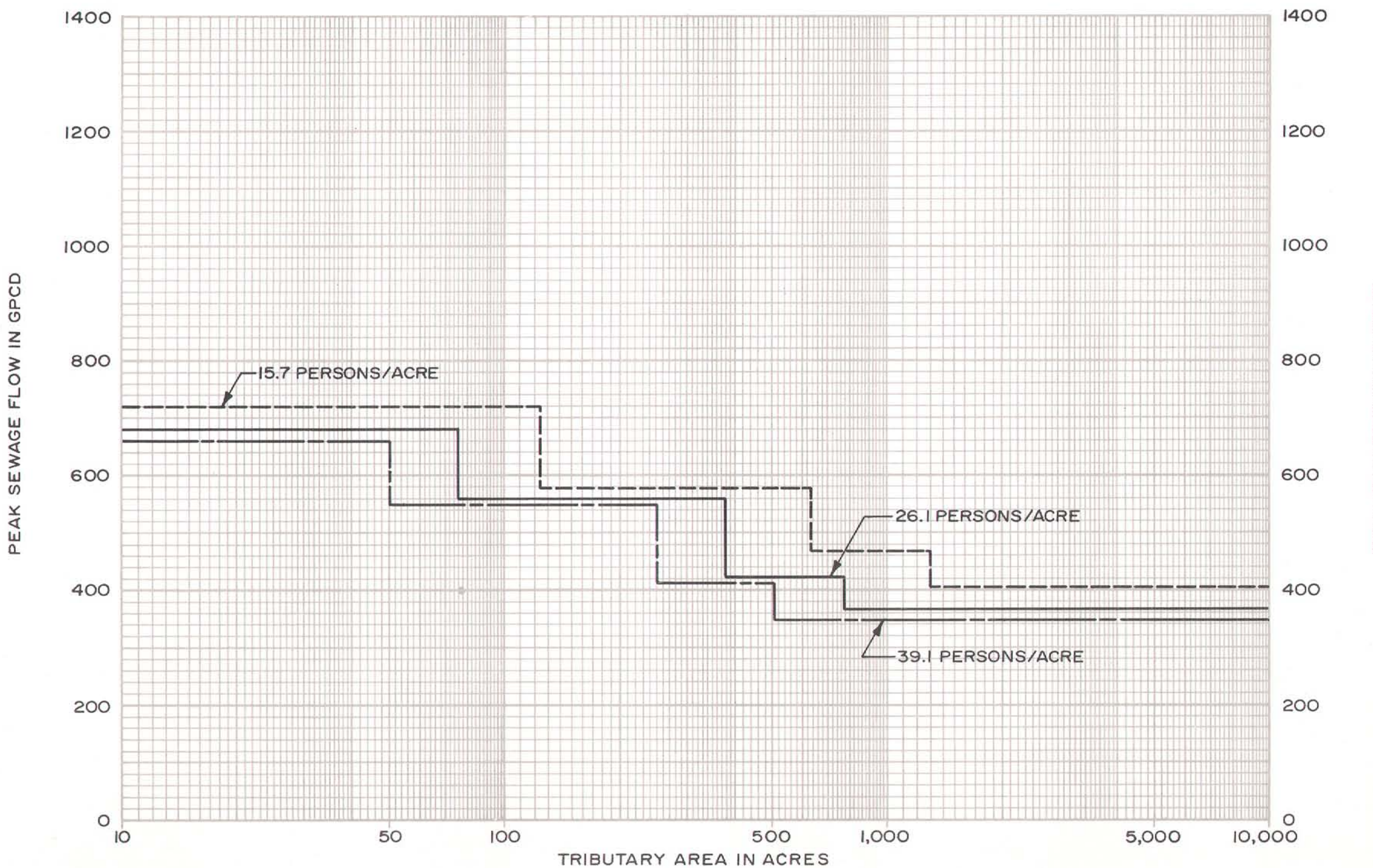


Figure 104--continued

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Cubic Feet Per Second Per Acre

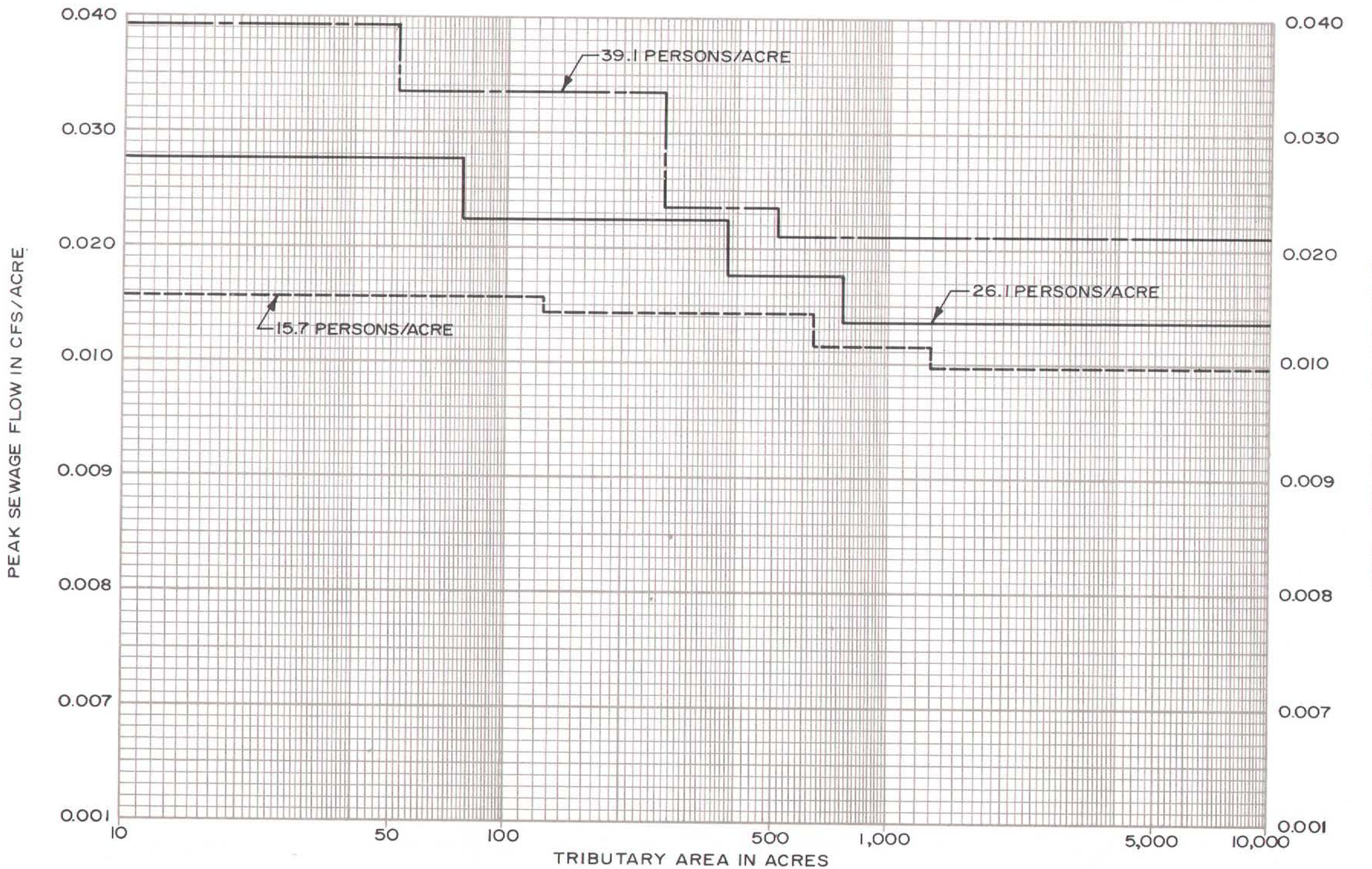
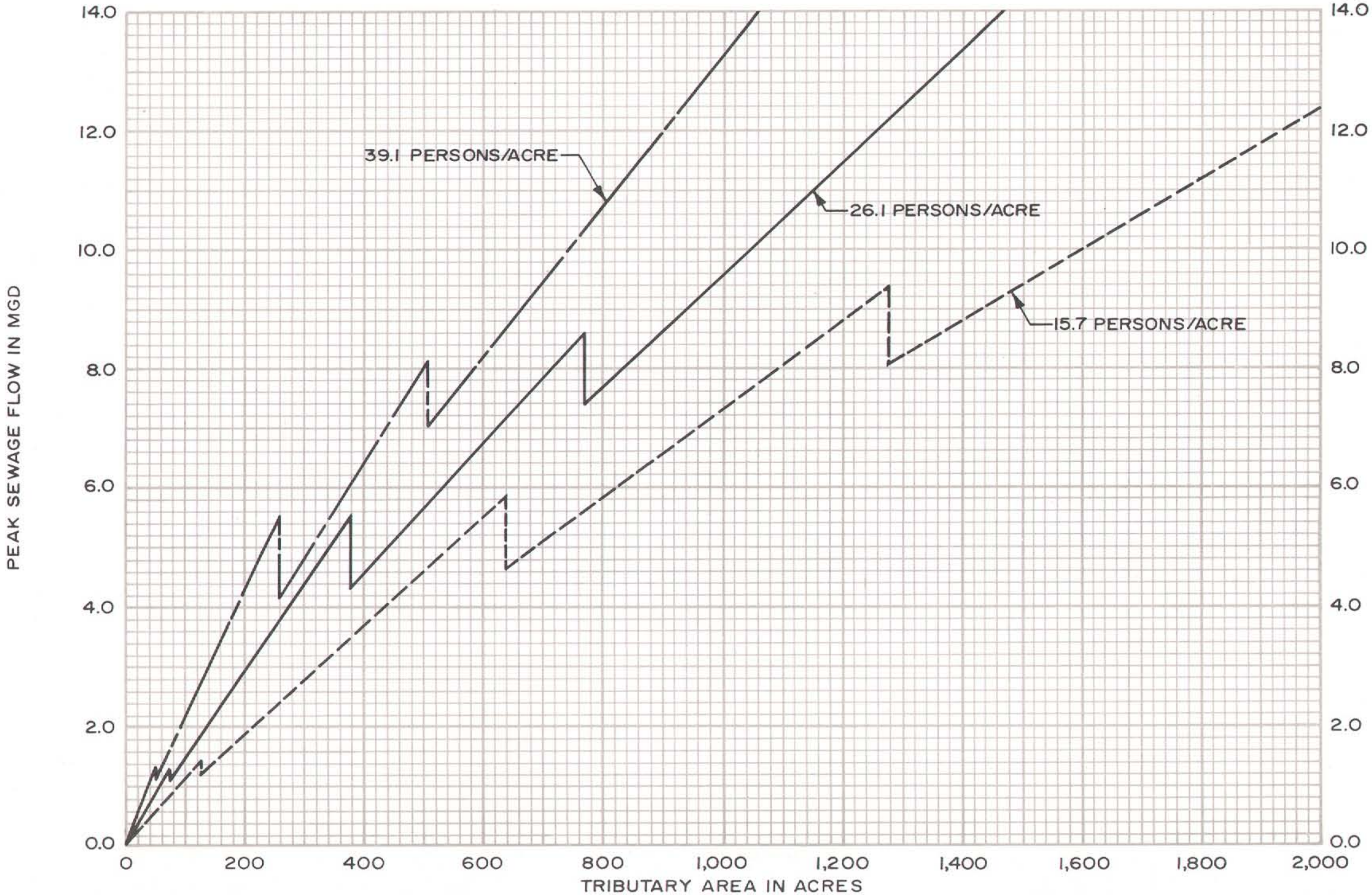


Figure 104--continued

Relationship Between Tributary Area in Acres and Peak Sewage Flow in Millions of Gallons Per Day



NOTES:

(1) PEAK SEWAGE FLOW RATES ASSUME THE FOLLOWING:

a. AVERAGE DAILY SEWAGE FLOW: 125 gpcd

b. PEAK-TO-AVERAGE RATIOS:

POPULATION RANGE	PEAK-TO-AVERAGE RATIO
0– 1,999	5.0
2,000– 9,999	4.0
10,000–19,999	3.0
20,000 OR MORE	2.5

c. INFILTRATION: 0.5 gpm/ACRE

d. STORM WATER INFLOW: 0.5 gpm/ACRE

(2) 15.7 PERSONS PER ACRE, 26.1 PERSONS PER ACRE, AND 39.1 PERSONS PER ACRE CORRESPOND TO THE LOWER END, MIDDLE, AND UPPER END, RESPECTIVELY, OF THE SEWRPC HIGH DENSITY URBAN DEVELOPMENT RANGE.

Source: Harza Engineering Company and SEWRPC.

age system planning program. This procedure incorporates the stated assumptions with respect to peak to average flow ratios, average daily per capita contribution of sanitary sewerage, infiltration, and storm water flows on an areal basis, but assumes that the 1990 forecast population is distributed within the sanitary sewer service area at medium density defined as 10.2 persons per acre. Thus the trunk sewer design criteria does not explicitly account for those scattered areas that may by 1990 contain low- or high-density residential development, but instead assumes that the population served will be at medium density.

Under this simplified procedure, the trunk sewer design flow was calculated by determining the forecast resident 1990 population in the tributary drainage area, multiplying this population by 125 gpcd, and multiplying this product by the appropriate peak to average flow ratio, the latter being based upon the forecast 1990 population level to be served. A combined infiltration and storm water inflow allowance of 1.2 gallons per minute per acre of tributary drainage area was then added to the product to obtain the required design flow. The forecast 1990 population was divided by 10.2 persons per acre to obtain the area to which the 1.2 gallons per minute combined infiltration and storm water allowance was applied.

The simplified trunk sewer design procedure used in the regional sanitary sewerage system planning program is set forth in Table 82. This design procedure is equivalent to using the curves for 10.2 persons per gross acre in Figure 103, provided that the designer enters that graph with an area computed as the quotient of forecast 1990 population and 10.2 persons per gross acre.

Although the trunk sewer design procedure applied under the sanitary sewerage study did not explicitly utilize the refined design procedures set forth in the aforementioned design curves, the adopted flow-generating procedures were determined to be precise enough for the intended purpose of comparing alternative trunk sewer configurations and selecting the most economic arrangement. A detailed analysis of the sensitivity of trunk sewer diameter to design flow and of trunk sewer costs to design flow revealed that the simplified trunk sewer design procedure, relative to the refined technique, will yield trunk sewer sizes within one or two standard pipe sizes, and more importantly, trunk sewer costs generally within plus or minus 20 percent regardless of which of the five sewer construction methods is used.

More specifically, if trunk sewers are sized for a low-density residential area with the assumption

Table 82

CRITERIA FOR TRUNK SEWER DESIGN FLOWS UTILIZED IN THE REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM

Sanitary Sewer Service Area		Sanitary Sewage				Infiltration[2]		Stormwater Inflow[2]	
1990 Population	Implicit Size[1] (Acres)	Average Daily Contribution (gpcd)	Peak-to-Average Ratio	Peak Daily Contribution (gpcd)	Percent of Total Instantaneous Peak Flow	Average Daily Contribution (gpcd)	Percent of Total Instantaneous Peak Flow	Average Daily Contribution (gpcd)	Percent of Total Instantaneous Peak Flow
0- 2,000	0- 196	125	5	625	78.6	85	10.7	85	10.7
2,000-10,000	196- 982	125	4	500	74.6	85	12.7	85	12.7
10,000-20,000	982-1,960	125	3	375	68.8	85	15.6	85	15.6
20,000+	1,960+	125	2.5	313	64.8	85	17.6	85	17.6

Sanitary Sewer Service Area		Total Instantaneous Peak Flow					
		Expressed in Gallons Per Capita Per Day		Expressed in Equivalent Units			
1990 Population	Implicit Size[1] (Acres)	(gpcd)	Percent Total	Million Gallons/Day (mgd)	Gallons/Acre/Day (gpad)	Cubic Feet/Second (cfs)	Cubic Feet/Second/ Acre (cfs/Acre)
0- 2,000	0- 196	795	100.0	0- 1.59	8,120	0- 2.46	0.0126
2,000-10,000	196- 982	670	100.0	1.34- 6.70	6,830	2.08-10.40	0.0106
10,000-20,000	982-1,960	545	100.0	5.45-10.90	5,550	8.45-16.90	0.00860
20,000+	1,960+	483	100.0	9.67+	4,930	15.0+	0.00765

[1]All sanitary service areas were assumed to be composed of medium density urban land uses with 10.2 persons per acre. The size, in acres, of the sanitary sewer service area resulting from this assumption is obtained by dividing the population served by 10.2 people per acre.

[2]The infiltration rate and the stormwater inflow rate for medium density residential land use are each 0.6 gpm per acre of residential area served. Since population density is assumed to be 10.2 people per acre, infiltration and stormwater inflow may each be expressed on a per capita basis as 85 gpcd.

Source: Harza Engineering Company and SEWRPC.

that the forecast 1990 population is distributed at a medium density of 10.2 persons per acre, the resulting trunk sewer design flow could be as little as 60 percent of the design flow that would be obtained from the design curves for a low-density distribution of 3.2 persons per acre. The design trunk sewer diameter would be smaller than, but within two standard pipe sizes of, that needed to carry the precisely determined flow, and the design cost would be less than, but within 20 percent of the cost of, the precisely determined sewer size.

If, on the other hand, trunk sewers are sized for a high-density residential area with the assumption that the 1990 forecast population is distributed at a medium density of 10.2 persons per acre, the resulting trunk sewer design flow would be as much as 130 percent of the design flow that would be obtained from the design curves for a high-density distribution of 26.1 persons per acre. The design trunk sewer diameter would be larger than, but within one standard pipe size of, that needed to carry the precisely determined flow, and the design cost would be more than, but within 15 percent of the cost of, the precisely determined sewer size.

There are, of course, relatively few sanitary sewer service areas that are projected to have primarily low- or high-density residential development in 1990. This is especially true for densities of less than 3,500 persons per square mile or 5.5 persons per acre since, as discussed elsewhere in this report, sanitary sewer systems are generally not economic for such low-density areas and therefore not recommended unless soil conditions are unsuitable for onsite sewage disposal systems. Furthermore, the bulk of the forecast 1990 sanitary service areas contains at least some medium-density residential land use and, therefore, the aforementioned pipe size and pipe cost tolerances are in excess of that which will be associated with most trunk sewers in the alternative and recommended plans.

In summary, then, the simplified procedure used to size trunk sewers under the regional sanitary sewerage system planning program is precise enough for the stated purpose of evaluating alternative trunk sewer configurations and selecting the most economic system; that is, the simplified procedure will adequately determine the relative costs between alternative sewerage system configurations. It might be added that although it would be technically possible to use both 1990 forecast population and forecast population density to design trunk sewers for the sanitary sewerage system plan, this degree of detail would not be warranted because of local variations in land use relative to those projections that are likely to occur between now and 1990.

The design criteria set forth above were utilized in the regional sanitary sewerage system planning program to size all sewerage system components except sewage treatment plants. The criteria were not, however, used to size trunk sewers lying within the service area of the Milwaukee-Metropolitan Sewerage Commissions, the long-range system plan adopted by those Commissions being incorporated into the regional system plan without change.

The sanitary sewerage system plans developed by the Regional Planning Commission under the Fox and Milwaukee River watershed studies were reanalyzed under the regional sanitary sewerage system planning program, utilizing the aforementioned design criteria. In each case, it was determined that the application of the design criteria selected for use in the regional sanitary sewerage system planning program would not substantially alter the design of the sewerage system components already recommended in the comprehensive plans for the Fox and Milwaukee River watersheds.

A tabular comparison of the trunk sewer design criteria used in the sanitary sewerage system planning program with certain design criteria commonly used in other sewer planning efforts within the Region is set forth in Table 83. Sewerage study trunk sewer design criteria are compared with those used in the SEWRPC Fox and Milwaukee River watershed studies, with trunk sewer design criteria included in the "Ten States Standards" and with those recommended by the Milwaukee-Metropolitan Sewerage Commissions and the City of Milwaukee Bureau of Engineers.

There are, of course, other design criteria used in the planning region, but the selected ones included in Table 83 are sufficient to illustrate the relatively wide range in existing design criteria applied to sanitary sewer service areas containing primarily residential land use. This variability in design criteria is probably attributable to a variety of factors, including observed behavior of local sewer systems and different

Table 83

COMPARISON OF TRUNK SEWER DESIGN FLOW CRITERIA

Population Served	Planning Study, Agency, or Organization					
	SEWRPC Fox River Watershed Study (gpcd)	SEWRPC Milwaukee River Watershed Study[2] (gpcd)	SEWRPC Regional Sanitary Sewerage System Planning Study (gpcd)	Ten States Standards[3] (gpcd)	Metropolitan Sewerage Commission of Milwaukee County[4] (gpcd)	City of Milwaukee[5] (gpcd)
0- 2,000	240	240 to 290	795	250	700 - 970	760
2,000-10,000	240 or 360	290 to 370	670	250	700 - 970	760
10,000-20,000	360	370 to 400	545	250	700 - 970	760
20,000+	360	400 -	483	250	700 - 970	760

[1]Restricted to sanitary sewer service areas containing primarily residential development; includes allowance for infiltration and storm water inflow.
[2]Per capita contribution is a continuous function of population as shown on page 235, Figure 36 in SEWRPC Planning Report No. 13, Volume I.
[3]Minimum recommended per capita flows.
[4]Sewerage Commission criteria specify a design flow of 0.015 cfs per gross acre for population densities in the range of 10 to 14 people per gross acre which is equivalent to instantaneous peak design flow range of 700 to 970 gpcd. At medium urban population density, defined for purposes of this study as 10.2 people per acre, Sewerage Commission instantaneous design flows are equivalent-to 950 gpcd. These design criteria are applicable to sanitary sewers connected directly to trunk and intercepting sewers under the jurisdication of the Sewerage Commission. Those trunk sewers and intercepting sewers are designed to carry 450 gpcd.
[5]City of Milwaukee design criteria specify a design flow of 0.010 to 0.014 cfs per gross acre for single family residential areas having 4.86 to 3.64 dwelling units per net residential acre. At medium density, defined by SEWRPC as having an average of 4.3 dwelling units per net residential acre, City of Milwaukee design flows are, by interpolation, about 0.012 cfs per gross acre. At medium density, defined by SEWRPC as having an average of 10.2 people per gross acre, the City of Milwaukee instantaneous design flow is equivalent to 760 gpcd.
[6]240 gpcd for a population of less than 5,000 and 360 gpcd for a population of 5,000 or more.

Source: SEWRPC.

judgements among design engineers with regard to the absolute and relative magnitude of sewage flow components such as sanitary sewage, infiltration, and storm water inflow which should be considered in establishing peak flows. Design criteria used in the sewerage system planning program are seen to be high on a per capita basis relative to all other criteria except those of the Milwaukee-Metropolitan Sewerage Commissions. The criteria selected for use in the sewerage study are considered reasonable, however, since as discussed in this chapter they were rationally developed by combining projected average per capita contributions of sanitary sewage flow (125 gpcd), documented sanitary sewage peak to average flow ratios (ranging from a low of 2.5 to a high of 5.0) as reported in the ASCE Manual Design and Construction of Sanitary and Storm Sewers, medium-density population distribution (10.2 persons per acre), and estimates of infiltration and storm water inflow (0.6 gpm per acre for each) in general conformance with both accepted infiltration rates and with regional experience as discussed later in this chapter.

Sewer Hydraulics

The selection of design criteria for determining hydraulic factors involved in sewer design such as friction, capacity, velocity, slope, and depth of sewage flow is equally as important as the determination of the amount of sewage flow anticipated in a given component of a sanitary sewerage system. This section of the chapter presents the hydraulic design criteria utilized in the regional sanitary sewerage system planning program.

Considerable attention has been directed in recent years to the analyses of the relationship between sewage flow velocity and deposition in sewers. If the average depth of flow in a sewer decreases, the slope necessary to provide a scouring velocity increases. Since sewers installed with a flow capacity corresponding to projected population development for a 20-year plan design period will initially be flowing at partial depths, it is important to determine the self-cleansing velocity at partial depth flow. Sewers designed to provide self-cleansing velocity at full pipe flow may well not be self-cleansing at partial depth flow.

The Manning equation, $V = \frac{1.486}{n} R^{2/3} S^{1/2}$, was used in the regional sanitary sewerage system planning program to determine the hydraulic characteristics of components of the sanitary sewerage systems contained in the plan.[16] Values for the Manning roughness coefficient "n" vary with the type and conditions of the sewer, the depth of flow in the sewer, and the diameter of the sewer. For velocity calculations at less than full depth, the values of "n" are selected from the curves shown in Figure 105. The significant variation of Manning's "n" with depth is evident from an examination of the curves shown in Figure 105. In the past, sanitary engineers have assumed that the same velocity existed in a sewer when it flowed one-half full as when it flowed full. The relationships portrayed in Figure 105, however, indicate that the full-flow velocity is not attained until the ratio of partial depth to full-flow depth equals 0.78, instead of 0.5 ratio as previously assumed. However, the self-cleansing velocity decreases as the depth decreases, as shown by the curve in Figure 106 labeled "velocity for equal cleansing."

In the regional sewerage plan, sewers were designed to flow full at a velocity of two feet per second for the peak design flow. The concept of constructing sewers on slopes great enough to provide self-cleansing velocities for the flow from

[16] *Several formulas may be used in hydraulic computations. The Chezy formula, experimentally developed about 1770 by the French engineer Antoine Chezy, is the basis for most formulas used for turbulent flow in open channels, that is, liquid flow in which the fluid surface is in contact with the atmosphere, as well as closed conduit or pipe flow defined as fluid flow in which the fluid does not have a free surface but instead completely assumes the shape of the conduit and is generally at a pressure greater than that of the atmosphere. Sanitary sewers are normally designed to function as open channel conveyance devices although it is occasionally necessary for them to be designed to operate under pipe flow conditions, such as when they are connected to the discharge end of lift stations or when they are an integral part of an inverted siphon beneath a stream or other obstacle. The Chezy formula is:*

$$V = C(RS)^{1/2}$$

where: V is the mean velocity in feet per second, C is a flow resistance factor called Chezy's C, R is the hydraulic radius of the channel or conduit in feet defined as the quotient of the cross-sectional area of flow A and the wetted perimeter P, and S is the slope of the hydraulic grade line. Although Antoine Chezy originally developed and verified the formula using experimental data for open channel flow, it may be mathematically derived for both open channel flow and pipe flow.

From the time of its introduction, the principal problem associated with practical application of the Chezy formula has been determination of the Chezy flow resistance factor C. As a result, many investigators have developed and reported on experimentally derived formulas for Chezy's C. The more significant formulas include one by Ganguillet and Kutter, two Swiss engineers, which was published in 1869 and expressed Chezy's C as a function of S, $R^{1/2}$ and a coefficient of channel roughness called Kutter's n; the Basin formula proposed in 1897 by the French engineer of that name which expressed C as a function of only $R^{1/2}$ and Bazin's m, the latter being a coefficient of channel roughness. In 1867 P. G. Gauckler, a French engineer, proposed an experimentally derived equation for open channel flow that was equivalent to expressing Chezy's C as being directly proportional to $R^{1/6}$. Subsequently, many other investigators, including the Irish engineer Robert Manning in 1889, proposed the same dependence of Chezy's C on $R^{1/6}$. The proportionality constant was later determined to be 1.49/n where n, the coefficient of channel roughness, has been incorrectly attributed to Manning, inasmuch as it is now referred to as Manning's n. Manning's n may be considered identical to Kutter's n for sanitary sewer hydraulics computation. Thus, based on the work begun by Gauckler, and completed by others, Chezy's C is expressed as:

$$C = \frac{1.49}{n} R^{1/6}$$

and this expression, combined with the Chezy formula, yields the familiar open channel formula

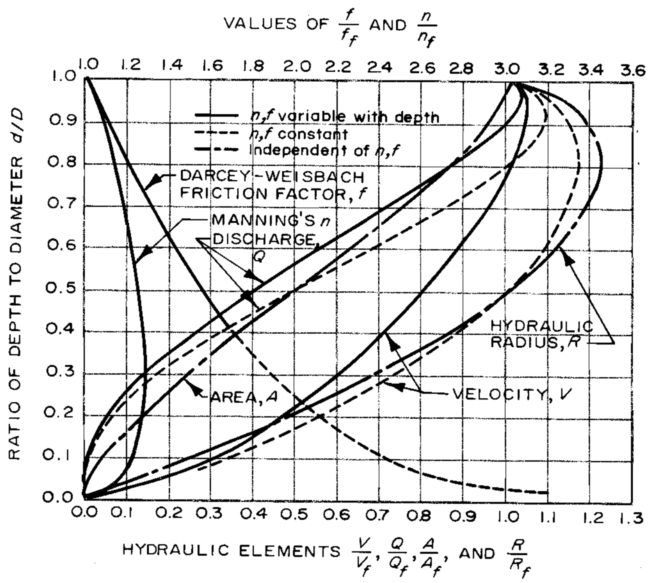
$$V = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

which has been misnamed and is now commonly accepted as the Manning formula.

The Ganguillet and Kutter formula, the Basin formula, and other available formulas are generally not as suitable for practical application as the Manning formula because they are either based on limited experimental data, as is the Bazin formula, or are cumbersome to use without computational aids, as is the Ganguillet-Kutter formula. The Manning formula produces results equal to or better than all other formulas and lends itself to rapid calculations, primarily because of its relatively simple form and the availability of a variety of nomographs and other computational aids. Because of this combination of accuracy and ease of use, the Manning formula is the most widely used of all open channel flow formulas both internationally and in the United States, and was recommended for international use in 1936 by the Third World Power Conference. Therefore, the Manning equation is recommended by SEWRPC for open channel computations related to sanitary sewerage system analysis and design. (References: V. T. Chow, Open Channel Hydraulics, Chapter 5, McGraw-Hill Book Company, Inc., 1959; and G. P. Williams, "Manning Formula--A Misnomer," Journal of the Hydraulics Division, ASCE, Volume 96, Number HY1, January 1970, page 193.)

Figure 105

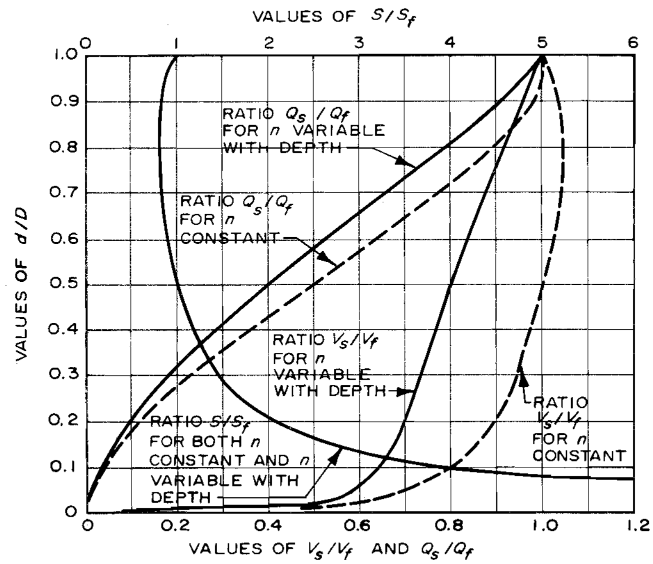
HYDRAULIC ELEMENTS OF CIRCULAR SEWERS



Source: *ASCE Manual No. 37*, *__Design and Construction of Sanitary and Storm Sewers__*, *1969, p. 87.*

Figure 106

HYDRAULIC ELEMENTS OF CIRCULAR SEWERS THAT EXHIBIT EQUAL CLEANSING PROPERTIES AT ALL DEPTHS



DEFINITIONS:

SELF-CLEANSING CONDITION: VELOCITY AND SLOPE VALUES UNDER LESS THAN FULL FLOW DEPTH CONDITIONS THAT ARE REQUIRED TO TRANSPORT THE SAME SIZE ORGANIC PARTICLES AND GRIT AS WOULD BE TRANSPORTED WHEN THE SEWER FLOWS FULL.

n	MANNING ROUGHNESS COEFFICIENT
Q_f	DISCHARGE FLOWING FULL
Q_s	DISCHARGE AT LESS THAN FULL FLOW DEPTH BUT WITH A SELF-CLEANSING VELOCITY
S_f	SLOPE FLOWING FULL
S	SLOPE REQUIRED AT LESS THAN FULL FLOW DEPTH TO OBTAIN SELF-CLEANSING VELOCITY
V_s	VELOCITY AT LESS THAN FULL FLOW DEPTH BUT SUFFICIENT FOR SELF-CLEANSING
V_f	VELOCITY FLOWING FULL

Source: *ASCE Manual No. 37*, *__Design and Construction of Sanitary and Storm Sewers__*, *1969, p. 90.*

the 1970 population was investigated but rejected because of the increased frequency of pumping stations which this would require and the associated costs and maintenance problems. Sewers designed for 1990 flows may experience some deposition under initial flow conditions, but scouring velocities should occur at least once a day even under such initial flow conditions. For example, a 48-inch diameter sewer with a capacity of about 15 mgd at two fps will serve a population of 30,000 persons assuming medium-density development. If only 30 percent of the assumed tributary population, about 9,000 persons, were initially connected, an initial peak flow of about 6.0 mgd and a resulting self-cleansing velocity would be achieved. This relationship can be calculated using the ratio of flows and Figure 106. For flows from a population less than 30 percent of the design population, self-cleansing velocities will not be developed and sewer flushing will be required periodically.

As shown by the curves in Figure 106, partially full sewers develop the same self-cleansing characteristics at lower velocities. The maximum velocity allowable in gravity flow sewers was assumed to equal 15 feet per second. In addition, since slime growths and grease deposition are anticipated on all pipe materials, a uniform flow for "n" for all full-flowing pipes was used. This value is equal to 0.013. An "n" of 0.015 was used for cement-lined cast iron force mains.

Design conditions which tend to cause stoppages in sewers should also be avoided wherever feasible. These conditions include changes in grade from a steep slope to a flatter slope causing subsequent reduction in velocity and resulting sedimentation, and changes in grade from a relatively flat slope to a considerably steeper slope where the depth of sewage decreases to less than critical depth, thereby possibly stranding settleable materials which may eventually block the sewer.

In summary, the following hydraulic design criteria were utilized for the sizing of sewers included in the regional sanitary sewerage system plan:

1. The Manning formula was used for calculation of sewer flow velocities, discharges, and slopes.

2. A Manning roughness coefficient, "n value," of 0.013 was used for sewer hydraulics calculations with the exception of cement-lined cast iron force mains where a coefficient of 0.015 was used.

3. Sewers were designed to flow full at a maximum velocity of 15 feet per second and at a minimum velocity of two feet per second under peak design flow conditions.

Construction Practices

In addition to design criteria relating to sewage flow and the hydraulic characteristics of sewers, assumptions must be made in the design of sewers as to construction practices. Included in this category of design assumptions are such factors as minimum and maximum depth of sewers, minimum diameter of sewers, manhole spacing, and sewer trench excavation.

Trench excavation represents a significant component of sewer construction costs. It is, therefore, desirable to locate trunk sewers at as shallow a depth as possible. In glaciated areas such as southeastern Wisconsin, soil conditions may vary greatly with depth. Consequently, the deeper the sewer the less certainty there is about potential construction conditions such as bedrock, soil texture, and groundwater levels.

The minimum depth of trunk sewers is dictated by the frost depth, the ability to provide gravity drainage of sewage from basements, live and dead loads on trenches, interference with other utilities, and existing and proposed street grades. In the regional sanitary sewerage system planning program, the sewers were designed to provide a gravity flow system wherever possible. In some cases, however, a small collection system must be located relatively deep in the ground. It is more economical to locally pump the collected sewage to the trunk sewers than to lower the trunk sewers to influent sewer elevation.

A practical minimum depth of trunk sewers is established by the depth of the frost line. Based upon a conservative interpretation of the frost penetration data presented in Chapter IV of this report, a minimum cover of 7 feet to the top of the sewer was maintained in the design of all sewers in the regional sanitary sewerage system plan. In those instances where sewers cross streams having a continuous flow throughout the winter, the top of the sewer was held to a minimum depth of 3 feet below the bottom of the stream bed. Where streamflow is not ensured during the winter, a minimum depth of 7 feet was maintained where sewers cross such streams. Where inverted siphon crossings are required, a minimum of two conduits was assumed with appropriate control structures to prevent deposition of sewage solids.

Areas covered by soils poorly suited for the construction of sanitary sewerage systems were avoided where possible in siting of the system components. In some situations, it was not possible to avoid such poor soil areas. In such cases, the cost estimates were adjusted to reflect increased construction costs due to rock excavation or trench dewatering.

The minimum diameter trunk sewer contained in the regional sanitary sewerage system plan is 8 inches. Such small trunk sewers occur in some of the smaller communities in the Region. In the urbanized areas of the three metropolitan areas of the Region, the regional sanitary sewerage system plan includes only those gravity trunk sewers greater than 12 inches in diameter.

The spacing of manholes along trunk sewers contained in the regional sanitary sewerage system plan was varied depending upon the size of the sewer. Table 84 presents the maximum manhole spacing utilized in the program. In addition, it was assumed that manholes would be constructed

Table 84

MAXIMUM SPACING OF MANHOLES UTILIZED IN THE REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM

Diameter (inches)	Maximum Spacing (feet)
8 - 30	400
33 - 36	600
39 - 42	700
48	800
54 - 60	900
Larger than 60	1,000

Source: Harza Engineering Company.

at all changes in grade, direction, and diameter of sewer. It is recognized that the spacing utilized in the design of these sewers in part exceeds that now permitted under the Wisconsin Administrative Code. The spacing utilized, however, reflects good current engineering practice and meets current maintenance requirements.

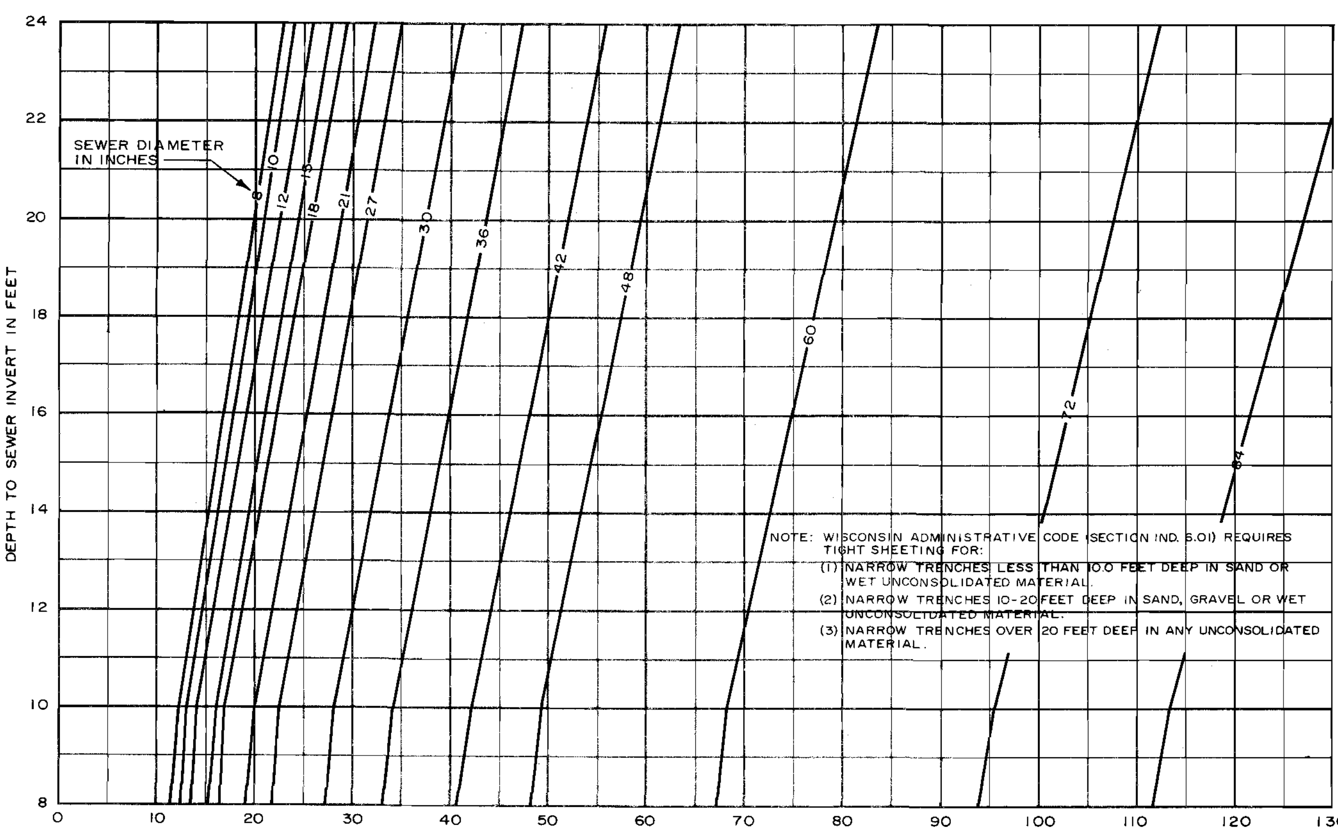
Cost Estimates

In order to permit economic evaluation and comparison of alternative sewerage system plans, a consistent method of sewerage system construction and operation cost estimation was developed based upon the use of a series of estimation curves. The curves, intended for use in the economic evaluation of alternative system plans, are not intended to be used for project cost estimating purposes. In order to provide consistency in the necessary economic evaluations and comparisons, the same unit costs were used throughout the Region. It should be recognized that actual costs will vary somewhat throughout the Region, with the costs in the larger urbanized areas of the Region tending to be higher than in the outlying rural areas of the Region, primarily because of varying labor rates. All costs are adjusted to January 1970.

The costs utilized in the regional sanitary sewerage system planning program for trunk sewers are shown in a series of curves contained in Figures 107 through 111. These cost curves, which were applied to all gravity flow trunk sewers and to force mains contained in the regional sanitary sewerage system plan, were developed to include sewer construction costs such as trench excavation, pipe and related materials, backfill, and labor, but not costs related to engineering, inspection, and contingencies. An allowance of 35 percent was added to cover these latter items. All necessary manholes and appurtenances are included in these cost estimates, which were developed especially for the Southeastern Wisconsin Region utilizing 1970 as a base year and

Figure 107

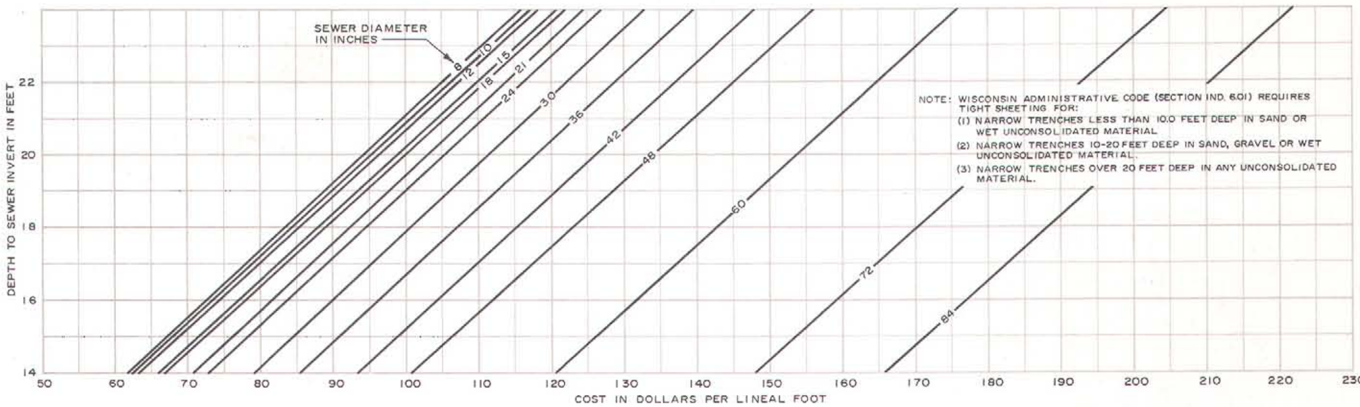
CONSTRUCTION COSTS OF TRUNK SEWERS IN HARD, SOLID, AND DRY SOILS WITH MINIMUM SHEETING



Source: Harza Engineering Company and SEWRPC.

Figure 108

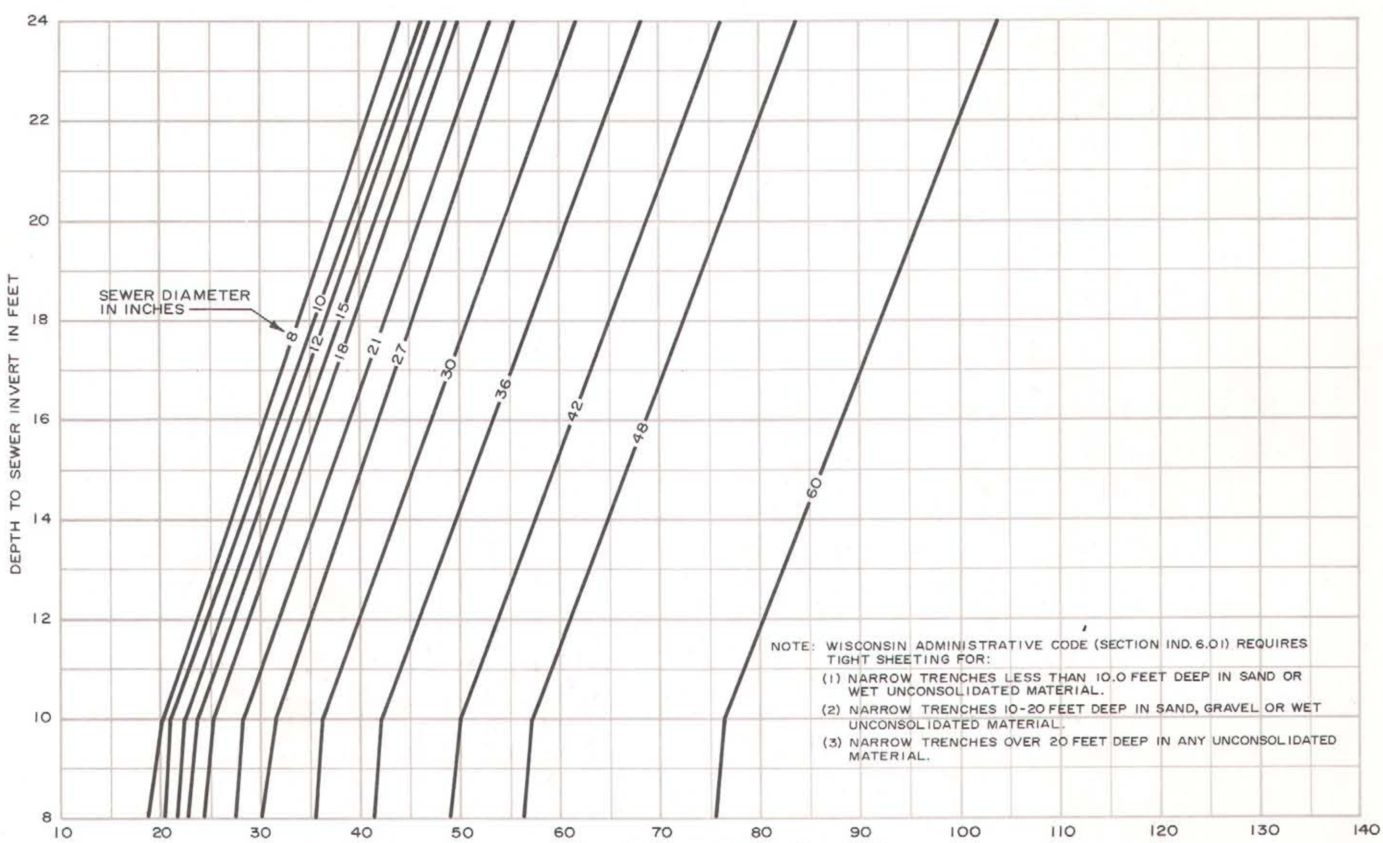
CONSTRUCTION COSTS OF TRUNK SEWERS IN HARD, SOLID, AND DRY SOILS WITH FULL SHEETING



Source: Harza Engineering Company and SEWRPC.

Figure 109

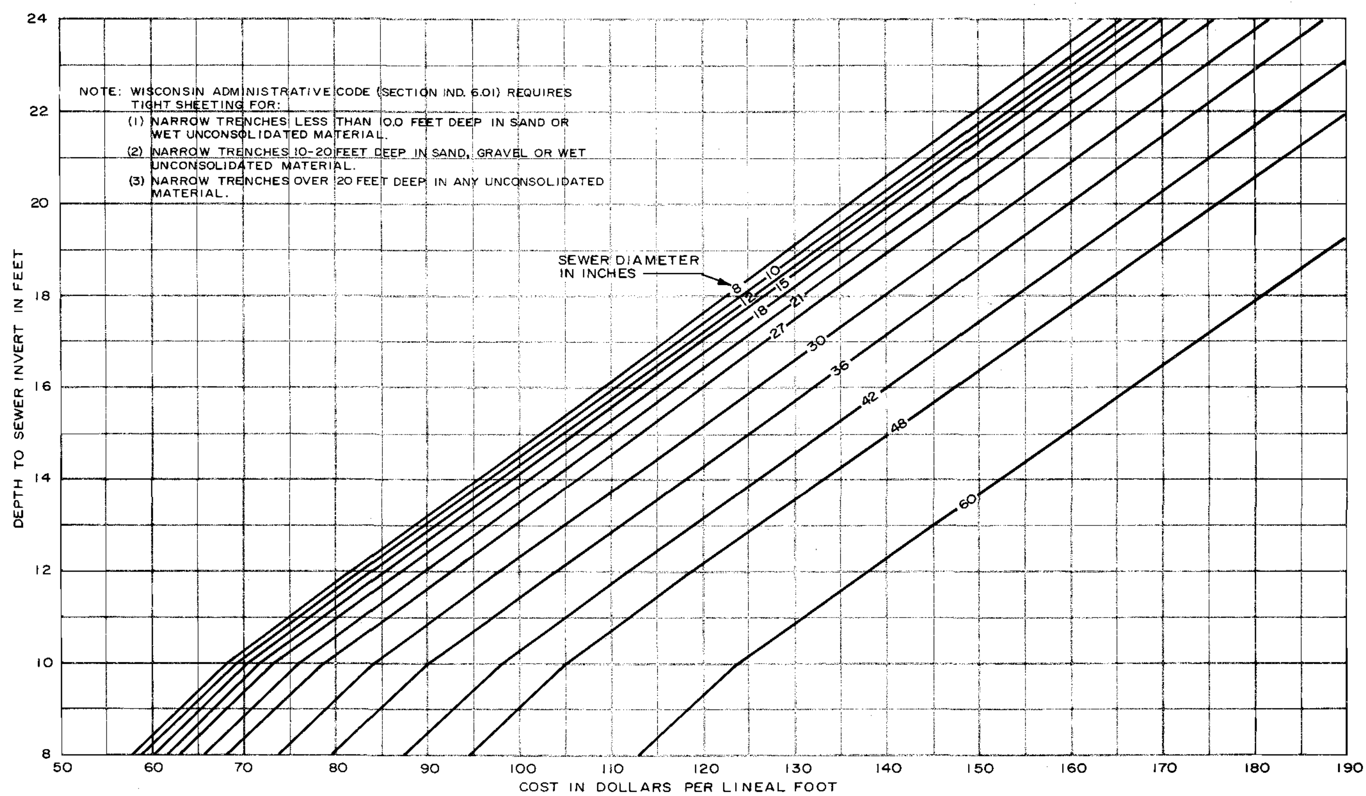
CONSTRUCTION COSTS OF TRUNK SEWERS IN WET SOILS WITH WELL POINTS AND MINIMUM SHEETING



Source: Harza Engineering Company and SEWRPC.

Figure 110

CONSTRUCTION COSTS OF TRUNK SEWERS IN WET SOILS WITH WELL POINTS AND TIGHT SHEETING



Source: Harza Engineering Company and SEWRPC.

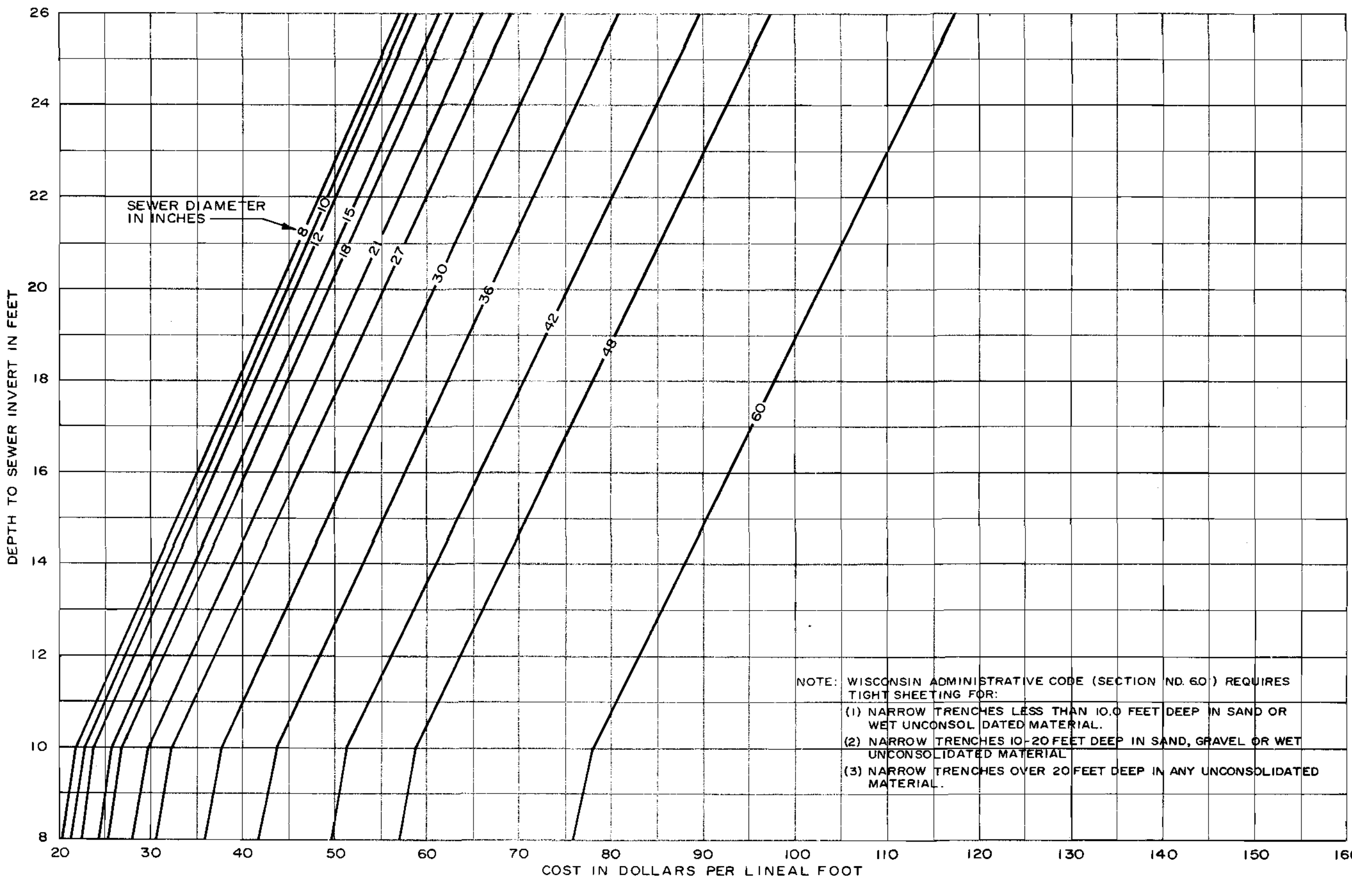
utilizing prevailing unit costs for labor, equipment, and material. No land costs were included. These costs were considered typical of the sewer construction costs in the Milwaukee urbanized area and may be conservatively high in the more rural portions of the Region. As typical costs, they represent averages rather than costs involved in extraordinary situations, such as constructing a new trunk sewer in a heavily urbanized area where extensive relocation of underground utility facilities would be involved.

The curves in Figures 107 and 108 represent costs of constructing trunk sewers in urban or rural areas where the soils are predominantly dry and where a minimum amount of sheeting and full sheeting, respectively, would be required. The curves in Figure 109 represent costs of constructing trunk sewers in developed urban areas where the soils are primarily wet, where wellpoints would have to be utilized to dewater the trench, but where only minimum sheeting would be required. The curves in Figure 110 represent costs of constructing trunk sewers in developed urban areas where soils are predominantly wet, where wellpoints would have to be utilized to dewater the trench, and where full sheeting would be required. The curves in Figure 111 represent costs of constructing trunk sewers in areas undergoing transition from rural to urban use where the soils are predominantly wet, where wellpoints would have to be utilized to dewater the trench, and where the layback method of construction would be feasible. In any case where the open cut method of sewer construction would not be feasible and where, therefore, tunneling would be required, the costs of such tunnel sections were individually determined.

It was assumed that the annual operation and maintenance costs of all sewers in the regional sanitary sewerage system plan would average \$250 per mile. This average cost was utilized in the study in order to complete the total cost analysis. It is recognized that the actual cost of operating and maintaining sewers could vary widely from the estimated average cost depending upon the location, alignment, age, and condition of the sewers.

Figure 111

CONSTRUCTION COSTS OF TRUNK SEWERS IN WET SOILS WITH WELL POINTS AND LAYBACK CONSTRUCTION



Source: Harza Engineering Company and SEWRPC.

PUMPING AND LIFT STATION DESIGN CRITERIA AND ANALYTIC PROCEDURES

In the regional sanitary sewerage planning program, the term "pumping station" is defined as a relatively large sewage pumping device designed not only to lift sewage to a higher elevation but to convey it through force mains to gravity flow points located relatively long distances from the station. The term "lift station" is defined as a relatively small sewage pumping device to lift sewage to a gravity flow sewer at a higher elevation when the continuance of the gravity flow sewer would involve excessive depths of trench. In addition, lift stations might be designed to lift sewage to areas too low to drain into available sewers. Lift stations normally discharge through relatively short force mains to gravity flow points located at or very near the lift station.

Hydraulic and Construction Considerations

In the regional sanitary sewerage system planning program, pumping and lift stations were sized to pass the peak flow rates from the tributary sewers discharging to the station. Wet wells in the stations were designed to have sufficient depth to eliminate surcharging of influent sewers under all but the most unusual conditions. A minimum of two pumping units were provided at each station. Sufficient pump capacity was provided at each station to meet the peak flow assuming that the largest unit would be out of service.

Analyses of construction costs were made to determine the most economical maximum size unit for prefabricated lift and pumping stations. Based on these analyses, prefabricated stations were assumed to be installed wherever a capacity of up to 1 mgd was required, with greater capacities requiring onsite-constructed stations. For onsite-constructed stations, costs for the provision of a standby source of power of sufficient capacity to provide peak pumping power was included in the cost estimates. In small lift and pumping stations where maintenance-free operation is desired, it was assumed that relatively low efficiency nonclog pumps and pneumatic ejectors would be utilized. In larger pumping stations where economy of operation is paramount, it was assumed that bar screens and/or comminutors would be installed to minimize pump clogging, and centrifugal nonclogging pumps would be used.

Cost Estimates

The construction costs utilized in the regional sanitary sewerage system planning program for pumping and lift stations were determined from a curve shown in Figure 112. This curve was developed from actual cost data compiled by Harza Engineering Company and adjusted to meet prevailing (1970) wage and material costs for the Southeastern Wisconsin Region. The operation and maintenance costs of pumping and lift stations used in the program were determined from a series of curves shown in Figure 113. These curves were developed by Harza Engineering Company from national data and adjusted to meet prevailing (1970) wage and material costs for the Southeastern Wisconsin Region.

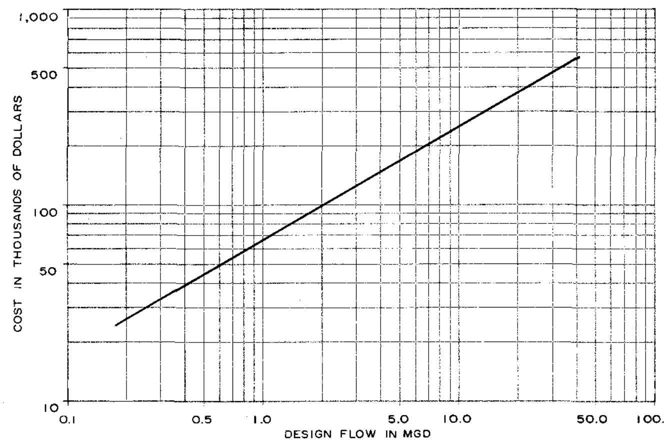
SEWAGE TREATMENT PLANT DESIGN CRITERIA AND ANALYTIC PROCEDURES

Alternative sanitary sewerage system plans were developed and compared under the regional sanitary sewerage system planning program for the purpose of determining the optimum combination of municipal sewage treatment plant location and treatment processes such that existing and probable future sanitary sewage flows in southeastern Wisconsin might be treated and discharged in a manner that will help to abate and prevent water pollution and contribute to the achievement of the adopted water use objectives and supporting water quality standards.

Several factors must be considered in the design of sewage treatment plants, including hydraulic loadings, pollution loadings, streamflows, and waste assimilative capacities; the kind and level of treatment to be provided; and construction and operation costs. The following discussion summarizes the design criteria and analytic procedures utilized in the regional sanitary sewerage

Figure 112

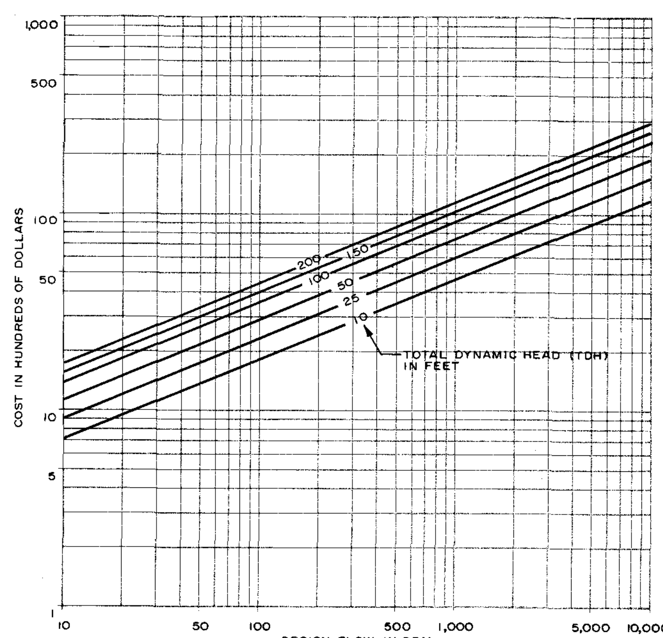
CONSTRUCTION COSTS OF PUMPING AND LIFT STATIONS



Source: J. C. Geyer and J. J. Lentz, An *Evaluation of the Problems of Sanitary Sewer System Design*, Final Report of the Residential Sewerage Research Project of the Federal Housing Administration, Technical Studies Program, 1964.

Figure 113

ANNUAL OPERATION AND MAINTENANCE COSTS FOR PUMPING AND LIFT STATIONS



Source: J. C. Geyer and J. J. Lentz, An *Evaluation of the Problems of Sanitary Sewer System Design*, Final Report of the Residential Sewerage Research Project of the Federal Housing Administration, Technical Studies Program, 1964.

system planning program for the design of sewage treatment plants, and in addition discusses the basis of the cost estimates for such plants.

Hydraulic Loading

Sewage treatment plants frequently are sized to treat sewage at an average daily flow rate including a constant groundwater infiltration volume. Plants can be sized at slight additional costs to provide a hydraulic capacity up to four times the organic design flow rate without bypassing but with a resultant loss in treatment efficiency. Generally, the flow at sewage treatment plants is more than the average daily flow from about 8 a.m. until about 8 p.m., and is less than the average daily flow for the remainder of the day. The concentrations of suspended solids and $CBOD_5$ are also greater than the average concentrations during the period when the flow is higher. Rates of sewage flow at selected sewage treatment plants in the Region are shown in a series of figures presented in Chapter VI of this report.

In the regional sanitary sewerage system planning program the design capacity of sewage treatment plants was obtained, basically, by calculating the estimated sewage flow from the entire tributary service area based on a flow rate of 125 gpcd. In addition, a constant rate of infiltration was assumed at 0.6 gpm per acre, with the acreage being computed by dividing the forecast 1990 population by a medium population density of 10.2 persons per acre. This procedure results in an equivalent infiltration flow of 85 gpcd which, when added to the sanitary sewage flow of 125 gpcd, yields a design flow of 210 gpcd. Design flows for sewage treatment plants serving primarily residential development were, therefore, computed as the product of 210 gpcd and the forecast 1990 population of the service area, except where 1970 sewage treatment plant flows were known, in which case the design flow was calculated as the 1970 flow plus the product of 210 gpcd and the forecast 1990 population increment. In instances where the 1970 per capita flow was less than 210 gpcd, however, the design flow was computed as the product of 210 gpcd and the 1990 design population.

The above simplified design procedure was adequate for determining the approximate size of most sewage treatment plants as well as for determining the approximate cost and relative costs of treatment facilities in alternative sewerage system plans. In the extreme, unrealistic case of sewage treatment plants serving areas composed almost entirely of either low- or high-density residential land use, the adopted procedure would underestimate or overestimate, respectively, treatment plant average hydraulic design capacities by as much as 40 percent. An analysis of the sensitivity of sewage treatment plant capital cost and annual operation and maintenance costs to variations in average hydraulic design capacity under those extreme and unrealistic conditions indicates that this 40 percent error in hydraulic capacity would be equivalent to an approximately 30 percent error in both capital cost and annual operation and maintenance costs.

The above relatively large percent of error in average hydraulic design capacity, in treatment plant capital costs, and in operation and maintenance costs is not present in the analyses conducted under the sanitary sewerage system planning program since it assumes extreme, unrealistic conditions. There are, for example, no existing municipal sewage treatment plants serving areas that are composed almost entirely of low- or high-density residential areas. Furthermore, no such situations exist in the recommended sanitary sewerage plan. A few alternative plans did incorporate sewage treatment facilities serving populations of less than 3,000 persons at a low density, but these alternatives were found to be uneconomic or not feasible for other reasons. A refinement of the analysis of those alternatives using higher per capita flows consistent with low-density development would simply increase the costs and, therefore, make the alternative even less attractive. The peak hydraulic design loading for each sewage treatment plant contained in the regional sanitary sewerage system planning program was obtained by doubling the design loading described above. The 2 to 1 ratio of peak hydraulic loading to sewage flow design loading was selected after reviewing similar design factors utilized throughout the Southeastern Wisconsin Region.

Pollution Loading

Domestic sewage is the waste water from kitchen, bathroom, lavatory, toilet, and laundry. Domestic sewage contains human excretion, paper, soap, dirt, food wastes, grease, and other substances in dissolved and suspended states. Much of the waste is of an organic nature that can be decomposed by microorganisms. In addition, domestic sewage contains disease-producing organisms and for this reason sewage effluent must be disinfected. The strength of domestic sewage is most commonly measured in terms of suspended solids and $CBOD_5$.

For the purposes of the regional sanitary sewerage system planning program, average daily per capita contributions of 0.21 pounds of suspended solids and $CBOD_5$ each were assumed. With an assumed per capita sewage flow rate excluding infiltration flow of 125 gcpd, these loadings produce $CBOD_5$ and suspended solids concentrations each of 200 mg/l. For a sewage treatment plant design flow of 210 gpcd, which includes infiltration, the $CBOD_5$ and suspended solids concentrations would be 120 mg/l. Each pound of carbonaceous material, as measured by the five-day CBOD test, requires about 1.4 pounds of oxygen for complete oxidation assuming a deoxygenation rate constant of 0.26 per day (base e computations).

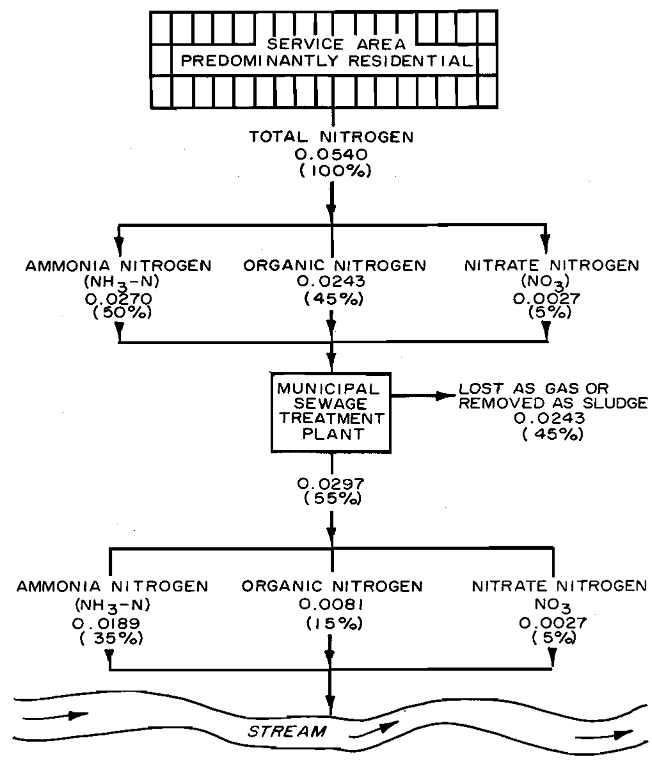
The nitrogen loading to a municipal sewage treatment plant was assumed as 0.054 pounds per capita per day as total nitrogen, with 0.027 pounds per day of this nitrogen as ammonia. This represents approximately 50 percent of the total nitrogen in the influent. Nitrogen in the organic form is assumed as 45 percent of the total nitrogen in the influent or 0.0243 pounds per capita per day. The remaining 5 percent of the total nitrogen, 0.0027 pounds, is assumed to be in the nitrate form. It was further assumed for a secondary treatment facility, based on plant studies, that about 45 percent of the influent nitrogen was removed in the sludge or lost as gases from the system. Of the remaining 55 percent discharged to the stream, 35 percent of the total was in the ammonia form, 15 percent was organic nitrogen, and 5 percent was nitrate. This represents a removal of 30 percent of the nitrogenous oxygen demand excluding the effect of further decomposition of the organic nitrogen to ammonia, and assumes that only nitrogen in the ammonia form will exert an oxygen demand. The nitrogen budget of a municipal sewage treatment plant providing secondary treatment is illustrated in Figure 114.[17]

With an assumed per capita sewage flow rate, excluding infiltration, of 125 gpcd, this total nitrogen loading of 0.054 pounds per capita per day to a municipal sewage treatment plant is equivalent to a nitrogen concentration of 51 mg/l. For a sewage treatment plant design flow of 210 gpcd, which includes infiltration, this per capita nitrogen contribution is equivalent to a sewage treatment plant influent concentration of 31 mg/l. Phosphorus waste loads were assumed in the regional sanitary sewerage system planning program to equal 0.01 pounds (as elemental phosphorus) per capita per day. With an assumed per capita sewage flow rate, excluding infiltration, of 125 gpcd, this loading is equivalent to a phosphorus concentration of 9.6 mg/l. For a sewage treatment plant design flow of 210 gpcd, which includes infiltration, this per capita phosphorus contribution is equivalent to a sewage treatment plant influent concentration of 5.7 mg/l.

Industrial waste waters are derived from manufacturing processes, and include manufacturing

Figure 114

ASSUMED NITROGEN BUDGET FOR A MUNICIPAL SEWAGE TREATMENT PLANT PROVIDING SECONDARY WASTE TREATMENT



NOTE: (1) QUANITIES ARE IN POUNDS PER CAPITA PER DAY AS NITROGEN AND PERCENTS RELATIVE TO TOTAL NITROGEN.

(2) 0.0189 POUNDS PER CAPITA PER DAY OF AMMONIA NITROGEN DISCHARGED TO THE RECEIVING WATERS IS EQUIVALENT TO AN AMMONIA NITROGEN CONCENTRATION OF 10.7 MG/L FOR A MUNICIPAL SEWAGE TREATMENT PLANT SERVING MEDIUM DENSITY RESIDENTIAL AREAS UNDER CONDITIONS OF AVERAGE SANITARY SEWAGE FLOW PLUS INFILTRATION (TOTAL: 210 GPCD)

Source: Harza Engineering Company and SEWRPC.

[17] *C. N. Sawyer, et al, Metcalf & Eddy, Inc., "Nitrification and Denitrification Facilities," Design Seminar for Wastewater Treatment Facilities--Chicago, Illinois, November 1972.*

process, washing, and flushing waste waters. Of these various types of waste water, some are highly organic, some are partly organic and partly inorganic, while others, such as cooling water, contain almost no addition of wastes to the water supplied. The tests that identify, and even the characteristics which apply to, the strength of domestic sewage frequently cannot be applied to industrial waste discharges. Strong acids and alkalies, toxic substances, and high values of oxygen demand produce erratic $CBOD_5$ values, because frequently the chemicals present in the waters interfere with biologic action. For this reason, industrial wastes are frequently expressed in terms of chemical oxygen demand (COD) or total organic carbon (TOC). Where sufficient information was available, the individual waste loadings from the industries within each service area were separately evaluated.

Stream Low Flows

As noted earlier in this chapter, the Wisconsin Department of Natural Resources evaluates compliance of a given municipal sewage treatment plant discharge with state water use objectives and supporting standards by assuming a streamflow at the discharge point that is equivalent to the lowest average for any period of seven consecutive days in the most recent 10 years. Development of alternative plans for the treatment and discharge of sanitary sewage, therefore, requires an estimate of the 7 day-10 year low flow at each potential site for a new or an expanded municipal sewage treatment plant.

Seven day-10 year low flows at all existing sewage treatment plant sites had previously been estimated for locations throughout the Fox and Milwaukee River watersheds as part of the Commission's comprehensive studies of those two watersheds. It was necessary, however, under the sanitary sewerage system planning program, to estimate low flows for many locations in the Region lying outside of the Fox and Milwaukee River watersheds and for a few additional locations within these two watersheds. The most recent 10-year period for which streamflow data were available and which could be used in developing streamflows for the regional sanitary sewerage system planning program was the period 1960 through 1969. Records for nine streamflow gaging stations were used in the analysis, with three of the gaging stations being located outside the Region. The location of the nine gaging stations is shown on Map 50, while low-flow data for the stations are summarized in Table 85.

Streamflow records for the nine gaging stations were examined to determine the low flow in cubic feet per second. These recorded flows were adjusted to represent natural conditions by subtracting the flow component attributable to existing upstream sewage treatment plants, and the unit low flow was then computed in cubic feet per second per square mile of tributary area. Table 85 summarizes the above computational process for each of the nine gaging stations.

The forecast 1990 7 day-10 year low flows were estimated for existing and potential sewage treatment plant locations as the sum of the natural flow plus the forecast 1990 flow from upstream sewage treatment plants. The natural flow was based on the unit low flow in cfs/square mile developed for each watershed, and the tributary drainage area upstream from the discharge point in question. The calculated natural flow then was adjusted for 1990 conditions by adding the 1990 design flow of upstream sewage treatment plants.

Table 85

LOW FLOW DATA AT U. S. GEOLOGICAL SURVEY GAGING STATIONS

Station Identification					Tributary Drainage Area (Sq. Mi.)	Sanitary Sewerage Study 7-Day, 10 Yr. Low Flow						U.S. Geological Survey 7-Day, 10 Yr. Low Flow[2, 3] (cfs)
Gage Name	USGS Gage Number	Stream	Watershed	County		Period of Record Examined[1]	Period of 7-Day Low Flows	Low Flows (cfs)	Upstream Sewage Treatment Plant Flow (cfs)	Natural Low Flow (cfs)	Unit Natural Low Flow (cfs/mi²)	
Cedarburg...	4-0865	Cedar Creek	Milwaukee	Ozaukee	121	1960-1969	8/16-8/22, 1963	4.4	0.1	4.3	0.0357	1.5
Clinton.........	5-4315	Turtle Creek	Rock	Rock	186	1960-1969	9/12-9/18, 1963	29.0	2.9	26.1	0.140	24.0
Franklin.......	4-0872.2	Root River	Root	Milwaukee	49	1963-1969	12/26, 1963-1/1, 1964	1.6	1.4	0.2	0.00403	0.9
Franklin.......	4-0872.33	Root River Canal	Root	Racine	57	1963-1969	1/12-1/18, 1964	0.3	0.3	0.0	0.00	0.4
Mayville.......	5-4240	East Branch of Rock River	Rock	Dodge	179	1960-1969	7/4-7/10, 1964	2.2	0.4	1.8	0.010	0.7
Russell, Ill...	5-5278	Des Plaines	Des Plaines	Lake	124	1967-1970	8/28-9/3, 1970	0.0	0.4	0.0	0.00	—
Waukesha ...	5-5438.3	Fox River	Fox River	Waukesha	127	1963-1969	9/4-9/10, 1963	5.8	2.3	3.5	0.0276	1.7
Wauwatosa..	4-0871.2	Menomonee River	Menomonee River	Milwaukee	123	1961-1969	9/6-9/12, 1963	4.4	2.6	1.8	0.0146	2.7
Wilmot.........	5-5465	Fox River	Fox River	Kenosha	868	1959-1969	9/22-9/28, 1964	67.0	16.0	51.0	0.059	50.0

[1]10-year period of 1960-1969 or portion of that period for which streamflow records are available.

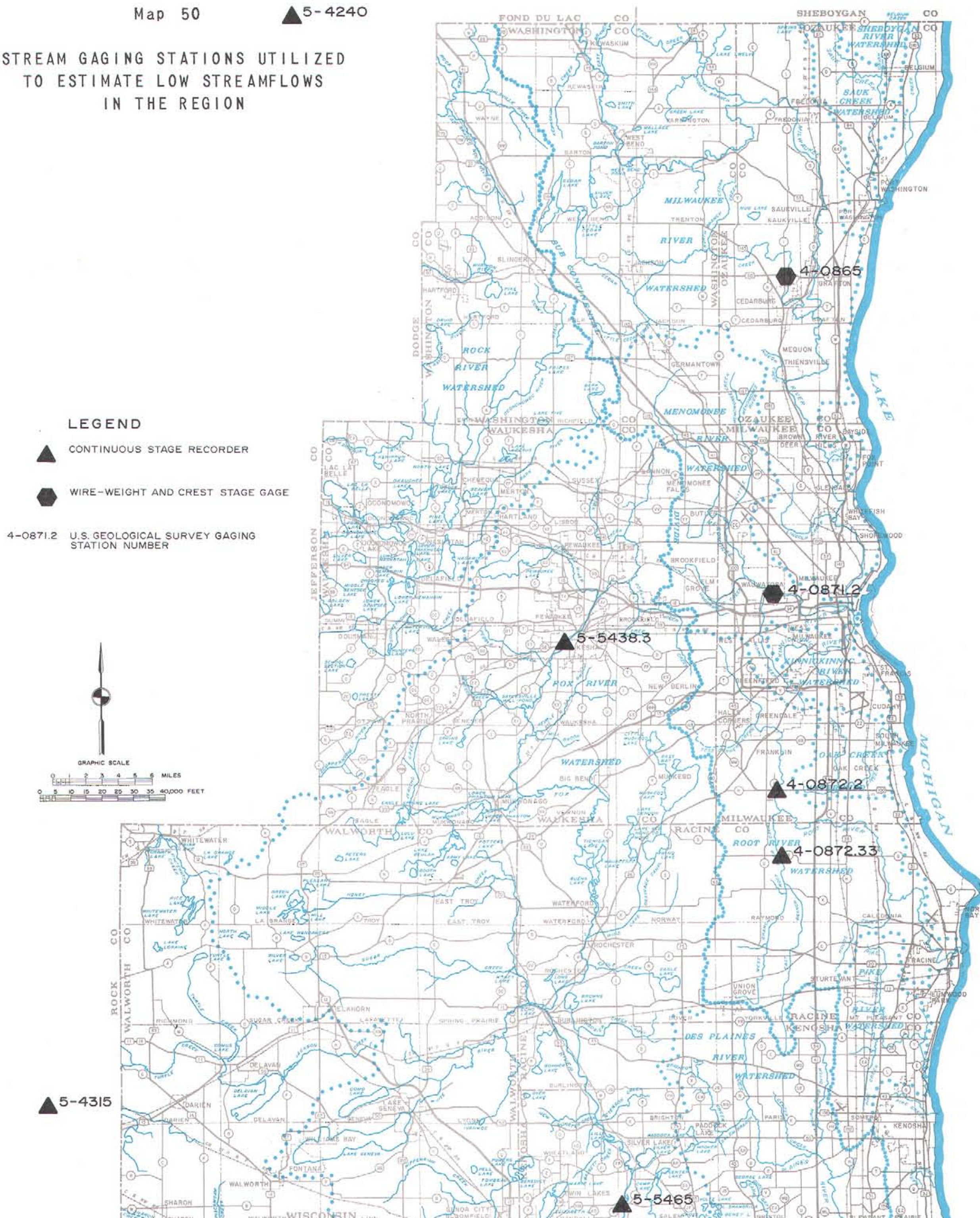
[2]Low flows determined by the U.S. Geological Survey as reported in Hydrologic Investigations Atlas HA-390, "Low-flow Frequency of Wisconsin Streams," 1971. As discussed in the text, these low flows are based on the new recurrence interval definition of low flow and are presented here for comparison purposes.

Source: SEWRPC.

[3]For a detailed comparison of SEWRPC and U.S.G.S. low flow estimates available at the time of report publication, and an analysis of the effect of differences in these estimates on sewage treatment level recommendations, see Appendix E.

Map 50

STREAM GAGING STATIONS UTILIZED TO ESTIMATE LOW STREAMFLOWS IN THE REGION



Recommended levels of treatment for municipal sewage treatment plants must result in the removal of sufficient quantities of pollutants so that the stream water use objectives and supporting water quality standards are met under conditions of extreme low streamflow. In the regional sanitary sewerage system planning program, low streamflow at potential sewage treatment plant discharge points was defined as the lowest average flow for any period of seven consecutive days during the most recent 10-year period. Historic streamflow data collected at the nine U. S. Geological Survey stream gaging stations in or near the Region as indicated on this map were utilized as the basis for developing low streamflow estimates in the program to supplement such estimates previously made under the Commission's comprehensive studies of the Fox and Milwaukee River watersheds.

Source: SEWRPC.

An example of this procedure is the calculation of the 7 day-10 year low flow at the point where the City of Delavan sewage treatment plant discharges to Turtle Creek in the Rock River watershed. The Turtle Creek gaging station at Clinton in Rock County has a drainage area of 186 square miles, and that tributary area contains the City of Delavan. The recorded 7 day-10 year low flow of 29 cfs at the Clinton gaging station less the estimated sewage treatment plant's flow from upstream sewage treatment plants of 2.9 cfs resulted in a natural low flow of 26.1 cfs. The watershed unit runoff was, therefore, calculated as 0.14 cfs/square mile. To determine the natural streamflow at the Delavan sewage treatment plant, this unit runoff factor was multiplied by the 63.5 square mile drainage area located upstream of the plant site, producing an estimated natural low flow of 8.9 cfs. The estimated sewage contribution, 2.1 cfs from Elkhorn, was then added to the upstream natural flow, resulting in a dilution water discharge rate of 11.0 cfs at the Delavan sewage treatment plant outfall.

The U. S. Geological Survey (USGS), in cooperation with the Wisconsin Department of Natural Resources, is currently (1973) conducting a statewide low-flow study. The objective of this study is to collate existing streamflow records, to determine low flows at gaging stations and to develop a methodology for predicting low-flow characteristics at sewage treatment plant outfalls and other points of concern. Because of this work, the Wisconsin Department of Natural Resources is proposing to change its definition of the term "low flow" as used in relation to sewage treatment plant design. The new definition uses a recurrence interval concept and defines the 7 day-10 year low flow as the minimum 7 day mean flow that may be expected to occur on the average of once every 10 years. There is thus under this definition a 10 percent probability that the actual 7-day low flow in any given year will be equal to or less than the 7 day-10 year low flow.

The first phase of the study, which consists of an analysis of low streamflows at selected gaging stations throughout the state, has been completed.[18] The resulting USGS low flows corresponding to the continuous gaging stations utilized in the regional sanitary sewerage study are presented in Table 85 to permit comparison to the low flows used as the basis for sewerage study analysis. The USGS values are seen to be somewhat lower than the values derived in the sewerage study for seven of the eight gaging station locations compared in the table. There are several possible reasons for the differences noted in the table. While the values derived in the sewerage study are based on, at most, ten years of streamflow record as is consistent with the former low-flow definition, the USGS values utilize longer periods of record where available. In several instances, the periods of record do not overlap because whereas the sanitary sewerage study incorporated up to ten years of flow records ending in 1969, some of the USGS analyses use streamflow data for a period ending in 1959. A possible explanation for the generally lower streamflow values obtained by the USGS is the inclusion, either directly or by extrapolation, of a period of severe drought that occurred in the early 1930s.

The aforementioned differences between the sanitary sewerage study 7 day-10 year streamflows and those reported by USGS are not of major concern in the regional sanitary sewerage system planning program. Seven day-10 year streamflows in southeastern Wisconsin, irrespective of how they may be defined, are generally so low relative to municipal sewage treatment plant average hydraulic design flows as to require the highest of the three levels of treatment utilized in the planning study in order to achieve adopted water use objectives. The practical overall effect of incorporating the lower USGS low-flow values presented in Table 85 into the sanitary sewerage study may be expected to be generally insignificant since most sewage facility recommendations already prescribe the highest of the three available levels of sewage treatment. The engineering design phase of sanitary sewerage system plan implementation may encounter some unusual situations where, because of low-flow differences, treatment levels recommended in the plan may have to be adjusted either upward or downward. As noted in the introductory section of this chapter, however, such plan refinements are to be expected as recommended sanitary sewerage system projects advance from the planning phase to the engineering design phase.

The USGS anticipates publishing another report setting forth the findings and recommendations of the low-flow study late in 1973. During implemen-

[18] *W. A. Gebert, "Low Flow Frequency of Wisconsin Streams," Hydrologic Investigations Atlas HA-390, U. S. Geological Survey, 1971.*

tation of the regional sanitary sewerage system plan, it is recommended that the low flows and methodologies presented in USGS Hydrologic Investigation Atlas HA-390 and other anticipated USGS reports to be used in lieu of the flows and methodologies included in this report except where the latter are judged to be more appropriate or where more refined information is available.

The Waste Assimilative Capacity of Streams

Flowing streams have, under careful management, the ability to accept waste water discharges resulting from human activity without producing pollution problems. This characteristic of a flowing stream is commonly referred to as its waste assimilative capacity. Streams assimilate wastes by diluting the potentially troublesome substance in a waste water discharge, and in some cases, by effecting favorable biochemical changes in those substances. For example, a flowing stream may effectively assimilate the oxygen-demanding organic material in a waste water discharge both by diluting the organic material, effecting an immediate reduction in the concentration of $CBOD_{ult}$ and $NBOD_{ult}$; and by providing an environment in which aerobic bacteria gradually biodegrade the organic matter to stable compounds.

The waste assimilation processes that occur in a flowing stream are very similar to those that exist in a conventional municipal sewage treatment plant. In fact, optimum utilization of natural resources and economic resources requires that water quality management seek to integrate the waste assimilative processes that occur within the confines of a man-made sewage treatment plant with the waste assimilative processes that occur in the natural stream receiving the effluent from that sewage treatment plant. This integration of the sewage treatment processes with the natural waste assimilative capacity of the stream seeks to make maximum use of the latter.

Although the waste assimilative, or self-purification, processes of a stream are always operative, the processes may become ineffective from a practical standpoint if the stream's waste assimilative capacity is exceeded. A stream's waste assimilative capacity is said to be exceeded when pollution occurs, that is, when foreign substances originating from human activity occur in the stream in such a form and concentration so as to render the flowing water unsuitable for desired beneficial uses as set forth in adopted water use objectives.

The major interrelated factors that determine whether extensive gross pollution will occur are the amount and quality of water available in the stream to dilute the wastes relative to the quantity and concentration of these wastes. No single water quality indicator can be used to determine the extent to which a stream has assimilated wastes. Under the regional sanitary sewerage system planning program, stream waste assimilative capacity was determined by the effect that a given waste discharge would have on two important water quality indicators downstream of the discharge point—dissolved oxygen level and ammonia concentration.

The minimum dissolved oxygen concentration was determined as a function of stream background quality, sewage treatment plant effluent quality, rate constants for biochemical processes occurring in the stream, and the ratio of streamflow to sewage treatment plant effluent flow. In the development of alternative water quality plan elements, the type of treatment was selected so as to achieve acceptable dissolved oxygen levels. An oxygen sag curve model was developed and used, as discussed later in this chapter, for the purpose of assessing the probable impact of a given sewage treatment plant on the oxygen resources of the receiving stream.

The maximum allowable effluent ammonia concentration was computed as a function of the dilution ratio, stream background ammonia concentration, and the maximum concentration of ammonia that can be tolerated by fish. Alternative water quality plan elements were designed such that the maximum allowable stream ammonia concentration would not be exceeded.

Provision for Secondary Treatment and Disinfection

The State of Wisconsin, as noted in Chapter VII of this report, requires that all municipal sewage treatment plants provide at least secondary treatment and that the effluent be disinfected before discharge to surface waters. Each alternative plan evaluated under the regional sanitary sewerage system planning program includes, therefore, provision for at least secondary treatment with effluent disinfection. The secondary treatment components of new sewage treatment plants were, in most cases, assumed to be of the activated sludge type.

Provision for Phosphorus Removal

As a result of recommendations of the Lake Michigan Enforcement Conference, the Wisconsin Department of Natural Resources has imposed minimum phosphorus removal criteria for all sewage treatment plants located within the Wisconsin portion of the Lake Michigan Basin. Certain municipal sewage and industrial waste water plants discharging directly to Lake Michigan or to any of its tributaries, in accordance with the legal requirements set forth in Chapter VII of this report, are required to remove at least 85 percent of the influent phosphorus. At a November 1972 session, the Lake Michigan Environment Conference supplemented its earlier phosphorus removal recommendations so as to also require a maximum effluent total phosphorus concentration of 1.0 mg/l.

The per capita phosphorus and flow contributions assumed in the regional sanitary sewerage system planning program for treatment plant design are such that an 85 percent removal of influent phosphorus will result in the discharge of treated waste with slightly less than 1.0 mg/l of phosphorus. Therefore, the original 85 percent phosphorus removal requirement governs under the sanitary sewerage system study since it is more stringent than the more recently established 1.0 mg/l maximum.

These phosphorus removal criteria are strictly applicable to sewage treatment plants located east of the subcontinental divide, and similar criteria are not in effect for that portion of the seven-county planning Region lying west of the subcontinental divide. The Wisconsin Department of Natural Resources retains, however, the option of requiring special phosphorus removal facilities for municipal sewage treatment plants located west of the subcontinental divide where such removal is considered necessary for achievement of water use objectives.

As described in Chapter IV of this report, the Commission's recently completed Milwaukee and Fox River watershed studies, the latter of which is not tributary to Lake Michigan, as well as the Commission's earlier regional water quality study, revealed serious algae and weed growth problems in the lakes and streams of southeastern Wisconsin, with excessive nutrient loadings being a principal cause of these problems. Lake Michigan Enforcement Conference phosphorus recommendations notwithstanding, the Milwaukee River watershed study concluded that phosphorus removal should be provided at most municipal sewage treatment plants. Similar phosphorus removal recommendations were made under the Fox River watershed study.

The regional sanitary sewerage system plan includes recommendations with respect to levels of treatment in general, and phosphorus removal in particular, for municipal sewage treatment plants located west of the subcontinental divide and outside of the Fox River watershed on the western fringe of the seven-county planning Region. These treatment facilities, all of which are located in the extreme headwater areas of the Rock River watershed, are subject to neither the Lake Michigan Enforcement Conference phosphorus removal recommendations nor the SEWRPC Fox and Milwaukee River watershed study phosphorus removal recommendations.

Individual analyses were made for each of these treatment facilities to determine if phosphorus removal should be provided. The need for this form of advanced treatment was based, in each case, on the adopted water use objectives and supporting standards. More particularly, phosphorus removal recommendations were included in those instances where such treatment would substantially contribute to maintaining instream phosphorus levels below the approximate 0.10 mg/l threshold level for algal blooms. Where phosphorus removal was recommended, it was assumed that it would be accomplished primarily through the addition of chemicals in aeration tanks.

The effects of discharging various amounts of phosphorus which contribute to algae and other aquatic plant growth in streams cannot be accurately predicted at present, due to the limitations of existing knowledge about interaction among nutrients, growth of aquatic life, and the stream environment. It is reasonable to assume, however, that high levels of nutrient are indeed directly responsible for excessive algae and weed growths. It is also reasonable to expect that discharge to surface waters of large amounts of phosphorus in the effluent from sewage treatment plants will contribute to excessive growth of algae and aquatic weeds which will, in turn, severely interfere with the maintenance of a healthy fishery in, and the recreational and aesthetic enjoyment of, the Region's streams and lakes. Excessive daily fluctuations in the dissolved oxygen content of the stream sufficient to render the stream unsuitable for fish life may also be expected to occur.

Because of the effects of urban and rural storm water runoff and septic tank effluent seepage, it may not be possible to continuously maintain, through control of the waste contribution from the municipal sewage treatment plants alone, phosphorus levels at all points in the stream below the approximate threshold level for algal blooms of 0.10 mg/l. High levels of phosphorus removal at sewage treatment plants, however, should serve to minimize nuisance growths of algae and other aquatic plants.

Oxygen Sag Curve Model for Determination of Treatment Levels Required to Provide Adequate Dissolved Oxygen

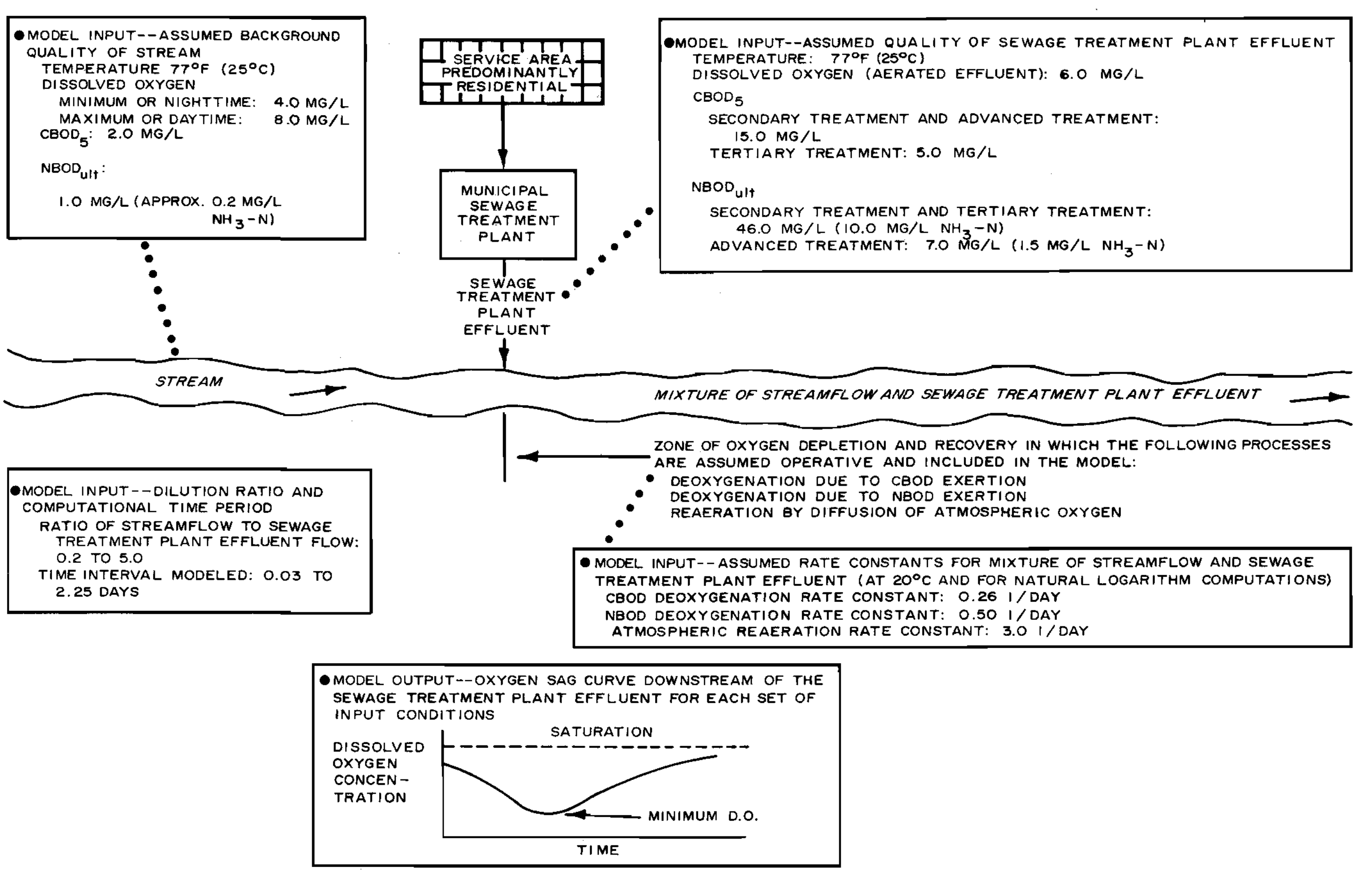
The computations which must be executed in order to determine the minimum dissolved oxygen concentration in a given stream that would result from a particular waste being discharged into that stream are complex and, therefore, a mathematical model was formulated using these relationships and a digital computer program was written to perform computations. A schematic representation of the oxygen sag curve model, including assumed values of all variables, is shown in Figure 115. The minimum dissolved oxygen concentration in a stream downstream of a sewage treatment plant discharge point was computed as a function of the following types of data:

1. Background quality of the stream expressed in terms of temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, and nitrogenous biochemical oxygen demand.

2. Sewage treatment plant effluent quality expressed in terms of temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, and nitrogenous biochemical oxygen demand.

Figure 115

OXYGEN SAG CURVE MODEL USED IN THE PREPARATION OF ALTERNATIVE SEWAGE TREATMENT PLANT PLAN ELEMENTS



Source: SEWRPC.

3. Rate constants for biochemical processes occurring in the mixture of streamflow and sewage treatment plant effluent, which processes include deoxygenation due to carbonaceous biochemical oxygen demand, deoxygenation due to nitrogenous biochemical oxygen demand, and reaeration by diffusion of atmospheric oxygen across the air-water interface.

4. Dilution ratio, defined as the ratio of streamflow to sewage treatment plant effluent flow and time interval to be modeled.

This section compares the model to stream oxygen models used in Commission watershed studies, describes the mathematical formulation used to express minimum dissolved oxygen as a function of the aforementioned four factors, and then describes the assumed model input and the manner in which the computer computations were executed. The results of the dissolved oxygen analysis are presented in the graphic form actually used in establishing the type of treatment for sewage treatment plants considered under alternative water quality plans.

Comparison of Regional Sanitary Sewerage Study Oxygen Sag Curve Model to Watershed Study Models: In Chapter II of this report the relationships existing between the Commission's sanitary sewerage system planning program and the Commission's comprehensive watershed planning programs were discussed; and the subtle as well as complex nature of the interrelationships between these two quite different, yet inextricably interrelated, planning programs was pointed out. One of the more subtle interrelationships between these two kinds of planning programs involves the characteristics of the water quality simulation models used in the two programs. A general comparison of the two modeling methodologies is appropriate in order to provide a better understanding of the models used in the comprehensive watershed planning programs as well as in the sanitary sewerage planning program, and in order to further clarify the relationship between these two kinds of planning programs and the plans produced by these programs.

Stream water quality simulation models—or more specifically, stream oxygen utilization and reaeration models—were developed for use in both the Commission's Fox and Milwaukee River watershed studies. Certain important differences, as well as similarities, exist between these models and the oxygen sag curve model developed for use in the regional sanitary sewerage system planning program. The basic concepts on which the watershed and the sanitary sewerage system models are based are identical in that both are intended to simulate the same basic processes affecting oxygen levels in flowing streams and do so by using the same mathematical equations to represent these processes. Thus the models incorporate three basic processes as the primary determinants of the dissolved oxygen content of stream water, namely deoxygenation due to the exertion of carbonaceous biochemical oxygen demand, deoxygenation due to the exertion of nitrogenous biochemical oxygen demand,[19] and reaeration by the diffusion of atmospheric oxygen into the flowing stream across the air-water interface.

The fundamental difference between the watershed models and the sanitary sewerage system model lies in the manner in which the equations representing the fundamental processes were applied. For watershed planning purposes, the stream systems of the watershed were modeled on a continuous flow basis wherein the stream water quality level outputs of the model equations from one river reach provided inputs to the next downstream reach, thus simulating the behavior of the total stream system with respect to water quality under varying pollution loads. This procedure takes into account the varying physical characteristics of the river system and any interaction of the effects of one waste source on river conditions upstream from another waste source. The models used in the watershed studies thus were intended to reflect the interaction between various elements in the surface water quality system by incorporating such phenomena as the combined effect of a series of sewage and industrial waste treatment plant discharges on a long stream reach

[19] *The dissolved oxygen models used in the sanitary sewerage system planning program and in the Milwaukee River watershed study contain almost identical conceptual formulations and mathematical equations. These two models differ from the dissolved oxygen model used in the earlier Fox River watershed planning program in that the Fox River model did not consider the effects of nitrogenous biochemical oxygen demand. Its inclusion in the more recent Milwaukee River watershed and regional sanitary sewerage system planning program models reflects an advance in the state-of-the-art of water quality modeling since preparation of the Fox River watershed model.*

and the effect of diffused sources of oxygen-demanding substances, such as those attributable to urban and rural runoff. The watershed study models were in effect calibrated on a reach-by-reach basis to the stream system of the watershed as it existed in the base year of the study. The purpose of the watershed study models was to provide a means of analyzing the effect of various watershed stream system adjustments on surface water quality and to ultimately select the best combination of treatment facility location, levels and types of treatment, and land use practice necessary to achieve the adopted water use objectives and supporting standards.

A more generalized single-reach procedure was used in the application of equations representing the basic oxygen utilization and reaeration processes in the model developed and applied in the regional sanitary sewerage system planning program. In this approach, sewage treatment needs are based on 7 day-10 year low streamflows as forecast for each existing and proposed sewage treatment plant site. These forecasts assume that through implementation of the adopted watershed plans and the attendant abatement of all major diffused as well as all point sources of pollution, stream water quality conditions immediately upstream of a sewage treatment plant discharge point will, under low flow conditions, meet or exceed the established water quality standards. The primary purpose of the sewerage system planning program model is to determine, given forecast low streamflow conditions and design year sewage flows, the level of treatment required to assure that the treatment plant effluent can be assimilated by the stream without depressing the stream water quality levels below those required by the adopted water use objectives and supporting standards.

Thus, three factors dictated the use of a generalized single-reach approach to stream water quality modeling in the sanitary sewerage system planning program as opposed to the more specific prevailing streamflow condition model in the comprehensive watershed studies. The first, and most important, reason for using a more generalized single-reach procedure in the sanitary sewerage system planning program modeling was the differing yet interrelated objectives of the sanitary sewerage system planning program and the comprehensive watershed planning programs. The watershed planning programs were intended to take a comprehensive approach to the problem of surface water quality management and to consider the effects of not only municipal sewage treatment plant discharges on surface water quality but the effects of other point sources of pollution such as industrial waste discharges, and the effects of such diffused sources of pollution as sanitary and combined sewer overflows and agricultural runoff. The comprehensive nature of the watershed studies thus necessitated the adoption of an equally comprehensive water quality simulation model. In contrast to the comprehensive nature of the watershed studies, the sanitary sewerage system planning program was limited to consideration of the water quality effects of the municipal sewage treatment plants, and therefore a more limited water quality simulation model was selected for application. The watershed study model was selected in conformance with this assumption in that it serves the limited purpose of determining the effect of a municipal sewage treatment plant discharge on a stream which meets the adopted water use objectives and standards.

A second reason for using a generalized, single-reach approach to oxygen modeling in the sewerage study is the nature of prevailing streamflow conditions outside of the Fox and Milwaukee River watersheds. Streams in the Region which will receive sewage treatment plant effluent and are outside the Fox and Milwaukee River watersheds are generally small with very low minimum flows. The precision in modeling such streams is inherently very poor because of the typically widely varying hydraulic conditions along their length as compared to the more uniform hydraulic characteristics of larger rivers.

The third reason for using a more generalized single-reach procedure in the sanitary sewerage system planning program modeling is the generally wide separation of existing and potential municipal sewage treatment plant sites in the more rural areas of the Region outside the Fox and Milwaukee River watersheds. The relatively long distance and concomitant long flow times between existing and potential municipal sewage treatment plant sites reduce the need for a model that can simulate the cumulative water quality effect of sewage treatment plant discharges, since under such conditions the oxygen demand resulting from a given sewage treatment plant discharge will be essentially satisfied before the next major downstream discharge point is encountered. More specifically, the sanitary sewerage study water quality model indicates that the oxygen sag effects of sewage treatment plants providing secondary, tertiary, or advanced treatment as discussed in this chapter will be essentially dissipated within about one day's flow time downstream of the discharge point. At a streamflow velocity of 0.5 feet per second, which may be reasonably expected to occur during low flow periods, stream oxygen levels would be recovered within a distance of about eight miles downstream of the sewage treatment plant. Plant site spacings within the Region generally exceed this distance, and assuming that the recommendations contained in the adopted watershed plans are implemented to eliminate the effects of other water pollution sources, interactions should not occur.

The data requirements of the two types of water quality simulation models differ greatly. The watershed study models, which were intended to simulate the water quality conditions of the stream systems as they existed in the base year of the study, required extensive water quality data for model calibration so that the models would adequately reproduce the water quality behavior of the existing stream system. These data had to be provided by relatively expensive field sampling and laboratory analysis procedures.

Extensive data on existing levels of water quality were not required for the sanitary sewerage system planning program model since that model is based on the assumption that the quality of the receiving waters would meet or exceed the standards required by the established water use objectives. Some water quality inputs to this model were generalized from regional water quality data collected by the Commission under its initial stream water quality surveys undertaken in 1964.

In summary, the water quality simulation model used in the regional sanitary sewerage system planning program is similar to the water quality simulation models used in the Commission's Fox and Milwaukee River watershed studies in that both models are based upon the same basic reoxygenation processes, although the Fox River model does not include nitrogenous biochemical oxygen demand, and utilizes essentially the same mathematical equations to represent these processes. The difference in the models relates to the different purposes which they are intended to serve within the framework of the Commission's comprehensive watershed planning as opposed to sanitary sewerage system planning. The former planning programs require a comprehensive approach to water resource management and, therefore, a continuous flow approach to water quality modeling with specific calibration of the model to existing stream water quality conditions. The latter program, having a more limited objective, requires a modeling effort which can readily determine the effect of municipal sewage treatment plant discharges on a receiving stream that satisfies adopted water use objectives and standards in the design year.

Mathematical Formulation of Model: The basic relationship used in the computer program for determining stream dissolved oxygen deficit downstream of a sewage treatment plant outfall is a modification of the Streeter-Phelps equation. The Streeter-Phelps equation, which has long been a standard analytic tool used to predict the effect of a waste water discharge on the oxygen level in a stream, expresses dissolved oxygen deficit at a given time or distance downstream of a discharge point as a function of two opposing processes—deoxygenation due to the exertion of CBOD and reaeration attributable to the diffusion of atmospheric oxygen into the flowing stream across the air-water interface. A graph of stream dissolved oxygen versus flow time or distance downstream of a sewage treatment plant discharge point as computed by the Streeter-Phelps equation characteristically exhibits a decline in dissolved oxygen occurring at a decreasing rate until a minimum level is reached, after which there is a gradual rise in dissolved oxygen. This characteristic dissolved oxygen decline, minimum, and subsequent increase as predicted by the Streeter-Phelps equation are commonly called the oxygen sag curve.

The modified equation used in the model for the regional sanitary sewerage system planning program incorporates one important process in addition to the two included in the Streeter-Phelps formulation. That additional process is the utilization of dissolved oxygen in oxidizing ammonia to nitrate, that is, the model explicitly accommodates nitrogenous biochemical oxygen demand.[20]

---

[20] *W. Whipple, et al, Instream Aeration of Polluted Rivers, Chapter III, "Dissolved Oxygen Dynamics and Analytic Procedures," Water Resources Research Institute, Rutgers University, August 1969.*

The equation used in the computer program to compute the dissolved oxygen sag curve in a stream reach beginning at a municipal sewage treatment plant effluent discharge point is:

$$D = D_o e^{-K_a t} + \frac{K_d L_o}{K_a - K_d}(e^{-K_d t} - e^{-K_a t}) + \frac{K_n N_o}{K_a - K_n}(e^{-K_n t} - e^{-K_a t})$$

Where:

- t = Flowtime from the beginning of the reach in days.
- D = Dissolved oxygen deficit in mg/l, that is, saturation concentration of dissolved oxygen minus actual concentration of dissolved oxygen, at a flow time (t) downstream of the beginning of the reach.
- D_o = Dissolved oxygen deficit of the streamflow-effluent mixture at the beginning of the reach in mg/l.
- e = Natural logarithm base.
- K_a = Atmospheric reaeration rate constant in day^{-1}. Fraction of remaining oxygen deficit satisfied per unit of time.
- K_d = CBOD deoxygenation rate constant in day^{-1}. Fraction of CBOD remaining exerted per unit of time.
- K_n = NBOD deoxygenation rate constant in day^{-1}. Fraction of NBOD remaining exerted per unit of time.
- L_o = $CBOD_{ult}$ of the streamflow-effluent mixture at the beginning of the reach in mg/l.
- N_o = $NBOD_{ult}$ of the streamflow-effluent mixture at the beginning of the reach in mg/l.

It is important to note that the parameters D_o, L_o, and N_o, which pertain to the beginning of a stream reach immediately downstream of a municipal sewage treatment plant outfall, represent the oxygen deficit, $CBOD_{ult}$, and $NBOD_{ult}$ of the mixture of streamflow and sewage treatment plant effluent. These parameters are calculated within the computer program as a function of streamflow water quality data, sewage treatment plant effluent quality data, and the ratio of streamflow to sewage treatment plant effluent flow, all of which are provided as input to the computer program. The three rate constants, K_a, K_d, and K_n are input to the model for conditions of 20°C and adjusted by the computer program for temperatures other than 20°C.

Dissolved oxygen deficit is computed by the model and printed in the model output as a function of flow time in the reach, rather than distance downstream of the beginning of the reach. Any flow time, such as the flow time corresponding to the maximum dissolved oxygen deficit, may be converted to a corresponding distance downstream of the beginning of the reach by multiplying the flow time by the estimated average velocity of the stream.

Model Input: As stated above and as depicted in Figure 115, input data for the computer program used to generate curves for evaluating the effect of sewage treatment plant effluent on streamflow dissolved oxygen levels may be placed in four categories: background quality of streamflow, sewage treatment plant effluent quality, rate constants for biochemical processes, and the ratio of streamflow to sewage treatment plant effluent flow and computation time interval. The assumed values for variables in each of these four categories are presented below along with the rationale for the selections.

Stream Background Quality: Background stream water quality is defined as the set of values of selected water quality indicators that are most likely to occur upstream of sewage treatment plant discharge points during the period of summer low streamflow, with the additional assumption that the stream quality is sufficient to satisfy the quality standards corresponding to the adopted water use objectives. The following stream water quality indicators were used in the model: temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, and nitrogenous biochemical oxygen demand. Stream water quality values most likely to occur during the summer low streamflow period were selected, since a stream's waste assimilative capacity is normally minimal at that time because of the relatively small volume of water available for dilution, because of low dissolved oxygen, and because of high water temperature and attendant increased reaction rates for aerobic biochemical processes.

A temperature of 77°F (25°C) was used to represent probable stream background temperature and sewage treatment plant effluent temperature throughout the Region during critical summer, low flow conditions. The selected temperature approximates that which may be expected to occur in streams during summer daytime hours.

DO levels as low as 0.5 mg/l have been observed upstream from sewage treatment plants on the Fox and Milwaukee Rivers, while super saturation DO concentrations as high as 18.4 mg/l have been observed in impoundments on the Milwaukee River on hot, sunny days. These extreme variations are attributed primarily to respiration and photosynthesis by algae and other aquatic plants. It is assumed that in the future these extreme fluctuations will be reduced as steps are taken to reduce the input of nutrients which foster excessive aquatic plant growth. To reflect the diurnal variation of DO due to respiration and photosynthesis during the summer low streamflow period, 4.0 mg/l was assumed as the minimum or nighttime background concentration of DO, and 8.0 mg/l was assumed as the maximum or daytime concentration. A minimum or nighttime dissolved oxygen concentration of 4.0 mg/l was selected since it is the minimum concentration specified by the Wisconsin Department of Natural Resources for preservation and enhancement of fish and other aquatic life. The maximum or daytime concentration of 8.0 mg/l was chosen since it approximates the saturation concentration of dissolved oxygen in a stream at 77°F (25°C).

The background $CBOD_5$ is probably attributable to natural sources of organic oxygen-demanding materials such as decaying plants and agricultural runoff. The concentration of five-day, 20°C CBOD as would be determined by a standard laboratory test was assumed to be 2.0 mg/l, which is equivalent to a $CBOD_{ult}$ of 2.6 mg/l assuming a laboratory environment deoxygenation rate constant (base e) of 0.30 per day. The selected background $CBOD_5$ was based partly on average values of water samples taken on the Milwaukee River under the Commission's Milwaukee River watershed study. The assumed background concentration of $CBOD_5$ has little effect on a stream's waste assimilative capacity relative to other stream background quality indicators, and is therefore not a particularly critical parameter.

Background ammonia is attributable to natural sources such as decaying plant material and agricultural runoff. Ammonia is considered acutely toxic to fish life at a concentration in excess of 2.50 mg/l ammonia nitrogen, and the biochemical conversion of ammonia to nitrate requires 4.6 pounds of oxygen for each pound of ammonia nitrogen that is converted. The background concentration of ammonia nitrogen was set at 0.20 mg/l, based partly on ammonia measurements made on the upper Milwaukee River under the Commission's Milwaukee River watershed study. Since, as noted above, 4.6 pounds of oxygen are required to convert one pound of ammonia nitrogen to nitrate, the background $NBOD_{ult}$ was set at 1.0 mg/l which approximately corresponds to the assumed background ammonia nitrogen of 0.20 mg/l.

Sewage Treatment Plant Effluent Quality: Required computer program input for sewage treatment plant effluent quality includes temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, and nitrogenous biochemical oxygen demand. The expected values of these indicators that would be anticipated in effluents from sewage treatment plants employing various treatment processes were, therefore, used in the model and are set forth in Table 86. These sewage treatment plant effluent characteristics were based partly on the performance of existing municipal sewage treatment plants in the planning region and partly on treatment efficiencies reported in the literature. The assumed sewage treatment plant effluent quality values in Table 86 are intended to represent three categories of treatment: category I, secondary treatment; category II, tertiary treatment consisting of secondary treatment plus provision for high $CBOD_{ult}$ removal; and category III, advanced treatment consisting of secondary treatment plus provision for nitrification.

Rate Constants: As noted above, oxygen sag curve computations as performed by the model require the assignment of values for K_a, the atmospheric reaeration rate constant; K_d, the CBOD deoxygenation rate constant; and K_n, the NBOD deoxygenation rate constant. Water quality analyses and estimates of stream hydraulic characteristics required to determine rate constants were available for the Milwaukee River watershed stream system as a result of the Commission's comprehensive study of that watershed, and values for the three rate constants were selected for use in the sewerage study model primarily on the basis of values previously determined for the Milwaukee River watershed.

In the Milwaukee River watershed study, the value of the reaeration rate, K_a, was computed using an empirical equation[21] relating the constant to stream velocity and stream depth:

[21] *W. Whipple, et al.*

Table 86

ASSUMED MUNICIPAL SEWAGE TREATMENT PLANT EFFLUENT QUALITY FOR USE IN THE OXYGEN SAG CURVE MODEL

Treatment			Effluent Quality			
Category	Level	Typical Process	Temperature (°F)	Dissolved Oxygen (mg/1)[1]	$CBOD_5$ (mg/1)	Ammonia Nitrogen NH_3-N (mg/1)[2]
I	Secondary	Activated Sludge Trickling Filter, Naturally Aerated Stabilization Lagoon	77	6	15[4]	10
II	Tertiary (high $CBOD_5$ removal)	Filtration	77	6	5[4]	10
III	Advanced (Nitrification)	Mechanically Aerated Stabilization Lagoon, Modified Activated Sludge	77	6	15[4]	1.5[3]

[1]*Effluents are assumed to be aerated to assure a minimum dissolved oxygen concentration of 6 mg/1.*

[2]*Approximately 4.6 pounds of oxygen are required to convert 1.0 pound of ammonia nitrogen (ammonia, NH_3, expressed as nitrogen, N) to nitrate. Therefore effluent ammonia nitrogen concentrations of 10 mg/1 and 1.5 mg/1 are equivalent to effluent ultimate nitrogenous biochemical oxygen dement ($NBOD_{ult}$) values of 46 mg/1 and 7 mg/1, respectively.*

Source: Harza Engineering Company.

[3]*This optimum or lowest value is expected to occur during summer low flow period but not necessarily throughout the year.*

[4]*At sewage treatment plant average hydraulic design capacity, the influent flow, which is composed of sanitary sewage plus infiltration, is 210 gpcd with a $CBOD_5$ of 120 mg. per 1. (equivalent to domestic sewage contribution of 125 gpcd with a $CBOD_5$ of 200 mg. per 1.) Therefore, secondary and advanced treatment are assumed to effect at least an 88.5 percent $CBOD_5$ reduction, while tertiary treatment is assumed to provide at least a 95 percent reduction.*

$$K_a = \frac{12.9U^{1/2}}{H^{3/2}}$$

where:

K = reaeration rate constant at 20°C in $days^{-1}$.

U = average stream velocity in feet per second.

H = average stream depth in feet.

Under the Milwaukee River watershed study, estimates of stream velocity and depth for 32 locations on the watershed stream system were substituted into the equation and K_a was computed for each location. The 32 computed reaeration rate constants for 20°C conditions ranged from 0.34 to 14.0 with a median of 3.60. A K_a value of 3.00 at 20°C was selected as representative of the Region's streams and used in the regional sanitary sewerage system planning program oxygen sag curve model.

Values of the CBOD deoxygenation rate constant, K_d, were determined under the Milwaukee River watershed study from an analysis of long-term biochemical oxygen demand tests, with suppression of nitrification. These analyses, which were conducted on water samples obtained at three locations along the river system, yielded 20°C K_d values ranging from 0.10 to 0.26 day^{-1}. A value of 0.26 day^{-1} was selected as representative of the Region's streams and used in the oxygen sag curve model. This value is in general agreement with numerous suggested deoxygenation rate coefficients cited in the literature.

The NBOD deoxygenation rate constant, K_n, was evaluated under the Milwaukee River watershed study using a sampling and laboratory procedure similar to that used for the CBOD deoxygenation rate constant. Long-term biochemical demand tests were used without suppression of nitrification and compared to similar analyses conducted with suppression of nitrification. The Milwaukee River watershed analyses yielded 20°C K_n values of 0.10 and 0.70. A value of 0.50 day^{-1} at 20°C was selected as representative of the Region's streams and used in the oxygen sag curve model.

Dilution Ratio and Computational Time Period: The ratio of streamflow upstream of a sewage treatment plant effluent discharge point to the effluent discharge is an important factor in an oxygen sag analysis, since it determines the relative influence of stream background water quality and sewage treatment plant effluent quality on the quality of the mixture of streamflow and treatment plant effluent.

The oxygen sag curve model was, for a given set of streamflow and effluent quality characteristics, programmed to compute oxygen sag curves for streamflow-effluent ratios ranging from 0.2 to

5.0. This ratio range was selected to include most existing and potential municipal sewage treatment sites in the planning region after an examination of 7 day-10 year low streamflows estimated for each of those sites and the design sanitary sewage flow for each site. The 7 day-10 year low streamflow was used in establishing the ratio range since, as discussed earlier in this chapter, that flow is used by the Wisconsin Department of Natural Resources in evaluating compliance of a given municipal sewage treatment plant discharge with state water use objectives and supporting standards.

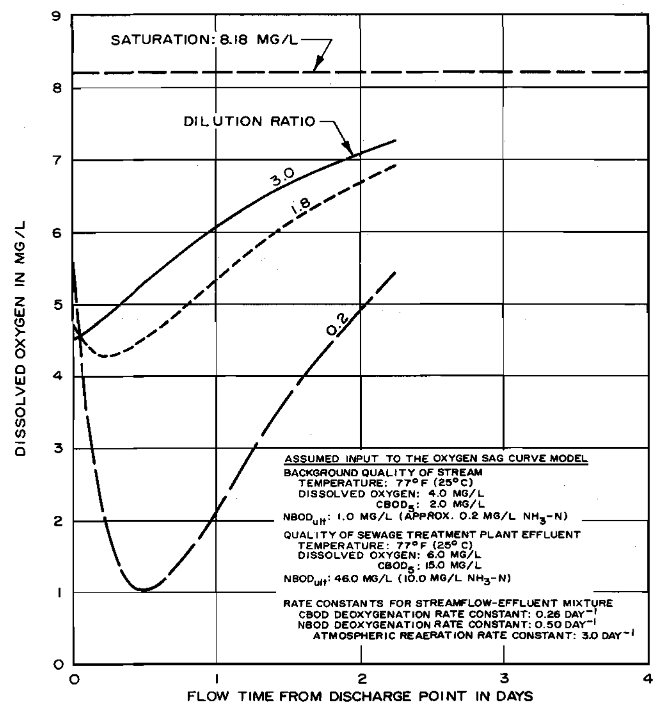
With respect to the time period used in the oxygen sag curve model, the computer program was, for a given set of streamflow and effluent quality characteristics and a given flow ratio, programmed to compute the oxygen deficit for a 2.25-day period or flow time downstream of the effluent discharge point. Experience with the model indicated that this time period was more than sufficient to include the time in which the oxygen depletion would achieve its maximum value and also include most of the oxygen recovery.

Model Runs and Resulting Design Curves: The oxygen sag curve model was operated to generate oxygen sag curves which were then used to construct design curves for use in the preparation of alternative plans. Figure 116 shows three representative oxygen sag curves obtained from the model along with the input data and information used to generate the sag curves. These curves, which represent the nighttime effect of the discharge of secondary sewage treatment plant effluent to a stream, are a portion of the 150 oxygen sag curves computed by the model and then used to develop the six design curves shown in Figure 117. These design curves give the minimum dissolved oxygen concentration downstream of a sewage treatment plant outfall as a function of the type of treatment and the ratio of streamflow to sewage treatment plant effluent flow. Implicit in the curves, of course, are the assumptions with respect to stream background quality, sewage treatment plant effluent quality, and rate constants in the stream-effluent mixtures.

Figure 117 contains three pairs of curves, with each pair corresponding to one of the three treatment categories set forth in Table 86, which categories may be generalized as category I, secondary treatment; category II, tertiary treatment providing high $CBOD_{ult}$ removal; and category III, advanced treatment providing nitrification. Each pair contains a solid curve denoting minimum or nighttime dissolved oxygen conditions and a dashed curve for maximum daytime dissolved oxygen conditions.

Figure 116

NIGHTTIME OXYGEN SAG CURVES DOWNSTREAM OF A CONVENTIONAL SECONDARY SEWAGE TREATMENT PLANT

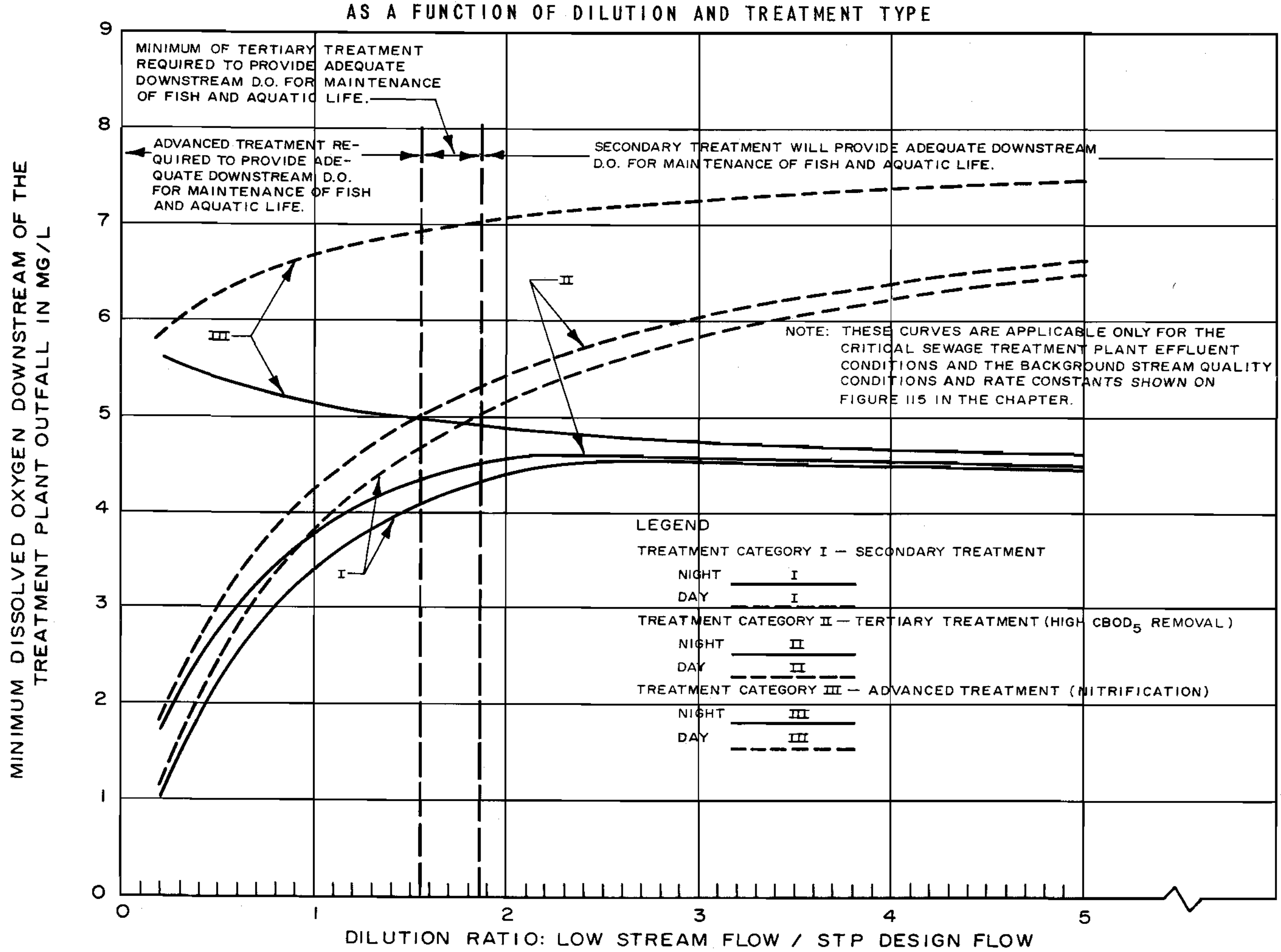


Source: Harza Engineering Company and SEWRPC.

Points used to construct any one of the six curves were obtained from the oxygen sag curve model by holding constant all input for stream background quality, sewage treatment plant effluent quality, and rate constants, and then operating the model for a range of streamflow-effluent flow ratios. Each dilution ratio produced an oxygen sag curve and the minimum dissolved oxygen concentration on that curve was plotted versus the flow ratio on the graph. A smooth curved line connecting all pairs of minimum dissolved oxygen-flow ratio values produced one of the six curves. It is important to note that each of the six curves in Figure 117 is not an oxygen sag curve, but instead represents many oxygen sag curves. Each curve is a graph of minimum downstream dissolved oxygen versus dilution ratio for one of the three treatment categories in combination with daytime or nighttime dissolved oxygen conditions.

Figure 117

MINIMUM DISSOLVED OXYGEN DOWNSTREAM OF A TREATMENT PLANT AS A FUNCTION OF DILUTION AND TREATMENT TYPE



Source: Harza Engineering Company and SEWRPC.

Use of Design Curves: The design curves were intended for use in determining the level and type of treatment required at a potential treatment plant site in order that the adopted water use objectives and supporting standards with respect to the oxygen requirements of fish and aquatic life may be met. As shown on Map 49, most surface waters in the Region are intended to support a warm water fishery. Water quality standards commensurate with such a fishery stipulate maintenance of a minimum dissolved oxygen concentration of 4.0 mg/l, with the added requirement that the DO level be maintained at 5.0 mg/l or more for at least 16 hours of any 24-hour period. For use with the design curves, these DO standards are interpreted to mean that nighttime dissolved oxygen concentrations shall not drop below 4.0 mg/l while daytime levels must be 5.0 mg/l or more, since the diurnal DO variation attributable to algae and other aquatic plants is characterized by low DO levels during the nighttime hours and relatively higher DO levels during the daylight period.

Assume, for example, that the streamflow-effluent ratio for a potential municipal sewage treatment plant is 0.5. The design curves indicate that sewage treatment plants in categories I and II, secondary treatment and tertiary treatment for high $CBOD_{ult}$ removal, respectively, would be inadequate because of excessive oxygen depletion during both daytime and nighttime periods. The minimum dissolved oxygen concentration downstream of a secondary treatment plant would be 2.40 mg/l during the day and 2.25 mg/l at night, which concentrations are below the allowable daytime and nighttime minimums of 5.0 and 4.0 mg/l, respectively. The minimum dissolved oxygen concentration downstream of a tertiary treatment plant providing high $CBOD_{ult}$ removal would be

3.00 mg/l during the day and 2.75 mg/l at night, which concentrations are also below the allowable daytime and nighttime maximums of 5.0 and 4.0 mg/l, respectively. A sewage treatment plant in category III, that is, advanced treatment providing nitrification, would produce acceptable downstream dissolved oxygen levels in that the minimum downstream DO concentration would be 6.25 mg/l during the day, which is greater than the 5.0 mg/l daytime minimum, and 5.40 mg/l at night, which is greater than the 4.0 mg/l nighttime minimum.

The above example, in addition to illustrating a specific application of the design curves, suggests some generalizations that can be made upon examination of the rule curves. If the streamflow-effluent ratio is equal to or greater than 1.85, any of the three categories of treatment are acceptable with respect to their effect on downstream dissolved oxygen levels. All three categories of treatment will produce, for ratios of 1.85 or more, minimum daytime downstream oxygen levels of 5.0 mg/l or more, thereby satisfying the daytime oxygen requirement, and minimum nighttime downstream oxygen levels of 4.0 mg/l or more, thereby satisfying the nighttime oxygen requirement.

If the ratio of streamflow to effluent discharge is less than 1.85, secondary sewage treatment will produce daytime DO values below the 5.0 mg/l minimum. Therefore, secondary treatment cannot be utilized for flow ratios below 1.85, and advanced treatment providing nitrification, or tertiary treatment providing higher $CBOD_{ult}$ removal, should be considered.

If the ratio of streamflow to effluent discharge is less than 1.55, tertiary treatment providing higher $CBOD_{ult}$ removal will produce daytime DO values below the 5.0 mg/l minimum. Therefore, neither secondary treatment nor tertiary treatment may be utilized for flow ratios below 1.55. Only advanced treatment providing nitrification is capable of maintaining the required dissolved oxygen level when the streamflow-effluent discharge ratio falls below 1.55. The design curves indicate that advanced treatment will maintain satisfactory DO levels for all dilution ratios including zero dilution.

In summary, if the standards for fish and aquatic life are to be met downstream of a municipal sewage treatment plant outfall, the following treatment levels must be provided for the indicated dilution ratio ranges in order to maintain adequate dissolved oxygen levels:[22]

1. Dilution ratio of 1.85 or more—secondary treatment.
2. Dilution ratio of 1.55 to 1.85—minimum of tertiary treatment required.
3. Dilution ratio of less than 1.55—advanced treatment required.

These generalizations are indicated in Figure 117 and are strictly applicable only for the critical sewage treatment plant effluent conditions, background stream quality conditions, and rate constants shown in Figure 115 of this chapter.

It is interesting to note the minimum downstream DO levels predicted by the model for very large dilution ratios. As the dilution ratio becomes larger, the minimum downstream DO for the three nighttime condition curves approaches the assumed nighttime stream background DO of 4.0 mg/l, while the minimum downstream DO for the three daytime condition curves approaches the assumed daytime stream background DO of 8.0 mg/l. That is, as the dilution of the effluent increases for a given treatment category, oxygen demands on the stream effluent mixture, as reflected by the sewage treatment plant effluent $CBOD_5$ and NOD_{ult}, are diminished and the mixture acquires dissolved oxygen characteristics that approach those of the stream.

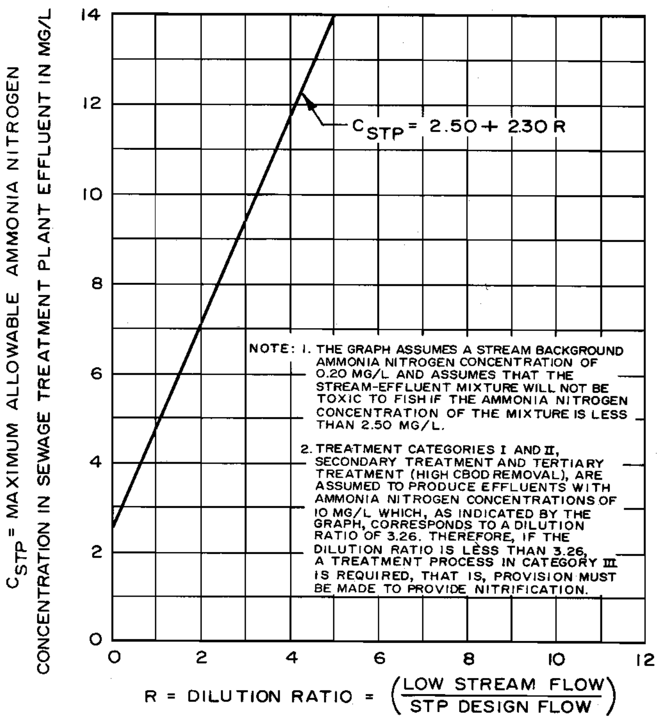
<u>Treatment Required to Avoid Ammonia Toxicity</u>

The toxic effect of sewage treatment plant effluent ammonia on fish was considered in the development of alternative municipal sewage treatment plant locations and treatment levels. As stated earlier, ammonia is considered acutely toxic to fish life at concentrations in excess of 2.50 mg/l ammonia nitrogen. This was used to develop the

[22] *The analyses described in this chapter for determining the level of sewage treatment required to meet the dissolved oxygen standards associated with a water use objective which seeks to maintain fish and aquatic life were completed prior to the adoption by the Wisconsin Natural Resources Board in October 1973 of more stringent dissolved oxygen standard supporting this objective (see Tables 72 and 73). Although the revised dissolved oxygen standard would require a higher level of treatment to maintain the specified higher nighttime instream dissolved oxygen levels, that level of treatment would not be as high as that required to avoid ammonia toxicity. Therefore, the revision of the state standard for dissolved oxygen content has no effect on the selection of treatment levels required to meet the water use objectives.*

Figure 118

MAXIMUM ALLOWABLE SEWAGE TREATMENT PLANT AMMONIA NITROGEN AS A FUNCTION OF DILUTION RATIO



Source: Harza Engineering Company and SEWRPC.

relationship shown in Figure 118, which gives the maximum allowable concentration of ammonia nitrogen in a sewage treatment plant effluent as a function of the available dilution ratio. The graph illustrates the positive effect of dilution of a wastewater discharge in that an increasing dilution, as reflected by a larger ratio of low streamflow to effluent flow, allows a larger concentration of ammonia nitrogen in the treatment plant effluent. For example, when the dilution ratio is 1.0, the maximum allowable ammonia nitrogen concentration in the sewage treatment plant effluent is 4.80 mg/l in order that the ammonia nitrogen concentration in the stream-effluent mixture not exceed 2.50 mg/l. At a higher dilution ratio of 2.0, however, the sewage treatment plant effluent may contain up to 7.10 mg/l ammonia nitrogen because of the increased availability of streamflow having a low ammonia nitrogen concentration.

The earlier discussion of the oxygen sag curve model indicated that sewage treatment plant effluents were assumed to have an ammonia nitrogen concentration of either 10.0 mg/l or 1.5 mg/l depending on the type of treatment (see Table 86). The larger ammonia nitrogen level corresponds to secondary and tertiary municipal sewage treatment plants, that is, those not employing nitrification, whereas the lower ammonia nitrogen concentration corresponds to advanced sewage treatment plants, that is, facilities having provision for nitrification.

The significance of the ammonia nitrogen analysis as presented in Figure 118 is that if the receiving stream is to support a warm-water fishery, and if the dilution ratio is less than 3.26, which corresponds to an effluent ammonia nitrogen concentration of 10.0 mg/l, nitrification must be provided to reduce effluent ammonia nitrogen below 10.0 mg/l such that the ammonia nitrogen level in the stream-effluent mixture will be less than 2.50 mg/l. A comparison of treatment required to avoid the toxic effects of ammonia nitrogen to the treatment requirements necessary to maintain sufficient downstream dissolved oxygen reveals that the former governs. That is, nitrification is not required for dilution ratios in excess of 3.26, but when the dilution ratio falls below 3.26 a sewage treatment process providing nitrification is required to prevent fish poisoning, with nitrification being required for that purpose down to a dilution ratio of 1.85. Below a dilution ratio of 1.85, nitrification is required to prevent fish poisoning, and nitrification, or tertiary treatment, for dilution ratios of 1.55 to 1.85 is needed to maintain adequate instream dissolved oxygen, that is, to prevent asphyxiation.

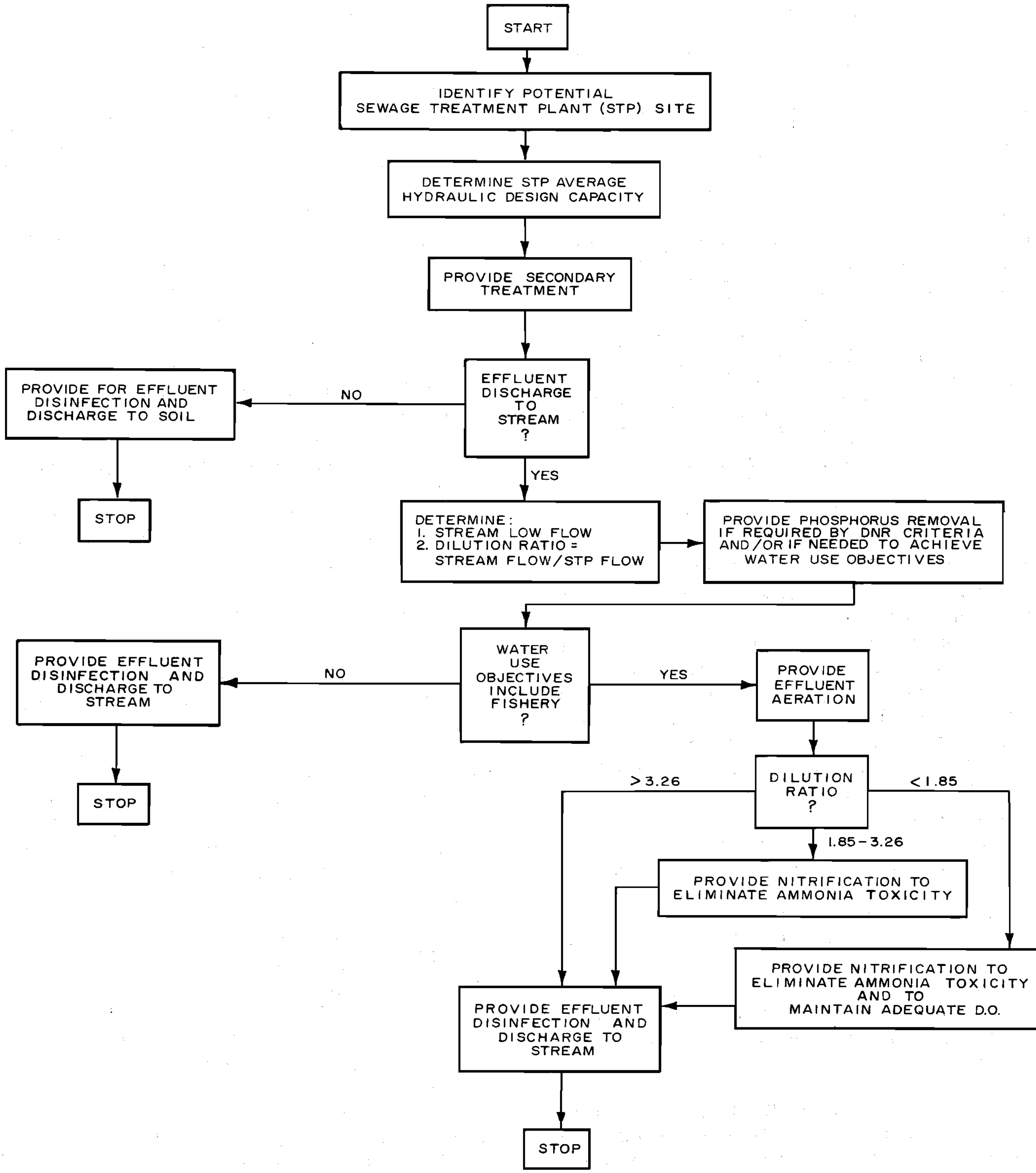
In summary, existing and potential sewage treatment plants were assumed to have treatment in category III, that is, provision for nitrification, when the dilution ratio is less than 3.26 and the facility is located on a stream intended to support fish and aquatic life as set forth in state water use objectives. A decision flow chart is shown in Figure 119. This chart summarizes procedures, discussed in detail above, that were used to determine required treatment levels for municipal sewage treatment plants.

Evolving Concepts With Respect to Nitrogen Compounds

The water quality control components of the Commission's Fox River watershed study, Milwaukee River watershed study, and regional sanitary sewerage system planning program reflect significant changes with respect to the effect of sewage treatment plant effluent nitrogen and ammonia on receiving waters. In particular, these successive planning studies reflect a decreased emphasis on the critical nature of nitrogen as a nutrient and the increased emphasis on the oxygen demand imposed by effluent nitrogen in the form of ammonia and on the toxic effect of that ammonia.

Figure 119

CRITERIA FOR DETERMINING TREATMENT LEVELS AS APPLIED UNDER THE REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM



Source: SEWRPC.

The Fox River watershed study placed strong emphasis on nitrogen removal, reflecting contemporary thinking on the importance of nitrogen as a limiting nutrient in the growth of algae and aquatic plants. Present information indicates that nitrogen is not as critical a nutrient as phosphorus and therefore nitrogen removal is not a primary consideration in municipal sewage treatment. Although nitrogen removal was recommended in the Fox River watershed study, it was not recommended in the Milwaukee River watershed study or in the sewerage study.

Current understanding of water quality phenomena indicates that municipal sewage treatment should provide for nitrification in order to significantly reduce the oxygen demand exerted by nitrogen in the form of ammonia because of the significance of that demand on the oxygen balance of the Region's streams, and in order to prevent fish poisoning due to the toxic effects of ammonia. The detrimental toxic effect of ammonia nitrogen was not considered in the Fox and Milwaukee River watershed studies, and although nitrogenous biochemical oxygen demand was an important factor in the Milwaukee River watershed study, the toxic effect of ammonia was not incorporated in that planning program. It is now apparent, however, that the possibility of both downstream fish asphyxiation and fish poisoning must be examined at each municipal sewage treatment plant, and if sufficient dilution is not available at low streamflow conditions, nitrification must be provided in order to achieve the adopted water use objectives with respect to maintenance of a fishery.

Accordingly, then, the sewerage study recommends provision for nitrification at nearly all municipal sewage treatment plants in the planning region. Treatment recommendations previously set forth in the Fox River watershed study were altered, using regional sanitary sewerage system study design criteria so as to replace nitrogen removal with nitrification and effluent aeration. Milwaukee River watershed recommendations with respect to municipal sewage treatment plants were supplemented, where necessary, so as to include nitrification where it would be necessary to prevent fish toxicity.

Action of the Technical Coordinating and Advisory Committee with Respect to Nitrification Recommendations

Most of the recommendations in this report with respect to the treatment levels to be provided at municipal sewage treatment plants include provisions for producing a nitrified effluent. This nitrification is necessary partly to reduce the ammonia nitrogen levels in treatment plant effluents so as to eliminate, or significantly reduce, the possibility of detrimental oxygen utilization by the process of nitrification in the receiving stream. Although provisions for nitrification are not normally included at present in the design of municipal sewage treatment plants, it is probable, as discussed in Appendix C of this report, that instream nitrification may be expected to occur with sufficient severity in stream reaches downstream of secondary sewage treatment plants employing biological processes so as to merit consideration of such nitrification in assessing the impact of the discharge on the oxygen budget of the receiving waters. The need for discharging a nitrified effluent is reinforced by the likelihood of fish toxicity problems associated with the discharge to the stream of secondary treatment plant effluent containing high concentrations of ammonia.

The Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning, after lengthy and careful deliberation, unanimously endorsed both the need to explicitly consider instream nitrification when evaluating the impact of a given sewage treatment plant discharge on the receiving water and the nitrification treatment recommendations included in this report. The Committee's unanimous recommendations were, however, qualified. This qualification was based upon the need to consider three factors that may, in the future, require a refinement of, or a change in, the nitrification recommendations for any given municipal sewage treatment plant ultimately included in the regional sanitary sewerage system plan.

The first of these factors relates to the limitations of the nitrification data base for the Region and the very real possibility of expanding that base in the near future. Although field data from other areas of the country judged to be representative of river reaches downstream of biological treatment plants in southeastern Wisconsin indicate the need to consider instream nitrification, only minimal nitrification data are currently available for streams within the seven-county planning Region. It is anticipated, however, that the regional nitrification data base will be enlarged upon in the next few years as a result of alterations in the continuing SEWRPC-DNR annual stream water quality monitoring program, surface water quality data obtained under the Commission's current comprehensive study of the Menomonee River watershed, and other special studies that may be undertaken in response to increased interest in surface water quality in general and instream nitrification in particular.

A second factor that was of concern to the Technical Coordinating and Advisory Committee, because it might result in a future refinement to, or change in, the nitrification treatment recommendations, is the current state of the art of water quality simulation modeling, particularly the manner in which instream nitrification is accommodated. Future laboratory and field studies may result in a better understanding of the NBOD process, thereby permitting an improved mathematical representation of that process. Water quality simulation model runs using these modeling improvements, in combination with local streamflow and local or regional water quality data that may become available in the future, may suggest alterations in the nitrification treatment recommendations for a given site.

The third factor of concern to the Committee with respect to the recommendations of providing a nitrified effluent at municipal sewage treatment plants was the imminent changes expected in both state and federal water use objectives and supporting standards. These changes, which are expected to incorporate more stringent requirements with respect to both sewage treatment plant effluent quality and instream water quality, may make it necessary to alter the nitrification treatment recommendations of the regional sanitary sewerage system plan.

Accordingly, the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning unanimously endorsed the recommendations concerning nitrification set forth in this report upon the condition that the Commission, as a part of its continuing areawide water resources planning effort within the Region, and in cooperation with the Wisconsin Department of Resources, propose to undertake the collection and analysis of additional data concerning instream nitrification and undertake a detailed stream water quality simulation modeling program for selected stream reaches within the Region designed to achieve a better understanding of the relationship between sewage treatment, instream nitrification, and resulting instream water quality. The Commission is to review the recommendations contained in this report in light of the results of these recommended planning and research efforts and in light of any revisions in both sewage treatment plant effluent and instream water quality standards which may be made by the state or federal government in relation to currently established water use objectives and supporting water quality standards.

Cost Estimates

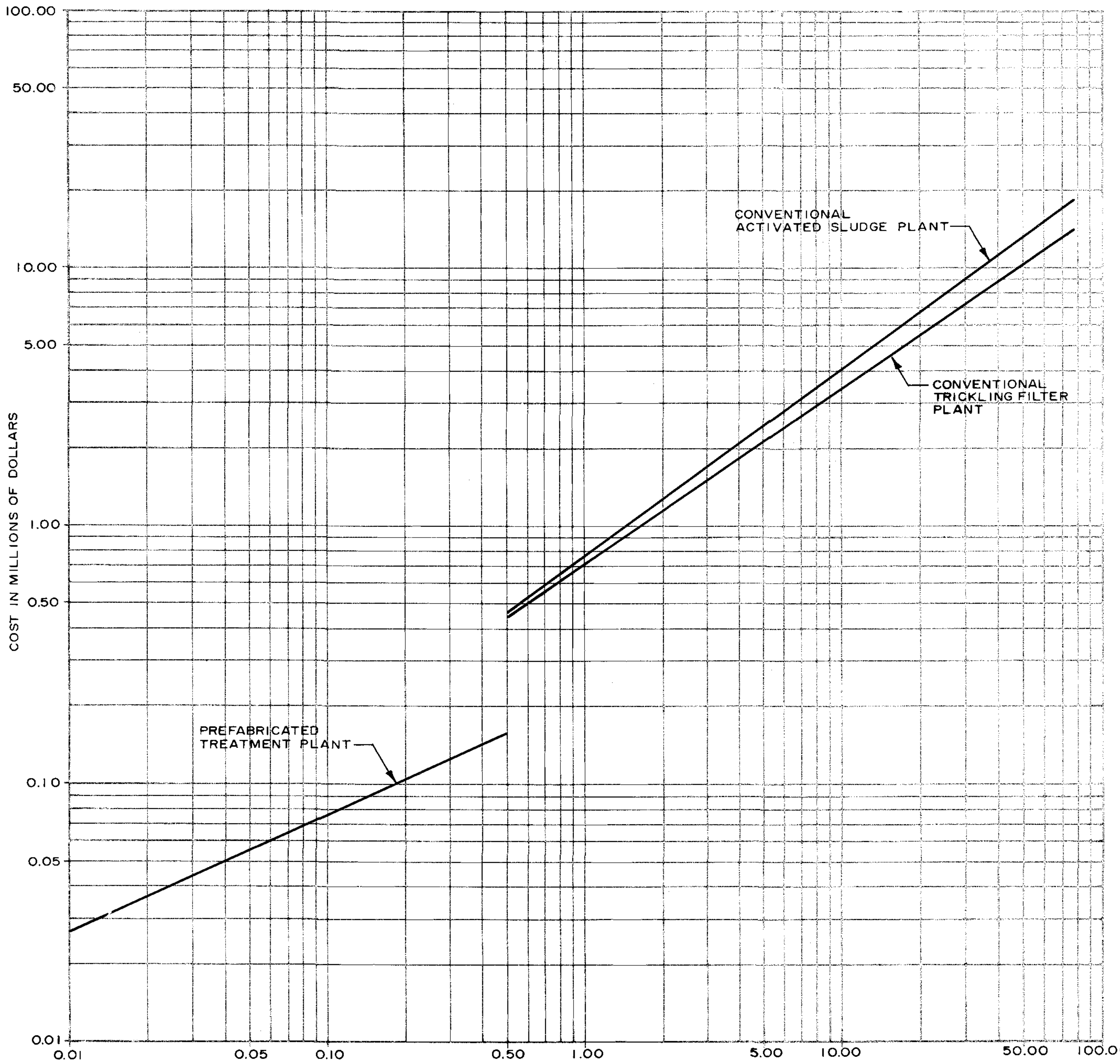
The costs utilized in the regional sanitary sewerage system planning program for sewage treatment facilities are shown in a series of curves contained in Figures 120 through 126. These cost estimates were developed especially for the Southeastern Wisconsin Region utilizing 1970 as a base year and utilizing prevailing unit costs for labor, equipment, and material by the Harza Engineering Company from national cost data compiled by the American Society of Civil Engineers, Engineering News-Record, and the U. S. Environmental Protection Agency.

For purposes of cost estimates, existing municipal sewage treatment plants were assumed to be abandoned whenever significant additional hydraulic capacity or levels of treatment were required to meet the 1990 conditions. For example, the regional sanitary sewerage system plan recommends abandonment of existing treatment facilities at the Village of Dousman and the City of Oconomowoc and construction of new facilities at these locations, since the existing hydraulic capacity at both of these plants is small relative to 1990 needs and existing treatment levels are well below those needed to meet water use objectives. In contrast, existing sewage treatment plants at the Cities of Racine and Kenosha were not assumed to be abandoned and serve as examples of situations where existing facilities constitute a significant portion of the 1990 needs, both in terms of hydraulic capacity and treatment levels, and therefore could be economically enlarged.

The above assumptions with respect to abandonment of treatment facilities will tend to result in conservative, or high, construction cost estimates. It may be possible to reduce the construction costs of certain plan elements calling for plant abandonment by closely examining, during the plan implementation phase, the treatment units and other facilities at existing municipal sewage treatment plants in order to determine if some of those units and facilities could be salvaged and integrated into the recommended new treatment plants, thereby achieving a cost reduction.

Figure 120

CONSTRUCTION COSTS FOR SECONDARY SEWAGE TREATMENT PLANTS

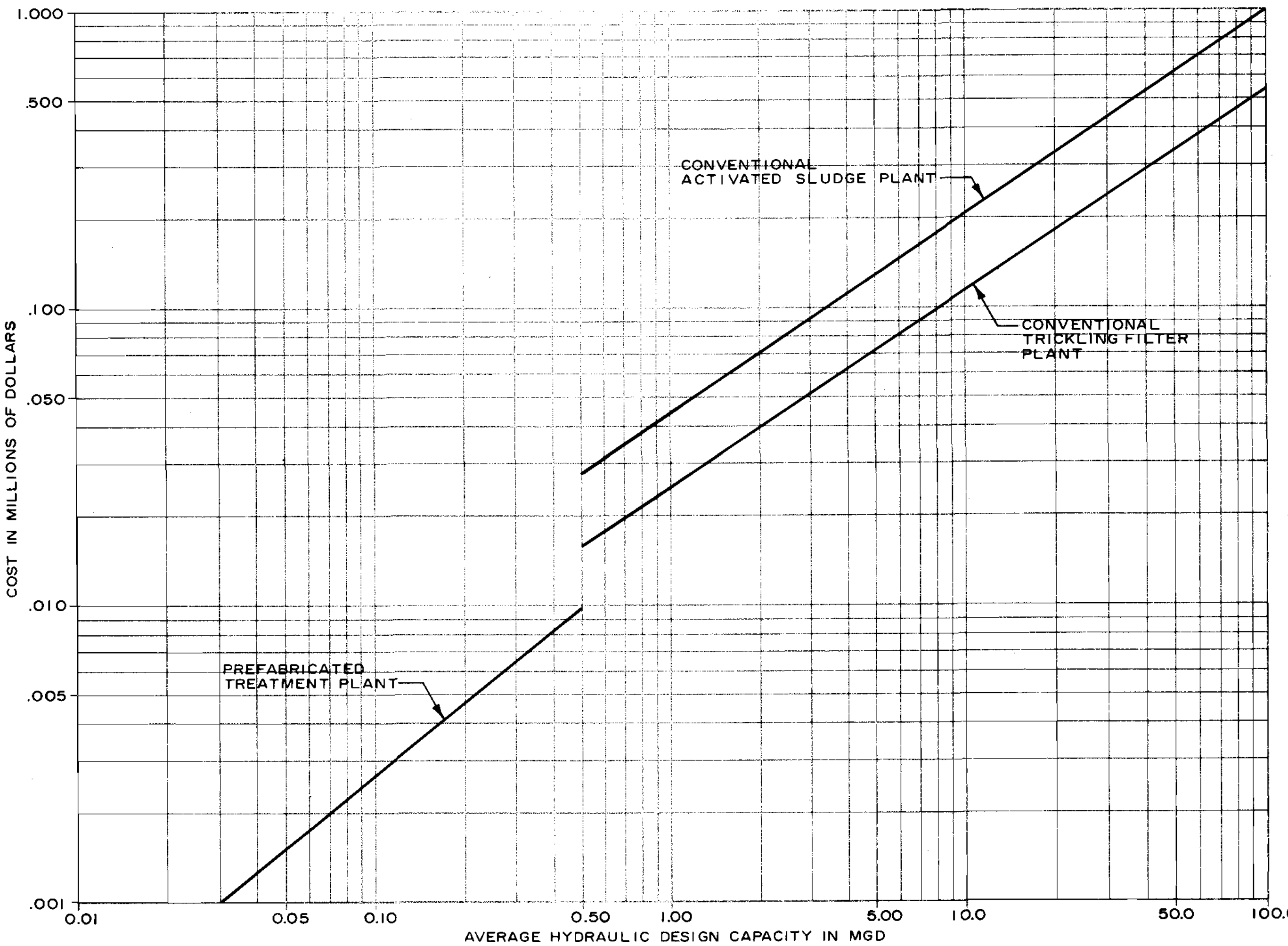


Source: R. Smith, A Compilation of Cost Information for Conventional and Advanced Wastewater Treatment Plants and Processes, FWQA, 1967, and Means 1970 Cost Data. Data adjusted to January 1970 using PHS index.

Costs of Treatment Processes and Land: Treatment facility cost curves shown in Figures 120 through 126 exclude land costs, engineering and legal fees, administrative costs, financing costs, and an allowance for contingencies. Operation and maintenance costs include the costs of equipment, labor, electrical power, and parts replacement. The curves in Figure 120 represent the 1970 cost of constructing a secondary treatment plant of the activated sludge or trickling filter type, and for design flows of less than 1.0 mgd, the construction cost for package treatment plants. Annual

Figure 121

ANNUAL OPERATION AND MAINTENANCE COSTS FOR SECONDARY SEWAGE TREATMENT PLANTS



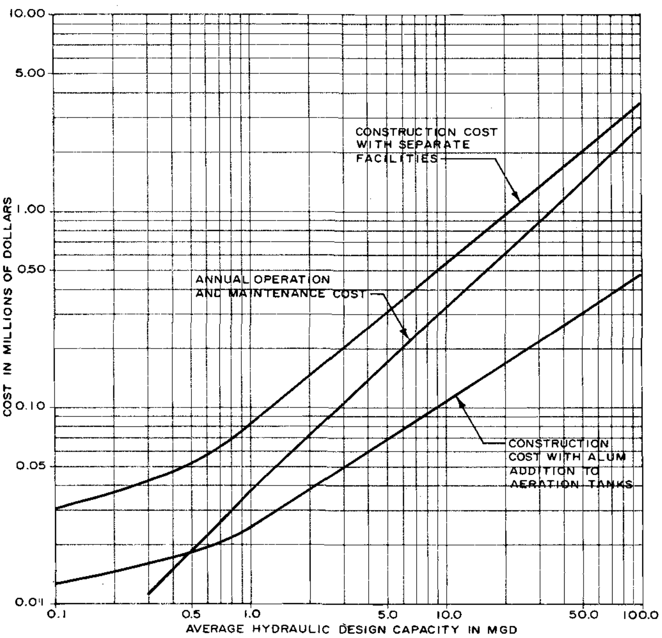
Source: *R. Smith, A Compilation of Cost Information for Conventional and Advanced Wastewater Treatment Plants and Processes, FWQA, 1967. Data adjusted to January 1970 using PHS index. Data for package treatment plants is from Harza Engineering Company.*

operation and maintenance costs for secondary sewage treatment facilities, including package plants, are presented in Figure 121. The curves include the cost of constructing, operating, and maintaining primary treatment facilities. The curves in Figure 122 represent the 1970 construction costs and annual operation and maintenance costs for providing 85 percent phosphorus removal by the addition of the coagulant alum in aeration tanks. Costs are presented for the construction of the necessary supplemental facilities on existing aeration tanks and for the construction of new separate facilities for phosphorus removal such as would be required at trickling filter type treatment plants.

The curves in Figure 123 represent the 1970 cost of constructing aeration facilities and also include the annual operation and maintenance costs associated with those facilities. The curves assume that diffused aeration will be utilized in a tank at the effluent of an activated sludge plant and the effluent dissolved oxygen concentration will be raised from 1.0 mg/l to 5.0 mg/l. Aeration facility construction costs and operation and maintenance costs were not applied at treatment plants using mechanically aerated waste stabilization lagoons, since it was assumed that the effluent from such units would contain sufficient dissolved oxygen.

Figure 122

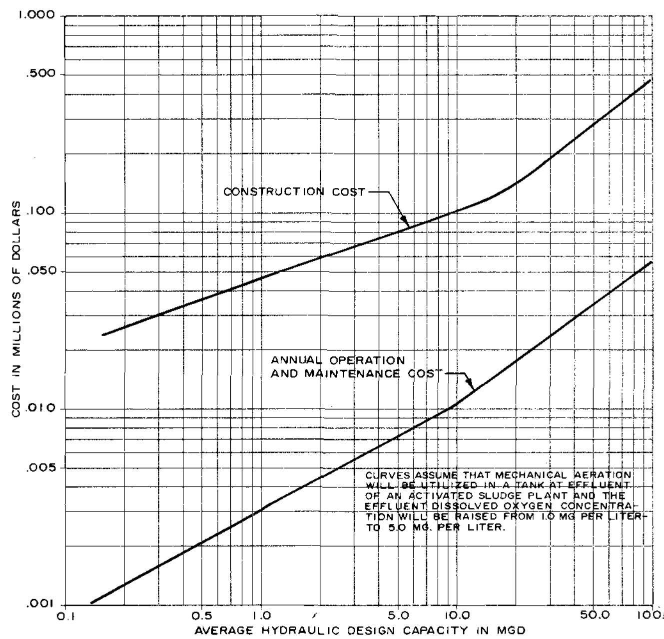
CONSTRUCTION COSTS AND ANNUAL OPERATION AND MAINTENANCE COSTS FOR PHOSPHORUS REMOVAL FACILITIES AT SEWAGE TREATMENT PLANTS



Source: Harza Engineering Company and SEWRPC.

Figure 123

CONSTRUCTION COSTS AND ANNUAL OPERATION AND MAINTENANCE COSTS FOR EFFLUENT AERATION AT SEWAGE TREATMENT PLANTS



Source: R. Smith, A Compilation of Cost Information for Conventional and Advanced Wastewater Treatment Plants and Processes, FWQA, 1967. Data adjusted to January 1970 using PHS index.

The curves in Figure 124 represent the 1970 cost of constructing disinfection facilities and the associated annual operation and maintenance expenditures. These cost curves assume that the disinfection agent is chlorine. The curves in Figure 125 represent 1970 construction costs for naturally aerated and mechanically aerated waste stabilization lagoons. Annual operation and maintenance costs for waste stabilization lagoons are presented in Figure 126.

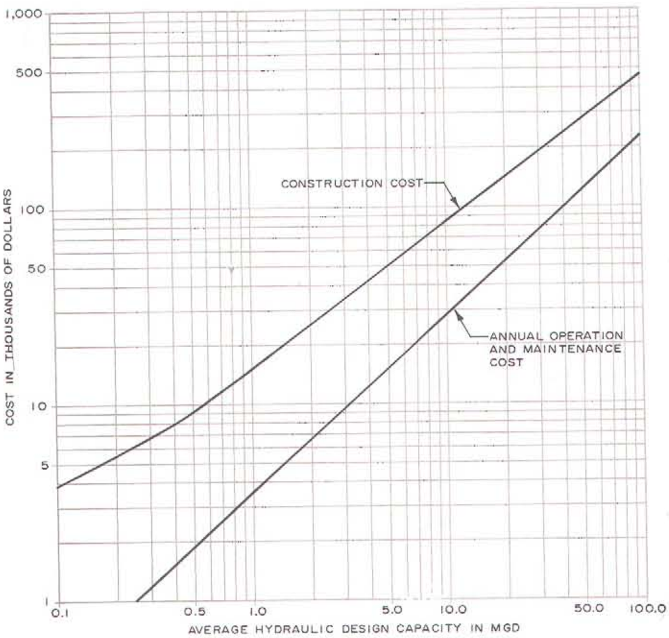
Special cost curves were not developed for the provision of nitrification treatment. If the sewage treatment plant design criteria called for nitrification and if the facility was to use an activated sludge process, a construction cost increment and an annual operation and maintenance cost increment were provided, and were assumed to be 40 percent of the construction cost and 40 percent of the annual operation and maintenance costs, respectively, of the secondary sewage treatment facility. In those instances where mechanically aerated waste stabilization lagoons could be utilized, a cost increment for nitrification was not applied, since it was assumed that a mechanically aerated waste stabilization lagoon would provide nitrification without additional facilities or operation and maintenance.

Land requirements for secondary treatment plants employing activated sludge or trickling filter processes, and for treatment facilities using naturally aerated and mechanically aerated waste stabilization ponds, are represented in Figure 127. Indicated areal requirements for secondary treatment include the land needed for primary treatment units. The incremental land area needed for advanced treatment and auxiliary treatment is negligible compared to the land required for the basic secondary treatment plant, and is, therefore, not included in the curves. Using land area requirements from Figure 127, land acquisition costs were computed on the basis of $5,000 per acre except where unusual site preparation problems dictated a higher unit value.

The curves in Figure 127 demonstrate the large land needs of waste stabilization lagoons relative to land requirements for municipal sewage treat-

Figure 124

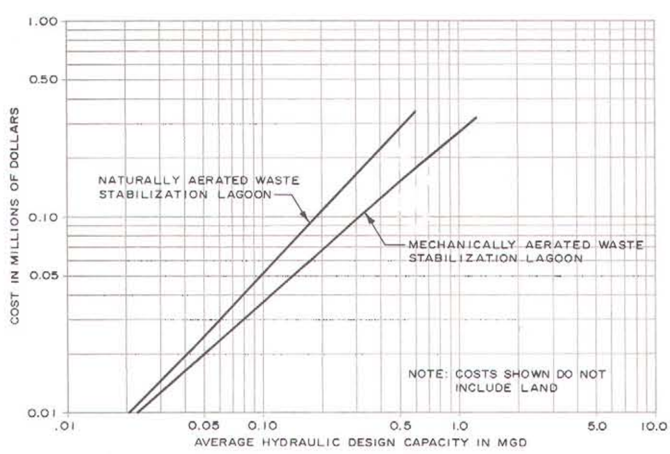
CONSTRUCTION COSTS AND ANNUAL OPERATION AND MAINTENANCE COSTS FOR EFFLUENT DISINFECTION BY CHLORINATION AT SEWAGE TREATMENT PLANTS



Source: R. Smith, *A Compilation of Cost Information for Conventional and Advanced Wastewater Treatment Plants and Processes*, FWQA, 1967. Data adjusted to January 1970 using PHS index.

Figure 125

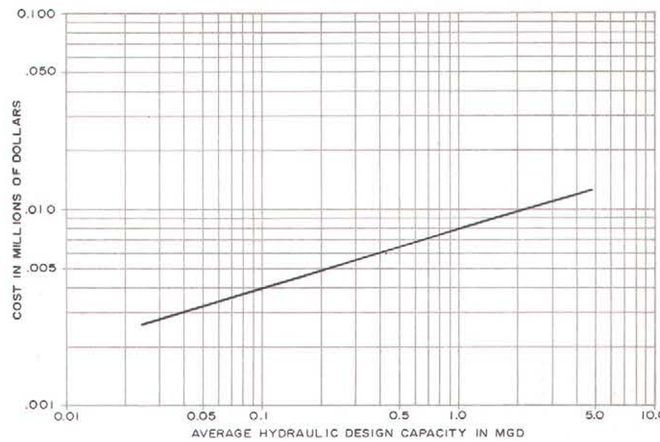
CONSTRUCTION COSTS FOR NATURALLY AERATED AND MECHANICALLY AERATED WASTE STABILIZATION LAGOONS



Source: Harza Engineering Company and SEWRPC.

Figure 126

ANNUAL OPERATION AND MAINTENANCE COSTS FOR NATURALLY AERATED AND MECHANICALLY AERATED WASTE STABILIZATION LAGOONS



Source: Harza Engineering Company and SEWRPC.

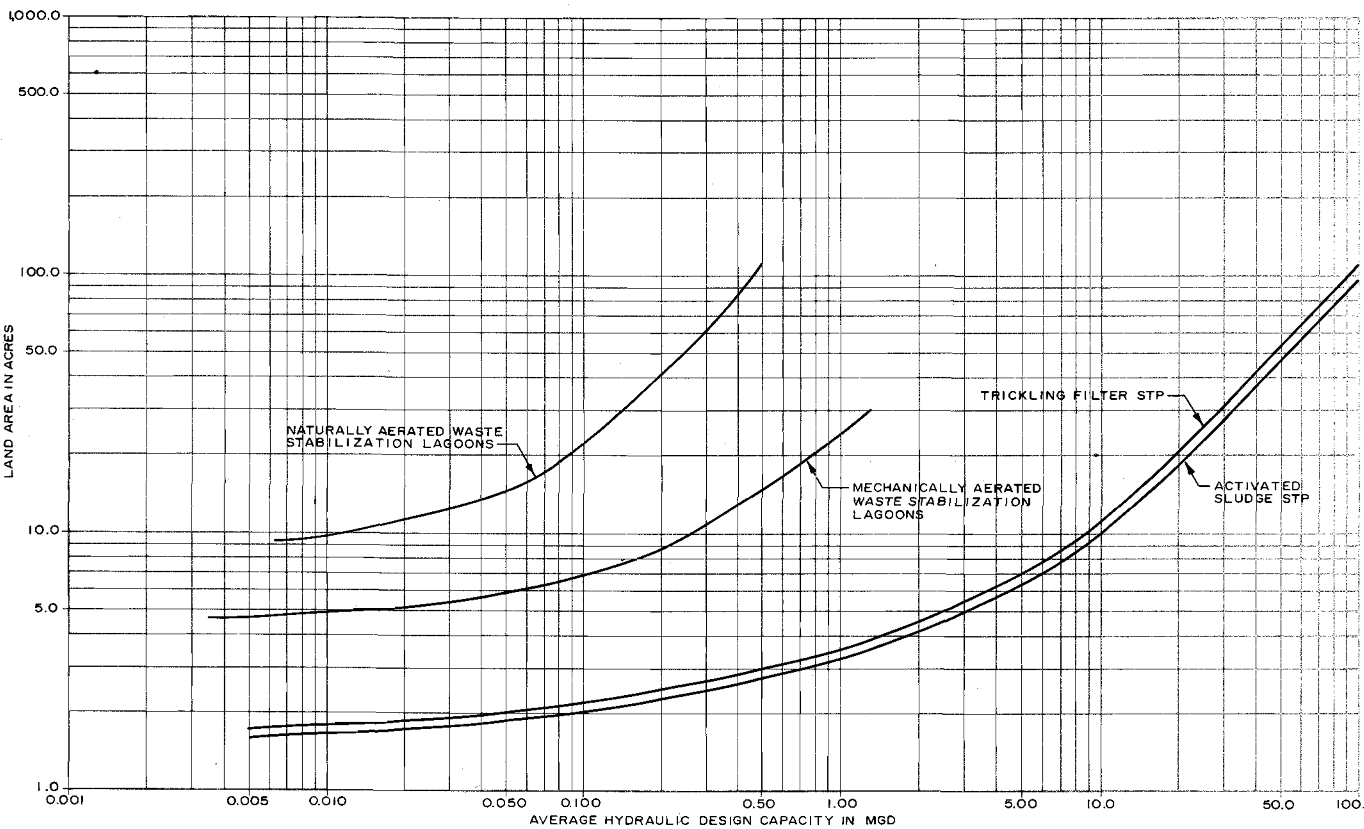
ment plants employing the activated sludge or trickling filter processes. At a design flow of 0.5 mgd, for example, a mechanically aerated lagoon would require 15 acres of land or about five times as much as the approximately 3.0 acres of land required for an activated sludge or trickling filter plant. A naturally aerated lagoon for a 0.5 mgd design flow would require 110 acres of land or about 37 times as much as the 3.0 acres needed for the activated sludge or trickling filter plant.

Total Costs, Cost Comparisons, and Economy of Scale: Having presented cost criteria for the various components in sewage treatment plants, it is useful to compare, for a wide range of average hydraulic design capacity, the relative magnitude of the capital costs of each level of treatment and the relative magnitude of the annual operation and maintenance costs for each treatment level. It is also important to demonstrate the economy of scale in both capital costs and annual operation and maintenance costs that is associated with increased sewage treatment plant size as that size is expressed in terms of average hydraulic design capacity.

Figure 128 presents absolute capital costs and capital cost per mgd of average hydraulic design capacity of various treatment levels as a function of sewage treatment plant capacity. Figure 129 shows absolute annual operation and maintenance

Figure 127

LAND REQUIREMENTS FOR SELECTED SEWAGE TREATMENT PROCESSES



Source: Harza Engineering Company and SEWRPC.

costs and annual operation and maintenance cost per mgd of average hydraulic design capacity as a function of sewage treatment plant capacity. These two figures, which were prepared from the previously presented cost curves, serve to illustrate the relative cost of various levels of treatment as well as the economy of scale achieved by large municipal sewage treatment plants employing primary treatment followed by secondary treatment using the activated sludge process; advanced treatment consisting of phosphorus removal and nitrification; and auxiliary treatment consisting of effluent disinfection and aeration.

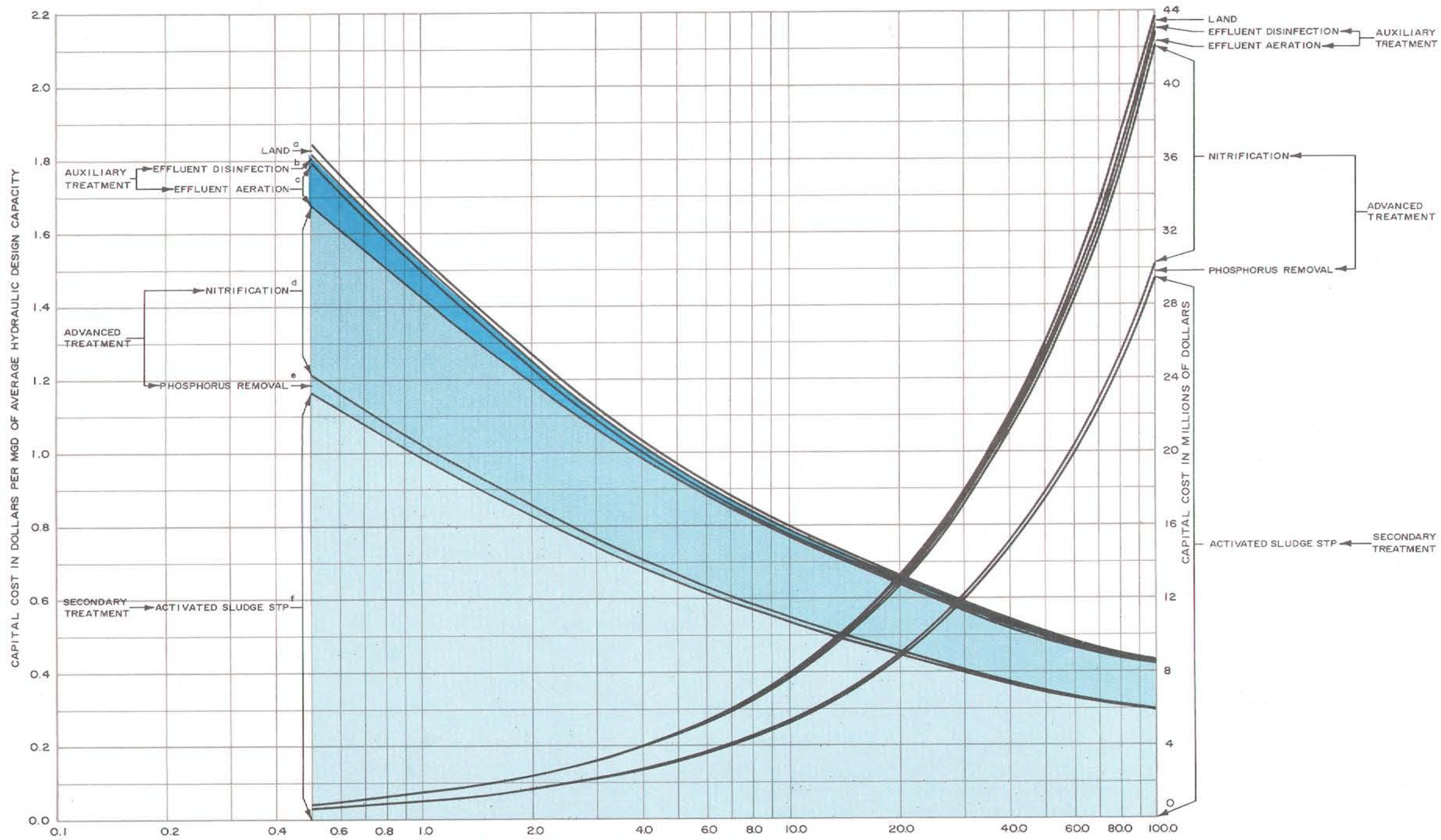
Regardless of the average hydraulic design capacity, primary and secondary treatment facilities account for about two-thirds of the capital cost of a new municipal sewage treatment plant, with most of the remaining one-third of the capital costs being represented by advanced treatment facilities, as shown in Figure 128. Auxiliary treatment facilities and land costs constitute a small part, less than 4 percent, of the total capital costs.

Economy of scale in the capital costs of treatment levels and processes is also illustrated in Figure 128. The total sewage treatment plant capital cost per mgd of average hydraulic design capacity, as well as the capital cost of each treatment level and process, decreases markedly with increased capacity. For example, a 1.0 mgd facility providing complete treatment would have a unit capital cost of $1.53 million per mgd of average hydraulic design capacity, a 10.0 mgd plant would have a smaller unit capital cost of $0.80 million per mgd of capacity, and a 100 mgd would have an even smaller unit capital cost of $0.44 million per mgd of capacity.

An examination of annual operation and maintenance costs shown in Figure 129 indicates that, regardless of average hydraulic design capacity, advanced treatment accounts for over half of annual operation and maintenance costs, with an excess of three-quarters of that being attributable to phosphorus removal. Secondary treatment, which accounts for about two-thirds of the capital costs, represents only about one-quarter of the

Figure 128

SUMMARY OF CAPITAL COSTS FOR VARIOUS LEVELS OF SEWAGE TREATMENT



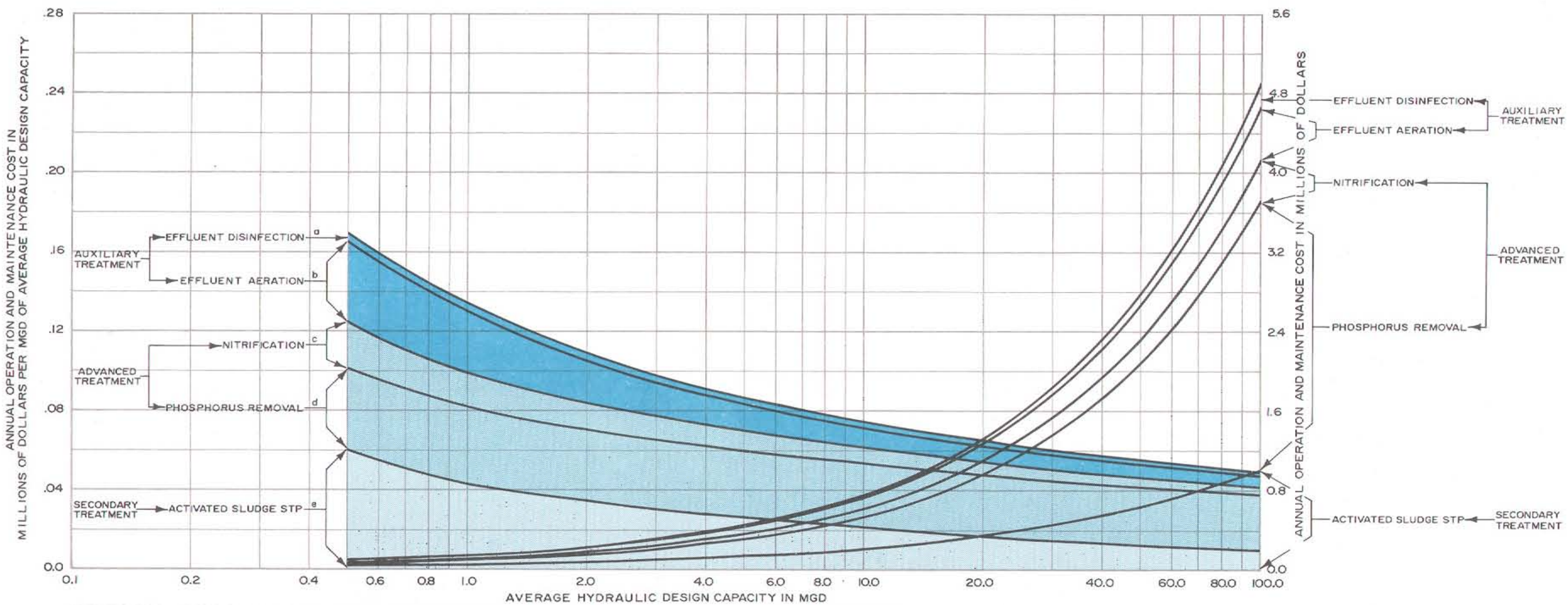
NOTE: THIS GRAPH WAS DEVELOPED USING THE TREATMENT FACILITY CONSTRUCTION COST CURVES INCLUDED IN THIS CHAPTER. CAPITAL COSTS ARE 1.35 TIMES CONSTRUCTION COSTS WITH THE DIFFERENCE BETWEEN CONSTRUCTION AND CAPITAL COSTS ACCOUNTING FOR CONTINGENCIES, ENGINEERING AND LEGAL FEES, ADMINISTRATIVE COSTS, AND FINANCING COSTS.

a LAND ACQUISITION COSTS WERE COMPUTED ON THE BASIS OF $5,000 PER ACRE.
b EFFLUENT DISINFECTION CAPITAL COSTS ASSUME DISINFECTION WITH CHLORINE.
c EFFLUENT AERATION CAPITAL COSTS ASSUME A MECHANICAL AERATION DEVICE OPERATING IN A TANK LOCATED AT THE END OF A SEWAGE TREATMENT FACILITY EMPLOYING THE ACTIVATED SLUDGE PROCESS.
d THE GRAPH ASSUMES THAT NITRIFICATION WILL BE ACCOMPLISHED IN CONJUNCTION WITH THE ACTIVATED SLUDGE PROCESS WITH THE CAPITAL COST OF NITRIFICATION COMPUTED AS 40 PERCENT OF THE CAPITAL COST OF SECONDARY TREATMENT.
e PHOSPHORUS REMOVAL CAPITAL COSTS ASSUME THAT ALUM FACILITIES ARE ADDED TO EXISTING AERATION TANKS.
f SECONDARY TREATMENT CAPITAL COSTS INCLUDE PRIMARY TREATMENT AND ASSUME SECONDARY TREATMENT IS ACHIEVED BY THE ACTIVATED SLUDGE PROCESS.

Source: Harza Engineering Company and SEWRPC.

Figure 129

SUMMARY OF ANNUAL OPERATION AND MAINTENANCE COSTS
FOR VARIOUS LEVELS OF SEWAGE TREATMENT



NOTE: THIS GRAPH WAS DEVELOPED USING THE TREATMENT FACILITY OPERATION AND MAINTENANCE COST CURVES INCLUDED IN THIS CHAPTER.

a EFFLUENT DISINFECTION OPERATION AND MAINTENANCE COSTS ASSUME DISINFECTION WITH CHLORINE.

b EFFLUENT AERATION CAPITAL OPERATION AND MAINTENANCE COSTS ASSUME A MECHANICAL AERATION DEVICE OPERATING IN A TANK LOCATED AT THE END OF A SEWAGE TREATMENT FACILITY EMPLOYING THE ACTIVATED SLUDGE PROCESS.

c THE GRAPH ASSUMES THAT NITRIFICATION WILL BE ACCOMPLISHED IN CONJUNCTION WITH THE ACTIVATED SLUDGE PROCESS WITH THE OPERATION AND MAINTENANCE COST OF NITRIFICATION COMPUTED AS 40 PERCENT OF THE OPERATION AND MAINTENANCE COST OF SECONDARY TREATMENT.

d PHOSPHORUS REMOVAL OPERATION AND MAINTENANCE COSTS ASSUME THAT ALUM FACILITIES ARE ADDED TO EXISTING AERATION TANKS.

e SECONDARY TREATMENT OPERATION AND MAINTENANCE COSTS INCLUDE PRIMARY TREATMENT AND ASSUME SECONDARY TREATMENT IS ACHIEVED BY THE ACTIVATED SLUDGE PROCESS.

Source: Harza Engineering Company and SEWRPC.

annual operation and maintenance expenditure, with auxiliary treatment representing somewhat less than one-quarter of the operation and maintenance costs.

Figure 129 also serves to illustrate the economy of scale that can be achieved in sewage treatment plant operation and maintenance expenditures. The total annual operation and maintenance cost per mgd of average hydraulic design capacity decreases markedly with increased capacity. For example, a 1.0 mgd facility providing complete treatment would have a unit annual operation and maintenance cost of $135,000 per mgd; and 10.0 mgd plant would have a smaller unit annual operation and maintenance cost of $75,000 per mgd; and a 100 mgd plant would have an even smaller unit annual operation and maintenance cost of $50,000 per mgd.

In summary, Figures 128 and 129 demonstrate that primary and secondary treatment facilities account for about two-thirds of the capital cost of a municipal sewage treatment plant that provides secondary, advanced, and auxiliary treatment. Over half of the annual operation and maintenance costs of such a treatment facility, however, are attributable to the advanced treatment component. Finally, there is a significant economy of scale, both with respect to capital costs and operation and maintenance costs, associated with large municipal sewage treatment plants.

COMPARISON OF DESIGN CRITERIA WITH REGIONAL SEWAGE FLOW AND QUALITY VALUE

The various design sewage flow and strength criteria as set forth in this chapter and used in the preparation of the regional sanitary sewerage system plan can be compared with the sewage flow and sewage strength values found in the Southeastern Wisconsin Region under the investigations described in Chapter VI of this report. This comparison is summarized in Table 87. In general, it may be concluded that the sewage flow and sewage strength criteria selected for use in the regional sanitary sewerage system planning program compare favorably with the actual sewage flow and sewage strength data collected within the Region. In this respect it should be recognized that the estimation of sewage flow and strength characteristics for design purposes is less than an exact science and necessarily involves the exercise of experienced engineering judgement. Therefore, the design criteria used were not based solely upon the measured sewage flow and strength data presented in Chapter VI, but were also based upon and incorporated the results of a careful search of the literature and the experienced judgement of the very knowledgeable sanitary engineers who served as the Commission's Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning.

With respect to those design criteria relating to sewage flows, it may be concluded that the selected design criteria are conservative in nature, in that the criteria selected for use, with but one exception, exceed somewhat the observed values. The design of sanitary sewerage systems under the regional sanitary sewerage system planning program should, therefore, be fully adequate to accommodate the anticipated 1990 demand for sewage conveyance and treatment. The utilization of a 125 gallons per capita per day criterion for domestic sewage flow, as compared to the average of 88 gallons per capita per day currently found in the Region, is justified based upon the increasing trend in per capita water consumption discussed in Chapter VI of this report (see Table 64). It is reasonable to assume that persons living within the Region will increase their per capita consumption of water over the next 20 years, much as they have increased such consumption over the past 10 years.

The 7,500 gallons per acre per day design criterion for sewage flow contribution from major industrial land use concentrations is somewhat less than the average such values found today in the Region, or 12,270. This design criterion can be justified, however, on the basis of recent trends toward industrial water conservation and reuse in order to avoid increasing costs of treating industrial waste waters in municipal sewage treatment plants. The 7,500 gallons per acre per day design criterion for sewage flow contribution from major commercial land uses corresponds very closely to, but is slightly below, the existing value found in the Region.

The infiltration design criteria selected for use exceed the regional average, but lie well within the range of such values found in the Region. The storm water inflow design criteria correspond very closely to the average found in the Region. The peak-to-average flow ratios selected for use in the design of trunk sewers and sewage treatment plants very closely approximate the observed peak-to-average ratios in the Region.

Table 87

COMPARISON OF SEWAGE FLOW AND STRENGTH VALUES FOUND IN THE REGION WITH DESIGN CRITERIA SELECTED FOR USE IN THE REGIONAL SANITARY SEWERAGE SYSTEM PLANNING PROGRAM

	Sewage Flow									
Determined Values or Selected Criteria	Per Capita Domestic Sewage Flow Contribution (gpcd)	Major Industrial Land Use Sewage Flow Contribution (gpad)	Major Commercial Land Use Sewage Flow Contribution (gpad)	Groundwater Infiltration (gpm/acre)		Storm Water Inflow (gpm/acre)		Peak-to-Average Ratios: Trunk Sewers		Peak-to-Average Ratios: Sewage Treatment Plants
Average Values Found in Region[1]	88	12,270	7,640	0.24		0.57		3.72		1.87
Range of Values Found in Region[1]	78-103	1,430-24,660	2,580-13,620	0.09-0.73		0.23-1.68		2.83-4.61		1.34-2.66
Design Criteria Selected for Regional Sanitary Sewerage System Planning Program[2]	125	7,500	7,500	Type of Development		Type of Development		Population Range		2.00
				High Density	0.5	High Density	0.5	0- 2,000	5.0	
								2-10,000	4.0	
				Medium Density	0.6	Medium Density	0.6	10-20,000	3.0	
								>20,000	2.5	
				Low Density	0.5	Low Density	0.5			

	Sewage Strength				
Determined Values Or Selected Criteria	Carbonaceous Biochemical Oxygen Demand (Five-Day) (lbs/capita/day)	Suspended Solids (lbs/capita/day)	Phosphorus (lbs/capita/day)	Organic Nitrogen (lbs/capita/day)	Ammonia Nitrogen (lbs/capita/day)
Average Values Found in Region[1]	0.259	0.219	0.0138	0.0111	0.0143
Range of Values Found in Region[1]	0.0627-1.523	0.0656-0.676	0.0055-0.0535	0.0061-0.0208	0.0063-0.0233
Design Criteria Selected for Regional Sanitary Sewerage System Planning Program[2]	0.21	0.21	0.01	0.024	0.027

[1]As determined in sewage flow and strength investigations described in Chapter VI of this report.
[2]As set forth in Chapter IX of this report.

Source: SEWRPC.

With respect to sewage strength criteria, it may be concluded that the design criteria selected for use in the regional sanitary sewerage system planning program correspond very closely to the average of such values found in the Region. In particular, the design criteria selected for biochemical oxygen demand, suspended solids, and phosphorus are very close to the observed values. The design criteria for organic and ammonia nitrogen exceed by a factor of two the observed values. This difference may be attributed to a nonrepresentative sample selected for use in the analyses presented in Chapter VI, since such samples were largely from very small sanitary sewerage systems in the Region exhibiting relatively high dilution, and as such are not typical of the larger systems.

ECONOMIC EVALUATION CRITERIA

The alternative regional sanitary sewerage system plans identified in the planning program were evaluated and compared both by economic analysis procedures and through the identification and consideration of intangible factors. The weight or degree of consideration given the intangible factors in the process of synthesizing a recommended regional sanitary sewerage system plan was determined by the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning and by other elected and appointed public officials and concerned citizens during the public hearing process. The economic analysis and evaluation which was carried out by the planning and engineering staff during the planning program is described in the following discussion.

It is customary to evaluate plans for water resource development projects on the basis of benefits and costs. This is particularly appropriate if the prospective development represents opportunities for investments to provide economic return to the public and if a comparison of alternative investments is desirable. In the case of public sanitary sewerage systems, however, it is assumed that such systems must be provided to meet a fundamental need of the community, and that the alternative of investment in another economic sector does not exist. Accordingly, it is assumed that the least cost plan that meets statutory requirements and the adopted regional development objectives will be economically the most desirable plan.

No attempt was made to calculate monetary benefits of meeting the statutory requirements and the regional development objectives. Benefit-cost ratios were not, therefore, calculated. If monetary benefits are created in other sectors such as recreation or agriculture, however, from the multiple-purpose use of elements of sanitary sewerage plans, these benefits may be used to reduce the economic cost of that element and the plan of which it is a part.

The economic evaluations conducted under the regional sanitary sewerage system planning program included the selection of a design period and an economic life; an interest rate; depreciation and salvage values; and various costs, including construction, capital, present worth, and equivalent annual costs.

Design Period and Economic Life

The physical life of a property is that period between the original acquisition and final disposal of the property. The physical life of a given property is usually longer than the economic life. The economic life is defined as the period after which the incremental benefits from continued use no longer exceed the incremental cost of operation. In the economic analyses conducted under the sanitary sewerage system planning program, the time period over which the facility is totally depreciated is made equal to the economic life.

The design period for the regional sanitary sewerage system planning program was selected at 20 years. This 20-year design period is fully coordinated with the design period utilized by the Commission in its other planning programs and in particular represents the design period utilized for the regional land use plan. It is recognized, however, that the economic life of sanitary sewer facilities exceeds that of the plan design period. For purposes of economic analysis, economic lives of 50 years for sewers, force mains, and land, and 25 years for pumping and lift stations and sewage treatment facilities were selected for use in the program.

The foregoing 25-year economic life of sewage treatment facilities was selected based upon an analysis of the cost of various treatment plant components relative to the total cost and anticipated useful life for the various components. This analysis is summarized in Table 88. This table presents the computation of the weighted capital recovery factor for sewage treatment plants. The weighted total, 0.079495, is approximately the capital recovery factor for a 24-year economic life. For convenience, then, an economic life of 25 years was used for lift and pumping stations and sewage treatment plants included in the regional sanitary sewerage system plan.

While the plan design period is 20 years, from 1970 to 1990, the economic analysis period was taken as 1970 to 2020, based on the longest economic life of components of the regional sanitary sewerage system plan. Cost computations under the regional sanitary sewerage study assume that construction of major system elements such as sewers, pumping and lift stations, and sewage treatment plants and the acquisition of land will begin in 1975. All costs, however, are expressed as 1970 values.

Following the principles of engineering economic analyses, no escalation of costs for construction, operation, maintenance, or replacement was considered. In the economic evaluations, provisions for the replacement of shorter-lived components are incorporated in total economic costs through the selection of an economic life. The economic analyses of alternatives assumes replacement of

Table 88

COMPUTATION OF WEIGHTED CAPITAL RECOVERY FACTOR FOR SEWAGE TREATMENT PLANTS

Item	Economic Life	Capital Recovery Factor at 6 Percent Annual Interest	Fraction of Plant Cost	Product of Capital Recovery Factor and Fraction of Plant Cost
Concrete structures	40	0.06646	0.32	0.021267
Piping, valves, fittings, miscellaneous iron, and steel	25	0.07823	0.12	0.009388
Process equipment	15	0.10296	0.32	0.032947
Excavation and backfill	40	0.06646	0.09	0.005981
Electrical, heating and ventilating, and piping	25	0.07823	0.05	0.003912
Engineering, legal and financial costs	--	0.06	0.10	0.006
			Weighted Total	0.079495

Source: *Harza Engineering Company.*

facilities at specified life intervals. Although it can be rightly argued that concrete structures have longer lives than 25 years, it can be countered that sewers may have longer lives than 50 years. Therefore, the relative economics comparisons will result in the same conclusions. A salvage value was credited to facilities whose economic life extended beyond the year 2020. For example, a sewer with a life of 50 years assumed to be constructed in 1990 was given a credit for 20 years of life after 2020.

Interest Rate

An interest rate of 6 percent was used in all of the economic analyses under the regional sanitary sewerage system planning program. The 6 percent interest rate had previously been used by the Commission in economic evaluations under the Root, Fox, and Milwaukee River watershed studies. While interest rates from 4 to 10 percent are often proposed for studies of this nature, a value of 6 percent is considered reasonable because it represents the approximate rate to citizens on conservative investments and, therefore, is representative of the cost to the individual of foregoing opportunities for investment elsewhere.

Depreciation and Salvage Values

For the purposes of the economic analyses conducted under the regional sanitary sewerage system planning program, it was assumed that all of the facilities would depreciate at an average annual rate over the economic life. At the end of economic life it was assumed that no value remained; thus, no salvage values were included in the economic analysis except for those facilities with an economic life extending beyond the year 2020.

Construction the Capital Costs

The construction costs of all facilities included in the regional sanitary sewerage system plan were estimated from the series of curves previously presented in this chapter. These construction costs were multiplied in the economic analysis by a factor of 1.35 to obtain capital costs. The additional 35 percent of the estimated construction costs is added to account for unforeseen items in the cost estimates (contingencies), engineering and legal fees, administrative costs, and financing costs. The multiplier was derived as shown in the following tabulation.

Construction Cost	=		1.0
Contingencies	=		0.15
Subtotal			1.15
Engineering	= 1.15	x 0.08	= 0.092
Legal and Administrative	= 1.15	x 0.02	= 0.023
Interest during Construction	= 1.15	x 0.045	= 0.052
Subtotal			1.317
Financing	= 1.317	x 0.03	= 0.039
Total (rounded)			1.35

Present Worth and Annual Costs

Four terms are commonly used in preparing economic analyses of important engineering projects. These are the single payment present worth factor (PWF), the uniform series present worth factor (SPWF), the gradient present worth factor (GPWF), and the capital recovery factor (CRF).

The single payment present worth factor converts the cost of a single expenditure at some future time to a value at present or close to the present. The uniform annual series present worth factor converts a series of uniform annual payments to equivalent present value. Where annual payments are increasing by a fixed amount per year, the gradient present worth factor is used to determine the present value of the series. This factor, multiplied by the gradient (annual increase) is added to the present worth of a series of payments equal to the first year's payment to obtain total present worth. In a 10-year series, the gradient is equal to the difference between the 10th year cost and the first year cost divided by the time base minus one year. The divisor is always one less than the series length because the amount of the gradient is zero for the first period. This method was applied to sewage treatment plant operation and maintenance costs, assuming that they increase in a straight line from the costs at the initial operating flow to the maximum at plant capacity. After the facility is operating at capacity, the present worth of operation and maintenance costs is calculated as the present worth of a uniform annual series starting at a point in the future equal to the gradient time base.

The present worth of future single, uniform, or nonuniform annual series payments is always less than the absolute value of the single payment or the sum of the annual payments. The capital recovery factor converts a lump payment at the beginning of a period into a series of uniform annual payments over the length of the period. The sum of these uniform annual payments is always greater than the lump payment.

The following is an example of the use of present worth and annual cost analyses:

> Assume that a sewage treatment plant designed with 20 mgd of capacity is to be constructed immediately at a cost of \$5.5 million. The initial flow is 5 mgd and the plant will reach the design flow in 10 years. The annual operation and maintenance cost at 5 mgd is \$0.11 million and the annual operation and maintenance cost at 20 mgd is \$0.29 million. The present worth of this plant for a 25-year operation period is computed as follows: (ALL VALUES IN MILLIONS OF DOLLARS)
>
> P. W. of construction = \$5.5
>
> P. W. of operation and maintenance
>
> $$= SPWF_{25}^{6\%}(\$0.11) + GPWF_{10}^{6\%}(0.29 - 0.11)$$
>
> $$+ SPWF_{15}^{6\%}(\$0.29 - 0.11)\ PWF_{10}^{6\%}$$
>
> $$= (12.783)\ (\$0.11) + (24.58)\ (\$0.18)$$
>
> $$+ (9.712)\ (\$0.18)\ (0.5584)$$
>
> $$= \$2.9$$
>
> Total P. W. = \$8.4
>
> The annual cost calculation is as follows:
>
> Annual cost of construction
>
> $$CRF_{25}^{6\%} \times \$5.5 = 0.07823 \times \$5.5 = \$0.43$$
>
> Annual cost of operation and maintenance
>
> $$CRF_{25}^{6\%} \times \$2.9 = 0.07823 \times \$2.9 = \$0.66$$
>
> Total annual cost = \$1.09

In addition to the present worth and equivalent cost analyses as described above, annual per capita costs were calculated for each of the recommended plan elements in order to provide a perspective for the evaluation of financial as opposed to economic feasibility. Annual per capita costs were computed by dividing the annual cost by the average of the existing (1970) and future (1990) population of the service area of the plan element.

SUMMARY

A review of the state of the art of sanitary sewerage conducted as a part of the regional sanitary sewerage system planning program concluded that the system of using water carriage for domestic wastes to central locations for treatment can be expected to remain the normal sewerage practice for at least the next several decades. Despite the seemingly high capital costs of the sewerage system necessary to collect and convey the sewage to central locations, it was concluded that the water carriage system of sewage disposal has fewer and less serious disadvantages than the practically available alternatives. The disadvantages of alternatives, which necessarily consist of various onsite disposal systems, include higher unit costs, inability to dispose of kitchen wastes and wash water, maintenance problems, and lack of demonstrated technical feasibility. Except for septic tanks, currently available alternatives to the water carriage system do not appear likely to present any economic advantage over centralized waste collection and treatment. Septic tanks may have an economic advantage over centralized systems in areas of very low population density and where suitable soils may be found. A widespread pattern of low-density urban development, however, would not only make the provision of other public facilities and services more costly, but would also entail heavy social costs. Moreover, much of the Southeastern Wisconsin Region simply does not have soils suitable for septic tank development even at very low development densities.

The review of the state of the art of sanitary sewerage also concluded that the current policy of building separate storm and sanitary sewerage systems is sound, and there is no reason to question the validity of continued reliance on separate sewerage systems. This conclusion was reached even though it was conceded that treatment of storm water may eventually be required. Treatment of combined sewage presents serious problems resulting from the handling of large fluctuations of flow volume and sewage strength. Even though storm water treatment might eventually be required, it it unlikely that such treatment will have to provide as high a level of treatment as required for sanitary sewerage. Present facilities capable of treatment of storm water, such as relatively small, intermittently operating treatment units located at individual sewer outfalls are considerably cheaper than sanitary sewerage treatment plants and it is likely that these costs will diverge even more in the future.

The state of the art discussion included a review of treatment levels currently achievable at municipal sewage treatment plants, which levels include primary, secondary, tertiary, advanced, and auxiliary treatment. A number of sewage treatment processes occurring in a variety of interconnected treatment units are available for achieving these treatment levels and were discussed in this chapter.

In addition to reviewing the state of the art of sanitary engineering and interpreting the significance of the state of the art for the regional sanitary sewerage system planning program, this chapter presented the engineering design criteria applied and analytic procedures used under the sanitary sewerage study. These criteria and procedures were used to synthesize a regional sanitary sewerage system plan capable of meeting the study objectives. Sewerage study engineering design criteria and analytic procedures were applied in the inventory and analysis of data, in the synthesis and testing of alternative plans, and in making economic comparisons between those plans. Sewer systems, pumping and lift stations, and municipal sewage treatment plants comprise the three major types of sanitary sewerage system components that are combined to form an alternative plan.

Sanitary sewer design and pumping and lift station design require determination of peak hydraulic loadings which are composed of sanitary sewage, infiltration, and storm water inflow. Hydraulic considerations and construction practices are also important factors, as are estimates of construction costs and, particularly in the case of pumping and lift stations, operation and maintenance costs.

For purposes of the regional sanitary sewerage system planning program, only those major trunk sewers which have areawide significance by virtue of the fact that they serve a multiple municipal area were analyzed, even though additional minor trunk sewers will be required for service within each service area. The trunk sewer planning design makes maximum use of gravity drainage concepts for cost comparisons of alternative areawide systems, although gravity systems are usually only one of several ways to interconnect various sewer service areas.

Alternative municipal sewage treatment plant locations, sizes, and levels of treatment were synthesized under the regional sanitary sewerage planning program and subjected to technical and economic analyses. To assist in the formulation and evaluation of the sewage treatment plant portion of the plan, a standard procedure generalized for the Region was developed to establish the type of treatment required at each existing and potential municipal sewage treatment plant site. The procedure used to establish the type of treatment at a given location involved determination of hydraulic and pollution loadings; consideration of Wisconsin Department of Natural Resources requirements with regard to secondary treatment, effluent disinfection, and phosphorus removal; requirements with respect to phosphorus removal for locations west of the subcontinental divide; maintenance of adequate dissolved oxygen levels downstream of sewage treatment plant outfalls, as determined by an oxygen sag curve model; and protection against toxic concentration of ammonia. The methodology recognizes the waste assimilative capacity of streams in that it matches the sewage treatment plant processes that would be required for a given site with the natural waste assimilative processes of the receiving stream under 7 day-10 year low flow conditions, such that the quality of the resulting streamflow-effluent mixture would be adequate to meet the water use objectives for the reach.

Explicit in the aforementioned standard procedure is the assumption that through implementation of the adopted watershed plans and the attendant abatement of all major diffused as well as all point sources of pollution, stream water quality conditions immediately upstream of a sewage treatment plant discharge point will, under low flow conditions, meet or exceed the established water quality standards. The primary purpose of the municipal sewage treatment plant design criteria and analytic procedures is to determine, given forecast low streamflow conditions and design year sewage flows, the level of treatment required to assure that the treatment plant effluent can be assimilated by the stream without depressing the stream water quality levels below those required by the adopted water use objectives and supporting standards.

This chapter also presented a comparison of sewage flow and sewage quality values used in the sewerage study with regional sewage flow and quality data. It was generally concluded that sewage flow and quality criteria applied under the sanitary sewerage study compare favorably with actual data available for the Region. The differences that did occur were such that the sanitary sewerage study criteria would generally result in conservative designs, that is, tending to provide for some modest reserve capacity for sewers, pumping and lift stations, and municipal sewage treatment plants.

The chapter concluded with a discussion of the criteria that were utilized to make economic comparisons between alternative sanitary sewerage system plan elements. For purposes of these economic analyses, an interest rate of six percent was used and sewers and land were assumed to have an economic life of 50 years, whereas treatment facilities and pumping and lift stations were assigned a 25-year economic life. Although the plan design period is for the 20-year period from 1970 to 1990, the economic analysis period was taken as the 50-year period from 1970 to 2020. Cost computations assume that construction of major sewerage system plan elements such as sewers, pumping and lift stations, and sewage treatment plants will commence in 1975. All construction costs and all equivalent annual costs, however, are expressed as 1970 values.

Chapter X

ANTICIPATED GROWTH AND CHANGE IN THE REGION

INTRODUCTION

In any planning effort, forecasts are required of all future events and conditions which lie outside of the scope of the plan but which affect either the design of the plan or its implementation. With respect to the regional sanitary sewerage system plan for southeastern Wisconsin, the future demand for sewerage facilities in the Region will be determined primarily by the size and spatial distribution of future population and employment. Although the spatial distribution of future population and employment levels can be influenced by public land use regulation, control of changes in the population and economic activity levels per se lies largely outside the scope of governmental activity at the regional and local level. In the preparation of a regional sanitary sewerage system plan, therefore, future population and economic activity levels within the Region must be forecast. These forecasts, when converted to either a proposed or a forecast land use pattern and combined with engineering design criteria, can then be used to quantify the probable future demand for sewerage facilities in the Region, and a sewerage system plan prepared to meet this demand.

As discussed in Chapter I of this report, sound planning and engineering practice dictates that individual sewer lines, such appurtenant facilities as pumping stations, and sewage treatment plants be planned and designed as integral parts of an areawide system in which the major sewerage facilities are carefully fitted to projected waste loadings derived from a desirable future land use pattern as proposed in adopted areawide and local land use plans. Thus, a regional sanitary sewerage system plan should provide for the orderly and economical extension of sanitary sewer service to developing areas of the Region consistent with adopted areawide and local land use plans, and should further provide for the abatement of water pollution problems and the protection and wise use of the natural resource base. Since the Commission has adopted a regional land use plan—a plan which incorporated to the maximum extent practicable adopted local land use plans and zoning ordinances—and since this plan was based upon carefully prepared forecasts of probable future levels of population and economic activity within the Region, the potential future demand for sewerage facilities in the Region could be derived from the adopted regional land use plan by applying sewage flow generation criteria to that plan. Accordingly, separate forecasts of population and economic activity and of the future demand for land in the Region were not prepared under the regional sanitary sewerage system planning program.

The following sections of this chapter provide a brief overview of the regional land use plan and the population and economic activity forecasts which formed important inputs to that plan. Attention is focused on recent analyses of population and economic activity levels within the Region made possible by the 1970 U. S. Census of Population; upon revised forecasts of probable future population and employment levels in the Region; and upon land use development in the Region since adoption of the regional land use plan in December 1966. In addition, the revised forecasts of population change in the Region are compared with recent population projections promulgated by the U. S. Environmental Protection Agency and the Wisconsin Departments of Administration and Natural Resources for sewerage system planning purposes.

REGIONAL LAND USE PLAN DESCRIPTION

The regional land use plan for the seven-county Southeastern Wisconsin Planning Region as adopted by the Commission is fully documented in a three-volume Commission planning report.[1] The basic forecasts of probable future levels of population and economic activity in the Region underlying the land use plan are presented in Volume Two of that planning report, while the recommended regional land use plan is fully described in Volume Three of that report. A very brief description of the

[1] *SEWRPC Planning Report No. 7, The Regional Land Use-Transportation Study, Volume One, Inventory Findings--1963; Volume Two, Forecasts and Alternative Plans--1990; and Volume Three, Recommended Regional Land Use and Transportation Plans--1990.*

adopted regional land use plan and the forecast levels of population and economic activity incorporated in that plan follows.

Commission forecasts prepared as part of the initial regional land use-transportation study in 1965 indicated that the population of the Southeastern Wisconsin Region could be expected to reach a level of about 2.7 million persons by 1990, an increase of approximately one million persons over the 1963 population level, while employment could be expected to reach nearly the one million job level by 1990, an increase of nearly 350,000 jobs over the 1963 level. The regional land use plan was designed to accommodate this anticipated growth in population and employment through the conversion of approximately 200 square miles of land from rural to urban use over the 27-year period extending from 1963 to 1990. The future land use pattern proposed by the plan is shown graphically on Map 51 and is quantified by major land use category in Table 89. It is this plan that forms the basic framework for the design of the regional sanitary sewerage system plan.

Residential Development

The adopted regional land use plan proposes to add about 71,000 acres of land to the existing stock of residential land within the Region in order to meet the housing needs of the anticipated population increase over the 27-year period. Of this total, about 75 percent, or 54,000 acres, would be developed at medium densities, with lot sizes ranging from 6,300 to 19,800 square feet per dwelling unit and with gross residential population densities ranging from 3,500 to 9,999 persons per square mile. An additional 21 percent, or about 15,000 acres, would be developed at low densities, with lot sizes ranging from 19,800 square feet to five acres per dwelling unit and with gross residential population densities ranging from 350 to 3,499 persons per square mile. The remaining 4 percent of the new residential land, or about 2,800 acres, would be developed at high densities with lot sizes ranging from 2,400 to 6,300 square feet per dwelling unit and with gross residential population densities ranging from 10,000 to 25,000 persons per square mile. These three urban residential categories are shown in orange, yellow, and brown, respectively, on Map 51.

The adopted land use plan recommends that all new medium- and high-density residential development be served with public sanitary sewer and public water supply facilities, so that by 1990 over 95 percent of the total urban area within the Region and about 95 percent of the total regional population would be served by such facilities. To accomplish this objective, it was recognized in the plan that the historic trend in the post World War II development era toward highly dispersed, low density, large lot residential development utilizing onsite septic tank sewage disposal systems would have to be reversed. The adopted land use plan thus envisions urban residential development occurring in a concentric fashion along the full periphery of and outward from existing urban centers. The plan further envisions new urban residential development occurring in planned residential development units, commonly called neighborhood units, providing a full range of housing costs, types, and styles, and incorporating all of the supporting land uses required for sound residential development.

Commercial Development

The recommended regional land use plan proposes to add by 1990 about 5,000 acres of new commercial land to the existing stock of such land within the Region. This increase would meet the areal requirements of the anticipated increase in retail and service employment and the demands of the growing population within the Region. In addition to retaining 13 of 15 major commercial cen-

Table 89

EXISTING AND PROPOSED LAND USE IN THE REGION: 1963 AND 1990 ADOPTED LAND USE PLAN

Land Use Category	Existing (1963)		Planned Increment		Total 1990	
	Acres	Percent of Major Category	Acres	Percent Change	Acres	Percent of Major Category
Urban Land Use						
Residential	*129,358*	*44.6*	*71,187*	*55.0*	*200,545*	*48.0*
High-Density	34,463	11.9	2,790	8.0	37,253	8.9
Medium-Density	24,748	8.5	53,784	217.3	78,532	18.8
Low-Density	70,147	24.2	14,613	20.8	84,760	20.3
Commercial[1]	6,706	2.3	5,048	75.2	11,754	2.8
Industrial[1]	9,746	3.4	5,123	52.5	14,869	3.6
Governmental[2]	14,722	5.1	9,573	65.0	24,295	5.8
Transportation[3]	96,117	33.1	28,623	29.7	124,740	29.8
Recreation	33,262[4]	11.5	8,718[5]	26.2	41,980	10.0
Total Urban Land Use	289,911	100.0	128,272	44.2	418,183	100.0
Rural Land Use						
Agriculture	*1,085,144*	*75.8*	*-102,837*	*- 9.4*	*982,307*	*75.4*
Prime Agriculture	443,952	31.0	- 21,267	- 4.7	422,685	32.5
Other Agriculture	641,192	44.8	- 81,570	-12.7	559,622	42.9
Other Open Lands[6]	345,951	24.2	- 25,435	- 7.3	320,516	24.6
Total Rural Land Use	1,431,095	100.0	-128,272	- 8.9	1,302,823	100.0
Total	1,721,006	--	--	--	1,721,006	--

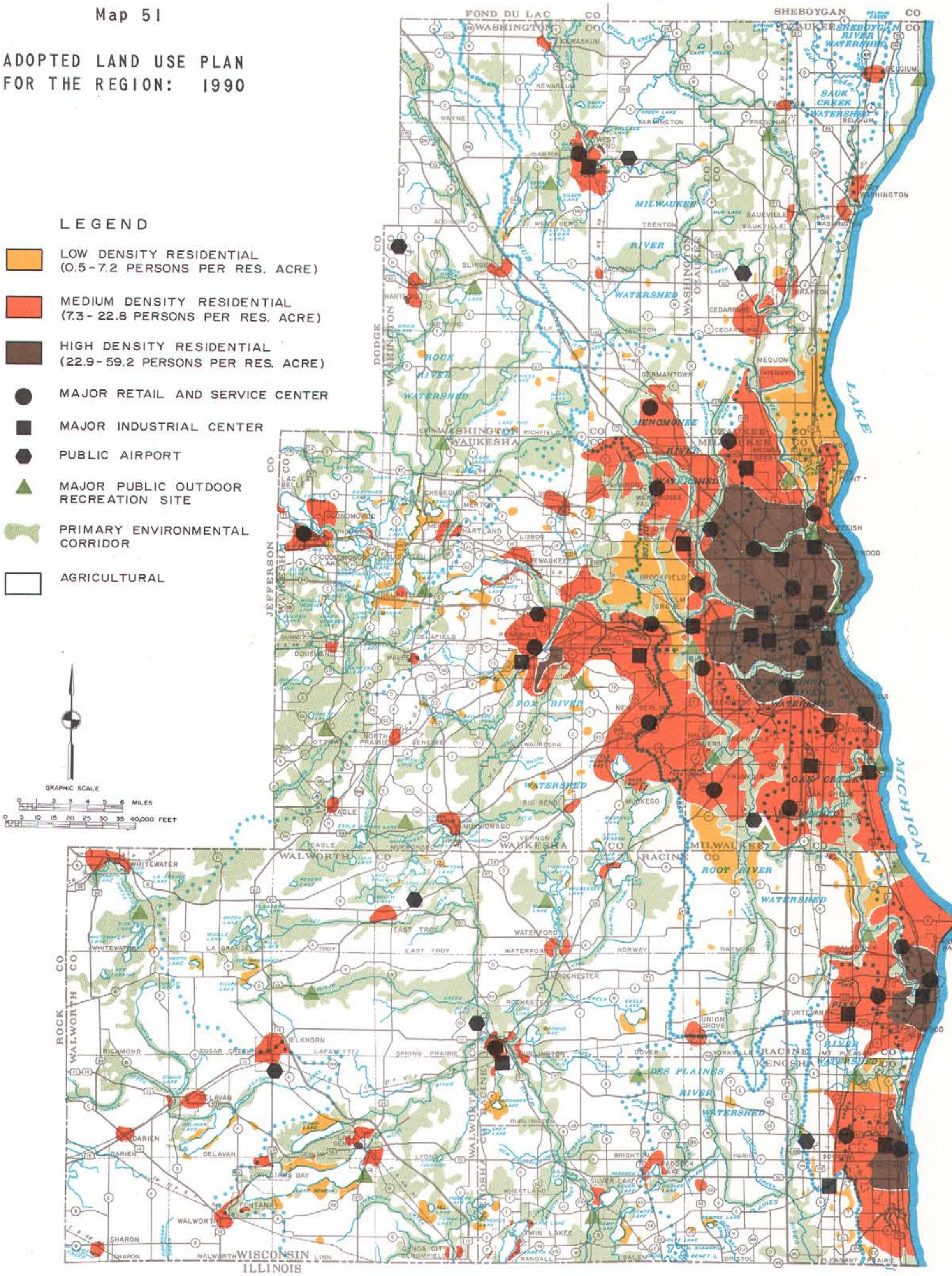
Note: Figures in italics indicate subtotals.

[1]Includes on-site parking.
[2]Includes institutional uses and on-site parking.
[3]Includes communications and utilities uses.
[4]Includes the entire site areas of public and nonpublic recreation sites.
[5]Includes only that increment recommended for public recreation uses.
[6]Includes woodlands, water, wetlands, and quarries.

Source: SEWRPC.

Map 51

ADOPTED LAND USE PLAN FOR THE REGION: 1990



The adopted regional land use plan places heavy emphasis on the continued effect of the urban land market in determining the location, intensity, and character of future development. In so doing, however, it seeks to modify the effect of this market on regional development by attempting to guide new urban development into those areas of the Region most suitable for such development. Most importantly, the plan seeks to prevent urban development from intruding on the primary environmental corridors of the Region, which contain all of the lakes and streams and associated undeveloped shorelands and floodlands; the best remaining woodlands, wetlands, and wildlife habitat; and the best remaining potential park and open-space sites within the Region, as well as the recharge areas for the deep aquifer underlying the Region.

Source: SEWRPC.

ters found within the Region in 1963, the plan proposed the addition of 10 new major commercial centers to provide employment for over 14,000 persons. Each new center would serve a market area containing between 75,000 and 150,000 persons. The locations of the 23 major retail and service centers proposed in the plan are shown on Map 51. Although not spatially distributed on the regional land use plan map, the plan proposed to accommodate about 4,000 new acres of highway-oriented and local commercial development, which areas would be distributed throughout the 1990 urban area as needed and would employ nearly 113,000 persons.

Industrial Development

The adopted regional land use plan also proposes to add by 1990 more than 5,000 acres of industrial land to the existing stock of such land within the Region. This is proposed to be accomplished through the development of planned industrial centers properly located with respect to the existing and proposed transportation system; through the protection and enhancement of existing industrial areas; and through the efficient provision of adequate public utility services. In addition to retaining the 17 major industrial areas existing within the Region in 1963, the plan proposed to add six new major industrial centers, which centers would provide employment for over 35,000 persons. The locations of the existing and proposed industrial centers within the Region are shown on Map 51. These major industrial centers are of particular importance in the design of the regional sanitary sewerage system plan because of the potential for major waste loadings emanating from the centers. Although not spatially distributed on the regional land use plan map, the plan also provides for more than 1,500 acres of new industrial land in small industrial centers distributed throughout the 1990 urban area. Such local industrial areas would employ over 24,000 persons.

Recreational Development

The recommended regional land use plan proposes an additional 8,700 acres of public recreational lands by 1990. About 60 percent of this amount, or about 5,300 acres, would be utilized to create 12 new major regional parks (see Map 51). The remaining 40 percent, or about 3,400 acres, would be utilized to provide local park acres. Because of the potential for daytime waste loadings, such major regional outdoor recreation areas must be considered in the design of the regional sanitary sewerage system plan.

Other Land Use Development

In addition to the land use categories of residential, commercial, industrial, and recreational, the adopted regional land use plan proposes to add by 1990 about 9,600 acres of new governmental and institutional land to the existing stock of such land within the Region. Similarly, the plan proposed to add by 1990 more than 28,000 acres of new street and highway, other transportation, and public utility land to the existing stock of such land within the Region. Neither of these land use categories was specifically allocated in the plan but rather was assumed to be distributed as needed throughout the designated 1990 urban area in proportion to the more basic land uses.

Primary Environmental Corridors

The most important elements of the natural resource base of the Region, including the best remaining woodlands, wildlife habitat, and surface water, together with the natural floodlands, wetland areas, and historic, scenic, and scientific sites were found to occur within the Region in linear patterns termed "primary environmental corridors." As discussed in Chapter IV of this report, the preservation and protection of these corridors is essential to the maintenance of a wholesome environment within the Region and the preservation of the economic, cultural, and natural heritage of the Region, as well as its natural beauty. The plan proposes the permanent protection and preservation of about 283,000 acres of primary environmental corridor land. It is essential that the design of the regional sanitary sewerage system plan seeks to promote implementation of this important land use plan recommendation.

Prime Agricultural Lands

Certain rural areas were delineated in the regional land use planning effort as prime agricultural lands based upon soil capabilities, the size and extent of the area farmed, and the historic capabilities of the area to consistently produce better than average crop yields. About 444,000 acres of the approximately 1.1 million acres of land within the Region devoted to agricultural use were considered to be prime agricultural land. Under the adopted regional land use plan, urban expansion within the Region would require the conversion of about 21,000 acres of the prime agricultural land from rural to urban use. The remaining nearly

423,000 acres of prime agricultural lands are proposed in the plan to be set aside for preservation in permanent agricultural use.

Population Distribution

As noted earlier, the adopted regional land use plan was designed to accommodate a forecast 1990 regional population level of about 2.7 million persons, or an increase in population of about one million persons over the 1963 level. This population increment was forecast to be distributed by county as shown in Table 90, and the land use pattern shown in the adopted regional land use plan was designed to accommodate the forecast regional and county population levels. The absolute increases in county population levels were anticipated to range from about 360,000 persons in Milwaukee County to about 32,000 persons in Walworth County, while the relative increases would range from 155 percent in Ozaukee County to 33 percent in Milwaukee County. As proposed in the plan, the population density within the developed urban area of the Region would continue to decrease but at a substantially slower rate than in the recent past, decreasing from a density of about 4,800 persons per square mile in 1963 to about 4,400 persons per square mile by 1990. This important change in historic development trends was to result from implementation of plan proposals which recommended that the majority of new residential land uses within the Region be developed at medium—instead of low—densities and be provided with public sanitary sewer and water supply services.

Employment Distribution

Total employment within the Region was forecast to increase by nearly 350,000 jobs, distributed by county as shown in Table 91. Implementation of the regional land use plan would result in employment increases for each county in the Region, ranging from an additional 9,400 jobs in Walworth County to an additional 156,000 jobs in Milwaukee County. Only about 15 percent, or 50,000 jobs, would be provided for in the new major commercial and industrial centers, with nearly 300,000 new jobs provided for in existing employment centers or new local employment centers.

Public Sanitary Sewer and Water Supply Services

In 1963 about 217 square miles, or 64 percent of the total developed urban area of the Region, and about 1,419,000 persons, or 85 percent of the total population of the Region, were served by public sanitary sewer facilities; and about 200 square miles, or 59 percent of the total developed urban area of the Region, and about 1,372,000 persons, or 82 percent of the total population of the Region, were served by public water supply facilities. Under the recommended plan, about 480 square miles, or 95 percent of the developed urban area, and about 2,547,000 persons, or 95 percent of the total population, would by 1990 be served by both public sanitary sewer facilities and public water supply facilities (see Table 92).

The plan seeks to discourage the development of residential areas dependent upon onsite sewage disposal systems and shallow private wells and to encourage development served by gravity drained centralized sanitary sewer facilities tributary to existing sewerage systems and by public water supply systems. The plan proposals would thus serve to reduce and control the amount of untreated and partially treated domestic and industrial wastes discharged into the streams,

Table 90

EXISTING AND PROPOSED POPULATION DISTRIBUTION IN THE REGION BY COUNTY: 1963 AND 1990 ADOPTED LAND USE PLAN

County	Existing (1963)		Planned Increment[1]		Total 1990	
	Number	Percent of Region	Number	Percent Change	Number	Percent of Region
Kenosha	106,700	6.4	95,300	89.3	202,000	7.5
Milwaukee	1,086,300	64.9	359,700	33.1	1,446,000	54.0
Ozaukee	41,600	2.5	64,400	154.8	106,000	4.0
Racine	150,600	9.0	132,400	87.9	283,000	10.6
Walworth	55,500	3.3	31,500	56.7	87,000	3.2
Washington	49,500	2.9	46,500	93.9	96,000	3.6
Waukesha	184,200	11.0	273,800	148.6	458,000	17.1
Regional Total	1,674,400	100.0	1,003,600	59.9	2,678,000	100.0

[1]The planned increment is equal to the forecast increment because the adopted plan was designed to meet the forecast population level for each county.

Source: SEWRPC.

Table 91

EXISTING AND PROPOSED EMPLOYMENT DISTRIBUTION IN THE REGION BY COUNTY: 1963 AND 1990 ADOPTED LAND USE PLAN

County	Existing (1963)		Planned Increment		Total 1990	
	Number	Percent of Region	Number	Percent Change	Number	Percent of Region
Kenosha	41,900	6.6	38,100	90.9	80,000	8.1
Milwaukee	471,700	74.3	156,000	30.9	627,700	63.8
Ozaukee	10,800	1.7	15,700	145.3	26,500	2.7
Racine	52,100	8.2	45,000	86.3	97,100	9.9
Walworth	12,700	2.0	9,400	74.0	22,100	2.2
Washington	12,100	1.9	14,000	115.7	26,100	2.7
Waukesha	33,600	5.3	70,900	211.0	104,500	10.6
Regional Total	634,900	100.0	349,100	54.9	984,000	100.0

Source: SEWRPC.

Table 92

EXISTING AND PROPOSED DEVELOPED AREA AND POPULATION SERVED BY PUBLIC SANITARY SEWER AND PUBLIC WATER SUPPLY IN THE REGION: 1963 AND 1990 ADOPTED LAND USE PLAN

Extent of Service	Existing (1963)		Planned Increment		Total 1990	
	Public Sewer Service	Public Water Supply	Public Sewer Service	Public Water Supply	Public Sewer Service	Public Water Supply
Developed Area:						
Total Square Miles[1]	339.7	339.7	269.3	269.3	609.0	609.0
Square Miles Served	217.0	200.0	362.9	379.9	579.9	579.9
Percent of Total Served	63.9	58.8	--	--	95.2	95.2
Population:						
Total Population	1,674,400	1,674,400	1,003,600	1,003,600	2,678,000	2,678,000
Population Served	1,419,025	1,372,480	1,127,645	1,174,190	2,546,670	2,546,670
Percent of Total Served	84.7	81.9	--	--	95.0	95.0

[1]*It should be noted that the proposed increment in total area developed for urban purposes of 269.3 square miles included in this table represents a conceptually different, but related, indicator of land area proposed for conversion from rural to urban use over the 27-year planning period 1963-1990, than the 200 square mile urban land area increment referred to in the accompanying text. The 200 square mile figure represents the estimated amount of land that would be actually converted from a specific rural to a specific urban land use. The 269.3 square mile figure refers to the incremental land area that would be included within the proposed 1990 urban growth ring under the adopted regional land use plan and, therefore, includes, in addition to the 200 square miles of actually converted land, about 69 square miles of open space type land – consisting of woodlands, wetlands, and other open lands – that would remain in essentially the same use as in 1963 but would be enveloped by lands actually converted to urban land uses.*

Source: SEWRPC.

rivers, lakes, and groundwater reservoirs of the Region; would reduce and control the number of points at which treated wastes are discharged into the surface and ground waters of the Region; permit a better adjustment of waste treatment and disposal facilities to the waste assimilation capacities of the streams and rivers; and assure a pure supply of water for all existing and potential users within the Region.

Concluding Remarks—Regional Land Use Plan

The foregoing brief description of the adopted regional land use plan provides an overview of the plan recommendations with particular respect to the plan's relationship to the regional sanitary sewerage system plan. Such a regional land use plan is an essential input into the design of a regional sanitary sewerage system plan, since sewerage system planning must assume some anticipated distribution of future urban land uses in order to properly size and locate sewage conveyance and treatment facilities and must further assume anticipated population and economic activity levels in order to determine future waste loadings on the existing and proposed sewerage systems. Thus, the interrelationship between land use and sewerage system planning is quite evident. It is not possible to rationally prepare a regional land use plan without certain general assumptions concerning the provision of sanitary sewerage service. Similarly, it is not possible to prepare a regional sanitary sewerage system plan without certain assumptions concerning the future distribution of land uses and future population and economic activity levels. The two planning processes are inextricably interrelated.

DEVELOPMENTS SUBSEQUENT TO REGIONAL LAND USE PLAN ADOPTION

As noted above, the regional land use plan, which was adopted in December 1966 and which was based upon basic data collected in the year 1963, comprised a very important input to the preparation of the regional sanitary sewerage system plan. Ideally, the regional land use plan and the regional sanitary sewerage system plan would have been prepared concurrently. In a broad comprehensive planning effort such as that established for the Southeastern Wisconsin Region, however, it is simply not practicable to prepare all elements of the comprehensive plan on a concurrent basis. For this reason the preparation of two interrelated plan elements at two different points in time may pose several problems with respect to developments occurring since adoption of the initial—in this case regional land use—plan element. It is important, therefore, to consider the potential effects that such recent developments may have upon the overall validity of the subsequent plan element—in this case the regional sanitary sewerage system plan—which is based upon the initial plan element. Accordingly, this section of the chapter attempts to briefly discuss pertinent developments in the Region since adoption of the regional land use plan, including the findings of the 1970 U. S. Census of Population, the 1970 land use reinventory conducted by the Commission, the preparation by the Commission of revised 1990 population and employment forecasts and the extension of such forecasts to the year 2000, and a comparison of the new Commission population forecasts with population projections prepared by state and federal agencies involved in water quality management planning.

1970 U. S. Census of Population

Upon adoption of the regional land use plan in 1966, the Commission mounted in 1967 a continuing regional land use–transportation study designed in part to monitor development in the Region and to assess the continued validity of the regional population forecasts that underlie the regional land use plan. In April 1970 the 19th Decennial U. S. Census of Population was conducted, thus providing important new base year socioeconomic data for regional planning purposes. This census effort enabled a comparison to be made between the census results, in terms of total population size and distribution, against the initial Commission population forecast for the year 1970. This comparison is shown in Table 93. The forecast regional level of population differed from the actual level by about 6 percent in 1970 and, as shown in Figure 130, the trend in actual regional population growth was apparently departing from the trend in the forecast population level. This departure was due, in part, to significant changes in the rates of the two components of population change—natural increase and migration—which occurred within the Region during the late 1960s. In terms of actual numbers of persons, the most significant difference in comparing the 1970 population level with the 1970 forecast level occurred in Milwaukee County, where the census count was about 116,000, or 11 percent, below the anticipated forecast level. In two additional counties—Kenosha and Racine—the forecast level was also above the U. S. Census level. In the remaining four counties, however, the U. S. Census count exceeded the anticipated forecast level.

In general, then, the results of the 1970 U. S. Census of Population indicated that population is tending to grow more rapidly in the outlying areas of the Region than originally anticipated and less rapidly in the three counties having the large central cities of the Region—Kenosha, Milwaukee, and Racine.

In comparing the census figures with the forecast population levels, however, it must be realized that the census figures represent a measurement of the population level at a given point in time and like all measurements contain a certain degree of error. In fact, the U. S. Bureau of the Census acknowledges that the 1970 Census undercounted the population of the United States, with the overall degree of undercounting approximately 2.5 percent, ranging from 1.9 percent of the white population up to 7.7 percent of the black population. The core areas of large metropolitan regions could accordingly be expected to be affected more than the outlying suburban areas. It is probable, therefore, that the true population levels of Milwaukee, Kenosha, and Racine Counties lie somewhere between the reported census counts and the 1970 Commission forecast levels, with the differences ranging from approximately 3.5 to 8.5 percent.

1970 SEWRPC Land Use Inventory

In order to provide basic land use data which could be correlated with the data obtained from the U. S. Census of Population and Housing, the Commission conducted a complete reinventory of existing land use within the Region utilizing aerial photographs taken in April 1970. This reinventory of land use within the Region indicated that between 1963 and 1970 about 96 square miles of land were committed to urban use within the Region, representing a conversion rate of approximately 14 square miles per year. In general, the inventory revealed that substantial progress had been made in implementing the recommendations contained in the regional land use plan with respect to the establishment of the major activity centers, that is, the new major retail and service, industrial, and public outdoor recreation centers. Of the 10 proposed new retail and service centers, three were under development in 1970, with the remaining seven sites

Table 93

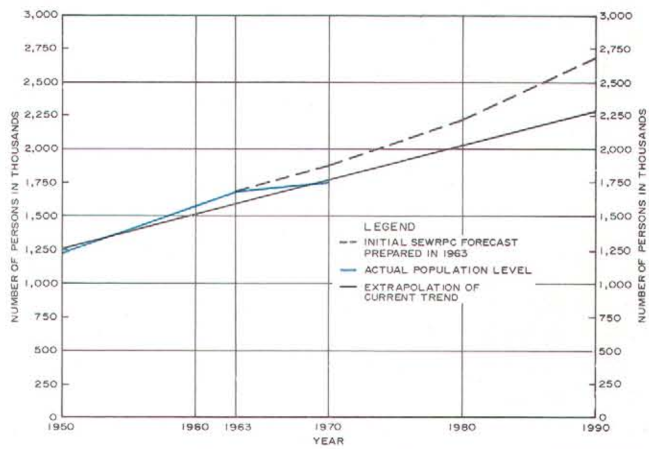
COMPARISON OF THE 1970 U. S. CENSUS OF POPULATION AND THE 1970 SEWRPC POPULATION FORECAST FOR THE REGION BY COUNTY

County	Population		Difference SEWRPC Forecast Minus U.S. Census	
	U.S. Census (April 1, 1970)	SEWRPC Forecast (July 1, 1970)	Number	Percent
Kenosha	117,917	124,900	+ 6,983	+ 5.92
Milwaukee	1,054,249	1,170,400	+ 116,151	+ 11.01
Ozaukee	54,461	53,900	- 561	- 0.97
Racine	170,838	173,100	+ 2,262	+ 1.32
Walworth	63,444	62,100	- 1,344	- 2.12
Washington	63,839	57,900	- 5,939	- 9.30
Waukesha	231,338	228,000	- 3,338	- 1.44
Region	1,756,086	1,870,300	+ 114,214	+ 6.50
Region Except Milwaukee County	701,837	699,900	- 1,937	- 0.27

Source: U.S. Department of Commerce, Bureau of the Census and SEWRPC.

Figure 130

COMPARISON OF INITIAL SEWRPC 1990 POPULATION FORECAST AND ACTUAL U. S. BUREAU OF THE CENSUS POPULATION LEVELS FOR THE REGION: 1950-1990



Source: U. S. Bureau of the Census and SEWRPC.

properly zoned for future commercial development. One new major retail and service center was under development in 1970 in a location not recommended in the regional land use plan. The inventory further revealed that development was proceeding at each of the proposed six new major industrial centers. Of the 12 proposed new major regional outdoor recreation centers, nine had been acquired and at least partially developed by 1970.

With respect to the recommendations contained in the regional land use plan pertaining to the placement of new residential development, including supporting local commercial, industrial, park, and other auxiliary land uses, the inventory revealed a somewhat mixed pattern. Substantial development occurred within the Region in areas recommended for development by 1990 in the plan. On the other hand, the inventory revealed that although new residential development without public sanitary sewer service had virtually halted in most of the communities within the Kenosha, Milwaukee, and Racine urbanized areas, substantial amounts of new highly diffused, low-density residential development occurred in scattered fashion throughout the Region where soils more suitable to the use of septic tank sewage disposal systems could be found.

Revised Population and Employment Forecasts

In light of the results of the 1970 Census of Population and the 1970 reinventory of land use, and in accordance with sound planning and engineering practice, the Commission began in 1972 a major effort toward reevaluation of the adopted regional land use and transportation plans. As a first step in this reevaluation, the Commission prepared revised population and employment forecasts for the year 1990 and extended such forecasts to the year 2000 in order to provide a new target year for regional plan preparation.

Revised Population Forecasts: In order to provide a basis for selecting a single best forecast for population growth in the Region and the counties which comprise the Region, the Commission prepared a series of population projections based on varying assumptions with respect to fertility, mortality, and migration, the factors which affect population change.[2] From 1950 to 1960 the population of the Region increased from about 1.24 million to about 1.57 million. About one-third of this increase was accounted for by net in-migration to the Region and about two-thirds by natural increase. The accompanying crude birth rate was very high, at about 26 births per 1,000 population. During the 1960 to 1970 decade, the Region's population increased from 1.57 million to about 1.76 million. Since the Region actually experienced net out-migration during this decade, all of the population increase was due to natural increase. The crude birth rate, however, dropped to about 17 births per thousand population.

Given these changing factors that affect population size and distribution, 12 alternative population projections were prepared for the year 2000. These projections ranged from a low of 2.18 million persons in the Region by 2000 under the assumptions of replacement fertility, current mortality, and no migration; to a high of nearly 3.76 million under assumptions of current fertility, current mortality, and the resumption of the 1950-1960 net in-migration pattern. These 12 alternative population projections were presented to the Commission Socioeconomic Subcommittee of the Technical Coordinating and Advisory Committee on Regional Land Use-Transportation Planning for review and selection of a single best projection to be utilized as a forecast of future population growth in the Region for comprehensive planning purposes. The Committee indicated that the future population of the Region could be reasonably expected to range from a low of 2.38 million in the year 2000 to a high of 2.70 million, with the most significant factor influencing where in this range the actual future population level will fall being economic development and its effect upon migration.

The projection ultimately selected for use as a forecast—and therefore as a basis for plan preparation and evaluation—was based upon the assumption of a continuation of the current fertility rates to 1985, replacement fertility from 1985 to 2000, a continuation of current mortality rates to 2000, and current migration to 2000. These assumptions result in a forecast population for the Region in 2000 of about 2.59 million, or approximately 90,000 less than the initial 1990 regional population forecast prepared in the mid-1960s of about 2.68 million. The attendant revised 1990 population forecast, based upon the stated assumptions, is about 2.29 million. On a gross regional basis, therefore, it may be concluded that the population anticipated for the Region by 1990 at the time of the preparation of the regional

[2] *See SEWRPC Technical Report No. 11, The Population of Southeastern Wisconsin, February 1973.*

Table 94

INITIAL AND REVISED 1990 AND NEW 2000 SEWRPC POPULATION FORECASTS FOR THE REGION BY COUNTY

County	1970 Population		Initial SEWRPC 1990 Population Forecast		Revised SEWRPC 1990 Population Forecast		Difference Between Initial and Revised 1990 Population Forecasts		New SEWRPC 2000 Population Forecast		Increment 1990 (Revised)-2000	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent Change -	Number	Percent of Total	Number	Percent Change
Kenosha	117,917	6.7	202,000	7.5	152,400	6.7	- 49,600	-24.6	168,400	6.5	16,000	10.5
Milwaukee	1,054,249	60.1	1,446,000	54.0	1,122,200	49.6	- 323,800	-22.4	1,147,500	44.3	25,300	2.3
Ozaukee	54,461	3.1	106,000	4.0	100,400	4.5	- 5,600	- 5.3	136,600	5.3	36,200	36.0
Racine	170,838	9.7	283,000	10.6	233,100	10.3	- 49,900	-17.6	270,600	10.4	37,500	16.1
Walworth	63,444	3.6	87,000	3.2	92,100	4.1	+ 5,100	+ 5.9	107,000	4.1	14,900	16.2
Washington	63,839	3.6	96,000	3.6	108,500	4.8	+ 12,500	+13.0	138,900	5.4	30,400	28.0
Waukesha	231,338	13.2	458,000	17.1	452,400	20.0	- 5,600	- 1.2	621,100	24.0	168,700	37.3
Region Total	1,756,086	100.0	2,678,000	100.0	2,261,100	100.0	- 416,900	-15.6	2,590,100	100.0	329,000	14.6

Source: SEWRPC.

land use plan—about 2.68 million—will probably now be reached by the year 2000, and that the regional population in 1990 will approximate 2.26 million persons, or 420,000 persons less than originally forecast.

It is important to compare the initial and revised 1990 population forecasts for the Region on a county-by-county basis in order to determine the anticipated changing population distribution within the Region. Table 94 shows such a comparison between the initial 1990 population forecast and the revised 1990 population forecast on a county-by-county basis. As noted above, for the Region as a whole the 1990 population forecast has been revised downward from about 2.7 million to about 2.3 million persons, representing a decrease of about 400,000 persons, or about 15 percent. When viewed on a county basis, however, it is apparent that three of the seven counties—Kenosha, Milwaukee, and Racine—are expected to experience population growth by 1990 substantially less than that initially forecast; two counties—Ozaukee and Waukesha—are expected to experience virtually the same population increase as initially forecast; while two counties—Walworth and Washington—are expected to experience an even greater population growth by 1990 than initially forecast. By far the greatest change in terms of absolute difference between the initial and revised 1990 population forecasts occurs in Milwaukee County, which is now anticipated to increase by only about 70,000 over its current level of 1.05 million (see Table 94).

Table 94 also shows the anticipated increment between the revised 1990 population forecast and the new 2000 population forecast on a county-by-county basis. With respect to the Region as a whole, the population is expected to increase from about 2.3 million in 1990 to about 2.6 million in 2000, representing an increase of about 329,000 persons, or about 15 percent, over the revised 1990 level. It is significant to note that the new year 2000 population forecast of about 2.6 million is very close to the initial 1990 population forecast of 2.7 million used in the preparation of the regional land use plan. When viewed on a county-by-county basis, however, there are substantial differences between the initial 1990 and new 2000 population forecasts, reflecting changing trends in the distribution of population throughout the Region, which trends may have significant ramifications with respect to land use and supporting public facility development. As in the case of the revised 1990 forecast noted above, the population in Milwaukee County is forecast for the year 2000 to increase by only 93,000 persons above the 1970 level. The substantial difference noted in Kenosha County between the initial and revised 1990 population forecasts remains when the initial 1990 forecast is compared with the 2000 forecast. In Racine County, however, the 2000 forecast is within 4 percent of the initial 1990 forecast. The populations of the four remaining counties in the Region are all anticipated to grow by the year 2000 to levels substantially beyond that initially forecast for 1990. This is particularly true of Waukesha County, where the difference between the initial 1990 and the new 2000 forecasts is over 160,000 persons. On a relative basis, an even greater difference is seen in Washington County where an increase of about 45 percent, or about 43,000 persons, is found between

Table 95

INITIAL AND REVISED 1990 AND NEW 2000 SEWRPC EMPLOYMENT FORECASTS FOR THE REGION BY COUNTY

County	1970 Employment		Initial SEWRPC 1990 Employment Forecast		Revised SEWRPC 1990 Employment Forecast		Difference Between Initial and Revised 1990 Employment Forecasts		New SEWRPC 2000 Employment Forecast		Increment 1990 (Revised)-2000	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent Change	Number	Percent of Total	Number	Percent Change
Kenosha	39,200	5.3	80,000	8.1	43,500	4.6	- 36,500	-45.6	45,100	4.3	+ 1,600	+ 3.7
Milwaukee	510,900	68.9	627,700	63.8	580,700	61.4	- 47,000	- 7.5	614,100	58.6	+ 33,400	+ 5.7
Ozaukee	17,900	2.4	26,500	2.7	32,100	3.4	+ 5,600	+21.1	39,800	3.8	+ 7,700	+24.0
Racine	61,900	8.3	97,100	9.9	87,000	9.2	- 10,100	-10.4	99,600	9.5	+ 12,600	+14.5
Walworth	24,200	3.3	22,100	2.2	38,800	4.1	+ 16,700	+75.6	46,100	4.4	+ 7,300	+18.8
Washington	20,300	2.7	26,100	2.7	32,200	3.4	+ 6,100	+23.4	37,700	3.6	+ 5,500	+17.1
Waukesha	67,200	9.1	104,500	10.6	131,500	13.9	+ 27,000	+25.8	165,600	15.8	+ 34,100	+25.9
Region Total	741,600	100.0	984,000	100.0	945,800	100.0	- 38,200	- 3.9	1,048,000	100.0	+ 102,200	+10.8

Source: SEWRPC.

the initial 1990 and new 2000 population forecasts. The anticipated impact of these changes in forecast population levels on a county-by-county basis on the regional sanitary sewerage system plan is discussed below.

Revised Employment Forecasts: As noted earlier in this chapter, the adopted regional land use plan was based in part upon a forecast distribution of employment in 1990 throughout the Region. As part of the plan reevaluation effort under the continuing regional land use-transportation study, new forecasts were prepared for the Region by county for the year 1990 and extended to the new plan target year of 2000.[3] Table 95 presents a comparison between the initial and revised 1990 employment forecasts for the Region on a county-by-county basis. As was the case above in population distribution, the three counties of the Region having large central cities—Kenosha, Milwaukee, and Racine—are now expected to experience less job growth, with a concomitant increase in job growth in the four outlying counties of Ozaukee, Walworth, Washington, and Waukesha. For the Region as a whole, the revised 1990 employment forecast is only about 4 percent below the initial 1990 forecast, as compared with a 16 percent difference in the initial and revised 1990 regional population forecasts. The difference in magnitude in the revisions in the 1990 population and employment forecasts may be attributed primarily to substantial growth in the service sector of the economy and an increasing participation rate of persons in the work force, particularly with respect to women.

Table 95 presents the anticipated increment between the revised 1990 employment forecast and the new 2000 employment forecast for the Region on a county-by-county basis. Total employment in the Region is expected to surpass the one million mark by 2000 representing an increase of about 102,000, or about 11 percent, over the revised 1990 regional employment forecast of about 946,000. When viewed on a county-by-county basis, only Kenosha and Milwaukee Counties are not expected to reach by the year 2000 the job level initially forecast for the year 1990. The Kenosha County forecast in particular has been substantially revised downward, reflecting in large part recent job trends in the automotive equipment industry. Large increases in job growth are anticipated in Ozaukee, Walworth, Washington, and Waukesha Counties.

Comparison of Revised Population Forecasts With Population Projections of State and Federal Agencies

The revised year 1990 and new year 2000 population forecasts for the Region as prepared by the Commission may be compared with year 1990 and year 2000 population projections prepared by various state and federal agencies concerned with water quality management planning. Table 96 presents such a comparison, including population projections prepared by the Wisconsin Department of Administration, the Wisconsin Department of Natural Resources, and the U. S. Environmental Protection Agency.

[3] *See SEWRPC Technical Report No. 10, The Economy of Southeastern Wisconsin, December 1972.*

Table 96

COMPARISON BETWEEN REVISED SEWRPC 1990 POPULATION FORECAST, SEWRPC 2000 POPULATION FORECAST, AND 1990 AND 2000 POPULATION PROJECTIONS PREPARED BY STATE AND FEDERAL AGENCIES FOR THE REGION BY COUNTY AND STANDARD METROPOLITAN STATISTICAL AREA

County and SMSA	1990								2000			
	Revised SEWRPC Population Forecast		Wisconsin Department of Administration Population Projection[1]		Wisconsin Department of Natural Resources Population Projection[2]		U.S. Environmental Protection Agency Population Projection[3]		SEWRPC Population Forecast		U.S. Environmental Protection Agency Population Projection[3]	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Kenosha County and SMSA	152,400	6.7	148,900	6.8	150,068	6.5	153,200	--	168,400	6.5	171,100	--
Milwaukee County	1,122,200	49.6	1,089,700	49.5	1,180,213	50.7	N/A	--	1,147,500	44.3	N/A	--
Ozaukee County	100,400	4.5	95,500	4.3	104,301	4.5	N/A	--	136,600	5.3	N/A	--
Washington County	108,500	4.8	113,900	5.2	136,603	5.9	N/A	--	138,900	5.4	N/A	--
Waukesha County	452,400	20.0	420,800	19.1	419,182	18.0	N/A	--	621,100	24.0	N/A	--
Subtotal Milwaukee SMSA	1,783,500	78.9	1,719,900	78.1	1,840,299	79.1	1,848,400	--	2,044,100	79.0	2,082,000	--
Racine County and SMSA	233,100	10.3	250,100	11.4	222,770	9.6	220,300	--	270,600	10.4	248,100	--
Walworth County	92,100	4.1	81,600	3.7	112,594	4.8	N/A	--	107,000	4.1	N/A	--
Region Total	2,261,100	100.0	2,200,500	100.0	2,325,731	100.0	N/A	--	2,590,100	100.0	N/A	--

N/A means data not available.

[1] *Wisconsin Population Projections (Second Edition), Wisconsin Department of Administration, March 1972.*

[2] *Small Area Population Projections for Wisconsin, Technical Bulletin No. 59, Wisconsin Department of Natural Resources, 1972.*

[3] *Population and Economic Activity in the United States and Standard Metropolitan Statistical Areas 1950-2020, U.S. Environmental Protection Agency and U.S. Department of Housing and Urban Development, July 1972.*

Source: SEWRPC.

With respect to the year 1990, the revised Commission regional population forecast lies in between the Wisconsin Department of Administration population projection and the Wisconsin Department of Natural Resources population projection, there being a difference of about 125,000 persons in the two state agency population projections. On a county-by-county basis, however, there are some differences between the revised Commission 1990 population forecast and the population projections prepared by the state agencies, although the pattern of difference is not consistent. Perhaps the most significant difference lies in Waukesha County, where both state agency projections anticipate a 1990 population of only about 420,000, whereas the Commission population forecast anticipates a population level of about 452,000.

The U. S. Environmental Protection Agency (EPA) population projections are available only on a standard metropolitan statistical area (SMSA) basis. In the Southeastern Wisconsin Region there are three SMSA's: the Kenosha SMSA, consisting entirely of Kenosha County; the Milwaukee SMSA, consisting of Milwaukee, Ozaukee, Washington, and Waukesha Counties; and the Racine SMSA, consisting entirely of Racine County. Since the EPA makes no population projection for Walworth County, it lying outside of any SMSA, it is not possible to compare the EPA projections with the Commission forecasts on a regional basis. With respect to the year 1990, the EPA population projection for the Kenosha SMSA is slightly above that of the revised Commission forecast; that for the Milwaukee SMSA substantially above the revised Commission forecast; and that for the Racine SMSA somewhat below the revised Commission forecast. With respect to the year 2000, as shown in Table 96, these relationships remain the same except that the gap between the two forecasts in the Milwaukee SMSA is considerably narrowed, whereas that for the Racine SMSA is somewhat widened.

In general, then, there are some differences between the various population forecasts and projections promulgated by regional, state, and federal agencies involved in comprehensive water quality management planning efforts. Since population forecasting is a difficult task at best, such differences are to be expected, particularly for areas smaller than the Region. It is, nevertheless, necessary to select a single forecast to be utilized in the preparation of a plan. In the Southeastern Wisconsin Region the Commission has utilized for planning purposes its own independently prepared population forecast, which, as noted above, corresponds very closely to state and federal agency population projections on a regional level—but differs somewhat on a county level. With respect to the regional sanitary sewerage system plan, those design engineers working for local units of government in the Region and charged with the responsibility for plan implementation should be aware of the various forecasts and projections that are available and, in light of the best available knowledge at the time, select the forecast level believed most likely to be achieved for the given community or group of communities being served by a planned sewerage facility. Except in rare instances, this level should very likely closely approximate the level utilized in the preparation of the regional sanitary sewerage system plan.

The Effect of Changing Development Patterns on the Regional Sanitary Sewerage System Plan

In light of the changing patterns of population size and distribution and job distribution noted for the Region in the foregoing discussion, which changes have come about since preparation and adoption of the regional land use plan, it is necessary to assess the probable impact of such changes on the regional sanitary sewerage system plan. Since, as noted earlier in this chapter, it is not always possible to prepare every interrelated regional plan element simultaneously, even though such a course of action would be highly desirable, it is to be expected that, in this case, a subsequently prepared regional sanitary sewerage system plan might require some changes and modifications in light of changes in actual land use development patterns, and in light of the implications which these changes, in turn, hold for the adopted regional land use plan upon which the sewerage system plan must be based. Indeed, the process of monitoring areawide growth and development and adjusting already adopted and completed areawide plan elements is at the very heart of the continuing regional planning process. It is also the point at which many planning programs—local as well as areawide—have failed. By recognizing in advance the potential ramifications of change on a given plan element, it is, then, possible to set the stage for future plan adjustment and modification.

For the Region as a whole, the revised population forecasts indicate that the initially forecast 1990 population level of 2.68 million persons will probably now be reached by the year 2000, and that the regional population in the year 1990 will approximate 2.26 million persons. Perhaps the most significant change in the population and employment forecasts for 1990, and as extended to the year 2000, occurs in Milwaukee County, where it is now anticipated that population growth will increase only moderately from its existing level and where most job growth is anticipated to be in the service sector of the economy. At first it may seem that this substantial departure from the initial assumptions in the regional land use plan that Milwaukee County would continue to grow by about 360,000 persons over the 1963 population level of 1,086,300 would have a substantial impact upon the regional sanitary sewerage system plan. Upon more careful analysis, however, it becomes apparent that whether or not Milwaukee County grows by an additional 360,000 persons, remains at its current level, or even decreases in absolute population size, the basic areawide sanitary sewerage system for the county is already substantially in place and, for system continuity as well as surface water pollution abatement purposes, must be completed as initially planned by the Milwaukee-Metropolitan Sewerage Commissions. As discussed in Chapter XI of this report, the long-range trunk and intercepting sewer system plan adopted and already substantially implemented by the joint Commissions in Milwaukee County was taken as a committed decision for purposes of regional sanitary sewerage system plan preparation, and is necessary in any case to abate existing major sources of surface water pollution from separate sanitary sewerage system surcharging and overflows.

As a practical matter, then, the changing pattern of population distribution throughout the Region will have a very limited effect upon the basic sanitary sewerage system plan for Milwaukee County and the existing and committed service areas in Ozaukee, Racine, Washington, and Waukesha Counties tributary to the Milwaukee-metropolitan sewerage system. Indeed, as documented in Chapter V of this report, there is evidence to indicate that despite the fact that the total resident population served by sanitary sewers in Milwaukee County declined from 1963 to 1970, the total average daily sewage flow from within the county substantially increased over the same period.

Finally, it should be recognized that substantial new urban development could occur in Milwaukee County in future years while not increasing the overall county population level, if densities in the older developed portions of the county decline substantially from the present levels.

With respect to Racine and Kenosha Counties, which, as noted earlier, are also anticipated to experience less growth than initially forecast, it is also likely that densities may decline in the older central cities that are already served by sewerage systems, while new urban development takes place in other areas of these counties not now provided with sewer service. Thus, despite a decrease in the forecast population level for each county, even by the year 2000, it is most probable that the sewerage facilities proposed in the regional sanitary sewerage system plan, as based upon the adopted regional land use plan, will be needed. To the extent that development takes place in areas beyond those recommended for development in the adopted regional land use plan, reflecting population redistribution within these counties, even additional sewerage facilities would be required.

In the remaining four counties of the Region, either no change or an actual increase in population levels over the initially forecast 1990 level may be anticipated. Thus, there is every reason to expect that not only will the sewerage facilities contained in the recommended sanitary sewerage system plan for the Region be needed but that additional facilities will be needed as well to handle even greater anticipated future growth. This becomes even more apparent when the new year 2000 county population forecasts for these four counties are examined.

In general, then, it may be concluded that, despite the changes made in the regional population and employment forecasts since preparation of the regional land use plan, it is highly unlikely that the land use plan now being revised and extended to the year 2000 will depart substantially from that initially prepared for the year 1990, except perhaps for those areas of the Region already served by centralized sanitary sewerage systems. There will be differences, to be sure, but, as discussed above, such differences are likely to consist of even greater areas of urban growth in at least four counties of the Region coupled with lesser growth in the three counties of the Region having the older, well-established urban plants and, hence, the already existing and committed major sewerage systems. Thus it may be concluded that the adopted land use plan still provides a sound basis for the preparation of the regional sanitary sewerage system plan. Obviously, as is the case in any planning effort, the regional sanitary sewerage system plan will have to be continuously reevaluated after its adoption. Such reevaluation must take place not only at the areawide level, as a new regional land use plan for the year 2000 is prepared, but also at the local level as design engineers prepare preliminary engineering reports for the various sewerage facilities proposed in the recommended plan.

SUMMARY

In the preparation of a sanitary sewerage system plan for the Southeastern Wisconsin Region, future population and economic activity levels must be forecast. These forecasts, when combined with engineering design criteria, can then be converted to future demand for sewerage facilities in the Region, and a sewerage system plan prepared to meet the demand. Individual sewerage facilities must be planned and designed not in isolation on an ad hoc basis, but rather as integral parts of an areawide system in which the major sewerage facilities are carefully fitted to projected waste loadings derived from an adopted areawide land use plan. Accordingly, in the Southeastern Wisconsin Region the adopted regional land use plan was utilized as a basis for preparation of the regional sanitary sewerage system plan. Since the regional land use plan was based upon carefully prepared forecast levels of population and economic activity in the Region, separate forecasts of such activity and of the future demand for land in the Region were not prepared as part of the regional sanitary sewerage system planning program.

The adopted regional land use plan was based upon an initial 1990 forecast population level of about 2.7 million persons, representing an increase of approximately one million persons over the 1963 population level. Employment in the Region was expected to reach nearly the one million job level by 1990, an increase of nearly 350,000 jobs over the 1963 level. The regional land use plan was designed to accommodate this anticipated growth in population and employment through the conversion of about 200 square miles of land from rural to urban use over the 27-year period 1963-1990. The regional land use plan contains specific recommendations for the amount and spatial location of future residential development, as well as the establishment of major commercial, industrial, and recreational centers. In addition, the plan recommends the permanent protection and preservation of about 283,000 acres of primary environmental corridor land and about 423,000 acres of prime agricultural lands.

The regional land use plan was prepared to meet 1990 county forecast population levels, with increases in county population anticipated to range from about 360,000 persons in Milwaukee County to about 32,000 persons in Walworth County. The plan further recommended that the majority of new residential land uses within the Region be developed at medium densities and be provided with public sanitary sewer and water supply services. By 1990 the plan envisioned about 580 square miles, or 95 percent of the developed urban area, and about 2.5 million persons, or 95 percent of the total population, being served by both public sanitary sewer and water supply facilities.

The regional land use plan was an essential input into the design of the regional sanitary sewerage system plan, since sewerage system planning must assume some anticipated distribution of future urban land uses in order to properly size and locate sewage conveyance and treatment facilities, and must further assume anticipated population and economic activity levels in order to determine future waste loadings on sewerage systems. Thus, the interrelationship between land use and sewerage system planning is clearly evident, it being impossible to prepare a regional land use plan without certain assumptions concerning the provision of sanitary sewer service nor a regional sanitary sewerage system plan without certain assumptions concerning the future distribution of land uses and future population and economic activity levels.

The regional land use plan was adopted in 1966. Since that time changes in the existing trends of population and economic activity levels have begun to appear, as evidenced in the 1970 U. S. Census of Population. While the forecast regional level of population for 1970 differed from the actual level by only about 6 percent, the trend in actual regional population growth was apparently departing from the trend in the forecast population level, which level was utilized as the basis for regional land use plan preparation. Significant changes have been noted in the rates of the two components in population change during the late 1960s—natural increase and migration. Particularly significant changes in population trends were evidenced in 1970 in the three counties containing the major central cities of the Region—Kenosha, Milwaukee, and Racine. In each of these three cases, the 1970 population forecast was above the U. S. Census level. In the remaining four counties of the Region, however, the census counts exceeded the 1970 forecast level. Thus, the results of the 1970 Census of Population indicated that population is tending to grow more rapidly in the outlying areas of the Region than originally anticipated and less rapidly in the three counties containing the large central cities of the Region.

The Commission began in 1972 a major effort toward reevaluation of the adopted regional land use plan, and as a first step prepared revised population and employment forecasts for the year 1990 and extended such forecasts to the year 2000. After examining alternative population projections, a new population forecast for the Region was selected based upon the assumptions of current fertility to 1985, replacement fertility from 1985 to 2000, current mortality to 2000, and current migration to 2000, which, during the 1960s, was a pattern of out-migration. This forecast anticipates a 1990 regional population of about 2.3 million persons and a 2000 regional population of about 2.6 million persons. On a regional basis, therefore, the population initially anticipated for the Region by 1990 at the time of the preparation of the regional land use plan appears now most likely to be reached in the year 2000. On a county-by-county basis, however, more significant differences are found between the initial and revised population forecasts. Of particular significance is the anticipated change in growth within Milwaukee County, where it is now considered most likely that the county will not substantially increase its present population level. In Kenosha and Racine Counties the initially assumed rates of growth have also been revised downward, whereas in the remaining four counties of the Region—Ozaukee, Walworth, Washington, and Waukesha—substantially greater rates of population growth than initially anticipated have now been forecast.

The probable impact of these changing regional development patterns on the regional sanitary sewerage system plan was evaluated. With respect to Milwaukee County and the basic Milwaukee-metropolitan sewerage system, it may be concluded that whether or not Milwaukee County grows as initially forecast, remains at its current level, or even decreases in absolute population size, the basic areawide sanitary sewerage system for the metropolitan area is already substantially in place and, for system continuity and water pollution abatement purposes, must be completed as initially planned. Similarly, in Kenosha and Racine Counties the anticipated growth may take place in areas not now served with centralized sewerage systems, accompanied by decreased densities in central city areas. With respect to the remaining four counties in the Region, it is clear that not only would sewerage facilities based upon the adopted regional land use plan for the Region be needed, but that additional facilities may be needed as well to handle even greater anticipated future growth. Clearly, the basic structure of a regional sanitary sewerage system plan based upon the adopted regional land use plan would be sound and would need to be adjusted and modified only as changes to the regional land use plan itself are made. Indeed, to the extent that regional growth takes place beyond that anticipated in the adopted regional land use plan, reflecting not only population growth but also population redistribution, additional sewerage facilities would likely be required.

(This page intentionally left blank)

Chapter XI

ALTERNATIVE REGIONAL SANITARY SEWERAGE SYSTEM PLANS

INTRODUCTION

Plan design, test, and evaluation comprise the very heart of the planning process. It is at this point in the planning process that the outputs of previous planning operations, including the formulation of objectives and standards, the conduct of inventories and analyses, and the preparation of forecasts of future demand, become inputs to the design problem of plan synthesis. The sanitary sewerage system design problem requires a reconciliation among the hydraulic and pollution loadings derived from the adopted regional land use plan, the ability of the environment to assimilate the treated wastes to be discharged, agreed-upon sanitary sewerage system design standards, existing sanitary sewerage system capacity, and facility capital and operating costs. In the system design phase, future sanitary sewerage system networks are synthesized to satisfy the regional land use, water use and quality, and sanitary sewerage development objectives and standards, while meeting criteria of system integration and cost minimization. The purpose of this chapter is to present the results of the plan design, test, and evaluation phase of the regional sanitary sewerage system planning program in terms of alternative sanitary sewerage system plans for subareas of the seven-county Southeastern Wisconsin Region.

The various alternative sanitary sewerage system plans considered were designed to meet the established water use objectives and supporting water quality standards as set forth in Chapter VII of this report, and, in addition, to contribute to the implementation of the adopted regional land use plan as presented in Chapter X of this report. There are a number of alternative means by which these objectives can be achieved. Alternatives relating to sewerage system technology were discussed in the section of Chapter IX of this report dealing with the state of the art of sanitary sewerage. In that discussion it was concluded that the present technique of water carriage of wastes can be expected to continue to be practiced at least through the 20-year plan design period. It was further concluded that the biological sewage treatment processes currently in use may be expected to continue in use through the plan design period, although physical-chemical treatment processes will be introduced at some sewage treatment facilities within the Region during the planning period. It was also concluded that treated sewage effluent would continue to be discharged to natural surface waters or be disposed of on lands either through seepage ponds or irrigation processes.

Earlier Commission studies, including the watershed studies, and an assessment of present technology, as set forth in Chapter IX of this report, indicated that in the regional sanitary sewerage system plan preparation, continued reliance should be placed upon conventional centralized sanitary sewerage systems, providing high degrees of treatment with discharge of treated wastes to surface waters. In both the Fox and Milwaukee River watershed studies, it was concluded that the provision of advanced waste treatment at a relatively small number of sewage treatment facilities serving centralized sewerage systems was the most economical and feasible alternative. Hence, for regional sanitary sewerage system planning purposes, the basic alternatives considered centered on the provision of advanced waste treatment where necessary to achieve established water use objectives, with the alternatives differing primarily with respect to the question of whether a given urban subarea of the Region should be served by a single sewage treatment facility or by multiple sewage treatment facilities. This required consideration of alternative trunk sewer or force main arrangements to convey the sewage to the treatment facility or facilities. The specific analytical procedures utilized in the preparation of alternative system plans are discussed in Chapter IX of this report and will not be repeated here.

The plan design process was thus basically one of finding successive approximations to the best arrangement of treatment and conveyance facilities, with specific solutions being proposed to specific problems in each iteration, then tested and evaluated through application of the hydraulic and pollution loadings and the objectives and supporting standards and criteria. The first step in the plan design was to determine the deficiencies of the existing sanitary sewerage systems under probable future land use and sewage loading conditions, such deficiencies including the lack of sanitary sewer service to existing and proposed urban development requiring such service. Proposals to overcome the indicated deficiencies were then advanced, tested, and evaluated.

It is important to note that the preliminary design solutions to be tested and evaluated were drawn from three important sources. The first and most important source consisted of proposals advanced in local sanitary sewerage system plans. These proposals originated with experienced professional engineers in the employ of, or in a consultant capacity to, the local units of government within the Region, and were consequently founded in an intimate knowledge of, and long-standing experience with, the existing sanitary sewerage systems. The second source for design solutions was developed directly from the system analyses conducted under the study, wherein solutions to correct system deficiencies became apparent from the knowledge acquired of the existing and probable future sewerage problems within the Region. The third source for design solutions was developed indirectly from the land use planning program of the Commission, wherein suggestions for service based upon land use development objectives were advanced. Wherever the analyses indicated that the existing and committed sewerage facilities were inadequate to meet the anticipated demand and the objectives and supporting standards, local system plans and local engineers were consulted for suggestions concerning possible system improvements which might alleviate the deficiency. These improvements were added to the existing system and the resulting new system tested and evaluated. Where design solutions drawn from the first source proved inadequate to alleviate deficiencies or where no solutions had been so proposed, resort was made to the second source of design solutions. The third source for design solutions was used primarily in the newly developing areas of the Region.

While major emphasis was placed in the study on the basic alternative of providing advanced levels of waste treatment at varying treatment plant locations throughout the Region and on the alternative means of conveying sewage to these locations, other concepts of waste management, such as the diversion of effluent from one watershed to another, particularly across the subcontinental divide traversing the Southeastern Wisconsin Region, and land disposal of effluent as an alternative to high degrees of waste treatment, were also considered. None of these alternative conceptual solutions to the water quality management problems of the Region were, however, considered viable on a regionwide scale.

DIVERSION OF SEWAGE EFFLUENT FROM LAKE MICHIGAN BASIN

Interest has been expressed from time to time, particularly by environmental interest groups, certain adjacent states, and federal officials, in the concept of eliminating all sewage effluent discharges to Lake Michigan or to streams which drain into Lake Michigan through the diversion of such effluent across the subcontinental divide traversing the Southeastern Wisconsin Region and into streams of the Rock, Fox, and Des Plaines River watersheds which are part of the larger Mississippi River drainage basin. The principal reason expressed for such interest in large-scale diversion of sewage effluent is the potential for possible irreversible deterioration of Lake Michigan due to eutrophication (overfertilization) attributable to the discharge of nutrients—particularly phosphorus—to the lake in sewage treatment plant effluent. Even though this concern is being directly addressed through the provision of phosphorus removal at all major sewage treatment plants in Wisconsin which discharge directly to Lake Michigan or to streams which drain into Lake Michigan, there nevertheless continues to be interest in the prospect of total diversion of effluent out of the Lake Michigan basin. Accordingly, representatives of the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency requested that an "order-of-magnitude" cost estimate be prepared for a Lake Michigan diversion alternative as part of the regional sanitary sewerage system planning program for the Region.

It should be noted that, as discussed in Chapter V of this report, about 243 million gallons per day (mgd), or 92 percent of the 265 mgd of sewage effluent discharged in the Region, is discharged either directly to Lake Michigan or to streams which drain into Lake Michigan. Thus, total diversion in the Southeastern Wisconsin Region would constitute a task of major proportions. It should be further noted that the cost of diversion of all sewage effluent out of the Lake Michigan basin would almost totally be an "add on" cost to any of the alternative system plans considered herein. That is to say, conveyance facilities required to effect diversion would represent an additional cost above and beyond what would be needed to provide sanitary sewer service and adequate sewage treatment if sewage effluent continued to be discharged either to Lake Michigan or to streams tributary to Lake Michigan.

One method of carrying out a diversion alternative is illustrated on Map 52. This map shows the recommended 1990 sanitary sewer service areas for that portion of the Region tributary to Lake Michigan, the location of all proposed sewage treatment facilities to serve the recommended area under a diversion scheme, and the approximate alignment of those additional trunk and effluent outfall sewers needed to provide complete diversion of the treated sewage effluent into the Mississippi River drainage basin. Under this conceptual alternative, diversion would occur at five locations. One location would serve the existing communities in the Washington County portion of the upper Milwaukee River watershed. Trunk sewers would convey raw sewage from the Villages of Jackson and Kewaskum, the Newburg Sanitary District, and the Green Lake area to the site of the existing West Bend sewage treatment facility. The West Bend facility would be expanded to handle all of the anticipated demand, and a diversion outfall sewer would be constructed from the West Bend plant to the East Branch of the Rock River at a point just north of the Allentown Sanitary District in the Town of Addison.

The second location would accommodate all sewage from existing communities in Ozaukee County, except the Village of Thiensville and the City of Mequon, which would discharge to the Milwaukee-Metropolitan system. Major trunk sewers would be constructed to connect the Belgium-Lake Church, Fredonia, Saukville, Port Washington, and Grafton sewer service areas to a major sewage treatment facility located at or near the site of the existing City of Cedarburg facility. From there a diversion outfall sewer would be constructed westerly to a location on the Ashippun River, a tributary of the Rock River, in the Town of Erin.

The third location would accommodate all sewage from the Milwaukee-Metropolitan sewer service area. Major deep tunnel diversion outfall sewers would be constructed to connect the Jones Island and South Shore sewage treatment facilities operated by the Milwaukee-Metropolitan Sewerage Commissions. The City of South Milwaukee sewage treatment facility would be abandoned and its service area connected to the South Shore plant. All effluent would be discharged to the Wind Lake drainage canal, a tributary of the Fox River, just below Wind Lake.

The fourth location would accommodate all sewage from the Kenosha and Racine metropolitan areas. Deep tunnel diversion effluent sewers would be constructed to convey effluent from the Kenosha and Racine sewage treatment plants jointly to a point on the Des Plaines River in the Town of Paris.

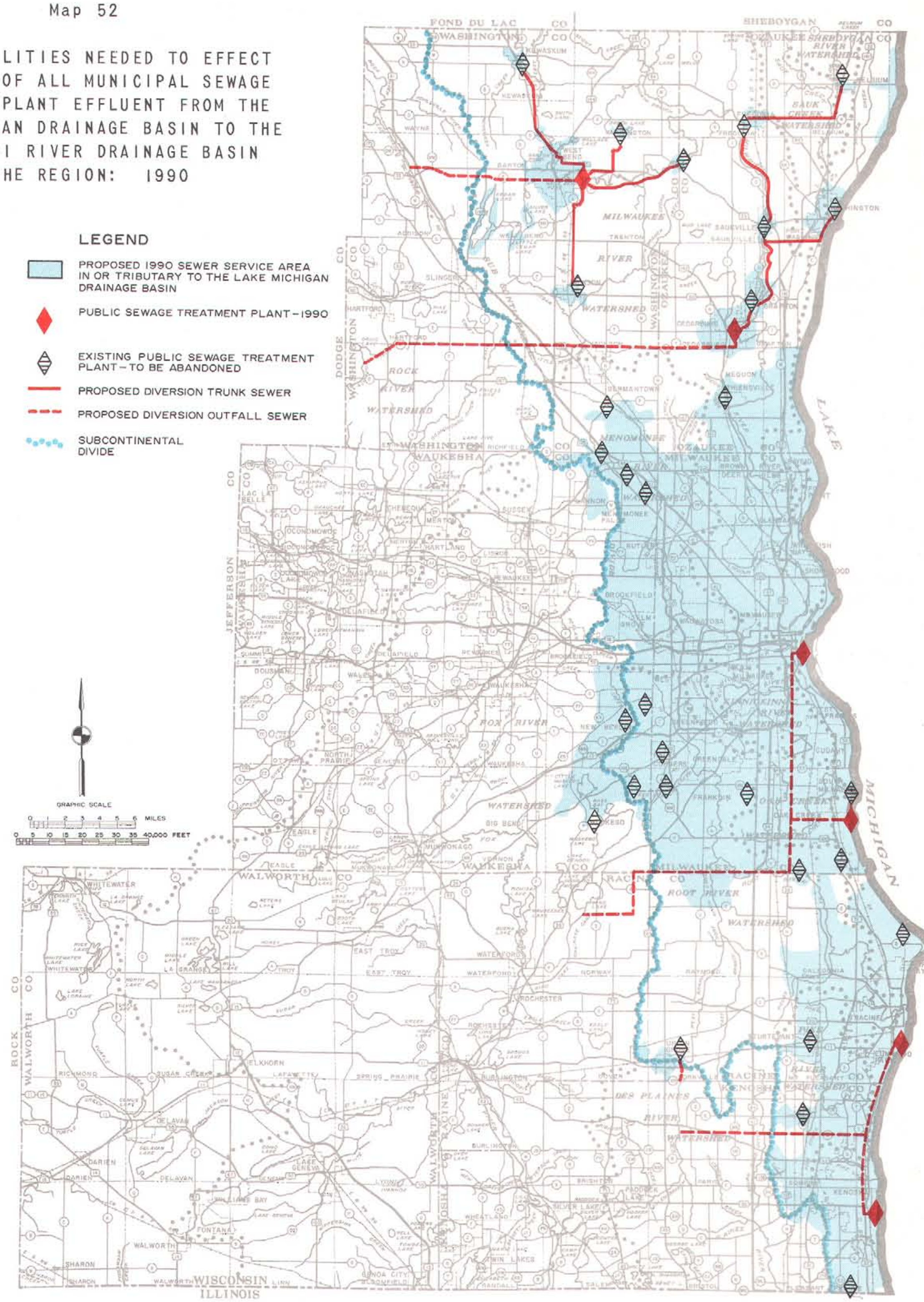
Finally, the fifth location would accommodate sewage flow from the Village of Union Grove and would consist of a minor diversion effluent sewer from the existing Union Grove sewage treatment facility across the subcontinental divide to the Des Plaines River in the Town of Paris.

As noted above, all costs associated with the diversion alternative would be in addition to sewerage facility costs associated with any of the alternative plans providing for advanced waste treatment and disposal of effluent within the Lake Michigan basin. The cost of providing treatment at the various facilities under the diversion alternative would approximate the cost of providing treatment under the advanced waste treatment alternatives, since nitrification would supplant phosphorus removal under the diversion alternative. In addition, all trunk sewers needed to abandon minor existing treatment facilities, as discussed later in this chapter under advanced waste treatment alternatives, would continue to be needed.

The cost for each of the major facilities needed to accommodate large-scale diversion out of the Lake Michigan basin are set forth in Table 97. It should be recognized that these are "order-of-magnitude" cost estimates and have not been prepared to the level of precision afforded the advanced waste treatment alternative plans presented later in this chapter. These estimates do provide, however, an "order-of-magnitude" approximation of the cost involved in any diversion of treated sewage effluent from Lake Michigan as an alternative waste management concept. As shown in Table 97, these costs would approximate $140.7 million.

Map 52

MAJOR FACILITIES NEEDED TO EFFECT DIVERSION OF ALL MUNICIPAL SEWAGE TREATMENT PLANT EFFLUENT FROM THE LAKE MICHIGAN DRAINAGE BASIN TO THE MISSISSIPPI RIVER DRAINAGE BASIN IN THE REGION: 1990



The trunk and outfall sewers shown on the above map represent those conveyance facilities which would be required to fully effect diversion of all municipal sewage treatment plant effluent from the Lake Michigan drainage basin across the subcontinental divide to the Mississippi River drainage basin. The concept of total effluent diversion from the Lake Michigan drainage basin receives support from time to time because of concern over the possible irreversible deterioration of Lake Michigan from overfertilization attributable to the discharge of nutrients--particularly phosphorus--to the lake in sewage treatment plant effluent. This diversion scheme was prepared at the request of federal and state officials in order to provide an "order of magnitude" cost estimate for a Lake Michigan diversion alternative. It is important to note that the cost of diversion would comprise an "add on" cost in the sense that the cost of the diversion facilities required would be over and above those facilities included in the recommended regional sanitary sewerage system plan. Diversion of sewage effluent from the Lake Michigan basin should be undertaken only after very careful consideration and documentation of the need to exclude such effluent from Lake Michigan. Long-term effects of the continued discharge of treated effluent to Lake Michigan and, therefore, the need for diversion, can be established only on the basis of a water quality management study for the entire Lake Michigan basin.

Source: SEWRPC.

Table 97

COST ESTIMATES OF MAJOR FACILITIES NEEDED TO EFFECT DIVERSION OF ALL MUNICIPAL SEWAGE TREATMENT PLANT EFFLUENT FROM THE LAKE MICHIGAN DRAINAGE BASIN TO THE MISSISSIPPI RIVER DRAINAGE BASIN IN THE REGION

	Estimated Cost						
		Present Worth 1970-2020			Equivalent Annual		
Major Diversion Facility	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Washington County Diversion System							
Kewaskum-Green Lake-Newburg-Jackson Trunk Sewers	$ 3,562,600	$ 3,202,900	$ 264,800	$ 3,467,700	$ 203,200	$ 16,800	$ 220,000
Outfall Sewer to East Branch Rock River	5,950,000	4,366,100	31,500	4,397,600	277,000	2,000	279,000
Subtotal	9,512,600	7,569,000	296,300	7,865,300	480,200	18,800	499,000
Ozaukee County Diversion System							
Belgium-Fredonia-Saukville-Port Washington-Grafton Trunk Sewers	7,851,900	5,926,500	584,800	6,511,300	376,000	37,100	413,100
Outfall Sewer to Ashippun River	11,147,000	8,306,600	323,100	8,629,700	527,000	20,500	547,500
Subtotal	18,998,900	14,233,100	907,900	15,141,000	903,000	57,600	960,600
Milwaukee-Metropolitan Area Diversion System							
South Milwaukee Trunk Sewer	920,000	788,100	189,100	977,200	50,000	12,000	62,000
Outfall Sewer to Wind Lake Canal	77,700,000	58,414,000	34,219,300	92,633,300	3,706,000	2,171,000	5,877,000
Subtotal	78,620,000	59,202,100	34,408,400	93,610,500	3,756,000	2,183,000	5,939,000
Racine-Kenosha Metropolitan Area Diversion System							
Outfall Sewer to Des Plaines River	33,040,000	24,368,100	9,848,100	34,216,200	1,546,000	624,800	2,170,800
Subtotal	33,040,000	24,368,100	9,848,100	34,216,200	1,546,000	624,800	2,170,800
Union Grove Diversion System							
Outfall Sewer to Des Plaines River	572,000	419,300	6,300	425,600	26,600	400	27,000
Subtotal	572,000	419,300	6,300	425,600	26,600	400	27,000
Total	$140,743,500	$105,791,600	$45,467,000	$151,258,600	$6,711,800	$2,884,600	$9,596,400

Source: SEWRPC.

As already noted, the primary advantage of this alternative plan element would be the elimination of all discharges of treated sewage effluent to Lake Michigan, thereby reducing the potential for possible irreversible deterioration of the lake due to eutrophication. Other attendant advantages would include low-flow augmentation in the headwater areas of the Rock, Des Plaines, and Fox Rivers, which would receive the diverted effluent, and positive, although very minor if not negligible, effects upon high lake levels and attendant shoreline flooding and erosion problems.

The primary disadvantage of this alternative plan element would be the substantial additional cost entailed, a cost over and above the costs attendant to other alternatives which would meet the established water use objectives. Other disadvantages include the potential contribution to flooding problems on the receiving streams, and the direct conflict of the proposal with present legal constraints which operate against any major diversion of surface water between the Lake Michigan and Mississippi River basins. These very complex legal constraints were more fully discussed in Chapter VII of this report and would be very difficult to remove, involving, as they do, international, as well as interstate, considerations. Finally, it is possible that diversion would have to be accompanied by higher levels of treatment because of the very limited waste assimilation capacities of the small receiving streams, with nitrification, as well as phosphorus removal, becoming necessary.

Clearly, the diversion of all sewage effluent from the Lake Michigan basin to the Mississippi River basin would entail substantial additional costs and should be undertaken only after very careful consideration and documentation of the need to exclude such effluent from Lake Michigan. Long-term effects of the continued discharge of treated effluent to Lake Michigan, and, therefore, the need for diversion, can be established only on the basis of a basinwide water quality management study. Such a study lies beyond the responsibility of the Regional Planning Commission and should be undertaken by the Great Lakes Basin Commission, which has water resource planning responsibilities for the entire Great Lakes basin, as well as the Lake Michigan basin. In this respect, it should be understood that the diversion alternative remains available to the Region at any point in time with any of the alternative plans presented later in chapter, and that costs required to implement the advanced waste treatment management concept, as set forth later in this chapter and in Chapter XII of this report, would have to be incurred in any case to provide for sewage collection, conveyance to, and treatment at central locations prior to diversion.

EFFLUENT DISPOSAL BY LAND IRRIGATION

A second waste management concept in which environmental interest groups and certain public officials have expressed interest involves effluent disposal by land irrigation, as opposed to effluent disposal through direct discharge to surface water bodies. The advantages and disadvantages of effluent disposal by land irrigation have been discussed in Chapter IX of this report and will not be repeated here. The Region's viable suitability for liquid waste disposal, based primarily on soil and geologic conditions, was discussed in Chapter IV of this report, with the conclusion reached that only a relatively small portion of the Southeastern Wisconsin Region is well-suited for land disposal of liquid wastes. In addition, Commission studies conducted as part of comprehensive planning programs for the Fox and Milwaukee River watersheds resulted in findings that effluent disposal by land irrigation was considerably more expensive than the provision of advanced waste treatment and direct effluent discharge into the surface waters of the Region. The cost for such an alternative stream water quality management plan for the Fox River watershed within southeastern Wisconsin, for example, was found to be approximately 30 percent higher on an equivalent annual cost basis than the provision of advanced waste treatment facilities for the watershed. The costs for land irrigation, moreover, were based on the assumption that a $20 per acre annual benefit from crop production yield could be achieved through the irrigation, thus offsetting the overall cost of the land disposal.

Perhaps the single biggest problem encountered in implementing this waste management concept is the extremely large amount of land needed to successfully dispose of the very large volumes of waste generated daily within the Region. This factor alone would militate against its serious consideration on a regionwide basis, although the possibility certainly remains that individual communities, particularly small urban communities located in predominantly rural areas of the Region, could utilize the land irrigation method for liquid waste disposal.

In order to demonstrate the magnitude of the land area problem at the regionwide scale, an estimate was made of the total land area that would be needed to accommodate the anticipated 1990 sewage flow from throughout the Region. Based upon studies conducted at the University of Pennsylvania, an assumption was made that sewage effluent, after conventional primary and secondary treatment, could be applied to agricultural lands at a rate of one inch per week over the 30-week growing season in the Region extending from May to October. Under this assumption, approximately 450 acres of land would need to be acquired to accommodate each million gallons of average daily sewage flow, including area for storage of the treated effluent during winter months. Since the total average daily sewage flow within the Region in 1990 is estimated at about 520 mgd, the resulting gross land requirement for land disposal of effluent is about 230,000 acres, or about 360 square miles. This represents an area larger than Racine County and clearly demonstrates the impracticality of applying this method of effluent disposal on a regionwide basis. In addition, another 16 square miles of land would be needed to accommodate the estimated average annual overflow from the combined sewer areas in Milwaukee, Racine, and Kenosha.

A recent study commissioned by the U. S. Army Corps of Engineers[1] for the Chicago metropolitan area utilized a more liberal assumption concerning land requirements for land disposal. The preliminary conclusion drawn in this study was that 190 acres of land would be needed to accommodate each million gallons of average daily

[1] *Regional Waste Water Management Systems for the Chicago Metropolitan Area--Summary Report*, *Office of the Chief of Engineers, U. S. Department of the Army, March 1972.*

sewage flow, including area for storage of the treated effluent during winter months. The concept applied by the Corps of Engineers in this instance, however, includes the recovery of effluent after passing through the soil by tile drainage systems, with ultimate discharge to surface waters. Thus, under this concept of land disposal, the effluent continues to be discharged to surface waters with the soil serving as a form of advanced waste treatment. If the rate of application of sewage effluent proposed by the Corps of Engineers were applied to southeastern Wisconsin, the total area required for disposal of effluent by land treatment would approximate 96,000 acres, or about 150 square miles. This area would approximate the combined area of four normal sized townships and would be nearly 20 times as large as the abandoned Bong Air Force Base in the Town of Brighton, Kenosha County.

Clearly, land disposal of sewage effluent is a waste management concept having many interrelated problems. As already noted, the most severe problem is the extremely large amount of land needed to accommodate the concept when applied to large urban regions. Irrespective of this and other problems, however, Commission studies have indicated that land irrigation is more costly than advanced waste treatment. Since advanced waste treatment will meet the established stream water use objectives and supporting water quality standards, there appears to be little advantage in consideration of land irrigation on a large scale. In addition, the Commission studies have indicated that the economic disadvantage of land irrigation increases proportionately with the size of the population served. Its application to wastes generated in the large Milwaukee, Racine, and Kenosha metropolitan areas, therefore, seems highly unlikely. Given these problems, then, the alternative waste management concept of land disposal of effluent was not fully costed out as an alternative in the preparation of the regional sanitary sewerage system plan. Its application on a regionwide scale is highly questionable. Its application on a small individual community scale, particularly in the more rural reaches of the Region, however, is within the realm of possibility and should be considered by design engineers during plan implementation. Indeed, Chapter 147 of the Wisconsin Statutes, created by the Wisconsin Legislature in 1973, requires that the feasibility of land disposal be considered during such plan implementation.

Finally, it should be noted that the foregoing discussion and the conclusions relate to the land disposal of sewage effluent and not to the land disposal of sewage sludge. Land disposal of the latter is feasible and widely practiced within the Region. Sludge disposal is discussed further as an auxiliary plan element in Chapter XII of this report.

FORMULATION OF ALTERNATIVE PLANS

As noted earlier, major emphasis in the regional sanitary sewerage system planning program was placed upon the formulation of alternative plans centered on the provision of advanced waste treatment where necessary to achieve established water use objectives, with the alternatives differing primarily with respect to the degree of centralization of treatment within urban subareas of the Region. The following discussion describes the process by which alternative plans were formulated, including the designation of subregional areas for system analysis, the determination of 1990 sewer service areas, the screening of potential alternative plans, the determination of the type and level of treatment required, and the consideration given to private sewage treatment facilities.

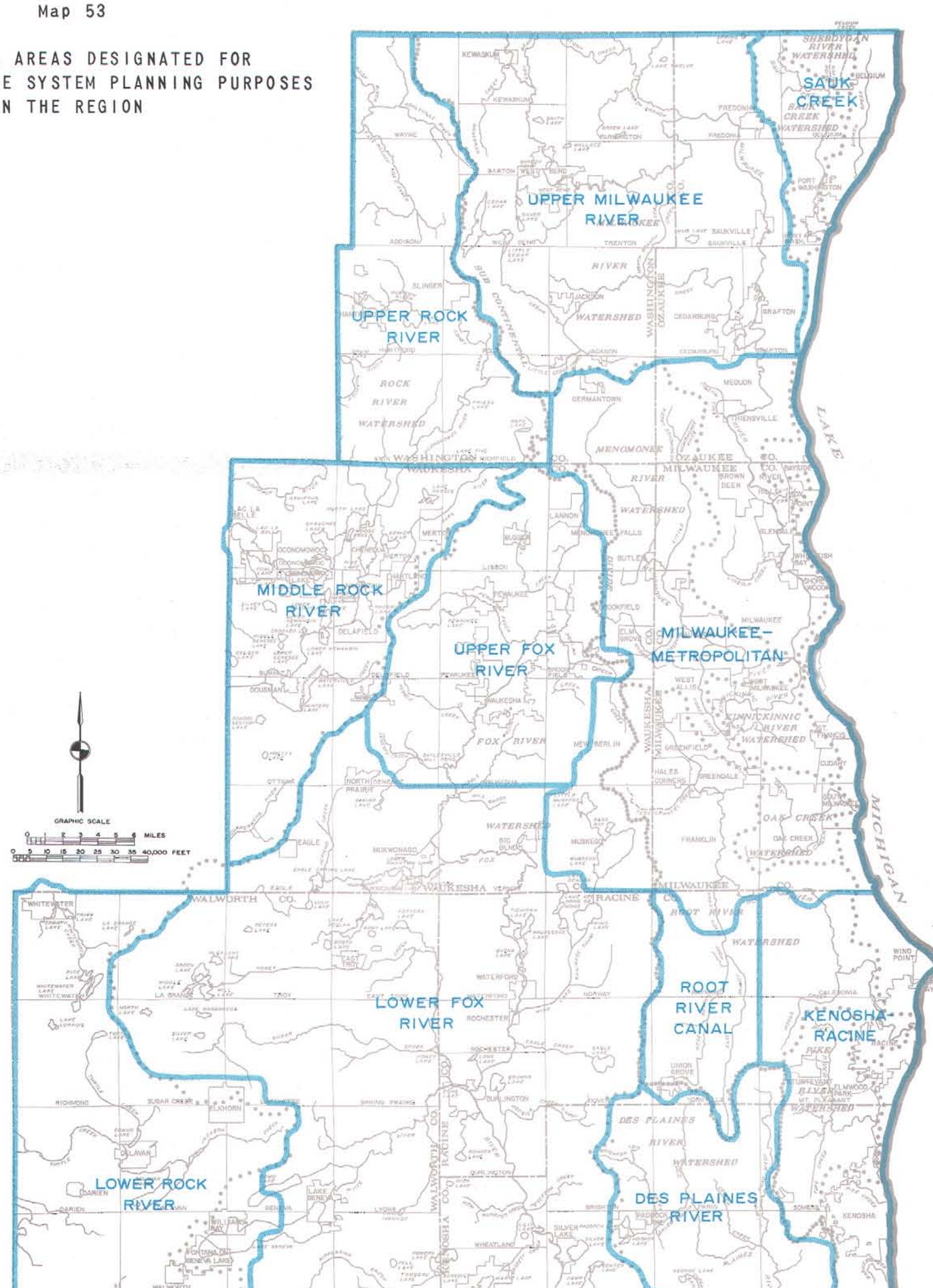
Designation of Subregional Areas

In order to provide a rational basis for the preparation, test, and evaluation of alternative plan elements, it was necessary to delineate geographic subareas of the Region for sewerage system planning purposes. This concept of geographic subareas, particularly with respect to natural watersheds, is discussed in Chapter II of this report. The boundaries of these 11 areas were based upon natural major watershed divides, the exterior boundaries of the Region, the existing and potential service areas of existing centralized sanitary sewerage systems, and existing and probable future areas of urban concentration. Eleven such areas were designated (see Map 53).

1. The Milwaukee-metropolitan subregional area, including all of Milwaukee County and those portions of Ozaukee, Racine, Waukesha, and Washington Counties which either presently contract, or are proposed to contract, with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment services.

Map 53

SUBREGIONAL AREAS DESIGNATED FOR SANITARY SEWERAGE SYSTEM PLANNING PURPOSES IN THE REGION



Eleven distinct subregional areas were identified for sanitary sewerage system planning purposes within the Region. The boundaries of these 11 areas were delineated on the basis of natural major watershed divides, existing and potential service areas of existing centralized sanitary sewerage systems, and existing and probable future areas of urban concentration as recommended in the adopted regional land use plan. In determining the boundaries of the subregional areas, natural watershed divides were crossed only where necessary to recognize the effects of potential urban development and attendant sewerage facilities which crossed such divides.

Source: SEWRPC.

2. The Upper Milwaukee River subregional area, including all of the Milwaukee River watershed within the Region north of the northern limits of the City of Mequon.[2]

3. The Sauk Creek subregional area, including all of the Sauk Creek watershed, that portion of the Sheboygan River watershed lying within the Region, and minor tributary areas which drain directly to Lake Michigan lying generally north of the City of Port Washington.

4. The Racine-Kenosha subregional area, including all that area of Racine and Kenosha Counties lying east of IH 94 except that portion within the Des Plaines River watershed lying west of the subcontinental divide.

5. The Root River Canal subregional area, including all that part of the Root River watershed in Racine County west of IH 94 which generally drains northerly toward Milwaukee County and the main stem of the Root River at the Milwaukee-Racine County line.

6. The Des Plaines River subregional area, including all of the Des Plaines River watershed within the Region.

7. The Upper Fox River subregional area, including nearly all of the Fox River watershed north of the Vernon Marsh in Waukesha County.

8. The Lower Fox River subregional area, including all of the Fox River watershed within the Region south of the Vernon Marsh, except the urban concentrations at the west end of Geneva Lake in Walworth County.

9. The Upper Rock River subregional area, including all that area of the Rock River watershed within the Region lying within Walworth County.

10. The Middle Rock River subregional area, including all that area of the Rock River watershed within the Region lying within Waukesha County.

11. The Lower Rock River subregional area, including all that area of the Rock River watershed within the Region lying within Walworth County and the urban concentrations in the Fox River watershed at the western end of Geneva Lake.

The boundaries of these 11 subregional areas generally follow natural major watershed divides. Such natural watershed divides were crossed only where necessary to provide a more rational planning area or a more convenient method of presenting the alternative plans considered. In general, it was possible to consider all of the alternative plans within each subregional area, although in a few instances it became necessary to consider, at least in the preliminary analysis stage, alternative plans which transcended subregional area boundaries.

Determination of 1990 Sewer Service Areas

The adopted regional land use plan provided the basis for the delineation of land areas to which sewer service should be extended by the plan design year of 1990. In addition, an analysis was undertaken to identify those areas committed to urban development since preparation of the regional land use plan which lay beyond the urban area limits as recommended on the regional land use plan map. Any areas so identified, when contiguous or in close proximity to areas recommended for development in the regional land use plan, were added to the proposed 1990 sewer service areas.

Several distinct 1990 sewer service areas were thus identified within each subregional sewerage system planning area. The number of areas so identified was based upon several factors, including existing minor civil division boundaries and known communities of interest, particularly with respect to urban development along lakeshores. Once the 1990 sewer service areas within each subregional area were identified, the process of formulating alternative plans could begin. It is

[2] *The Commission has completed and adopted a comprehensive plan for the entire Milwaukee River watershed, including the headwater areas of the watershed in Fond du Lac and Sheboygan Counties outside the Region. This plan includes a series of recommendations relating to sewerage facility development to serve urban areas in this portion of the watershed. These recommendations are set forth in SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume 2, Alternative Plans and Recommended Plan, and have been reiterated and updated as necessary in Appendix D of this report.*

important to note that under any of the alternative plans considered for a given subregional area, the total area proposed to be served remained the same.

The recommended sewer service standards set forth in Chapter VIII of this report were utilized in the delineation of areas recommended to be served with centralized sanitary sewer service by 1990. Therefore, the recommended sewer service areas include most of the urban concentrations—high, medium, and low density—as recommended in the adopted regional land use plan. There exist throughout the Region, however, additional urban areas identified in the plan which were not included within the recommended 1990 sewer service areas. In most cases, these areas are very small and consist of clusters of residential and commercial land uses located either along the shorelines of small lakes or at rural highway intersections. In some cases, however, these areas lie within incorporated municipalities. Taken together, these areas were not recommended for sewer service by 1990 because they are very small and isolated from other urban development; consist in part of seasonal homes; are located in or adjacent to the Kettle Moraine State Forest where additional urban development should not be encouraged; or are located on soils generally well suited for the use of onsite soil absorption sewage disposal systems. Such areas were included in the proposed service area, however, if there was substantial evidence of widespread septic tank system failure, if the Wisconsin Department of Natural Resources had ordered the installation of sanitary sewers, or if there existed local proposals for the installation of such sewers. With respect to those urban areas not included within the recommended 1990 sewer service area, it is recommended that, should public health authorities, after careful investigation, advise at some future date that centralized sewer service is needed, analyses then be made of the alternatives that are available for the provision of such service. Because of remoteness, it is anticipated that in most cases such service could only be economically provided through construction of a new sewage treatment facility.

Formulation of Subregional Alternatives

Many potential alternative interconnections between municipal sewerage systems are possible within each subregional sanitary sewerage system planning area. Most of these potential interconnections, however, are clearly impractical in terms of the costs and benefits involved. For this reason, it was necessary to establish a systematic procedure for eliminating from consideration those alternatives that are clearly impractical. A two-step screening procedure was utilized to reduce the number of alternatives to be studied in greater detail. The two steps consisted of an initial screening using guidelines established by the Wisconsin Department of Natural Resources, and the conduct of preliminary economic analyses. All alternatives remaining in consideration after these two steps were included in the more detailed engineering investigations presented in this chapter.

Initial Screening: As discussed in Chapter VII of this report, the Wisconsin Department of Natural Resources has prepared guidelines for evaluating the potential economic feasibility of interconnecting municipal sewerage systems. These guidelines relate the sewer lengths required for interconnection to the populations of the "sending" and "receiving" communities (see Table 74). These guidelines are not intended as a substitute for economic analysis, but rather are designed to identify situations where the possibility of interconnection should be investigated. As such, the guidelines deliberately tend to favor interconnection, and it may be expected that, in many cases, more detailed subsequent investigation will reveal that interconnection is uneconomical. The following assumptions were used by the Wisconsin Department of Natural Resources in developing the guidelines:

1. The connecting sewer would flow by gravity along a direct line between the communities, or sewer service areas, proposed to be interconnected.

2. There are no existing sewage treatment plants at either community.

3. The per capita design flow would equal 100 gallons per day.

4. Conventional activated sludge secondary treatment would be provided at each site or at the combined site.

5. The interest rate would be 6 percent.

The first three assumptions all bias the guidelines toward favoring interconnection, since the need for pumping stations, larger per capita flows, and the need to abandon existing sewage treatment plants would all tend to increase the cost of interconnection. In addition, measuring the distance between communities as a straight line rather than along potential sewer routes further increases the bias toward interconnection.

In formulating alternative sanitary sewerage system plans for each subregional area, the Wisconsin Department of Natural Resources guidelines were applied to make an initial determination of those potential interconnections of systems that merited more detailed engineering investigations. Straight line distances were measured between the centers of the communities involved and community populations were derived from Commission 1990 population forecasts. Thus, whenever the measured distance between two urban communities fell within the guidelines set forth in Table 74 of this report, the potential interconnection was considered to be an alternative meriting further study.

Preliminary Economic Analysis: The second trip in the screening process consisted of the preliminary sizing of connecting conveyance and sewage treatment facilities for those interconnections which passed the initial screening. The sewerage facility design criteria presented in Chapter IX of this report were utilized in this preliminary analysis. This preliminary economic analysis was also deliberately biased in favor of interconnection, being based upon the following assumptions:

1. The connecting sewer would flow by gravity along a direct line between the communities, or sewer service areas, proposed to be interconnected.

2. The sewers would be sized to accommodate the design flow derived from application of the engineering criteria developed under the study at the minimum slope required to achieve a velocity of two feet per second, flowing full.

3. Conventional activated sludge secondary treatment would be provided at each site, or at the combined site.

4. Sewer construction would occur in favorable soils, with no dewatering of trenches during construction necessary.

5. The equivalent annual cost of construction, operation, and maintenance for the treatment plant or plants would be 10 percent of the capital cost of construction, based upon a capital recovery factor of 0.7823, the factor for amortization over a 25-year period at a 6 percent rate of interest with an additional allowance to account for operation and maintenance costs.

6. The equivalent annual cost of sewers would include construction, operation, and maintenance costs and contingencies for construction in less favorable soils. This cost was estimated at 6.5 percent of the capital cost of construction, based upon a capital recovery factor of 0.06444 over a 50-year period at a 6 percent interest rate, with an additional allowance to account for operation and maintenance.

More detailed economic analyses were considered to be merited only for those alternatives for which the preliminary economic analyses indicated a cost for the interconnected system of no more than 20 percent above the total cost of two or more independent systems. Interconnection was rejected as a feasible alternative, and more detailed economic evaluations were not made, when the cost increment for interconnection was greater than 20 percent.

Detailed Analysis. Each of the alternatives which passed the initial screening and the preliminary economic analysis steps was subject to more detailed engineering and economic analyses. Documentation of all such analyses is presented in this chapter. The detailed analyses consisted of a detailed sizing and costing of all sewerage facility components needed to carry out the alternatives, utilizing the design criteria, costs, and economic analysis criteria presented in Chapter IX of this report. In this detailed evaluation, sewer alignments were located on standard 7.5 minute U. S. Geological Survey quadrangle maps (scale: 1" = 2000', contour interval: 10 feet); pumping and lift stations and force mains were included as required; and credit was given to existing treatment plant capacities available at "receiving" communities in determining additional treatment plant capacity requirements.

Determination of Type and Level of Treatment
The specific criteria established for determining the type and level of treatment recommended to be

provided at sewage treatment facilities included within each alternative plan were described in detail in Chapter IX of this report. Briefly, the particular level of treatment recommended for each sewage treatment facility relates to the established water use objectives and supporting water quality standards for the particular stream. Water quality simulation models developed in the Commission watershed studies for the Fox and Milwaukee River watersheds and under the regional sanitary sewerage system planning program were utilized to determine the particular level of treatment. With respect to Lake Michigan, the recommended level of treatment consisted uniformly of primary treatment, secondary treatment, advanced treatment in terms of phosphorus removal, and auxiliary treatment in terms of effluent disinfection.

It is important to note that the water quality simulation models developed in the Commission watershed studies and in the regional sanitary sewerage system planning program are based upon the same theoretical concepts and related mathematical equations. The amount of actual stream water quality data available, however, for use in application of the models was significantly different. Because the watershed studies include special stream water quality sampling surveys, a richer data base is available for the model application and thus permits the model to more precisely represent the actual stream water quality conditions within the watershed. These data include reaeration and deoxygenation rate constants and such indicators of background water quality conditions as $CBOD_5$ and $NBOD_5$. In the sewerage study it was necessary to make generalized assumptions concerning these same data with respect to all streams lying outside of the Fox, Milwaukee, and Root River watersheds. For this reason, it should be recognized that, as plan implementation proceeds, refinements in the specific treatment level recommendations for a given sewage treatment plant location may be possible and should be investigated by the design engineer.[3]

[3] *For a more detailed discussion of the differences between the application of the water quality simulation model in the Commission watershed studies and in the Commission sewerage system study, see Chapter IX of this report. For a more detailed discussion of the conceptual differences between the Commission watershed planning programs and the Commission regional sanitary sewerage system planning program, see Chapter II of this report.*

While in most cases the conventional activated sludge sewage treatment facility was selected for use in the analysis, in a few instances aerated waste stabilization lagoon treatment facilities were evaluated. These few instances occurred where no existing sewage treatment facility was in operation, where the average daily design flow was less than 0.5 mgd and where large fluctuations in the design flow exist due to seasonal sewage flows from industries or intensive use recreational facilities, where phosphorus removal is not required, and where relatively large amounts of land were readily available for use as lagoon sites. It should be noted that while such aerated waste stabilization lagoons were utilized in costing out the alternative plans, local decisions to implement the plan through an alternate waste treatment design, such as activated sludge or physical-chemical treatment, would be fully compatible with the plan recommendations.

In constructing the alternative plan elements, decisions had to be made for economic analysis purposes concerning the abandonment of existing sewage treatment facilities approaching the end of their economic lives. For analysis purposes, existing sewage treatment facilities were assumed to be abandoned and completely replaced if one or more of the following factors was found to exist:

1. The existing sewage treatment facility was more than 10 years old in 1970, and thus would be more than 15 years old by 1975, the earliest year in which plan implementation involving major facility improvement could be expected to take place;

2. The capacity of the existing sewage treatment facility was less than one-third that needed to accommodate 1990 demand; and

3. The existing facility was of a trickling filter design, a design which cannot be readily adapted to phosphorus removal.

The foregoing assumptions concerning the abandonment of existing sewage treatment plants, although considered realistic, were made in order to facilitate consistent economic analyses for system planning purposes. In practice, the decision to abandon or reconstruct all or parts of an existing sewage treatment plant will have to be determined on the basis of detailed engineering investigations during plan implementation.

It should be noted that the recommended sewage treatment plant performance standards set forth in this chapter and in Chapter XII were the result of not only the technical analyses conducted under the study, but also of very lengthy and careful deliberation by the Technical Coordinating and Advisory Committee. In its review of the performance standards as derived from the technical analyses, which analyses are discussed in Chapter IX, the Committee addressed itself particularly to two interrelated issues: 1) the time frame to which the standards should be referred; and 2) the expression of the standards in terms of effluent, as opposed to removal, efficiencies. The Committee, after careful consideration of the possible use of maximum, average monthly, and average annual effluent quality standards to specify performance, as well as the use of removal efficiency standards, concluded that for long-range system planning purposes the performance standards could best be expressed in terms of annual average sewage treatment plant effluent quality.

The specific performance standards, per se, were also the subject of very lengthy and careful deliberation by the Committee, which in its deliberations sought to strike a balance between the practical problems involved in treatment plant design, operation, and maintenance and the attainment of the performance standards required as indicated by the planning analyses. The Committee concluded that an ordinary secondary activated sludge sewage treatment plant incorporating the recirculation of sludge digestion tank supernatant should not be expected, even under the best management, to consistently produce an effluent with less than 15 mg/l $CBOD_5$ and, therefore, it was unreasonable to specify this level of effluent quality as a "maximum" or even "average monthly" goal. Consequently, this level of effluent quality on an "annual average" basis was selected as the performance standard for all ordinary secondary activated sludge sewage treatment plants discharging effluent to Lake Michigan. This standard represents, in the considered opinion of the Committee, the application of best practical available technology. In this respect it should be realized that the effect on water quality objectives and supporting standards could not be analyzed under the study for Lake Michigan as it could for the streams and watercourses of the Region; and, therefore, recourse to the letter and spirit of the recommendations of the past Lake Michigan Enforcement Conference was necessary. In addition, the Committee believed that all secondary sewage treatment plants discharging wastes to Lake Michigan should, in the interests of consistency and fairness, be required to produce the best quality of effluent practical with that type of treatment.

It was, moreover, the opinion of the Technical Advisory Committee that only marginal improvements in the efficiency of secondary treatment plants could be achieved in the near future through the use of such devices as flow equalization tanks and chemical additives. The effect of such marginal improvements on plant efficiencies could well be offset by the increasing strength of the influent sewage which may occur as industrial waste loadings on the public system are reduced and clear water inflows are abated. Consequently, where the analyses conducted under the study indicated that the stream water use objectives required the provision of a higher performance standard with respect to the removal of oxygen demanding organic matter, tertiary or advanced treatment is specified.

It is important to note that the recommended performance standards are consistent with the assumptions made in the stream water quality simulation efforts conducted by the Commission under the comprehensive watershed planning programs and with the other stream water quality analyses conducted by the Commission under the sewerage study, which modeling and analyses efforts, as reported in Chapter IX of this report, assumed that secondary sewage treatment plants would be capable of producing an effluent with a maximum $CBOD_5$ content of 15 mg/l. The ability of ordinary secondary activated sludge sewage treatment plants to produce an effluent of this quality is affected by a number of very complex interrelated factors, including the strength of the influent sewage, air and sewage temperatures, sunlight, and even by the effects of the changing seasons on the biological organisms involved. It was the Committee's conclusion that the specification of this particular performance standard in terms of an annual average is actually more conservative than the specification of such a performance standard on the basis of a 30-day average. This is true because, in order to achieve the annual average, a sewage treatment plant would have to be operated at a very high level of efficiency during the summer months when activated sludge plants exhibit their best performance—a time when the critical low flows and low dissolved oxygen contents occur in the receiving streams and watercourses.

In the interest of consistency, the performance standards set forth in this chapter and in Chapter XII were all expressed in terms of annual average effluent quality goals. Depending upon the character of the influent sewage and other factors which can only be properly considered during preliminary engineering, these goals can be achieved by $CBOD_5$ removal efficiencies of 90 to 95 percent and total phosphorus removal efficiencies of 85 to 95 percent.

Consideration of Private Sewage Treatment Plants

The inventory of known existing point sources of water pollution in the Region conducted as part of the regional sanitary sewerage system planning program revealed the existence of 217 known point sources of wastewater other than municipal sewage treatment plants (see Chapter V). Fifty-nine of these known point sources of wastewater were categorized as private sewage treatment plants. In general, major industrial or commercial chemical or biological treatment facilities which discharge treated effluent directly or indirectly via storm sewer systems to surface water were considered to be private sewage treatment plants. In addition, major waste sources providing treatment of wastewater followed by effluent disposal in seepage lagoons or spray irrigation facilities were also classified as private sewage treatment plants. Excluded from this classification were certain highly specialized industrial waste treatment facilities which provided minor levels of treatment, such as sedimentation for grit removal and skimming or flotation for oil and grease removal, and which discharged an effluent which was essentially clear water and, as such, should not, unlike the effluent from other types of industrial waste "pretreatment" facilities, be discharged to a sanitary sewerage system. Also not included were septic tanks followed by conventional soil absorption seepage fields, or clear cooling water discharges having no pretreatment.

In the preparation of the alternative plans, existing private sewage treatment facilities were recommended to be abandoned if the land uses they serve lie within the proposed 1990 sewer service area and if the facility was not of a type especially designed to treat unusual industrial wastes. Conversely, if the facility is a special-purpose facility accommodating unusual industrial wastes, it was recommended to be retained. Those facilities serving isolated land uses beyond the 1990 recommended sewer service area were recommended to be retained provided that satisfactory operation is achieved and continued. Since those private sewage treatment facilities recommended to be retained in the plan generally are unique in terms of the type of wastes to be treated, recommendations concerning the type and level of treatment to be provided must be formulated on a case-by-case basis during plan implementation.

MILWAUKEE-METROPOLITAN SUBREGIONAL AREA

The Milwaukee-metropolitan subregional area consists of all of Milwaukee County and those portions of Ozaukee, Racine, Washington, and Waukesha Counties which contract, or are proposed to contract, with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment services. The Milwaukee-metropolitan subregional area is comprised of all or portions of several major watersheds, including all of the Menomonee, Kinnickinnic, and Oak Creek watersheds; major portions of the Milwaukee and Root River watersheds; a minor portion of the Fox River watershed in the Muskego Lakes area; and minor areas which drain directly to Lake Michigan. The area contains by far the largest single concentration of urban development within the Southeastern Wisconsin Region and, indeed, comprises the urban-industrial heart of the Region.

As noted in Chapter V of this report, centralized sanitary sewer service in the Milwaukee-metropolitan subregional area was provided by 10 systems in 1970: the large Milwaukee-metropolitan sewerage system and smaller systems operated within the Cities of Franklin, Oak Creek, and South Milwaukee in Milwaukee County; the Cities of Muskego and New Berlin and the Village of Menomonee Falls in Waukesha County; the Village of Germantown in Washington County; the Village of Thiensville in Ozaukee County; and the Caddy Vista Sanitary District in the Town of Caledonia, Racine County. All but the South Milwaukee system are considered locally to be temporary, with ultimate connection to the Milwaukee-metropolitan sewerage system. Together these 10 systems served a total area of about 207 square miles and an estimated population of about 1,096,300 persons. Specific population, service area, and related characteristics of the 10 systems are presented in Chapter V of this report.

In 1970 there were nearly 65,000 persons living within the Milwaukee—metropolitan subregional area not served by centralized sanitary sewers. This development was concentrated within the Milwaukee-Metropolitan Sewerage District primarily within the Cities of Franklin, Greenfield, and Oak Creek and within the existing and proposed contract service areas in the Cities of Brookfield, Mequon, Muskego, and New Berlin and the Villages of Menomonee Falls and Germantown.

Sewer Service Analysis Areas

The boundaries of the Milwaukee-metropolitan subregional area reflect not only the existing, large centralized sanitary sewer system operated by the Milwaukee-Metropolitan Sewerage Commissions but also the committed future sewer service area designated by the Commissions in their long-range planning efforts. Commission watershed studies for the Root and Milwaukee River watersheds have resulted in several small additional areas proposed for eventual sewer service by the joint Commissions. This total area may be divided into 13 sewer service analysis areas (see Table 98). These 13 sewer service analysis areas are also shown on Map 54 and may be described as follows:

1. Area A—This area consists of the entire Milwaukee-Metropolitan Sewerage District and includes all that area of Milwaukee County except the City of South Milwaukee, which has not elected to become part of the District. In 1970, sewer service was provided in this area to about 174 square miles having a total resident population slightly in excess of one million persons. By 1990 the total area anticipated to be served approximates 234 square miles with a projected population of about 1.4 million persons. This subarea is referenced as the "Milwaukee-Metropolitan" sewer service area in the ensuing discussion.

2. Area B—This area consists of the City of South Milwaukee. In 1970, sewer service was provided in this area to nearly five square miles having a total resident population of about 23,000 persons. The entire area may be considered served by centralized sanitary sewer service. By 1990 the area is anticipated to contain a population of about 27,000 persons. This subarea is referenced as the "South Milwaukee" sewer service area in the ensuing discussion.

3. Area C—This area consists of that portion of the City of Mequon recommended for sewer service by 1990. In 1970, sewer service was provided in this area to nearly nine square miles having a total resident population of about 6,600 persons. By 1990 the total area anticipated to be served approximates 25 square miles with a forecast population of about 49,000 persons. This subarea is referenced as the "Mequon" sewer service area in the ensuing discussion.

4. Area D—This area consists of the Village of Thiensville. The adopted Milwaukee River watershed plan recommended that this area be connected to the Milwaukee-metropolitan sewerage system with concomitant abandonment of the existing Thiensville sewage treatment facility. In 1970, sewer service was provided in this area to nearly one square mile having a total resident population of about 3,600 persons. The entire area may be considered to be served by centralized sanitary sewer service. By 1990 the total population anticipated to be served is about 4,100 persons. This subarea is referenced as the "Thiensville" sewer service area in the ensuing discussion.

5. Area E—This area consists of that portion of the Village of Germantown recommended for sewer service by 1990. In 1970, sewer service was provided in this area to nearly 0.6 square mile, having a total resident population of about 2,400 persons. By 1990 the total area anticipated to be served approximates 7 square miles with a projected population of about 26,700 persons. This subarea is referenced as the "Germantown" sewer service area in the ensuing discussion.

6. Area F—This area generally consists of that portion of the Village of Menomonee Falls lying east of the subcontinental divide. In 1970, sewer service was provided in this area to nearly four square miles, having a total resident population of about 17,400 persons. By 1990 the total area anticipated to be served approximates 19 square miles with a projected population of about 72,000 persons. This subarea is referenced as the "Menomonee

Table 98

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE MILWAUKEE-METROPOLITAN SUBREGIONAL AREA: 1970 AND 1990

Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Milwaukee-Metropolitan Sewerage District	174.32	1,011,400	178.8	19,600	234.48	1,414,000	263.44
B	South Milwaukee	4.68	23,300	3.8	--	4.80	27,500	6.00
C	Mequon	8.88[2]	6,600	0.9	3,700	25.06[2]	49,100	9.77
D	Thiensville	0.99	3,600	0.7	--	1.03	4,100	0.82
E	Germantown	0.56	2,400	0.4	1,600	7.45[3]	26,700	5.50
F	Menomonee Falls	3.77	17,400	2.4	11,700	19.37	72,400	13.88
G	Butler	0.78	2,100	0.4	--	0.78	3,100	0.61
H	Brookfield	3.70	8,500	1.5	7,500	11.79	21,200	3.92
I	Elm Grove	3.25	6,600	0.9	--	3.25	7,900	1.17
J	New Berlin	4.59	8,700	1.7	14,900	21.48	63,200	13.41
K	Muskego	1.80	4,500	0.4	5,100	12.09	31,600	5.69
L	Raymond	--	--	--	800	5.20	8,200	1.72
M	Caddy Vista	0.18	1,200	0.1	--	0.45	1,900	0.23
Total		207.50	1,096,300	192.0	64,900	347.23	1,730,900	236.16

[1]*See Map 54.*
[2]*Includes 0.09 square mile in the Village of Bayside, Ozaukee County.*
[3]*Includes 0.02 square mile in the City of Milwaukee, Washington County.*
Source: SEWRPC.

Falls" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Butler. In 1970, sewer service was provided to the entire village, having a total area of about 0.8 square mile and a total resident population of about 2,100 persons. By 1990 the population served is anticipated to reach 3,100 persons. This subarea is referenced as the "Butler" sewer service area in the ensuing discussion.

8. Area H—This area consists of all of the City of Brookfield lying east of the subcontinental divide except for certain areas already served by the City of Brookfield through the Fox River watershed sanitary sewerage system, generally located west of the subcontinental divide. In 1970, sewer service was provided in this area to about four square miles, having a total resident population of about 8,500 persons. By 1990 the total area anticipated to be served approximates nearly 12 square miles, with a total projected population of about 21,000 persons. This subarea is referenced as the "Brookfield" sewer service area in the ensuing discussion.

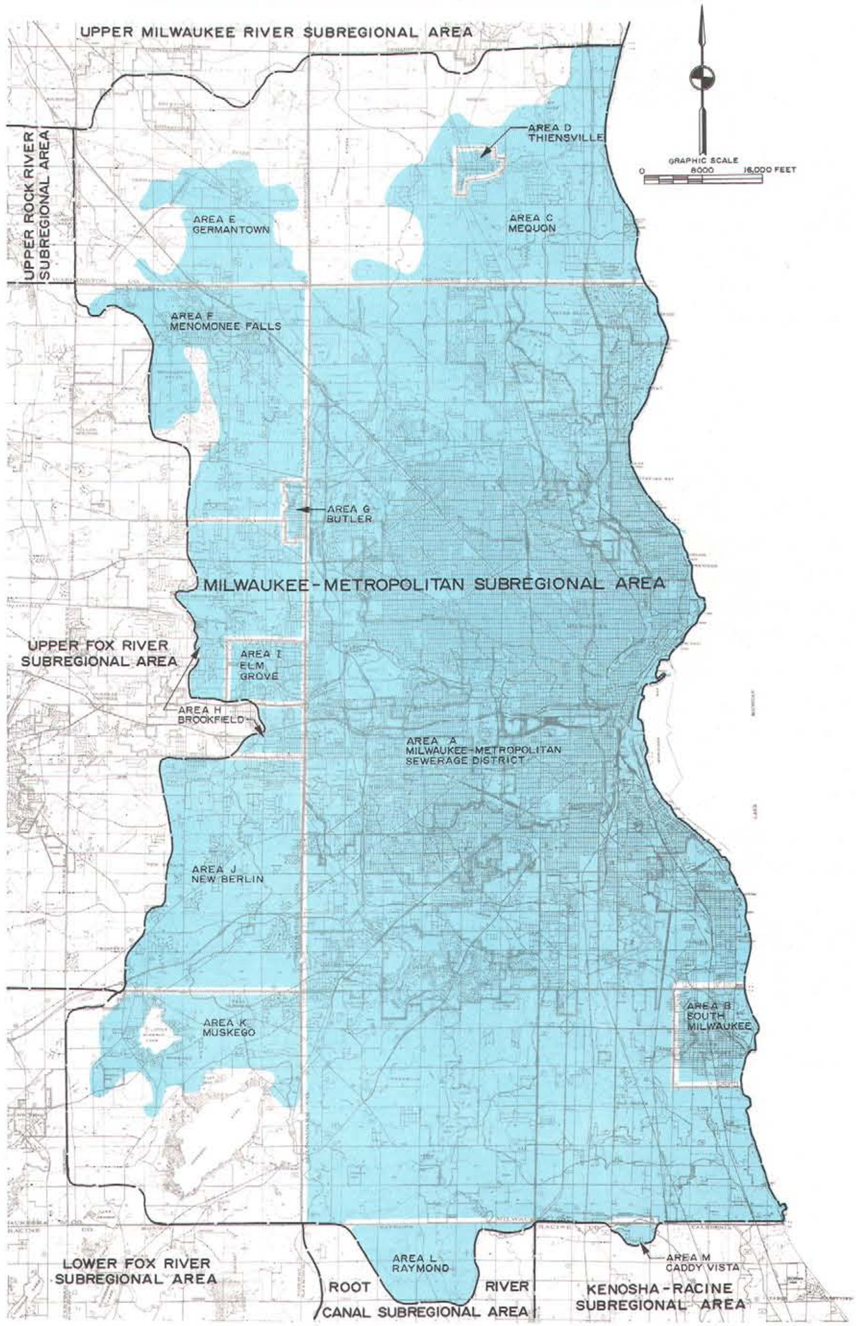
9. Area I—This area consists of the Village of Elm Grove. In 1970, sewer service was provided to the entire village with a total sewer service area of about three square miles and a total served resident population of about 6,600 persons. By 1990 the total population projected to be served is about 7,900 persons. This subarea is referenced as the "Elm Grove" sewer service area in the ensuing discussion.

10. Area J—This area consists of all of the City of New Berlin lying east of the subcontinental divide. In 1970, sewer service was provided in this area to nearly five square miles, having a total resident population of about 8,700 persons. By 1990 the total area anticipated to be served approximates 21 square miles with a projected population of about 63,000 persons. This subarea is referenced as the "New Berlin" sewer service area in the ensuing discussion.

11. Area K—This area consists of all of that portion of the City of Muskego recommended for sewer service by 1990. In 1970, sewer service was provided in this area to nearly two square miles with a total resident population of about 4,500 persons. By 1990 the total area anticipated to be served approximates 12 square miles with a projected population of nearly 32,000 persons. This subarea is refer-

Map 54

SEWER SERVICE ANALYSIS AREAS
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA



For analysis purposes, the Milwaukee-Metropolitan Subregional Area was divided into 13 sewer service analysis areas. Two of the 13 analysis areas are located in Milwaukee County, one consisting of the entire Milwaukee-Metropolitan Sewerage District and the other consisting of the City of South Milwaukee. The remaining 11 areas consist of existing or proposed contract sewer service areas in Ozaukee, Washington, Waukesha, and Racine Counties. The Milwaukee-Metropolitan subregional area contains by far the largest single concentration of urban development within the Region. This subregional area is comprised of all or portions of several major watersheds, including all of the Menomonee, Kinnickinnic, and Oak Creek watersheds; major portions of the Milwaukee and Root River watersheds; a minor portion of the Fox River watershed in the Muskego Lakes area; and minor areas which drain directly to Lake Michigan.

Source: SEWRPC.

enced as the "Muskego" sewer service area in the ensuing discussion.

12. Area L—This area consists of a portion of the Town of Raymond recommended in the regional land use and Root River watershed plans for urban development by 1990. No sewer service was provided in this area in 1970. By 1990 the total area anticipated to be served is approximately 5 square miles with a projected total population of about 8,000 persons. This subarea is referenced as the "Raymond" sewer service area in the ensuing discussion.

13. Area M—This area consists of the Caddy Vista Sanitary District in the Town of Caledonia, which is recommended in the adopted Root River watershed plan to be connected to the Milwaukee-metropolitan sewerage system, with concomitant abandonment of the existing Caddy Vista sewage treatment facility. In 1970, sewer service was provided in this area to about 0.2 square mile with a total resident population served of about 1,200 persons. By 1990 it is anticipated that the total population served in this area will approximate 1,900 persons. This subarea is referenced as the "Caddy Vista" sewer service area in the ensuing discussion.

Formulation of Alternatives

The Milwaukee-Metropolitan Sewerage Commissions and the local communities within the Milwaukee-Metropolitan Sewerage District, as well as the existing and proposed contract areas, have over the years conducted many long-range sewerage planning and engineering studies. The sewerage facilities recommended as a result of these studies were considered committed for the purposes of the regional sanitary sewerage system planning program. The typical procedure of formulating alternative plans developed in the study for use in the remainder of the Region is not, therefore, applicable to the Milwaukee-metropolitan subregional area. With but one exception, all of the communities located within the Milwaukee-metropolitan subregional area have agreed to the construction of essentially a single centralized sanitary sewerage system served by two major treatment facilities—the Jones Island and South Shore plants operated by the Milwaukee-Metropolitan Sewerage Commissions—with ultimate abandonment of all remaining public and private sewage treatment facilities that currently serve urban development in the subregional area. The single exception involves the City of South Milwaukee, which has historically declined to join the Milwaukee-Metropolitan Sewerage District. Since the City of South Milwaukee and the Milwaukee-Metropolitan Sewerage Commissions operate sewage treatment facilities on an almost side-by-side basis along the Lake Michigan shoreline, it was determined to evaluate an alternative plan that would involve the ultimate connection of the City of South Milwaukee to the Milwaukee-metropolitan sewerage system and abandonment of the South Milwaukee treatment facility.

South Milwaukee Alternatives

The City of South Milwaukee lies along the Lake Michigan shoreline immediately north of the South Shore treatment facility placed into operation during 1968 by the Milwaukee-Metropolitan Sewerage Commissions. The existing (1970) average hydraulic design capacity of the City of South Milwaukee sewage treatment facility is 3.0 mgd. In 1971, the city began construction of additions to the treatment facility designed to provide secondary and, in accordance with the Lake Michigan Enforcement Conference recommendations, advanced levels of treatment for an average hydraulic design capacity of 6.0 mgd. In effect, then, a decision has been made by the City of South Milwaukee, and has been reinforced by approval of the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency, to continue to operate the South Milwaukee sewage treatment facility at least through 1990, the design year of the regional sanitary sewerage system plan. Since an economic analysis was performed under the regional sanitary sewerage study concerning the alternative of abandonment of the South Milwaukee plant, however, it was deemed desirable to document for the historical record the results of that analysis.

The analysis concerning South Milwaukee basically centered on two alternatives. The first alternative would provide for the expansion of the South Milwaukee sewage treatment facility to a total average hydraulic design capacity of 6.0 mgd and the construction of an outfall sewer. This facility would provide primary treatment, secondary treatment, advanced waste treatment in terms of phosphorus removal, and the auxiliary treatment of effluent disinfection. As shown in

Table 99, the capital costs for this alternative were estimated at about $1.9 million, with an equivalent annual cost of about $330,000.

Under the second alternative, the South Milwaukee facility would be abandoned and the sewage conveyed to the South Shore sewage treatment facility through a pumping station and force main (see Map 55). An additional 6 mgd of primary, secondary, and advanced treatment capacity would be provided at the South Shore plant to accommodate the South Milwaukee wastes. The costs of carrying out this alternative are also presented in Table 99. The capital cost totals about $2.9 million, with an equivalent annual cost of about $309,000.

The cost data presented in Table 99 thus indicate that the most economical, long-term solution for treating the City of South Milwaukee sewage would be to convey the sewage to the South Shore plant operated by the joint Milwaukee-Metropolitan Sewerage Commissions. As noted above, since the City of South Milwaukee has proceeded to undertake the required expansion of the facility and has completed (July 1973) all but the installation of phosphorus removal facilities, it may be concluded that the retention of the South Milwaukee facility has become a committed decision and should be incorporated as such in the recommended plan for the Milwaukee-metropolitan subregional area.

Subregional Area Plan

As noted above, many decisions have been made pertaining to the future development of the Milwaukee-metropolitan sewerage system, including the adoption by the joint Commissions of a long-range sewerage facility development plan designed to provide for sewage conveyance and treatment for the entire sewerage district, as well as the existing and proposed contract service areas. This sewerage facility development plan, together with related development plans by the contract area communities, were taken as committed decisions in the preparation of the regional sanitary sewerage system plan. The following paragraphs describe the basic areawide components of these well-established long-range sewerage facility planning efforts.

Treatment Facilities: The Milwaukee-Metropolitan Sewerage Commissions have rapidly been moving toward the provision of the treatment facilities necessary to serve the entire Milwaukee-metropolitan subregional area, excepting only the City of South Milwaukee. Major renovations have been made in the recent past at the Jones Island sewage treatment facility, and for purposes of the regional sanitary sewerage system plan, no expansion of that facility has been envisioned during the 20-year design period through 1990, although major improvements of a maintenance nature will probably be required. In addition,

Table 99

DETAILED COST ESTIMATES
SOUTH MILWAUKEE ALTERNATIVE PLANS
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA

South Milwaukee Alternative Plan	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Expand Existing Facility							
Treatment Facilities (6.0 MGD)[1]	$1,668,000	$1,862,000	$3,199,700	$5,061,700	$118,300	$203,000	$321,300
Outfall Sewer	270,000	198,600	--	198,600	12,600	--	12,600
Total	1,938,000	2,060,600	3,199,700	5,260,300	130,900	203,000	333,900
Connect to Milwaukee-Metropolitan Sewerage District							
Treatment Facilities (6.0 MGD)[2]	2,004,100	1,807,900	2,091,600[3]	3,899,500	114,700	132,700[3]	247,400
Trunk Sewer	920,000	788,100	184,400	972,500	50,000	11,700	61,700
Total	$2,924,100	$2,596,000	$2,276,000	$4,872,000	$164,700	$144,400	$309,100

[1]Assumes the addition of the following: 3.0 MGD of primary capacity; 6.0 MGD of secondary capacity; and facilities for phosphorus removal and effluent disinfection.

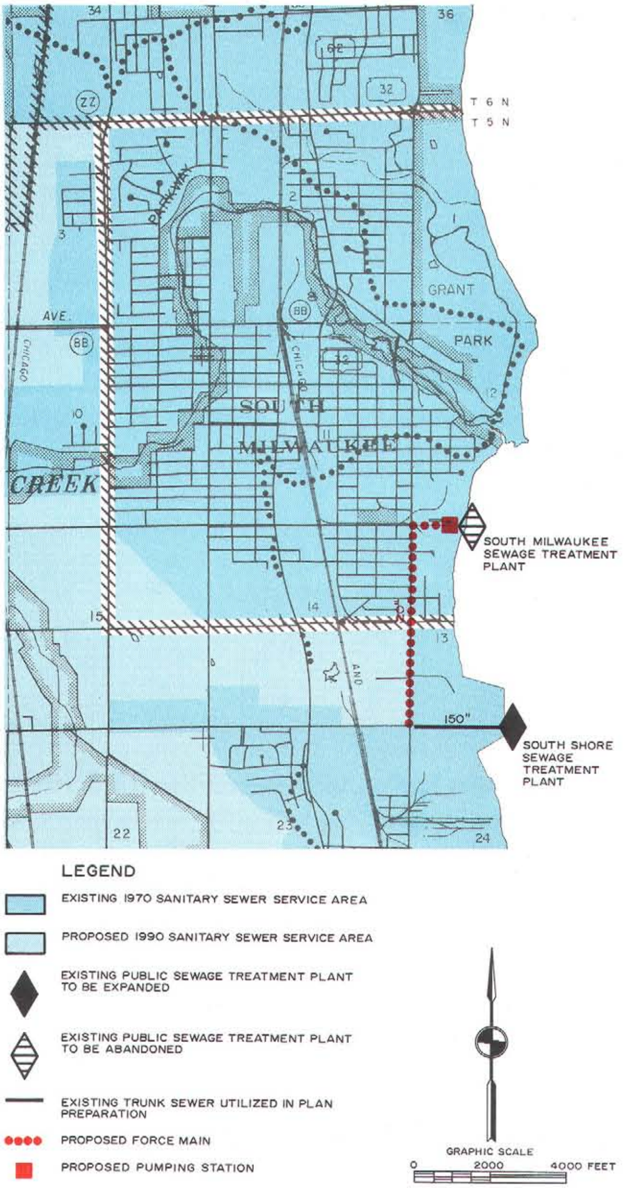
[2]Assumes the addition of the following to the South Shore sewage treatment plant: 6.0 MGD of primary capacity; 6.0 MGD of secondary capacity; and facilities for phosphorus removal and effluent disinfection.

[3]Operation and maintenance costs are based on the ratio of the South Milwaukee flow to the total flow at the South Shore plant.

Source: SEWRPC.

Map 55

SOUTH MILWAUKEE ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2--CONNECTION TO MILWAUKEE-METROPOLITAN SEWERAGE SYSTEM



An alternative method of providing treatment for sewage generated in the City of South Milwaukee would entail the abandonment of the existing South Milwaukee sewage treatment facility and connection of the tributary service area to the South Shore sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions and located about one mile south of the South Milwaukee plant on the Lake Michigan shoreline. Economic analyses performed under the regional sewerage systems study found that, on an equivalent annual cost basis, it would be more economical to abandon the South Milwaukee facility in the manner proposed on the above map than to expand and continue to operate the South Milwaukee facility and make necessary improvements to provide secondary and advanced waste treatment. During the course of conducting the study, however, the City of South Milwaukee did request and receive approval from the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency to increase the average hydraulic design capacity of the plant and to provide for secondary and advanced levels of waste treatment. Since these improvements have been made, it was concluded that retention of the South Milwaukee facility was and would remain a committed decision at least through the design year 1990.

Source: SEWRPC.

since the treated effluent from the Jones Island Sewage Treatment Plant is presently discharged to the Milwaukee Harbor, costs have been included in the plan for the construction of an outfall sewer to convey and discharge the treated effluent outside of the quiescent Harbor area. It should be noted that the economic analysis presented in Table 100 does assume replacement of the entire Jones Island facility in the year 2000, 10 years beyond the plan design year of 1990. Thus, the equivalent annual cost shown in Table 100 for the Jones Island facility includes a capital investment component. As discussed in Chapter V of this report, the South Shore treatment facility has an average hydraulic design capacity of 120 mgd and provided in 1970 only a primary level of treatment. The plan proposes, and construction is already underway on, the addition of secondary and advanced waste treatment facilities at the South Shore plant. The total capital cost of providing such additional treatment is estimated at nearly $27 million (see Table 100). The third public sewage treatment facility proposed to serve the Milwaukee-metropolitan subregional area is the recently expanded facility serving the City of South Milwaukee. Costs associated with the expansion of this facility are also included in Table 100.

In total, then, the plan provides for sewage treatment facilities in the Milwaukee-metropolitan subregional area with a combined average hydraulic design capacity of about 326 mgd. The three plants involved—Jones Island, South Shore, and South Milwaukee—would serve one large system in the case of the Jones Island and South Shore plants, and one small system in the case of the South Milwaukee plant. The total estimated capital cost for providing the necessary improvements to the treatment facilities is about $31.4 million. Recommended performance standards for the three treatment facilities are set forth in Table 101.

<u>Metropolitan District Trunk Sewers:</u> Proposed extensions to the existing trunk sewer system operated by the Milwaukee-Metropolitan Sewerage Commissions are shown on Map 56. Many of the extensions involve key sewers designed to provide sewer service to existing and proposed contract service areas. Several of the sewers will also provide relief to portions of the trunk sewer system now experiencing periods of overloading. The total cost of constructing the recommended metropolitan trunk sewer extensions is estimated

Table 100

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA

		Estimated Cost					
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
Plan Subelement	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plants							
Milwaukee-Metropolitan Sewerage Commissions—							
Jones Island Plant (200.0 MGD)	$ --	$ 8,689,600	$ 65,309,800	$ 73,999,400	$ 551,300	$4,143,500	$ 4,694,800
Outfall Sewer	2,632,500	1,929,300	--	1,929,300	122,400	--	122,400
Subtotal	2,632,500	10,618,900	65,309,800	75,928,700	673,700	4,143,500	4,817,200
Milwaukee-Metropolitan Sewerage Commissions—							
South Shore Plant (120.0 MGD)	26,865,000	25,805,500	40,057,500	65,863,000	1,637,200	2,541,400	4,178,600
Subtotal	26,865,000	25,805,500	40,057,500	65,863,000	1,637,200	2,541,400	4,178,600
South Milwaukee (6.0 MGD)	1,668,000	1,862,000	3,199,700	5,061,700	118,300	203,000	321,300
Outfall Sewer	270,000	198,600	--	198,600	12,600	--	12,600
Subtotal	1,938,000	2,060,600	3,199,700	5,260,300	130,900	203,000	333,900
Subtotal — Sewage Treatment Facilities	$ 31,435,500	$ 38,485,000	$108,567,000	$147,052,000	$2,441,800	$6,887,900	$ 9,329,700
Trunk Sewers							
Milwaukee-Metropolitan Sewerage District	$126,401,300	$ 93,172,300	$ 398,800	$ 93,571,100	$5,911,200	$ 25,300	$ 5,936,500
Caddy Vista	151,200	116,100	28,400	144,500	7,400	1,800	9,200
Muskego	1,466,000	1,075,000	11,000	1,086,000	68,200	700	68,900
New Berlin	749,700	550,100	7,900	558,000	34,900	500	35,400
Greenfield-New Berlin	507,200	372,000	6,300	378,300	23,600	400	24,000
Brookfield-Menomonee Falls	480,600	351,800	4,800	356,600	22,300	300	22,600
Menomonee Falls[1]	522,000	383,000	3,200	386,200	24,300	200	24,500
Germantown	1,067,900	941,700	878,000	1,819,700	59,800	55,700	115,500
Thiensville-Mequon	558,400	435,000	69,300	504,300	27,600	4,400	32,000
Subtotal — Trunk Sewers	$131,904,300	$ 97,397,000	$ 1,407,700	$ 98,804,700	$6,179,300	$ 89,300	$ 6,268,600
Total	$163,339,800	$135,882,000	$109,974,700	$245,856,700	$8,621,100	$6,977,200	$15,598,300

[1]*This trunk sewer has already been constructed (1973) but cannot be placed into service until completion of certain key metropolitan trunk sewer segments.*

Source: SEWRPC.

at about $126 million, representing an equivalent annual cost of nearly $6 million (see Table 100).[4]

The Milwaukee-metropolitan trunk sewer system is being designed in part to provide for selective routing of sewage flows to the two major treatment facilities. Map 57 shows those portions of the District and contract area directly tributary to the Jones Island treatment facility, those portions directly tributary to the South Shore treatment facility, and those portions which may be selectively routed to either facility as needs dictate.

[4] *Because all of the metropolitan trunk sewers are to be constructed in deep tunnels, the cost data presented in Chapter IX could not be used in this analysis. Rather, a cost estimate of $6 per inch diameter foot was obtained from the staff of the Milwaukee-Metropolitan Sewerage Commissions and applied to all the deep tunnel trunk sewers.*

Local Trunk Sewers: A number of major trunk sewers will be needed in the District and the existing and proposed contract sewer service areas to provide for abandonment of existing temporary sewage treatment facilities as well as the future extension of sewer service to areas not now served. A total of eight such major sewers are shown on Map 56 and have been specifically included in the recommended plan. These eight sewers may be described as follows:

1. A trunk sewer designed to permit abandonment of the existing sewage treatment facility serving the Caddy Vista Sanitary District. This abandonment, which was initially recommended in the adopted Root River watershed plan, is proposed to be accommodated through a local trunk sewer constructed by the City of Oak Creek with sufficient capacity to provide for Caddy Vista sewage conveyance. This particular method of connection to the Milwaukee-

Table 101

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Level(s)	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Milwaukee-Metropolitan Sewerage Commissions—Jones Island Plant (200.0 MGD)	Milwaukee-Metropolitan Sewerage District Mequon Thiensville Germantown Menomonee Falls Butler Brookfield Elm Grove New Berlin Muskego Raymond Caddy Vista	1,701,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Milwaukee-Metropolitan Sewerage Commissions—South Shore Plant (120.0 MGD)			Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
South Milwaukee (6.0 MGD)	South Milwaukee	27,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 54.*

Source: SEWRPC.

metropolitan system for the Caddy Vista Sanitary District differs slightly from that presented in the adopted Root River watershed plan, reflecting plan implementation decision-making since the Root River Plan was completed and adopted. This sewer would have an estimated capital cost of about $151,000, with an equivalent annual cost of about $9,200.

2. A trunk sewer designed to permit abandonment of two sewage treatment plants currently (1973) operated by the City of Muskego on a temporary basis. This major trunk sewer would extend from a proposed metropolitan trunk sewer at the Milwaukee-Waukesha County line about one-half mile south of W. Rawson Avenue extended. The estimated capital cost of constructing this sewer is about $1.5 million, with an equivalent annual cost of about $68,900.

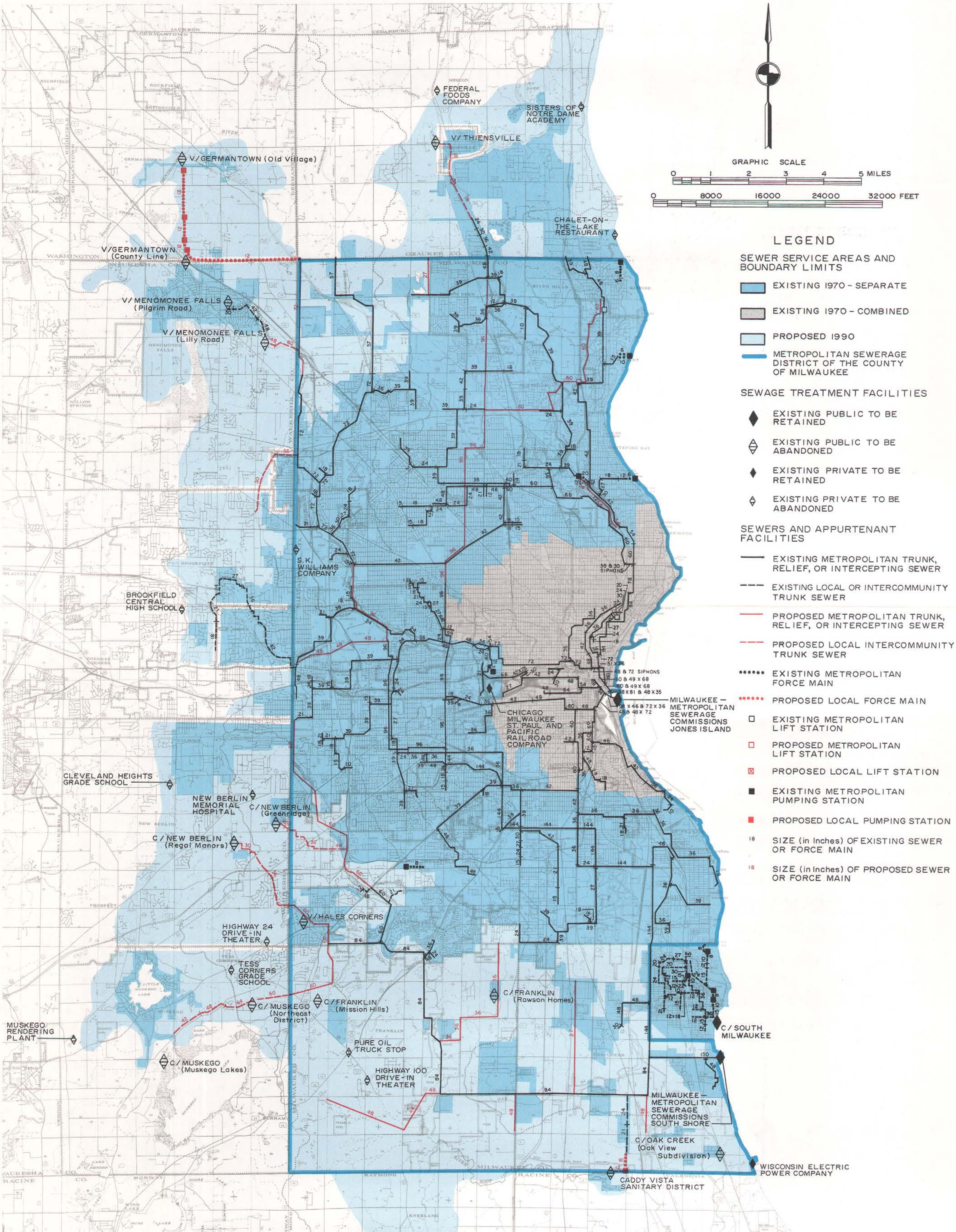
3. A trunk sewer designed to permit abandonment of the existing Regal Manors sewage treatment facility currently operated by the City of New Berlin on a temporary basis. This sewer would connect to a proposed metropolitan trunk sewer at the Milwaukee–Waukesha County line near W. Grange Avenue. The estimated capital cost of constructing this trunk sewer is about $750,000, with an equivalent annual cost of about $35,400.

4. A trunk sewer designed to permit abandonment of the existing Greenridge sewage treatment facility operated by the City of New Berlin on a temporary basis. This sewer would be constructed jointly by the City of New Berlin and the City of Greenfield and would connect to an existing metropolitan trunk sewer on W. Cold Spring Road near S. 104th Street. The estimated capital cost of constructing this trunk sewer is about $507,000, with an equivalent annual cost of about $24,000.

5. A trunk sewer designed to serve portions of the City of Brookfield and Village of Menomonee Falls and to be constructed by a joint sewerage commission recently formed for that purpose. While this trunk sewer would not permit the abandonment of any existing sewage treatment facilities, it has been included in the plan since it is areawide in nature, serving more than a single contract area community. The estimated capital cost of constructing this sewer is about $481,000, with an equivalent annual cost of about $22,600.

Map 56

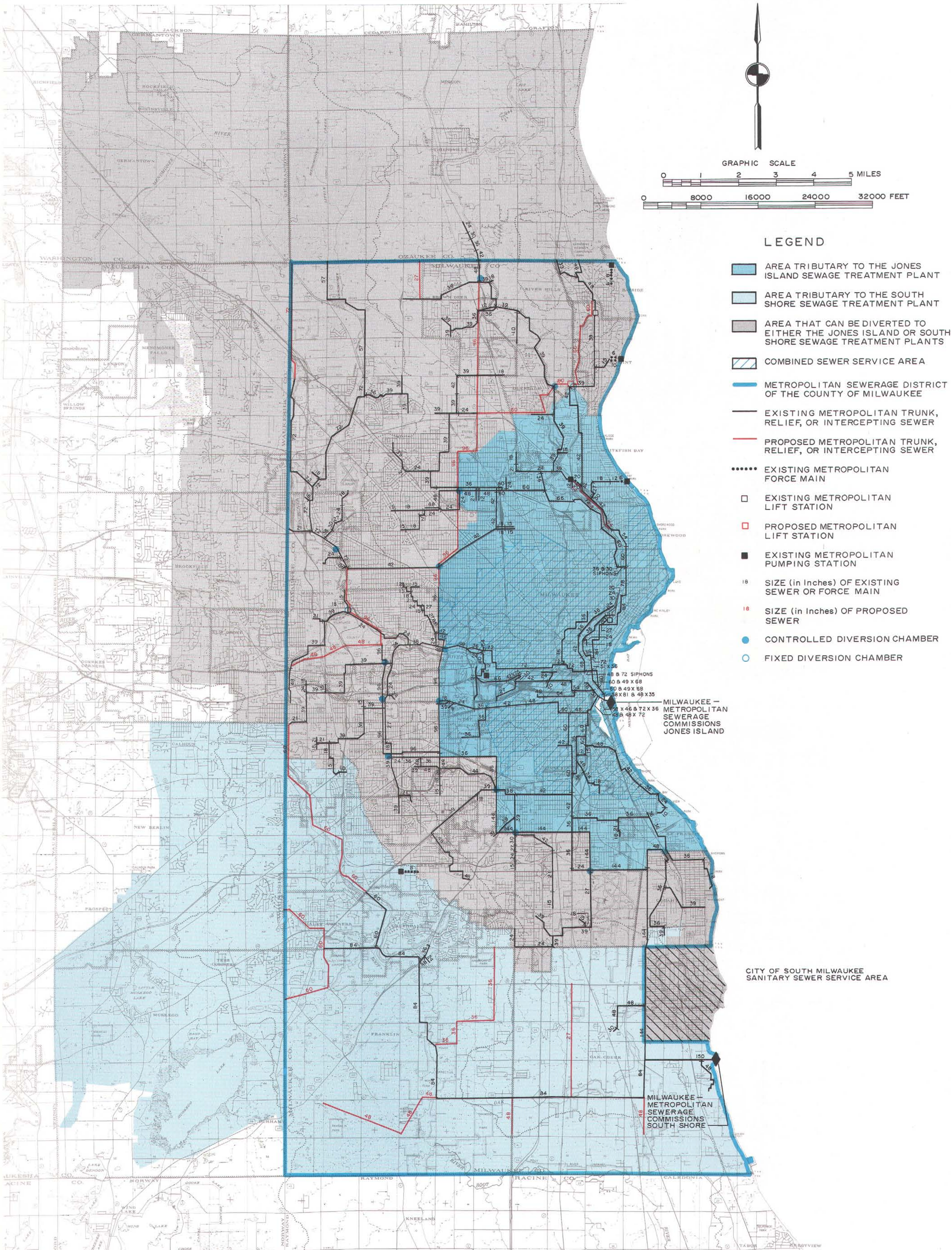
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MILWAUKEE-METROPOLITAN SUBREGIONAL AREA: 1990



Source: SEWRPC

Map 57

AREAS TRIBUTARY TO THE JONES ISLAND AND SOUTH SHORE SEWAGE TREATMENT PLANTS OPERATED BY THE MILWAUKEE – METROPOLITAN SEWERAGE COMMISSIONS



Source: SEWRPC

6. A trunk sewer designed to permit the abandonment of the two existing sewage treatment facilities operated by the Village of Menomonee Falls.[5] This trunk sewer would be connected to a proposed metropolitan trunk sewer at the Milwaukee-Waukesha County line near the Menomonee River crossing.

7. A trunk sewer designed to permit abandonment of the sewage treatment facility serving the Village of Germantown. The village recently (1973) abandoned a smaller sewage treatment facility at the Waukesha-Washington County line. The proposed trunk sewer would consist of a series of pumping stations and force mains and would connect with a proposed metropolitan trunk sewer at the extreme northwesterly corner of Milwaukee County. This trunk sewer connection, which initially was proposed as a solution to an areawide sewerage system problem studied as part of the Commission's federal grant review function, will effectively serve the entire Village of Germantown through the year 1990. Ultimately, it may be desirable to provide a gravity flow connection for Germantown through the Village of Menomonee Falls. The estimated capital cost of constructing this sewer is about $1.07 million, with an equivalent annual cost of about $115,500.

8. A trunk sewer proposed to permit abandonment of the sewage treatment facility serving the Village of Thiensville as initially recommended in the Milwaukee River watershed plan. The Village of Thiensville has agreed in principle to the connection and has begun negotiations with the joint Commissions to provide for future sewage treatment services. The estimated capital cost of constructing this trunk sewer, which is intended to also serve a portion of the City of Mequon, is about $558,000, with an equivalent annual cost of about $32,000.

In total, the recommended local trunk sewers would have an estimated capital construction cost of about $5.5 million, with an equivalent annual cost of about $332,000. These cost estimates are set forth in Table 100.

Combined Sewer Overflow Abatement Plan

The foregoing sewage treatment facilities and trunk sewers are directed both at extending existing sewerage systems throughout the entire Milwaukee-metropolitan subregional area and at providing flow relief to separate sanitary sewers now experiencing periods of overloading. An additional problem of major proportions present in the Milwaukee-metropolitan subregional area concerns the combined sewer overflows. This water quality problem was studied in great detail as part of the Milwaukee River watershed study.[6] Briefly, the adopted watershed plan recommends construction of a combination deep tunnel mined storage/flow-through treatment system to collect, convey, and adequately treat all combined sewer overflows throughout the 17,200-acre combined sewer service area in Milwaukee County (see Map 58). The total capital cost of constructing this system was estimated at about $130 million, with an equivalent annual cost, including operation and maintenance, of about $11 million (costs updated to base year 1970—see Table 102). This recommended course of action with respect to resolving combined sewer overflow problems is proposed to be incorporated directly into the regional sanitary sewerage system plan.

It should be noted that the Milwaukee-Metropolitan Sewerage Commissions have adopted the Milwaukee River watershed plan and have taken steps toward implementing the combined sewer overflow abatement plan element. The joint Commissions have requested the Regional Planning Commission to prepare a prospectus for conducting the necessary engineering feasibility studies and have budgeted funds for such studies during the 1973 fiscal year.

Abandonment of Public Sewage Treatment Facilities

Implementation of the foregoing plan recommendations would permit the abandonment of 12 public sewage treatment facilities in the Milwaukee-metropolitan subregional area. These facilities are those currently serving the Village of Thiens-

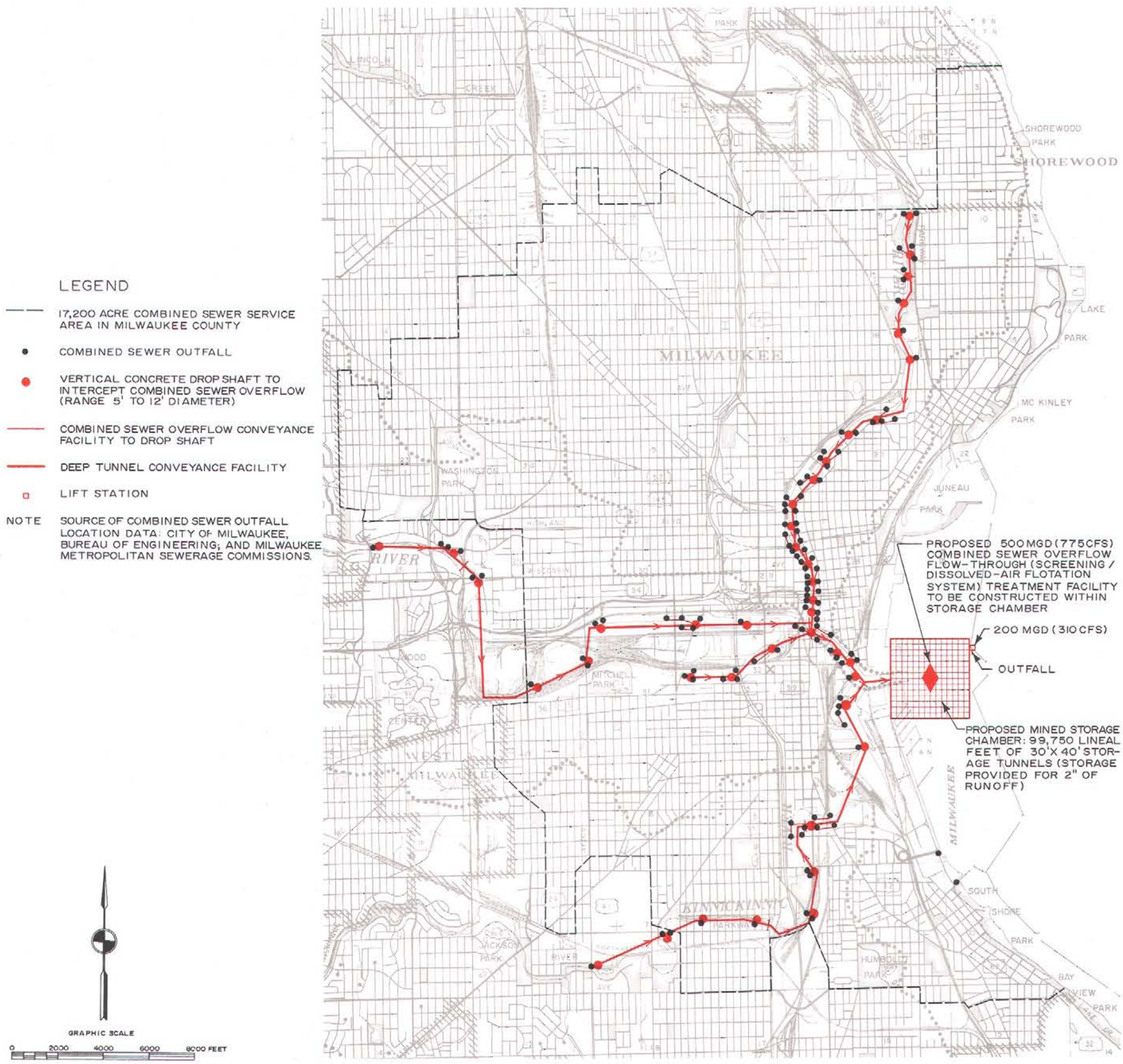
---

[5] *This trunk sewer has already been constructed (1973) but cannot be placed into service until completion of certain key metropolitan trunk sewer segments.*

[6] *See SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume 2, Alternative Plans and Recommended Plan.*

Map 58

RECOMMENDED COMBINED SEWER OVERFLOW POLLUTION ABATEMENT PLAN ELEMENT FOR MILWAUKEE COUNTY--DEEP TUNNEL CONVEYANCE, MINED STORAGE, AND SCREENING/DISSOLVED-AIR FLOTATION SYSTEM



This map illustrates the combined sewer overflow pollution abatement plan element for Milwaukee County as initially recommended in the Milwaukee River watershed plan and as recommended for inclusion in the regional sanitary sewerage system plan. Under this proposal, all combined sewer overflows would be intercepted by vertical shafts connected to intercepting sewers constructed in deep tunnels; conveyed by these sewers to a mined storage chamber constructed in the bedrock underlying the Milwaukee Harbor; and treated utilizing a flow-through treatment process, with treatment facilities located in the storage chamber and the treated effluent discharged to Lake Michigan. In 1973 the Milwaukee-Metropolitan Sewerage Commissions adopted the Milwaukee River watershed plan and directed that initial steps be taken toward implementing the combined sewer overflow abatement plan element. Toward this end, the Regional Planning Commission and the joint Sewerage Commissions prepared and adopted a prospectus for conducting the necessary engineering feasibility studies and endorsed applications for a federal grant-in-aid to finance such studies.

Source: SEWRPC.

Table 102

COST ESTIMATES--RECOMMENDED COMBINED SEWER OVERFLOW POLLUTION ABATEMENT PLAN ELEMENT FOR MILWAUKEE COUNTY

Recommended Plan Element	Capital Cost (Construction)									
	Storage Design Criteria (Inches of Runoff)	AERC Flotation Treatment Facilities	Instrumentation and Controls	Conveyance Tunnels	Diversion and Drop Shaft System	Mined Storage	Tunnel and Reservoir Aeration	Lift Pump Equipment and Minor Sewer Connections	Aquifer Recharge	Total
Deep tunnel conveyance, mined storage, and screening/dissolved-air flotation treatment system	2	$4,601,000	$321,000	$41,409,000	$16,371,000	$53,500,000	$7,704,000	$4,387,000	$1,712,000	$130,005,000

Recommended Plan Element	Present Worth (1970-2020)			Equivalent Annual			Annual Cost Per Acre	Capital Cost Per Acre
	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total		
Deep tunnel conveyance, mined storage, and screening/-dissolved-air flotation treatment system	$148,730,000	$24,610,000	$173,340,000	$9,416,000	$1,562,000	$10,978,000	$638	$7,558

Source: SEWRPC.

ville, the Village of Germantown, the Village of Menomonee Falls (Pilgrim Road plant and Lilly Road plant), the City of New Berlin (Regal Manors plant and Greenridge plant), the City of Muskego (Muskego Lakes plant and Northeast District plant), the Village of Hales Corners, the City of Franklin (Rawson Homes plant and Mission Hills plants), and the Caddy Vista Sanitary District in the Town of Caledonia. Two additional existing (1970) public sewage treatment facilities—the Oak View Subdivision plant in the City of Oak Creek and the County Line plant in the Village of Germantown—have been abandoned in 1971 and 1973, respectively, through the construction of local trunk sewers not included in the foregoing plan recommendations.

Private Sewage Treatment Plants

Implementation of the plan recommendations would permit the abandonment of 12 private sewage treatment facilities in the Milwaukee-metropolitan subregional area which discharge to surface water bodies. These facilities serve the Highway 100 Drive-In Theater and the Pure Oil truck stop in the City of Franklin; the Chalet-on-the-Lake Restaurant, the Sisters of Notre Dame Academy, and the Federal Foods Company in the City of Mequon; the S. K. Williams Company facility in the City of Wauwatosa;[7] the Brookfield Central High School in the City of Brookfield; the Cleveland Heights Grade School, the Highway 24 Drive-in Theater, and the New Berlin Hospital in the City of New Berlin; and the Muskego Rendering plant and the Tess Corners Grade School in the City of Muskego. Two private industrial sewage treatment facilities would be retained: the Wisconsin Electric Power Company facility in the City of Oak Creek and the Milwaukee Road facility in the City of Milwaukee. If properly maintained and operated, these two facilities should not constitute significant sources of water pollution.

[7] *Initial inventory findings reported in Chapter V of this report indicated that the S. K. Williams Company sewage treatment facility was considered to be a specialized, permanent industrial facility. Subsequently (1973), a local determination has been made to provide for ultimate abandonment of this facility through connection of the Company to the Milwaukee-metropolitan sewerage system.*

UPPER MILWAUKEE RIVER SUBREGIONAL AREA

The Upper Milwaukee River subregional area consists of all of the Milwaukee River watershed within the Southeastern Wisconsin Region north of the northern limits of the City of Mequon. This area has been subject in recent years to relatively rapid urban growth, particularly in the Cedarburg, Grafton, Saukville, and West Bend urban areas.

As noted in Chapter V of this report, centralized sanitary sewer service in the Upper Milwaukee River subregional area was provided by eight systems in 1970: those operated by the Cities of Cedarburg and West Bend; the Villages of Fredonia, Grafton, Kewaskum, Jackson, and Saukville; and the Newburg Sanitary District in the Towns of Trenton, Washington County, and Saukville, Ozaukee County. Together, the service areas of these eight systems comprised an area of nearly 12 square miles and served an estimated population of about 35,800 persons. In 1970 there were about 26,000 persons residing within the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the eight systems are presented in Chapter V of this report.

Sewer Service Analysis Areas

A total of 10 sewer service analysis areas may be identified within the Upper Milwaukee River subregional area (see Table 103). These 10 sewer service analysis areas are shown on Map 59 and may be described as follows:

1. Area A—This area consists of the Village of Kewaskum and environs. In 1970, sewer service was provided in this area to about 0.7 square mile, having a total resident population of about 1,900 persons. By 1990 the total area anticipated to be served approximates 1.2 square miles, with a projected population of about 3,200 persons. This subarea is referenced as the "Kewaskum" sewer service area in the ensuing discussion.

2. Area B—This area consists of the City of West Bend and environs. In 1970, sewer service was provided in this area to about five square miles, having a total resident population of about 16,400 persons. By 1990 the total area anticipated to be served approximates eight square miles, with a projected population of about 25,300. This subarea is referenced as the "West Bend" sewer service area in the ensuing discussion.

3. Area C—This area consists of urban development along the shorelines of Big Cedar Lake, Little Cedar Lake, and Silver Lake in the Towns of West Bend and Polk. No sewer service was provided in this area in 1970. By 1990 the total area anticipated to be served approximates 2.7 square miles, with a projected population of about 7,200 persons, including 4,700 seasonal residents. This subarea is referenced as the "Tri-Lakes" sewer service area in the ensuing discussion.

4. Area D—This area consists of the Village of Jackson and environs. In 1970, sewer service was provided in this area to about 0.6 square mile, having a total resident population of about 600 persons. By 1990 it is estimated that sewer service would be extended to a total area of nearly one square mile, with a projected population of about 1,700 persons. This subarea is referenced as the "Jackson" sewer service area in the ensuing discussion.

5. Area E—This area consists of the Newburg Sanitary District and environs. In

Table 103

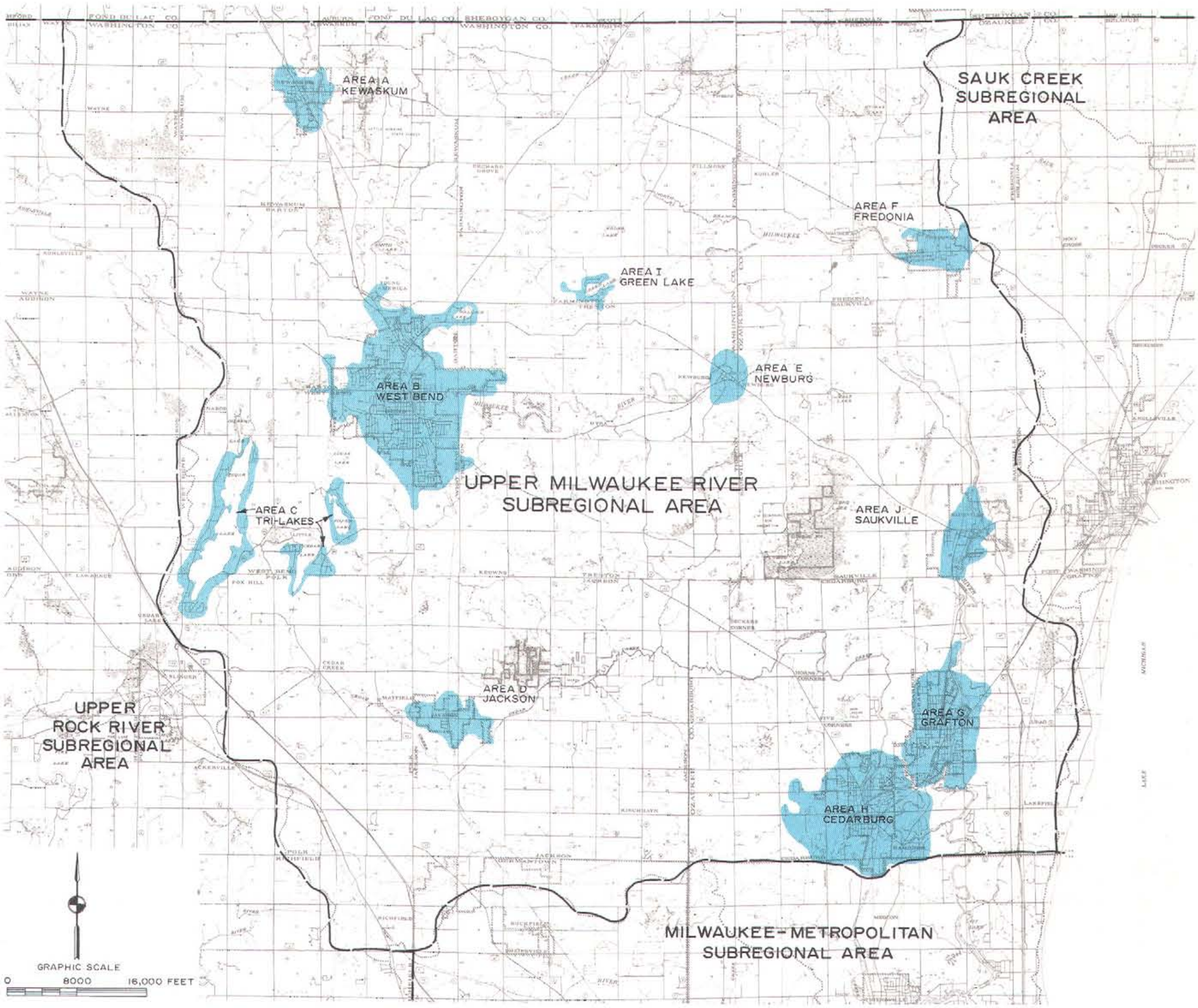
SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE UPPER MILWAUKEE RIVER SUBREGIONAL AREA 1970 and 1990

Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Kewaskum	0.72	1,900	0.49	200	1.15	3,200	0.92
B	West Bend	5.17	16,400	2.27	1,600	8.45	25,300	5.14
C	Tri-Lakes	--	--	--	2,500	2.69	7,200[2]	0.96
D	Jackson	0.64	600	0.08	40	0.92	1,700	0.50
E	Newburg	0.10	400	0.04	200	0.74	1,100	0.12
F	Fredonia	0.71	1,000	0.10	100	1.12	1,800	0.23
G	Grafton	1.87	6,400	0.80	600	3.64	10,700	1.90
H	Cedarburg	2.34	8,000	1.26	1,500	6.27	14,300	2.48
I	Green Lake	--	--	--	200	0.23	700[3]	0.09
J	Saukville	0.31	1,100	0.25	500	1.43	2,600	0.40
	Total	11.86	35,800	5.29	7,440	26.64	68,600	12.74

[1]See Map 59.
[2]Includes an estimated seasonal peak population of 4,700 persons.
[3]Includes an estimated seasonal peak population of 500 persons.
Source: SEWRPC.

Map 59

SEWER SERVICE ANALYSIS AREAS
UPPER MILWAUKEE RIVER SUBREGIONAL AREA



Ten distinct sewer service analysis areas were identified within the Upper Milwaukee River subregional area. In eight of the areas--Kewaskum, West Bend, Jackson, Newburg, Fredonia, Grafton, Cedarburg, and Saukville--centralized sanitary sewer service was being provided in 1970. These eight existing systems provide a basis for expansion to serve anticipated 1990 demand. The two remaining areas--Tri-Lakes and Green Lake--comprise relatively intensive areas of existing inland lake-oriented urban development now served by septic tank systems and for which the provision of centralized sanitary sewer service was initially recommended in the adopted Milwaukee River watershed plan.

Source: SEWRPC.

1970, sewer service was provided in this area to about 0.1 square mile, having a total resident population of about 400 persons. By 1990 the total area anticipated to be served approximates 0.7 square mile, with a projected population of about 1,100 persons. This subarea is referenced as the "Newburg" sewer service area in the ensuing discussion.

6. Area F—This area consists of the Village of Fredonia and environs. In 1970, sewer

service was provided in this area to about 0.7 square mile, having a total resident population of about 1,000 persons. By 1990 the total area anticipated to be served approximates one square mile, with a projected population of about 1,800 persons. This subarea is referenced as the "Fredonia" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Grafton and environs. In 1970, sewer service was provided in this area to nearly two square miles, having a total resident population of about 6,400 persons. By 1990 the total area anticipated to be served approximates 3.6 square miles, with a projected population of about 10,700 persons. This subarea is referenced as the "Grafton" sewer service area in the ensuing discussion.

8. Area H—This area consists of the City of Cedarburg and environs. In 1970, sewer service was provided in this area to about 2.3 square miles, having a total resident population of about 8,000 persons. By 1990 the total area anticipated to be served approximates 6.3 square miles, with a projected population of about 14,300 persons. This subarea is referenced as the "Cedarburg" sewer service area in the ensuing discussion.

9. Area I—This area consists of urban development along the shoreline of Green Lake in the Town of Farmington, Washington County. No sewer service was provided in this area in 1970. The adopted Milwaukee River watershed plan recommends that a centralized sanitary sewerage system be established to serve this urban development. By 1990 the total area anticipated to be served approximates 0.2 square mile, with a projected population of about 700 persons, including 500 seasonal residents. This subarea is referenced as the "Green Lake" sewer service area in the ensuing discussion.

10. Area J—This area consists of the Village of Saukville and environs. In 1970, sewer service was provided in this area to about 0.3 square mile, having a total resident population of about 1,100 persons. By 1990 the total area anticipated to be served approximates 1.4 square miles, with a projected population of about 2,600 persons. This subarea is referenced as the "Saukville" sewer service area in the ensuing discussion.

Summary of Milwaukee River Watershed Plan Recommendations

The Milwaukee River watershed plan, as adopted in March 1972 by the Regional Planning Commission, contained a series of specific recommendations pertaining to sewerage facility development for the Upper Milwaukee River subregional area. These recommendations followed a detailed examination of five basic stream water quality management alternative plan elements for the upper watershed: 1) the provision of secondary and advanced waste treatment (phosphorus removal); 2) the provision of secondary waste treatment, tertiary waste treatment (high level $CBOD_5$ removal), and advanced waste treatment (phosphorus and $NBOD_5$ removal); 3) secondary waste treatment and land irrigation of effluent; 4) advanced waste treatment (phosphorus removal) and instream aeration; and 5) advanced waste treatment (phosphorus removal) and low-flow augmentation. Several subalternatives consisting of different potential system interconnection arrangements were also considered. The recommended plan was a combination of several of the alternatives, primarily centering, however, on the provision of high levels of advanced waste treatment with selective instream aeration and low-flow augmentation to satisfy dissolved oxygen requirements in certain stream segments.

Within the Southeastern Wisconsin Region, and with respect to the Upper Milwaukee River subregional area, the watershed plan recommendations may be summarized as follows:

1. The provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection at the municipal sewage treatment facilities serving the Village of Fredonia and the Newburg Sanitary District.

2. The provision of secondary waste treatment, of advanced waste treatment for phosphorus removal, and of auxiliary waste treatment for effluent disinfection at the municipal sewage treatment facilities serv-

ing the Villages of Kewaskum, Jackson, and Saukville.

3. The provision of secondary waste treatment at individual sewage treatment facilities serving the City of Cedarburg and the Village of Grafton, combined with the provision of advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection at a proposed new sewage treatment facility to be located near the confluence of the Milwaukee River and Cedar Creek. Trunk sewers to connect the existing Cedarburg and Grafton plants with the proposed new advanced waste treatment plant were also included in the plan.

4. The provision of secondary waste treatment, advanced waste treatment for phosphorus removal, auxiliary waste treatment for effluent disinfection, and instream aeration at the municipal sewage treatment facility serving the City of West Bend. The West Bend facility was proposed to become an areawide facility serving not only the West Bend sewer service area but also proposed sanitary sewer service areas around Tri-Lakes. Trunk sewers needed to connect the Tri-Lakes area with the West Bend plant were also included in the plan, as were instream mechanical aerators—proposed to be located on the Milwaukee River main stem below the West Bend treatment facility at distances of 0.7 and 1.8 miles—and diffuser aerators—proposed to be located in the Newburg Pond.

The foregoing recommended watershed plan elements, together with related sewerage elements applicable to communities in Fond du Lac and Sheboygan Counties outside the Region and to the Village of Thiensville in the Milwaukee-metropolitan subregional area, were deemed in the plan to represent the best combination of subalternatives considered, together constituting the least cost alternative which would meet the established water use objectives and standards.[8]

[8] *For a more complete description of the recommended sewerage facility elements in the adopted Milwaukee River watershed plan, see SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume 2, Alternative Plans and Recommended Plan, Chapter V.*

Developments Affecting the Watershed Plan Recommendations

Since the preparation and adoption of the Milwaukee River watershed plan, several developments have taken place which required reevaluation of the recommendations in the adopted Milwaukee River watershed plan prior to the integration of these recommendations into the regional sanitary sewerage system plan. One of these developments relates to the state of the art of water quality management, namely the observed toxic effect of ammonia in sewage treatment plant effluent on fish and other aquatic life in receiving streams. As discussed in Chapter IX of this report, such ammonia toxicity has just recently received increased attention and was deemed to be of enough significance to warrant its specific consideration in the reevaluation of the sewerage facility development recommendations for the upper watershed contained in the adopted Milwaukee River watershed plan. As discussed below with respect to individual sewage treatment facilities, this reevaluation resulted in a decision to modify certain of the sewage treatment plant recommendations contained in the adopted watershed plan. It should be noted in this respect that ammonia reduction facilities can be readily added to most conventional sewage treatment plants in the form of additional aeration tanks.

The other development which has taken place since adoption of the Milwaukee River watershed plan relates to sewerage facility expansion. The City of Cedarburg completed in 1972 an expansion of its existing treatment facility to provide an average hydraulic design capacity of 3.0 mgd and an improved level of waste treatment by the addition of phosphorus removal and effluent disinfection through chlorination. The new average hydraulic design capacity of the Cedarburg plant is anticipated to provide sufficient plant capacity to serve the City of Cedarburg through the design growth increment assumed in preparation of the regional land use plan. The Village of Grafton, adjacent to the City of Cedarburg, completed a minor addition to its treatment facility in 1972 to provide for an average hydraulic design capacity of 1.0 mgd and an improved level of waste treatment by the addition of phosphorus removal and effluent disinfection. The capacity of the improved treatment facility is about one-half of the total capacity anticipated to be needed to serve the Village of Grafton through the design growth increment assumed in preparation of the regional land use plan. In addition, the Village of Kewaskum expanded its sewage treatment facility in 1971 to provide an average hydraulic design capacity of 1.0 mgd and an improved level of waste treatment by the addition of phosphorus removal. The City of West Bend formally approved a preliminary engineering study in 1972 relating to the expansion of its sewage treatment facility. The study recommends the provision of advanced waste treatment for phosphorus removal and sufficient treatment capacity to serve the Tri-Lakes sewer service area as well as the City of West Bend service area. Finally, the Village of Jackson during 1971 completed engineering studies for the construction of a replacement treatment facility designed to serve not only the village but also the Libby, McNeill, and Libby canning plant in the Town of Jackson and to provide for phosphorus removal. All of the foregoing sewerage facility developments were taken into account in the reevaluation of the watershed plan recommendations as part of the preparation of the regional sanitary sewerage system plan.

Proposed Subregional Area Plan

Because of the extensive consideration of alternative sewerage system plans under the Milwaukee River watershed study, the procedure for formulating alternative plans developed in the sewerage study was not used for the Upper Milwaukee River watershed subregional area. The alternatives presented in the watershed study report, together with the recommended plans presented in that report, instead provided a point of departure for the reevaluation of the adopted plan recommendations, and, as such, were incorporated into the regional sanitary sewerage system planning effort. Consequently, only recommended plan elements are described in this section, such recommended elements consisting of the recommendations included in the adopted Milwaukee River watershed plan modified as necessary to reflect the results of the reevaluation conducted under the sewerage system planning program. Basic data utilized in formulating recommended levels of sewage treatment are presented in Table 104.

Kewaskum Subarea: The recommendation set forth in the adopted watershed plan that the Kewaskum sewage treatment facility be expanded and provide advanced waste treatment (phosphorus removal) and the auxiliary waste treatment of effluent disinfection was reconfirmed by the reevaluation. Ammonia toxicity was found not to constitute a significant factor in management of the water quality of the Milwaukee River in this stream

Table 104

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Stream	Stream Low Flow and Dilution Ratio Data: 7-Day, 10-Year Low Flow[1] CFS	7-Day, 10-Year Low Flow[1] MGD	Upstream Sewage Treatment Plant Flow-1990[2] CFS	Upstream Sewage Treatment Plant Flow-1990[2] MGD	Total Design Low Flow-1990 CFS	Total Design Low Flow-1990 MGD	Total Design Sewage Flow-1990[3] CFS	Total Design Sewage Flow-1990[3] MGD	Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Level of Treatment Required: Secondary	Advanced: Phosphorus Removal	Advanced: Nitrification	Auxiliary: Effluent Aeration	Auxiliary: Disinfection
Kewaskum	Milwaukee River	5.30	3.42	0.69	0.44	5.99	3.87	1.42	0.92	4.22	Yes	Yes	No	No	Yes
West Bend	Milwaukee River	8.40	5.43	2.16	1.39	10.56	6.82	9.45	6.10	1.12	Yes	Yes	Yes	No	Yes
Jackson	Cedar Creek	1.90	1.23	0.00	0.00	1.90	1.23	0.77	0.50	2.47	Yes	Yes	Yes	No	Yes
Newburg	Milwaukee River	9.00	5.81	11.60	7.48	20.60	13.31	0.19	0.12	108.50	Yes	No	No	No	Yes
Fredonia	Milwaukee River	15.20	9.82	12.65	8.16	27.85	17.99	0.36	0.23	77.50	Yes	No	No	No	Yes
Grafton[4]	Milwaukee River	16.60	10.73	13.23	8.55	29.83	19.28	2.94	1.90	10.15	Yes	Yes	No	No	Yes
Grafton (North)[5]	Milwaukee River	16.60	10.73	13.23	8.55	29.83	19.28	1.55	1.00	19.28	Yes	Yes	No	No	Yes
Grafton (South)[5]	Milwaukee River	16.60	10.73	14.78	9.55	31.38	20.28	1.39	0.90	22.58	Yes	Yes	No	No	Yes
Cedarburg[6]	Cedar Creek	4.40	2.84	1.90	1.22	6.30	4.06	3.84	2.48	1.64	Yes	Yes	Yes	No	Yes
Cedarburg[7]	Milwaukee River	16.60	10.73	16.17	10.45	32.77	21.18	3.84	2.48	8.53	Yes	Yes	No	No	Yes
Green Lake	Marsh Tributary to Milwaukee River	N/A	N/A	N/A	N/A	N/A	N/A	0.14	0.09	N/A	Yes	No	Yes	No	Yes
Saukville	Milwaukee River	15.80	10.21	13.01	8.40	28.81	18.61	0.62	0.40	46.40	Yes	Yes	No	No	Yes

NOTE: N/A indicates not applicable.

[1]See SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume One, Inventory Findings and Forecasts, page 349.

[2]See SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume Two, Alternative Plans and Recommended Plan, Chapter V.

[3]See SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume Two, Alternative Plans and Recommended Plan, Chapter V. The design sewage flow for the Village of Kewaskum was adjusted upward to accommodate observed additional industrial sewage flows since 1967, the base year of the Milwaukee River watershed study.

[4]Corresponds to Grafton alternative plan 1.

[5]Corresponds to Grafton alternative plan 2.

[6]Corresponds to Cedarburg alternative plan 1.

[7]Corresponds to Cedarburg alternative plan 2.

Source: SEWRPC.

reach. The specific recommended performance standards for the Kewaskum sewage treatment plant are set forth in Table 105. Based on inventory data collected under the sewerage study, which revealed substantial increases in industrial waste flows, the recommendation as to the sizing of the plant has been revised upward to about 1.0 mgd of average hydraulic design capacity, as compared with the watershed plan recommendation of about 0.7 mgd. The capital cost of constructing the necessary facilities was reestimated at slightly over $1 million, with an equivalent annual cost of about $116,000 (see Table 106). The proposed 1990 service area for the Village of Kewaskum is shown on Map 60.

As noted earlier, the Village of Kewaskum very recently completed expansion of its sewage treatment facility to provide an average hydraulic design capacity of 1.0 mgd, an advanced level of waste treatment in terms of phosphorus removal, and effluent disinfection through chlorination. Thus, the village has already fully carried out the sewerage system plan recommendations. Absent any substantial change in growth patterns in the Kewaskum area, there should be no need to provide for further expansion through the 20-year design period of the sewerage system plan.

West Bend and Tri-Lakes Subarea: The recommendation set forth in the watershed plan that the West Bend sewage treatment facility be expanded, provide advanced waste treatment (phosphorus removal), and provide instream aeration to resolve serious oxygen depletion problems downstream of the plant was modified based

Table 105

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SEWERAGE SYSTEM PLAN FOR THE KEWASKUM SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards In Terms of Effluent Quality (All Numbers Represent Annual Averages)
Kewaskum (0.92 MGD)	Kewaskum	3,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 60.
Source: SEWRPC.

Table 106

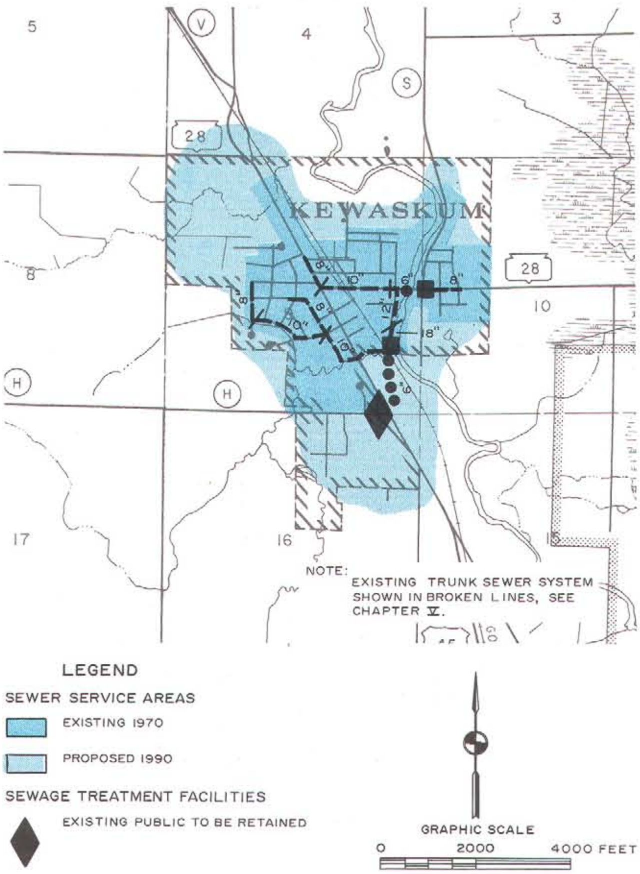
DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE KEWASKUM SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Kewaskum[1]							
Facilities (0.92 MGD)	$1,037,000	$935,000	$872,000	$1,807,000	$59,500	$55,500	$115,000
Land (3.3 Acres)	16,500	12,100	--	12,100	800	--	800
Subtotal	1,053,500	947,100	872,000	1,819,100	60,300	55,500	115,800
Trunk Sewers--None							
Total	$1,053,500	$947,100	$872,000	$1,819,100	$60,300	$55,500	$115,800

[1]Includes the cost of additional treatment capacity constructed and placed into operation by the Village of Kewaskum in 1971.
Source: SEWRPC.

Map 60

PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE KEWASKUM SEWER SERVICE AREA UPPER MILWAUKEE RIVER SUBREGIONAL AREA 1990



In keeping with the sewerage facility development recommendations included in the Milwaukee River watershed plan, the Village of Kewaskum completed in 1972 an expansion program at its sewage treatment facility to provide for an average hydraulic design capacity of about 1.0 mgd, an advanced level of waste treatment for phosphorus removal, and effluent disinfection through chlorination. Thus, with respect to sewage treatment facilities, the village has already carried out the sewerage system plan recommendations and should be able to provide adequate treatment for sewage generated in the Kewaskum area through the plan design year of 1990.

Source: SEWRPC.

upon the plan reevaluation conducted under the regional sewerage system study. Ammonia toxicity was found to be a significant factor in management of the water quality of the main stem of the Milwaukee River in this stream reach. Accordingly, it is now recommended that the West Bend facility, in addition to being expanded and in addition to providing phosphorus removal, also provide advanced waste treatment, including nitrification. Because the nitrification process, in addition to converting ammonia to nitrates, also provides a reduction in $NBOD_5$ demand, it should no longer be necessary to provide for instream aeration downstream from the West Bend treatment facility to meet the established water use objectives. It should be noted that this modification in treatment level recommendations to provide for nitrification at the West Bend plant in effect constitutes the selection of alternative water quality management plan 2-B as set forth in the Milwaukee River watershed study planning report. As included in the watershed plan, this alternative provided for nitrogenous oxygen demand (NOD) removal, which is equivalent to the nitrification recommendation being made herein. In all other respects, the watershed plan recommendation for sewerage facility development in the West Bend and Tri-Lakes sewer service areas remains unchanged.

Accordingly, the plan proposes that the West Bend sewage treatment facility be expanded to an average hydraulic design capacity slightly in excess of 6 mgd, while providing secondary waste treatment, advanced waste treatment in terms of phosphorus removal and nitrification, and auxiliary waste treatment in terms of effluent disinfection. The specific recommended performance standards for the West Bend sewage treatment plant are set forth in Table 107. The plan further provides that the West Bend facility be considered an areawide facility serving the Tri-Lakes sewer service area. The plan further recommends the construction of trunk sewers to connect the Tri-Lakes sewer service area with the West Bend treatment facility (see Map 61).

The costs of implementing the recommended plan for the West Bend and Tri-Lakes areas are set forth in Table 108. These costs reflect the costs set forth for alternative plan 2-B in the Milwaukee River watershed study report, adjusted to the year 1970. The estimated capital cost for constructing the necessary treatment facilities is about \$2.6 million, with an equivalent annual cost of about \$638,000. The estimated capital cost of constructing the trunk sewers to serve the Tri-Lakes area is about \$1 million, with an equivalent annual cost of about \$78,000.

Table 107

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WEST BEND AND TRI-LAKES SEWER SERVICE AREAS
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
West Bend (6.10 MGD)	West Bend Tri-Lakes	32,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 61.*

Source: SEWRPC.

Table 108

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WEST BEND AND TRI-LAKES SEWER SERVICE AREAS
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

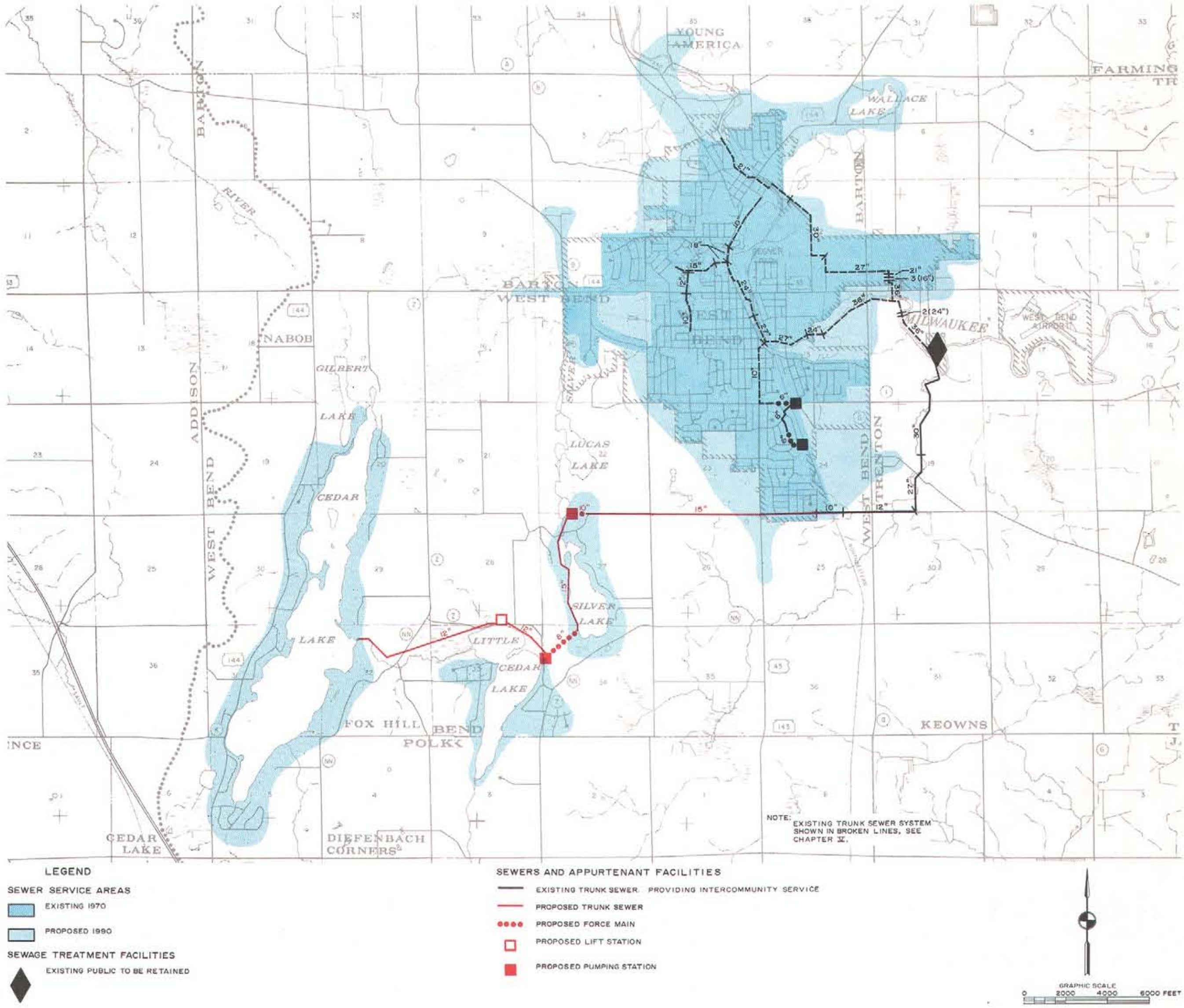
Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
West Bend							
Facilities (6.10 MGD)	$2,620,400	$3,609.100	$6,008,000	$ 9,617,100	$228,700	$407,300	$636,000
Land (5.4 Acres)	27,000	27,000	--	27,000	1,700	--	1,700
Subtotal	2,647,400	3,636,100	6,008,000	9,644,100	230,400	407,300	637,700
Trunk Sewer							
Tri-Lakes to West Bend	1,046,000	1,063,000	174,000	1,237,000	67,300	11,000	78,300
Subtotal	1,046,000	1,063,000	174,000	1,237,000	67,300	11,000	78,300
Total	$3,693,400	$4,699,100	$6,182,000	$10,881,100	$297,700	$418,300	$716,000

Source: SEWRPC.

Jackson Subarea: The recommendation set forth in the watershed plan that the Jackson sewage treatment facility be relocated and provide for advanced waste treatment in terms of phosphorus removal was also modified based upon the plan reevaluation. Ammonia toxicity was found to be a significant factor in management of the water quality of Cedar Creek in this reach. Accordingly, it is recommended that the Jackson facility, in addition to being relocated and expanded and in addition to providing phosphorus removal, also provide advanced waste treatment for nitrification. In all other respects, the watershed plan recommendation for sewerage facility development in the Jackson sewer service area remains unchanged. Accordingly, the plan proposes that the Jackson sewage treatment facility be relocated on a new site and provide a capacity of about 0.5 mgd (see Map 62). The plant should provide secondary waste treatment, advanced waste treatment in terms of both phosphorus removal and nitrification, and auxiliary waste treatment in terms of effluent disinfection. The specific recommended performance standards for the Jackson sewage treatment plant are set forth in Table 109. The cost of implementing the recommended plan for the Jackson area is set forth in Table 110. Because of the modification in the plan recommendation, it was necessary to prepare entirely new cost estimates. The estimated capital cost

Map 61

PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WEST BEND AND TRI-LAKES SEWER SERVICE AREAS UPPER MILWAUKEE RIVER SUBREGIONAL AREA 1990

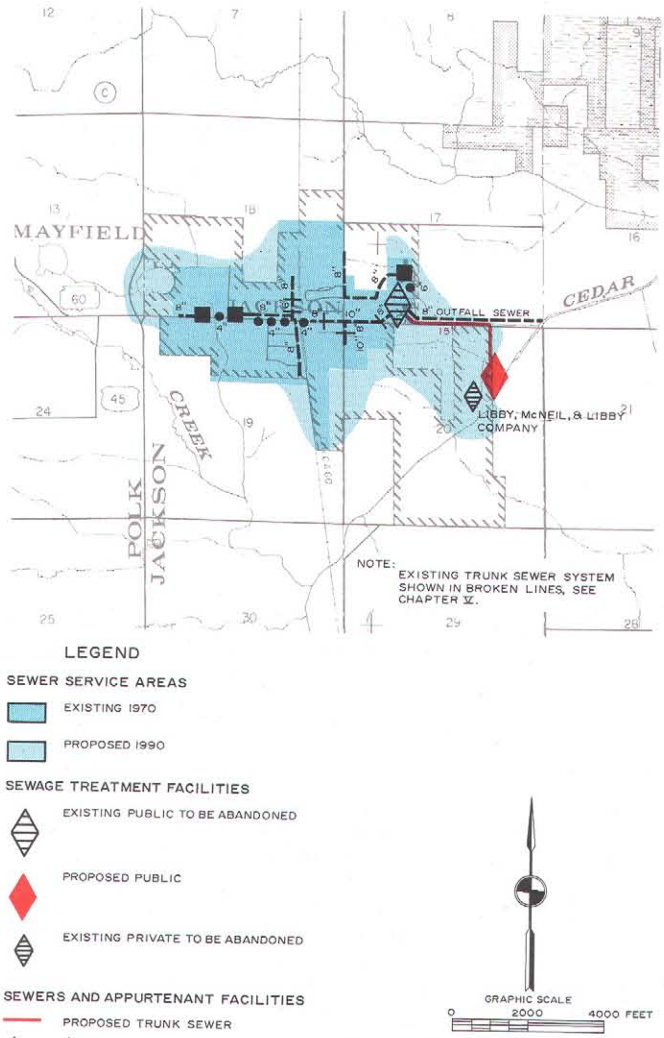


It is proposed that the West Bend sewage treatment facility serve as an areawide treatment facility providing sewer service not only to urban development in the West Bend area itself but also to existing lake-oriented urban development located around Big Cedar, Little Cedar, and Silver Lakes. This map indicates the trunk sewer proposed to connect the Tri-Lakes sewer service area to the West Bend sewage treatment facility. The plan proposes that the West Bend treatment facility be upgraded to provide secondary waste treatment, advanced waste treatment for both nitrification and phosphorus removal, and auxiliary waste treatment for effluent disinfection.

Source: SEWRPC.

Map 62

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE JACKSON SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990



As shown on the above map, the plan proposes that the Jackson sewage treatment facility be relocated on a new site and provide sufficient capacity to enable the abandonment of the adjacent private sewage treatment facility serving the Libby, McNeill, and Libby, Inc. canning plant. The proposed new Jackson treatment facility should provide secondary waste treatment, advanced waste treatment for both nitrification and phosphorus removal, and auxiliary waste treatment for effluent disinfection.

Source: SEWRPC.

for constructing the necessary treatment facilities is about $838,000, with an equivalent annual cost of about $142,000. The capital cost of providing a trunk sewer from the existing plant site to the proposed site is estimated to be $91,800, with an equivalent annual cost of about $4,400.

Newburg Subarea: The recommendation set forth in the watershed plan that the Newburg sewage treatment facility be expanded and provide secondary waste treatment and the auxiliary waste treatment of effluent disinfection remains unchanged. Ammonia toxicity was found not to constitute a significant factor in management of the water quality of the Milwaukee River in this stream reach. Accordingly, it is recommended that the plant be expanded to an average hydraulic design capacity of about 0.12 mgd. The specific recommended performance standards for the Newburg sewage treatment plant are set forth in Table 111. The estimated capital cost of constructing the necessary treatment facilities, adjusted to the year 1970, is about $107,000, with an equivalent annual cost of about $24,000 (see Table 112). The proposed 1990 sewer service area for Newburg is shown on Map 63.

Fredonia Subarea: The recommendation set forth in the watershed plan that the Fredonia sewage treatment facility be expanded and provide secondary waste treatment and the auxiliary waste treatment of effluent disinfection also remains unchanged. Ammonia toxicity was found not to constitute a significant factor in management of the water quality of the Milwaukee River in this stream reach. Accordingly, it is recommended that the plant be expanded to an average hydraulic design capacity of about 0.23 mgd. The specific recommended performance standards for the Fredonia sewage treatment plant are set forth in Table 113. The estimated capital cost of constructing the necessary treatment facilities, adjusted to the year 1970, is about $157,000, with an equivalent annual cost of about $35,000 (see Table 114). The proposed 1990 sewer service area for Fredonia is shown on Map 64.

Cedarburg-Grafton Subarea: As noted earlier, the Milwaukee River watershed plan recommended that the adjoining communities of Cedarburg and Grafton consolidate their treatment facilities at a new site located at the confluence of Cedar Creek and the Milwaukee River. As a first step toward such consolidation, the plan recommended the construction of a single common facility for the provision of advanced waste treatment at the new site, together with necessary conveyance sewers.

Table 109

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE JACKSON SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Jackson (0.50 MGD)	Jackson	1,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 62.

Source: SEWRPC.

Table 110

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE JACKSON SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Jackson							
Facilities (0.50 MGD)	$824,100	$1,016,400	$1,210,900	$2,226,900	$64,400	$76,700	$141,100
Land (2.8 Acres)	14,000	14,000	--	14,000	900	--	900
Subtotal	838,100	1,030,400	1,210,500	2,240,900	65,300	76,700	142,000
Trunk Sewer							
Jackson	91,800	67,800	1,600	69,400	4,300	100	4,400
Subtotal	91,800	67,800	1,600	69,400	4,300	100	4,400
Total	$929,900	$1,098,200	$1,212,100	$2,310,300	$69,600	$76,800	$146,400

Source: SEWRPC.

Table 111

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE NEWBURG SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

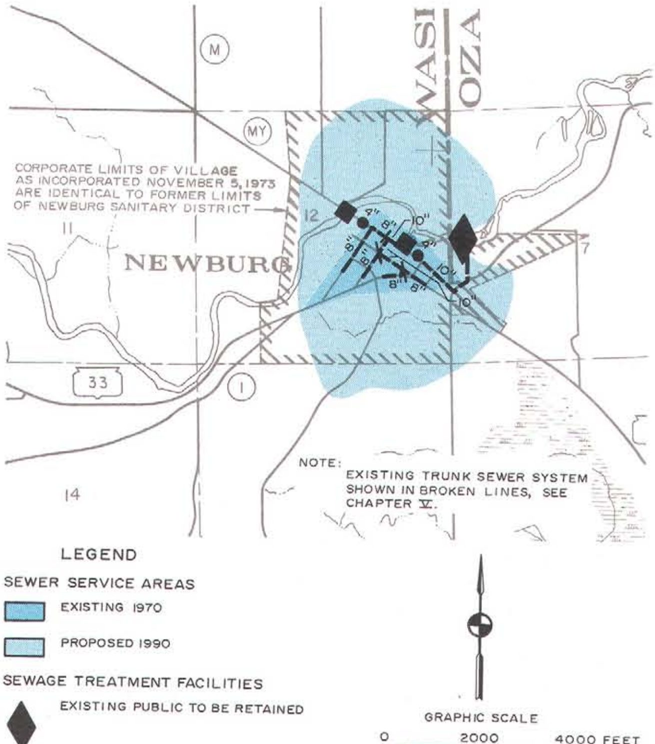
Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Newburg (0.12 MGD)	Newburg	1,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 63.

Source: SEWRPC.

Map 63

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE NEWBURG SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990

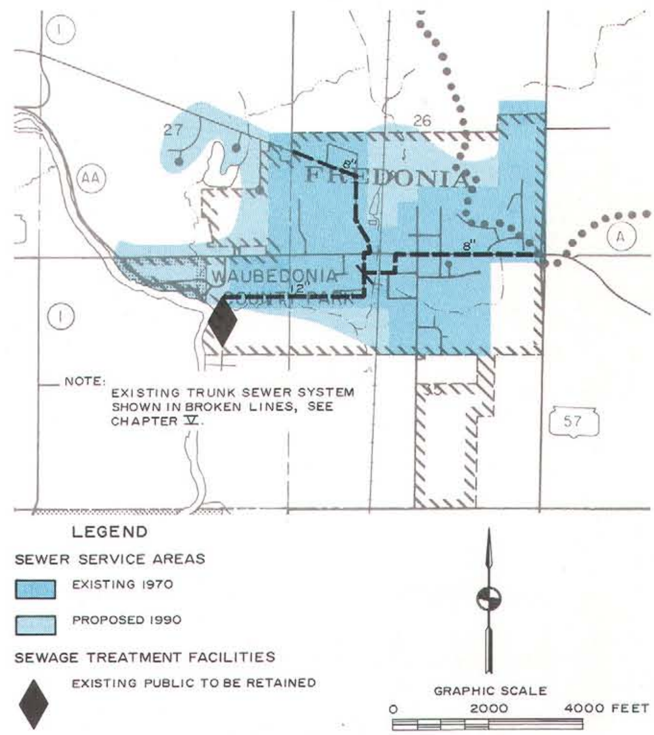


Analyses performed under the regional sewerage study reconfirmed the recommendation set forth in the Milwaukee River watershed plan that the sewage treatment facility serving the Newburg Sanitary District be expanded to meet anticipated 1990 demand while providing secondary waste treatment and auxiliary waste treatment for effluent disinfection. Recently (November 1973), the area comprising the Newburg Sanitary District was incorporated as the Village of Newburg.

Source: SEWRPC.

Map 64

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE FREDONIA SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990



It is proposed that the Fredonia sewage treatment facility be expanded to serve the anticipated 1990 demand while providing secondary waste treatment and auxiliary waste treatment for effluent disinfection. Analyses performed under the regional sewerage study reconfirmed the foregoing recommendation as initially made in the Milwaukee River watershed plan. The substantial dilution capacity in the Milwaukee River at Fredonia precludes the need to consider the provision of advanced waste treatment for nitrification in order to resolve water quality management problems relating to ammonia toxicity.

Source: SEWRPC.

In light of the recent sewerage facility developments noted above, the recommendation for a single treatment facility to serve the Cedarburg-Grafton area was reconsidered in the regional sanitary sewerage system planning program. First, comparative analyses were made relative to two alternative sanitary sewerage system plans for the Cedarburg sewer service area, which alternatives were based upon the capacity of the Cedarburg sewage treatment plant as of 1973. Under alternative plan 1, additional advanced waste treatment facilities would be provided at the Cedarburg plant in order to provide nitrification, since ammonia toxicity was found to constitute a significant factor in management of

Table 112

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE NEWBURG SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Newburg							
Facilities (0.12 MGD)	$ 98,400	$140,000	$229,000	$369,000	$8,900	$14,500	$23,400
Land (1.8 Acres)	9,000	9,000	--	9,000	600	--	600
Subtotal	107,400	149,000	229,000	378,000	9,500	14,500	24,000
Trunk Sewers --None							
Total	$107,400	$149,000	$229,000	$378,000	$9,500	$14,500	$24,000

Source: SEWRPC.

Table 113

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE FREDONIA SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Fredonia (0.23 MGD)	Fredonia	1,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 64.*
Source: SEWRPC.

Table 114

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE FREDONIA SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Fredonia							
Facilities (0.23 MGD)	$146,600	$212,600	$333,800	$546,400	$13,500	$21,200	$34,700
Land (2.1 Acres)	10,500	11,000	--	11,000	700	--	700
Subtotal	157,100	223,600	333,800	557,400	14,200	21,200	35,400
Trunk Sewers--None							
Total	$157,100	$223,600	$333,800	$557,400	$14,200	$21,200	$35,400

Source: SEWRPC.

water quality of Cedar Creek in the Cedarburg reach of that Creek. As shown in Table 115, the total estimated capital cost of carrying out this alternative plan is about $481,500, with an equivalent annual cost of about $59,800. Under the second alternative plan presented, advanced waste treatment facilities for nitrification would not be required since this alternative assumes the construction of an outfall sewer discharging effluent to the Milwaukee River—where greater dilution capacity is available—rather than to Cedar Creek (see Map 65). The total estimated capital cost of carrying out this alternative plan for the Cedarburg sewer service area is about $261,100, with an equivalent annual cost of about $17,100.

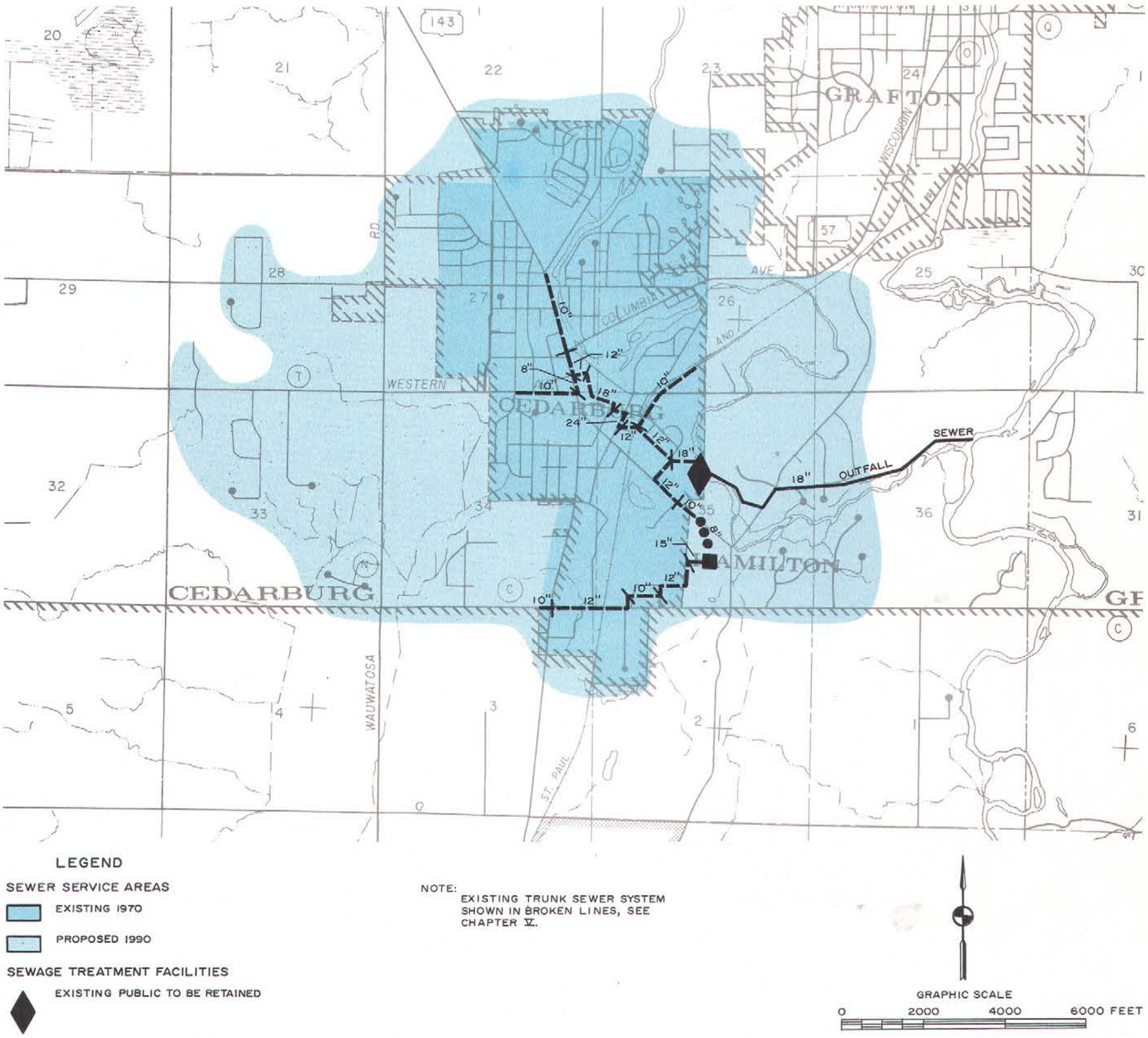
Clearly, it would be more advantageous for Cedarburg to construct the recommended outfall sewer and discharge sewage effluent directly to the Milwaukee River than to construct additional advanced waste treatment facilities to provide for nitrification and continue discharging effluent to Cedar Creek above the Hamilton Pond. It should be noted that the outfall sewer included in alternative plan 2 is identical to the proposed truck sewer recommended in the adopted Milwaukee River watershed plan. At such time as consolidation of the City of Cedarburg and the Village of Grafton facilities becomes feasible, the proposed outfall sewer would serve as a trunk sewer conveying raw sewage from the existing Cedarburg plant site to the proposed joint plant site. Cost estimates for carrying out the proposed plan for Cedarburg, based upon 1970 capacity of the Cedarburg sewage treatment plant and including the outfall sewer proposed in alternative plan 2 above, are set forth in Table 116. The specific recommended performance standards for the Cedarburg sewage treatment plant are set forth in Table 117.

With respect to the Village of Grafton, it is important to note that ammonia toxicity was not found to constitute a significant factor in management of the water quality of the Milwaukee River. Accordingly, the treatment level recommendation for Grafton as set forth in the watershed plan remains unchanged. It is recognized that while the Village of Grafton has recently (1972) provided a modest capacity increment to its existing sewage treatment facility, as well as improvement in the level of waste treatment provided in terms of phosphorus removal and effluent disinfection, nearly an additional 1.0 mgd of average hydraulic design capacity will be required to meet the anticipated demand created by development proposed in the adopted regional land use plan. Comparative analyses were thus made relative to two alternative sanitary sewerage system plans for the Grafton sewer service area. Recommended treatment levels and performance standards under each alternative are set forth in Table 118, with detailed cost estimates for each alternative set forth in Table 119. Under alternative plan 1 the existing Grafton sewage treatment facility would be expanded to provide a total average hydraulic design capacity of about 1.9 mgd, and would continue to provide advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection (see Map 66). The estimated capital cost of carrying out this alternative plan is $670,800, with an equivalent annual cost of about $139,500. Under the second alternative plan presented, the anticipated increment in treatment plant capacity would be provided at a proposed new plant to be located at or near the proposed joint Cedarburg-Grafton plant site shown in the adopted watershed plan (see Map 67). Under this alternative the village would continue to operate its existing sewage treatment facility in addition to constructing the new facility. The total estimated capital cost of carrying out this alternative plan is about $1.0 million, with an equivalent annual cost of about $151,200. Each of the two treatment plants under this alternative would provide advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection.

Based upon the foregoing analyses, it would be more advantageous for the Village of Grafton to provide additional capacity at its existing sewage treatment facility to accommodate anticipated future demand, at least with respect to the extent of urban development as proposed in the adopted regional land use plan, than to construct and operate a second facility. Accordingly, it is proposed that the Village of Grafton proceed with additional expansion of its treatment facility to a total capacity of about 2.0 mgd. It is important to note in this respect that with the proposed expansion the Grafton treatment plant site will be fully utilized with little potential for further expansion. At such time as additional treatment capacity should be required above and beyond the approximately 2.0 mgd, therefore, consideration should be given to providing such capacity at the proposed Cedarburg-Grafton areawide treatment plant site as recommended in the adopted Milwaukee River watershed plan.

Map 65

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE CEDARBURG SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990



Recent sewerage facility development by the City of Cedarburg, including the addition of advanced waste treatment for phosphorus removal at the existing sewage treatment plant, lead to a reconsideration of the sewerage facility development recommendation made in the Milwaukee River watershed plan to provide for advanced waste treatment of Cedarburg wastes at a joint waste treatment facility proposed to be constructed in cooperation with the Village of Grafton at a site located near the confluence of Cedar Creek and the Milwaukee River. Since the City of Cedarburg now has sufficient average hydraulic design capacity to meet anticipated 1990 demand, it is recommended that the City now construct an outfall sewer that would discharge the sewage effluent directly to the Milwaukee River and thus avoid the necessity to construct additional advanced waste treatment facilities to provide nitrification and continue discharging effluent to Cedar Creek above the Hamilton Pond. Construction of such an outfall sewer would represent a more cost effective solution to meeting the water use objectives for Cedar Creek than would the provision of additional nitrification facilities. In addition, the proposed outfall sewer could serve as an influent trunk sewer to a future areawide treatment facility on the Milwaukee River that may be needed to serve the Cedarburg-Grafton area beyond the 1990 plan design period.

Source: SEWRPC.

Table 115

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE CEDARBURG SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Plan Subelement[1]	Estimated Cost						
	Capital Construction	Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
		Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1 Addition of advanced waste treatment facilities (nitrification) at existing Cedarburg sewage treatment plant	$481,500	$593,900	$348,800	$942,700	$37,600	$22,200	$59,800
ALTERNATIVE PLAN 2 Construction of outfall sewer to the Milwaukee River	$261,100	$261,400	$ 8,500	$269,900	$16,600	$ 500	$17,100

[1]*Each of the two alternative plans presented is based upon the capacity of the Cedarburg sewage treatment plant as of 1973 rather than 1970, the base year of the regional sanitary sewerage system plan.*

Source: SEWRPC.

Table 116

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE CEDARBURG SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
	Capital Construction	Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
		Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Cedarburg[1]							
Facilities (2.48 MGD)	$ 898,300	$1,296,300	$2,723,200	$4,019,500	$ 82,200	$172,800	$255,000
Outfall Sewer	261,100	261,400	8,500	269,900	16,600	500	17,100
Land (3.7 Acres)	18,500	18,500	--	18,500	1,200	--	1,200
Subtotal	1,177,900	1,576,200	2,731,700	4,307,900	100,000	173,300	273,300
Trunk Sewers--None							
Total	$1,177,900	$1,576,200	$2,731,700	$4,307,900	$100,000	$173,300	$273,300

[1]*Includes the cost of additional treatment capacity constructed and placed into operation by the City of Cedarburg in 1972.*

Source: SEWRPC.

Table 117

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE CEDARBURG SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Cedarburg[2] (2.48 MGD)	Cedarburg	14,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 65.*
[2]*Assumes the construction of an outfall sewer from the existing Cedarburg sewage treatment plant to the Milwaukee River.*

Source: SEWRPC.

Table 118

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE GRAFTON SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Grafton (North) (1.9 MGD)	Grafton	10,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Grafton (North) (1.0 MGD)	Grafton (part)	5,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Grafton (South) (0.9 MGD)	Grafton (part)	5,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Maps 66 and 67.*

Source: SEWRPC.

Table 119

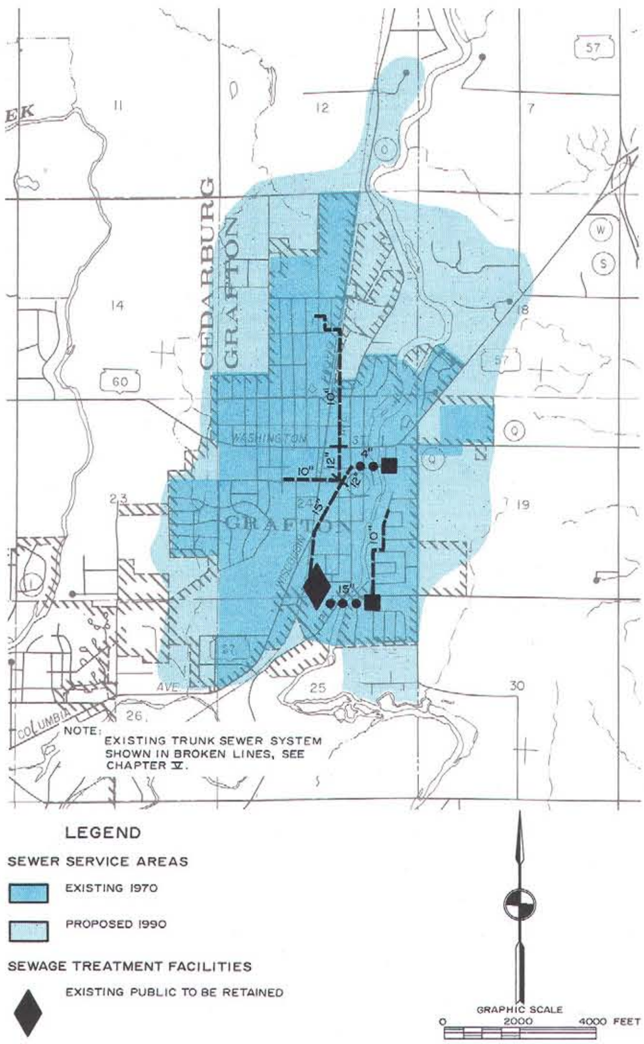
DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE GRAFTON SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
Plan Subelement	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plant							
Grafton (North)							
Facilities (1.9 MGD)	$ 654,800	$ 734,500	$1,453,300	$2,187,800	$46,600	$92,200	$138,800
Land (3.2 Acres)	16,000	11,000	--	11,000	700	--	700
Subtotal	670,800	745,500	1,453,300	2,198,800	47,300	92,200	139,500
Trunk Sewers--None							
Total	$ 670,800	$ 745,500	$1,453,300	$2,198,800	$47,300	$92,200	$139,500
ALTERNATIVE PLAN 2							
Sewage Treatment Plants							
Grafton (North)							
Facilities (1.0 MGD)	$ --	$ 151,300	$ 668,300	$ 819,600	$ 9,600	$42,400	$ 52,000
Subtotal	--	151,300	668,300	819,600	9,600	42,400	52,000
Grafton (South)							
Facilities (0.9 MGD)	995,000	885,800	666,700	1,552,500	56,200	42,300	98,500
Land (3.2 Acres)	16,000	11,000	--	11,000	700	--	700
Subtotal	1,011,000	896,800	666,700	1,563,500	56,900	42,300	99,200
Trunk Sewers--None							
Total	$1,011,000	$1,048,100	$1,335,000	$2,383,100	$66,500	$84,700	$151,200

Source: SEWRPC.

Map 66

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1
FOR THE GRAFTON SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990

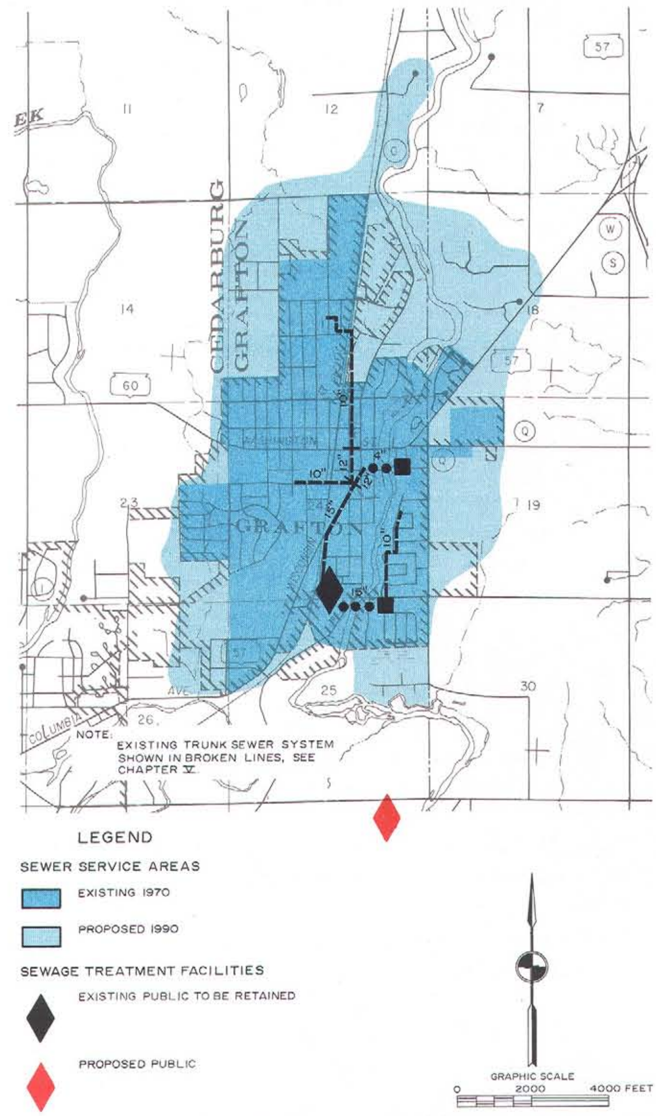


The first alternative sanitary sewerage system plan for the Grafton sewer service area proposes expansion of the existing Village of Grafton sewage treatment plant to a total average hydraulic design capacity of about 1.9 mgd and thus provide for anticipated growth in the village through 1990. The village would continue to provide advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. Advanced waste treatment for nitrification would not be necessary because of the substantial dilution capacity available in the Milwaukee River at this location. This alternative was found to be more cost effective than the second alternative, as shown on Map 67, which would provide for the construction of a second Village of Grafton sewage treatment facility at a downstream location.

Source: SEWRPC.

Map 67

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE GRAFTON SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990



The second alternative sanitary sewerage system plan for the Grafton sewer service area would provide the additional sewage treatment plant capacity needed to serve the Village of Grafton through the year 1990 at a new sewage treatment plant located downstream from the existing plant site and near the confluence of the Milwaukee River and Cedar Creek. This alternative was found to be less cost effective than the provision of a similar amount of capacity at the existing Village of Grafton sewage treatment plant site. Accordingly, it is proposed that the Village of Grafton expand its existing treatment facility to provide for a total 1990 average hydraulic design capacity of about 2.0 mgd.

Source: SEWRPC.

In summary, the proposed sanitary sewerage system plan for the Cedarburg-Grafton area consists of the following:

1. Construction of an outfall sewer from the existing Cedarburg treatment facility to the Milwaukee River near the Cedar Creek confluence in lieu of the provision of more expensive nitrification facilities at the Cedarburg plant.

2. Expansion of the existing Grafton treatment facility to provide for a total average hydraulic design capacity of about 2.0 mgd.

3. At such time as urban development in the Cedarburg-Grafton area exceeds that anticipated in the adopted regional land use plan, the reconsideration of sewage treatment alternatives to include at least the following:

   a. Further expansion of the existing Cedarburg and Grafton sewage treatment facilities.

   b. Construction of a joint sewage treatment facility to serve the Cedarburg-Grafton area on a site near the confluence of Cedar Creek and the Milwaukee River.

Green Lake: The recommendation set forth in the watershed plan that sanitary sewer service be established to serve urban development on the shoreline of Green Lake in the Town of Farmington was modified based upon the reevaluation. Since the plant is recommended to discharge into a wetland area tributary to the main stem of the Milwaukee River, ammonia toxicity may be expected to constitute a significant water quality management problem. Accordingly, the plan proposes that an aerated lagoon type sewage treatment facility be constructed to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent disinfection. An aerated lagoon type facility is considered feasible in the Green Lake area because of its remoteness from major areas of concentrated urban development, the availability of land for the lagoon site, and its very small size—about 0.09 mgd. Specific recommended performance standards for the Green Lake sewage treatment plant are set forth in Table 120.

The costs of implementing the recommended plan for the Green Lake area are set forth in Table 121. These costs assume construction of an aerated lagoon type treatment facility rather than an activated sludge type facility as assumed in the Milwaukee River watershed study. The estimated capital cost of constructing the sewage treatment facility is about $78,900, with an equivalent annual cost of about $6,900. The proposed 1990 sewer service area for Green Lake is shown on Map 68.

Saukville: The recommendation set forth in the watershed plan that the Saukville sewage treatment facility be expanded and provide secondary waste treatment, advanced waste treatment for phosphorus removal, and the auxiliary waste treatment of effluent disinfection remains unchanged.

Table 120

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE GREEN LAKE SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Green Lake (0.09 MGD)	Green Lake	700	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 68.

Source: SEWRPC.

Ammonia toxicity was found not to constitute a significant factor in management of the water quality of the Milwaukee River in this stream reach. Accordingly, it is recommended that the plant be expanded to an average hydraulic design capacity of about 0.4 mgd. Specific recommended performance standards for the Saukville sewage treatment plant are set forth in Table 122. The estimated capital cost of constructing the necessary treatment facilities, adjusted from the watershed plan to the year 1970, is about $187,000, with an equivalent annual cost of about $52,400 (see Table 123). The proposed 1990 sewer service area for Saukville is shown on Map 69.

Concluding Remarks—Subregional Area Plan: A comparison between the recommended treatment levels at municipal sewage treatment plants in the Upper Milwaukee River subregional area as initially set forth in the adopted Milwaukee River watershed plan and as modified in the regional sanitary sewerage system plan is set forth in Table 124. In most cases no substantive changes in the watershed plan recommendation have been made. In three instances—West Bend, Jackson, and Green Lake—the watershed plan recommendations have been modified to provide for the additional advanced waste treatment process of nitrification because ammonia toxicity was found

Table 121

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE GREEN LAKE SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990

Plan Subelement	Estimated Cost						
	Capital Construction	Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
		Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Green Lake							
Facilities (0.09 MGD)	$45,900	$41,000	$44,100	$ 85,100	$2,600	$2,800	$5,400
Land (6.6 Acres)	33,000	23,600	--	23,600	1,500	--	1,500
Subtotal	78,900	64,600	44,100	108,700	4,100	2,800	6,900
Trunk Sewers--None							
Total	$78,900	$64,600	$44,100	$108,700	$4,100	$2,800	$6,900

Source: SEWRPC.

Table 122

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SAUKVILLE SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

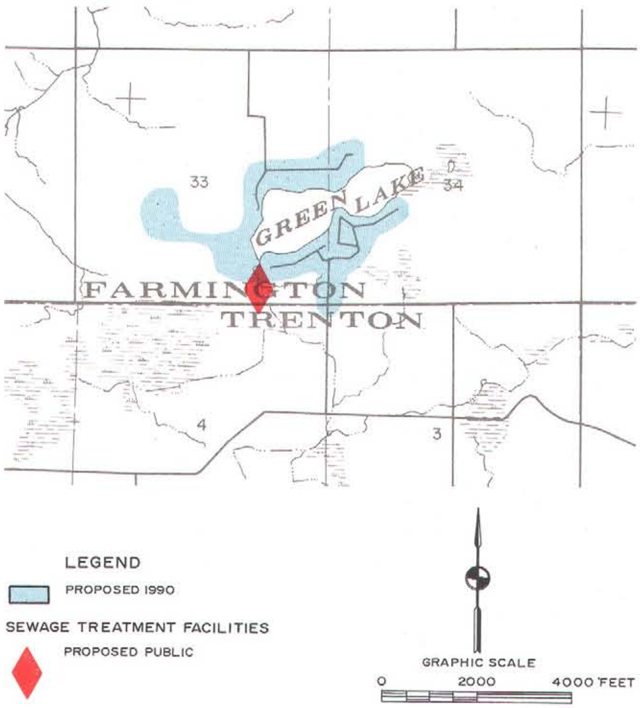
Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Saukville (0.40 MGD)	Saukville	2,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 69.*

Source: SEWRPC.

Map 68

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE GREEN LAKE SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990



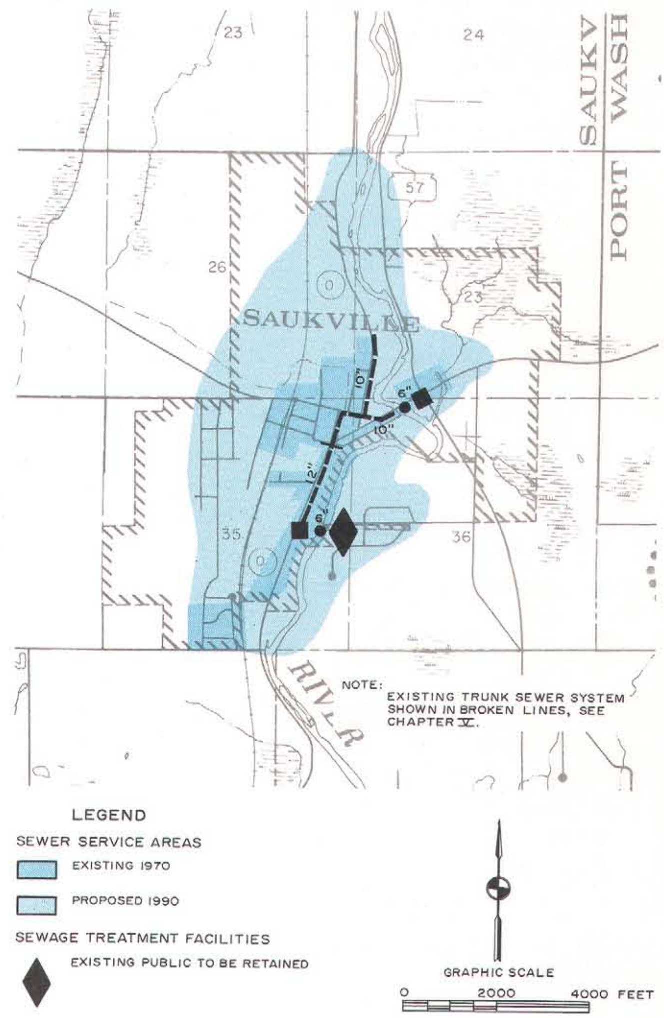
A centralized sanitary sewerage system to serve existing urban development along the shoreline of Green Lake was initially proposed in the adopted Milwaukee River watershed plan. The watershed plan recommendation was modified slightly during preparation of the regional sanitary sewerage system plan in light of consideration of the ammonia toxicity factor on water quality management of the watershed stream system. Accordingly, the sewerage system plan proposes that an aerated lagoon treatment facility be constructed to provide not only secondary waste treatment and auxiliary waste treatment for effluent disinfection, as initially recommended in the watershed plan, but also advanced waste treatment for nitrification.

Source: SEWRPC.

to be a significant factor in water quality management of the particular stream involved. In the Cedarburg-Grafton area the watershed plan recommendation for a joint advanced waste treatment facility has been modified to provide for advanced waste treatment at the two individual plants, with Cedarburg proposed to discharge its effluent through an outfall sewer directly to the Milwaukee River.

Map 69

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE SAUKVILLE SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA
1990



The Milwaukee River watershed plan recommendation that the Village of Saukville sewage treatment facility be expanded and provide, in addition to secondary waste treatment, advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection, was reconfirmed in the regional sanitary sewerage system planning program. Because of the substantial dilution capacity available in this stream reach of the Milwaukee River, ammonia toxicity was not found to constitute a significant water quality management factor and, accordingly, advanced waste treatment for nitrification would not be required.

Source: SEWRPC.

Table 123

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE SAUKVILLE SEWER SERVICE AREA
UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Saukville							
Facilities (0.40 MGD)	$176,600	$284,600	$530,700	$815,300	$18,000	$33,700	$51,700
Land (2.2 Acres)	11,000	11,000	--	11,000	700	--	700
Subtotal	187,600	295,600	530,700	826,300	18,700	33,700	52,400
Trunk Sewers--None							
Total	$187,600	$295,600	$530,700	$826,300	$18,700	$33,700	$52,400

Source: SEWRPC.

Table 124

COMPARISON BETWEEN RECOMMENDED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANTS
IN THE UPPER MILWAUKEE RIVER SUBREGIONAL AREA:
MILWAUKEE RIVER WATERSHED PLAN AND REGIONAL SANITARY SEWERAGE SYSTEM PLAN

Sewage Treatment Plant	Milwaukee River Watershed Plan						Regional Sanitary Sewerage System Plan						Rationale for Change in Treatment Level Recommendations
		Advanced		Auxiliary				Advanced		Auxiliary			
	Secondary	Phosphorus Removal	Nitrification[1]	Effluent Aeration	Effluent Disinfection	Instream Aeration	Secondary	Phosphorus Removal	Nitrification	Effluent Aeration	Effluent Disinfection	Instream Aeration	
Kewaskum	Yes	Yes	No	No	Yes	No	Yes	Yes	No	No	Yes	No	No change.
West Bend	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Ammonia toxicity factor requires provision of nitrification. Nitrification also reduces oxygen demand and thereby eliminates the need for instream aeration facilities downstream from the plant (see Alternative 4 in the watershed study report).
Jackson	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	No	Yes	No	Ammonia toxicity factor requires provision of nitrification.
Newburg	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No	No change.
Fredonia	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No	No change.
Grafton	Yes	Yes[2]	No	No	Yes[2]	No	Yes	Yes	No	No	Yes	No	No change.
Cedarburg	Yes	Yes[2]	No	No	Yes[2]	No	Yes	Yes	No[3]	No	Yes	No	No change[3]
Green Lake	Yes	No	No	No	Yes	No	Yes	No	Yes	No	Yes	No	Ammonia toxicity factor requires provision of nitrification.
Saukville	Yes	Yes	No	No	Yes	No	Yes	Yes	No	No	Yes	No	No change.

[1]*Termed "nitrogenous oxygen demand (NOD) removal" in the Milwaukee River watershed plan.*

[2]*Phosphorus removal and disinfection for Cedarburg and Grafton were recommended in the Milwaukee River watershed plan to be provided at a joint advanced and auxiliary waste treatment facility on the Milwaukee River.*

[3]*Assumes the construction of an outfall sewer from the existing Cedarburg sewage treatment plant to the Milwaukee River.*

Source: SEWRPC.

Private Sewage Treatment Facilities

Implementation of the foregoing recommendations would result in the abandonment of one major private sewage treatment facility in the Upper Milwaukee River subregional area. This facility serves the Libby, McNeill, and Libby, Inc. canning plant in the Town of Jackson. This plant would be served by the proposed new Jackson sewage treatment facility. Three remaining private sewage treatment facilities, all directly related to the agricultural industry, would be retained. These are the Level Valley Dairy facility in the Town of Jackson (see Map 42), the Justro Feed Corporation facility in the Town of Cedarburg (see Map 36), and the River Road Cheese Factory facility in the Town of Saukville (see Map 36). All three of these facilities lie beyond the proposed 1990 service areas of the several sanitary sewerage systems in the subregional area. These facilities should be retained and continue to provide a level of waste treatment designed to meet the established water use objectives for streams in the Upper Milwaukee River subregional area.

SAUK CREEK SUBREGIONAL AREA

The Sauk Creek subregional area includes all of the Sauk Creek watershed, that portion of the Sheboygan River watershed lying within the Region, and minor drainage areas that are directly tributary to Lake Michigan lying generally north of the City of Port Washington. The entire subregional area lies within Ozaukee County. While predominantly rural and agricultural in character, this subregional area contains the City of Port Washington and environs, the Village of Belgium, concentrations of urban development along the shoreline of Lake Michigan in the Town of Belgium, and the newly established Harrington Beach State Park, a major outdoor recreation facility recommended to be established in the adopted regional land use plan.

As noted in Chapter V of this report, centralized sanitary sewer service in the Sauk Creek subregional area was provided by two systems in 1970: those operated by the City of Port Washington and the Village of Belgium. The service areas of these two systems together comprised an area of about 2.3 square miles and served an estimated population of about 9,600 persons. In 1970 there were about 3,300 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the two existing systems are presented in Chapter V of this report.

Sewer Service Analysis Areas

A total of three sewer service analysis areas may be identified within the Sauk Creek subregional area (see Table 125). These three sewer service analysis areas are shown on Map 70 and may be described as follows:

1. Area A—This area consists of the Village of Belgium and environs. In 1970 sanitary sewer service was provided in this area to about 0.3 square mile, having a total resident population of about 800 persons. By 1990 the total area anticipated to be served approximates 0.8 square mile, with a projected population of about 1,600 persons. This subarea is referenced as the "Belgium" sewer service area in the ensuing discussion.

2. Area B—This area consists of the unincorporated village of Lake Church in the Town of Belgium, existing urban development along the shoreline of Lake Michigan in the Town of Belgium, and the Harrington Beach State Park. About 700 persons resided in this area in 1970, but no sani-

Table 125

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE SAUK CREEK SUBREGIONAL AREA 1970 and 1990

Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Belgium	0.26	800	0.06	60	0.83	1,600	0.36
B	Lake Church	--	--	--	700	2.39	700	0.45[2]
C	Port Washington	2.01	8,800	1.05	300	3.64	12,400	2.60
Total		2.27	9,600	1.11	1,060	6.86	14,700	3.41

[1]See Map 70.
[2]Includes anticipated sewage flow of 0.30 MGD from the Harrington Beach State Park.
Source: SEWRPC.

tary sewer service was provided. Because of widespread failure of septic tank systems, the Wisconsin Department of Natural Resources has ordered the installation of centralized sanitary sewer service in the area comprising the unincorporated village of Lake Church. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 2.4 square miles, with a projected population of about 700 persons. In addition, the Harrington Beach State Park is anticipated to provide a design sewage flow of about 0.3 mgd. This subarea is referenced as the "Lake Church" sewer service area in the ensuing discussion.

3. Area C—This area consists of the City of Port Washington and environs. In 1970, sanitary sewer service was provided in this area to about two square miles, having a total resident population of about 8,800 persons. By 1990 the total area anticipated to be served approximates 3.6 square miles, with a projected population of about 12,400 persons. This subarea is referenced as the "Port Washington" sewer service area in the ensuing discussion.

Formulation of Alternatives

As discussed earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system planning program for the formulation of alternative plans. The first step in this process was to apply the Wisconsin Department of Natural Resources (DNR) guidelines relating distances between communities to the populations of both the "sending" and "receiving" communities in order to determine if potential interconnections between sanitary sewerage systems should be investigated. The results of the application of these criteria to the communities within the Sauk Creek subregional sewerage system planning area are summarized in Table 126.

Based on the DNR guidelines, the following potential interconnections between sewer service areas in the Sauk Creek subregional area were eliminated from further consideration:

1. Belgium to Port Washington.

2. Lake Church to Port Washington.

One interconnection—Lake Church to Belgium—was found to be potentially feasible through the application of the DNR guidelines. Conduct of a preliminary economic analysis for this potential interconnection further revealed that a detailed economic analysis was warranted. Accordingly, it was determined that the following sanitary sewerage system plans for the Sauk Creek subregional area should be prepared and evaluated:

1. A proposed plan for the Port Washington sewer service area.

2. Two alternative plans for the Belgium-Lake Church sewer service areas, including an alternative providing individual sewage treatment facilities at each of the two sewer service areas and an alternative providing for consolidation of treatment facilities at either the existing Belgium or a proposed Lake Church sewage treatment plant site.

Each of the sanitary sewerage system plan elements is described in the following paragraphs. Data pertaining to required treatment levels at each of the municipal sewage treatment plant sites considered in the preparation of these plan elements are presented in Table 127.

Proposed Plan—Port Washington Subarea

In 1970, the sewage treatment facility serving the Port Washington sewer service area had an average hydraulic design capacity of 1.0 mgd and provided only a primary level of waste treatment. Disposal of effluent is directly to Lake Michigan within the Port Washington Harbor. As noted in Chapter V, a sewage treatment plant expansion program is underway[9] to provide for a total average hydraulic design capacity of 1.25 mgd, including the provision of secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. By 1990 it is anticipated that future growth will require an average hydraulic design capacity for the treatment facility serving the Port Washington sewer service area of about 2.60 mgd.

The proposed plan for the Port Washington sewer service area includes construction of necessary primary, secondary, advanced, and auxiliary waste treatment facilities to provide for a total 1990 average hydraulic design capacity of 2.6 mgd. In

[9] *This expansion program was completed during 1973.*

addition, the plan proposes the construction of a new outfall sewer to carry the sewage effluent out into Lake Michigan south of the Port Washington Harbor area. The specific recommended performance standards for the Port Washington sewage treatment plant are set forth in Table 128.

The estimated capital cost for constructing the necessary treatment facilities at Port Washington is about $1.8 million, with an equivalent annual cost of about $244,000 (see Table 129). These costs include the cost of the necessary outfall sewer. The costs are based upon the provision of additional capacity to the plant as it existed in 1970 and, therefore, include the cost of the additional primary, secondary, and advanced waste treatment capacity currently under construction. The proposed 1990 service area for the Port Washington urban concentration is shown on Map 71.

Alternative Plans—Belgium-Lake Church

As indicated above, preliminary economic analyses revealed a need to consider the interconnection of the Belgium and Lake Church sewer service areas for sewage treatment purposes. In 1970 only the Village of Belgium operated a sewage treatment facility.

Two basic alternative plans were formulated, with subalternatives based upon varying treatment plant locations within the Lake Church sewer service area. The first alternative assumes the continuation of the existing Belgium treatment facility and the establishment of a new treatment facility to serve the Lake Church sewer service area, either discharging its effluent to Sucker Creek (alternative plan 1A) or directly to Lake Michigan (alternative plan 1B). The second alternative provides for one sewage treatment facility to serve both the Belgium and Lake Church sewer service areas, with the alternatives differing with respect to the location of the single plant. Alternative 2A locates the single plant at the existing site of the Belgium sewage treatment facility. Alternative 2B locates the plant on Sucker Creek in the Lake Church sewer service area. Alternative 2C locates the plant on Lake Michigan in the Lake Church sewer service area. Required sewage treatment levels and performance standards under all alternatives are set forth in Table 130, while detailed cost estimates pertaining to all alternatives are set forth in Table 131. The five proposals are shown in graphic form on Maps 72 through 76.

Under alternative 1A, the existing Belgium sewage treatment facility would be expanded from its present average hydraulic design capacity of 0.07 mgd to a proposed 1990 average hydraulic design capacity of 0.36 mgd. In order to meet the established water use objectives for the Onion River, a tributary of the Sheboygan River, this expanded facility would be required to provide not only secondary waste treatment but also advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. Also under alternative 1A, a new sewage treatment facility would be constructed on a site along Sucker Creek, a minor tributary to Lake Michigan, to serve the Lake Church sewer service area. This facility would need to provide an average hydraulic design capacity of about 0.45 mgd, which would accommodate an estimated 0.30 mgd of sewage from the Harrington Beach State Park. In order to meet the established water use objectives for Sucker Creek, this Lake Church facility would be required to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The total estimated capital cost of carrying out alternative plan 1A for the Belgium and Lake Church sewer service areas is about $1.6 million, with an equivalent annual cost of about $148,000.

Alternative plan 1B is similar to alternative plan 1A except that, with respect to the Lake Church sewage treatment facility, the plant is proposed to be located near the Lake Michigan shoreline and discharge its effluent through an outfall sewer directly to Lake Michigan rather than to Sucker Creek. The proposed treatment expansion for the Belgium facility under alternative 1B, and the recommended levels of treatment, are identical to alternative plan 1A. With respect to the Lake Church facility, alternative plan 1B would be sized similarly to that provided in alternative plan 1A, but the plant would have to provide only a secondary level of waste treatment and auxiliary waste treatment for effluent disinfection, since the effluent is no longer being discharged to Sucker Creek where more stringent treatment standards would be required to meet the water use objectives. The total estimated capital cost of carrying out alternative plan 1B for the Belgium and Lake Church sewer service areas, including an outfall sewer extending 1,000 feet into Lake Michigan as as integral part of the Lake Church treatment facility, is about $1.9 million, with an equivalent annual cost of about $152,000.

Table 126

RESULTS OF THE APPLICATION OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES INTERCONNECTION GUIDELINES AND PRELIMINARY ECONOMIC ANALYSES IN THE SAUK CREEK SUBREGIONAL AREA

Sewer Service Analysis Area(s)				Results of Application of DNR Guidelines		Results of Preliminary Economic Analysis			
Receiving		Sending		Straight Line Distance Between Sewer Service Areas (Miles)	Proceed to Preliminary Economic Analysis (Yes or No)	Total Equivalent Annual Cost		Percent Difference (B-A)/(A)	Proceed to Detailed Economic Analysis[1] (Yes or No)
Name	Estimated 1990 Population	Name	Estimated 1990 Population			Separate Plants (A)	Interconnection-One Plant (B)		
Port Washington	12,400	Belgium Lake Church	1,600 700	7.6 7.8	No No	$ -- --	$ -- --	-- --	-- --
Belgium	1,600	Lake Church	700	1.5	Yes	$95,700	$103,900	8.6	Yes

[1]If the estimated equivalent annual cost of interconnection was no more than 20 percent greater than the cost of providing separate sewage treatment facilities, a detailed economic analysis was deemed to be required.

Source: SEWRPC.

Table 127

REQUIRED TREATMENT LEVELS AT MUNICIPAL TREATMENT PLANT SITES IN THE SAUK CREEK SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Water Body	Stream Low Flow and Dilution Ratio Data									Level of Treatment Required				
		7-Day, 10-Year Low Flow		Upstream Sewage Treatment Plant Flow-1990		Total Design Low Flow-1990		Total Design Sewage Flow-1990		Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Secondary	Advanced		Auxiliary	
		CFS	MGD	CFS	MGD	CFS	MGD	CFS	MGD			Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Belgium[1,2]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	0.56	0.36	N/A	Yes	No	Yes	Yes	Yes
Belgium-Lake Church[3]	Onion River	0.00	0.00	0.00	0.00	0.00	0.00	1.21	0.81	0.00	Yes	No	Yes	Yes	Yes
Lake Church[1]	Sucker Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.45	0.00	Yes	No	Yes	Yes	Yes
Lake Church[2]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	0.70	0.45	N/A	Yes	No	No	No	Yes
Lake Church-Belgium[4]	Sucker Creek	0.00	0.00	0.00	0.00	0.00	0.00	1.21	0.81	0.00	Yes	No	Yes	Yes	Yes
Lake Church-Belgium[5]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	1.21	0.81	N/A	Yes	No	No	No	Yes
Port Washington	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	4.02	2.60	N/A	Yes	Yes	No	No	Yes

NOTE: N/A indicates not applicable.

[1]Corresponds to Belgium-Lake Church alternative plan 1A.
[2]Corresponds to Belgium-Lake Church alternative plan 1B.
[3]Corresponds to Belgium-Lake Church alternative plan 2A.
[4]Corresponds to Belgium-Lake Church alternative plan 2B.
[5]Corresponds to Belgium-Lake Church alternative plan 2C.

Source: SEWRPC.

Table 128

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE PORT WASHINGTON SEWER SERVICE AREA SAUK CREEK SUBREGIONAL AREA

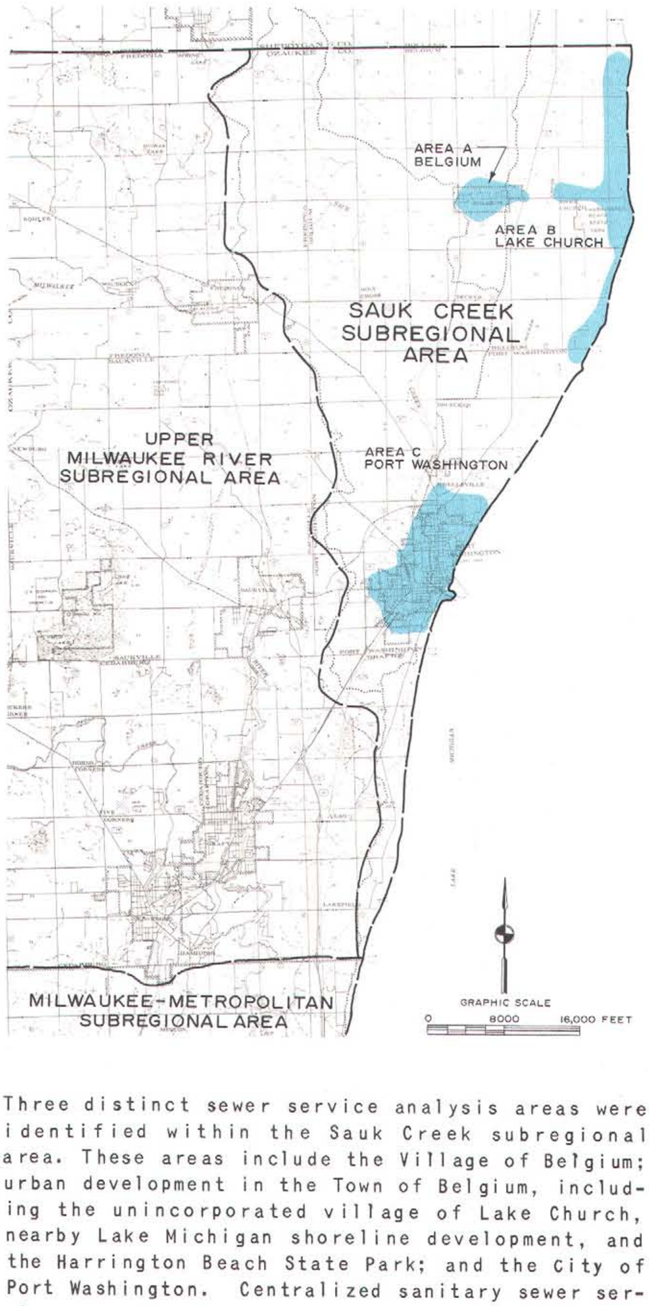
Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Port Washington (2.60 MGD)	Port Washington	12,400	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 71.

Source: SEWRPC.

Map 70

SEWER SERVICE ANALYSIS AREAS
SAUK CREEK SUBREGIONAL AREA

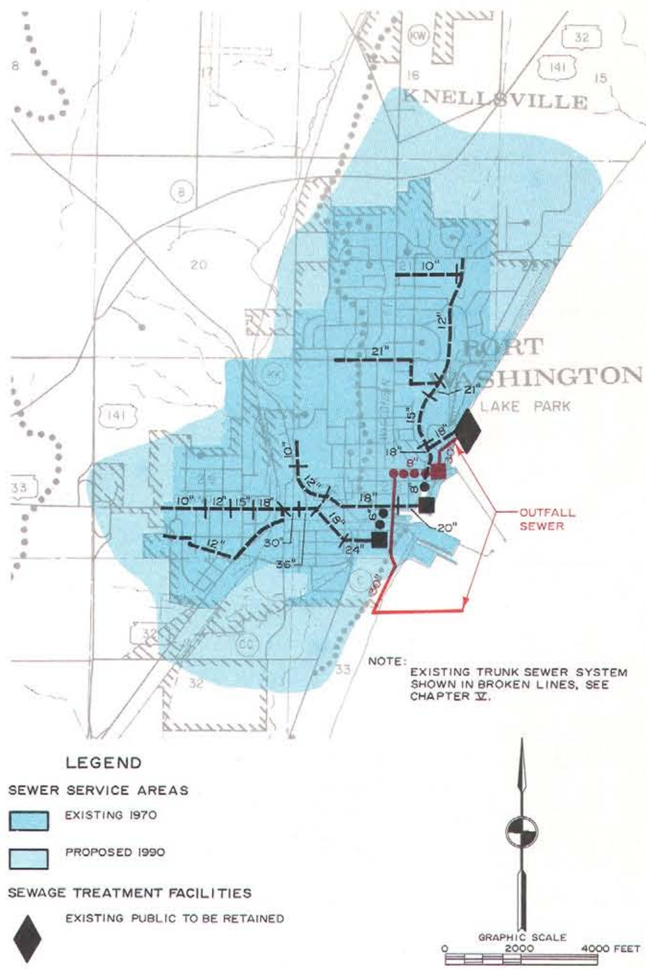


Three distinct sewer service analysis areas were identified within the Sauk Creek subregional area. These areas include the Village of Belgium; urban development in the Town of Belgium, including the unincorporated village of Lake Church, nearby Lake Michigan shoreline development, and the Harrington Beach State Park; and the City of Port Washington. Centralized sanitary sewer service was provided in 1970 in the Village of Belgium and the City of Port Washington, with the Lake Church area of the Village of Belgium under orders in 1970 from the Wisconsin Department of Natural Resources to provide such service. Analyses conducted under the regional sewerage study indicated that significant interconnection potential existed between the Belgium and Lake Church sewer service areas.

Source: SEWRPC.

Map 71

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE PORT WASHINGTON SEWER SERVICE AREA
SAUK CREEK SUBREGIONAL AREA
1990



In 1970 the City of Port Washington provided only primary waste treatment, with discharge of the treated effluent directly to Lake Michigan within the harbor area. The proposed plan for Port Washington includes construction of additional treatment facilities to provide not only primary treatment, but also secondary treatment, advanced treatment for phosphorus removal, and auxiliary treatment for disinfection. In addition, it is proposed that a new outfall sewer be constructed to carry the sewage effluent farther out into Lake Michigan south of the harbor area. The total estimated 1990 average hydraulic design capacity of the plant is 2.6 mgd. It should be noted that the City of Port Washington completed during 1973 construction of additional sewage treatment facilities to provide the recommended secondary, advanced, and auxiliary treatment levels for a plant design capacity of 1.25 mgd.

Source: SEWRPC.

As noted above, the second basic alternative involves the provision of only one sewage treatment facility to serve the Belgium-Lake Church sewer service areas. Under alternative plan 2A

Table 129

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE PORT WASHINGTON SEWER SERVICE AREA
SAUK CREEK SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Port Washington							
Facilities (2.60 MGD)	$ 892,000	$ 999,300	$1,825,200	$2,824,500	$ 63,400	$115,800	$179,200
Outfall Sewer	908,000	848,000	157,600	1,005,600	53,800	10,000	63,800
Land (3.8 Acres)	19,000	14,000	--	14,000	900	--	900
Subtotal	$1,819,000	$1,861,300	$1,982,800	$3,844,100	$118,100	$125,800	$243,900
Trunk Sewers--None							
Total	$1,819,000	$1,861,300	$1,982,800	$3,844,100	$118,100	$125,800	$243,900

Source: SEWRPC.

the existing Belgium treatment facility would be expanded to a capacity of 0.81 mgd and provide treatment for sewage from the Belgium and Lake Church sewer service areas. In order to meet the established water use objectives for the Onion River, this facility would have to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The total estimated capital cost of carrying out alternative plan 2A for the Belgium and Lake Church sewer service areas, including the construction of a trunk sewer to convey sewage from Lake Church to Belgium, is about $1.6 million, with an equivalent annual cost of about $134,000.

Under alternative plan 2B, all sewage from the Belgium and Lake Church sewer service areas would be treated at a new 0.81 mgd sewage treatment facility to be located at Lake Church on Sucker Creek. In order to meet the established water use objectives for Sucker Creek, this facility would be required to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The total estimated capital cost of carrying out alternative plan 2B for the Belgium and Lake Church sewer service areas, including a trunk sewer to convey sewage from Belgium to Lake Church, is about $1.6 million, with an equivalent annual cost of about $133,000.

Under alternative plan 2C, all sewage from the Belgium and Lake Church sewer service areas would be treated at a proposed new 0.81 mgd sewage treatment facility to be located near the Lake Michigan shoreline in the Lake Church sewer service area. This facility would discharge its effluent directly to Lake Michigan through an outfall sewer extending 1,000 feet into the lake. This facility would be required to provide secondary waste treatment and auxiliary waste treatment for effluent disinfection. The total estimated capital cost of carrying out alternative plan 2C for the Belgium and Lake Church sewer service areas, including a trunk sewer to convey sewage from Belgium to Lake Church and a Lake Michigan outfall sewer, is about $2.0 million, with an equivalent annual cost of about $148,000.

Between the two basic alternatives considered for the Belgium and Lake Church sewer service areas, the alternative of providing one new centralized sewage treatment plant is more economical than the alternative that would provide for two sewage treatment plants, no matter where the Lake Church plant would be located, when viewed on an equivalent annual cost basis. Between the three subalternatives, each of which provides for one single waste treatment facility, the first two considered, which would provide for new sewage treatment plants on the Onion River and Sucker Creek, respectively, are somewhat less expensive than the Lake Michigan plant alternative,

Table 130

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS
SAUK CREEK SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1A					
Belgium (0.36 MGD)	Belgium	1,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Lake Church (0.45 MGD) (Sucker Creek)	Lake Church	700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 1B					
Belgium (0.36 MGD)	Belgium	1,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Lake Church (0.45 MGD) (Lake Michigan)	Lake Church	700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2A					
Belgium (0.81 MGD)	Belgium Lake Church	2,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2B					
Lake Church (0.81 MGD) (Sucker Creek)	Belgium Lake Church	2,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3 N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2C					
Lake Church (0.81 MGD) (Lake Michigan)	Belgium Lake Church	2,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 71.*

Source: SEWRPC.

indicating that the capital cost of the outfall sewer is greater than the capital cost of the additional advanced waste treatment facilities and the additional operation and maintenance costs required to provide a higher level of waste treatment at a plant on either the Onion River or Sucker Creek. Alternative plan 2A has the added advantage of using the existing Village of Belgium sewerage system as a basis upon which to build the proposed areawide system to serve both sewer service areas.

Private Sewage Treatment Plants

Two private sewage treatment facilities currently discharge wastes in the Sauk Creek subregional area. These facilities serve the Krier Preserving Company in the Town of Belgium and the Hiller Cheese Company in the Town of Fredonia (see

Table 131

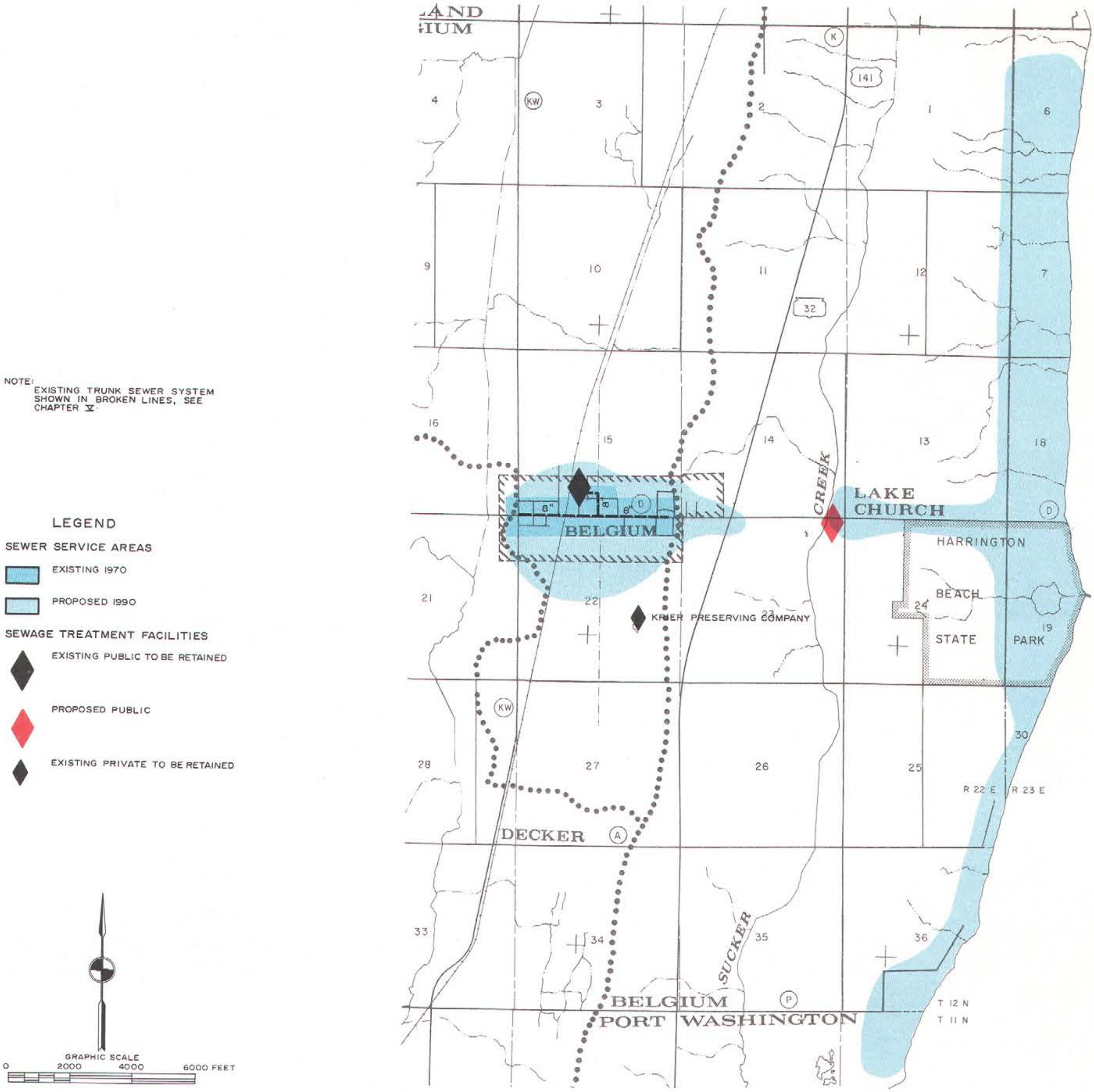
DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS
SAUK CREEK SUBREGIONAL AREA

	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
Plan Subelement	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1A							
Sewage Treatment Plants							
Belgium							
Facilities (0.36 MGD)	$ 714,800	$ 646,200	$338,900	$ 985,100	$ 41,000	$21,500	$ 62,500
Land (2.6 Acres)	13,000	9,500	--	9,500	600	--	600
Subtotal	727,800	655,700	338,900	994,600	41,600	21,500	63,100
Lake Church (Sucker Creek)							
Facilities (0.45 MGD)	851,200	769,200	556,400	1,325,600	48,800	35,300	84,100
Land (2.7 Acres)	13,000	9,500	--	9,500	600	--	600
Subtotal	864,200	778,700	556,400	1,335,100	49,400	35,300	84,700
Subtotal — Sewage Treatment Plants	1,592,000	1,434,400	895,300	2,329,700	91,000	56,800	147,800
Trunk Sewers--None							
Total	$1,592,000	$1,434,400	$895,300	$2,329,700	$ 91,000	$56,800	$147,800
ALTERNATIVE PLAN 1B							
Sewage Treatment Plants							
Belgium							
Facilities (0.36 MGD)	$ 714,800	$ 646,200	$338,900	$ 985,100	$ 41,000	$21,500	$ 62,500
Land (2.6 Acres)	13,000	9,500	--	9,500	600	--	600
Subtotal	727,800	655,700	338,900	994,600	41,600	21,500	63,100
Lake Church (Lake Michigan)							
Facilities (0.45 MGD)	578,500	523,300	430,300	953,600	33,200	27,300	60,500
Outfall Sewer	592,400	433,500	1,600	435,100	27,500	100	27,600
Land (2.7 Acres)	13,500	9,500	--	9,500	600	--	600
Subtotal	1,184,400	966,300	431,900	1,398,200	61,300	27,400	88,700
Subtotal — Sewage Treatment Plants	1,912,200	1,622,000	770,800	2,392,800	102,900	48,900	151,800
Trunk Sewers--None							
Total	$1,912,200	$1,622,000	$770,800	$2,392,800	$102,900	$48,900	$151,800
ALTERNATIVE PLAN 2A							
Sewage Treatment Plants							
Belgium							
Facilities (0.81 MGD)	$1,282,500	$1,158,500	$586,300	$1,744,800	$ 73,500	$37,200	$110,700
Land (3.1 Acres)	15,500	11,000	--	11,000	600	--	600
Subtotal	1,298,000	1,169,500	586,300	1,755,800	74,100	37,200	111,300
Trunk Sewers							
Lake Church-Belgium	287,800	230,100	122,900	353,000	14,600	7,800	22,400
Subtotal	287,800	230,100	122,900	353,000	14,600	7,800	22,400
Total	$1,585,800	$1,399,600	$709,200	$2,108,800	$ 88,700	$45,000	$133,700
ALTERNATIVE PLAN 2B							
Sewage Treatment Plants							
Lake Church (Sucker Creek)							
Facilities (0.81 MGD)	$1,282,500	$1,158,500	$586,300	$1,744,800	$ 73,500	$37,200	$110,700
Land (3.1 Acres)	15,500	11,000	--	11,000	600	--	600
Subtotal	1,298,000	1,169,500	586,300	1,755,800	74,100	37,200	111,300
Trunk Sewers							
Belgium-Lake Church	288,400	234,900	107,200	342,100	14,600	6,800	21,400
Subtotal	288,400	234,900	107,200	342,100	14,600	6,800	21,400
Total	$1,586,400	$1,404,400	$693,500	$2,097,900	$ 88,700	$44,000	$132,700
ALTERNATIVE PLAN 2C							
Sewage Treatment Plants							
Lake Church (Lake Michigan)							
Facilities (0.81 MGD)	$ 881,600	$ 796,000	$406,700	$1,202,700	$ 50,500	$25,800	$ 76,300
Outfall Sewer	595,700	436,600	1,600	438,200	27,200	100	27,800
Land (3.1 Acres)	15,500	11,000	--	11,000	600	--	600
Subtotal	1,492,800	1,243,600	408,300	1,651,900	78,300	25,900	104,700
Trunk Sewers							
Belgium-Lake Church	552,500	450,800	233,300	684,100	28,600	14,800	43,400
Subtotal	552,500	450,800	233,300	684,100	28,600	14,800	43,400
Total	$2,045,300	$1,694,400	$641,600	$2,336,000	$106,900	$40,700	$148,100

Source: SEWRPC.

Map 72

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN IA
FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS
SAUK CREEK SUBREGIONAL AREA
1990

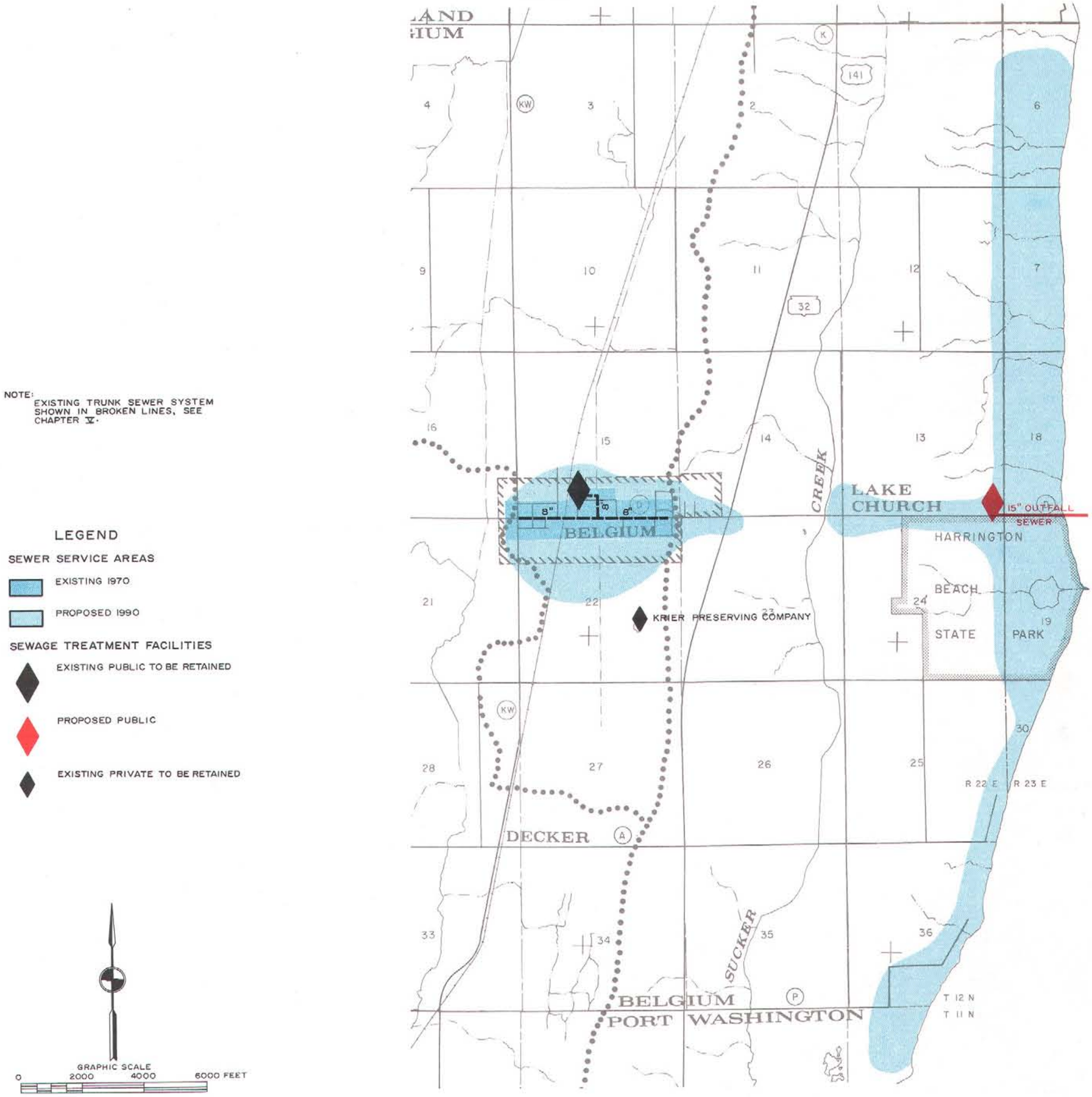


The first alternative plan considered for the Belgium and Lake Church sewer service areas proposes the establishment of two sewage treatment facilities, one to serve the Belgium area and one to serve the Lake Church area. Two subalternatives were identified, differing only with respect to the location of the Lake Church facility. The above map illustrates the first subalternative--IA. The existing Belgium sewage treatment facility would be expanded and provide, in addition to secondary waste treatment, advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. A new Lake Church sewage treatment facility would be constructed on a site along Sucker Creek and would also provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection.

Source: SEWRPC.

Map 73

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN IB
FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS
SAUK CREEK SUBREGIONAL AREA
1990

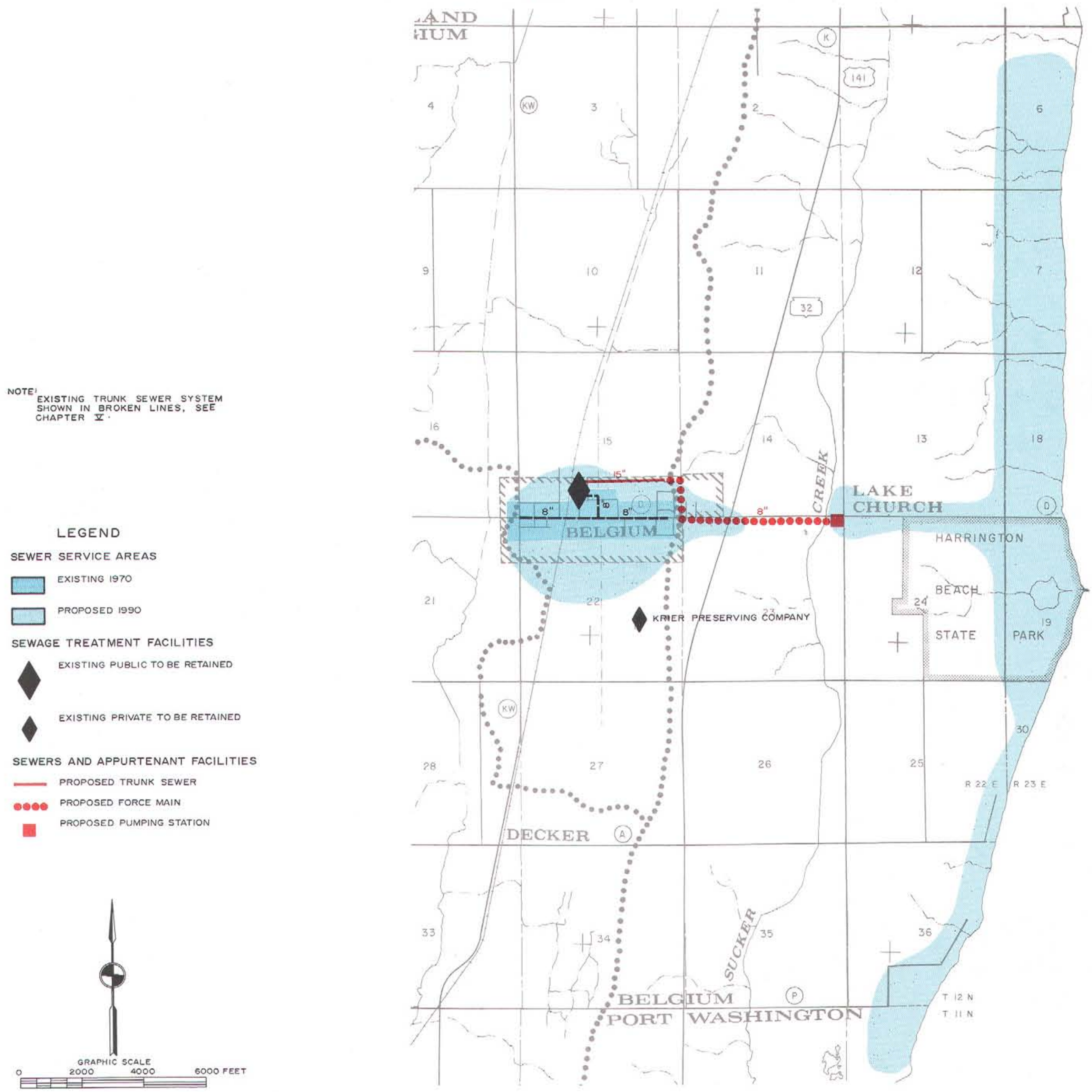


The proposed sewerage facilities under alternative plan IB for the Belgium and Lake Church areas shown on this map differ only slightly from the facilities shown on Map 72. Under this subalternative plan, the Belgium facility would be expanded as under the first subalternative, with the location of the Lake Church sewage treatment facility changed to a site closer to the Lake Michigan shoreline. An outfall sewer to discharge effluent into Lake Michigan is also proposed under this subalternative. The Lake Church facility would need to provide only secondary waste treatment and auxiliary waste treatment for effluent disinfection.

Source: SEWRPC.

Map 74

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2A
FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS
SAUK CREEK SUBREGIONAL AREA
1990

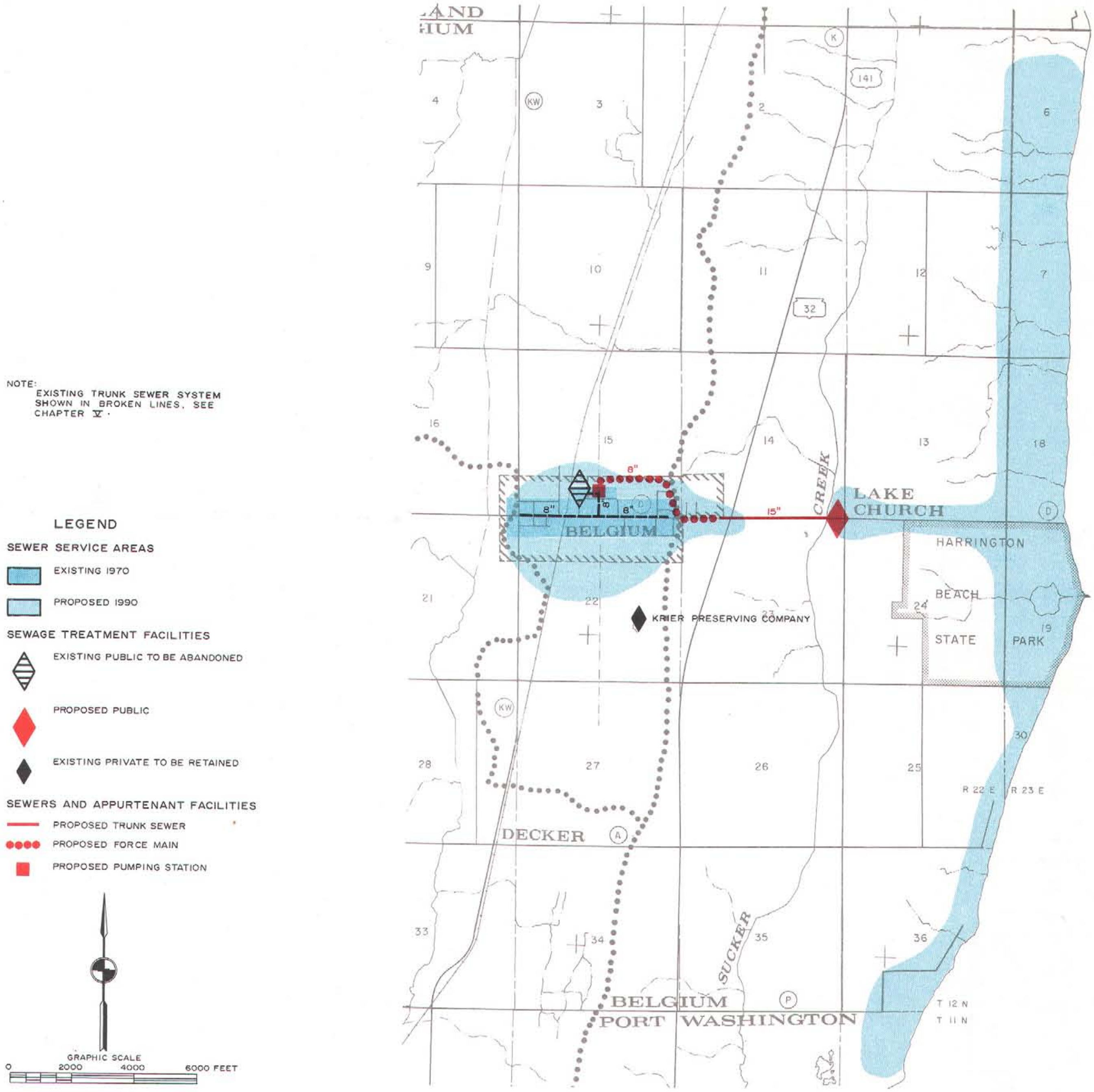


The second alternative plan for the Belgium and Lake Church sewer service areas provides for a single sewage treatment facility to serve both areas. Three subalternatives were formulated. As shown on this map, under subalternative plan 2A, the existing Belgium sewage treatment facility would be expanded to provide sewage treatment to both the Belgium and Lake Church sewer service areas. This facility would provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The trunk sewer system necessary to convey sewage from Lake Church to Belgium is shown on the above map.

Source: SEWRPC.

Map 75

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2B
FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS
SAUK CREEK SUBREGIONAL AREA
1990

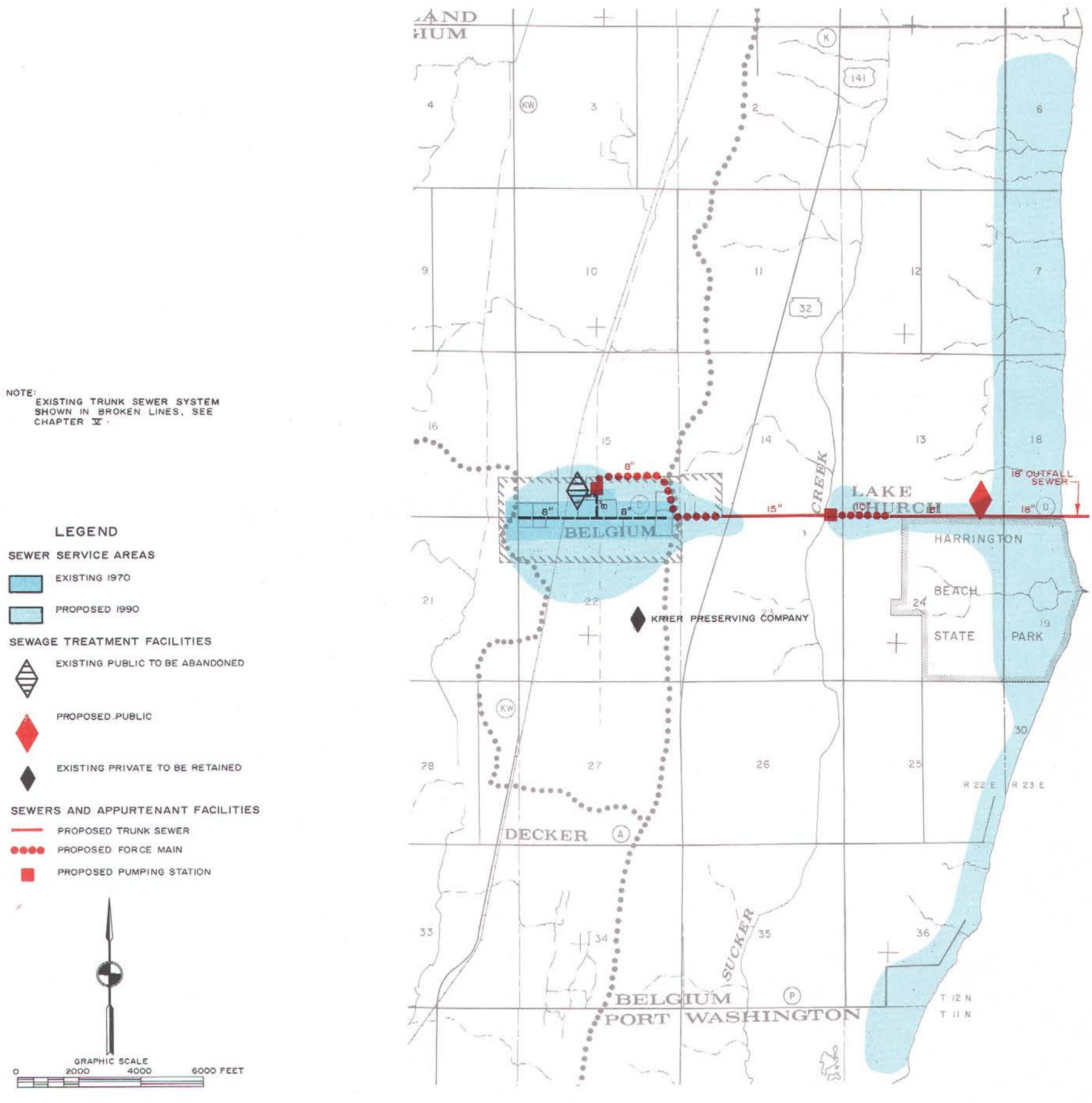


Subalternative plan 2B for the Belgium and Lake Church sewer service areas would provide for a new treatment facility at Lake Church on Sucker Creek together with abandonment of the existing Belgium sewage treatment facility. The Lake Church facility would be required to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The trunk sewer system necessary to convey sewage from Belgium to Lake Church is also shown on the above map.

Source: SEWRPC.

Map 76

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2C
FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS
SAUK CREEK SUBREGIONAL AREA
1990



Subalternative plan 2C for the Belgium and Lake Church sewer service areas differs from plan 2B only with respect to the location of the Lake Church sewage treatment facility. Under subalternative plan 2C, the Lake Church facility would be located near the Lake Michigan shoreline and would include an outfall sewer into Lake Michigan. This treatment facility would be required to provide only secondary waste treatment and auxiliary waste treatment for effluent disinfection.

Source: SEWRPC.

Map 36). These two facilities should provide a level of waste treatment adequate to meet the water quality objectives and standards for the Sauk Creek watershed and should be retained. Should it become necessary at some future date to expand the Krier Preserving Company facility, consideration should be given to integrating this facility with the proposed Belgium-Lake Church facility, perhaps through a controlled feeding system similar to that proposed for the Libby, McNeill, & Libby canning plants located at both the Village of Jackson and the City of Hartford.

KENOSHA-RACINE SUBREGIONAL AREA

The Kenosha-Racine subregional area consists of all that area of Racine and Kenosha Counties lying east of IH 94 except that portion within the Des Plaines River watershed and, therefore, west of the subcontinental divide. This subregional area contains all of the Pike River watershed, a major portion of the Root River watershed, and several minor watersheds that drain directly to Lake Michigan. The area is rapidly urbanizing and includes the central cities of Kenosha and Racine; the Villages of Sturtevant, Elmwood Park, Wind Point, and North Bay; and the highly urbanized Towns of Caledonia, Mt. Pleasant, Somers, and Pleasant Prairie.

As noted in Chapter V of this report, centralized sanitary sewer service in the Kenosha-Racine subregional area was provided by six individual systems in 1970. These systems are the City of Kenosha system, which in addition to serving the city proper provides contract service to the Town of Somers Sanitary District No. 1 and the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C; the Town of Somers Sanitary District No. 2 system; the Pleasant Park Utility Company, Inc. system, a privately owned sewer utility classified for planning purposes as a centralized sanitary sewerage system in the regional sewerage study; the City of Racine system, which in addition to serving the city proper provides contract service to the Village of North Bay, the Caledonia Sewer Utility District No. 1, and the Mt. Pleasant Sewer Utility District; the Village of Sturtevant system; and the North Park Sanitary District system which serves the Village of Wind Point and parts of the Town of Caledonia, including contract service to the Crestview Sanitary District in the Town of Caledonia. Together the service areas of these six systems comprised an area of about 46 square miles and served an estimated population of about 209,000 persons. In 1970 there were about 18,200 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the six existing systems are presented in Chapter V of this report.

Previously adopted areawide plan recommendations relating to water quality management and to the provision of centralized sanitary sewer service apply to major portions of the Kenosha-Racine subregional area. More specifically, the Root River watershed plan, as prepared and adopted by the Commission in 1966, recommended that, with respect to urban development in the Root River watershed portion of the Kenosha-Racine subregional area, centralized sanitary sewer service be extended from the existing City of Racine system to serve the entire anticipated 1990 urban development area. In addition, the Root River watershed plan recommended that the private sewage treatment facility serving the Franks Pure Food Company in the Towns of Caledonia and Mt. Pleasant be abandoned and the Company connected to the centralized sanitary sewerage system operated by the City of Racine and the Town of Caledonia Sewer Utility District No. 1.[10] With respect to the Kenosha portion of the Kenosha-Racine subregional area, the Commission prepared in 1967, and adopted in 1972, a comprehensive plan for the Kenosha Planning District.[11] This comprehensive plan included a recommendation that the entire anticipated 1990 urban area within the Kenosha Planning District be served through appropriate extensions of the existing City of Kenosha sanitary sewerage system. Under this plan recommendation, the existing sewage treatment facilities operated by the Town of Somers Sanitary District No. 2 and the Pleasant Park Utility Company, Inc. would be abandoned and their tributary service areas connected to the expanded centralized sewer service system. Similarly, the plan recommended that the private sewage treatment facilities serving the American Motors Truck Service Garage in the Town of Somers and the Sienadale Motherhouse in the Town of Pleasant Prairie be aban-

---

[10] *See SEWRPC Planning Report No. 9, A Comprehensive Plan for the Root River Watershed.*

[11] *See SEWRPC Planning Report No. 10, A Comprehensive Plan for the Kenosha Planning District.*

doned and connected to the Kenosha system as truck sewer service became available. It is important to note that the foregoing sewerage system recommendations contained in both the Root River and Kenosha Planning District comprehensive plans have been not only adopted by key local units of government, but these units of government have set in motion a series of plan implementation actions designed to carry out the plan recommendations.

In a planning effort concurrent with the regional sanitary sewerage system planning program, the Regional Planning Commission was requested by Racine County, acting on behalf of several local units of government in the Racine portion of the Kenosha-Racine subregional area, to prepare a comprehensive plan for the Racine Urban Planning District. This plan was to have as a major component a sanitary sewerage system element. While it was initially intended to confine the geographical scope of the investigation in the Racine Urban Planning District to the area encompassed by the District, several factors intervened during the course of conducting the District planning program that dictated the need to expand the geographic scope of the sewerage system investigations to include, as a unit, the entire Kenosha-Racine subregional area. These factors included the interconnection planning requirements set forth by the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency, and a local proposal by the Town of Mt. Pleasant to construct a major new sewage treatment plant on the Pike River, which proposal included the ultimate provision of sanitary sewer service to a portion of the Town of Somers and thus conflicted with the sewerage system plan recommendations contained in the adopted Kenosha Planning District plan. For these reasons it became necessary to reopen the question of sewerage system extensions in the Kenosha Planning District and consider the Kenosha and Racine Planning Districts as a single planning unit under the regional sanitary sewerage system planning program. The analyses conducted under this program and presented below were first presented as an integral part of the comprehensive plan for the Racine Urban Planning District. The alternative plan analyses presented hereinafter are identical to those included in the planning report documenting the findings and recommendations of the comprehensive planning program of the Racine Urban Planning District.[12]

Sewer Service Analysis Areas

A total of nine sewer service analysis areas may be identified within the Kenosha-Racine subregional area (see Table 132). The delineation of these analysis areas was based upon considera-

[12] *See SEWRPC Planning Report No. 14, A Comprehensive Plan for the Racine Urban Planning District, Volume 2, The Recommended Comprehensive Plan. It should be noted that the cost estimates for alternative plans 1 and 3 as shown in this report differ slightly from those set forth in SEWRPC Planning Report No. 14 due to the erroneous inclusion of certain trunk sewer improvements in the cost tables set forth in the latter report.*

Table 132

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE KENOSHA-RACINE SUBREGIONAL AREA 1970 and 1990

Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Racine	17.44	104,700	19.53	200	20.78	125,400	26.5
B	Crestview-North Park	2.84	7,800	1.46	800	9.28	15,600	3.0
C	Caledonia	2.45	2,400	0.45	2,000	17.03	30,200	6.5
D	Sturtevant-Mount Pleasant	1.64	4,100	0.77	3,500	12.07	41,000	11.5
E	Sanders Park	1.05	2,900	0.54	200	2.36	5,100	1.0
F	Kenosha	18.28	85,500	15.97	2,600	23.97	137,500	27.0
G	Parkside	1.61	100	0.02	500	3.18	4,200	1.0
H	Somers	0.26	500	0.09	1,400	13.88	16,200	3.5
I	Carol Beach	0.54	1,400	0.26	3,000	10.31	22,500	4.7
Total		46.11	209,400	39.09	14,200	112.86	400,700	84.7

[1]*See Map 77.*

Source: SEWRPC.

tion of both the existing sanitary sewer service areas and the natural drainage areas in both the Kenosha and Racine Planning Districts. As rational sewerage system planning areas, these subareas do not necessarily correspond directly to the existing civil division or special purpose districts boundaries, and should not be confused with such legal entities as discussed in the sewerage system inventories presented in Chapter V of this report. These nine sewer service analysis areas are shown on Map 77 and may be described as follows:

1. Area A—This area consists of the City of Racine, the Villages of Elmwood Park and North Bay, and contiguous urban development in the Towns of Caledonia and Mt. Pleasant. In 1970, sanitary sewer service was provided in this area to about 17.4 square miles, having a total population of nearly 105,000 persons. By 1990 the total area anticipated to be served approximates 21 square miles, with a projected population of about 125,400 persons. This subarea is referenced as the "Racine" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Village of Wind Point and a major portion of the Town of Caledonia, and includes the existing Crestview and North Park Sanitary Districts. In 1970, sanitary sewer service was provided in this area to about 2.8 square miles, having a total population of about 7,800 persons. By 1990 the total area anticipated to be served approximates 9.3 square miles, with a projected population of about 15,600 persons. This subarea is referenced as the "Crestview-North Park" sewer service area in the ensuing discussion.

3. Area C—This area consists of a major portion of the Town of Caledonia generally lying within the Root River watershed, and includes the Caledonia Sewer Utility District No. 1. In 1970, sanitary sewer service was provided in this area to about 2.5 square miles, having a total population of about 2,400 persons. By 1990 the total area anticipated to be served approximates 17 square miles, with a projected population of about 30,200 persons. This subarea is referenced as the "Caledonia" sewer service area in the ensuing discussion.

4. Area D—This area consists of the Village of Sturtevant and a major portion of the Town of Mt. Pleasant in the Pike River watershed. In 1970, sanitary sewer service was provided in this area to about 1.6 square miles, having a total population of about 4,100 persons. By 1990 the total area anticipated to be served approximates 12 square miles, with a projected population of about 44,000 persons. This subarea is referenced as the "Sturtevant-Mt. Pleasant" sewer service area in the ensuing discussion.

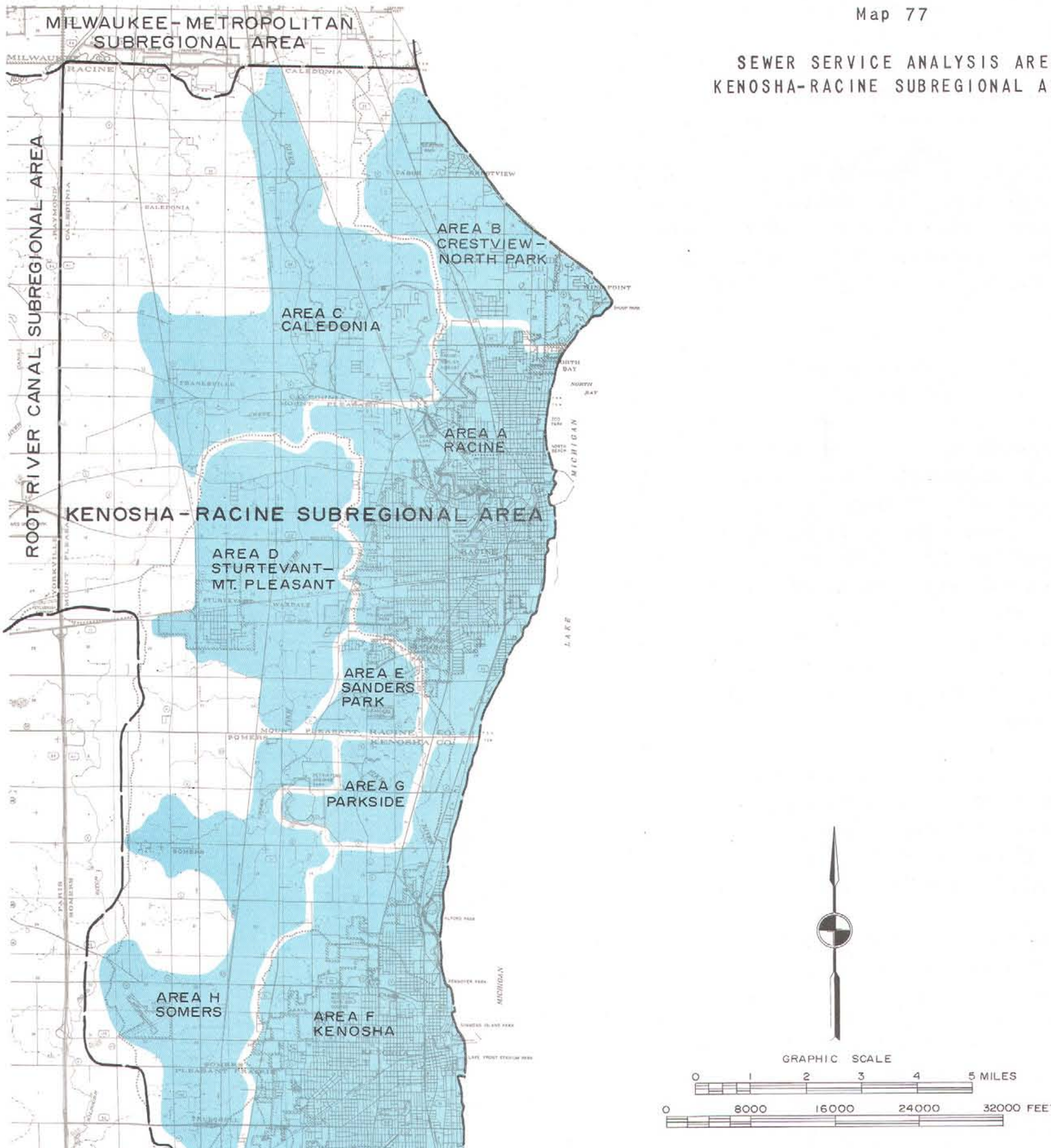
5. Area E—This area consists of a small portion of the City of Racine and a portion of the Town of Mt. Pleasant lying in the Sorenson Creek subwatershed of the Pike River watershed. In 1970, sanitary sewer service was provided in this area to about one square mile, having a total population of about 2,900 persons. By 1990 the total area anticipated to be served approximates 2.4 square miles, with a projected population of about 5,100 persons. This subarea is referenced as the "Sanders Park" sewer service area in the ensuing discussion.

6. Area F—This area consists of all of the City of Kenosha and portions of the Towns of Pleasant Prairie and Somers, including the Town of Somers Sanitary District No. 1 and the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, and C. In 1970, sanitary sewer service was provided in this area to about 18.3 square miles, having a total population of about 85,500 persons. By 1990 the total area anticipated to be served approximates 24 square miles, with a projected population of nearly 137,500 persons. This subarea is referenced as the "Kenosha" sewer service area in the ensuing discussion.

7. Area G—This area includes the easterly portion of the Pike River watershed in the Town of Somers, including the University of Wisconsin-Parkside campus. In 1970, sanitary sewer service was provided in this area to about 1.6 square miles, having a total resident population of about 100

Map 77

SEWER SERVICE ANALYSIS AREAS
KENOSHA-RACINE SUBREGIONAL AREA



The contiguity of the Kenosha-Racine metropolitan areas, together with the surface water drainage and urban land use development patterns in these areas, necessitated the consideration of these two areas as a single unit for sanitary sewerage system planning purposes. Nine individual sewer service analysis areas within the Kenosha-Racine subregion were identified. The delineation of these areas was based upon the consideration of existing sanitary sewer service areas and of the natural drainage areas in both the Kenosha and Racine urban planning districts. By 1990 it is anticipated that centralized sanitary sewer service will be extended throughout all of the nine areas, serving an anticipated resident population of about 400,000 persons. Five individual alternative sanitary sewerage system plans were prepared to provide such service, which alternatives are shown on the ensuing five maps in this report.

Source: SEWRPC.

persons. By 1990 the total area anticipated to be served approximates 3.2 square miles with a projected resident population of about 4,200 persons. This subarea is referenced as the "Parkside" sewer service area in the ensuing discussion.

8. Area H—This area consists of the westerly portion of the Pike River watershed in the Towns of Somers and Pleasant Prairie. In 1970, sanitary sewer service was provided in this area to about 0.3 square mile, having a total population of about 500 persons. By 1990 the total area anticipated to be served approximates 13.9 square miles, with a projected population of about 16,200 persons. This subarea is referenced as the "Somers" sewer service area in the ensuing discussion.

9. Area I—This area consists of a major portion of the Town of Pleasant Prairie along the Lake Michigan shoreline. In 1970, sanitary sewer service was provided in this area to about 0.5 square mile, having a total population of about 1,400 persons. By 1990 the total area anticipated to be served approximates 10.3 square miles, with a projected population of about 22,500 persons. This subarea is referenced as the "Carol Beach" sewer service area in the ensuing discussion.

Alternative Plans

Since all of the nine foregoing sewer service analysis areas are contiguous, the interconnection criteria established by the Wisconsin Department of Natural Resources are not applicable, it being assumed that, because of contiguity, detailed interconnection analyses are required. Out of the many potential alternative sanitary sewerage system plans for the Kenosha-Racine subregional area, five basic alternatives were selected for economic analysis. These five alternatives were selected based upon considerations relating to existing sanitary sewerage systems, existing and committed patterns of contract sewer service, and county boundaries. In three of the alternatives considered, centralized sanitary sewer service to the entire subregional area would be provided by two major sewage treatment facilities. In a fourth alternative, an additional major facility would be added to serve urban development in the Pike River watershed. Finally, in a fifth alternative, an additional facility would be added to serve the northeast portion of the Racine Urban Planning District.

Each of the five alternative sanitary sewerage system plan elements is described in the following paragraphs. Data pertaining to required treatment levels at each of the municipal treatment plant sites considered in these alternative plans are presented in Table 133.

Table 133

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE KENOSHA-RACINE SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Water Body	Stream Low Flow and Dilution Ratio Data: 7-Day, 10-Year Low Flow CFS	7-Day, 10-Year Low Flow MGD	Upstream Sewage Treatment Plant Flow-1990 CFS	Upstream Sewage Treatment Plant Flow-1990 MGD	Total Design Low Flow-1990 CFS	Total Design Low Flow-1990 MGD	Total Design Sewage Flow-1990 CFS	Total Design Sewage Flow-1990 MGD	Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Level of Treatment Required: Secondary	Advanced: Phosphorus Removal	Advanced: Nitrification	Auxiliary: Effluent Aeration	Auxiliary: Disinfection
Racine[1]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	82.04	53.00	N/A	Yes	Yes	No	No	Yes
Racine[2]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	75.08	48.50	N/A	Yes	Yes	No	No	Yes
Racine[3]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	57.28	37.00	N/A	Yes	Yes	No	No	Yes
Racine[4]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	52.63	34.00	N/A	Yes	Yes	No	No	Yes
Kenosha[5]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	73.84	47.70	N/A	Yes	Yes	No	No	Yes
Kenosha[2]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	56.04	36.20	N/A	Yes	Yes	No	No	Yes
Kenosha[6]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	50.62	32.70	N/A	Yes	Yes	No	No	Yes
Kenosha[1]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	49.07	31.70	N/A	Yes	Yes	No	No	Yes
Pike River[6]	Pike River	0.00	0.00	0.00	0.00	0.00	0.00	23.22	15.00	0.00	Yes	Yes	Yes	Yes	Yes
North Park[4]	Lake Michigan	N/A	N/A	N/A	N/A	N/A	N/A	4.64	3.00	N/A	Yes	Yes	No	No	Yes

NOTE: N/A indicates not applicable.
[1]Corresponds to alternative plan 1.
[2]Corresponds to alternative plan 3.
[3]Corresponds to alternative plans 2 and 4.
[4]Corresponds to alternative plan 5.
[5]Corresponds to alternative plan 2.
[6]Corresponds to alternative plans 4 and 5.
Source: SEWRPC.

Alternative Plan 1: The first alternative sanitary sewerage system plan considered for the Kenosha-Racine subregional area would provide for the expansion of the existing City of Racine and City of Kenosha sewage treatment facilities in order to provide sanitary sewer service to the entire subregional area. Under this alternative, the Caledonia, Crestview-North Park, Racine, Sturtevant-Mt. Pleasant, Sanders Park, Somers, and Parkside sewer service areas would be served by the Racine sewage treatment facility. The remaining area, consisting of the Kenosha and Carol Beach sewer service areas, would be served by the Kenosha sewage treatment facility (see Map 78). In accordance with federal Lake Michigan Enforcement Conference recommendations pertaining to the discharge of sewage effluent into Lake Michigan, both the Racine and Kenosha sewage treatment facilities would be required to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. Required sewage treatment levels and performance standards for the Kenosha and Racine sewage treatment facilities under this alternative are set forth in Table 134. Under this alternative, the existing public sewage treatment facilities at North Park, Sturtevant, and Somers would all be ultimately abandoned, as would the existing treatment facility operated by the Pleasant Park Utility Company, Inc.

Facilities needed for this alternative sanitary sewerage system plan include the expansion of the existing Racine sewage treatment facility from its current average hydraulic design capacity of 23 mgd to a proposed 1990 average hydraulic design capacity of 53 mgd, and the expansion of the existing Kenosha sewage treatment facility from its current average hydraulic design capacity of 18 mgd to a proposed 1990 average hydraulic design capacity of 31.7 mgd. Major improvements to existing trunk sewers would be required in the Crestview-North Park and Caledonia sewer service areas. Finally, major new trunk sewers would be required to connect the Caledonia, Crestview-North Park, Sturtevant-Mt. Pleasant, Sanders Park, Somers, and Parkside sewer service areas to the Racine sewage treatment facility and the Carol Beach sewer service area to the Kenosha sewage treatment facility. The location of these major trunk sewer improvements and additions is shown on Map 78.

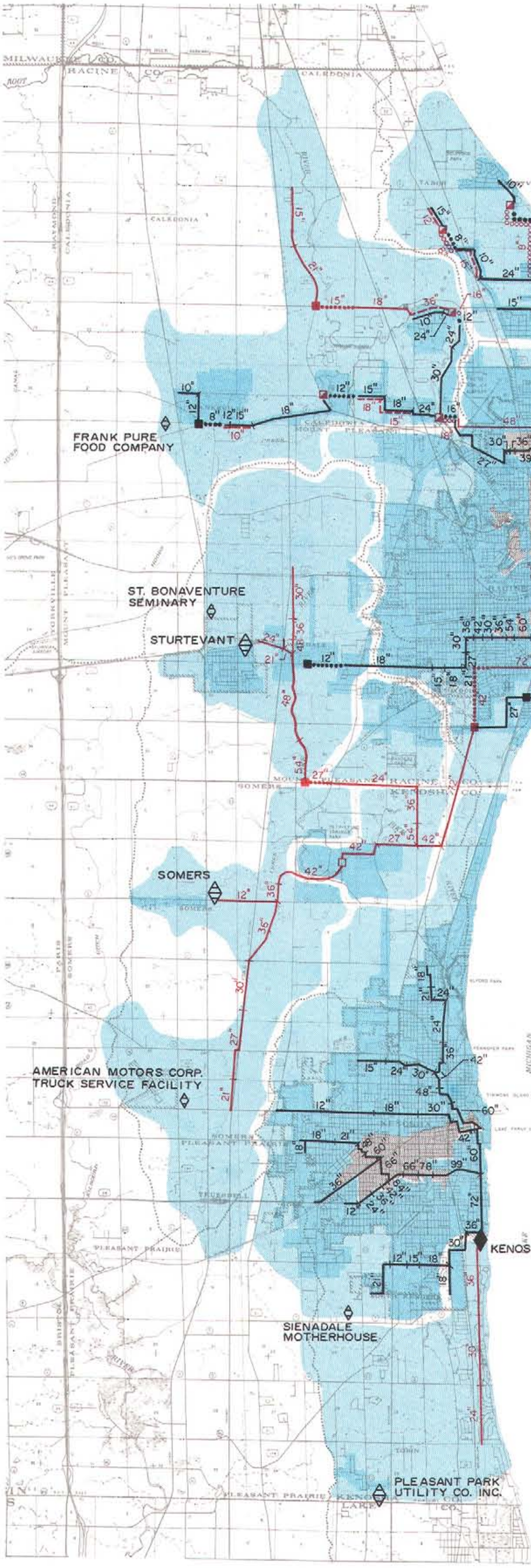
The total estimated capital cost of carrying alternative plan 1 for the Kenosha-Racine subregional area is about $35 million, with an equivalent annual cost of about $4.7 million. Detailed cost estimates for this alternative plan are presented in Table 135.

Alternative Plan 2: The second alternative sanitary sewerage system plan considered for the Kenosha-Racine subregional area would, like alternative plan 1, provide for the expansion of the existing City of Racine and City of Kenosha sewage treatment facilities in order to provide sanitary sewer service for the entire subregional area. Under this second alternative, the Caledonia, Crestview-North Park, Racine, and Sanders Park sewer service areas would be served by the Racine sewage treatment facility. The remaining area, including the Kenosha, Sturtevant-Mt. Pleasant, Somers, Parkside, and Carol Beach sewer service areas, would be served by the Kenosha sewage treatment facility (see Map 79). In accordance with federal Lake Michigan Enforcement Conference recommendations pertaining to the discharge of sewage effluent to Lake Michigan, both the Kenosha and Racine sewage treatment plants would be required to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. Required treatment levels and performance standards for the Kenosha and Racine sewage treatment facilities under this alternative are set forth in Table 134. Under this alternative, the existing public sewage treatment facilities at North Park, Sturtevant, and Somers would be ultimately abandoned, as would the private sewage treatment facility operated by the Pleasant Park Utility Company, Inc.

The facilities needed for this alternative sanitary sewerage system plan include the expansion of the existing Racine sewage treatment facility from its current average hydraulic design capacity of 23 mgd to a proposed 1990 average hydraulic design capacity of 37 mgd, and the expansion of the existing Kenosha sewage treatment facility from its current average hydraulic design capacity of 18 mgd to a proposed 1990 average hydraulic design capacity of 47.7 mgd. In addition, major improvements to existing trunk sewers would be required in the Crestview-North Park, Caledonia, and Racine sewer service areas. Finally, major new trunk sewers would be required to connect the Caledonia, Crestview-North Park, and Sanders Park sewer service areas to the Racine sewage

Map 78

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
KENOSHA-RACINE SUBREGIONAL AREA
1990



LEGEND

SEWER SERVICE AREAS

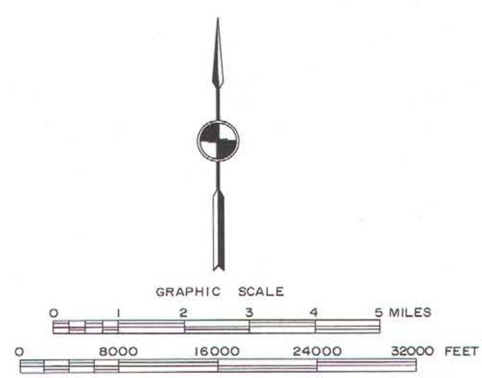
- EXISTING 1970 – SEPARATE
- EXISTING 1970 – COMBINED
- PROPOSED 1990

SEWAGE TREATMENT FACILITIES

- EXISTING PUBLIC TO BE RETAINED
- EXISTING PUBLIC TO BE ABANDONED
- PROPOSED PUBLIC
- EXISTING PRIVATE TO BE RETAINED
- EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

- EXISTING TRUNK SEWER
- PROPOSED IMPROVEMENT TO EXISTING SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED IMPROVEMENT TO EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- EXISTING PUMPING STATION TO BE EXPANDED
- PROPOSED PUMPING STATION



Under the first alternative plan considered for the Kenosha-Racine area, the existing Racine and Kenosha sewage treatment plants would be expanded to provide sanitary sewer service to the entire 1990 urban area, with the Racine treatment facility serving not only all of the area within Racine County but additional areas in the Town of Somers, Kenosha County. Major new trunk sewers needed to provide such service are shown on this map. Implementation of this alternative would enable the abandonment of the existing North Park and Sturtevant sewage treatment facilities in the Racine area and the Somers and Pleasant Park Utility Company treatment facilities in the Kenosha area.

Source: SEWRPC.

Table 134

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS KENOSHA-RACINE SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Racine (53.0 MGD)	Racine Crestview-North Park Caledonia Sturtevant-Mt. Pleasant Sanders Park Parkside Somers	240,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Kenosha (31.7 MGD)	Kenosha Carol Beach	160,000	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Racine (37.0 MGD)	Racine Crestview-North Park Caledonia Sanders Park	176,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Kenosha (47.7 MGD)	Kenosha Sturtevant-Mt. Pleasant Parkside Somers Carol Beach	224,400	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 3					
Racine (48.5 MGD)	Racine Crestview-North Park Caledonia Sturtevant-Mt. Pleasant Sanders Park	220,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Kenosha (36.2 MGD)	Kenosha Parkside Somers Carol Beach	180,400	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 4					
Racine (37.0 MGD)	Racine Crestview-North Park Caledonia Sanders Park	176,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Kenosha (32.7 MGD)	Kenosha Parkside Carol Beach	164,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Pike River (15.0 MGD)	Sturtevant-Mt. Pleasant Somers	60,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 5					
Racine (34.0 MGD)	Racine Caledonia Sanders Park	160,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Kenosha (32.7 MGD)	Kenosha Parkside Carol Beach	164,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Pike River (15.0 MGD)	Sturtevant-Mt. Pleasant Somers	60,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
North Park (3.0 MGD)	Crestview-North Park	15,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 77.*

Source: SEWRPC.

Table 135

DETAILED COST ESTIMATES

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1

KENOSHA-RACINE SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Treatment Plants							
Racine							
Facilities (53.0 MGD)	$12,430,000	$12,216,000	$24,226,000	$36,442,000	$ 775,000	$1,537,000	$2,312,000
Land (17 Acres)	1,270,000	946,000	--	946,000	60,000	--	60,000
Subtotal	13,700,000	13,162,000	24,226,000	37,388,000	835,000	1,537,000	2,372,000
Kenosha							
Facilities (31.7 MGD)	2,940,000	4,272,000	16,345,000	20,617,000	271,000	1,037,000	1,308,000
Land (10 Acres)	100,000	71,000	--	71,000	4,500	--	4,500
Subtotal	3,040,000	4,343,000	16,345,000	20,688,000	275,500	1,037,000	1,312,500
Subtotal — Treatment Facilities	16,740,000	17,505,000	40,571,000	58,076,000	1,110,500	2,574,000	3,684,500
Trunk Sewer Improvements							
Caledonia	965,000	867,000	594,000	1,461,000	55,000	37,700	92,700
Crestview-North Park	747,000	646,000	473,000	1,119,000	41,000	30,000	71,000
Subtotal — Trunk Sewer Improvements	1,712,000	1,513,000	1,067,000	2,580,000	96,000	67,700	163,700
New Trunk Sewers							
Caledonia	983,000	772,000	142,000	914,000	49,000	9,000	58,000
Sturtevant-Mt. Pleasant, Sanders Park, Somers, and Parkside to Racine	9,695,000	7,156,000	878,000	8,034,000	454,000	55,700	509,700
Caledonia and Crestview-North Park to Racine	5,104,000	4,461,000	205,000	4,666,000	283,000	13,000	296,000
Carol Beach to Kenosha	729,000	536,000	11,000	547,000	34,000	700	34,700
Subtotal — New Trunk Sewers	16,511,000	12,925,000	1,236,000	14,161,000	820,000	78,400	898,400
Total	$34,963,000	$31,943,000	$42,874,000	$74,817,000	$2,026,500	$2,720,100	$4,746,600

Source: SEWRPC.

treatment facility and the Sturtevant-Mt. Pleasant, Somers, Parkside, and Carol Beach sewer service areas to the Kenosha Sewage treatment facility. The location of these major new trunk sewers and additions is shown on Map 79.

The total estimated capital cost of carrying out alternative plan 2 for the Kenosha-Racine subregional area is about $37.5 million, with an equivalent annual cost of about $4.9 million. Detailed cost estimates for this alternative plan are presented in Table 136.

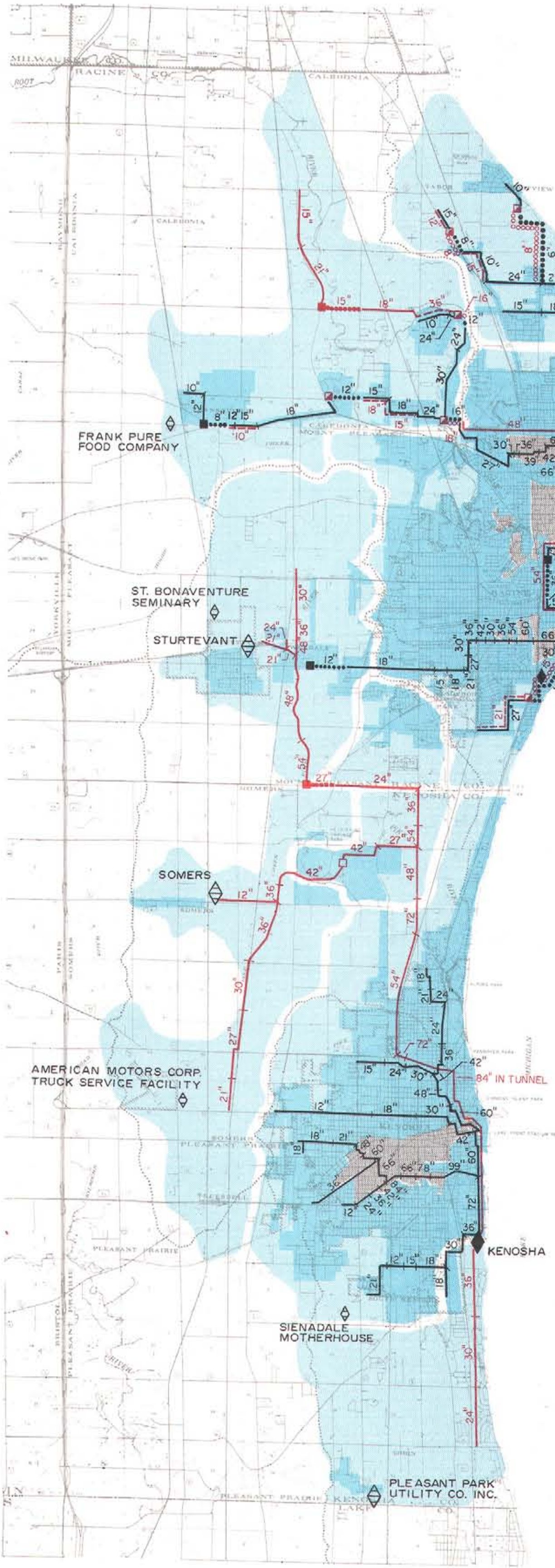
Alternative Plan 3: The third alternative sanitary sewerage system plan considered for the Kenosha-Racine subregional area would, like the first and second alternatives, provide for the expansion of the existing City of Racine and City of Kenosha sewage treatment facilities in order to provide sanitary sewer service for the entire subregional area. Under this alternative, the Caledonia, Crestview-North Park, Racine, Sturtevant-Mt. Pleasant, and Sanders Park sewer service areas would be served by the Racine sewage treatment facility. The remaining area, including the Kenosha, Somers, Parkside, and Carol Beach sewer service areas, would be served by the Kenosha sewage treatment facility (see Map 80).

In accordance with federal Lake Michigan Enforcement Conference requirements pertaining to the discharge of sewage effluent to Lake Michigan, the Kenosha and Racine sewage treatment facilities would be required to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. Required sewage treatment levels and performance standards for the Kenosha and Racine sewage treatment facilities under this alternative are set forth in Table 134. Under this alternative, the existing public sewage treatment facilities at North Park, Sturtevant, and Somers would be ultimately abandoned, as would the existing treatment facility operated by the Pleasant Park Utility Company, Inc.

The facilities needed for this alternative sanitary sewerage system plan include the expansion of the existing City of Racine sewage treatment facility from its current average hydraulic design capacity of 23 mgd to a proposed 1990 average hydraulic design capacity of 48.5 mgd, and the expansion of the existing City of Kenosha sewage treatment facility from its existing average hydraulic design capacity of 18 mgd to a proposed 1990 average hydraulic design capacity of 36.2 mgd. In addition,

Map 79

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
KENOSHA-RACINE SUBREGIONAL AREA
1990



LEGEND

SEWER SERVICE AREAS

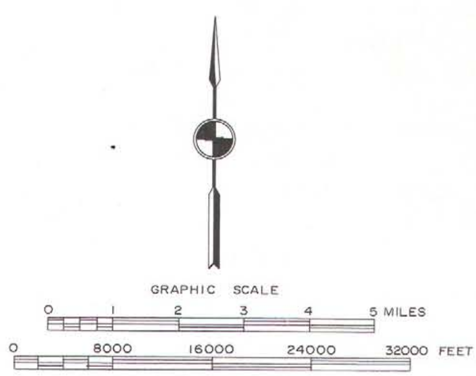
- EXISTING 1970 – SEPARATE
- EXISTING 1970 – COMBINED
- PROPOSED 1990

SEWAGE TREATMENT FACILITIES

- EXISTING PUBLIC TO BE RETAINED
- EXISTING PUBLIC TO BE ABANDONED
- PROPOSED PUBLIC
- EXISTING PRIVATE TO BE RETAINED
- EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

- EXISTING TRUNK SEWER
- PROPOSED IMPROVEMENT TO EXISTING SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED IMPROVEMENT TO EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- EXISTING PUMPING STATION TO BE EXPANDED
- PROPOSED PUMPING STATION



Under the second alternative plan considered for the Kenosha-Racine subregional area, sewage treatment would be provided at expanded Kenosha and Racine sewage treatment facilities, with the Kenosha facility serving not only all of the area in Kenosha County but also the Sturtevant and Mt. Pleasant areas in Racine County. The major new trunk sewers needed to effect the provision of such service are shown on this map. Implementation of this alternative would, like the first alternative, enable the ultimate abandonment of the North Park and Sturtevant sewage treatment facilities in the Racine area and the Somers and Pleasant Park Utility Company treatment facilities in the Kenosha area.

Source: SEWRPC.

Table 136

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
KENOSHA-RACINE SUBREGIONAL AREA

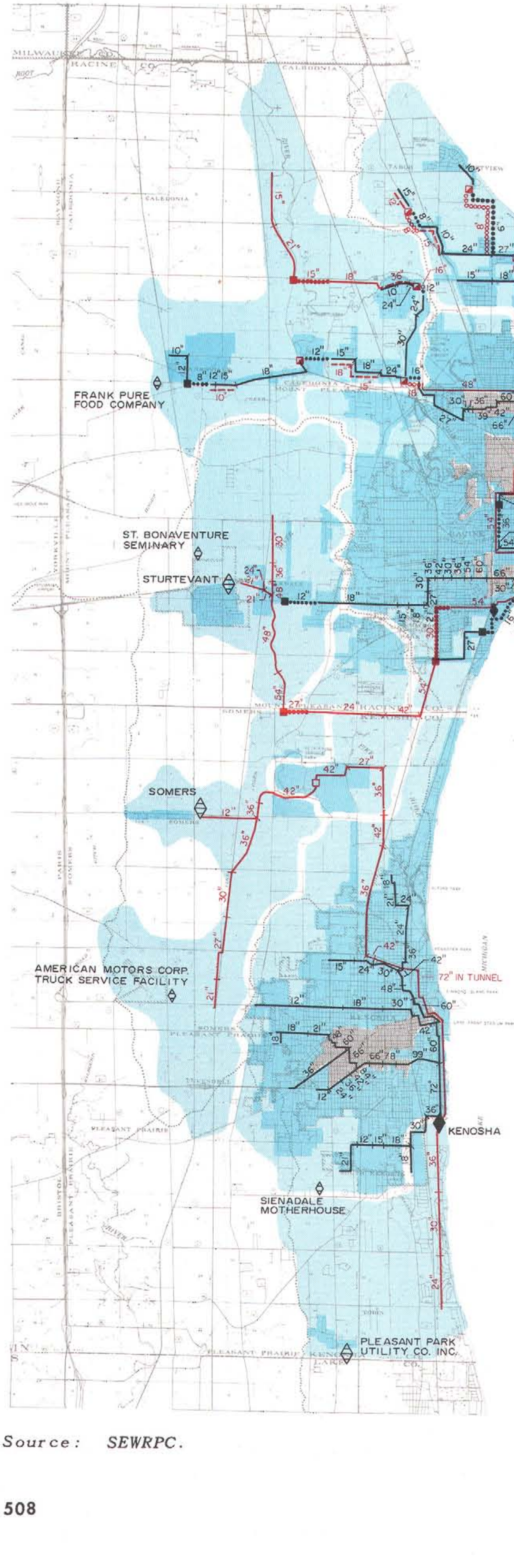
Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Treatment Plants							
Racine							
Facilities (37.0 MGD)	$ 8,100,000	$ 8,180,000	$18,315,000	$26,495,000	$ 519,000	$1,162,000	$1,681,000
Land (3.5 Acres)	262,000	195,000	--	195,000	12,400	--	12,400
Subtotal	8,362,000	8,375,000	18,315,000	26,690,000	531,400	1,162,000	1,693,400
Kenosha							
Facilities (47.7 MGD)	7,720,000	8,575,000	22,603,000	31,178,000	544,000	1,434,000	1,978,000
Land (26 Acres)	260,000	183,000	--	183,000	11,600	--	11,600
Subtotal	7,980,000	8,758,000	22,603,000	31,361,000	555,600	1,434,000	1,989,600
Subtotal — Treatment Facilities	16,342,000	17,133,000	40,918,000	58,051,000	1,087,000	2,596,000	3,683,000
Trunk Sewer Improvements							
Caledonia	965,000	867,000	594,000	1,461,000	55,000	37,700	92,700
Crestview-North Park	747,000	646,000	473,000	1,119,000	41,000	30,000	71,000
Racine	500,000	487,000	252,000	739,000	31,000	16,000	47,000
Subtotal — Trunk Sewer Improvements	2,212,000	2,000,000	1,319,000	3,319,000	127,000	83,700	210,700
New Trunk Sewers							
Caledonia	983,000	772,000	142,000	914,000	49,000	9,000	58,000
Caledonia and Crestview-North Park to Racine	5,104,000	4,461,000	205,000	4,666,000	283,000	13,000	296,000
Sturtevant-Mt. Pleasant, Sanders Park, and Parkside to Kenosha	12,100,000	8,937,000	567,000	9,504,000	567,000	36,000	603,000
Carol Beach to Kenosha	729,000	536,000	11,000	547,000	34,000	700	34,700
Subtotal — New Trunk Sewers	18,916,000	14,706,000	925,000	15,631,000	933,000	58,700	991,700
Total	$37,470,000	$33,839,000	$43,162,000	$77,001,000	$2,147,000	$2,738,400	$4,885,400

Source: SEWRPC.

major improvements to existing trunk sewers would be required in the Crestview-North Park and Caledonia sewer service areas. Finally, major new trunk sewers would be required to connect the Caledonia, Crestview-North Park, Sturtevant-Mt. Pleasant, and Sanders Park sewer service areas to the Racine sewage treatment facility and the Somers, Parkside, and Carol Beach sewer service areas to the Kenosha sewage treatment facility. The location of the major new trunk sewers and additions is shown on Map 80.

The total estimated capital cost of carrying out alternative plan 3 for the Kenosha-Racine subregional area is estimated at about $37.7 million, with an equivalent annual cost of about $4.9 million. Detailed cost estimates for this alternative plan are presented in Table 137.

Alternative Plan 4: The fourth alternative sanitary sewerage system plan considered for the Kenosha-Racine subregional area would provide for more limited expansion of the existing City of Racine and City of Kenosha sewage treatment facilities combined with the construction of a new major sewage treatment facility on the Pike River in the Town of Somers. These three major sewage treatment facilities would provide sanitary sewer service to the entire subregional area. Under this alternative, the Caledonia, Crestview-North Park, Racine, and Sanders Park sewer service areas would be served by the Racine sewage treatment facility. The Parkside, Kenosha, and Carol Beach sewer service areas would be served by the Kenosha sewage treatment facility. The Sturtevant-Mt. Pleasant and Somers sewer service areas would be served by the proposed new Pike River sewage treatment plant in the Town of Somers (see Map 81). In accordance with federal Lake Michigan Enforcement Conference recommendations pertaining to the discharge of sewage effluent to Lake Michigan, the Kenosha and Racine sewage treatment facilities would be required to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. In order to meet the established water use objectives for the Pike River, as well as carry out the Lake Michigan Enforcement Conference recommendations, the proposed Pike River sewage treatment plant would be required to provide secondary waste treatment, advanced waste treat-



Source: SEWRPC.

Map 80

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 3
KENOSHA-RACINE SUBREGIONAL AREA
1990

LEGEND

SEWER SERVICE AREAS

- EXISTING 1970 – SEPARATE
- EXISTING 1970 – COMBINED
- PROPOSED 1990

SEWAGE TREATMENT FACILITIES

- EXISTING PUBLIC TO BE RETAINED
- EXISTING PUBLIC TO BE ABANDONED
- PROPOSED PUBLIC
- EXISTING PRIVATE TO BE RETAINED
- EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

- EXISTING TRUNK SEWER
- PROPOSED IMPROVEMENT TO EXISTING SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED IMPROVEMENT TO EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- EXISTING PUMPING STATION TO BE EXPANDED
- PROPOSED PUMPING STATION

GRAPHIC SCALE

0 1 2 3 4 5 MILES

0 8000 16000 24000 32000 FEET

The third alternative sanitary sewerage system plan for the Kenosha-Racine subregional area would, like the first two alternatives, centralize sewage treatment through the expansion of the existing Racine and Kenosha sewage treatment facilities. The Kenosha treatment facility would, under this alternative, serve only the area within Kenosha County, with the Racine treatment facility serving only the area in Racine County. The major trunk sewers necessary to effect implementation of this alternative are shown on the above map. As in the first two alternatives considered, implementation of this alternative would enable the ultimate abandonment of the North Park and Sturtevant sewage treatment facilities in the Racine area and the Somers and Pleasant Park Utility Company treatment facilities in the Kenosha area.

Table 137

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 3
KENOSHA-RACINE SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Treatment Plants							
Racine							
Facilities (48.5 MGD)	$11,600,000	$11,806,000	$22,619,000	$34,425,000	$ 749,000	$1,435,000	$2,184,000
Land (13 Acres)	975,000	728,000	--	728,000	46,200	--	46,200
Subtotal	12,575,000	12,534,000	22,619,000	35,153,000	795,200	1,435,000	2,230,200
Kenosha							
Facilities (36.2 MGD)	4,200,000	5,391,000	17,527,000	22,918,000	342,000	1,112,000	1,454,000
Land (14 Acres)	140,000	99,000	--	99,000	6,300	--	6,300
Subtotal	4,340,000	5,490,000	17,527,000	23,017,000	348,300	1,112,000	1,460,300
Subtotal — Treatment Facilities	16,915,000	18,024,000	40,146,000	58,170,000	1,143,500	2,547,000	3,690,500
Trunk Sewer Improvements							
Caledonia	965,000	867,000	594,000	1,461,000	55,000	37,700	92,700
Crestview-North Park	747,000	646,000	473,000	1,119,000	41,000	30,000	71,000
Subtotal — Trunk Sewer Improvements	1,712,000	1,513,000	1,067,000	2,580,000	96,000	67,700	163,700
New Trunk Sewers							
Caledonia	983,000	772,000	142,000	914,000	49,000	9,000	58,000
Caledonia and Crestview-North Park to Racine	5,104,000	4,461,000	205,000	4,666,000	283,000	13,000	296,000
Carol Beach to Kenosha	729,000	536,000	11,000	547,000	34,000	700	34,700
Sturtevant-Mt. Pleasant, and Sanders Park to Racine	4,631,000	3,494,000	706,000	4,200,000	221,700	44,800	266,500
Somers and Parkside to Kenosha	7,649,000	5,586,000	216,000	5,802,000	354,400	13,700	368,100
Subtotal — New Trunk Sewers	19,096,000	14,849,000	1,280,000	16,129,000	942,100	81,200	1,023,300
Total	$37,723,000	$34,386,000	$42,493,000	$76,879,000	$2,181,600	$2,695,900	$4,877,500

Source: SEWRPC.

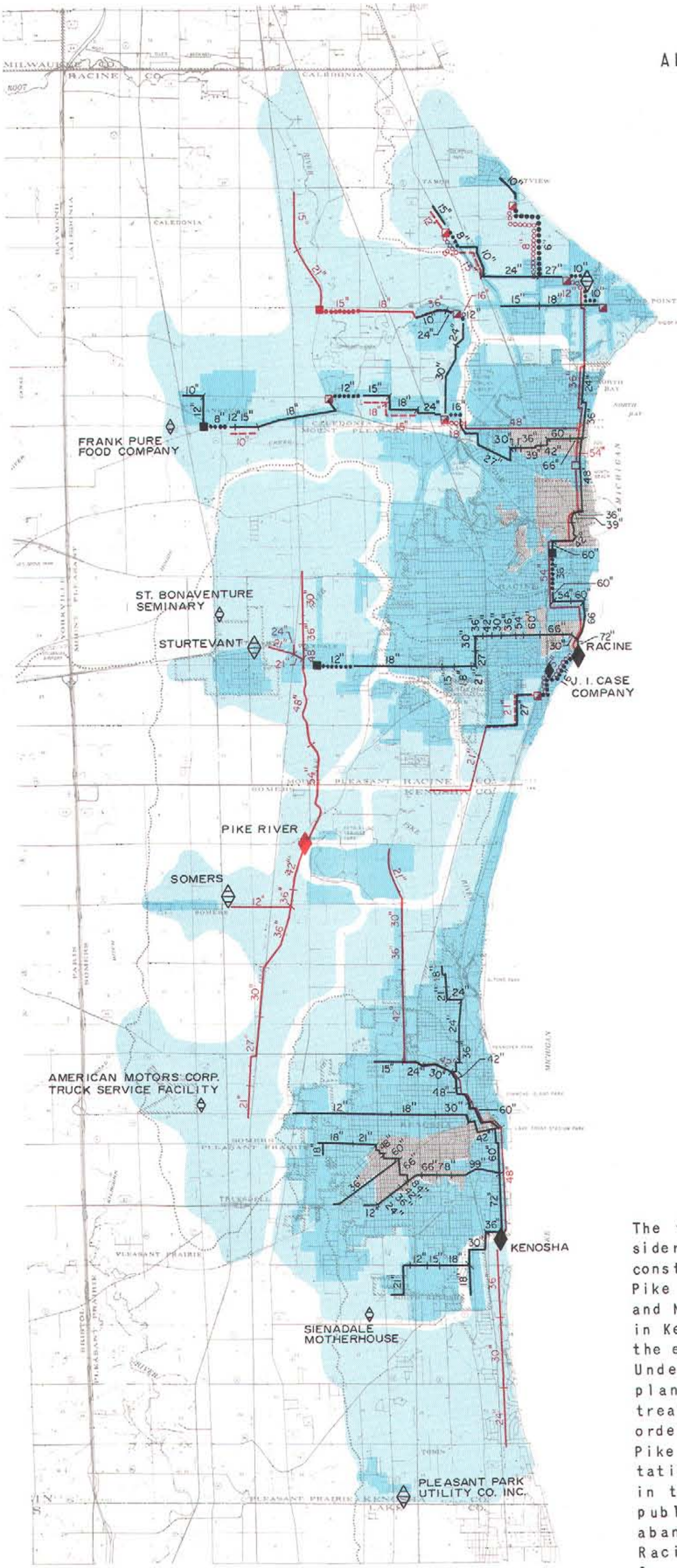
ment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection.[13] Required sewage treatment levels and performance standards for the Kenosha, Racine, and Pike River sewage treatment facilities are set forth in Table 134. Under this alternative, the existing public sewage treatment facilities at North Park, Sturtevant, and Somers would be ultimately abandoned, as would the sewage treatment facility operated by the Pleasant Park Utility Company, Inc.

[13] *It should be noted that this alternative plan, as presented in SEWRPC Planning Report No. 14, A Comprehensive Plan for the Racine Urban Planning District, Volume 2, The Recommended Comprehensive Plan, called for the auxiliary waste treatment of instream aeration for the Pike River sewage treatment facility rather than the auxiliary waste treatment of effluent aeration as recommended herein. This slight modification in sewage treatment recommendations has been made under the regional sanitary sewerage system planning program since publication of the aforementioned planning report. This modification does not affect the costs nor the comparison of the five alternatives presented.*

The facilities needed for this alternative sanitary sewerage system plan include the expansion of the existing Racine sewage treatment facility from its current average hydraulic design capacity of 23 mgd to a proposed 1990 average hydraulic design capacity of 37 mgd; the expansion of the existing Kenosha sewage treatment facility from its current average hydraulic design capacity of 18 mgd to a proposed 1990 average hydraulic design capacity of 32.7 mgd; and the construction of a new 15.0 mgd sewage treatment facility on the Pike River in the Town of Somers. In addition, major improvements to existing trunk sewers would be required in the Crestview-North Park, Caledonia, and Racine sewer service areas. Finally, major new trunk sewers would be required to connect the Caledonia, Crestview-North Park, and Sanders Park sewer service areas to the Racine sewage treatment facility; the Parkside and Carol Beach sewer service areas to the Kenosha sewage treatment facility; and the Sturtevant-Mt. Pleasant and Somers sewer service areas to the proposed Pike River sewage treatment facility. The location of these new major trunk sewers and additions is shown on Map 81.

Map 81

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 4
KENOSHA-RACINE SUBREGIONAL AREA
1990



LEGEND

SEWER SERVICE AREAS

- EXISTING 1970 – SEPARATE
- EXISTING 1970 – COMBINED
- PROPOSED 1990

SEWAGE TREATMENT FACILITIES

- EXISTING PUBLIC TO BE RETAINED
- EXISTING PUBLIC TO BE ABANDONED
- PROPOSED PUBLIC
- EXISTING PRIVATE TO BE RETAINED
- EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

- EXISTING TRUNK SEWER
- PROPOSED IMPROVEMENT TO EXISTING SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED IMPROVEMENT TO EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- EXISTING PUMPING STATION TO BE EXPANDED
- PROPOSED PUMPING STATION

GRAPHIC SCALE

0 1 2 3 4 5 MILES

0 8000 16000 24000 32000 FEET

The fourth alternative sanitary sewerage system plan considered for the Kenosha-Racine subregional area proposes the construction of a major new sewage treatment facility on the Pike River in the Town of Somers to serve both the Sturtevant and Mt. Pleasant areas in Racine County and the Somers area in Kenosha County, combined with a more limited expansion of the existing Racine and Kenosha sewage treatment facilities. Under this alternative, the Pike River sewage treatment plant would have to provide an advanced level of waste treatment for both nitrification and phosphorus removal in order to meet the established water use objectives for the Pike River. The trunk sewers necessary to effect implementation of this alternative are shown on the above map. As in the case of the first three alternatives, four existing public sewage treatment facilities would ultimately be abandoned: the North Park and Sturtevant facilities in Racine County and the Somers and Pleasant Park Utility Company facilities in Kenosha County.

Source: SEWRPC.

The total estimated capital cost of carrying out alternative plan 4 for the Kenosha-Racine subregional area is about $40.4 million, with an equivalent annual cost of about $5.3 million. Detailed cost estimates for this alternative plan are presented in Table 138.

Alternative Plan 5: The fifth alternative sanitary sewerage system plan considered for the Kenosha-Racine subregional area would, like the fourth alternative, provide for limited expansion of the existing City of Racine and City of Kenosha sewage treatment facilities combined with the construction of a new major sewage treatment facility on the Pike River in the Town of Somers. In addition, however, the existing North Park sewage treatment plant would be retained and expanded as a major sewage treatment facility. These four major sewage treatment facilities, then, would provide sanitary sewer service for the entire subregional area. Under this alternative, the Caledonia, Racine, and Sanders Park sewer service areas would be served by the Racine sewage treatment plant. The Parkside, Kenosha, and Carol Beach sewer service areas would be served by the Kenosha sewage treatment facility. The Sturtevant-Mt. Pleasant and Somers sewer service areas would be served by the proposed new Pike River sewage treatment facility in the Town of Somers. The Crestview-North Park sewer service area would be served by an expanded North Park sewage treatment facility (see Map 82). In accordance with federal Lake Michigan Enforcement Conference recommendations pertaining to the discharge of sewage effluent into Lake Michigan, the Kenosha, Racine, and North Park sewage treatment facilities would be required to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. In order to meet the established water use objectives for the Pike River, as well as carry out the

Table 138

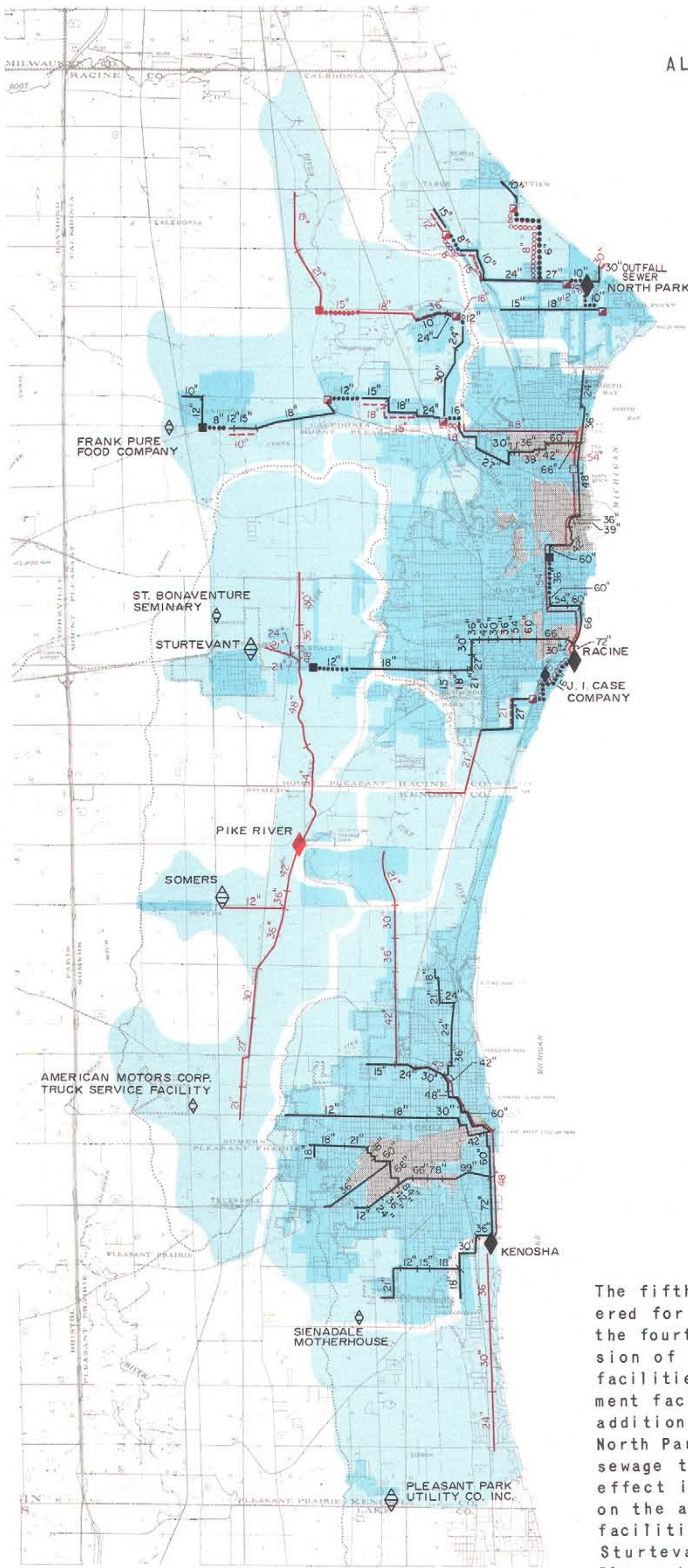
DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 4
KENOSHA-RACINE SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	*Construction*	*Operation and Maintenance*	*Total*	*Construction*	*Operation and Maintenance*	*Total*
Treatment Plants							
Racine							
Facilities (37.0 MGD)	$ 8,100,000	$ 8,180,000	$18,315,000	$26,495,000	$ 519,000	$1,162,000	$1,681,000
Land (3.5 Acres)	262,000	195,000	--	195,000	12,400	--	12,400
Subtotal	8,362,000	8,375,000	18,315,000	26,690,000	531,400	1,162,000	1,693,400
Kenosha							
Facilities (32.7 MGD)	3,360,000	4,634,000	16,487,000	21,212,000	294,000	1,046,000	1,340,000
Land (10 Acres)	100,000	71,000	--	71,000	4,500	--	4,500
Subtotal	3,460,000	4,705,000	16,487,000	21,283,000	298,500	1,046,000	1,344,500
Pike River							
Facilities (15.0 MGD)	10,653,000	10,545,000	8,338,000	18,883,000	669,000	529,000	1,198,000
Land (15 Acres)	30,000	20,000	--	20,000	1,300	--	1,300
Subtotal	10,683,000	10,565,000	8,338,000	18,903,000	670,300	529,000	1,199,300
Subtotal — Treatment Facilities	22,505,000	23,645,000	43,140,000	66,876,000	1,500,200	2,737,000	4,237,200
Trunk Sewer Improvements							
Caledonia	965,000	867,000	594,000	1,461,000	55,000	37,700	92,700
Crestview-North Park	747,000	646,000	473,000	1,119,000	41,000	30,000	71,000
Racine	500,000	487,000	252,000	739,000	31,000	16,000	47,000
Subtotal — Trunk Sewer Improvements	2,212,000	2,000,000	1,319,000	3,319,000	127,000	83,700	210,700
New Trunk Sewers							
Caledonia	983,000	772,000	142,000	914,000	49,000	9,000	58,000
Sturtevant-Mt. Pleasant, and Somers to New Pike River Plant	4,988,000	4,256,000	47,000	4,303,000	270,000	3,000	273,000
Caledonia, Crestview-North Park, and Sanders Park to Racine	5,104,000	4,461,000	205,000	4,666,000	283,000	13,000	296,000
Carol Beach to Kenosha	729,000	536,000	11,000	547,000	34,000	700	34,700
Parkside to Kenosha	3,867,500	2,834,000	22,100	2,856,100	179,800	1,400	181,200
Subtotal — New Trunk Sewers	15,671,500	12,859,000	427,100	13,286,100	815,800	27,100	842,900
Total	$40,388,500	$38,504,000	$44,886,100	$83,481,000	$2,443,000	$2,847,800	$5,290,800

Source: SEWRPC.

Map 82

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 5
KENOSHA-RACINE SUBREGIONAL AREA
1990



LEGEND

SEWER SERVICE AREAS

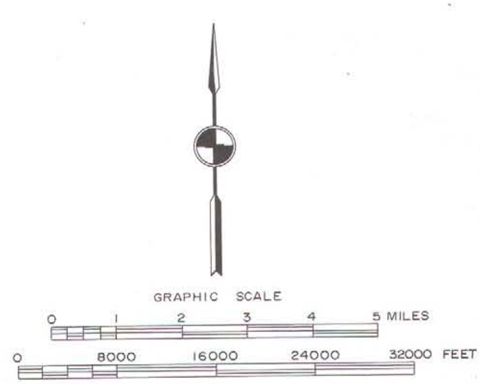
- EXISTING 1970 – SEPARATE
- EXISTING 1970 – COMBINED
- PROPOSED 1990

SEWAGE TREATMENT FACILITIES

- EXISTING PUBLIC TO BE RETAINED
- EXISTING PUBLIC TO BE ABANDONED
- PROPOSED PUBLIC
- EXISTING PRIVATE TO BE RETAINED
- EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

- EXISTING TRUNK SEWER
- PROPOSED IMPROVEMENT TO EXISTING SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED IMPROVEMENT TO EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- PROPOSED LIFT STATION
- EXISTING PUMPING STATION
- EXISTING PUMPING STATION TO BE EXPANDED
- PROPOSED PUMPING STATION



The fifth alternative sanitary sewerage system plan considered for the Kenosha-Racine subregional area is similar to the fourth alternative in that it provides for limited expansion of the existing Racine and Kenosha sewage treatment facilities and the construction of a new major sewage treatment facility on the Pike River in the Town of Somers. In addition, this alternative proposes to expand the existing North Park sewage treatment plant to serve as a major public sewage treatment facility. The trunk sewers necessary to effect implementation of this alternative plan are shown on the above map. Three existing public sewage treatment facilities would be abandoned under this alternative: the Sturtevant facility in Racine County and the Somers and Pleasant Park Utility Company facilities in Kenosha County.

Source: SEWRPC.

Lake Michigan Enforcement Conference recommendations, the proposed Pike River sewage treatment plant would be required to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. Required sewage treatment levels and performance standards for the Kenosha, Racine, Pike River, and North Park sewage treatment facilities are set forth in Table 134. Under this alternative, the existing public sewage treatment facilities at Sturtevant and Somers would be ultimately abandoned, as would be the sewage treatment facility operated by the Pleasant Park Utility Company, Inc.

The facilities needed for this alternative sanitary sewerage system plan would include the expansion of the existing Racine sewage treatment facility from its current average hydraulic design capacity of 23 mgd to a proposed 1990 average hydraulic design capacity of 34 mgd; the expansion of the existing Kenosha sewage treatment facility from its current average hydraulic design capacity of 18 mgd to a proposed 1990 average hydraulic design capacity of 32.7 mgd; the construction of a new 15.0 mgd sewage treatment facility on the Pike River in the Town of Somers; and the expansion of the existing North Park sewage treatment facility from its current average hydraulic design capacity of 0.9 mgd to a proposed 1990 average hydraulic design capacity of 3.0 mgd, and the extension of the outfall sewer from plant a distance of at least 500 feet into the lake. In addition, major improvements to the existing trunk sewers would be required in the Crestview-North Park, Caledonia, and Racine sewer service areas. Finally, major new trunk sewers would be required to connect the Caledonia and Sanders Park sewer service areas to the Racine sewage treatment facility; the Parkside and Carol Beach sewer service areas to the Kenosha sewage treatment facility; and the Sturtevant-Mt. Pleasant and Somers sewer service areas to the proposed Pike River sewage treatment facility. The location of these new major trunk sewers and additions is shown on Map 82.

The total estimated capital cost of carrying out alternative plan 5 for the Kenosha-Racine subregional area is about $39.8 million, with an equivalent annual cost of about $5.4 million. Detailed cost estimates for this alternative plan are presented in Table 139.

Comparison of Alternatives: From a total annual cost point of view, it is apparent that the first three alternatives presented, which alternatives provide for two major sewage treatment facilities in the Kenosha-Racine subregional area, are more economical than the alternative plans 4 and 5, which provide for additional sewage treatment facilities on the Pike River and at the North Park Sanitary District site, respectively. The difference in cost between the lowest cost alternative—alternative plan 1—and the highest cost alternative—alternative plan 5—is only about 11 percent, however, within the range of precision with which the costs of each of these five alternative plans can be estimated. It is important to consider other factors of the alternative plans presented, therefore, in order to provide a sound basis for ultimately selecting the best alternative to be included in the regional sanitary sewerage system plan.

Alternative plans 1, 2, and 3 all have the advantage of relying heavily on the existing large Racine and Kenosha sanitary sewerage systems and all of the technical staff capabilities which have been acquired over the years in the construction, operation, and maintenance of the systems. The utilization of the Racine and Kenosha sewage treatment plants to provide sanitary sewer service for all of the proposed 1990 urban development area in the Kenosha-Racine subregional area takes advantage of the economies of scale inherent in the operation of large plants and avoids needless duplication of staff and equipment. In addition, concentration of water pollution abatement efforts at these two major facilities results in allocating the costs involved in the provision of costly advanced waste treatment facilities on a larger areawide basis, with an attendant better correlation between needs and available financial resources.

Of the first three alternative plans—alternatives which are all very similar in terms of total annual cost—it is apparent that alternative plan 3 best fits the long-established major utility system patterns in the Kenosha and Racine Planning Districts, particularly because each of the two systems proposed would be confined to a single county. Thus, the Racine sewage treatment facility would serve the entire Racine Urban Planning District and the Kenosha sewage treatment facility would serve the entire Kenosha Planning District. This alternative also conforms to the recommendations contained in the adopted comprehensive

Table 139

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 5
KENOSHA-RACINE SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Treatment Plants							
Racine							
Facilities (34.0 MGD)	$ 7,500,000	$ 7,771,000	$17,464,000	$25,235,000	$ 493,000	$1,108,000	$1,601,000
Subtotal	7,500,000	7,771,000	17,464,000	25,235,000	493,000	1,108,000	1,601,000
Kenosha							
Facilities (32.7 MGD)	3,360,000	4,634,000	16,487,000	21,121,000	294,000	1,046,000	1,349,000
Land (15 Acres)	100,000	71,000	--	71,000	4,500	--	4,500
Subtotal	3,460,000	4,705,000	16,487,000	21,192,000	298,500	1,046,000	1,353,500
Pike River							
Facilities (15.0 MGD)	10,653,000	10,545,000	8,338,000	18,883,000	669,000	529,000	1,198,000
Land (15 Acres)	30,000	20,000	--	20,000	1,300	--	1,300
Subtotal	10,683,000	10,565,000	8,338,000	18,903,000	670,300	529,000	1,199,300
North Park							
Facilities (3.0 MGD)	1,404,000	1,419,000	2,475,000	3,894,000	90,000	157,000	247,000
Outfall Sewer	244,400	179,700	1,600	181,300	11,400	100	11,500
Land (3 Acres)	6,000	5,000	--	5,000	300	--	300
Subtotal	1,654,400	1,603,700	2,476,600	4,080,300	101,700	157,100	258,800
Subtotal — Treatment Facilities	23,297,400	24,644,700	44,765,600	69,410,300	1,563,500	2,840,100	4,412,600
Trunk Sewer Improvements							
Caledonia	965,000	867,000	594,000	1,461,000	55,000	37,700	92,700
Crestview-North Park	747,000	646,000	473,000	1,119,000	41,000	30,000	71,000
Racine	500,000	487,000	252,000	739,000	31,000	16,000	47,000
Subtotal — Trunk Sewer Improvements	2,212,000	2,000,000	1,319,000	3,319,000	127,000	83,700	210,700
New Trunk Sewers							
Caledonia and Sanders Park	983,000	772,000	142,000	914,000	49,000	9,000	58,000
Sturtevant-Mt. Pleasant and Somers to Pike River Plant	4,988,000	4,256,000	47,000	4,303,000	270,000	3,000	273,000
Caledonia to Racine	3,745,000	2,814,000	161,000	2,975,000	178,500	10,200	188,700
Carol Beach to Kenosha	729,000	536,000	11,000	547,000	34,000	700	34,700
Parkside to Kenosha	3,867,500	2,834,000	22,100	2,856,100	179,800	1,400	181,200
Subtotal — New Trunk Sewers	14,312,500	11,212,000	383,100	11,595,100	711,300	24,300	735,600
Total	$39,821,900	$37,856,700	$46,467,700	$84,324,400	$2,401,800	$2,948,100	$5,358,900

Source: SEWRPC.

plan for the Kenosha Planning District. From the standpoint of practicality of plan implementation, therefore, alternative 3 is superior to either alternative 1 or alternative 2, both of which involve transmission of considerable amounts of sewage across the Kenosha-Racine county line through either the Kenosha or Racine sewage treatment plants. In terms of establishing a method of implementing the sanitary sewerage system plan, it may be concluded that alternative 3 would lend itself more readily to the establishment of the needed institutional structure for plan implementation than either alternative plans 1 or 2.

Alternative plans 4 or 5 are slightly more costly than alternative plans 1, 2, and 3 and, in addition, involve the establishment of bi-county sanitary sewerage systems, which systems would not fit the established major utility system patterns in the two planning districts. In addition, alternative plans 4 and 5 involve the need to develop an adequate technical staff at one additional sewage treatment facility in the case of alternative plan 4, and two additional sewage treatment facilities in the case of alternative plan 5. Such staffs would have to be highly trained and capable of administering sanitary sewerage systems at a larger scale and at a higher level of treatment than is currently being provided at the small sewage treatment plants in the Kenosha-Racine subregional area and would, therefore, involve the duplication of staff already being provided at the Kenosha and Racine sewage treatment facilities. Although the capital costs of alternative plans 1, 2, and 3 are higher than alternative plans 4 and 5, these additional capital costs are more than offset in the long run through reduced operation and maintenance costs at the larger treatment facilities included in alternative plans 1, 2, and 3.

Private Sewage Treatment Facilities

Five private sewage treatment facilities currently discharge wastes in the Kenosha-Racine subregional area. These are: the American Motors Truck Service facility in the Town of Somers; the Sienadale Motherhouse facility in the Town of Pleasant Prairie; the Frank Pure Food Company facility in the Towns of Caledonia and Mt. Pleasant; the St. Bonaventure Seminary facility in the Town of Mt. Pleasant; and the J. I. Case Company facility in the Town of Mt. Pleasant. All five facilities lie within the proposed 1990 sewer service limits of the Kenosha-Racine subregional area, and all but the J. I. Case Company facility in the Town of Mt. Pleasant—which is a specialized treatment facility constructed for the purpose of treating foundry wastes, and which accordingly should be retained—would be abandoned and connected to the centralized sanitary sewerage systems in the Kenosha and Racine areas as trunk sewer service becomes available.

Combined Sewer Overflow Abatement Plan

As discussed in Chapter V of this report, portions of the Cities of Kenosha and Racine are served by combined sewer systems. In 1970, the area served by such combined systems in the City of Kenosha totaled about 1.6 square miles, or about 9 percent of the total area served by sanitary sewers. The area served by combined sewers in the City of Racine totaled about two square miles, or nearly 15 percent of the total area served by sanitary sewers. Both the Cities of Kenosha and Racine have embarked upon sewerage improvement programs designed to effect a greater degree of separation within the combined sewer areas. The City of Racine began its combined sewer separation program in 1935, while the City of Kenosha began its separation program in 1968. The specific areas of the Cities of Kenosha and Racine served by combined sewers, as well as the location of all combined sewer outfalls, are shown on maps presented in Chapter V of this report.

While both the Cities of Kenosha and Racine have undertaken major sewer separation projects as a means of eliminating combined sewer overflows, each community has also undertaken research and demonstration programs designed to determine the effectiveness of alternative means of resolving the remaining combined sewer overflow problems. In the City of Racine, a research and demonstration project jointly financed by the city, the Wisconsin Department of Natural Resources, and the U. S. Environmental Protection Agency is underway to evaluate the utilization of "flow-through" treatment as an alternative to sewer separation. The project consists of the construction and operation on a demonstration basis of a coarse and fine screening-dissolved air flotation treatment unit at selected outfall locations as an alternative to complete separation of the combined sewer area. The demonstration project serves about one-fourth of the remaining combined sewer area in Racine. These studies may indicate that the provision of such treatment at outfall locations is a more cost-effective method of resolving the problem. Subject to completion of the research and demonstration project and submittal of a final report on the findings and recommendations, with respect to which of the remaining combined definitive recommendations with respect to which of the remaining combined sewer areas in Racine should be separated and which should receive flow-through treatment facilities must be held in abeyance.

The research and demonstration project in the City of Kenosha is quite different than that in the City of Racine in that it is aimed at determining the feasibility of providing standby treatment capacity to treat combined storm water and sanitary sewage at the Kenosha treatment facility rather than at outfall locations. This research and demonstration project is being jointly funded by the City of Kenosha, the Wisconsin Department of Natural Resources, and the U. S. Environmental Protection Agency. As in the case of Racine, specific recommendations concerning the extent to which complete separation of combined sewer areas should take place is contingent upon the findings and recommendations of the research and demonstration program.

ROOT RIVER CANAL SUBREGIONAL AREA

The Root River Canal subregional area consists of all that area of the Root River watershed lying west of IH 94 in Racine and Kenosha Counties, except that portion of the Town of Raymond recommended for urban development in the adopted regional land use and Root River watershed plans which has been included for sewerage system analysis purposes in the Milwaukee-metropolitan subregional area. The Root River Canal subwatershed consists predominantly of rural, agricultural land uses, including a significant number of farms devoted to duck raising and butchering. The only incorporated municipality in the Root River Canal subregional area is the Village of Union Grove, which actually straddles the subcontinental divide, lying partially within the Root River watershed and partially within the Des Plaines River watershed. In addition, a major state institution—the Wisconsin Southern Colony Institution operated by the Wisconsin Department of Health and Social Services—is located west of the Village of Union Grove in the Town of Dover.

There are a total of seven private sewage treatment facilities which serve residential, institutional, and agricultural land use enclaves within the Root River Canal subregional area. These include the facilities serving the Fonk Mobile Homes Park No. 1 in the Town of Yorkville; the Racine County Highway and Office Building in the Town of Yorkville; the Wisconsin Southern Colony Institution in the Town of Dover; the Pekin, York, and C & D Duck Farms, all in the Town of Yorkville; and the Grove Duck Farm in the Town of Raymond (see Map 38). It should also be noted that one additional private sewage treatment facility—that serving the Meeter Brothers Canning Company in the Town of Yorkville adjacent to the Village of Union Grove—lies within the proposed 1990 sewer service area of the Village of Union Grove. This facility, however, discharges its effluent to a tributary of the Des Plaines River and, consequently, is included for planning purposes in the discussion of the Des Plaines River subregional area later in this chapter.

As noted in Chapter V of this report, centralized sanitary sewer service in the Root River Canal subregional area was provided in 1970 only by the Village of Union Grove to an area of about 0.7 square mile and serving an estimated resident population of about 2,800 persons. In 1970 there were also an estimated 7,200 persons residing within the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the Village of Union Grove sanitary sewerage system and the seven private sewage treatment facilities are presented in Chapter V of this report.

Sewer Service Analysis Areas

Two sewer service analysis areas may be identified within the Root River Canal subregional area (see Table 140). These two sewer service analysis areas are shown on Map 83 and may be described as follows:

1. Area A—This area consists of the Village of Union Grove and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.74 square mile, having a total resident population of about 2,800 persons. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.7 square miles, with a projected population of about 7,700 persons. This subarea is referenced as the "Union Grove" sewer service area in the ensuing discussion.

Table 140

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS
IN THE ROOT RIVER CANAL SUBREGIONAL AREA
1970 and 1990

Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Union Grove	0.74	2,800	0.43	200	1.73	7,700	1.43
B	Wisconsin Southern Colony	0.44	1,400	N/A	--	0.44	2,000	0.40
	Total	1.18	4,200	0.43	200	2.17	9,700	1.83

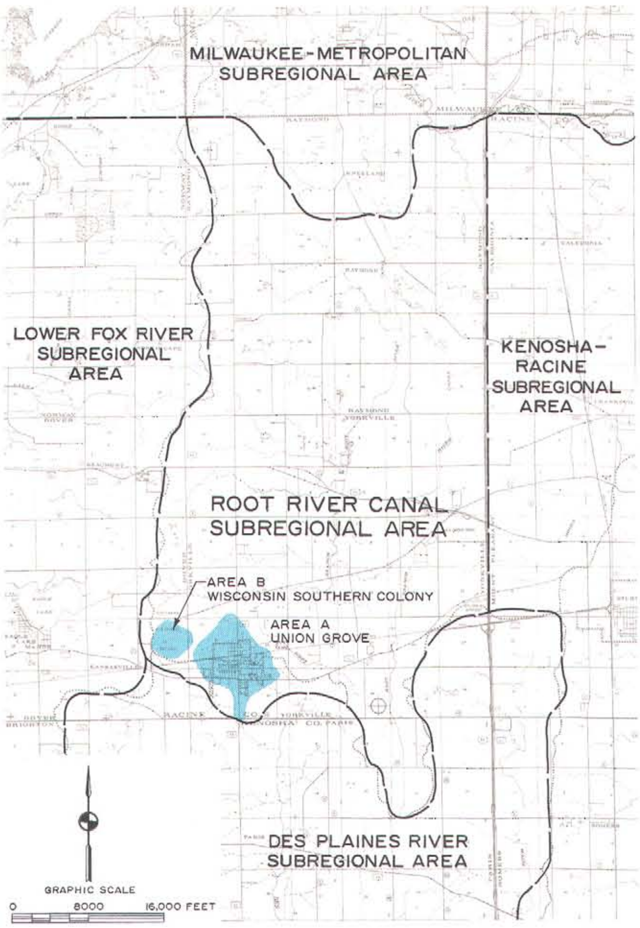
NOTE: N/A indicates data not available.

[1]See Map 83.

Source: SEWRPC.

Map 83

SEWER SERVICE ANALYSIS AREAS
ROOT RIVER CANAL SUBREGIONAL AREA



The Root River Canal subregional area consists predominantly of rural, agricultural land uses, including significant amounts of agricultural-related industry such as duck raising and butchering. One urban and one institutional sewer service area are located in this subregion, namely the Village of Union Grove and the Wisconsin Southern Colony Institution. Both the Union Grove and Southern Colony treatment facilities discharge effluent to the West Branch of the Root River Canal. Because of the proximity of these two urban type land use concentrations, it was determined under the regional sanitary sewerage study to examine the feasibility of interconnecting the two systems at a centralized treatment plant.

Source: SEWRPC.

2. Area B—This area consists of the Wisconsin Southern Colony Institution in the Town of Dover. While the sanitary sewerage system operated by the Wisconsin Department of Health and Social Services to serve this institution is not, strictly speaking, a public centralized sanitary sewerage system, the service area has all the characteristics of a small urban village and the sewage treatment facility is as large as many facilities serving typical villages throughout the Region. For this reason, and because of its proximity to the Village of Union Grove, the Wisconsin Southern Colony Institution has been considered as a separate sewer service area for regional sewerage system planning purposes. Based upon estimates prepared by the Wisconsin Department of Health and Social Services, the institution should accommodate an equivalent population of about 2,000 persons in the year 1990. This subarea is referenced as the "Wisconsin Southern Colony" sewer service area in the ensuing discussion.

Summary of Root River Watershed Plan Recommendations

The Root River watershed plan, as adopted in 1966 by the Regional Planning Commission, included a water pollution abatement plan element pertaining to sewerage facility development in the Root River Canal subregional area. The Root River watershed plan recommended an upgrading of the existing sewage treatment facilities serving the Village of Union Grove, the Wisconsin Southern Colony Institution, and the Cooper-Dixon Duck Farm (now called C & D Duck Farm). Such upgrading was to consist of the provision of additional capacity where necessary, coupled with the provision of higher levels of waste treatment.[14]

In 1968, the Wisconsin Department of Health and Social Services completed an upgrading of the sewage treatment facility serving the Wisconsin Southern Colony Institution. This facility discharges its effluent through an outfall sewer directly to the West Branch of the Root River Canal. Based upon present plans of the Department for the Southern Colony Institution, the existing treatment facility should provide adequate capacity for future growth at the institution through 1990.

[14] *For a more complete description of the water pollution abatement element of the Root River watershed plan, see SEWRPC Planning Report No. 9, A Comprehensive Plan for the Root River Watershed, Chapter XII.*

It should also be noted that in 1972 the Village of Union Grove completed engineering studies relating to the construction of a new sewage treatment facility. This facility would provide an average hydraulic design capacity of 1.0 mgd and would provide advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. The plant is proposed to be located on a new site adjacent to the West Branch of the Root River Canal and near the point where the effluent outfall from the Wisconsin Southern Colony Institution is located.

Alternative Plans—Union Grove–Wisconsin Southern Colony Subarea

For all practical purposes, the Village of Union Grove and the Wisconsin Southern Colony Institution are contiguous. For this reason, the interconnection of the two sewer service areas for sewage treatment purposes was considered under the regional sanitary sewerage system planning program. Two alternative plans were accordingly planned and evaluated. The first assumes the continued operation of two sewage treatment facilities, with the relocation of the existing Union Grove facility to a new site on the West Branch of the Root River Canal. The second provides for the integration of the two facilities for advanced waste treatment purposes at a common site also located on the West Branch of the Root River Canal. Streamflow and dilution ratio data pertaining to the two sewage treatment facilities are presented in Table 141; required sewage treatment levels and performance standards under both alternatives are set forth in Table 142; and detailed cost estimates pertaining to both alternatives are set forth in Table 143. The two proposals are shown in graphic form on Maps 84 and 85.

Under the first alternative, the Union Grove sewage treatment facility would be replaced by a new sewage treatment facility at a site already purchased by the village on the West Branch of the Root River Canal. A trunk sewer to intercept flow from the existing plant site and convey all sewage to the new plant site is also included within the proposed plan. The new plant would have an average hydraulic design capacity of about 1.43 mgd. In order to meet the established water use objectives for the West Branch of the Root River Canal, the Union Grove plant would be required to provide secondary treatment, advanced waste treatment for phosphorus removal and nitrification, and auxiliary waste treatment for effluent aeration and disinfection. In addition to the new Union Grove facility, the first alternative plan provides for the addition of advanced waste treatment facilities for nitrification at the Wisconsin Southern Colony plant in order to upgrade the level of treatment provided so as to meet the established water use objectives for the West Branch of the Root River Canal. No expansion of the plant in terms of average hydraulic design capacity is envisioned. The plant already discharges its effluent through a long outfall sewer directly to the West Branch of the Root River Canal (see Map 84). The total estimated capital cost of carrying out the first alternative plan for the Union Grove and Wisconsin Southern Colony sewer service areas is about $2.35 million, with an equivalent annual cost of about $263,500.

Under the second alternative plan considered, the Union Grove sewage treatment facility would be relocated as proposed under the first alternative plan, but it would have, in addition, sufficient advanced waste treatment capacity for nitrification and auxiliary waste treatment capacity for

Table 141

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE ROOT RIVER CANAL SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Stream	Stream Low Flow and Dilution Ratio Data: 7-Day, 10-Year Low Flow		Upstream Sewage Treatment Plant Flow-1990		Total Design Low Flow-1990		Total Design Sewage Flow-1990		Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Level of Treatment Required				
												Advanced		Auxiliary	
		CFS	MGD	CFS	MGD	CFS	MGD	CFS	MGD		Secondary	Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Union Grove	West Branch Root River Canal	0.00	0.00	0.00	0.00	0.00	0.00	2.21	1.43	0.00	Yes	Yes	Yes	Yes	Yes
Wisconsin Southern Colony	West Branch Root River Canal	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.40	0.00	Yes	No	Yes	Yes	Yes

Source: SEWRPC.

Table 142

RECOMMENDED SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE WISCONSIN SOUTHERN COLONY AND UNION GROVE SEWER SERVICE AREAS
ROOT RIVER CANAL SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Union Grove (1.43 MGD)	Union Grove	7,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Wisconsin Southern Colony (0.40 MGD)	Wisconsin Southern Colony	2,000[2]	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Union Grove[3] (1.88 MGD)	Union Grove Wisconsin Southern Colony	9,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Wisconsin Southern Colony[3] (0.40 MGD)	Wisconsin Southern Colony	2,000[2]	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l

[1] *See Map 83.*

[2] *Equivalent population based on projected institutional waste flow of 0.40 mgd.*

[3] *Under alternative plan 2, the Union Grove sewage treatment plant would provide secondary waste treatment and advanced waste treatment for phosphorus removal for the influent sewage from the Union Grove sewer service area (1.43 mgd) and advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection for the influent sewage from both the Union Grove and Wisconsin Southern Colony sewer service areas (1.88 mgd).*

Source: SEWRPC.

effluent aeration and disinfection to accommodate partially treated wastes from the Wisconsin Southern Colony Institution. Thus, no expansion of the Wisconsin Southern Colony sewage treatment facility would be necessary. Since an outfall sewer already conveys the partially treated wastes from the institution to the West Branch of the Root River Canal at the site selected for the new Union Grove sewage treatment plant, all that would be necessary to integrate the operation of the two plants would be to provide a lift station to discharge the effluent into the advanced and auxiliary waste treatment components of the new Union Grove sewage treatment plant. Under this alternative, then, the existing Wisconsin Southern Colony facility would continue to provide secondary waste treatment, with the new Union Grove sewage treatment facility providing secondary waste treatment and advanced waste treatment for phosphorus removal for wastes generated in the Union Grove sewer service area, and advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection for wastes generated in both the Union Grove and Wisconsin Southern Colony sewer service areas. The total estimated capital cost of carrying out the second alternative plan for the Union Grove and Wisconsin Southern Colony sewer service areas is about $2.36 million, with an equivalent annual cost of about $251,000.

The integration of the two treatment facilities in this subregional area as proposed under alternative plan 2 is thus more cost effective than the continued independent operation of each plant as proposed under alternative plan 1. In addition to cost, the second alternative plan also has the advantage of eliminating one additional waste outfall to the West Branch of the Root River Canal and thus provides a better basis for water quality management control on this stream. In addition, the immediate integration of the operation of these

Table 143

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE WISCONSIN SOUTHERN COLONY AND UNION GROVE SEWER SERVICE AREAS
ROOT RIVER CANAL SUBREGIONAL AREA

	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
Plan Subelement	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plants							
Union Grove							
Facilities (1.43 MGD)	$1,948,700	$1,760,600	$1,366,600	$3,127,200	$111,700	$ 86,700	$198,400
Land (3.7 Acres)	18,500	14,200	--	14,200	900	--	900
Subtotal	1,967,200	1,774,800	1,366,600	3,141,400	112,600	86,700	199,300
Wisconsin Southern Colony							
Facilities (0.40 MGD)	226,000	257,000	636,000	893,000	16,300	40,400	56,700
Subtotal	226,000	257,000	636,000	893,000	16,300	40,400	56,700
Subtotal--Treatment Facilities	2,193,200	2,031,800	2,002,600	4,034,400	128,900	127,100	256,000
Trunk Sewers							
Union Grove	158,000	115,100	3,200	118,300	7,300	200	7,500
Subtotal--Trunk Sewers	158,000	115,100	3,200	118,300	7,300	200	7,500
Total	$2,351,200	$2,146,900	$2,005,800	$4,152,700	$136,200	$127,300	$263,500
ALTERNATIVE PLAN 2							
Sewage Treatment Plants							
Union Grove							
Facilities (1.43 MGD & 1.88 MGD)[1]	$2,092,500	$1,889,900	$1,435,900	$3,325,800	$119,900	$ 91,100	$211,000
Land (4 Acres)	20,000	14,200	--	14,200	900	--	900
Subtotal	2,112,500	1,904,100	1,435,900	3,340,000	120,800	91,100	211,900
Wisconsin Southern Colony							
Facilities (0.40 MGD)	--	85,100	285,300	370,400	5,400	18,100	23,500
Subtotal	--	85,100	285,300	370,400	5,400	18,100	23,500
Subtotal--Treatment Facilities	2,112,500	1,989,200	1,721,200	3,710,400	126,200	109,200	235,400
Trunk Sewers							
Wisconsin Southern Colony	87,800	78,800	47,300	126,100	5,000	3,000	8,000
Union Grove	158,000	115,100	3,200	118,300	7,300	200	7,500
Subtotal--Trunk Sewers	245,800	193,900	50,500	244,400	12,300	3,200	15,500
Total	$2,358,300	$2,183,100	$1,771,700	$3,954,800	$138,500	$112,400	$250,900

[1] *Secondary and advanced (phosphorus removal) treatment capacity 1.43 MGD; advanced (nitrification) and auxiliary (effluent aeration and disinfection) treatment capacity 1.88 MGD.*

Source: SEWRPC.

two facilities as proposed under alternative plan 2 would provide the first step toward the ultimate abandonment of the facility serving the Wisconsin Southern Colony Institution at the end of its useful life, with all waste treatment ultimately being provided at the new areawide Union Grove sewage treatment plant site.

Private Sewage Treatment Plants

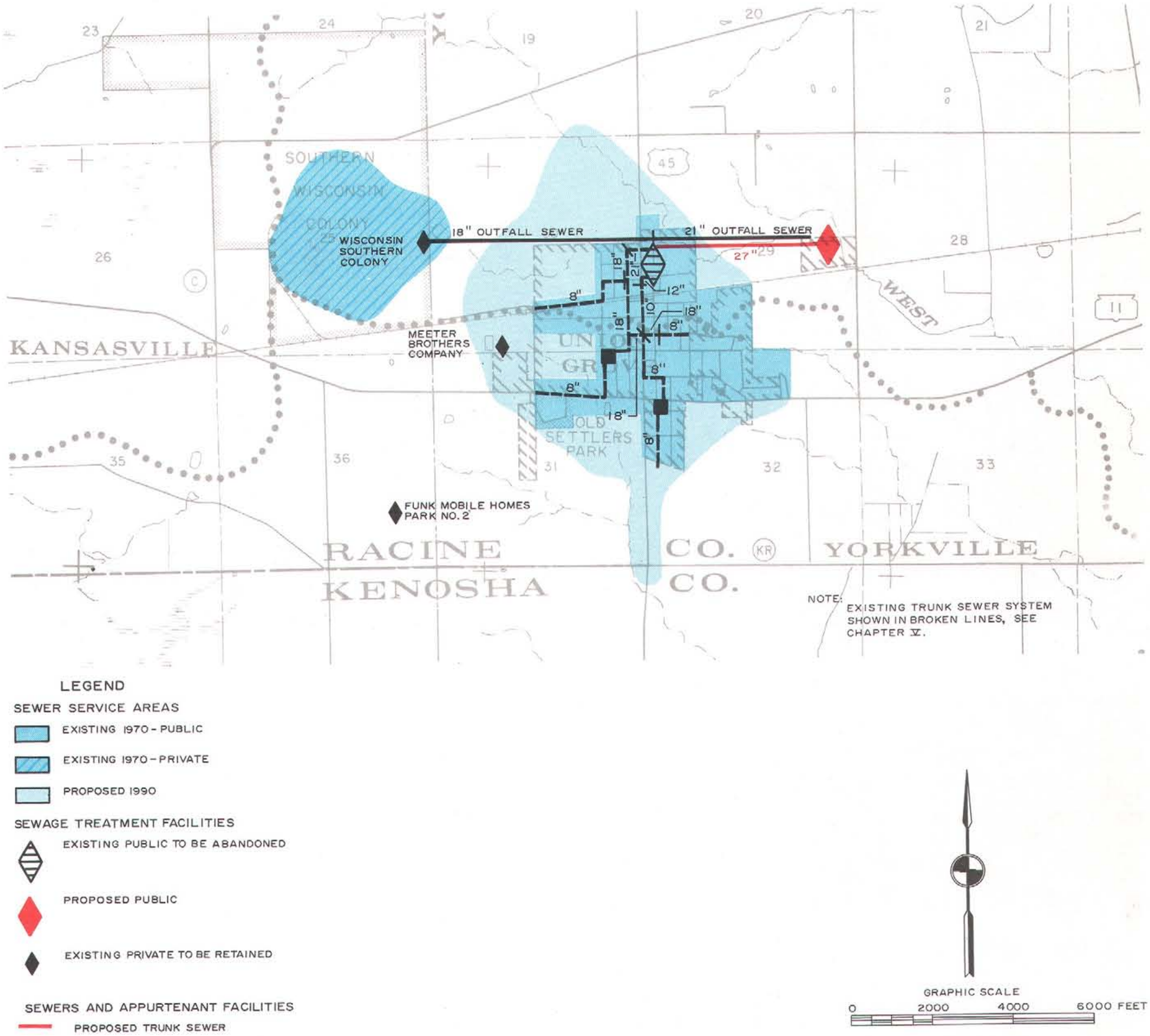
As noted earlier, six private sewage treatment facilities, in addition to the Wisconsin Southern Colony Institution facility, currently discharge wastes to streams in the Root River Canal subregional area. Each of these six facilities lies beyond the proposed 1990 service areas of the Wisconsin Southern Colony Institution and the Village of Union Grove. These facilities accordingly must be retained and, as necessary, be upgraded to meet the established water use objectives and supporting water quality standards of the streams within the Root River Canal subwatershed.

DES PLAINES RIVER SUBREGIONAL AREA

The Des Plaines River subregional area consists of all that area of the Des Plaines watershed in Kenosha and Racine Counties except for the concentration of urban development along the shore-

Map 84

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
FOR THE UNION GROVE AND WISCONSIN SOUTHERN COLONY SEWER SERVICE AREAS
ROOT RIVER CANAL SUBREGIONAL AREA
1990

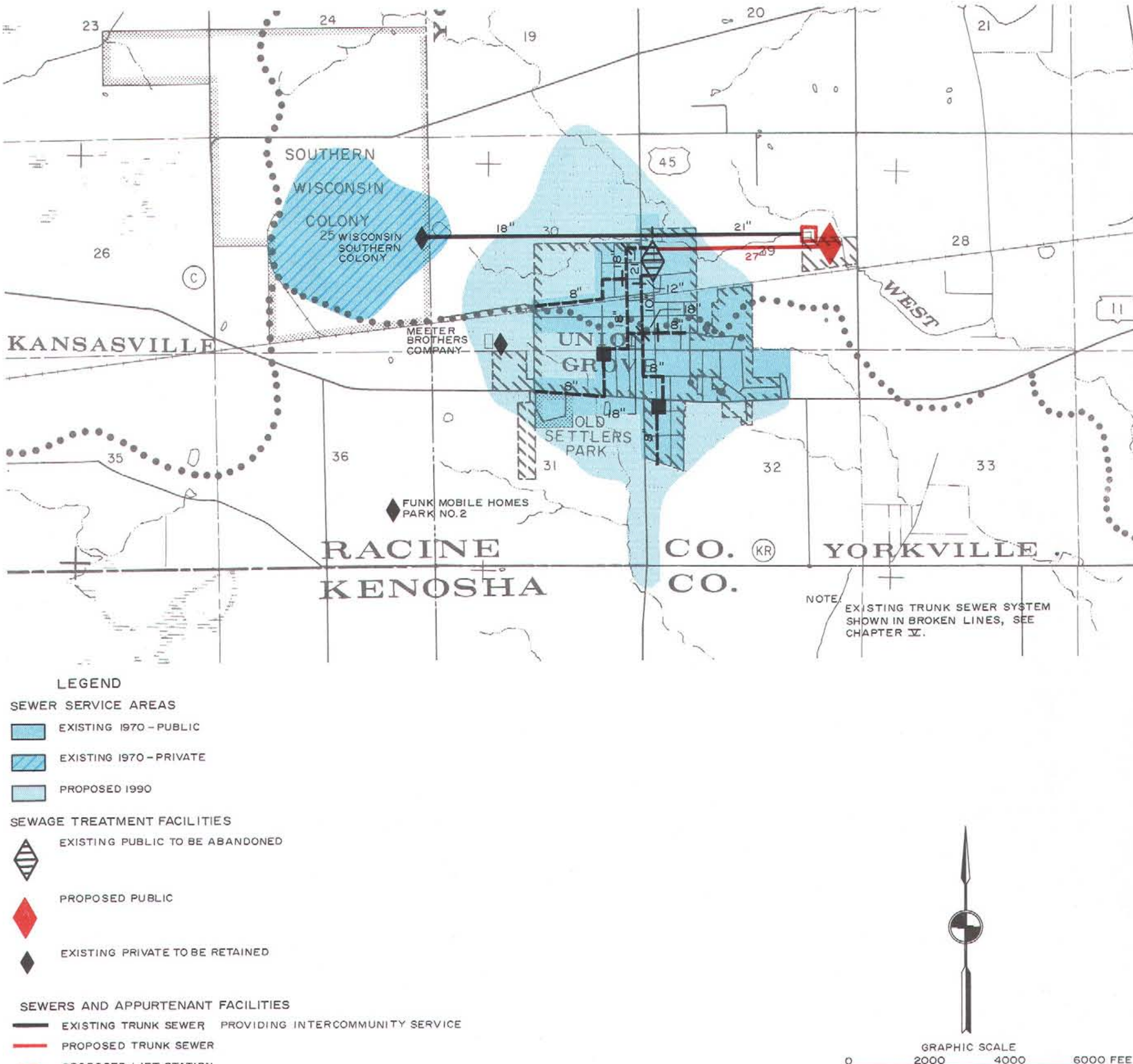


The first alternative plan for service to the Union Grove and Wisconsin Southern Colony areas proposes the continued operation of two sewage treatment facilities, with relocation of the existing Union Grove plant to a new site located on the West Branch of the Root River Canal. The new Union Grove plant would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The existing Southern Colony treatment facility would be upgraded to provide advanced waste treatment for nitrification. This alternative was found to be less cost effective than functionally integrating the two plants for advanced waste treatment purposes, as shown on Map 85.

Source: SEWRPC.

Map 85

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE UNION GROVE AND WISCONSIN SOUTHERN COLONY SEWER SERVICE AREAS
ROOT RIVER CANAL SUBREGIONAL AREA
1990



Under the second alternative plan considered for the Union Grove and Wisconsin Southern Colony areas, the Union Grove plant would be relocated as in the first alternative but would, in addition, have sufficient capacity to provide advanced and auxiliary treatment for wastes from the Southern Colony Institution. The existing Southern Colony facility would continue to provide secondary waste treatment until the end of its useful life. The functional integration of these two plants in this manner was found to be more cost effective than providing advanced waste treatment facilities at the Southern Colony plant.

Source: SEWRPC.

lines of Lake Shangrila and Benet Lake in the Towns of Bristol and Salem, which development has been grouped with adjacent development on the shorelines of Voltz Lake and Cross Lake in the Lower Fox River subregional area for sewerage system planning purposes. The Des Plaines watershed consists of predominantly rural and agricultural land uses with relatively small concentrations of urban development in the Towns of Pleasant Prairie, Bristol, and Salem and the Village of Paddock Lake.

As noted in Chapter V of this report, centralized sanitary sewer service in the Des Plaines River subregional area was provided by four systems in 1970: those operated by the Village of Paddock Lake, the Town of Pleasant Prairie Sewer Utility District D, the Town of Bristol Utility District No. 1, and the Town of Salem Sewer Utility District No. 1. Together the service areas of these four systems comprised an area of nearly two square miles and served an estimated population of about 3,600 persons. In 1970, there were about 7,700 persons residing within the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the four existing systems are presented in Chapter V of this report.

Sewer Service Analysis Areas

A total of six sewer service analysis areas may be identified within the Des Plaines River subregional area (see Table 144). These six sewer service analysis areas are shown on Map 86 and may be described as follows:

1. Area A—This area consists of the Village of Paddock Lake and environs. In 1970, sanitary sewer service was provided in this area to about 0.8 square mile, having a total resident population of about 1,500 persons. By 1990 the total area anticipated to be served approximates 1.8 square miles, with a projected population of about 3,800 persons. This subarea is referenced as the "Paddock Lake" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Town of Salem Sewer Utility District No. 1 and environs, including existing and proposed urban development along the shorelines of Hooker and Montgomery Lakes. In 1970, sanitary sewer service was provided in this area to about 0.4 square mile, having a total resident population of about 800 persons. By 1990 the total area anticipated to be served approximates 1.3 square miles, with a projected population of about

Table 144

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE DES PLAINES RIVER SUBREGIONAL AREA 1970 and 1990

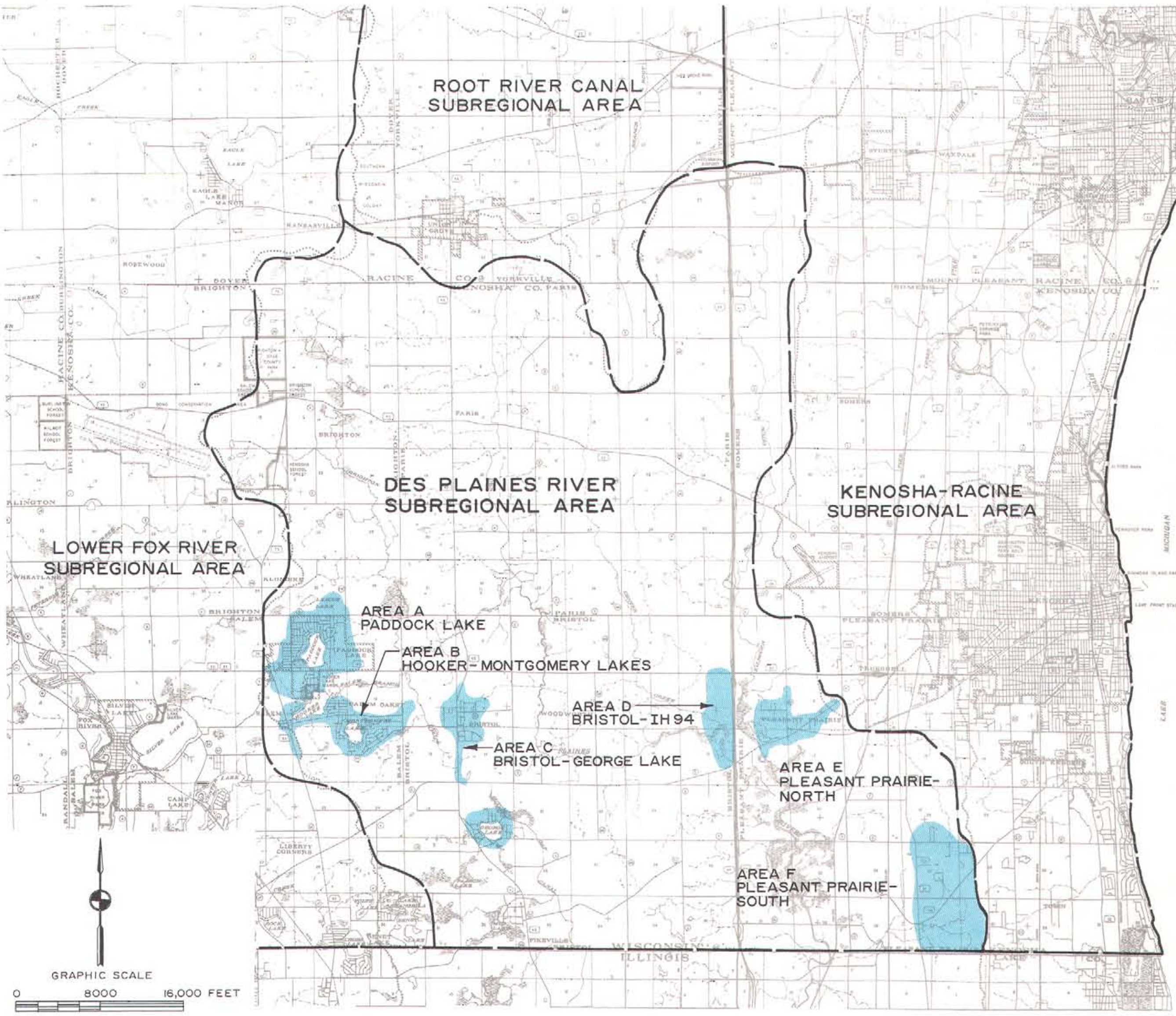
Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Paddock Lake	0.79	1,500	0.15	--	1.81	3,800	0.80
B	Hooker-Montgomery Lakes	0.38	800	0.05	110	1.33	1,300	0.27
C	Bristol-George Lake	0.19	500	0.06	360	1.04	1,500	0.32
D	Bristol-IH 94	--	--	--	60	0.80	1,600[2]	0.33
E	Pleasant Prairie-North	0.59	800	0.09	--	0.85	800	0.09
F	Pleasant Prairie-South	--	--	--	800	2.54	2,800[3]	0.60
	Total	1.95	3,600	0.35	1,330	8.37	11,800	2.41

[1]See Map 86.
[2]Population equivalent based on a projected industrial-commercial waste loading of 0.33 MGD.
[3]Includes existing (1970) population of 800 plus an additional 2,000 persons anticipated locally under current (1973) land development proposals. No incremental population was allocated to this area under the adopted regional land use plan.

Source: SEWRPC.

Map 86

SEWER SERVICE ANALYSIS AREAS
DES PLAINES RIVER SUBREGIONAL AREA



Six individual sewer service analysis areas were identified within the Des Plaines River subregional area. These include the Village of Paddock Lake, the Hooker-Montgomery Lakes area in the Town of Salem, the unincorporated village of Bristol and Lake George area in the Town of Bristol, the commercial-industrial land use complex located along IH 94 in the Town of Bristol, the unincorporated village of Pleasant Prairie, and a complex of existing and proposed urban land use concentrations in the Town of Pleasant Prairie near the Illinois-Wisconsin state line and west of the subcontinental divide. Preliminary economic analyses indicated that interconnection potential existed among these six areas only with respect to Paddock Lake and Hooker-Montgomery Lakes sewer service areas.

Source: SEWRPC.

1,300 persons. This subarea is referenced as the "Hooker-Montgomery Lakes" sewer service area in the ensuing discussion.

3. Area C—This area consists of the Town of Bristol Utility District No. 1 and environs, including existing and proposed urban development in the unincorporated village of Bristol and along the shoreline of George Lake. In 1970, sanitary sewer service was provided in this area to about 0.2 square mile, having a total resident population

of about 500 persons. By 1990 the total area anticipated to be served approximates one square mile, with a projected population of about 1,500 persons. This subarea is referenced as the "Bristol-George Lake" sewer service area in the ensuing discussion.

4. Area D—This area consists of a portion of the Town of Bristol lying along IH 94 between the STH 50 and CTH C interchanges. While no public sanitary sewer service was provided in this area in 1970, one private sewage treated facility was operated, serving the Howard Johnson Motor Lodge and an adjacent automobile service station. In addition, wastes from the truck service center operated by Beaver Transport Company and Quality Carriers, Inc., are currently trucked to the City of Kenosha sewage treatment plant. As noted in Chapter V of this report, the Town of Bristol has proposed the establishment of a public sanitary sewerage system to serve this area. This subarea is referenced as the "Bristol-IH 94" sewer service area in the ensuing discussion.

5. Area E—This area consists of the Town of Pleasant Prairie Sewer Utility District D. In 1970, sanitary sewer service was provided in this area to nearly 0.6 square mile, having a total resident population of about 800 persons. It is not anticipated that substantial additional growth will occur in this area by 1990. This subarea is referenced as the "Pleasant Prairie-North" sewer service area in the ensuing discussion.

6. Area F—This area consists of a portion of the Town of Pleasant Prairie approximately bounded by the Illinois-Wisconsin state line on the south, STH 31 on the west, CTH Q on the north, and the subcontinental divide on the east. No public sanitary sewer service was provided in this area in 1970. Since 1970, however, the Town of Pleasant Prairie and the Wisconsin Department of Natural Resources have given approval to urban land development proposals and the construction of a public sewage treatment facility to serve this area. By 1990 this 2.5 square mile area is anticipated to have a resident population of 2,800. This subarea is referenced at the "Pleasant Prairie-South" sewer service area in the ensuing discussion.

Formulation of Alternatives

As discussed earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system planning program for the formulation of alternative plans. The first step in this process was to apply the Wisconsin Department of Natural Resources (DNR) guidelines relating distances between communities to the populations of both the "sending" and "receiving" communities in order to determine if potential interconnections between sanitary sewerage systems should be investigated. The results of the application of these criteria to the communities within the Des Plaines River subregional sewerage system planning area are summarized in Table 145.

Based on the DNR guidelines, the following potential interconnections between sewer service areas in the Des Plaines River subregional area were eliminated from further consideration:

1. Bristol-George Lake to Paddock Lake.
2. Paddock Lake to Bristol-George Lake.
3. Hooker–Montgomery Lakes to Bristol–George Lake.
4. Pleasant Prairie-North to Pleasant Prairie-South.

Two interconnections—Hooker-Montgomery Lakes to Paddock Lake and Bristol-IH 94 to Pleasant Prairie—were found to be potentially feasible through the application of the DNR guidelines. Conduct of preliminary economic analyses for these potential interconnections further revealed that a detailed economic analysis was warranted only for the Hooker-Montgomery Lakes to Paddock Lake interconnection. Accordingly, it was determined that the following sanitary sewerage system plans for the Des Plaines River subregional area should be prepared and evaluated:

1. A proposed plan for the Bristol-George Lake sewer service area.
2. A proposed plan for the Bristol-IH 94 sewer service area.

Table 145

RESULTS OF THE APPLICATION OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES INTERCONNECTION GUIDELINES AND PRELIMINARY ECONOMIC ANALYSES IN THE DES PLAINES RIVER SUBREGIONAL AREA

Sewer Service Analysis Area(s)				Results of Application of DNR Guidelines		Results of Preliminary Economic Analysis			
Receiving		Sending				Total Equivalent Annual Cost			
Name	Estimated 1990 Population	Name	Estimated 1990 Population	Straight Line Distance Between Sewer Service Areas (Miles)	Proceed to Preliminary Economic Analysis (Yes or No)	Separate Plants (A)	Interconnection-One Plant (B)	Percent Difference (B–A) / (A)	Proceed to Detailed Economic Analysis[1] (Yes or No)
Paddock Lake	3,800	Hooker-Montgomery Lakes Bristol-George Lake	1,300 1,500	1.2 2.7	Yes No	$125,500 --	$123,800 --	-1.3 --	Yes --
Bristol-George Lake	1,500	Paddock Lake Hooker-Montgomery Lakes	3,800 1,300	2.7 2.5	No No	-- --	-- --	-- --	-- --
Pleasant Prairie-North	800	Bristol-IH 94	1,600[2]	1.4	Yes	53,800	75,800	40.9	No
Pleasant Prairie-South	2,800	Pleasant Prairie-North	800	3.6	No	--	--	--	--

[1]*If the estimated equivalent annual cost of interconnection was no more than 20 percent greater than the cost of providing separate sewage treatment facilities, a detailed economic analysis was deemed to be required.*
[2]*Population equivalent based on a projected industrial-commercial waste loading of 0.33 MGD.*

Source: SEWRPC.

Table 146

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE DES PLAINES RIVER SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Water Body	Stream Low Flow and Dilution Ratio Data									Level of Treatment Required				
		7-Day, 10-Year Low Flow		Upstream Sewage Treatment Plant Flow-1990		Total Design Low Flow-1990		Total Design Sewage Flow-1990		Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Secondary	Advanced		Auxiliary	
		CFS	MGD	CFS	MGD	CFS	MGD	CFS	MGD			Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Paddock Lake[1]	Marsh tributary to Brighton Creek	0.00	0.00	0.00	0.00	0.00	0.00	1.24	0.80	0.00	Yes	Yes	Yes	Yes	Yes
Paddock Lake[2]	Marsh tributary to Brighton Creek	0.00	0.00	0.00	0.00	0.00	0.00	1.66	1.07	0.00	Yes	Yes	Yes	Yes	Yes
Hooker Lake[1]	Brighton Creek-Salem Branch	0.012	0.01	0.00	0.00	0.012	0.01	0.42	0.27	0.03	Yes	No	Yes	Yes	Yes
Bristol-George Lake	Tributary to Des Plaines River	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.32	0.00	Yes	No	Yes	Yes	Yes
Bristol-IH 94	Des Plaines River	0.45	0.29	2.12	1.37	2.57	1.66	0.51	0.33	5.04	Yes	No	No	Yes	Yes
Pleasant Prairie-North	Des Plaines River	0.60	0.39	2.63	1.70	3.23	2.09	0.14	0.09	23.07	Yes	No	No	No	Yes
Pleasant Prairie-South	Des Plaines River	0.80	0.52	2.80	1.81	3.60	2.33	0.93	0.60	3.87	Yes	Yes	No	Yes	Yes

[1]*Corresponds to Paddock Lake-Hooker-Montgomery Lakes alternative plan 1.*
[2]*Corresponds to Paddock Lake-Hooker-Montgomery Lakes alternative plan 2.*

Source: SEWRPC.

3. A proposed plan for the Pleasant Prairie-North sewer service area.

4. A proposed plan for the Pleasant Prairie-South sewer service area.

5. Two alternative plans for the Paddock Lake—Hooker—Montgomery Lakes sewer service areas, including an alternative providing individual sewage treatment facilities at each of the two service areas and an alternative providing for consolidation of treatment facilities at the Paddock Lake sewage treatment site.

Each of these sanitary sewerage system plan elements is described in the following paragraphs. Data pertaining to required treatment levels at each of the municipal sewage treatment plant sites considered in the preparation of these plan elements are presented in Table 146.

Proposed Plan—Bristol-George Lake Subarea

In 1970, the sewage treatment facility serving the Bristol-George Lake sewer service area had an average hydraulic design capacity of 0.06 mgd and provided a secondary level of waste treatment. As noted in Chapter V, this facility was recently expanded (1972) to provide for an average hydraulic design capacity of 0.16 mgd. This expansion was made to accommodate additional sewage flow from the George Lake portion of the sewer service area. By 1990 it is anticipated that future growth will require an average hydraulic design capacity for the Bristol sewer service area of about 0.32 mgd. In addition, and in order to meet established water use objectives for the Des Plaines River, it will be necessary for the Bristol sewage treatment facility to provide not only a secondary level of sewage treatment but also an advanced level of treatment in terms of nitrification, and the auxiliary waste treatment of effluent aeration and disinfection. The specific recommended performance standards for the Bristol sewage treatment plant are set forth in Table 147.

The estimated capital cost for constructing the necessary treatment facilities at Bristol is about $601,000, with an equivalent annual cost of about $65,000 (see Table 148). These costs are based upon the provision of additional capacity to the plant as it existed in 1970 and, therefore, include the cost of the additional secondary treatment capacity constructed and placed into operation in

Table 147

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE BRISTOL-GEORGE LAKE SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Bristol (0.32 MGD)	Bristol-George Lake	1,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 87.*

Source: SEWRPC.

Table 148

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE BRISTOL-GEORGE LAKE SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Bristol							
Facilities (0.32 MGD)	$589,000	$545,000	$478,000	$1,023,000	$34,600	$30,300	$64,900
Land (2.4 Acres)	12,000	8,800	--	8,800	600	--	600
Subtotal	601,000	553,800	478,000	1,031,800	35,200	30,300	65,500
Trunk Sewers--*None*							
Total	$601,000	$553,800	$478,000	$1,031,800	$35,200	$30,300	$65,500

Source: SEWRPC.

1972. The costs also include those additional facilities needed to provide the required advanced and auxiliary waste treatment processes. The proposed 1990 service area for the Bristol urban concentration is shown on Map 87.

Proposed Plan—Bristol-I 94 Subarea

As noted above, the Town of Bristol has proposed the establishment of a public sanitary sewerage system to serve existing and proposed commercial, industrial, and residential development along IH 94 between the STH 50 and CTH C interchanges. The town has estimated the total 1990 average daily hydraulic loading from this area at 0.33 mgd. The establishment of such a system will resolve existing wastewater treatment problems that now necessitate the trucking of industrial wastes to the City of Kenosha sewage treatment facility on Lake Michigan, and will further permit the abandonment of the existing private sewage treatment facility serving the Howard Johnson Motor Lodge.

Accordingly, it is proposed to include in the regional sanitary sewerage system plan a new sewage treatment facility to serve this area of the Town of Bristol. This facility would discharge its effluent to the Des Plaines River and, in order to meet the established water use objectives for that river, would provide secondary waste treatment and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Bristol-IH 94 sewage treatment plant are set forth in Table 149. The estimated capital cost of constructing the necessary treatment facility is about $509,000, with an equivalent annual cost of about $46,500 (see Table 150). The proposed 1990 service area for the Bristol-IH 94 urban land use concentration is shown on Map 88.

Proposed Plan—Pleasant Prairie-North Subarea

In 1970, the sewage treatment facility serving the Town of Pleasant Prairie Sewer Utility District D had an average hydraulic design capacity of about 0.13 mgd, which was more than adequate to handle the average hydraulic loading in 1970 of 0.09 mgd. Based upon the development assumptions underlying the regional land use plan, it is anticipated that the existing treatment capacity at the Pleasant Prairie facility will be adequate to handle future growth through 1990. Accordingly, the proposed plan does not envision expansion of this facility unless development trends depart substantially from those recommended in the regional land use plan. It is proposed, however, that an outfall sewer be constructed to permit direct discharge of effluent to the Des Plaines River rather than to a small, unnamed tributary as at present. The construction of the outfall sewer would take advantage of the substantial dilution capacity available in the Des Plaines River and avoid the need to add advanced waste treatment facilities to the existing plant. The recommended performance standards for the Pleasant Prairie sewage treatment facility are set forth in Table 151, while the related economic analyses for construction, operation, and maintenance of the existing facility and the proposed outfall sewer are set forth in Table 152. The proposed 1990 sewer service area for this facility is shown on Map 89.

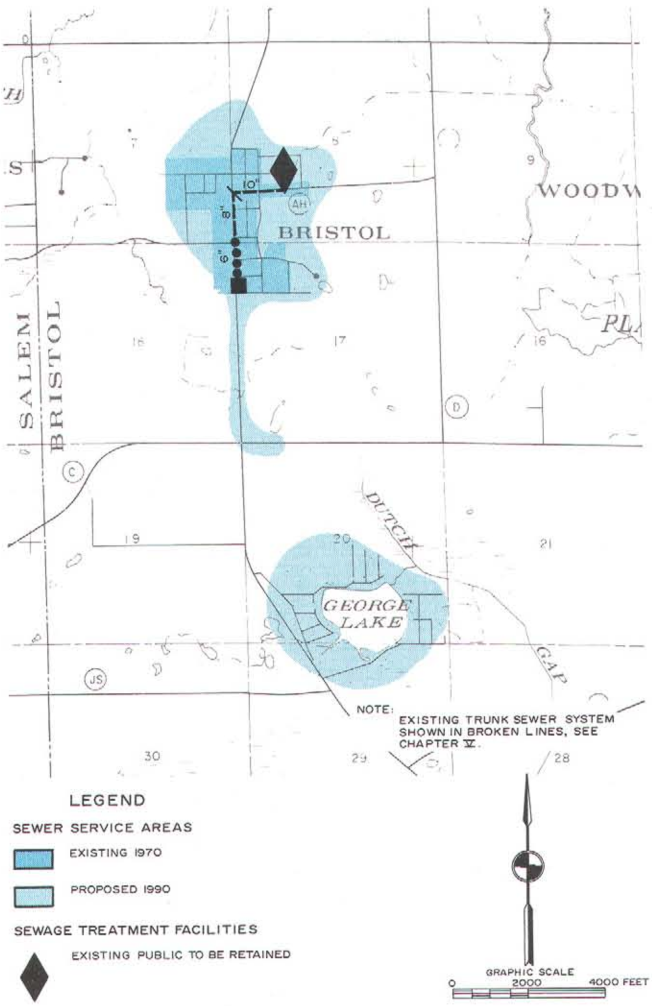
Proposed Plan—Pleasant Prairie-South Subarea

In the absence of an adopted water quality management plan for the Des Plaines watershed, and in recognition of the need to provide sanitary sewer service to existing and proposed urban development located in the Town of Pleasant Prairie west of the subcontinental divide and, therefore, beyond the proposed service area of the Kenosha sewerage system, the Wisconsin Department of Natural Resources in 1973 made a commitment to issue a permit for the construction of a new public sewage treatment facility to be located on the Des Plaines River near the Wisconsin-Illinois state line. This proposed facility was envisioned by the Department of Natural Resources as ultimately serving all urban development located in the Town of Pleasant Prairie west of the subcontinental divide, including such development currently served by the existing sewage treatment facility operated by the Pleasant Prairie Sewer Utility District D, and existing and proposed highway-oriented commercial land uses located or proposed to be located along IH 94, such as the Wisconsin Tourist Information center and a motel-restaurant complex proposed to be developed at the traffic interchange between IH 94 and CTH V.

In recognition of this decision, the regional sanitary sewerage system plan proposes the establishment of a new public sewage treatment facility to initially serve the Pleasant Prairie-South sewer service area (see Map 90), and to ultimately, that is, beyond 1990, serve both the Pleasant Prairie-South and Pleasant Prairie-North sewer service areas and highway-oriented commercial development located along IH 94 in the Town of Pleasant Prairie. Recommended performance standards for this proposed new Pleasant Prairie sewage

Map 87

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE BRISTOL-GEORGE LAKE SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA
1990



The sewage treatment facility serving the unincorporated village of Bristol was recently (1972) expanded to accommodate additional sewage flow from the Lake George area of the Town of Bristol. It is proposed in the regional sanitary sewerage system plan that the Bristol sewage treatment facility continue to provide not only the current secondary level of sewage treatment, but also provide advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection.

Source: SEWRPC.

Map 88

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE BRISTOL-IH 94 SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA
1990

Industrial wastewaters requiring treatment now generated at truck terminal facilities along IH 94 in the Town of Bristol are currently trucked to the City of Kenosha sewage treatment facility located on the Lake Michigan shoreline. In addition, existing commercial developments along IH 94 are currently served by small private sewage treatment facilities. The regional sanitary sewerage system plan proposes the establishment of a new public sewage treatment facility to serve existing and proposed commercial, industrial, and residential development along IH 94 in the Town of Bristol between the STH 50 and CTH C interchanges. This new facility would discharge effluent to the Des Plaines River and would provide secondary waste treatment and auxiliary waste treatment for effluent aeration and disinfection.

Source: SEWRPC.

Table 149

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE BRISTOL-IH 94 SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Bristol-IH 94 (0.33 MGD)	Bristol-IH 94	1,600[2]	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 88.
[2]Population equivalent based on a projected industrial-commercial waste loading of 0.33 mgd.
Source: SEWRPC.

Table 150

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE BRISTOL-IH 94 SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Bristol-IH 94							
Facilities (0.33 MGD)	$496,100	$448,300	$276,200	$724,500	$28,400	$17,500	$45,900
Land (2.5 Acres)	12,500	9,500	--	9,500	600	--	600
Subtotal	508,600	457,800	276,200	734,000	29,000	17,500	46,500
Trunk Sewers--None							
Total	$508,600	$457,800	$276,200	$734,000	$29,000	$17,500	$46,500

Source: SEWRPC.

Table 151

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE PLEASANT PRAIRIE-NORTH SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA

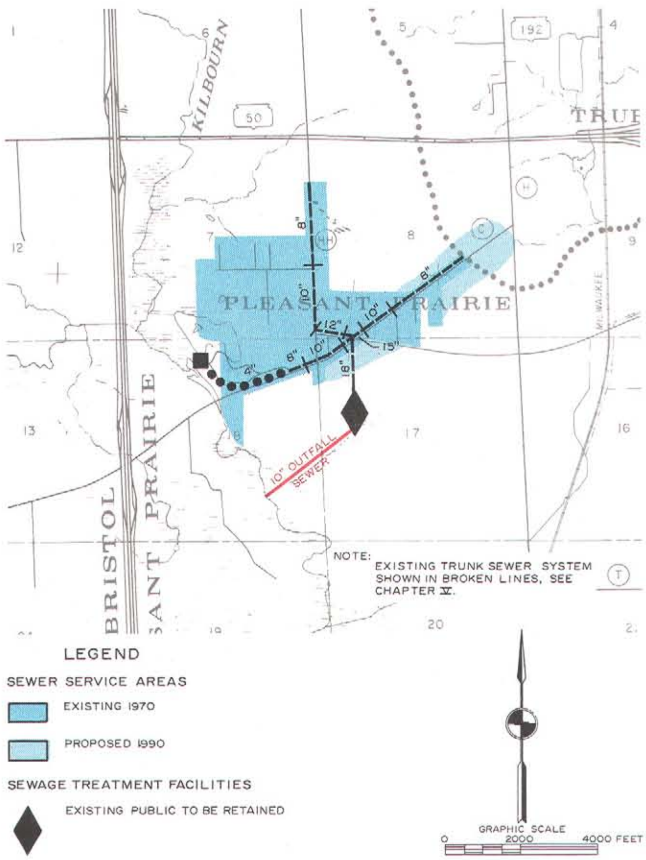
Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Pleasant Prairie-North (0.09 MGD)	Pleasant Prairie-North	800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 89.
Source: SEWRPC.

treatment facility are set forth in Table 153. Phosphorus removal is recommended in order to help assure that threshold levels for weed and algae growth in the Des Plaines River will not be reached. Detailed cost estimates pertaining to the construction, operation, and maintenance of the proposed facility and appurtenant sewers are set forth in Table 154.

Map 89

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE PLEASANT PRAIRIE-NORTH SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA
1990

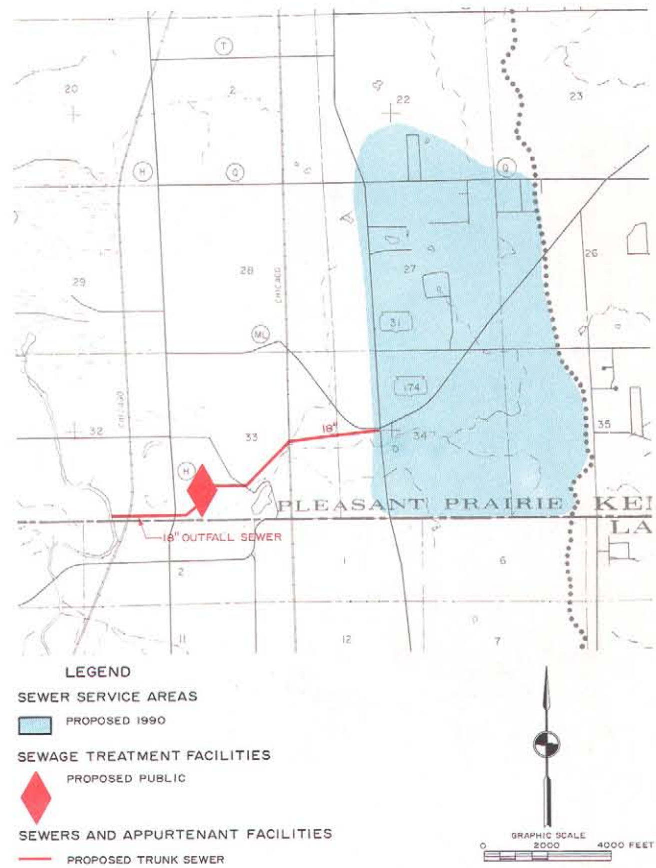


It is anticipated that the existing capacity of the treatment facility operated by the Town of Pleasant Prairie Sewer Utility District D will be adequate to accommodate future urban growth in this subarea through the next two decades. In order to avoid the need to provide advanced waste treatment facilities for nitrification at the existing plant, however, it is proposed that an outfall sewer be constructed to carry the sewage effluent directly to the Des Plaines River where substantial dilution capacity is available. The small, unnamed tributary to which the plant currently discharges effluent has little waste assimilation capacity, particularly during periods of low flows.

Source: SEWRPC.

Map 90

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE PLEASANT PRAIRIE-SOUTH SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA
1990



The Wisconsin Department of Natural Resources has given its approval to the establishment of a new public sewage treatment facility intended to serve existing and proposed urban development in the southwesterly portion of the Town of Pleasant Prairie and highway-oriented commercial development located in the town along IH 94. It is proposed that this new treatment facility discharge effluent directly to the Des Plaines River, and that advanced waste treatment for phosphorus removal be provided in order to ensure that threshold levels for weed and algae growth in the River will not be reached. It is further proposed that this treatment facility ultimately--beyond 1990--serve all urban development in the Town of Pleasant Prairie west of the subcontinental divide and highway-oriented commercial development along IH 94.

Source: SEWRPC.

Alternative Plans—Paddock Lake-Hooker-Montgomery Lakes Subarea

As indicated above, preliminary economic analyses revealed a need to consider an interconnection of the Paddock Lake and Hooker-Montgomery Lakes sewer service areas for sewage treatment purposes. Two sewage treatment facilities served these two adjacent areas in 1970, one operated by

Table 152

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE PLEASANT PRAIRIE-NORTH SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Pleasant Prairie-North							
Facilities (0.09 MGD)	$ --	$20,500	$53,600	$ 74,100	$1,300	$3,400	$4,700
Outfall Sewer	87,100	63,000	1,600	64,600	4,000	100	4,100
Subtotal	87,000	83,500	55,200	138,700	5,300	3,500	8,800
Trunk Sewers--None							
Total	$87,100	$83,500	$55,200	$138,700	$5,300	$3,500	$8,800

Source: SEWRPC.

Table 153

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE PLEASANT PRAIRIE-SOUTH SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Pleasant Prairie-South (0.60 MGD)	Pleasant Prairie-South	2,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 90.*
Source: SEWRPC.

Table 154

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE PLEASANT PRAIRIE-SOUTH SEWER SERVICE AREA
DES PLAINES RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Pleasant Prairie-South							
Facilities (0.60 MGD)	$ 905,200	$818,000	$687,200	$1,505,200	$51,900	$43,600	$95,500
Land (3.0 Acres)	15,000	11,000	--	11,000	700	--	700
Outfall Sewer	70,900	52,000	3,200	55,200	3,300	200	3,500
Subtotal	991,100	881,000	690,400	1,571,400	55,900	43,800	99,700
Trunk Sewer							
Pleasant Prairie-South	121,500	88,300	1,600	89,900	5,600	100	5,700
Subtotal	121,500	88,300	1,600	89,900	5,600	100	5,700
Total	$1,112,600	$969,300	$692,000	$1,661,300	$61,500	$43,900	$105,400

Source: SEWRPC.

the Village of Paddock Lake and the other operated by the Town of Salem Sewer Utility District No. 1.

Two alternative plans were accordingly prepared and evaluated. The first assumes the continuation of two sewage treatment facilities. The second provides for the abandonment of the Hooker Lake facility and the connection of the Hooker-Montgomery Lakes sewer service area to an expanded Paddock Lake treatment facility. Required sewage treatment levels and performance standards under both alternatives are set forth in Table 155, while detailed cost estimates pertaining to both alternatives are set forth in Table 156. The two proposals are shown in graphic form on Maps 91 and 92.

Under the first alternative, the Hooker Lake sewage treatment facility would not require expansion beyond its present average hydraulic design capacity of 0.30 mgd, since the anticipated 1990 sewage flow from the Hooker-Montgomery Lakes sewer service area is estimated at 0.27 mgd. In order to meet the established water use objectives for the Salem branch of Brighton Creek, however, additional treatment facilities would be required to provide for advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. The Paddock Lake sewage treatment facility under the first alternative would need to be approximately doubled in size from its existing 0.40 average hydraulic capacity to a 1990 average hydraulic design capacity of about 0.80 mgd. In addition, in order to meet the established water use objectives for Brighton Creek, the Paddock Lake facility would be required to provide advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. Phosphorus removal is being recommended in order to assure that threshold levels for weed and algae growth in Brighton Creek will not be reached. The total estimated capital cost of carrying out the first alternative plan for the Paddock Lake and Hooker-Montgomery Lakes sewer service areas is about $996,000, with an equivalent annual cost of about $144,000.

Under the second alternative plan considered, the existing Hooker Lake sewage treatment facility would be abandoned and the entire Hooker-Montgomery Lakes sewer service area connected

Table 155

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE
PADDOCK LAKE AND HOOKER-MONTGOMERY LAKES SEWER SERVICE AREAS
DES PLAINES RIVER SUBREGIONAL AREA

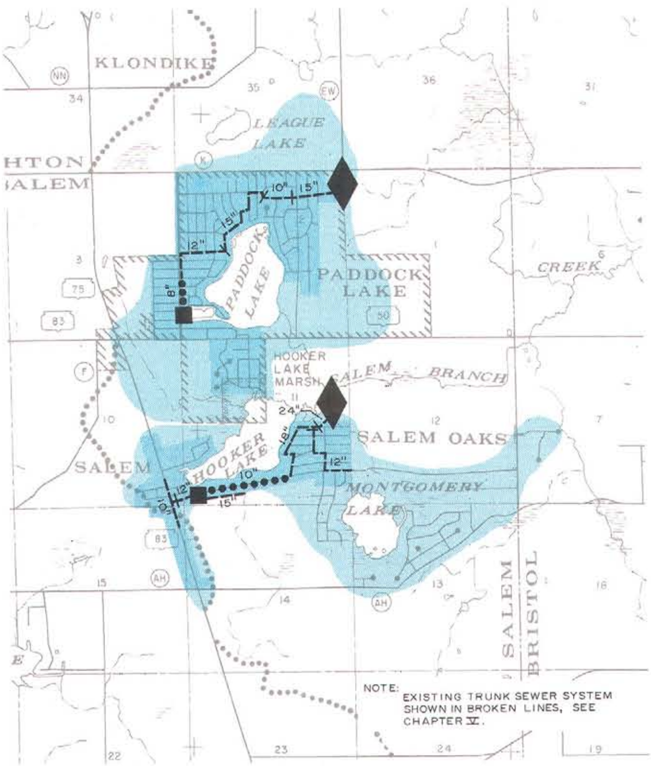
Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Paddock Lake (0.80 MGD)	Paddock Lake	3,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Hooker Lake (0.27 MGD)	Hooker-Montgomery Lakes	1,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Paddock Lake (1.07 MGD)	Paddock Lake Hooker-Montgomery Lakes	5,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 91.

Source: SEWRPC.

Map 91

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
FOR THE PADDOCK LAKE AND HOOKER-MONTGOMERY LAKES
SEWER SERVICE AREAS
DES PLAINES RIVER SUBREGIONAL AREA
1990



LEGEND

SEWER SERVICE AREAS

EXISTING 1970

PROPOSED 1990

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

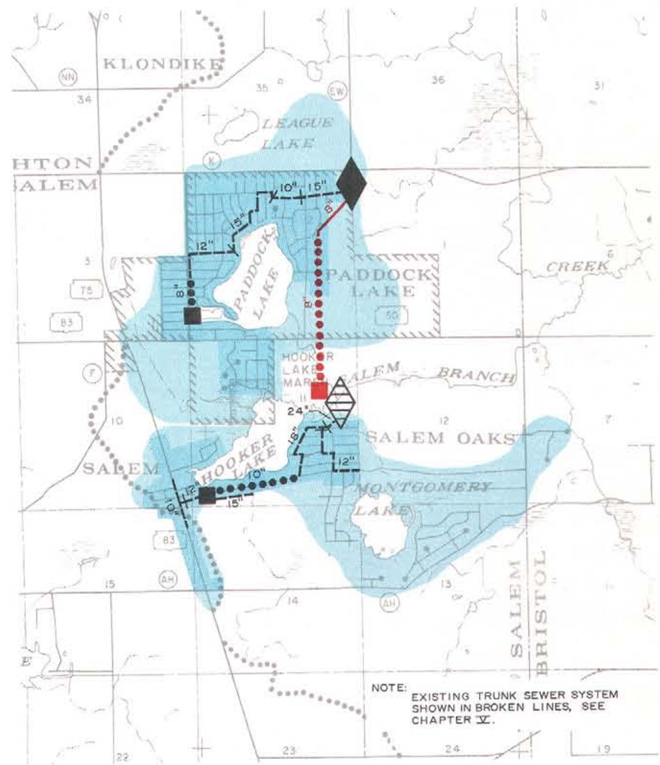
GRAPHIC SCALE 0 2000 4000 FEET

The first alternative sanitary sewerage system plan considered for the Paddock Lake and Hooker-Montgomery Lakes subarea of the Des Plaines River watershed would continue the operation of the existing Paddock Lake and Hooker Lake sewage treatment facilities. Under this alternative, the Hooker Lake treatment facility would provide not only the current secondary level of waste treatment, but also advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. The Paddock Lake treatment facility would also need to upgrade its level of treatment in order to provide advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. This alternative was found to be more cost effective than the alternative of abandoning the Hooker Lake treatment facility and connecting its tributary area to the Paddock Lake plant, as shown on Map 92.

Source: SEWRPC.

Map 92

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE PADDOCK LAKE AND HOOKER-MONTGOMERY LAKES
SEWER SERVICE AREAS
DES PLAINES RIVER SUBREGIONAL AREA
1990



LEGEND

SEWER SERVICE AREAS

EXISTING 1970

PROPOSED 1990

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

EXISTING PUBLIC TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

PROPOSED TRUNK SEWER

PROPOSED FORCE MAIN

PROPOSED PUMPING STATION

GRAPHIC SCALE 0 2000 4000 FEET

The second alternative sanitary sewerage system plan for the Paddock Lake and Hooker-Montgomery Lakes subarea of the Des Plaines River watershed includes a proposal to abandon the existing Hooker Lake sewage treatment facility and connect the entire Hooker-Montgomery Lakes sewer service area to an expanded Paddock Lake sewage treatment facility. The Paddock Lake facility would need to upgrade the level of treatment now being provided to include advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. This alternative was found to be less cost effective than retaining the Hooker Lake sewage treatment facility and upgrading the level of treatment provided at that facility.

Source: SEWRPC.

Table 156

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE PADDOCK LAKE AND HOOKER-MONTGOMERY LAKES SEWER SERVICE AREAS
DES PLAINES RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plants							
Paddock Lake							
Facilities (0.80 MGD)	$ 766,000	$ 774,000	$ 922,000	$1,696,000	$49,100	$58,500	$107,600
Land (2.9 Acres)	14,500	10,600	--	10,600	700	--	700
Subtotal	780,500	784,600	922,000	1,706,600	49,800	58,500	108,300
Hooker Lake							
Facilities (0.27 MGD)	204,000	249,000	308,000	557,000	15,800	19,400	35,200
Land (2.3 Acres)	11,500	8,400	--	8,400	500	--	500
Subtotal	215,500	257,400	308,000	565,400	16,300	19,400	35,700
Subtotal--Sewage Treatment Plants	996,000	1,042,000	1,230,000	2,272,000	66,100	77,900	144,000
Trunk Sewers--None							
Total	$ 996,000	$1,042,000	$1,230,000	$2,272,000	$66,100	$77,900	$144,000
ALTERNATIVE PLAN 2							
Sewage Treatment Plant							
Paddock Lake							
Facilities (1.07 MGD)	$1,026,000	$1,007,000	$1,141,000	$2,148,000	$63,900	$72,400	$136,300
Land (3.2 Acres)	16,000	11,700	--	11,700	700	--	700
Subtotal	1,042,000	1,018,700	1,141,000	2,159,700	64,600	72,400	137,000
Trunk Sewer							
Hooker Lake-Paddock Lake	293,500	232,000	101,000	333,000	14,700	6,400	21,100
Subtotal	293,500	232,000	101,000	333,000	14,700	6,400	21,100
Total	$1,335,500	$1,250,700	$1,242,000	$2,492,700	$79,300	$78,800	$158,100

Source: SEWRPC.

to an expanded Paddock Lake sewage treatment facility. The estimated capital cost of constructing the necessary trunk sewer is about $294,000, with an equivalent annual cost of about $21,100. The Paddock Lake sewage treatment facility would need to be expanded from its existing 0.40 average hydraulic design capacity to a 1990 average hydraulic design capacity of about 1.07 mgd. As in the first alternative, the expanded Paddock Lake facility would have to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The total estimated capital cost of expanding the Paddock Lake treatment facility under this alternative is about $1.04 million, an equivalent annual cost of about $137,000. In total, then, the estimated capital cost of carrying out the second alternative plan for the Paddock Lake and Hooker-Montgomery Lakes sewer service areas is about $1.36 million, with an equivalent annual cost of about $158,000.

The two alternatives considered would provide centralized sanitary sewer service to identical sewer service areas, and each would meet the adopted water use objectives for the tributaries to, and the main stem of, the Des Plaines River. When viewed on an equivalent annual cost basis, the first alternative, which provides for the continued operation of two treatment facilities, is somewhat less expensive than the second alternative, which would consolidate the two facilities at the Paddock Lake site, the difference in cost being approximately 10 percent. The second alternative would, of course, have the advantage of eliminating an additional point source of pollution and provide for a somewhat larger sewage treatment facility to serve all urban development in the Paddock Lake-Hooker Lake-Montgomery Lake contiguous urban area. The second alternative has certain advantages concerning the probability of implementation, in that sewage treatment facilities would continue to be operated by the two units of government now providing sewer service.

Private Sewage Treatment Plants

Six private sewage treatment facilities currently discharge relatively minor amounts of waste to streams in the Des Plaines River watershed. These six facilities serve the Fonk Mobile Homes Park No. 2 in the Town of Dover; the Brighton Dale County Park in the Town of Brighton on the abandoned Bong Air Force Base; the Howard Johnson Motor Lodge and an adjacent automobile service station facility in the Town of Bristol along IH 94; the Paramski Mobile Home Park in the Town of Bristol near the Illinois-Wisconsin state line; the Wisconsin Tourist Information Center operated by the Wisconsin Department of Natural Resources along IH 94 in the Town of Pleasant Prairie; and the Meeter Brothers Canning Company in the Town of Yorkville (see Maps 31 and 38). Except for the Howard Johnson Motor Lodge facility, each of these facilities lies beyond the proposed 1990 service areas of the public sanitary sewerage systems discussed above. These facilities accordingly must be retained and, as necessary, be upgraded to provide a level of waste treatment adequate to meet the water use objectives and standards for the streams within the Des Plaines River watershed. The Howard Johnson Motor Lodge facility would be abandoned upon implementation of the proposed sewerage system plan for the Bristol-IH 94 sewer service area.

UPPER FOX RIVER SUBREGIONAL AREA

The upper Fox River subregional area consists of all that area of the Fox River watershed lying generally north of the Vernon Marsh in Waukesha County. This rapidly urbanizing area includes the City of Waukesha and the westerly portion of the Cities of Brookfield and New Berlin; the Villages of Pewaukee, Sussex, and Lannon and the westerly portion of the Village of Menomonee Falls; and all of the Towns of Brookfield, Pewaukee, and Waukesha and portions of the Towns of Delafield, Lisbon, and Genesee.

As noted in Chapter V of this report, centralized sanitary sewer service in the upper Fox River subregional area was provided by four individual systems in 1970. These systems are operated by the Cities of Waukesha and Brookfield and the Villages of Pewaukee and Sussex. The service areas of these four systems together comprised a total area of about 16 square miles and serve an estimated population of about 59,000 persons. In 1970 there were about 35,800 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the four existing systems are presented in Chapter V of this report.

Sewer Service Analysis Areas

A total of five sewer service analysis areas may be identified within the upper Fox River subregional area (see Table 157). These five sewer service analysis areas are shown on Map 93 and may be described as follows:

1. Area A—This area consists of the entire Village of Lannon, a portion of the Village of Menomonee Falls, and a portion of the Town of Lisbon. About 4,400 persons resided in this area in 1970 but no sanitary sewer service was provided. By 1990

Table 157

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE UPPER FOX RIVER SUBREGIONAL AREA 1970 and 1990

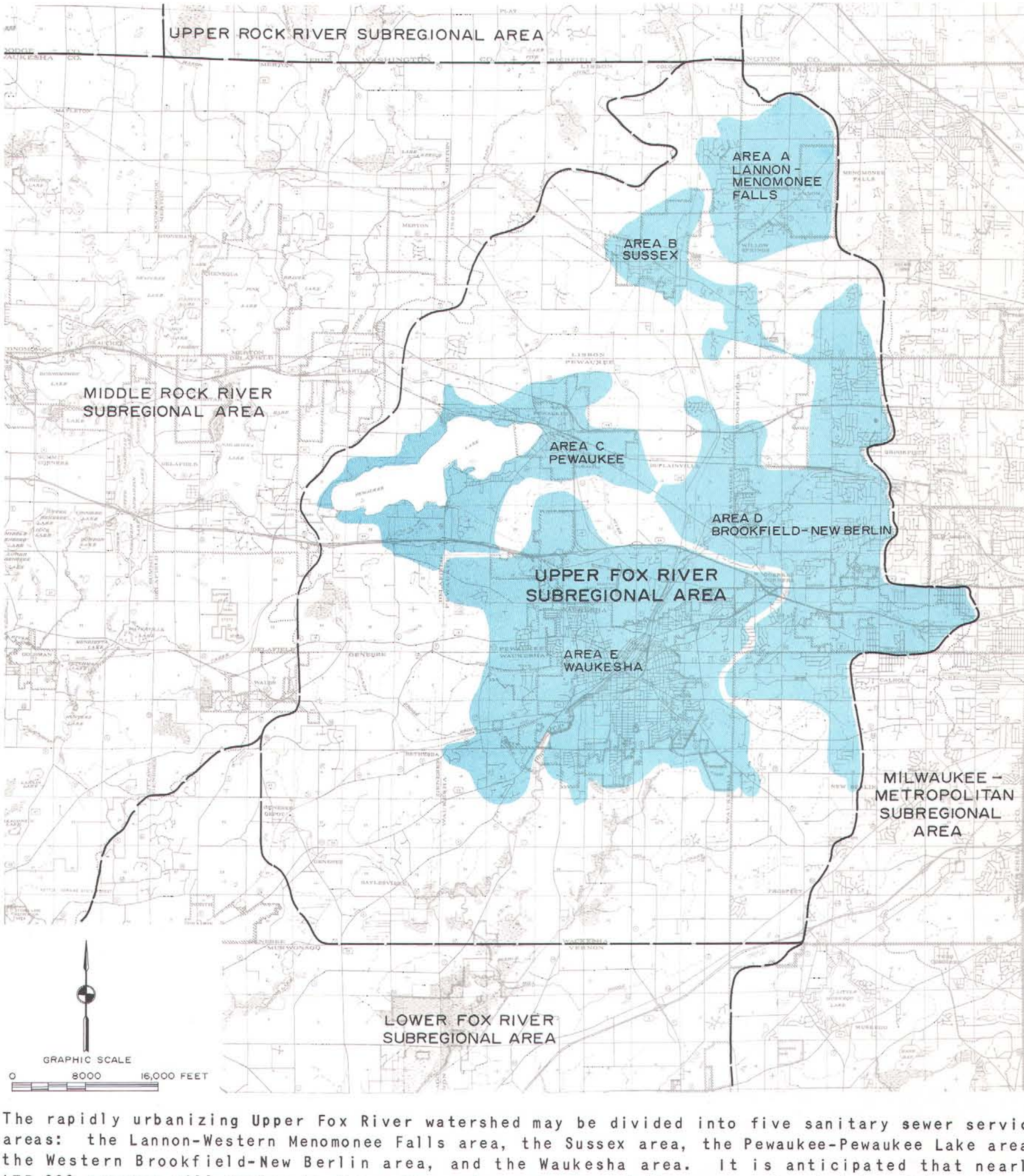
Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Lannon-Menomonee Falls	--	--	--	4,400	7.28	19,100	4.0
B	Sussex	0.89	2,800	0.29	400	2.81	8,100	1.7
C	Pewaukee	0.81	2,900	0.40	5,900	9.46	15,300	3.2
D	Brookfield-New Berlin	5.62	12,300	1.72	10,600	22.52	49,100	10.2
E	Waukesha	8.92	40,700	8.28	7,800	30.91	83,200	17.5
	Total	16.24	58,700	10.69	29,100	72.98	174,800	36.6

[1]See Map 93.

Source: SEWRPC.

Map 93

SEWER SERVICE ANALYSIS AREAS
UPPER FOX RIVER SUBREGIONAL AREA



The rapidly urbanizing Upper Fox River watershed may be divided into five sanitary sewer service areas: the Lannon-Western Menomonee Falls area, the Sussex area, the Pewaukee-Pewaukee Lake area, the Western Brookfield-New Berlin area, and the Waukesha area. It is anticipated that nearly 175,000 persons will reside in these five urban subareas of the upper watershed by 1990, with the total land in urban use anticipated to approximate 73 square miles. In 1970 there were about 89,000 persons residing in the upper watershed, of which about 59,000 were served by centralized sanitary sewer service, and 30,000 by onsite septic tank sewage disposal systems.

Source: SEWRPC.

the total area anticipated to be served with centralized sewer service approximates 7.3 square miles, with a projected population of about 19,000 persons. This subarea is referenced as the "Lannon-Menomonee Falls" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Village of Sussex and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.9 square mile, having a total resident population of about 2,800 persons. An additional 400 persons resided in the proposed 1990 sewer service area but were not provided with sanitary sewer service in 1970. By 1990 the total area anticipated to be served approximates 2.8 square miles with a projected population of about 8,100 persons. This subarea is referenced as the "Sussex" sewer service area in the ensuing discussion.

3. Area C—This area consists of the Village of Pewaukee and environs, including urban development along the shoreline of Pewaukee Lake in the Towns of Delafield and Pewaukee. In 1970, sanitary sewer service was provided in this area only within the Village of Pewaukee to a total area of about 0.8 square mile, having a total resident population of about 2,900 persons. An additional 5,900 persons resided in the proposed 1990 sewer service area but were not provided with sanitary sewer service in 1970. By 1990 the total area anticipated to be served approximates 9.5 square miles with a projected population of nearly 15,300 persons. This subarea is referenced as the "Pewaukee" sewer service area in the ensuing discussion.

4. Area D—This area consists of the westerly portion of the City of Brookfield together with portions of the Town of Brookfield, the Village of Menomonee Falls, and the City of New Berlin. In 1970, sanitary sewer service was provided in this area within the City of Brookfield to a total area of about 5.6 square miles, having a total resident population of about 12,300 persons. About 10,600 persons resided in the proposed 1990 sewer service area but were not provided with sanitary sewer service in 1970. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 22.5 square miles with a projected population of about 49,100 persons. This subarea is referenced as the "Brookfield-New Berlin" sewer service area in the ensuing discussion.

5. Area E—This area consists of the City of Waukesha and environs including portions of the Towns of Brookfield, Pewaukee, and Waukesha. In 1970, sanitary sewer service was provided in this area to a total area of nearly nine square miles having a total resident population of about 40,700 persons. An additional 7,800 persons resided in the proposed 1990 sewer service area but were not provided with sanitary sewer service in 1970. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 30.9 square miles, with a projected population of nearly 83,200 persons. This subarea is referenced as the "Waukesha" sewer service area in the ensuing discussion.

Summary of Fox River Watershed Plan Recommendations

The Fox River watershed plan, as adopted in June 1970 by the Regional Planning Commission, contained specific recommendations pertaining to sewerage system development and stream water quality management for the upper Fox River subregional area. These recommendations were developed from a detailed examination of seven basic alternative stream water quality management plan elements for the entire watershed: 1) the provision of secondary and advanced wastewater treatment (phosphorus and nitrogen removal); 2) the diversion of sewage to the Milwaukee-metropolitan sewerage system; 3) the provision of secondary waste treatment combined with effluent waste disposal through land irrigation; 4) the provision of secondary waste treatment only combined with instream chemical treatment for algae and weed control; 5) the provision of secondary treatment only combined with low-flow augmentation; 6) the provision of secondary treatment only; and 7) the provision of secondary and tertiary treatment, not including nutrient removal. Based upon the cost, performance, and related advantages and disadvantages of each of these seven alternatives, as discussed in the planning report selection was made while recognizing that implementation would be difficult because of the lack of an appropriate institutional structure.

Developments Affecting the Watershed Plan Recommendations

Since the preparation and adoption of the Fox River watershed plan, several developments occurred which required reevaluation of the recommendations in the adopted Fox River watershed plan prior to the integration of these recommendations into the regional sanitary sewerage system plan. Such developments may be classified as those relating to the state of the art of water quality management and those relating to plan implementation activities. The development relating to the state of the art has a relatively minor effect on the plan recommendations, resulting in the substitution of nitrification through additional aeration and biochemical treatment accomplished in tanks for the ammonia stripping originally recommended to be accomplished in aeration towers. Experience elsewhere in the country since completion of the Fox River watershed plan has indicated that the latter technique, while feasible, presents certain operating difficulties, especially in cold weather.

With respect to plan implementation activities, it should be noted that the Fox River watershed plan was approved by the Wisconsin Natural Resources Board, acting upon the recommendation of the Wisconsin Department of Natural Resources (DNR) in June 1971, and thereupon certified to the U. S. Environmental Protection Agency (EPA) as the state's official basin plan for the Fox (Illinois) River. The EPA subsequently requested that a specific implementation schedule with respect to 1A to a low of about $3.48 million for alternative 1B, a difference of less than 5 percent, or well within the limits of accuracy with which such costs can be estimated. Cost effectiveness alone, therefore, was not deemed to provide an adequate basis for choosing from among the subalternatives. Alternative 1C, however, was, on the basis of other tangible but nevertheless real considerations, deemed to be the most advantageous plan, since it would result in the allocation of the costs involved in the provision of advanced waste treatment facilities on a larger areawide basis, and thus better coordinate needs with available financial resources; would avoid duplication of staffs and supporting laboratory and related facilities; would eliminate the discharge of all sewage effluent to the Fox River above Waukesha; and would best lend itself to the creation of one single, centralized sewerage district for plan implementation, including stream water quality monitoring and control. The basic disadvantages of alternative plan 1C are the reduction of streamflow in the upper reaches of the Fox River, particularly through the Waukesha impoundment, and the need to create a new institutional structure for implementation. On balance, however, alternative plan 1C was deemed to be the best alternative by the Fox River Watershed Committee and was subsequently included in the watershed plan as adopted by the Regional Planning Commission.[15] This documenting the findings and recommendations of the Fox River watershed study, it was recommended that the first alternative plan element, including the provision of secondary and advanced waste treatment for both phosphorus and nitrogen removal, be adopted as the recommended stream water quality management plan for the entire Fox River watershed.

With respect to the upper Fox River watershed area, three subalternatives differing only with respect to the number of sewage treatment facilities to be provided to serve the existing and anticipated urban development pattern were developed and evaluated. The first alternative plan (1A) proposed separate sewage treatment plants at six locations in the upper watershed—Lannon, Sussex, Pewaukee, Brookfield (2), and Waukesha. The second alternative plan (1B) proposed two major sewage treatment facilities to serve the entire upper watershed area—one each at Waukesha and Brookfield—together with necessary trunk sewers to convey wastes to the centralized facilities. The third alternative plan (1C) proposed one major centralized sewage treatment facility to be located on a new site below Waukesha together with a system of trunk sewers to convey wastes from the entire upper watershed to the new plant site. It is important to note that with respect to stream water quality, all of the three subalternatives considered would provide advanced waste treatment for phosphorus and nitrogen removal and could thus basically meet the established water use objectives for the Fox River. The three subalternatives ranged in total equivalent annual cost from a high of about $3.65 million for alternative

[15] *For a more complete description of the alternative sewerage facility plan elements in the adopted Fox River watershed plan, including a complete discussion of the advantages and disadvantages of alternative plans 1A, 1B, and 1C, see SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume 2, Alternative Plans and Recommended Plan, Chapter V.*

the proposals for areawide sewerage system facility development for the Upper Fox River watershed be developed and included with the certified plan document. Accordingly, the DNR in December 1972 published such an implementation schedule. This schedule proposed the establishment in early 1974 of an Upper Fox River watershed metropolitan sewerage district, including at least the Cities of Brookfield and Waukesha and the Villages of Lannon, Pewaukee, and Sussex; the immediate initiation of an engineering study by the City of Waukesha for the construction of the first stage of the recommended areawide sewage treatment facility; the completion of the entire new areawide treatment facility by 1985; the connection of the Village of Pewaukee and the City of Brookfield to the centralized system by 1982; immediate expansion of the Village of Sussex sewage treatment facility on an interim basis; and the connection of the Village of Sussex and the Village of Lannon to the centralized system no later than 1985.[16]

This implementation schedule was the subject of a public informational meeting held by the DNR on January 18, 1973. Generally, public officials representing the local units of government in the Upper Fox River watershed expressed opposition to the creation of a metropolitan sewerage district for the Upper Fox River—an action that resulted in the creation of an ad hoc intergovernmental advisory committee to formulate a joint response to the plan implementation schedule initiated by the DNR. The Committee membership included the heads of the key local governments concerned, the engineering staffs of these governments, and representatives of the Wisconsin Department of Natural Resources and the Regional Planning Commission.

After a series of meetings, and after careful deliberation, all of the key units of government in the Upper Fox River watershed agreed to support full implementation of the first alternative sanitary sewerage system plan contained in the adopted Fox River watershed plan, provided that the subalternative selected be subalternative plan 1B as opposed to subalternative plan 1C. The local units of government involved carefully considered subalternative plan 1C, but rejected that subalternative on the basis that subalternative plan 1B would equally well meet the established water use objectives adopted for the Fox River; that the subalternative plans were virtually identical with respect to cost effectiveness; and, most importantly, that while full implementation of subalternative plan 1B was highly likely and feasible within the design year of the plan, political experience indicated that the same conclusion could not be drawn for alternative plan 1C. The agreement of the key local units of government involved to support and implement subalternative plan 1B was formally reflected in resolutions adopted by the governing bodies of the Cities of Brookfield, New Berlin, and Waukesha; the Villages of Menomonee Falls, Pewaukee, and Sussex; the Towns of Brookfield, Lisbon, and Pewaukee; and the Lake Pewaukee Sanitary District. Subsequent to this agreement at the local level as to which subalternative plan to follow in carrying out the stream water quality management recommendations in the adopted Fox River watershed plan, the local officials involved directed the preparation of a specific implementation schedule and requested that the Regional Planning Commission appropriately amend the adopted watershed plan and seek all necessary plan approvals at the state and federal levels of government. On September 13, 1973, the Commission took formal action to amend the Fox River watershed plan to include subalternative plan 1B in lieu of subalternative plan 1C in the adopted plan, and to further include as part of the adopted plan a Revised Implementation Schedule for Meeting Water Quality Objectives and Waste Treatment Requirements for the Fox (illinois) River Watershed, published in August 1973 by the Wisconsin Department of Natural Resources. This amendment was subsequently certified to the state and federal agencies concerned.

Proposed Subregional Area Plan

Because of the extensive consideration of alternative sanitary sewerage system plans under the Fox River watershed study, the procedure for formulating alternative plans developed in the sewerage study was not used for the upper Fox River subregional area. The alternatives presented in the watershed study report, together with the recommended plan presented in that report, instead provided a point of departure for the reevaluation of the adopted plan recommendations and, as such, were incorporated into the regional sanitary sewerage system planning effort.

[16] See *Implementation Schedule for Meeting the Water Quality Objectives and Waste Treatment Requirements in the Fox (Illinois) River Watershed*, Wisconsin Department of Natural Resources, December 1972.

Consequently, only the recommended plan is described in this section, such recommended plan consisting of the basic stream water quality management recommendations included in the adopted Fox River watershed plan modified as necessary to reflect the results of the reevaluation under the sewerage system planning program.

Based upon the foregoing discussion of plan implementation efforts and the changing state of the art of water quality management planning, the basic recommendation set forth in the adopted Fox River watershed plan that advanced waste treatment be provided in the upper Fox River watershed area was reaffirmed subject to the following refinements and modifications:

1. With respect to treatment levels, it is recommended that nitrification replace nitrogen removal in order to reflect more recent sanitary engineering experience and practice. The recommendation to remove phosphorus remains intact.

2. With respect to system configuration, it is recommended that, in concept, the sewerage facilities contained in subalternative plan 1B be included in the recommended regional sewerage system plan rather than those sewerage facilities comprising subalternative plan 1C as included in the watershed plan as initially adopted. Subalternative plan 1B will equally well meet the established water use objectives for the Fox River, has been judged by elected local public officials to have a higher probability of full implementation, and is equally as cost effective as subalternative 1C.

Based upon the foregoing, the proposed plan for the upper Fox River watershed area would consist of the following elements:

1. A new major sewage treatment facility to be constructed at Brookfield to serve the Lannon–Menomonee Falls, Sussex, Pewaukee, and Brookfield–New Berlin sewer service areas. This facility would have a 1990 average hydraulic design capacity of about 19 mgd and would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent disinfection. The treatment facility currently under construction by the City of Brookfield would represent the first stage of this recommended areawide treatment facility.

2. A major new sewage treatment facility to serve the Waukesha area. This facility would have a 1990 average hydraulic design capacity of nearly 18 mgd and provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent disinfection. Two possible locations should be considered for this plant—the location of the existing plant and a new location approximately two miles downstream from the existing plant—with the ultimate location determined by local engineering studies. The site of the existing Waukesha sewage treatment plant has several disadvantages as the site for the proposed plant providing areawide service, including limited area for expansion and a location lying partially in the natural floodlands of the Fox River. In addition, new urban development in the Waukesha area is occurring in areas downstream from the existing facility, and sewage from such development will have to be pumped to the old plant site. The relocation of the plant would overcome the aforementioned problems and would also provide greater flexibility by preserving the option of ultimately consolidating present municipal waste treatment in the upper Fox River watershed at a single location, as initially recommended in the adopted Fox River watershed plan, beyond the design year of the sewerage system plan. In order to provide a conservatively high estimate of plan implementation costs, it has been assumed in this report that the proposed plant will be located at the downstream site. Accordingly, the plan costs include, in addition to the phased construction of the new sewage treatment facility, the cost of constructing a trunk sewer from the old to the new treatment plant sites. It is recognized, however, that the detailed engineering design studies may result in a recommendation to retain and perhaps expand the existing treatment facility to serve future urban growth in the Waukesha area through the plan design year of 1990.

3. Trunk sewers to connect the Sussex, Lannon-Menomonee Falls, Pewaukee, and New Berlin sewer service areas to the new Brookfield sewage treatment plant.

4. A trunk sewer to convey sewage from the existing Waukesha sewage treatment plant to the new downstream site.

The basic data utilized in formulating recommended levels of sewage treatment are presented in Table 158; recommended treatment levels and performance standards for the Brookfield and Waukesha plants are set forth in Table 159 and and compared with the Fox River watershed plan recommendations in Table 160; and recommended sewer service areas, treatment plant locations, and trunk sewers are shown on Map 94.

The total estimated capital cost of carrying out the proposed sewerage system plan for the upper Fox River subregional area is about $35.4 million, with an equivalent annual cost of nearly $2.7 million. Detailed cost estimates for this proposed plan are presented in Table 161.

Private Sewage Treatment Facilities

Four private sewage treatment facilities were found in 1970 to discharge wastes in the upper Fox River subregional area. These are the Ramada Inn-Waukesha facility in the Town of Pewaukee; the Mammoth Springs Canning Company facility in the Town of Lisbon; the New Berlin West High School facility in the City of New Berlin; and the Oakton Manor-Tumblebrook Golf Course facility in the Town of Delafield. Since 1970 one additional private sewage treatment facility—that serving the Willow Springs Mobile Home Park in the Town of

Table 158

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE UPPER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Water Body	Stream Low Flow and Dilution Ratio Data									Level of Treatment Required				
		7-Day, 10-Year Low Flow		Upstream Sewage Treatment Plant Flow-1990		Total Design Low Flow-1990		Total Design Sewage Flow-1990		Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Secondary	Advanced		Auxiliary	
		CFS	MGD	CFS	MGD	CFS	MGD	CFS	MGD			Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Brookfield	Fox River	2.13	1.38	--	--	2.13	1.38	29.57	19.10	0.13	Yes	Yes	Yes	No	Yes
Waukesha	Fox River	4.70	3.04	29.57	19.10	34.27	22.14	27.09	17.50	1.23	Yes	Yes	Yes	No	Yes

Source: SEWRPC.

Table 159

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS PROPOSED SANITARY SEWERAGE SYSTEM PLAN UPPER FOX RIVER SUBREGIONAL AREA

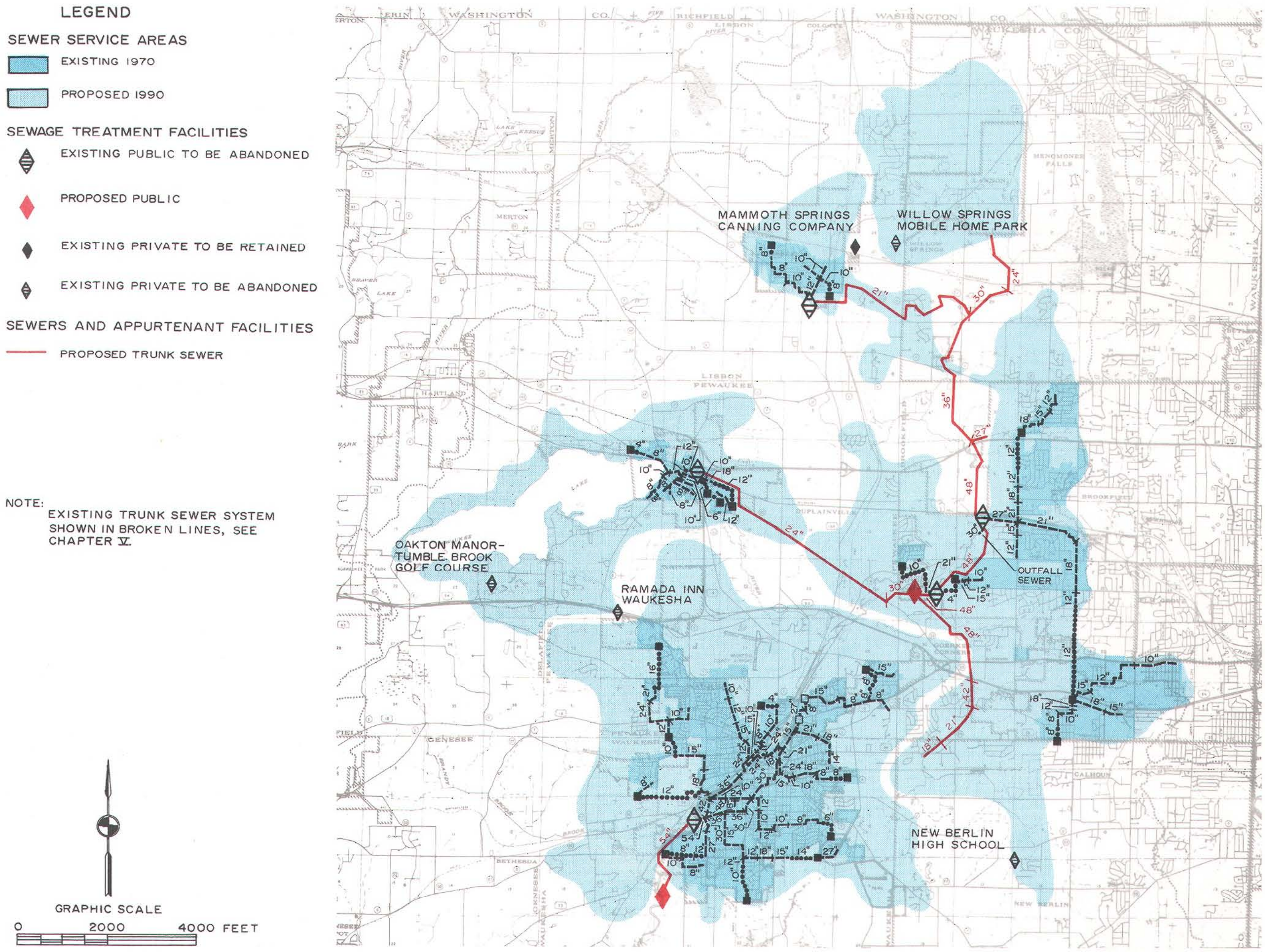
Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Brookfield (19.1 MGD)	Brookfield-New Berlin Lannon-Menomonee Falls Sussex Pewaukee	91,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Waukesha (17.5 MGD)	Waukesha	83,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 94.*

Source: SEWRPC.

Map 94

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE UPPER FOX RIVER SUBREGIONAL AREA
1990



The proposed sanitary sewerage system plan for the Upper Fox River watershed area includes two new areawide sewage treatment facilities, one located at Brookfield to serve the Lannon, Menomonee Falls, Sussex, Pewaukee, New Berlin, and Brookfield urban concentrations, and the other located below Waukesha to serve the City of Waukesha and environs. In order to meet the water use objectives for the Fox River, these two sewage treatment facilities would need to provide advanced waste treatment for both nitrification and phosphorus removal. The proposed plan also includes the major trunk sewers necessary to convey sewage from the urban concentrations to the two centralized sewage treatment facilities. Implementation of this plan would permit the abandonment of the existing Sussex, Pewaukee, and Brookfield sewage treatment facilities.

Source: SEWRPC.

Lisbon—has been established. Of these five facilities, all but the Mammoth Springs Canning Company facility lie within the proposed 1990 sewer service limits of the service areas within the upper Fox River subregional area and would accordingly be abandoned and connected to the centralized sanitary sewer system as trunk sewer service becomes available. The Mammoth Springs Canning Company facility is a specialized treatment facility constructed for the purpose of treating canning wastes and includes extensive spray irrigation facilities. This facility should be retained and continue to provide a level of waste treatment designed to meet the established water use objectives for streams in the upper Fox River watershed subregional area.

Table 160

COMPARISON BETWEEN RECOMMENDED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANTS IN THE UPPER FOX RIVER SUBREGIONAL AREA: FOX RIVER WATERSHED PLAN AND REGIONAL SANITARY SEWERAGE SYSTEM PLAN

Sewage Treatment Plant	Fox River Watershed Plan[1]					Regional Sanitary Sewerage System Plan					Rationale For Change in Treatment Level Recommendations
		Advanced			Auxiliary		Advanced			Auxiliary	
	Secondary	Phosphorus Removal	Nitrification	Nitrogen Removal	Effluent Disinfection	Secondary	Phosphorus Removal	Nitrification	Nitrogen Removal	Effluent Disinfection	
Brookfield	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Advancing state of the art reflects a greater emphasis on nitrification (NBOD reduction) than on nitrogen removal
Waukesha	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	

[1]*Corresponds to Alternative Plan 1B as described in SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume Two, Alternative Plans and Recommended Plan.*

Source: SEWRPC.

Table 161

DETAILED COST ESTIMATES PROPOSED SANITARY SEWERAGE SYSTEM PLAN UPPER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plants							
Brookfield							
Facilities (19.1 MGD)	$14,178,000	$10,482,000	$ 8,811,000	$19,293,000	$ 665,000	$ 559,000	$1,224,000
Land (17.0 Acres)	82,500	60,500	--	60,500	3,800	--	3,800
Subtotal	14,260,500	10,542,500	8,811,000	19,353,500	668,800	559,000	1,227,800
Waukesha							
Facilities (17.5 MGD)	12,990,300	9,602,200	8,073,300	17,675,500	609,200	512,200	1,121,400
Land (16.5 Acres)	85,000	62,300	--	62,300	4,000	--	4,000
Subtotal	13,075,300	9,664,500	8,073,300	17,737,800	613,200	512,200	1,125,400
Subtotal--Sewage Treatment Facilities	27,335,800	20,207,000	16,884,300	37,091,300	1,282,000	1,071,200	2,353,200
Trunk Sewers							
Sussex	632,000	461,700	11,000	472,700	29,300	700	30,000
Pewaukee	629,000	460,300	15,800	476,100	29,200	1,000	30,200
Brookfield-Lannon	3,739,000	2,735,000	20,200	2,755,200	173,500	1,300	174,800
Brookfield-New Berlin	989,600	725,100	7,900	733,000	46,000	500	46,500
Waukesha	2,080,100	1,524,200	4,700	1,528,900	96,700	300	97,000
Subtotal--Trunk Sewers	8,069,700	5,906,300	59,600	5,965,900	374,700	3,800	378,500
Total	$35,405,500	$26,113,300	$16,943,900	$42,057,200	$1,656,700	$10,075,000	$2,731,700

Source: SEWRPC.

LOWER FOX RIVER SUBREGIONAL AREA

The Lower Fox River subregional area consists of all that area of the Fox River watershed lying generally south of the Vernon Marsh in Waukesha County. This portionoof the Fox River watershed is comprised of all or portions of several subwatersheds, including the Mukwonago River subwatershed, the Honey Creek subwatershed, the Sugar Creek subwatershed, and the White River subwatershed. Concentrations of urban development are found in the Cities of Burlington and Lake Geneva and in the Villages of Mukwonago, East Troy, Rochester, Waterford, Silver Lake, Twin Lakes, and Genoa City. In addition, urban development is located along the shorelines of several major lakes, including Wind Lake, Tichigan Lake, Browns Lake, Eagle Lake, and Camp and Center Lakes.

As noted in Chapter V of this report, centralized sanitary sewer service in the Lower Fox River subregional area was provided by seven systems in 1970: those operated by the Cities of Burlington and Lake Geneva; the Villages of East Troy, Mukwonago, Genoa City, Silver Lake, and Twin Lakes; and the Western Racine County Sewerage District serving the Villages of Rochester and Waterford and a portion of the Town of Rochester. Together, the service areas of these seven systems comprised an area of about 7.6 square miles and served an estimated population of about 22,800 persons. In 1970 there were about 52,000 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the seven existing systems are presented in Chapter V of this report.

Sewer Service Analysis Areas

A total of 18 sewer service analysis areas may be identified within the Lower Fox River subregional area (see Table 162). These 18 sewer service analysis areas are shown on Map 95 and may be described as follows:

1. Area A—This area consists of the Village of Mukwonago and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 1.1 square miles, having a total resident population of about 2,600 persons. By 1990 the total

Table 162

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE LOWER FOX RIVER SUBREGIONAL AREA 1970 and 1990

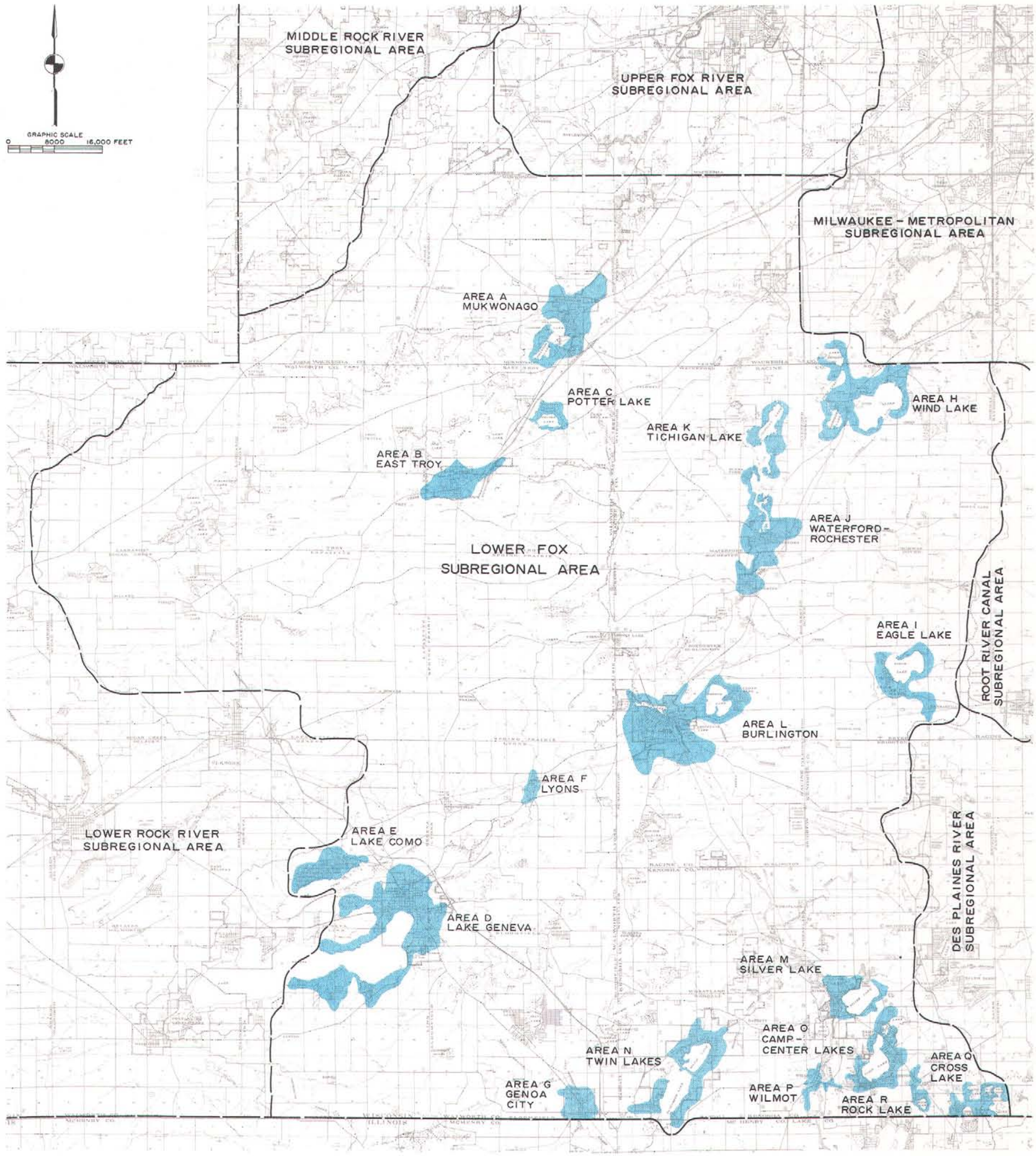
Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Mukwonago	1.07	2,600	0.30	600	2.72	7,800	1.39
B	East Troy	0.46	1,700	0.18	100	1.54	3,600	0.70
C	Potter Lake	--	--	--	800[2]	0.50	1,100[3]	0.23
D	Lake Geneva	1.54	4,700	0.64	2,100[2]	6.78	12,200[4]	2.30
E	Lake Como	--	--	--	1,200[2]	2.69	1,900[5]	0.40
F	Lyons	--	--	--	600	0.31	700	0.15
G	Genoa City	0.20	900	0.08	200	1.01	1,800	0.30
H	Wind Lake	--	--	--	3,300[2]	3.01	6,900[6]	1.45
I	Eagle Lake	--	--	--	1,000[2]	1.20	1,600[7]	0.32
J	Waterford-Rochester	1.07	2,500	0.24	300	3.11	6,100	1.00
K	Tichigan Lake	--	--	--	1,900[2]	1.02	2,500[8]	0.50
L	Burlington	2.08	7,500	1.20	2,100	6.04	15,000	2.50
M	Silver Lake	0.39	1,200	0.14	100	1.40	3,300	0.71
N	Twin Lakes	0.80	1,700	0.22	600[2]	2.74	4,200[9]	0.75
O	Camp-Center Lakes	--	--	--	1,700[2]	1.62	2,400[10]	0.53
P	Wilmot	--	--	--	400	0.46	600	0.13
Q	Cross Lake	--	--	--	1,100[2]	1.10	1,200[11]	0.25
R	Rock Lake	--	--	--	500[2]	0.32	700[12]	0.15
	Total	7.61	22,800	3.00	18,600	37.57	73,600	13.76

[1]*See Map 95.*
[2]*Does not include seasonal resident population on Potter Lake, Lake Geneva, Lake Como, Wind Lake, Eagle Lake, Tichigan Lake, Twin Lakes, Camp Lake, Cross Lake, and Rock Lake.*
[3]*Includes an estimated seasonal resident population of 200 persons.*
[4]*Includes an estimated seasonal resident population of 700 persons.*
[5]*Includes an estimated seasonal resident population of 100 persons.*
Source: SEWRPC.

[6]*Includes an estimated seasonal resident population of 500 persons.*
[7]*Includes an estimated seasonal resident population of 400 persons.*
[8]*Includes an estimated seasonal resident population of 400 persons.*
[9]*Includes an estimated seasonal resident population of 1,400 persons.*
[10]*Includes an estimated seasonal resident population of 700 persons.*
[11]*Includes an estimated seasonal resident population of 100 persons.*
[12]*Includes an estimated seasonal resident population of 100 persons.*

Map 95

SEWER SERVICE ANALYSIS AREAS
LOWER FOX RIVER SUBREGIONAL AREA



Urban development in the Lower Fox River watershed is concentrated in several relatively small cities and villages and unincorporated communities located along the shorelines of the many lakes which are found in this portion of the Region. For sewer service analysis purposes, 18 individual urban areas were identified, as shown on the above map. It is anticipated that nearly 74,000 persons may be expected to reside in these 18 urban areas of the lower watershed by 1990, with the total land in urban use anticipated to approximate nearly 38 square miles. In 1970 there were about 75,000 persons residing in the lower watershed, of which about 23,000 were served by centralized sanitary sewer service and 52,000 by onsite septic tank sewage disposal systems.

Source: SEWRPC.

area anticipated to be served approximates 2.7 square miles, with a projected population of about 7,800 persons. This area is referenced as the "Mukwonago" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Village of East Troy and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.5 square mile, having a total resident population of about 1,700 persons. By 1990 the total area anticipated to be served approximates 1.5 square miles, with a projected population of about 3,600 persons. This subarea is referenced as the "East Troy" sewer service area in the ensuing discussion.

3. Area C—This area consists of urban development along the shoreline of Potter Lake in the Town of East Troy. About 800 persons resided in this area on a year-round basis in 1970 but no centralized sanitary sewer service was provided. The East Troy Sanitary District No. 2 has been formed to provide centralized sanitary sewer service to this concentration of urban development. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 0.5 square mile, with a projected population of about 1,100 persons, including an estimated seasonal resident population of about 200 persons. This subarea is referenced as the "Potter Lake" sewer service area in the ensuing discussion.

4. Area D—This area consists of the City of Lake Geneva and environs, including urban development along the shoreline of Geneva Lake in the Towns of Linn and Geneva. In 1970, sanitary sewer service was provided in this area to a total area of about 1.5 square miles, having a total resident population of about 4,700 persons. By 1990 the total area anticipated to be served approximates 6.8 square miles, with a projected population of about 12,200 persons, including an estimated seasonal resident population of about 700 persons. This subarea is referenced as the "Lake Geneva" sewer service area in the ensuing discussion.

5. Area E—This area consists of urban development along the north shoreline of Lake Como in the Town of Geneva. About 1,200 persons resided in this area on a year-round basis in 1970 but no centralized sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 2.7 square miles, with a projected population of about 1,900 persons, including an estimated seasonal resident population of about 100 persons. This subarea is referenced as the "Lake Como" sewer service area in the ensuing discussion.

6. Area F—This area consists of the unincorporated village of Lyons in the Town of Lyons. About 600 persons resided in this area in 1970 but no centralized sanitary sewer service was provided. The Wisconsin Department of Natural Resources has ordered the installation of such service to the unincorporated village and, in response to this order, the Town of Lyons created a Sanitary District No. 2. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 0.3 square mile, with a projected population of about 700 persons. This subarea is referenced as the "Lyons" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Genoa City and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.2 square mile, having a total resident population of about 900 persons. By 1990 the total area anticipated to be served approximates 1.0 square mile, with a projected population of about 1,800 persons. This subarea is referenced as the "Genoa City" sewer service area in the ensuing discussion.

8. Area H—This area consists of urban development along the shorelines of Wind, Waubeesee, and Long Lakes in the Town of Norway and Lake Denoon in the City of Muskego. About 3,300 persons resided in this area on a year-round basis in the year 1970 but no centralized sanitary sewer service was provided. The Town of Nor-

way Sanitary District has been formed to provide centralized sanitary sewer service to that portion of the service area in Racine County. By 1990 the total area anticipated to be served approximates 3.0 square miles, with a projected population of about 6,900 persons, including an estimated seasonal resident population of about 500 persons. This subarea is referenced as the "Wind Lake" sewer service area in the ensuing discussion.

9. Area I—This area consists of urban development along the shoreline of Eagle Lake and in the unincorporated village of Kansasville in the Town of Dover. About 1,000 persons resided in this area on a year-round basis in 1970 but no centralized sanitary sewer service was provided. The Town of Dover Sewer Utility District No. 1 has been formed to provide centralized sanitary sewer service to this concentration of urban development. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.2 square miles, with a projected population of about 1,600 persons, including an estimated seasonal resident population of about 400 persons. This subarea is referenced as the "Eagle Lake" sewer service area in the ensuing discussion.

10. Area J—This area consists of the Villages of Rochester and Waterford and contiguous urban development in the Towns of Rochester and Waterford, and encompasses the entire service area of the Western Racine County Sewerage District. In 1970, sanitary sewer service was provided in this area to a total area of about 1.1 square miles, having a total resident population of about 2,500 persons. By 1990 the total area anticipated to be served approximates 3.1 square miles, with a projected population of about 6,100 persons. This subarea is referenced as the "Waterford-Rochester" sewer service area in the ensuing discussion.

11. Area K—This area consists of urban development along the shoreline of Tichigan Lake in the Town of Waterford. About 1,900 persons resided in this area on a year-round basis in 1970 but no centralized sanitary sewer service was provided. The Tichigan Lake Sanitary District has been formed to provide such service. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.0 square mile, with a projected population of about 2,500 persons, including an estimated seasonal resident population of about 400 persons. This subarea is referenced as the "Tichigan Lake" sewer service area in the ensuing discussion.

12. Area L—This area consists of the City of Burlington and environs, including urban development along the shoreline of Browns Lake in the Town of Burlington. In 1970, sanitary sewer service was provided in this area to a total area of about 2.1 square miles, having a total resident population of about 7,500 persons. By 1990 the total area anticipated to be served approximates 6.0 square miles, with a projected population of about 15,000 persons. This subarea is referenced as the "Burlington" sewer service area in the ensuing discussion.

13. Area M—This area consists of the Village of Silver Lake and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.4 square mile, having a total resident population of about 1,200 persons. By 1990 the total area anticipated to be served approximates 1.4 square miles, with a projected population of about 3,300 persons. This subarea is referenced as the "Silver Lake" sewer service area in the ensuing discussion.

14. Area N—This area consists of the Village of Twin Lakes and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.8 square mile, having a total resident population of about 1,700 persons. By 1990 the total area anticipated to be served approximates 2.7 square miles, with a projected population of about 4,200 persons, including an estimated seasonal resident population of about 1,400 persons. This subarea is referenced as the "Twin Lakes" sewer service area in the ensuing discussion.

15. Area O—This area consists of urban development along the shorelines of Camp and Center Lakes in the Town of Salem. About 1,700 persons resided in this area on a

year-round basis in 1970 but no centralized sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.6 square miles, with a projected population of about 2,400 persons, including an estimated seasonal population of about 700 persons. This subarea is referenced as the "Camp-Center Lakes" sewer service area in the ensuing discussion.

16. Area P—This area consists of the unincorporated village of Wilmot in the Town of Salem. About 400 persons resided in this area on a year-round basis in 1970, but no centralized sanitary sewer service was provided. By 1990 the total area anticipated to be served approximates 0.5 square mile, with a projected population of about 600 persons. This subarea is referenced as the "Wilmot" sewer service area in the ensuing discussion.

17. Area Q—This area consists of urban development along the shorelines of Cross, Voltz, Benet, and Shangrila Lakes in the Towns of Salem and Bristol. About 1,100 persons resided in this area on a year-round basis in 1970 but no centralized sanitary sewer service was provided. By 1990 the total area anticipated to be served approximates 1.1 square miles, with a projected population of about 1,200 persons, including an estimated seasonal resident population of about 100 persons. This subarea is referenced as the "Cross Lake" sewer service area in the ensuing discussion.

18. Area R—This area consists of urban development along the shoreline of Rock Lake and in the unincorporated village of Trevor in the Town of Salem. About 500 persons resided in this area on a year-round basis in 1970 but no centralized sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 0.3 square mile, with a projected population of about 700 persons, including an estimated seasonal resident population of about 100 persons. This subarea is referenced as the "Rock Lake" sewer service area in the ensuing discussion.

Summary of Fox River Watershed Plan Recommendations

The Fox River watershed plan, as adopted in June 1970 by the Regional Planning Commission, contained specific recommendations pertaining to sewerage system development and stream water quality management for the Lower Fox River subregional area. These recommendations were developed from a detailed examination of seven basic alternative stream water quality management plan elements for the entire watershed: 1) the provision of secondary and advanced waste treatment (phosphorus and nitrogen removal); 2) the diversion of sewage from the upper watershed area to the Milwaukee-metropolitan sewerage system; 3) the provision of secondary waste treatment combined with effluent waste disposal through land irrigation; 4) the provision of secondary waste treatment only combined with instream chemical treatment for algae and weed control; 5) the provision of secondary treatment only combined with low-flow augmentation; 6) the provision of secondary treatment only; and 7) the provision of secondary and tertiary treatment, not including nutrient removal. Based upon the cost, performance, and related advantages and disadvantages of each of these alternatives, as discussed in the planning report documenting the findings and recommendations of the Fox River watershed study, it was recommended that the first alternative plan element, including the provision of secondary and advanced waste treatment for both phosphorus and nitrogen removal, be adopted as the recommended stream water quality management plan for the entire Fox River watershed.

With respect to the Lower Fox River watershed area, the watershed plan recommendations may be summarized as follows:[17]

1. The provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection at the municipal sewage treatment facilities serving the Villages of Genoa City and Silver Lake.

2. The provision of secondary waste treatment, advanced waste treatment for re-

[17] *For a more complete description of the recommended sewerage facility plan elements in the adopted Fox River watershed plan, see SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume 2, Alternative Plans and Recommended Plan, Chapter V.*

moval of additional oxygen demanding organic matter and for phosphorus and nitrogen removal, and auxiliary waste treatment for effluent disinfection at the municipal sewage treatment facilities serving the Cities of Burlington and Lake Geneva; the Villages of East Troy, Mukwonago, and Twin Lakes; and the Western Racine County Sewerage District.

3. The establishment of new sanitary sewerage systems to serve urban development along the shorelines of Browns, Camp and Center, Como, Eagle, Tichigan, and Wind Lakes. In the case of Browns Lake, it was recommended that the proposed system be connected to the Burlington sewage treatment facility. In the case of the other lakes, it was recommended that sewage treatment facilities be constructed to provide secondary waste treatment and auxiliary waste treatment for effluent disinfection.

Developments Affecting the Watershed Plan Recommendations

Since the preparation and adoption of the Fox River watershed plan, several developments have occurred relating to the state of the art of water quality management which required reevaluation of the recommendations in the adopted Fox River watershed plan prior to the integration of these recommendations into the regional sanitary sewerage system plan. As noted above, the Fox River watershed plan recommended nitrogen removal as a form of advanced waste treatment at the major sewage treatment facilities in the watershed. This recommendation was based upon a recognition of nitrogen as a nutrient contributing to algae and weed growth. The plan recommended that nitrogen removal be accomplished in ammonia stripping towers. Experience elsewhere in the country since completion of the Fox River watershed plan has indicated that the stripping tower technique, while feasible, presents certain operating difficulties, especially in cold weather. In addition, nitrogen is no longer seen to be as critical a limiting nutrient as phosphorus in the growth of algae and aquatic plants. Since completion of the Fox River watershed plan, then, there has been a decreased emphasis on the critical nature of nitrogen as a nutrient. This has been accompanied by an increased emphasis on the oxygen demand imposed by effluent nitrogen in the form of ammonia, and on the toxic effect of that ammonia. Accordingly, it was determined to appropriately substitute the advanced waste treatment of nitrification for nitrogen removal in the reevaluation of the Fox River watershed plan recommendations under the regional sanitary sewerage system planning program.

In addition to the foregoing developments reflecting the changing state of the art of water quality management, the interconnection guidelines promulgated by the Wisconsin Department of Natural Resources caused a need to appropriately reconsider certain recommendations concerning individual sewage treatment facilities at lake areas in the adopted Fox River watershed plan. Accordingly, where appropriate, interconnection analyses were made and the results presented in the discussion below.

Proposed Subregional Area Plan

Because of the extensive consideration of alternative sanitary sewerage system plans under the Fox River watershed study, the procedure for formulating alternative plans developed in the sewerage study was not used in the Lower Fox River subregional area. The alternatives presented in the watershed study report, together with the recommended plan presented in that report, instead provided a point of departure for the reevaluation of the adopted plan recommendations, and as such were incorporated into the regional sanitary sewerage system planning effort. Consequently, except with respect to the Lake Geneva and Lake Como subarea where interconnection guidelines required consideration of alternative plans, only the recommended plan is described in this section, such recommended plan consisting of the basic stream water quality management recommendations included in the Fox River watershed plan and modified as necessary to reflect the results of the reevaluation under the regional sanitary sewerage system planning program. Data pertaining to required treatment levels at each of the municipal sewage treatment plant sites considered in the proposed plan are presented in Table 163.

Mukwonago Subarea: in 1970 the sewage treatment facility serving the Mukwonago sewer service area had an average hydraulic design capacity of about 0.24 mgd and provided a secondary level of waste treatment. Disposal of effluent is to the Mukwonago River. The plant is a trickling filter type constructed in 1950, and may be considered as having nearly reached the end of its useful life. In addition, local officials have indicated that the plant should be relocated farther downstream to better serve existing and anticipated future urban development. In order to accommodate future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 1.4 mgd will bé required for the Mukwonago facility. Accordingly, it is proposed that a new sewage treatment facility be constructed on a site downstream from the existing plant site along the Mukwonago River. In order to meet the established water use objectives for the Mukwonago River, it will be necessary for this new facility to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent disinfection. The specific recommended performance standards for the Mukwonago sewage treatment plant are set forth in Table 164.

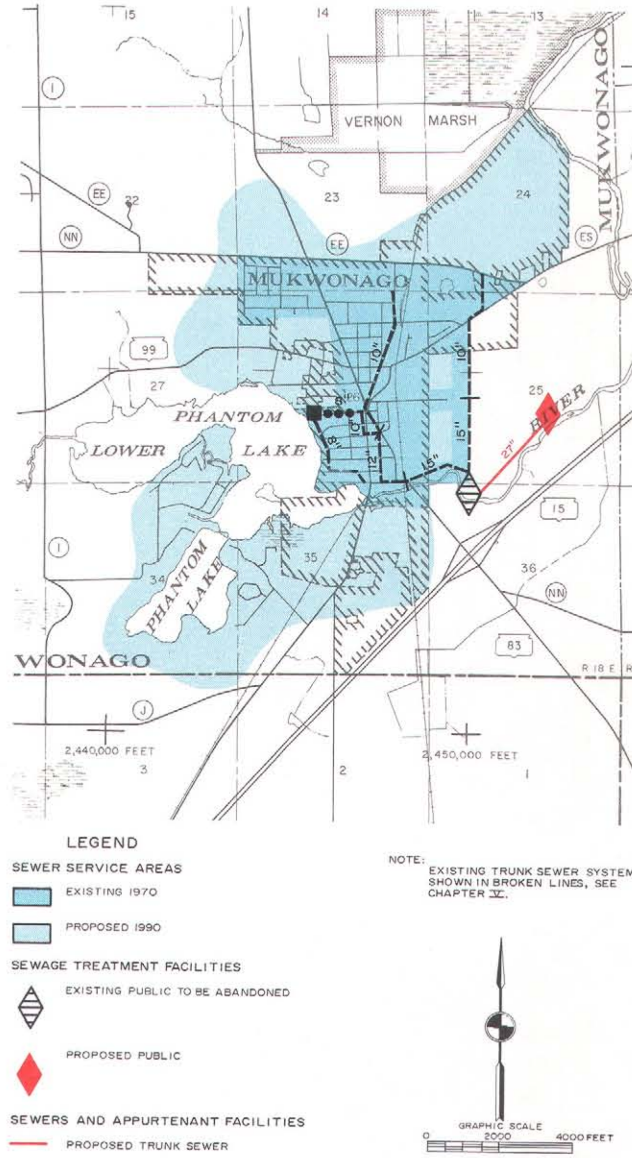
The estimated capital cost of constructing the necessary treatment facilities at Mukwonago, together with a trunk sewer to convey wastes from the existing plant to the proposed sewage treatment plant site, is about $2.0 million, with an equivalent annual cost of about $194,000 (see Table 165). The proposed 1990 service area for the Village of Mukwonago is shown on Map 96.

East Troy-Potter Lake Subarea: In 1970 the sewage treatment facility serving the East Troy sewer service area had an average hydraulic design capacity of about 0.32 mgd and provided a secondary level of waste treatment. Disposal of effluent is to Honey Creek. The plant is a trickling filter type constructed in 1960. While no sanitary sewer service was provided in 1970 to the Potter Lake sewer service area, the Town of East Troy Sanitary District No. 2 has completed preliminary engineering studies relating to the provision of such service, including a proposal to contract with the Village of East Troy for such sewage treatment service. This proposal has been accepted in principle by the Village Board of the Village of East Troy, and will contribute toward the objective of nonproliferation of sewage treatment facilities.

In order to accommodate projected future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 0.9 mgd will be required for this facility, which is proposed to serve both the East Troy and Potter Lake sewer service areas. In order to meet the established water use objectives for Honey Creek, it will be

Map 96

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE MUKWONAGO SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA
1990



The proposed sewerage system plan for the Mukwonago urban area includes relocation of the existing treatment plant to a site farther downstream on the Mukwonago River to better serve existing and anticipated future urban development. The existing plant is a trickling filter type that has nearly reached the end of its useful life. In order to meet the water use objectives for the Mukwonago River, the proposed new Mukwonago treatment facility would need to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent disinfection. The proposed plan also includes a trunk sewer to convey wastes from the existing to the proposed treatment plant site.

Source: SEWRPC.

Table 163

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Water Body	Stream Low Flow and Dilution Ratio Data: 7-Day, 10-Year Low Flow		Upstream Sewage Treatment Plant Flow-1990		Total Design Low Flow-1990		Total Design Sewage Flow-1990		Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Level of Treatment Required: Secondary	Advanced		Auxiliary	
		CFS	MGD	CFS	MGD	CFS	MGD	CFS	MGD			Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Mukwonago	Mukwonago River	7.00	4.52	0.00	0.00	7.00	4.52	2.15	1.39	3.25	Yes	Yes	Yes	Yes	Yes
East Troy	Honey Creek	2.40	1.55	0.00	0.00	2.40	1.55	1.08	0.70	2.22	Yes	Yes	Yes	Yes	Yes
Lake Geneva[1]	White River	0.10	0.06	0.00	0.00	0.10	0.06	3.56	2.30	0.03	Yes	Yes	Yes	Yes	Yes
Lake Geneva[2]	White River	0.10	0.06	0.00	0.00	0.10	0.06	4.18	2.70	0.02	Yes	Yes	Yes	Yes	Yes
Lake Como[1]	Como Creek	0.48	0.31	0.00	0.00	0.48	0.31	0.62	0.40	0.77	Yes	No	Yes	Yes	Yes
Lyons	White River	4.71	3.04	4.18	2.70	8.89	5.74	0.23	0.15	38.65	Yes	No	No	No	Yes
Genoa City	Nippersink Creek	2.80	1.81	0.00	0.00	2.80	1.81	0.46	0.30	6.09	Yes	No	No	No	Yes
Wind Lake	Waubeesee Lake Canal	0.00	0.00	0.00	0.00	0.00	0.00	2.24	1.45	0.00	Yes	Yes	Yes	Yes	Yes
Eagle Lake	Eagle Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.25	0.00	Yes	No	Yes	Yes	Yes
Rochester[3]	Fox River	19.00	12.27	58.51	37.80	77.51	50.07	1.55	1.00	50.01	Yes	Yes	No	No	Yes
Burlington	Fox River	37.40	24.16	67.80	43.80	105.20	67.96	3.87	2.50	27.18	Yes	Yes	No	No	Yes
Silver Lake	Fox River	50.60	32.69	72.60	46.90	123.20	79.59	1.10	0.71	112.00	Yes	Yes	No	No	Yes
Twin Lakes	Bassett Creek	0.00	0.00	0.00	0.00	0.00	0.00	1.16	0.75	0.00	Yes	Yes	Yes	Yes	Yes
Camp Lake	Fox River	51.00	32.95	73.70	47.61	124.70	80.56	1.64	1.06	76.04	Yes	Yes	No	No	Yes

[1]Corresponds to Lake Geneva-Lake Como alternative plan 1.
[2]Corresponds to Lake Geneva-Lake Como alternative plan 2.
[3]Plant operated by Western Racine County Sewerage District.

Source: SEWRPC.

Table 164

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MUKWONAGO SEWER SERVICE AREA LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Mukwonago (1.39 MGD)	Mukwonago	7,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 96.

Source: SEWRPC.

Table 165

DETAILED COST ESTIMATES PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MUKWONAGO SEWER SERVICE AREA LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost: Capital Construction	Present Worth (1970-2020): Construction	Operation and Maintenance	Total	Equivalent Annual (1970-2020): Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Mukwonago							
Facilities (1.39 MGD)	$1,861,700	$1,681,800	$1,257,800	$2,939,600	$106,700	$79,800	$186,500
Land (3.6 Acres)	18,000	12,600	--	12,600	800	--	800
Subtotal	1,879,700	1,694,400	1,257,800	2,952,200	107,500	79,800	187,300
Trunk Sewers							
Mukwonago	141,800	104,000	1,600	105,600	6,600	100	6,700
Subtotal	141,800	104,000	1,600	105,600	6,600	100	6,700
Total	$2,021,500	$1,798,400	$1,259,400	$3,057,800	$114,100	$79,900	$194,000

Source: SEWRPC.

necessary for this facility to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the East Troy sewage treatment plant are set forth in Table 166. The estimated capital cost of constructing the necessary sewage treatment facilities at East Troy, together with a trunk sewer to convey wastes from the Potter Lake sewer service area to the East Troy sewage treatment plant site, is about $1.9 million, with an equivalent annual cost of about $166,800 (see Table 167). The proposed 1990 service areas for East Troy and Potter Lake are shown on Map 97.

Lake Geneva-Lake Como Subarea: As indicated above, application of the Wisconsin Department of Natural Resources interconnection guidelines reveal the need to consider the interconnection of the Lake Geneva and Lake Como sewer service areas for sewage treatment purposes. The adopted Fox River watershed plan had recommended individual sewage treatment plants, including expansion of the existing Lake Geneva facility and establishment of a new facility to serve Lake Como. Accordingly, two basic alternative plans were formulated. The first alternative provides for two sewage treatment facilities, one at Lake Geneva and one at Lake Como, as recommended in the watershed plan. The second alternative provides for a single sewage treatment facility to

Table 166

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE EAST TROY AND POTTER LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
East Troy (0.93 MGD)	East Troy Potter Lake	4,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 97.
Source: SEWRPC.

Table 167

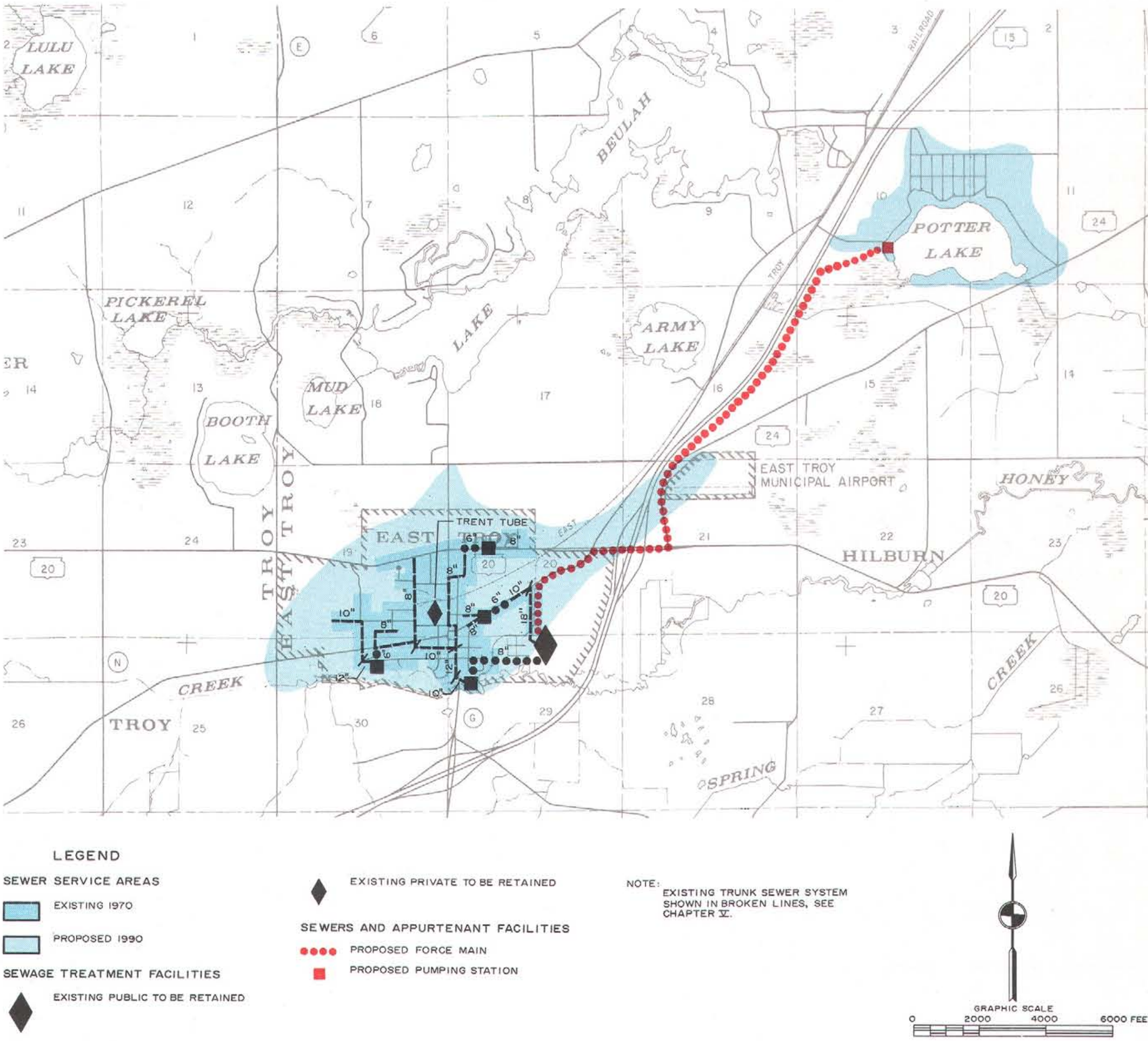
DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE EAST TROY AND POTTER LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
	Capital Construction	Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
		Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
East Troy							
Facilities (0.93 MGD)	$1,435,700	$1,297,200	$961,500	$2,258,700	$ 82,300	$61,000	$143,300
Land (3.2 Acres)	16,000	11,800	--	11,800	800	--	800
Subtotal	1,451,700	1,309,000	961,500	2,270,500	83,100	61,000	144,100
Trunk Sewers							
Potter Lake	445,900	340,400	17,400	357,800	21,600	1,100	22,700
Subtotal	445,900	340,400	17,400	357,800	21,600	1,100	22,700
Total	$1,897,600	$1,649,400	$978,900	$2,628,300	$104,700	$62,100	$166,800

Source: SEWRPC.

Map 97

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE EAST TROY AND POTTER LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA
1990



In order to resolve existing problems due to malfunctioning septic tank systems it is proposed that a sewerage system be constructed to serve urban development along the shoreline of Potter Lake, with treatment for the sewage being provided at an expanded East Troy sewage treatment facility. The above map shows the recommended Potter Lake sewer service area, as well as the force main proposed to convey sewage to the East Troy plant. If the water use objectives for Honey Creek are to be met, the East Troy facility will need to provide secondary waste treatment, advanced waste treatment for phosphorus removal and nitrification, and auxiliary waste treatment for effluent aeration and disinfection.

Source: SEWRPC.

serve both the Lake Geneva and Lake Como areas, locating the single plant at the Lake Geneva site. The required sewage treatment levels and performance standards under both alternatives considered are set forth in Table 168, while detailed cost estimates pertaining to the two alternatives are set forth in Table 169. The two proposals are shown on Maps 98 and 99.

Under alternative plan 1 the existing Lake Geneva sewage treatment facility, which is of the trickling filter type and which has nearly reached the end of its useful life, would be replaced by a new sewage treatment facility at or near the same location. In order to accommodate future growth, it is anticipated that by 1990 an average hydraulic design capacity of 2.3 mgd will be required for this facility under this alternative. In order to meet the established water use objectives for White River, to which effluent would be discharged, it will be necessary for this facility to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. New trunk sewers to serve the north and south shores of Lake Geneva are also included in this alternative. In addition, under alternative plan 1, a new sewage treatment facility would be constructed near the Lake Como outlet to serve the Lake Como sewer service area. This facility would need to provide a 1990 average hydraulic design capacity of about 0.4 mgd. In order to meet the established water use objectives for Como Creek, to which effluent would be discharged, the proposed new Lake Como facility would be required to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The total estimated capital cost of carrying out alternative plan 1 for the Lake Geneva and Lake Como sewer service areas, including the Lake Geneva trunk sewers, is about $11.4 million, with an equivalent annual cost of about $747,900.

As noted above, alternative plan 2 involves the provision of only one sewage treatment facility to serve the Lake Geneva and Lake Como sewer service areas. Under this alternative, the proposed Lake Geneva sewage treatment plant would provide for an average hydraulic design capacity of about 2.7 mgd in order to accommodate sewage from both the Lake Geneva and Lake Como sewer service areas. In order to meet the established

Table 168

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE LAKE GENEVA AND LAKE COMO SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Lake Geneva (2.30 MGD)	Lake Geneva	12,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Lake Como (0.40 MGD)	Lake Como	1,900	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Lake Geneva (2.70 MGD)	Lake Geneva Lake Como	14,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1] *See Map 98.*

Source: SEWRPC.

Table 169

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE LAKE GENEVA AND LAKE COMO SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plants							
Lake Geneva							
Facilities (2.3 MGD)	$ 2,764,100	$2,496,700	$1,959,200	$ 4,455,900	$158,400	$124,300	$282,700
Land (4.4 Acres)	22,000	15,800	--	15,800	1,000	--	1,000
Subtotal	2,786,100	2,512,500	1,959,200	4,471,700	159,400	124,300	283,700
Lake Como							
Facilities (0.4 MGD)	772,200	698,300	398,800	1,097,100	44,300	25,300	69,600
Land (2.6 Acres)	13,000	9,500	--	9,500	600	--	600
Subtotal	785,200	707,800	398,800	1,106,600	44,900	25,300	70,200
Subtotal--Treatment Facilities	3,571,300	3,220,300	2,358,000	5,578,300	204,300	149,600	353,900
Trunk Sewers							
Geneva Lake-North	2,989,100	2,211,400	126,100	2,337,500	140,300	8,000	148,300
Geneva Lake-South	4,836,000	3,603,200	269,500	3,872,700	228,600	17,100	245,700
Subtotal	7,825,100	5,814,600	395,600	6,210,200	368,900	25,100	394,000
Total	$11,396,400	$9,034,900	$2,753,600	$11,788,500	$573,200	$174,700	$747,900
ALTERNATIVE PLAN 2							
Sewage Treatment Plants							
Lake Geneva							
Facilities (2.70 MGD)	$ 3,119,900	$2,818,200	$2,211,400	$ 5,029,600	$178,800	$140,300	$319,100
Land (4.7 Acres)	23,500	17,300	--	17,300	1,100	--	1,100
Subtotal	3,143,400	2,835,500	2,211,400	5,046,900	179,900	140,300	320,200
Trunk Sewers							
Geneva Lake-North	2,989,100	2,211,400	126,100	2,337,500	140,300	8,000	148,300
Geneva Lake-South	4,836,000	3,603,200	269,500	3,872,700	228,600	17,100	245,700
Lake Como	587,100	450,900	121,400	572,300	28,600	7,700	36,300
Subtotal	8,412,200	6,265,500	517,000	6,782,500	397,500	32,800	430,300
Total	$11,555,600	$9,101,000	$2,728,400	$11,829,400	$577,400	$173,100	$750,500

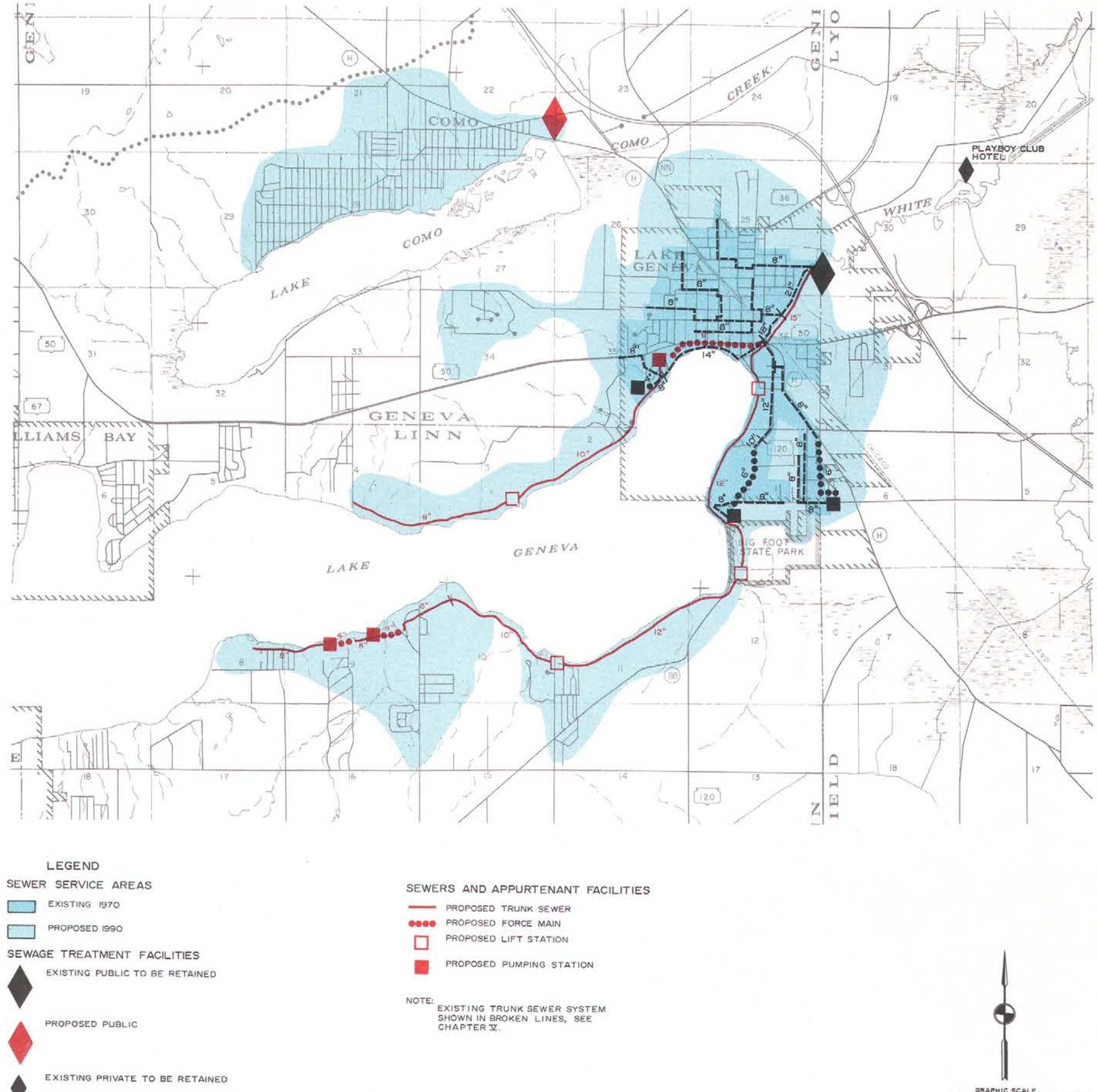
Source: SEWRPC.

water use objectives for the White River, this facility would have to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. In addition to the new trunk sewers proposed under alternative plan 1 to serve the north and south shores of Geneva Lake, alternative plan 2 provides for a trunk sewer to convey wastes from Lake Como to the Lake Geneva sewage treatment facility. The total estimated capital cost of carrying out alternative plan 2 for the Lake Geneva and Lake Como sewer service areas, including construction of the necessary trunk sewers, is about $11.6 million, with an equivalent annual cost of about $750,500.

The cost of implementing the two alternative sanitary sewerage system plans considered for the Lake Geneva and Lake Como sewer service areas and within 1 percent on an equivalent annual cost basis, well within the accuracy with which such costs can be estimated. Consequently, the two plans may be considered to be approximately the same cost. It is necessary, therefore, to consider other intangible, not nevertheless real, considerations in selecting a recommended plan from among the alternatives presented. The second alternative plan has the advantage of providing only one sewage treatment facility to serve the Lake Geneva and Lake Como urban areas, and thus avoids proliferation of treatment plants and unnecessary duplication of staffs and related

Map 98

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
FOR THE LAKE GENEVA AND LAKE COMO SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA
1990

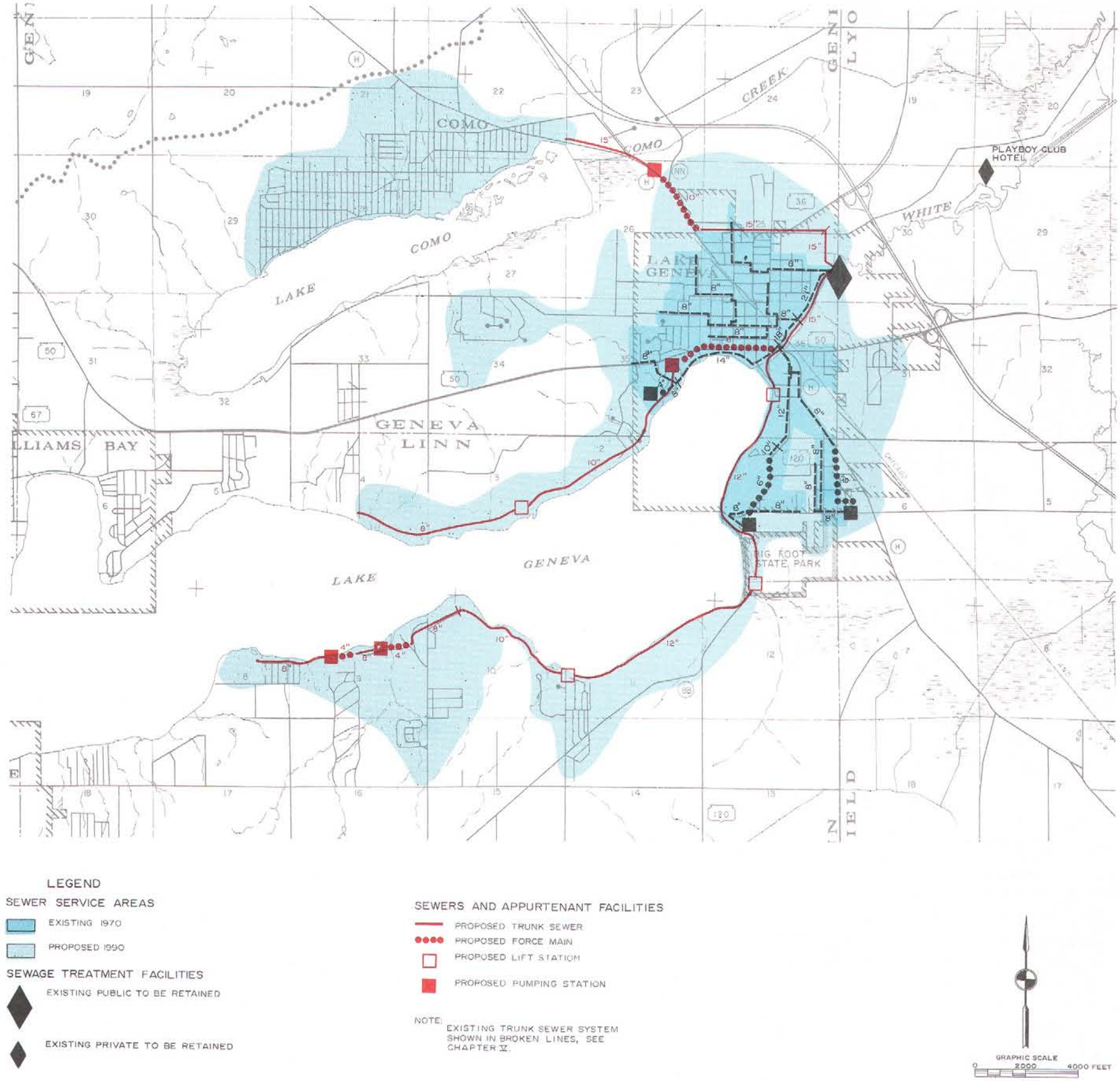


One of the alternative sanitary sewerage system plans considered for the Lake Geneva and Lake Como urban areas includes the establishment of a new sewage treatment facility to serve Lake Como, together with expansion of the existing Lake Geneva sewage treatment facility. New trunk sewers to serve existing urban development along the north and south shorelines of Lake Geneva in the Towns of Geneva and Linn are also included under this alternative. This alternative was found to have about the same cost effectiveness as the second alternative considered, shown on Map 99, which would consolidate sewage treatment at an expanded Lake Geneva plant.

Source: SEWRPC.

Map 99

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE LAKE GENEVA AND LAKE COMO SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA
1990



Another alternative sewerage system plan considered for the Lake Geneva and Lake Como urban areas would in effect extend the existing Lake Geneva sanitary sewerage system to include urban development on the Lake Como shoreline. As in the first alternative, trunk sewers are also proposed to serve the north and south shores of Lake Geneva in the Towns of Geneva and Linn. While this alternative was found to have about the same cost effectiveness as the first alternative considered, shown on Map 98, intangible considerations, such as avoidance of the unnecessary proliferation of treatment plants and unnecessary duplication of staff and facilities, render this alternative more advantageous than the first alternative.

Source: SEWRPC.

facilities. The second alternative also has the advantage of simply providing an expansion of an existing sanitary sewerage system. Conversely, the first alternative would create another sewage treatment facility and necessitate the establishment of a new sanitary sewerage system with a new staff. On balance, therefore, while the two alternatives are approximately equal in terms of equivalent annual cost, the second alternative plan providing for one sewage treatment facility to serve both the Lake Geneva and Lake Como sewer service areas is more advantageous when other intangible considerations are taken into account.

Lyons Subarea: No sanitary sewer service is currently being provided in the Lyons subarea. The Town of Lyons is under orders from the Wisconsin Department of Natural Resources to provide such service to the unincorporated village of Lyons because of widespread malfunctioning of onsite soil absorption sewage disposal systems. Application of the DNR interconnection criteria rules out any connection to any existing sewage treatment facility. Accordingly, the plan proposes the creation of a new sanitary sewerage system for the Lyons subarea, together with the establishment of a sewage treatment facility. It is anticipated that by 1990 an average hydraulic design capacity of about 0.15 mgd will be required for this facility. In order to meet the established water use objectives for the White River, to which effluent would be discharged, it will be necessary for this facility to provide secondary waste treatment and auxiliary waste treatment for effluent disinfection. The specific recommended performance standards for the Lyons sewage treatment plant are set forth in Table 170.

The estimated capital cost of constructing the necessary sewage treatment facility at Lyons is about $110,000, with an equivalent annual cost of about $9,100 (see Table 171). The proposed 1990 service area for Lyons is shown on Map 100.

Genoa City Subarea: In 1970 the sewage treatment facility serving the Genoa City sewer service area had an average hydraulic design capacity of about 0.2 mgd and provided a secondary level of waste treatment. Disposal of effluent is to Nippersink Creek. The plant is a trickling filter type initially constructed in 1923 and modified in 1959. In order to accommodate projected future urban growth, it is anticipated that this plant by 1990 will have to be expanded or replaced to provide an average hydraulic design capacity of about 0.30 mgd. In order to meet the established water use objectives for Nippersink Creek, it will be necessary for this facility to provide secondary waste treatment and auxiliary waste treatment for effluent disinfection. The specific recommended performance standards for the Genoa City sewage treatment plant are set forth in Table 172.

The estimated capital cost of constructing the necessary sewage treatment facility at Genoa City is about $185,300, with an equivalent annual cost of about $15,600 (see Table 173). The proposed 1990 service area for the Village of Genoa City is shown on Map 101.

Wind Lake Subarea: As noted above, the Fox River watershed plan recommended the establishment of a sanitary sewerage system to serve urban development on the shoreline of Wind Lake in the Town of Norway. In response to this recommendation, the Town of Norway Sanitary District No. 1 was established. Engineering studies completed by the District provide for an expansion of the recommendation contained in the Fox River watershed plan to include the provision of centralized

Table 170

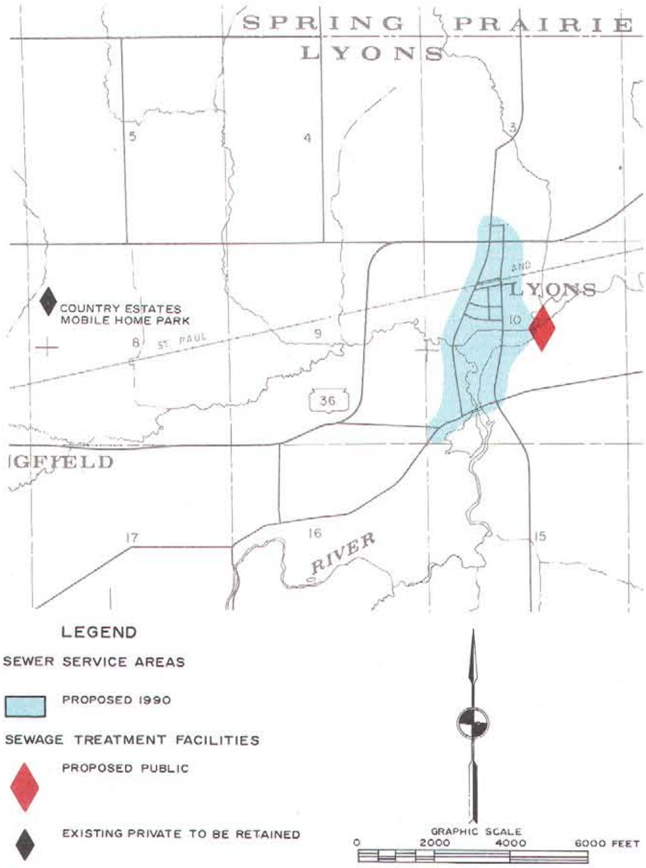
SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE LYONS SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Lyons (0.15 MGD)	Lyons	700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 100.
Source: SEWRPC.

Map 100

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE LYONS SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA
1990

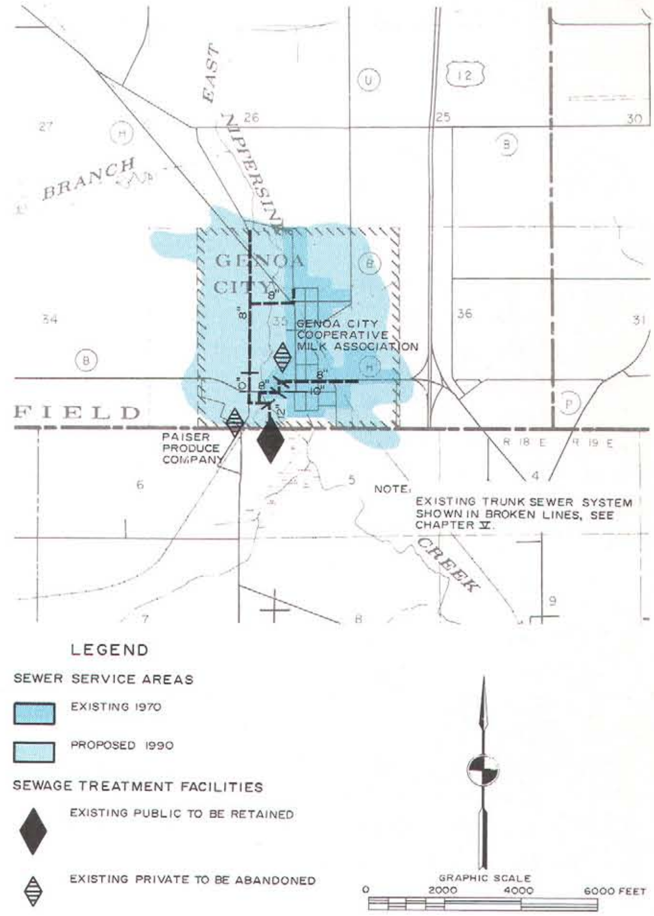


In response to a Wisconsin Department of Natural Resources order to provide centralized sanitary sewer service to urban development comprising the unincorporated village of Lyons, the Town of Lyons has formed a sanitary district and has completed preliminary engineering studies for establishing the necessary system. The isolated location of the Lyons sewer service area ruled out a cost effective connection to an existing sanitary sewerage system. Accordingly, the sewerage system plan proposes the establishment of a new sewage treatment facility to serve the Lyons area, with the facility to provide secondary waste treatment and auxiliary waste treatment for effluent disinfection.

Source: SEWRPC.

Map 101

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE GENOA CITY SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA
1990



The proposed 1990 sewer service area for the Village of Genoa City is shown on the above map. This facility will need to provide both secondary waste treatment and auxiliary waste treatment for effluent disinfection in order to meet the established water use objectives for Nippersink Creek. It is anticipated that the existing plant, a trickling filter type initially constructed in 1923 and modified in 1959, will have to be expanded or replaced to provide the capacity needed to accommodate urban growth by 1990.

Source: SEWRPC.

sanitary sewer service to existing urban development on the shorelines of the nearby Waubeesee, Long, and Denoon Lakes. In order to accommodate existing and projected future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 1.5 mgd will be required for the proposed Wind Lake facility. In order to meet the established water use objectives for the

Table 171

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE LYONS SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Lyons							
Facilities (0.15 MGD)	$ 71,600	$64,600	$67,800	$132,400	$4,100	$3,200	$7,300
Land (7.7 Acres)	38,500	28,400	--	28,400	1,800	--	1,800
Subtotal	110,100	93,000	67,800	160,800	5,900	3,200	9,100
Trunk Sewers--None							
Total	$110,100	$93,000	$67,800	$160,800	$5,900	$3,200	$9,100

Source: SEWRPC.

Table 172

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE GENOA CITY SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Genoa City (0.30 MGD)	Genoa City	1,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 101.
Source: SEWRPC.

Table 173

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE GENOA CITY SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Genoa City							
Facilities (0.30 MGD)	$172,800	$156,000	$80,400	$236,400	$ 9,900	$5,100	$15,000
Land (2.2 Acres)	12,500	9,500	--	9,500	600	--	600
Subtotal	185,300	165,500	80,400	245,900	10,500	5,100	15,600
Trunk Sewers--None							
Total	$185,300	$165,500	$80,400	$245,900	$10,500	$5,100	$15,600

Source: SEWRPC.

Waubeesee and Wind Lake canals, to which effluent would be discharged, it will be necessary for this facility to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Wind Lake sewage treatment plant are set forth in Table 174.

The estimated capital cost of constructing the necessary sewage treatment facilities at Wind Lake, together with a trunk sewer to serve the Waubeesee, Long, and Denoon Lake areas, is about $2.5 million, with an equivalent annual cost of about $256,700 (see Table 175). The proposed 1990 service area for Wind Lake is shown on Map 102.

Eagle Lake Subarea: As noted above, the Fox River watershed plan recommended the establishment of a sanitary sewerage system to serve urban development on the shoreline of Eagle Lake in the Town of Dover. In response to this recommendation, the Town of Dover Sewer Utility District No. 1 was created. Engineering studies completed by the District provide for an expansion of the recommendation contained in the Fox River watershed plan to include the provision of centralized sanitary sewer service to existing urban development in the nearby unincorporated village of Kansasville. In order to accommodate existing and projected future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 0.3 mgd will be required for the proposed Eagle Lake facility. In order to meet the established water use objectives for Eagle Creek, to which effluent would be discharged, it will be necessary for this facility to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Eagle Lake sewage treatment plant are set forth in Table 176.

The estimated capital cost of constructing the necessary treatment facility at Eagle Lake is about $191,500, with an equivalent annual cost of about $14,500 (see Table 177). The proposed 1990 sewer service area for Eagle Lake is shown on Map 103.

Rochester-Waterford-Tichigan Lake Subarea: In 1970 the sewage treatment facility serving the Rochester and Waterford sewer service areas, which facility is operated by the Western Racine County Sewerage District, had an average hydraulic design capacity of about 0.5 mgd and provided a secondary level of waste treatment. Disposal of effluent is to the Fox River. The plant is an activated sludge type constructed in 1968. The adopted Fox River watershed plan recommended that this plant continue in operation and ultimately serve, in addition to the Rochester and Waterford sewer service areas, existing urban development along the shoreline of Tichigan Lake and the main stem of the Fox River north of the Village of Waterford. The watershed plan recognized, however, that it may be necessary to construct an interim sewage treatment facility to serve only the Tichigan Lake area pending ultimate connection to the areawide system.

Since adoption of the watershed plan, however, a Tichigan Lake Sanitary District has been formed and has completed preliminary engineering studies. These preliminary engineering studies recommend immediate connection to the Western Racine

Table 174

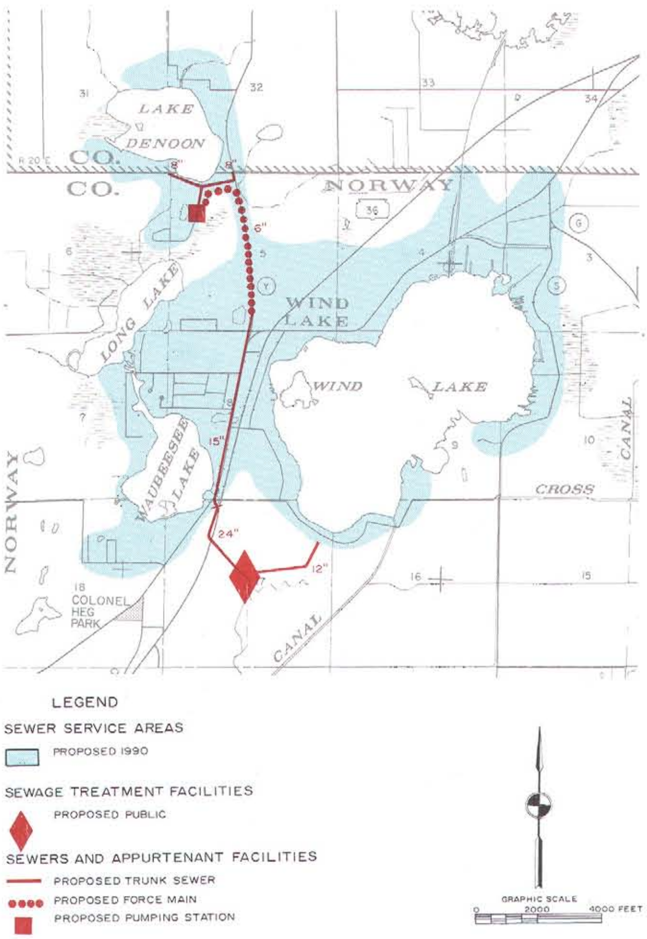
SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WIND LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Wind Lake (1.45 MGD)	Wind Lake	6,900	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 102.*
Source: SEWRPC.

Map 102

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WIND LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA
1990

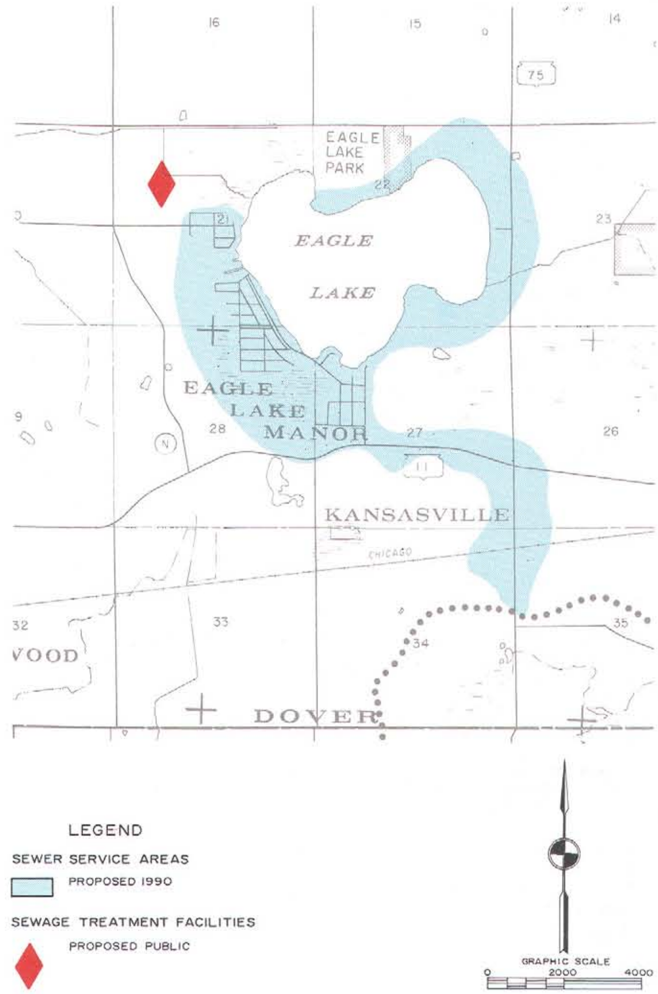


The Fox River watershed plan recommended the establishment of a new sanitary sewerage system to serve urban development along the shoreline of Wind Lake in the Town of Norway. In response to this recommendation, a sanitary district was established and engineering studies were completed by the District to form a basis for the creation of the necessary system. The District has proposed to provide such sewer service not only to urban development on the Wind Lake shoreline, but also to existing urban development on the shorelines of Waubesee and Long Lakes in the Town of Norway and Denoon Lake in the City of Muskego. The proposed treatment facility will need to provide not only secondary waste treatment but also advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection.

Source: SEWRPC.

Map 103

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE EAGLE LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA
1990



The Fox River watershed plan recommended the establishment of a new sanitary sewerage system to serve existing urban development along the shoreline of Eagle Lake in the Town of Dover. Subsequently, the Town of Dover established a sewer utility district and completed engineering studies to form a basis for establishing the necessary sewerage system. The District has proposed to extend service to the nearby unincorporated village of Kansasville. The proposed Eagle Lake sewage treatment facility will need to provide, in addition to secondary waste treatment, advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection.

Source: SEWRPC.

Table 175

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WIND LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Wind Lake							
Facilities (1.45 MGD)	$1,989,900	$1,798,400	$1,765,300	$3,563,700	$114,100	$112,000	$226,100
Land (3.7 Acres)	18,500	14,200	--	14,200	900	--	900
Subtotal	2,008,400	1,812,600	1,765,300	3,577,900	115,000	112,000	227,000
Trunk Sewers							
Denoon Lake-Wind Lake	505,700	381,400	86,700	468,100	24,200	5,500	29,700
Subtotal	505,700	381,400	86,700	468,100	24,200	5,500	29,700
Total	$2,514,100	$2,194,000	$1,852,000	$4,046,000	$139,200	$117,500	$256,700

Source: SEWRPC.

Table 176

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE EAGLE LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Eagle Lake (0.32 MGD)	Eagle Lake	1,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 103.
Source: SEWRPC.

Table 177

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE EAGLE LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Eagle Lake							
Facilities (0.32 MGD)	$135,000	$122,200	$64,600	$186,800	$ 7,750	$4,100	$11,850
Land (11.3 Acres)	56,500	41,000	--	41,000	2,600	--	2,600
Subtotal	191,500	163,200	64,600	227,800	10,350	4,100	14,450
Trunk Sewers--None							
Total	$191,500	$163,200	$64,600	$227,800	$10,350	$4,100	$14,450

Source: SEWRPC.

County Sewerage District treatment facility rather than construction of an interim plant. Accordingly, it is now recommended that the Rochester sewage treatment facility operated by the Western Racine County Sewerage District be expanded to provide a 1990 average hydraulic design capacity of about 1.5 mgd, and provide service to the Rochester, Waterford, and Tichigan Lake sewer service areas. In order to meet the established water use objectives for the Fox River, it will be necessary for this facility to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. The specific recommended performance standards for the Rochester sewage treatment plant are set forth in Table 178.

The estimated capital cost of constructing the necessary treatment facilities at Rochester, together with the cost of constructing a trunk sewer to connect the Tichigan Lake service area to the Rochester plant, is about $3.7 million, with an equivalent annual cost of $306,700 (see Table 179). The proposed 1990 service area for Rochester, Waterford, and Tichigan Lake is shown on Map 104.

Table 178

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WATERFORD-ROCHESTER AND TICHIGAN LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Rochester (1.50 MGD)[2]	Waterford-Rochester Tichigan Lake	8,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 104.*
[2]*Plant operated by the Western Racine County Sewerage District.*
Source: SEWRPC.

Table 179

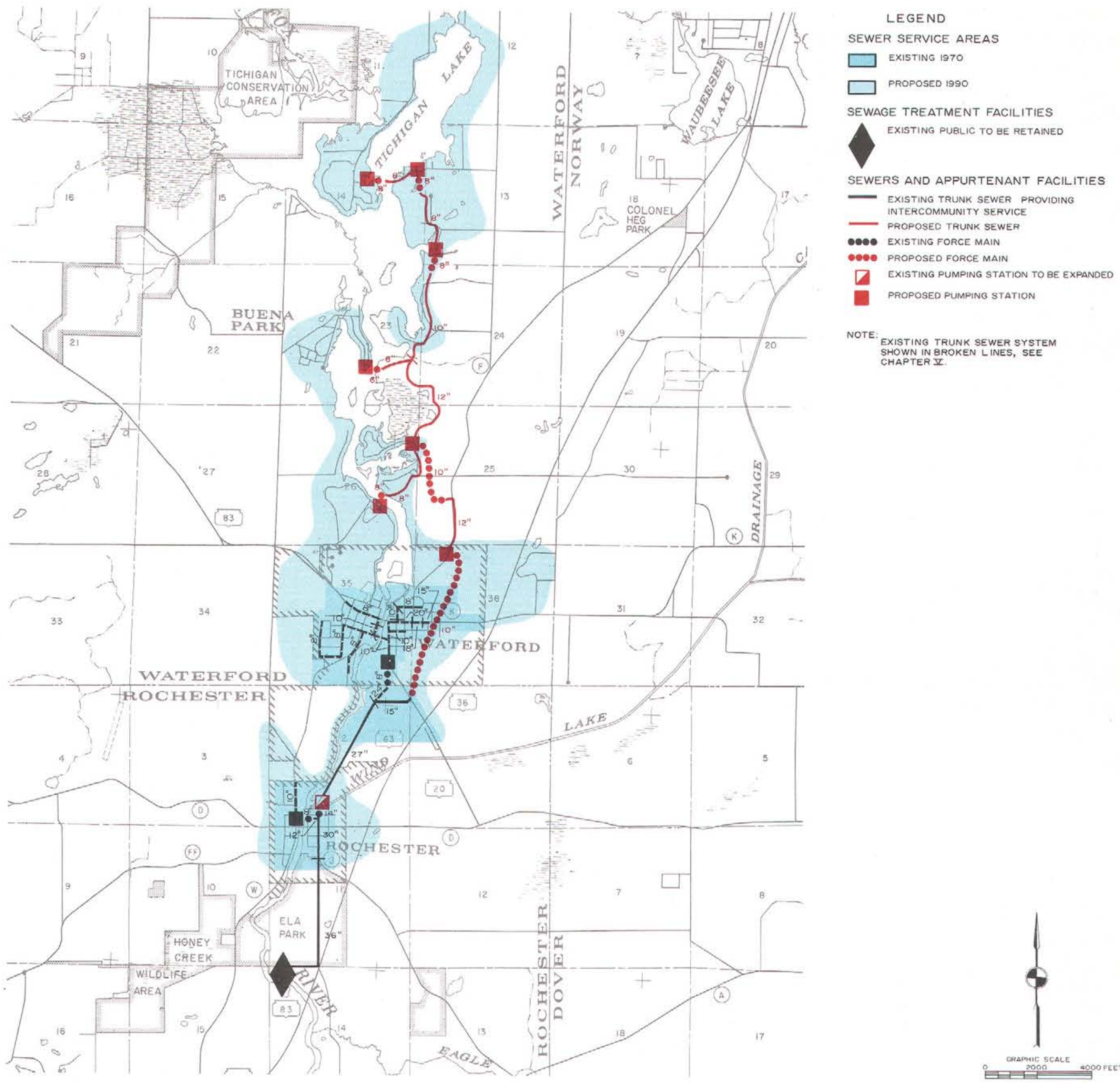
DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WATERFORD-ROCHESTER AND TICHIGAN LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Rochester[1]							
Facilities (1.50 MGD)	$1,191,600	$1,112,800	$1,104,900	$2,217,700	$ 70,600	$70,100	$140,700
Land (3.3 Acres)	16,500	12,600	--	12,600	800	--	800
Subtotal	1,208,100	1,125,400	1,104,900	2,230,300	71,400	70,100	141,500
Trunk Sewer							
Tichigan Lake	2,517,300	1,986,000	617,900	2,603,900	126,000	39,200	165,200
Subtotal	2,517,300	1,986,000	617,900	2,603,900	126,000	39,200	165,200
Total	$3,725,400	$3,111,400	$1,722,800	$4,834,200	$197,400	$109,300	$306,700

[1]*Plant operated by the Western Racine County Sewerage District.*
Source: SEWRPC.

Map 104

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WATERFORD-ROCHESTER AND TICHIGAN LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA
1990



The proposed plan for the Rochester-Waterford-Tichigan Lake urban subarea of the Lower Fox River watershed includes a recommendation to expand the Rochester sewage treatment facility operated by the Western Racine County Sewerage District so as to provide capacity for sewage generated by existing urban development along the shoreline of Tichigan Lake and the main stem of the Fox River in the Town of Waterford north of the Village of Waterford. The proposed plan, as shown on the above map, includes a recommended trunk sewer system to extend the existing sanitary sewerage system to the Town of Waterford. The Rochester sewage treatment facility will need to provide, in addition to secondary waste treatment, advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection.

Source: SEWRPC.

Burlington Subarea: In 1970 the sewage treatment facility serving the Burlington sewer service area had an average hydraulic design capacity of about 1.0 mgd and provided a secondary level of waste treatment. Disposal of effluent is to the Fox River. Since 1970 the City of Burlington has completed a conversion of the old trickling filter treatment facility to an activated sludge treatment facility, and has expanded the plant to a total average hydraulic design capacity of about 2.5 mgd. In addition, and in accordance with the Fox River watershed plan recommendations, the city agreed to provide sewage treatment on a contract basis for sewage generated in the Browns Lake Sanitary District in the Town of Burlington.

Since it is anticipated that an average hydraulic design capacity of 2.5 mgd will be sufficient for urban growth in the Burlington area through 1990, the City of Burlington has already carried out the recommendations contained in the watershed plan. This facility should continue to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. The specific recommended performance standards for the Burlington sewage treatment plant are set forth in Table 180.

Since the regional sanitary sewerage system plan was based upon conditions as they existed in 1970, an estimated cost of constructing the necessary sewage treatment facilities at the City of Burlington was provided even though the city has already carried out the treatment plant recommendations. The capital cost of such facilities is estimated at $1.5 million, with an equivalent annual cost of about $214,700 (see Table 181). The proposed 1990 service area for Burlington is shown on Map 105.

Table 180

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE BURLINGTON SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Burlington (2.50 MGD)	Burlington	15,000	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 105.
Source: SEWRPC.

Table 181

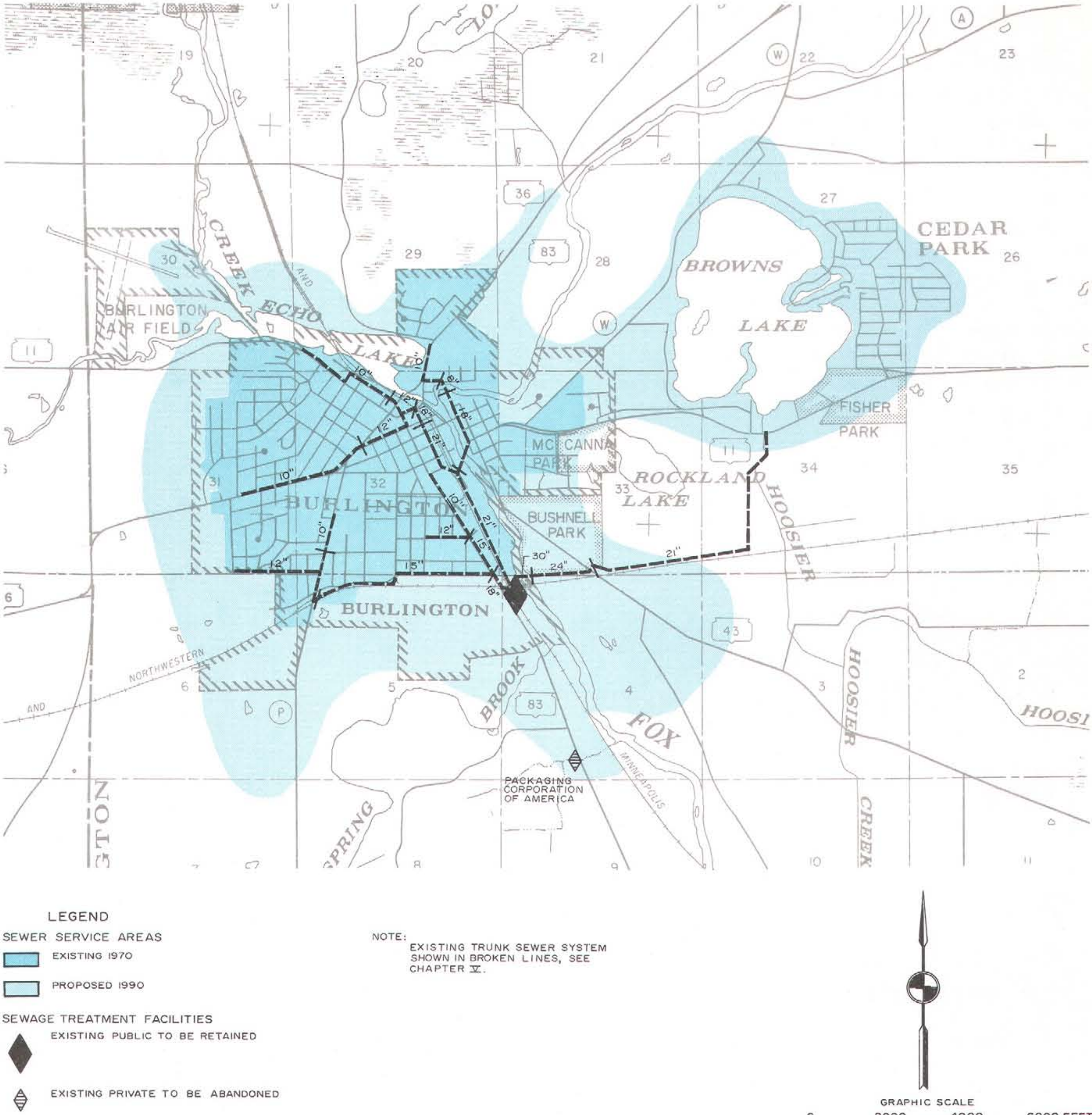
DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE BURLINGTON SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Burlington							
Facilities (2.50 MGD)	$1,524,000	$1,377,600	$1,504,000	$2,881,600	$87,400	$126,400	$213,800
Land (3.8 Acres)	19,000	14,200	--	14,200	900	--	900
Subtotal	1,543,000	1,391,800	1,504,000	2,895,800	88,300	126,400	214,700
Trunk Sewers--None							
Total	$1,543,000	$1,391,800	$1,504,000	$2,895,800	$88,300	$126,400	$214,700

Source: SEWRPC.

Map 105

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE BURLINGTON SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA
1990



Acting upon a recommendation contained in the adopted Fox River watershed plan, a sanitary sewerage system has been established in the Town of Burlington to serve urban development along the shoreline of Browns Lake, with treatment provided on a contract basis at the City of Burlington sewage treatment facility. The above map shows the recommended 1990 sewer service area for the Burlington and Browns Lake areas. Recent improvements and additions to the Burlington sewage treatment facility should serve to provide adequate capacity and levels of treatment for this area through the 1990 plan design year.

Source: SEWRPC.

Silver Lake Subarea: In 1970 the sewage treatment facility serving the Silver Lake sewer service area had an average hydraulic design capacity of about 0.3 mgd and provided a secondary level of waste treatment. Disposal of effluent is to the Fox River. The plant is an activated sludge type constructed in 1966. In order to accommodate projected future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 0.7 mgd will be required for this facility. In order to meet the established water use objectives for the Fox River, it will be necessary for this facility to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. These specific recommended performance standards for the Silver Lake sewage treatment plant are set forth in Table 182.

The estimated capital cost of expanding the Silver Lake sewage treatment facility and constructing a trunk sewer to extend centralized sanitary sewer service to the southeast side of Silver Lake in the Town of Salem is about $866,800, with an equivalent annual cost of about $84,600 (see Table 183). The proposed 1990 service area for the Village of Silver Lake is shown on Map 106.

Twin Lakes Subarea: In 1970 the sewage treatment facility serving the Twin Lakes sewer service area had an average hydraulic design capacity of about 0.8 mgd and provided a secondary level of waste treatment. Disposal of effluent is to Basset Creek. The plant actually consists of two components: one a trickling filter type constructed in 1958 and the other an activated sludge type constructed in 1970. The existing average hydraulic design capacity will likely be sufficient to provide for future urban growth through 1990. In order to meet the established water use objectives for Basset Creek, it will be necessary for this facility to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Twin Lakes sewage treatment plant are set forth in Table 184.

The estimated capital cost of constructing the necessary treatment facilities at Twin Lakes, including the replacement of the existing trickling filter plant and the provision of advanced and auxiliary waste treatment facilities, is about $743,900, with an equivalent annual cost of about $52,300 (see Table 185). The proposed 1990 sewer service area for the Village of Twin Lakes is shown on Map 107.

Camp-Center Lakes, Wilmot, Cross Lake, and Rock Lake Subarea: As noted above, the adopted Fox River watershed plan recommended the establishment of a sanitary sewerage system to serve development along the shoreline of Camp and Center Lakes. Acting on this recommendation, the Town of Salem has formed Sewer Utility District No. 2 and has completed preliminary engineering studies relating to the establishment of such a system. These studies have recommended the provision of sanitary sewer service not only to urban development on the shorelines of Camp and Center Lakes, but also urban development on the shorelines of Rock Lake, Cross Lake, Benet Lake, Shangrila Lake, and Voltz Lake and in the unincorporated villages of Wilmot and Trevor.

In order to accommodate existing and projected future urban growth, it is anticipated that by 1990

Table 182

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SILVER LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

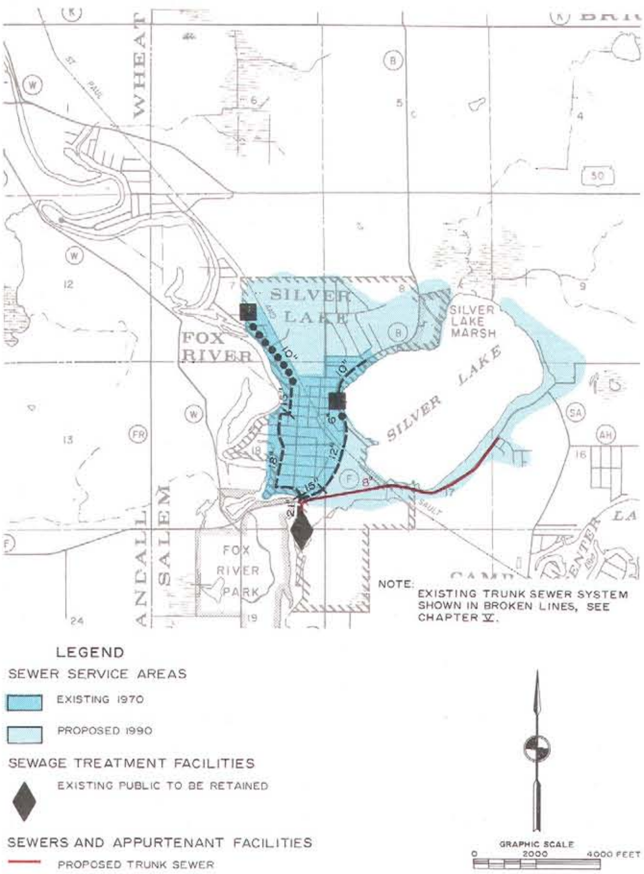
Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Silver Lake (0.71 MGD)	Silver Lake	3,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 106.

Source: SEWRPC.

Map 106

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE SILVER LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA
1990

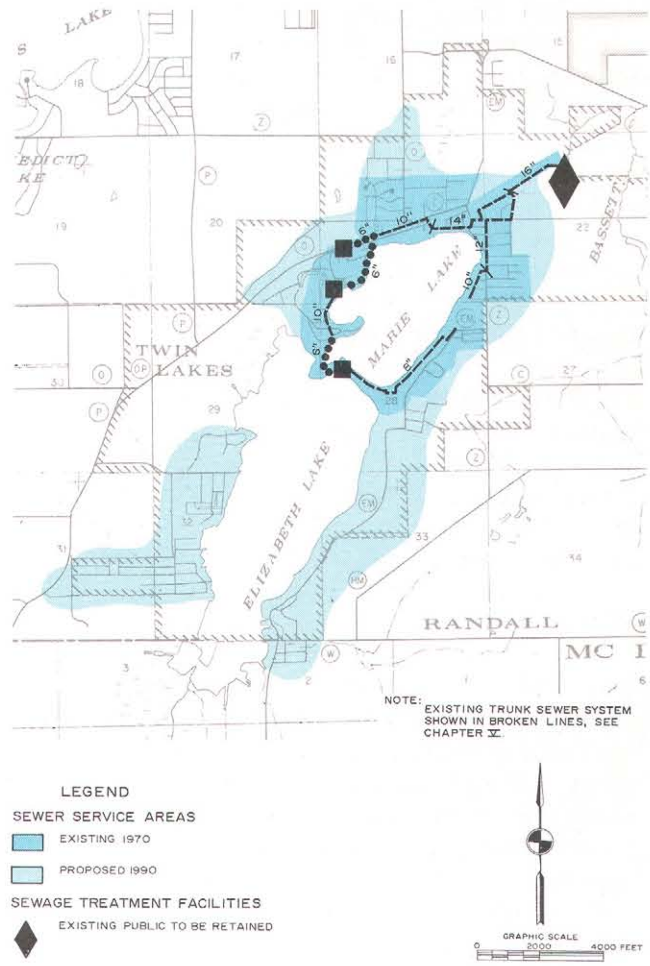


It is proposed that the Village of Silver Lake sanitary sewerage system be extended to provide sewer service to existing urban development along the south shoreline of Silver Lake in the Town of Salem. Service would further be extended to the newly established Silver Lake County Park operated by the Kenosha County Park Commission. In order to meet the water use objectives for the Fox River, the Silver Lake sewage treatment facility would need to provide, in addition to secondary waste treatment, advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection.

Source: SEWRPC.

Map 107

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE TWIN LAKES SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA
1990



The proposed 1990 sewer service area for the Village of Twin Lakes and environs is shown on the above map. It is anticipated that the existing Twin Lakes sewage treatment facility will have sufficient capacity to provide for future urban growth through 1990. It will be necessary for the Twin Lakes facility to provide not only secondary waste treatment but also advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection in order to meet the water use objectives for Basset Creek.

Source: SEWRPC.

Table 183

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE SILVER LAKE SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Silver Lake							
Facilities (0.71 MGD)	$649,600	$614,700	$556,400	$1,171,100	$39,000	$35,300	$74,300
Land (3.0 Acres)	15,000	11,000	--	11,000	700	--	700
Subtotal	664,600	625,700	556,400	1,182,100	39,700	35,300	75,000
Trunk Sewer							
Silver Lake	202,200	148,200	3,200	151,400	9,400	200	9,600
Subtotal	202,200	148,200	3,200	151,400	9,400	200	9,600
Total	$866,800	$773,900	$559,600	$1,333,500	$49,100	$35,500	$84,600

Source: SEWRPC.

Table 184

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE TWIN LAKES SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Types of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Twin Lakes (0.75 MGD)	Twin Lakes	4,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 107.*
Source: SEWRPC.

Table 185

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE TWIN LAKES SEWER SERVICE AREA
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Twin Lakes							
Facilities (0.75 MGD)	$743,900	$698,300	$126,100	$824,400	$44,300	$8,000	$52,300
Land (None)	--	--	--	--	--	--	--
Subtotal	743,900	698,300	126,100	824,400	44,300	8,000	52,300
Trunk Sewers--None							
Total	$743,900	$698,300	$126,100	$824,400	$44,300	$8,000	$52,300

Source: SEWRPC.

an average hydraulic design capacity of about 1.0 mgd will be required for the Camp Lake treatment facility. In order to meet the established water use objectives for the Fox River, to which effluent from the centralized sewage treatment plant will be discharged, it will be necessary for this facility to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. The specific recommended performance standards for the Camp Lake sewage treatment plant are set forth in Table 186.

The estimated capital cost of constructing the necessary treatment facilities at Camp Lake, together with cost of constructing trunk sewers to interconnect the Wilmot, Cross Lake, and Rock Lake sewer service areas with the Camp-Center Lakes sewer service area and the cost of an outfall sewer to the Fox River from the Camp sewage treatment plant site, is estimated at about $2.4 million, with an equivalent annual cost of about $211,900 (see Table 187). The proposed 1990 service areas for Camp-Center Lakes, Cross Lake, Wilmot, and Rock Lake are shown on Map 108.

Concluding Remarks—Subregional Area Plan: A comparison between the recommended treatment levels at municipal sewage treatment plants in the

Table 186

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE CAMP-CENTER LAKES, WILMOT, CROSS LAKE, AND ROCK LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Camp Lake (1.06 MGD)	Camp-Center Lakes Wilmot Cross Lake Rock Lake	4,900	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 108.*

Source: SEWRPC.

Table 187

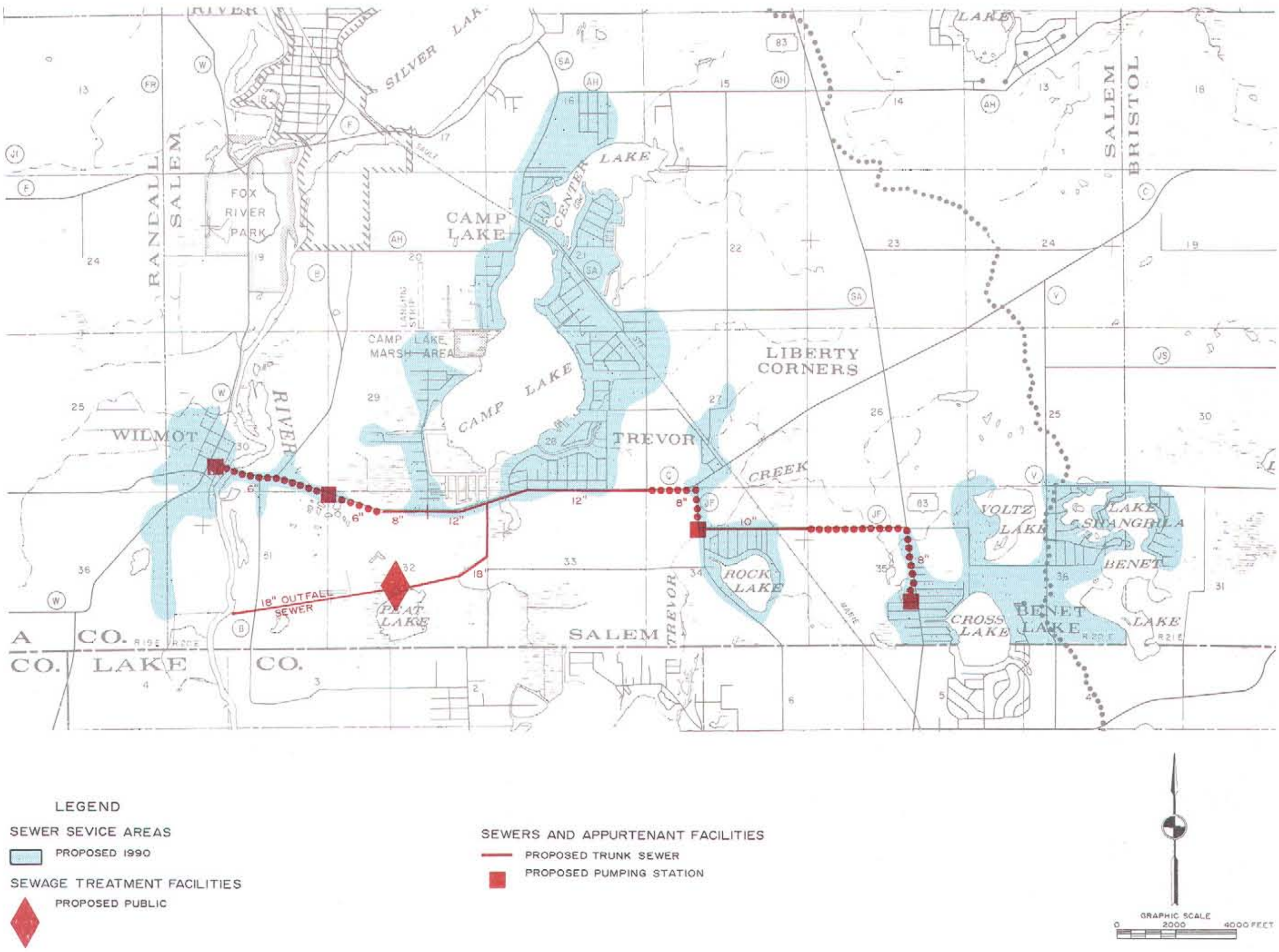
DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE CAMP-CENTER LAKES, WILMOT, CROSS LAKE, AND ROCK LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost: Capital Construction	Present Worth (1970-2020): Construction	Present Worth (1970-2020): Operation and Maintenance	Present Worth (1970-2020): Total	Equivalent Annual (1970-2020): Construction	Equivalent Annual (1970-2020): Operation and Maintenance	Equivalent Annual (1970-2020): Total
Sewage Treatment Plant							
Camp Lake							
Facilities (1.06 MGD)	$1,107,700	$1,000,900	$1,018,200	$2,019,100	$ 63,500	$64,600	$128,100
Outfall Sewer	171,200	126,100	3,200	129,300	8,000	200	8,200
Land (3.3 Acres)	16,500	12,600	--	12,600	800	--	800
Subtotal	1,295,400	1,139,600	1,021,400	2,161,000	72,300	64,800	137,100
Trunk Sewers							
Wilmot	245,800	200,200	119,800	320,000	12,700	7,600	20,300
Cross-Rock Lakes	436,300	354,700	209,700	564,400	22,500	13,300	35,800
Camp Lake	393,900	288,400	6,300	294,700	18,300	400	18,700
Subtotal	1,076,000	843,300	335,800	1,179,100	53,500	21,300	74,800
Total	$2,371,400	$1,982,900	$1,357,200	$3,340,100	$125,800	$86,100	$211,900

Source: SEWRPC.

Map 108

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE CAMP-CENTER LAKES, WILMOT, CROSS LAKE, AND ROCK LAKE SEWER SERVICE AREAS
LOWER FOX RIVER SUBREGIONAL AREA
1990



The adopted Fox River watershed plan recommended the establishment of a new sanitary sewerage system to serve existing urban development along the shorelines of Camp and Center Lakes in the Town of Salem. Preliminary engineering studies conducted by the Town of Salem Sewer Utility District No. 2 in response to this recommendation have included a proposal to extend such service not only to the Camp and Center Lakes urban areas but also to urban development along the shorelines of Rock, Cross, Bennet, Shangrila, and Voltz Lakes and to the unincorporated villages of Wilmot and Trevor. The above map shows the proposed 1990 service area for this proposed new sanitary sewerage system, as well as a proposed treatment plant location and major trunk sewer system. In order to meet the established water use objectives for the Fox River, it will be necessary for the Camp Lake facility to provide not only secondary waste treatment but also advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection.

Source: SEWRPC.

lower Fox River subregional area as initially set forth in the adopted Fox River watershed plan and as modified in the regional sanitary sewerage system plan are set forth in Table 188. With respect to the sewage treatment facilities serving Mukwonago, East Troy, Lake Geneva, and Twin Lakes, the watershed plan recommendations have been changed to substitute the advanced waste treatment process of nitrification for nitrogen removal and, except in the case of Mukwonago, to add the auxiliary waste treatment of effluent aeration. Advanced waste treatment processes have been added to the sewage treatment facilities serving Silver Lake, Camp Lake, Eagle Lake, and Wind Lake, reflecting larger proposed sanitary sewerage systems and greater anticipated

Table 188

COMPARISON BETWEEN RECOMMENDED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANTS IN THE LOWER FOX RIVER SUBREGIONAL AREA: FOX RIVER WATERSHED PLAN AND REGIONAL SANITARY SEWERAGE SYSTEM PLAN

Sewage Treatment Plant	Fox River Watershed Plan						Regional Sanitary Sewerage System Plan						Rationale for Change in Treatment Level Recommendations
		Advanced			Auxiliary			Advanced			Auxiliary		
	Secondary	Phosphorus Removal	Nitri-fication	Nitrogen Removal	Effluent Disin-fection	Effluent Aeration	Secondary	Phosphorus Removal	Nitri-fication	Nitrogen Removal	Effluent Disin-fection	Effluent Aeration	
Mukwonago	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	State-of-the-art now indicates nitrogen removal not critical for control of algae and weed growth; ammonia toxicity factor requires provision of nitrification.
East Troy	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	State-of-the-art now indicates nitrogen removal not critical for control of algae and weed growth; ammonia toxicity factor requires provision of nitrification; effluent aeration required to maintain dissolved oxygen levels.
Lake Geneva	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	State-of-the-art now indicates nitrogen removal not critical for control of algae and weed growth; ammonia toxicity factor requires provision of nitrification; effluent aeration required to maintain dissolved oxygen levels.
Lake Como	Yes	No	No	No	Yes	No	--	--	--	--	--	--	Cost effectiveness studies indicate connection to Lake Geneva feasible.
Lyons	--	--	--	--	--	--	Yes	No	No	No	Yes	No	Plant not included in watershed plan.
Genoa City	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	No	No change.
Wind Lake	Yes	No	No	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Larger plant required for expanded sewer service area; phosphorus removal economically justified for larger plant; ammonia toxicity factor requires provision of nitrification; effluent aeration required to maintain dissolved oxygen levels.
Eagle Lake	Yes	No	No	No	Yes	No	Yes	No	Yes	No	Yes	Yes	Larger plant required for expanded sewer service area; phosphorus removal economically justified for larger plant; ammonia toxicity factor requires provision of nitrification; effluent aeration required to maintain dissolved oxygen levels.
Tichigan Lake	Yes	No	No	No	Yes	No	--	--	--	--	--	--	Local plan implementation activities indicate feasibility of immediate connection to Rochester sewage treatment plant rather than a separate interim plant.
Rochester[1]	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	No	Yes	No	State-of-the-art now indicates nitrogen removal not critical for control of algae and weed growth.
Burlington	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	No	Yes	No	State-of-the-art now indicates nitrogen removal not critical for control of algae and weed growth.
Silver Lake	Yes	No	No	No	Yes	No	Yes	Yes	No	No	Yes	No	Larger plant required for expanded sewer service area; phosphorus removal economically justified for larger plant.
Twin Lakes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	State-of-the-art now indicates nitrogen removal not critical for control of algae and weed growth; ammonia toxicity factor requires provision of nitrification; effluent aeration required to maintain dissolved oxygen levels.
Camp Lake	Yes	No	No	No	Yes	No	Yes	Yes	No	No	Yes	No	Larger plant required for expanded sewer service area; phosphorus removal economically justified for larger plant.

[1]*Plant operated by the Western Racine County Sewerage District.*

Source: SEWRPC.

waste loadings. In the cases of sewage treatment facilities serving Rochester and Burlington, high dilution ratios indicated no need to provide nitrification. With respect to Lake Como and Tichigan Lake, connections to larger sewage treatment facilities are recommended rather than the establishment of separate sewage treatment facilities due to cost effectiveness studies and local plan implementation activities.

Private Sewage Treatment Plants

Eight private sewage treatment plants were found in 1970 to discharge wastes in the Lower Fox River subregional area. These facilities serve the Rainbow Springs Resort in the Town of Mukwonago; the Packaging Corporation of America plant in the Town of Burlington; the Holy Redeemer College in the Town of Dover; the Alpine Valley Lodge in the Town of LaFayette; the Trent Tube Company in the Village of East Troy; the Playboy Club Hotel in the Town of Lyons; and the Pasier Produce Company and the Genoa City Cooperation Milk Association in the Village of Genoa City (see Maps 38, 40, and 44). Since 1970 two additional private sewage treatment facilities—those serving the Country Estates Mobile Home Park in the Town of Lyons and the STH 15 rest area in the Town of LaFayette—have been established. Of these facilities, six—Alpine Valley Lodge, Playboy Club Hotel, Holy Redeemer College, Rainbow Springs Resort, Country Estates Mobile Home Park, and the STH 15 rest area—lie beyond the proposed 1990 sewer service areas and must, therefore, continue in operation. One—Trent Tube Company—is a specialized industrial facility within the Village of East Troy and should also continue in operation. These seven facilities should provide a level of waste treatment adequate to meet the water quality objectives and standards for the receiving streams. The remaining three facilities lie within the proposed 1990 sewer service areas and should accordingly be abandoned and connected to the appropriate sanitary sewerage system.

UPPER ROCK RIVER SUBREGIONAL AREA

The Upper Rock River subregional area consists of all that area of the Rock River watershed in Washington County. This portion of the Rock River watershed is comprised of all or portions of several subwatersheds, including the Rock River East Branch subwatershed, the Kohlsville River subwatershed, the Limestone Creek subwatershed, the Rubicon River subwatershed, the Bark River subwatershed, the Ashippun River subwatershed, and the Oconomowoc River subwatershed. Concentrations of urban development are found in the City of Hartford, the Village of Slinger, and the unincorporated village of Allenton in the Town of Addison. In addition, the southern portion of this subregional area has been subject in very recent years to extensive low-density urban residential development, particularly in the Towns of Erin and Richfield. The Upper Rock River subregional area contains all or portions of two major state-owned wildlife areas—the Theresa Marsh in the Town of Wayne and the Allenton Wildlife Area in the Town of Addison—as well as the newly established Pike Lake State Park, a major regional outdoor recreation facility recommended to be established in the adopted regional land use plan.

As noted in Chapter V of this report, centralized sanitary sewer service in the Upper Rock River subregional area was provided by three systems in 1970: those operated by the City of Hartford, the Village of Slinger, and the Allenton Sanitary District. Together, the service areas of these three systems comprised an area of about 2.2 square miles and served an estimated population of about 8,500 persons. In 1970 there were about 12,600 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the three existing systems are presented in Chapter V of this report.

Sewer Service Analysis Areas

A total of four sewer service analysis areas may be identified within the Upper Rock River subregional area (see Table 189). These four sewer service analysis areas are shown on Map 109 and may be described as follows:

1. Area A—This area consists of the unincorporated village of Allenton in the Town of Addison. In 1970, sanitary sewer service was provided in this area to a total area of about 0.2 square mile, having a total resident population of about 700 persons. By 1990 the total area anticipated to be served approximates 0.5 square mile, with a projected population of about 1,700 persons. This subarea is referenced as the "Allenton" service area in the ensuing discussion.

2. Area B—This area consists of the City of Hartford and environs. In 1970, sanitary sewer service was provided in this area to

Table 189

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE UPPER ROCK RIVER SUBREGIONAL AREA 1970 and 1990

Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Allenton	0.24	700	0.06	--	0.48	1,700	0.36
B	Hartford	1.68	6,800	1.24	300	4.54	9,300	2.65[2]
C	Pike Lake	--	--	--	800	1.81	1,000	0.31[3]
D	Slinger	0.31	1,000	0.09	400	1.67	3,200	0.67
	Total	2.23	8,500	1.39	1,500	8.50	15,200	3.99

[1]*See Map 109.*
[2]*Includes design sewage flow of 0.72 MGD from the Libby, McNeill, & Libby canning plant and of 0.17 MGD from the W. B. Place tannery.*
[3]*Includes design sewage flow of 0.14 MGD from the Pike Lake State Park.*
Source: SEWRPC.

a total area of about 1.7 square miles, having a total resident population of about 6,800 persons. By 1990 the total area anticipated to be served approximates 4.5 square miles, with a projected population of about 9,300 persons. This subarea is referenced as the "Hartford" sewer service area in the ensuing discussion.

3. Area C—This area consists of urban development along the shoreline of Pike Lake in the Town of Hartford and the newly established Pike Lake State Park. About 800 persons resided in this area in 1970 but no centralized sanitary sewer service was provided. The Wisconsin Department of Natural Resources currently operates a small sewage treatment facility to serve the Pike Lake State Park. This facility utilizes a seepage lagoon for effluent disposal. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.8 miles, with a population of about 1,000 persons. In addition, the Pike Lake State Park is anticipated to provide a design sewage flow of 0.14 mgd. This subarea is referenced as the "Pike Lake" sewer service area in the ensuing discussion.

4. Area D—This area consists of the Village of Slinger and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.3 square mile, having a total resident population of about 1,000 persons. By 1990 the total area anticipated to be served approximates 1.7 square miles, with a projected population of about 3,200 persons. This subarea is referenced as the "Slinger" sewer service area in the ensuing discussion.

Formulation of Alternatives

As discussed earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system planning program for the formulation of alternative plans. The first step in this process was to apply the Wisconsin Department of Natural Resources (DNR) guidelines relating distances between communities to the populations of both the "sending" and "receiving" communities in order to determine if potential interconnections between sanitary sewerage systems should be investigated. The results of the application of these criteria to the communities within the Upper Rock River subregional sewerage system planning area are summarized in Table 190.

Based on the DNR guidelines, the following potential interconnections between sewer service areas in the Upper Rock River subregional area were eliminated from further consideration:

1. Allenton to Hartford

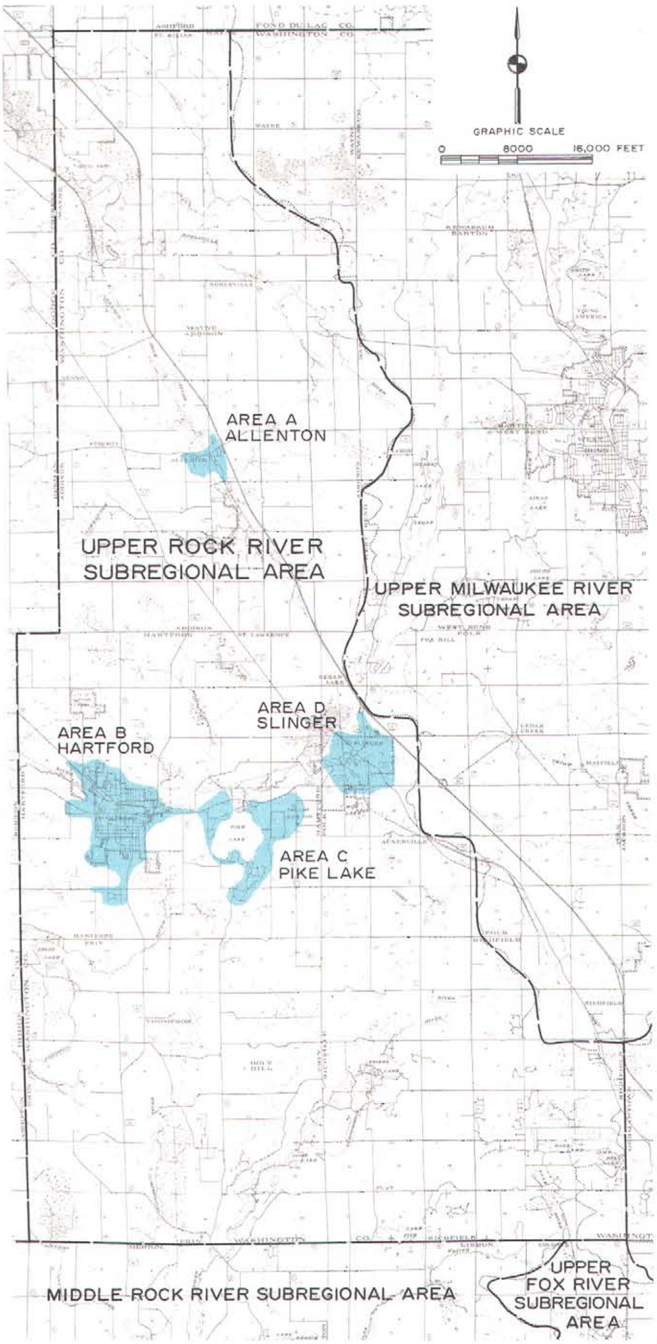
2. Slinger to Hartford

One interconnection—Pike Lake to Hartford—was found to be potentially feasible through the application of the DNR guidelines. Conduct of a pre-

Map 109

SEWER SERVICE ANALYSIS AREAS

UPPER ROCK RIVER SUBREGIONAL AREA



Four urban sewer service areas were identified in the Upper Rock River subregional area: the City of Hartford and environs, the Village of Slinger and environs, the unincorporated village of Allenton in the Town of Addison, and urban development along the shoreline of Pike Lake and the newly established Pike Lake State Park in the Town of Hartford. By 1990 it is anticipated that about 19,000 persons will reside in these four urban areas, with the total land in urban use anticipated to approximate nearly nine square miles. In 1970 there were about 21,000 persons residing in the Upper Rock River watershed area, of which about 8,000 were served by centralized sanitary sewer service and 13,000 by onsite septic tank sewage disposal systems.

Source: SEWRPC.

liminary economic analysis for this potential interconnection further revealed that a detailed economic analysis was warranted. Accordingly, it was determined that the following sanitary sewerage system plans for the Upper Rock River subregional area should be prepared and evaluated:

1. A proposed plan for the Allenton sewer service area.

2. A proposed plan for the Slinger sewer service area.

3. Two alternative plans for the Hartford-Pike Lake sewer service areas, including an alternative providing individual sewage treatment facilities at each of the two sewer service areas and an alternative providing for a single sewage treatment facility at the Hartford sewage treatment plant site.

Each of the sanitary sewerage system plan elements is described in the following paragraphs. Data pertaining to required treatment levels at each of the municipal sewage treatment sites considered in the preparation of these plan elements are presented in Table 191.

Proposed Plan—Allenton Subarea

In 1970 the sewage treatment facility serving the Allenton sewer service area had an average hydraulic design capacity of 0.10 mgd and provided a secondary level of waste treatment. Disposal of effluent is to the Rock River East Branch. In order to accommodate probable future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 0.36 mgd will be required for this facility. In order to meet the established water use objectives for the Rock River East Branch, it will be necessary for this facility to provide, in addition to the current secondary level of waste treatment, advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Allenton sewage treatment plant are set forth in Table 192.

The estimated capital cost of constructing the necessary treatment facilities at Allenton is about \$221,000 with an equivalent annual cost of about \$16,500 (see Table 193). The proposed 1990 service area for the Allenton sanitary district is shown on Map 110.

Table 190

RESULTS OF THE APPLICATION OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES INTERCONNECTION GUIDELINES AND PRELIMINARY ECONOMIC ANALYSES IN THE UPPER ROCK RIVER SUBREGIONAL AREA

Sewer Service Analysis Area(s)				Results of Application of DNR Guidelines		Results of Preliminary Economic Analysis			
Receiving		Sending		Straight Line Distance Between Sewer Service Areas (Miles)	Proceed to Preliminary Economic Analysis (Yes or No)	Total Equivalent Annual Cost			Proceed to Detailed Economic Analysis[1] (Yes or No)
Name	Estimated 1990 Population	Name	Estimated 1990 Population			Separate Plants (A)	Interconnection-One Plant (B)	Percent Difference (B-A)/(A)	
Hartford	9,300	Allenton	1,700	7.0	No	--	--	--	--
		Pike Lake	1,000	1.5	Yes	$193,200	$184,600	-4.5	Yes
		Slinger	3,200	4.0	No	--	--	--	--

[1]If the estimated equivalent annual cost of interconnection was no more than 20 percent greater than the cost of providing separate sewage treatment facilities, a detailed economic analysis was deemed to be required.

Source: SEWRPC.

Table 191

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE UPPER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Water Body	Stream Low Flow and Dilution Ratio Data									Level of Treatment Required				
		7-Day, 10-Year Low Flow		Upstream Sewage Treatment Plant Flow-1990		Total Design Low Flow-1990		Total Design Sewage Flow-1990		Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Secondary	Advanced		Auxiliary	
		CFS	MGD	CFS	MGD	CFS	MGD	CFS	MGD			Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Allenton	Rock River East Branch	0.29	0.19	--	--	0.29	0.19	0.56	0.36	0.52	Yes	No	Yes	Yes	Yes
Hartford[1]	Rubicon River	0.28	0.18	0.48	0.31	0.76	0.49	4.10	2.65	0.19	Yes	Yes	Yes	Yes	Yes
Hartford[2]	Rubicon River	0.28	0.18	--	--	0.28	0.17	4.58	2.96	0.08	Yes	Yes	Yes	Yes	Yes
Pike Lake[1]	Rubicon River	0.11	0.07	--	--	0.11	0.07	0.48	0.31	0.23	Yes	Yes	Yes	Yes	Yes
Slinger	Marsh Tributary to Rubicon River	0.05	0.03	--	--	0.05	0.03	1.04	0.67	0.05	Yes	No	Yes	Yes	Yes

[1]Corresponds to Hartford-Pike Lake alternative plan 1.
[2]Corresponds to Hartford-Pike Lake alternative plan 2.

Source: SEWRPC.

Table 192

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE ALLENTON SEWER SERVICE AREA UPPER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Allenton (0.36 MGD)	Allenton	1,700	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 110.

Source: SEWRPC.

Proposed Plan—Slinger Subarea

In 1970 the sewage treatment facility serving the Slinger sewer service area had an average hydraulic design capacity of 0.15 mgd and provided a secondary level of waste treatment. Disposal of effluent is to a minor drainage course leading to a marsh land drained by the Rubicon River. In order to accommodate probable future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of 0.67 mgd will be required for this facility. In order to meet the established water use objectives for the Rubicon River, it will be necessary for this facility to provide, in addition to the current secondary level of waste treatment, advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Slinger sewage treatment plant are set forth in Table 194.

The estimated capital cost of constructing the necessary treatment facilities at Slinger is about $1.1 million, with an equivalent annual cost of about $111,600 (see Table 195). The proposed 1990 service area for the Village of Slinger and environs is shown on Map 111.

Alternative Plans—Hartford-Pike Lake Subarea

As indicated above, preliminary economic analyses revealed a need to consider the interconnec-

Table 193

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE ALLENTON SEWER SERVICE AREA
UPPER ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
	Capital Construction	Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
		Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Allenton							
Facilities (0.36 MGD)	$166,500	$147,000	$73,000	$220,000	$ 9,300	$4,600	$13,900
Land (11 Acres)	55,000	40,300	--	40,300	2,600	--	2,600
Subtotal	221,500	187,300	73,000	260,300	11,900	4,600	16,500
Trunk Sewers--None							
Total	$221,500	$187,300	$73,000	$260,300	$11,900	$4,600	$16,500

Source: SEWRPC.

Table 194

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SLINGER SEWER SERVICE AREA
UPPER ROCK RIVER SUBREGIONAL AREA

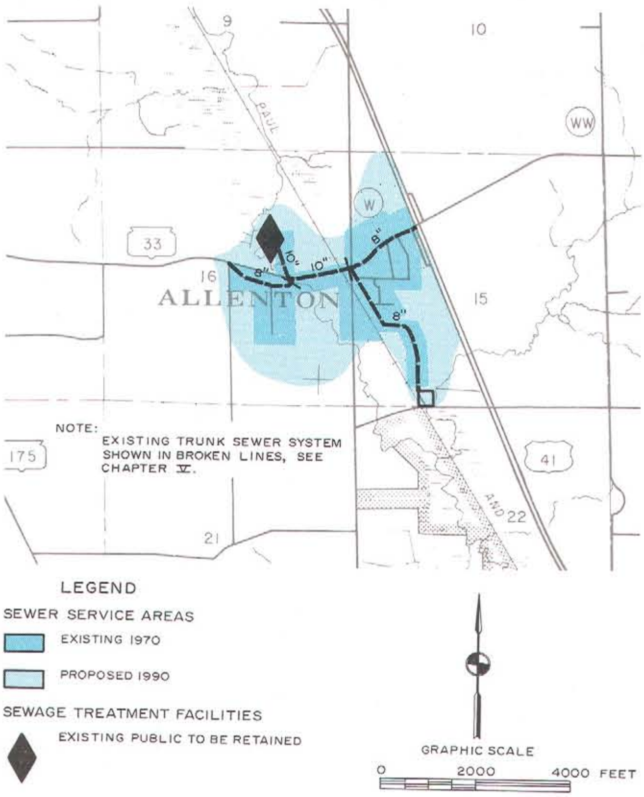
Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Slinger (0.67 MGD)	Slinger	3,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 111.*

Source: SEWRPC.

Map 110

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE ALLENTON SEWER SERVICE AREA
UPPER ROCK RIVER SUBREGIONAL AREA
1990

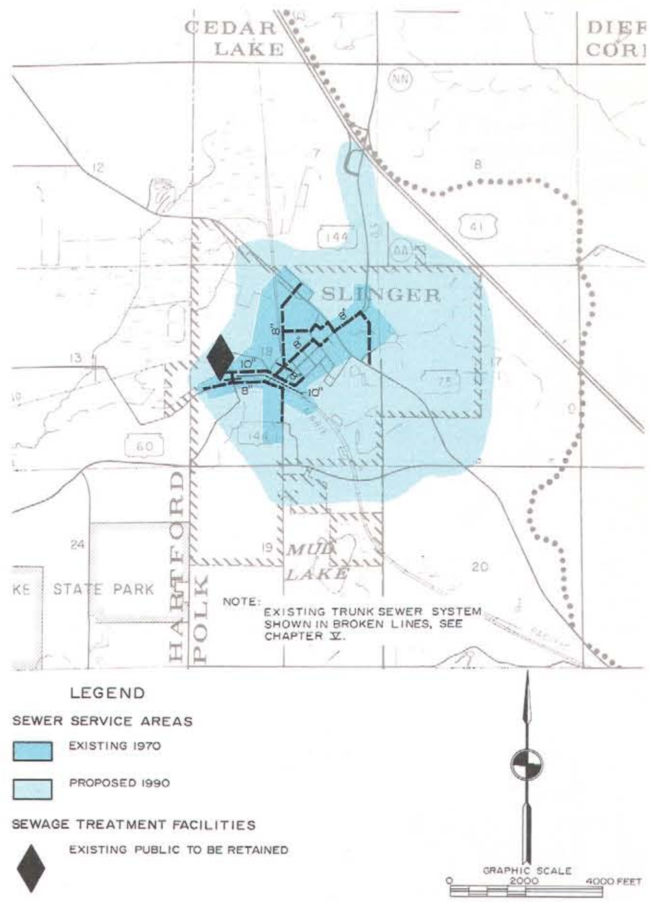


The proposed sanitary sewerage system plan for the Allenton sewer service area includes the recommendation to provide, in addition to the current secondary level of waste treatment, advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. Such additional levels of treatment are necessary in order to meet the established water use objectives for the Rock River east branch. It is further anticipated that the Allenton treatment facility would require a capacity expansion to accommodate probable future urban growth.

Source: SEWRPC.

Map 111

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE SLINGER SEWER SERVICE AREA
UPPER ROCK RIVER SUBREGIONAL AREA
1990



The proposed 1990 sewer service area for the Village of Slinger and environs is shown on the above map. The proposed plan includes a recommendation to provide, in addition to the current secondary level of waste treatment, advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. Such additional levels of treatment are necessary to meet the necessary water use objectives for the Rubicon River.

Source: SEWRPC.

tion of the Hartford and Pike Lake sewer service areas for sewage treatment purposes. In 1970 only the City of Hartford operated a public sanitary sewage treatment facility.

Two basic alternative plans were formulated. The first alternative assumes the construction of a new sewage treatment facility downstream from the existing Hartford facility, together with the establishment of a new treatment facility to serve the Pike Lake sewer service area. As indicated in Chapter V of this report, the existing Hartford treatment facility has reached the end of its useful life and was grossly overloaded in 1970. Both proposed new treatment facilities under this alternative would discharge effluent to the Rubicon River. The second alternative provides for a single sewage treatment facility to serve both the Hartford and Pike Lake sewer service areas, locating the single plant at the site of the proposed new Hartford sewage treatment facility. Required sewage treatment levels and performance standards under both alternatives considered are set forth in Table 196, while detailed cost estimates

Table 195

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SLINGER SEWER SERVICE AREA
UPPER ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost: Capital Construction	Present Worth (1970-2020): Construction	Present Worth (1970-2020): Operation and Maintenance	Present Worth (1970-2020): Total	Equivalent Annual (1970-2020): Construction	Equivalent Annual (1970-2020): Operation and Maintenance	Equivalent Annual (1970-2020): Total
Sewage Treatment Plant							
Slinger							
Facilities (0.67 MGD)	$1,095,000	$ 999,000	$749,000	$1,748,000	$63,400	$47,500	$110,900
Land (2.9 Acres)	14,500	10,600	--	10,600	700	--	700
Subtotal	1,109,500	1,009,600	749,000	1,758,600	64,100	47,500	111,600
Trunk Sewers--None							
Total	$1,109,500	$1,009,600	$749,000	$1,758,600	$64,100	$47,500	$111,600

Source: SEWRPC.

Table 196

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE HARTFORD AND PIKE LAKE SEWER SERVICE AREAS
UPPER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Hartford (2.65 MGD)	Hartford	9,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Pike Lake (0.31 MGD)	Pike Lake	1,000	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Hartford (2.96 MGD)	Hartford Pike Lake	10,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 112.
Source: SEWRPC.

pertaining to the two alternatives are set forth in Table 197. The two proposals are shown on Maps 112 and 113.

Under alternative plan 1, a new Hartford sewage treatment plant would be constructed on a site nearly a mile downstream from the existing treatment plant site. In order to accommodate projected future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 2.6 mgd will be required for this facility. In order to meet the established water use objectives for the Rubicon River, it will be necessary for this facility to provide not only secondary waste treatment but also advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. A new trunk sewer to convey the sewage from the old sewage treatment plant site to the new sewage treatment plant site is also included in this alternative plan. In addition, under alternative plan 1, a new sewage treatment facility would be constructed on a site adjacent to the Rubicon River near the outlet of Pike Lake to serve the Pike Lake sewer service area. This facility would need to provide a 1990 average hydraulic design capacity of about 0.31 mgd, which would accommodate an estimated 0.14 mgd of sewage from the Pike Lake State Park. In order to meet the established water use objectives for the Rubicon River, the proposed Pike Lake facility would be required to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal,

Table 197

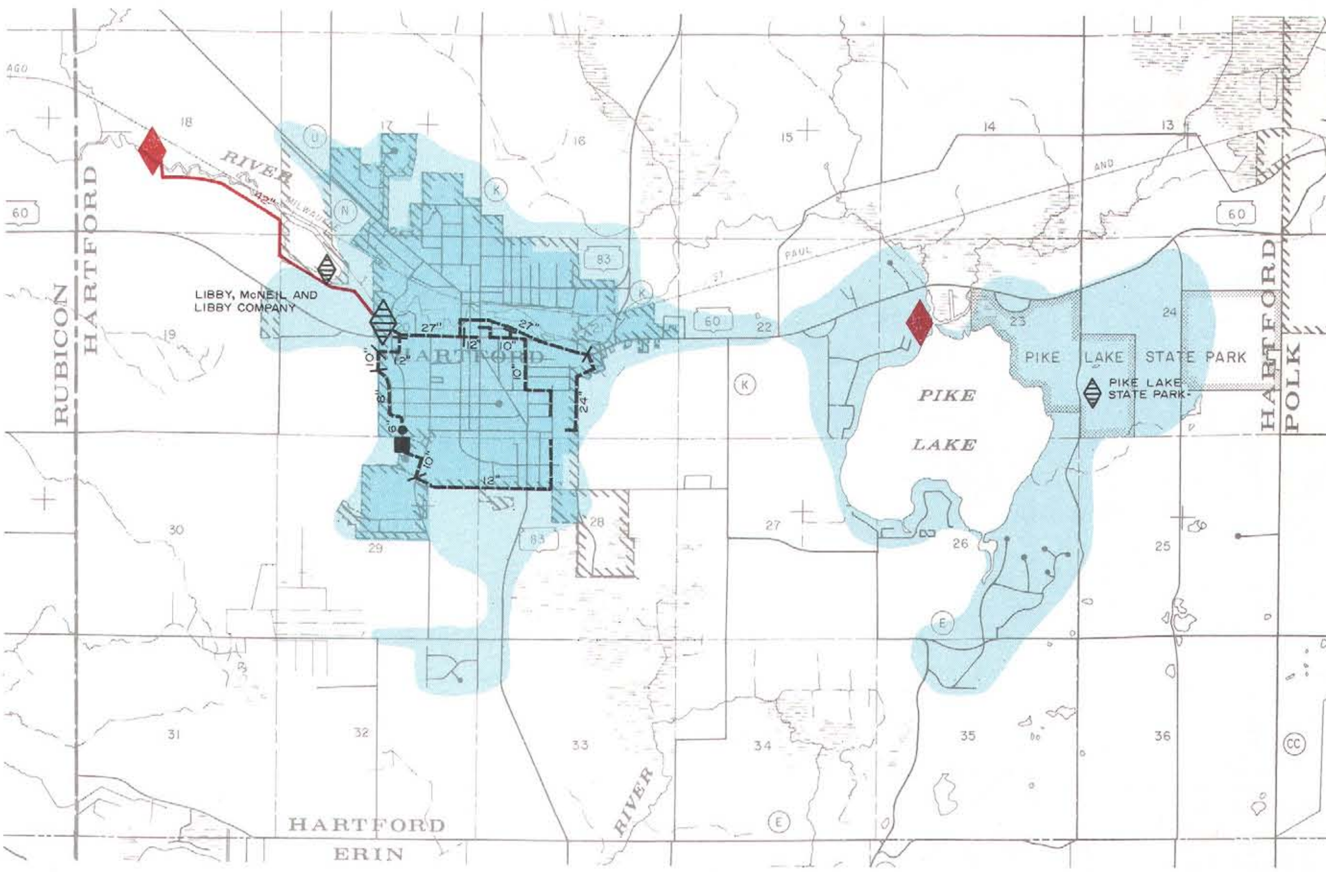
DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE HARTFORD AND PIKE LAKE SEWER SERVICE AREAS
UPPER ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plants							
Hartford							
Facilities (2.65 MGD)	$3,022,000	$2,730,000	$2,328,000	$5,058,000	$173,200	$147,700	$320,900
Land (4.7 Acres)	23,500	17,300	--	17,300	1,100	--	1,100
Subtotal	3,045,500	2,747,300	2,328,000	5,075,300	174,300	147,700	322,000
Pike Lake							
Facilities (0.31 MGD)	307,500	277,400	268,000	545,400	17,600	17,000	34,600
Land (2.50 Acre)	12,500	9,500	--	9,500	600	--	600
Subtotal	320,000	286,900	268,000	554,900	18,200	17,000	35,200
Subtotal--Sewage Treatment Facilities	3,365,500	3,034,200	2,596,000	5,630,200	192,500	164,700	357,200
Trunk Sewer							
Hartford	641,300	469,700	4,700	474,400	29,800	300	30,100
Subtotal	641,300	469,700	4,700	474,400	29,800	300	30,100
Total	$4,006,800	$3,503,900	$2,600,700	$6,104,600	$222,300	$165,000	$387,300
ALTERNATIVE PLAN 2							
Sewage Treatment Plant							
Hartford							
Facilities (2.96 MGD)	$3,318,300	$2,997,900	$2,572,400	$5,570,300	$190,200	$163,200	$353,400
Land (4.9 Acres)	24,500	17,300	--	17,300	1,100	--	1,100
Subtotal	3,342,800	3,015,200	2,572,400	5,587,600	191,300	163,200	354,500
Trunk Sewers							
Hartford	641,300	469,700	4,700	474,400	29,800	300	30,100
Pike Lake	237,700	187,600	85,200	272,800	11,900	5,400	17,300
Subtotal	879,000	657,300	89,900	747,200	41,700	5,700	47,400
Total	$4,221,800	$3,672,500	$2,662,300	$6,334,800	$233,000	$168,900	$401,900

Source: SEWRPC.

Map 112

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
FOR THE HARTFORD AND PIKE LAKE SEWER SERVICE AREAS
UPPER ROCK RIVER SUBREGIONAL AREA
1990



LEGEND

SEWER SERVICE AREAS

EXISTING 1970

PROPOSED 1990

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE ABANDONED

PROPOSED PUBLIC

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

PROPOSED TRUNK SEWER

NOTE: EXISTING TRUNK SEWER SYSTEM SHOWN IN BROKEN LINES, SEE CHAPTER V.

GRAPHIC SCALE

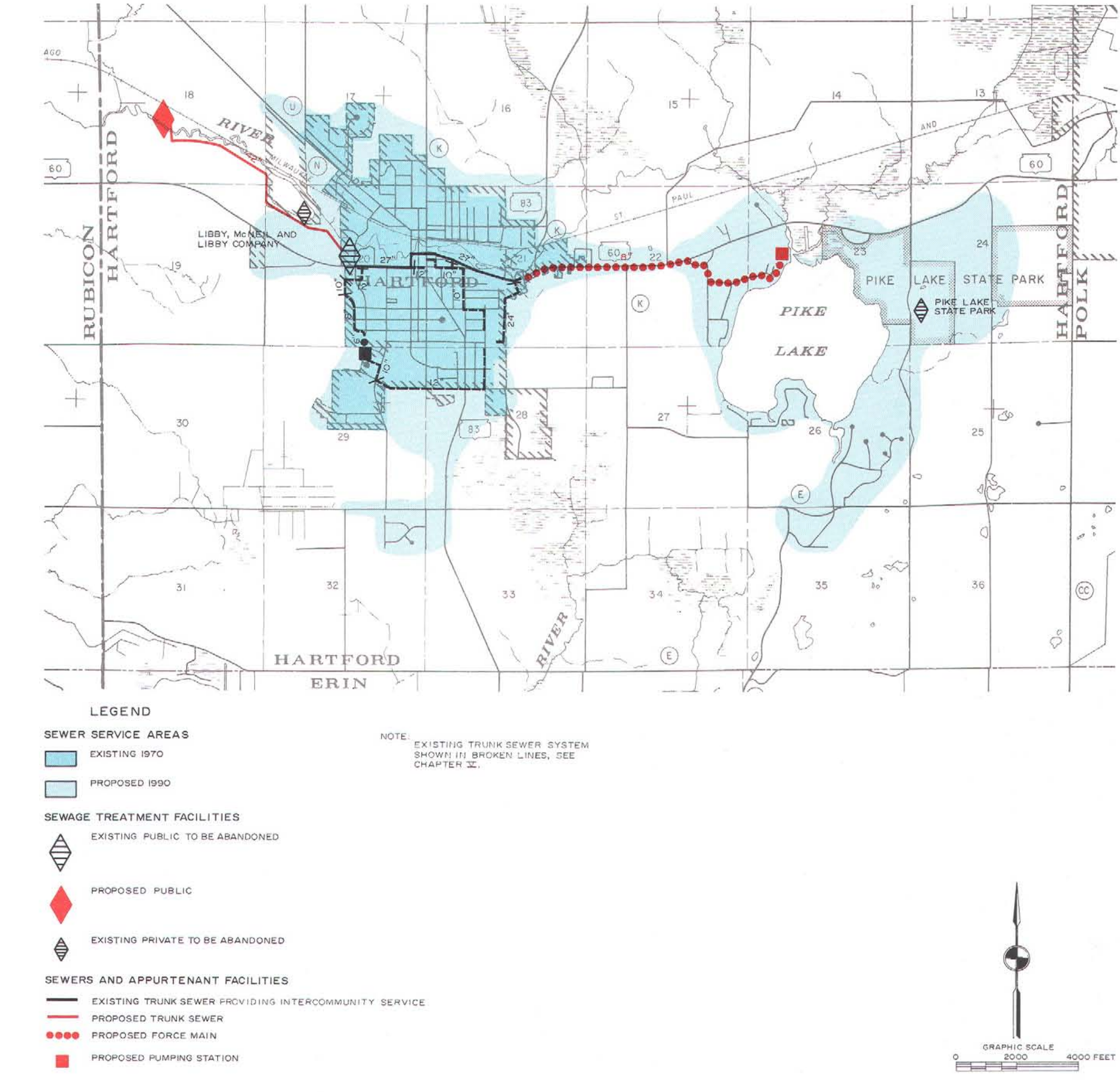
0 2000 4000 FEET

One of the alternative sanitary sewerage system plans considered for the Hartford and Pike Lake urban areas proposes the establishment of a new Pike Lake sewage treatment facility, as well as relocation of the existing Hartford sewage treatment facility to a new downstream site on the Rubicon River. Under this alternative, both the Hartford and Pike Lake treatment facilities would be required to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The existing treatment facility serving the Libby, McNeill, and Libby, Inc. canning plant in Hartford and the Pike Lake State Park would be abandoned upon implementation of this alternative plan. This alternative plan was found to be approximately as cost effective as the second alternative plan considered, shown on Map 113, but has the disadvantage of proliferating treatment facilities and requiring unnecessary duplication of staff and related facilities.

Source: SEWRPC.

Map 113

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE HARTFORD AND PIKE LAKE SEWER SERVICE AREAS
UPPER ROCK RIVER SUBREGIONAL AREA
1990



The second alternative sanitary sewerage system plan for the Hartford and Pike Lake urban areas would consolidate sewage treatment at a new Hartford sewage treatment facility located on a downstream site on the Rubicon River. As in the first alternative considered, the existing sewage treatment facility serving the Libby, McNeill, and Libby, Inc. canning plant in Hartford and the Pike Lake State Park would be abandoned upon plan implementation. The trunk sewer system necessary to convey wastes from the Pike Lake area to the new Hartford plant is shown on the above map. While this alternative is approximately as cost effective as the first alternative considered, shown on Map 112, it has the advantage of providing service through the extension of an already existing system and thus avoiding the need to establish a new system.

Source: SEWRPC.

and auxiliary waste treatment for effluent aeration and disinfection. The total estimated capital cost of carrying out alternative plan 1 for the Hartford and Pike Lake sewer service areas is about $4.0 million, with an equivalent annual cost of about $387,000.

As noted above, alternative plan 2 involves the provision of only one sewage treatment facility to serve the Hartford-Pike Lake sewer service areas. Under this alternative, a new Hartford treatment facility would be constructed on a site downstream from the existing facility as in the first alternative presented, but would provide for an average hydraulic design capacity of nearly 3.0 mgd in order to accommodate sewage from both the Hartford and Pike Lake sewer service areas. In order to meet the established water use objectives for the Rubicon River, this facility would have to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. In addition to the new trunk sewer to the new Hartford treatment plant site, included under alternative plan 1, alternative plan 2 provides for a trunk sewer from the Pike Lake sewer service area to an existing City of Hartford trunk sewer found to have sufficient capacity to handle the anticipated Pike Lake area waste flows. The total estimated capital cost of carrying out alternative plan 2 for the Hartford and Pike Lake sewer service areas, including the construction of the necessary trunk sewers, is about $4.2 million with an equivalent annual cost of about $402,000.

The costs of implementing the two alternative sanitary sewerage system plans considered for the Hartford and Pike Lake sewer service areas are within a range of about 4 percent on an equivalent annual cost basis, well within the accuracy within which such costs can be estimated. Consequently, the two plans may be considered to have approximately the same cost. It is necessary, therefore, to consider other intangible, but nevertheless very real, considerations in selecting a recommended plan from among the alternatives presented. The second alternative plan has the advantage of providing one centralized sewage treatment facility and thus avoiding proliferation of treatment plants and unnecessary duplication of staffs and related facilities, and the added advantage of not discharging any sewage treatment plant effluent to the Rubicon River above the Hartford impoundment. The second alternative has the further advantage of simply providing an extension of sanitary sewer service from an already existing system. Conversely, the first alternative presented would create another sewage treatment facility, which facility would discharge sewage effluent to the Rubicon River above the Hartford impoundment, and would necessitate the establishment of a new sanitary sewerage system with a new staff. On balance, therefore, while the two alternatives are approximately equal in terms of equivalent annual cost, the second alternative plan providing for one sewage treatment facility to serve both the Hartford and Pike Lake sewer service areas is more advantageous when other intangible considerations are taken into account.

Private Sewage Treatment Plants

Only two private sewage treatment facilities currently discharge wastes in the Upper Rock River subregional area. These facilities serve the Libby, McNeill and Libby, Inc. canning plant in the City of Hartford and the Pike Lake State Park in the Town of Hartford. Both of these facilities lie within the proposed 1990 sewer service area and would accordingly be abandoned and connected to the proposed Hartford areawide sanitary sewage treatment system. The new Hartford treatment facility under construction includes a design flow of 0.72 mgd for anticipated wastes from the Libby, McNeill and Libby, Inc. canning plant. A portion of this design flow will be detained in the existing sewage lagoons and released to the centralized sewerage system on a controlled basis. The Pike Lake State Park sewage treatment facility should be abandoned as soon as trunk sewer service around Pike Lake becomes available.

MIDDLE ROCK RIVER SUBREGIONAL AREA

The Middle Rock River subregional area consists of all that area of the Rock River watershed in Waukesha County. This portion of the Rock River watershed is comprised of all or portions of several subwatersheds, including the Oconomowoc River subwatershed, the Ashippun River subwatershed, the Bark River subwatershed, and the Scuppernong Creek subwatershed. A large portion of the Middle Rock River subregional area consists of existing and proposed Kettle Moraine State Forest Lands. To the north of the State Forest lands lies the rapidly urbanizing inland lakes area of western Waukesha County. Major concentrations of urban development are found in the Cities of Delafield and Oconomowoc and the Villages of Chenequa, Hartland, Dousman, Lac

LaBelle, Merton, Nashotah, and Wales. Urban development contiguous to the Village of Lac LaBelle in the Town of Ixonia, Jefferson County, outside of the Region, has also been included for sewerage system planning purposes in the Middle Rock River subregional area.

As noted in Chapter V of this report, centralized sanitary sewer service in the Middle Rock River subregional area was provided by three systems in 1970: those operated by the City of Oconomowoc and the Villages of Hartland and Dousman. The service areas of these three systems together comprised an area of about 3.3 square miles and served an estimated population of about 13,000 persons. In 1970 there were about 22,900 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the three existing systems are presented in Chapter V of this report.

Sewer Service Analysis Areas

A total of 13 sewer service analysis areas may be identified within the Middle Rock River subregional area (see Table 198). These 13 sewer service analysis areas are shown on Map 114 and may be described as follows:

1. Area A—This area consists of the City of Oconomowoc, the Village of Lac LaBelle, and contiguous urban development in the Towns of Oconomowoc and Summit in Waukesha County and in the Town of Ixonia outside of the Region in Jefferson County. In 1970, sanitary sewer service was provided in this area to a total area of about 2.1 square miles, having a total resident population of about 9,500 persons. By 1990 the total area anticipated to be served approximates 7.4 square miles, with a projected population of about 21,000 persons. This subarea is referenced as the "Oconomowoc-Lac LaBelle" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Village of Oconomowoc Lake, which encompasses all of the urban development along the shoreline of Oconomowoc Lake, and contiguous urban development in the Town of Summit. About 500 persons resided in this area in 1970, but no sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.9 square miles, with a projected population of about 600 persons. This subarea is referenced as the "Oconomowoc Lake" sewer service area in the ensuing discussion.

3. Area C—This area consists of the contiguous urban development along the shoreline of Okauchee Lake in the Towns of Ocono-

Table 198

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS
IN THE MIDDLE ROCK RIVER SUBREGIONAL AREA
1970 and 1990

Sewer Service Analysis Area[1]		Existing 1970				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Oconomowoc-Lac LaBelle	2.14	9,500	1.62	1,600	7.42	21,000	4.41
B	Oconomowoc Lake	--	--	--	500	1.91	600	0.13
C	Okauchee Lake	--	--	--	4,200	2.92	4,400	0.92
D	North Lake	--	--	--	700	1.19	1,100	0.23
E	Pine Lake	--	--	--	400	1.59	400	0.09
F	Beaver Lake	--	--	--	800	1.77	1,200	0.25
G	Hartland	0.81	2,900	0.27	300	2.56	9,300	1.95
H	Merton	--	--	--	600	0.73	1,700	0.38
I	Delafield-Nashotah	--	--	--	3,300	5.82	7,300	1.53
J	Nashotah-Nemahbin Lakes	--	--	--	1,500	1.49	1,500	0.32
K	Silver Lake	--	--	--	400	0.51	600	0.13
L	Dousman	0.36	600	0.08	100	0.77	2,200	0.46
M	Wales	--	--	--	900	1.29	1,100	0.23
	Total	3.31	13,000	1.97	15,300	29.97	52,400	11.03

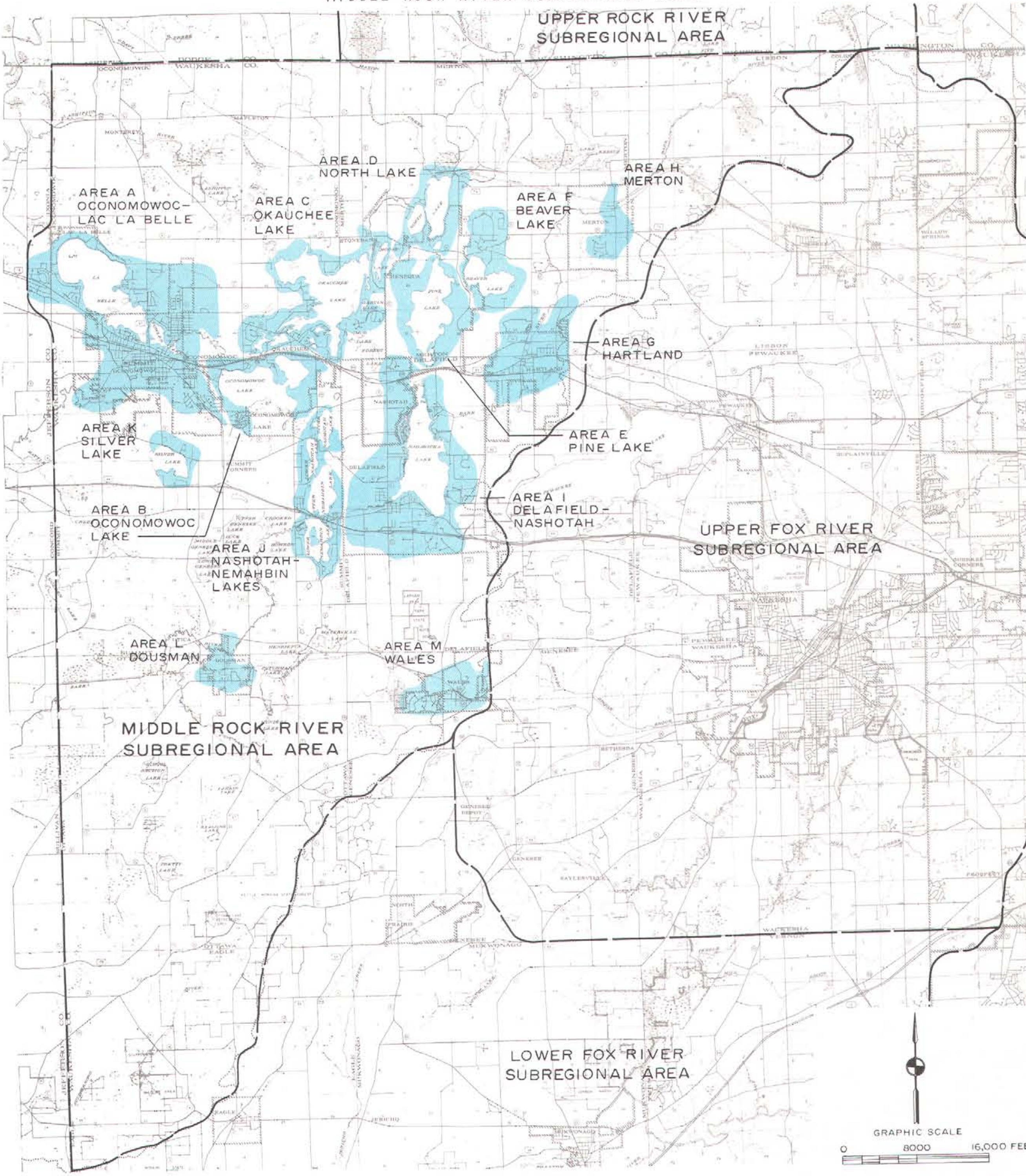
[1]*See Map 114.*

Source: SEWRPC.

Map 114

SEWER SERVICE ANALYSIS AREAS

MIDDLE ROCK RIVER SUBREGIONAL AREA



A total of 13 individual sewer service analysis areas were identified within the Middle Rock River subregional area. These 13 areas include the Cities of Delafield and Oconomowoc and environs and existing urban development located in the small villages and unincorporated communities found along the shorelines of the many lakes in this portion of the Rock River watershed. In 1970 there were 36,000 persons residing in the subregional area, of which an estimated 13,000 were served by centralized sanitary sewers and about 23,000 by onsite septic tank sewage disposal systems. By 1990 it is anticipated that about 52,000 persons residing in the Middle Rock River watershed will be served with centralized sanitary sewer service.

Source: SEWRPC.

mowoc and Merton. About 4,200 persons resided in this area in 1970, but no sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 2.9 square miles, with a projected population of about 4,400 persons. This subarea is referenced as the "Okauchee Lake" sewer service area in the ensuing discussion.

4. Area D—This area consists of the contiguous urban development along the shoreline of North Lake in the Village of Chenequa and the Town of Merton. About 700 persons resided in this area in 1970, but no sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.2 square miles, with a projected population of about 1,100 persons. This subarea is referenced as the "North Lake" sewer service area in the ensuing discussion.

5. Area E—This area includes all of the estate-type residential development along the shoreline of Pine Lake in the Village of Chenequa. About 400 persons resided in this area in 1970, but no sanitary sewer service was provided in this area in 1970, nor is it likely that centralized sanitary sewer service will be required in this area by 1990 because of the extremely low-density character of the existing development. This area has been included as a sewer service area for sewerage system planning analysis purposes, however, because it lies within a larger area for which centralized sanitary sewer service will likely be required. Sound long-range system planning requires, therefore, that this area be included in the alternative plans even though it may well be unnecessary to provide for the local trunk sewers to serve the Pine Lake development within the 20-year plan design period. This subarea is referenced as the "Pine Lake" sewer service area in the ensuing discussion.

6. Area F—This area consists of the urban development along and adjacent to the shoreline of Beaver Lake in the Village of Chenequa and the Town of Merton. About 800 persons resided in this area in 1970, but no sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.8 square miles, with a projected population of about 1,200 persons. This subarea is referenced as the "Beaver Lake" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Hartland and contiguous urban development in the Towns of Merton and Delafield. In 1970, sanitary sewer service was provided in this area to about 0.8 square mile, having a total resident population of about 2,900 persons. By 1990 the total area anticipated to be served approximates 2.6 square miles, with a projected population of about 9,300 persons. This subarea is referenced as the "Hartland" sewer service area in the ensuing discussion.

8. Area H—This area consists of the Village of Merton and environs. About 600 persons resided in this area in 1970 but no sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sewer service approximates 0.7 square mile, with a projected population of about 1,700 persons. This subarea is referenced as the "Merton" sewer service area in the ensuing discussion.

9. Area I—This area consists of the City of Delafield and the Village of Nashotah, which together encompass Nagawicka Lake. About 3,300 persons resided in this area in 1970, but no sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 5.8 square miles, with a projected population of about 7,300 persons. This subarea is referenced as the "Delafield-Nashotah" sewer service area in the ensuing discussion.

10. Area J—This area consists of the urban development along the shorelines of Upper and Lower Nashotah Lakes and Upper and Lower Nemahbin Lakes in the Town of Summit. About 1,500 persons resided in this area in 1970, but no sanitary sewer service was provided. By 1990 the total

area anticipated to be served approximates 1.5 square miles, with a projected population of about 1,500 persons. This subarea is referenced as the "Nashotah-Nemahbin Lakes" sewer service area in the ensuing discussion.

11. Area K—This area consists of urban development along the shoreline of Silver Lake in the Town of Summit. About 400 persons resided in this area in 1970, but no sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 0.5 square mile, with a projected population of about 600 persons. This subarea is referenced as the "Silver Lake" sewer service area in the ensuing discussion.

12. Area L—This area includes the Village of Dousman and environs. In 1970, sanitary sewer service was provided in this area to about 0.4 square mile, having a total resident population of about 600 persons. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 0.8 square mile, with a projected population of about 2,200 persons. This subarea is referenced as the "Dousman" sewer service area in the ensuing discussion.

13. Area M—This area consists of the Village of Wales and environs. About 900 persons resided in this area in 1970, but no sanitary sewer service was provided. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 1.3 square miles, with a projected population of about 1,100 persons. This subarea is referenced as the "Wales" sewer service area in the ensuing discussion.

Formulation of Alternatives

As discussed earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system planning program for the formulation of alternative plans. The first step in this process was to apply the Wisconsin Department of Natural Resources (DNR) guidelines relating distances between communities to the populations of both the "sending" and "receiving" communities in order to determine if potential interconnections between sanitary sewerage systems should be investigated. The results of the application of these criteria to the communities within the Middle Rock River subregional sewerage system planning area are summarized in Table 199.

The DNR guidelines were designed to be applied to noncontiguous communities. In the Middle Rock River subregional area, all but three of the 13 sewer service analysis areas—Merton, Dousman, and Wales—are essentially contiguous. It was

Table 199

RESULTS OF THE APPLICATION OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES INTERCONNECTION GUIDELINES AND PRELIMINARY ECONOMIC ANALYSES IN THE MIDDLE ROCK RIVER SUBREGIONAL AREA

Sewer Service Analysis Area(s)				Results of Application of DNR Guidelines		Results of Preliminary Economic Analysis			
Receiving		Sending				Total Equivalent Annual Cost			
Name	Estimated 1990 Population	Name	Estimated 1990 Population	Straight Line Distance Between Sewer Service Areas (Miles)	Proceed to Preliminary Economic Analysis (Yes or No)	Separate Plants (A)	Interconnection-One Plant (B)	Percent Difference (B-A)/(A)	Proceed to Detailed Economic Analysis[1] (Yes or No)
Delafield-Nashotah	7,300	Dousman Wales	2,200 1,100	4.8 4.2	No No	$ -- --	$ -- --	-- --	-- --
Hartland	9,300	Merton	1,700	3.5	Yes	143,100	214,400	49.8	No
Dousman	2,200	Delafield-Nashotah Wales	7,300 1,100	4.8 4.2	No No	-- --	-- --	-- --	-- --

[1]If the estimated equivalent annual cost of interconnection was no more than 20 percent greater than the cost of providing separate sewage treatment facilities, a detailed economic analysis was deemed to be required.

Source: SEWRPC.

assumed with respect to these 10 sewer service analysis areas, therefore, that contiguity would require detailed economic analyses of interconnection potential. Accordingly, the analyses presented in Table 199 apply only to the three noncontiguous communities. Based on the DNR guidelines, the following interconnections between sewer service areas in the Middle Rock River subregional area were eliminated from further consideration:

1. Dousman to Delafield
2. Wales to Delafield
3. Delafield to Dousman
4. Wales to Dousman

One interconnection—Merton to Hartland—was found to be potentially feasible through the application of the DNR guidelines. The conduct of a preliminary economic analysis for this potential interconnection, however, revealed that a detailed economic analysis was not warranted. Accordingly, this potential connection was also eliminated from further consideration.

Based upon the results of the foregoing preliminary analyses, it was determined that the following sanitary sewerage system plans for the Middle Rock River subregional area should be prepared and evaluated:

1. A proposed plan for the Merton sewer service area.
2. A proposed plan for the Wales sewer service area.
3. A proposed plan for the Dousman sewer service area.
4. Three alternative plans for the Oconomowoc-Lac LaBelle, Oconomowoc Lake, Okauchee Lake, Pine Lake, Silver Lake, North Lake, Beaver Lake, Hartland, Delafield–Nashotah, and Nashotah–Nemahbin Lakes sewer service areas, referred to hereinafter as the Oconomowoc-Delafield subarea. Conceptually, one of these three alternatives would be based upon the construction of individual sewage treatment facilities serving each sewer service analysis area; one upon the construction of two centralized sewage treatment facilities to serve the areas; and one upon the construction of one centralized sewage treatment facility to serve the areas.

Each of the sanitary sewerage system plan elements is described in the following paragraphs. Data pertaining to required treatment levels at each of the municipal sewage treatment plant sites considered in these plan elements are presented in Table 200.

Proposed Plan—Merton Subarea

As noted above, no centralized sanitary sewer service was provided in the Merton sewer service area in 1970. The proposed plan for this area includes the construction of a new sewage treatment plant having a 1990 average hydraulic design capacity of 0.38 mgd. It is proposed that this facility discharge its effluent to the Bark River. For cost analysis purposes it was assumed that an aerated lagoon type sewage treatment plant would be provided. In order to meet the established water use objectives for the Bark River, this facility would have to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The specific performance standards recommended for this facility are set forth in Table 201.

The estimated capital cost of constructing the necessary treatment facility at Merton is about $288,000, with an equivalent annual cost of about $30,000 (see Table 202). The proposed 1990 service area for the Village of Merton and environs is shown on Map 115.

Proposed Plan—Wales Subarea

Also as noted earlier, no centralized sanitary sewer service was provided in the Wales sewer service area in 1970. The proposed plan for this area includes the construction of a new sewage treatment plant having a 1990 average hydraulic design capacity of 0.23 mgd. It is proposed that this facility discharge its effluent to the Scuppernong Creek. For cost analysis purposes it was assumed that an aerated lagoon type sewage treatment plant would be provided. In order to meet the established water use objectives for Scuppernong Creek, this facility would have to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The

Table 200

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE MIDDLE ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Water Body	Stream Low Flow and Dilution Ratio Data: 7-Day, 10-Year Low Flow		Upstream Sewage Treatment Plant Flow-1990		Total Design Low Flow-1990		Total Design Sewage Flow-1990		Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Level of Treatment Required	Advanced		Auxiliary	
		CFS	MGD	CFS	MGD	CFS	MGD	CFS	MGD		Secondary	Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Oconomowoc[1]	Oconomowoc River	0.84	0.54	2.11	1.36	2.95	1.90	6.83	4.41	0.43	Yes	Yes	Yes	Yes	Yes
Oconomowoc[2]	Oconomowoc River	0.84	0.54	--	--	0.84	0.54	9.54	6.16	0.09	Yes	Yes	Yes	Yes	Yes
Oconomowoc[3]	Oconomowoc River	0.84	0.54	--	--	0.84	0.54	15.42	9.96	0.05	Yes	Yes	Yes	Yes	Yes
Delafield[1]	Bark River	0.41	0.27	3.99	2.58	4.40	2.85	2.86	1.85	1.54	Yes	Yes	Yes	Yes	Yes
Delafield[2]	Bark River	0.41	0.27	0.96	0.62	1.37	0.89	5.88	3.80	0.23	Yes	Yes	Yes	Yes	Yes
Hartland[1]	Bark River	0.27	0.17	0.98	0.63	1.25	0.80	3.02	1.95	0.41	Yes	Yes	Yes	Yes	Yes
Oconomowoc Lake[1]	Oconomowoc River	0.68	0.44	0.36	0.23	1.04	0.67	1.76	1.14	0.59	Yes	Yes	Yes	Yes	Yes
Merton	Bark River	0.19	0.12	--	--	0.19	0.12	0.59	0.38	0.32	Yes	Yes	Yes	Yes	Yes
Dousman[4]	Bark River	0.54	0.35	6.47	4.18	7.01	4.72	0.71	0.46	9.87	Yes	No	No	Yes	Yes
Beaver Lake[1]	Bark River	0.24	0.16	0.59	0.38	0.83	0.54	0.39	0.25	2.13	Yes	Yes	Yes	Yes	Yes
Wales	Scuppernong Creek	0.04	0.03	--	--	0.04	0.03	0.36	0.23	0.11	Yes	No	Yes	Yes	Yes
North Lake[1]	Oconomowoc River	0.52	0.34	--	--	0.52	0.34	0.36	0.23	1.44	Yes	No	Yes	Yes	Yes
Silver Lake[1]	Minor Tributary to Oconomowoc River	0.00	0.00	--	--	0.00	0.00	0.20	0.13	0.00	Yes	No	Yes	Yes	Yes

[1]Corresponds to Oconomowoc-Delafield area alternative plan 1.
[2]Corresponds to Oconomowoc-Delafield area alternative plan 2.
[3]Corresponds to Oconomowoc-Delafield area alternative plan 3.
[4]Assumes ultimate implementation of Oconomowoc-Delafield alternative plan 2.

Source: SEWRPC.

Table 201

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MERTON SEWER SERVICE AREA MIDDLE ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Merton (0.38 MGD)	Merton	1,700	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 115.

Source: SEWRPC.

Table 202

DETAILED COST ESTIMATES PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MERTON SEWER SERVICE AREA MIDDLE ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost: Capital Construction	Present Worth (1970-2020): Construction	Present Worth: Operation and Maintenance	Present Worth: Total	Equivalent Annual (1970-2020): Construction	Equivalent Annual: Operation and Maintenance	Equivalent Annual: Total
Sewage Treatment Plant							
Merton							
Facilities (0.38 MGD)	$228,000	$207,000	$225,000	$432,000	$13,100	$14,300	$27,400
Land (12 Acres)	60,000	44,200	--	44,200	2,800	--	2,800
Subtotal	288,000	251,200	225,000	476,200	15,900	14,300	30,200
Trunk Sewers--None							
Total	$288,000	$251,200	$225,000	$476,200	$15,900	$14,300	$30,200

Source: SEWRPC.

specific performance standards recommended for this facility are set forth in Table 203.

The estimated capital cost of constructing the proposed Wales treatment facility is about $197,000, with an equivalent annual cost of about $21,400 (see Table 204). The proposed 1990 service area for the Village of Wales and environs is shown on Map 116.

Proposed Plan—Dousman Subarea

In 1970 the sewage treatment facility serving the Dousman sewer service area had an average hydraulic design capacity of 0.12 mgd and provided a secondary level of waste treatment. Disposal of effluent is to the Bark River. In order to accommodate probable future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 0.46 mgd will be required for this facility. In order to meet the established water use objectives for the Bark River, it will be necessary for this facility to provide, in addition to the current secondary level of waste treatment, auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Dousman sewage treatment plant are set forth in Table 205.

The estimated capital cost of constructing the necessary treatment facilities at Dousman is about $565,000, with an equivalent annual cost of about $48,700 (see Table 206). The proposed 1990 service area for the Village of Dousman and environs is shown on Map 117.

Table 203

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WALES SEWER SERVICE AREA
MIDDLE ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Wales (0.23 MGD)	Wales	1,100	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 116.

Source: SEWRPC.

Table 204

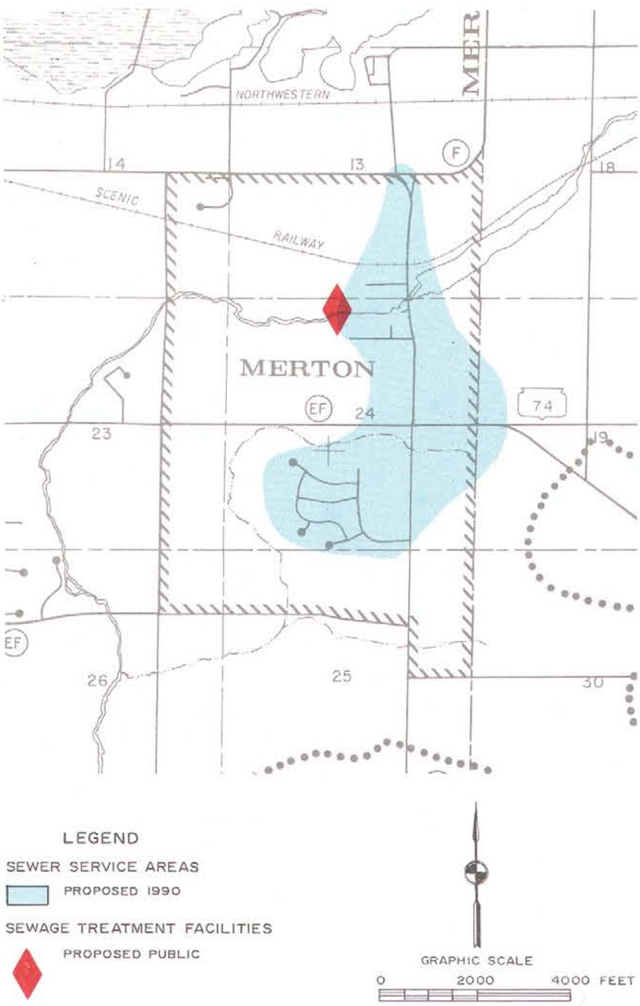
DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WALES SEWER SERVICE AREA
MIDDLE ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Wales							
Facilities (0.21 MGD)	$152,000	$137,000	$167,000	$304,000	$ 8,700	$10,600	$19,300
Land (9.0 Acres)	45,000	33,100	--	33,100	2,100	--	2,100
Subtotal	197,000	170,100	167,000	337,100	10,800	10,600	21,400
Trunk Sewers--None							
Total	$197,000	$170,100	$167,000	$337,100	$10,800	$10,600	$21,400

Source: SEWRPC.

Map 115

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE MERTON SEWER SERVICE AREA
MIDDLE ROCK RIVER SUBREGIONAL AREA
1990



Because the areas of potential growth surrounding the developed areas of the Village of Merton are generally covered by soils having severe and very severe limitations for the use of septic tank sewage disposal systems, it may become necessary to provide the Village of Merton and environs with a centralized sanitary sewerage system before 1990, the design year of the plan. The provision of sewer service would become necessary, however, only if the Village grows faster than envisioned in the regional land use plan or if a serious public health hazard should develop through the malfunctioning of the septic tank systems now serving the Village. The above map illustrates one way of providing such a system. Under this proposal an individual sewage treatment plant to serve the Village of Merton would be constructed, discharging effluent either to the groundwater reservoir or to the Bark River. In the latter case, the facility would have to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection so that the established water use objectives for the Bark River would be met. Depending upon the rate and direction of future urban development in the Merton area, it may also be feasible to extend the proposed Delafield-Hartland areawide sewerage system to serve the Merton area. At such time as it is deemed necessary to provide centralized sanitary sewer service, therefore, it is recommended that consideration be given to connecting the Village to the Delafield-Hartland system in lieu of the establishment of a separate sewage treatment facility.

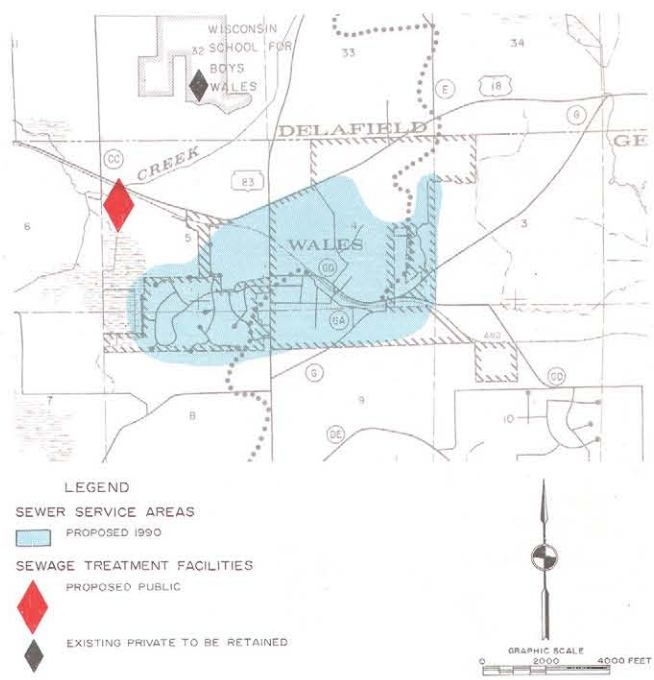
Source: SEWRPC.

Alternative Plans—Oconomowoc-Delafield Subarea

As indicated above, 10 of the 13 identified sewer service analysis areas in the Middle Rock River subregional area were considered for planning purposes to be contiguous and subject, therefore, to alternative investigations with respect to the provision of sewage treatment facilities. Of the many alternative interconnections possible, three were selected as reasonable alternatives considering the existing centralized sanitary sewer

Map 116

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WALES SEWER SERVICE AREA
MIDDLE ROCK RIVER SUBREGIONAL AREA
1990



Currently the Village of Wales and environs rely on private septic tank sewage disposal systems for the treatment and disposal of sewage. Historic growth trends, however, indicate that it may be necessary to establish a centralized sanitary sewerage system in the near future. The above map shows a proposed service area for such a system and a location for a sewage treatment facility, which would discharge effluent to Scuppernong Creek. Should it be deemed necessary to provide for centralized sanitary sewer service and establish such a treatment facility, the plant would have to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection if the established water use objectives for Scuppernong Creek are to be met.

Source: SEWRPC.

service in the subregional area, natural watershed boundaries, topography, and identifiable communities of interest. The first alternative plan considered would provide for seven individual sewage treatment facilities to serve the 10 identified sewer service analysis areas. The second alternative would provide for two centralized sewage treatment facilities to serve the same 10 areas. Finally, the third alternative would provide complete centralization at one sewage treatment facility.

Alternative Plan 1: The first alternative sanitary sewerage system plan provides for seven individual sewage treatment facilities to serve the 10 identified sewer service analysis areas deemed to be contiguous for system planning purposes. Under this alternative, sewage treatment facilities would be expanded or constructed as follows:

1. A new sewage treatment plant to serve the Oconomowoc-Lac LaBelle sewer service area would be constructed at a site adjacent to the existing City of Oconomowoc trickling filter-type sewage treatment plant, which plant would be abandoned, having reached the end of its useful life. Effluent from the new plant would be discharged to the Oconomowoc River. This sewage treatment facility would have a 1990 average hydraulic design capacity of 4.4 mgd and, in order to meet the established water use objectives for the Oconomowoc River, would provide secondary waste treatment,

Table 205

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE DOUSMAN SEWER SERVICE AREA
MIDDLE ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Dousman (0.46 MGD)	Dousman	2,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 117.
Source: SEWRPC.

Table 206

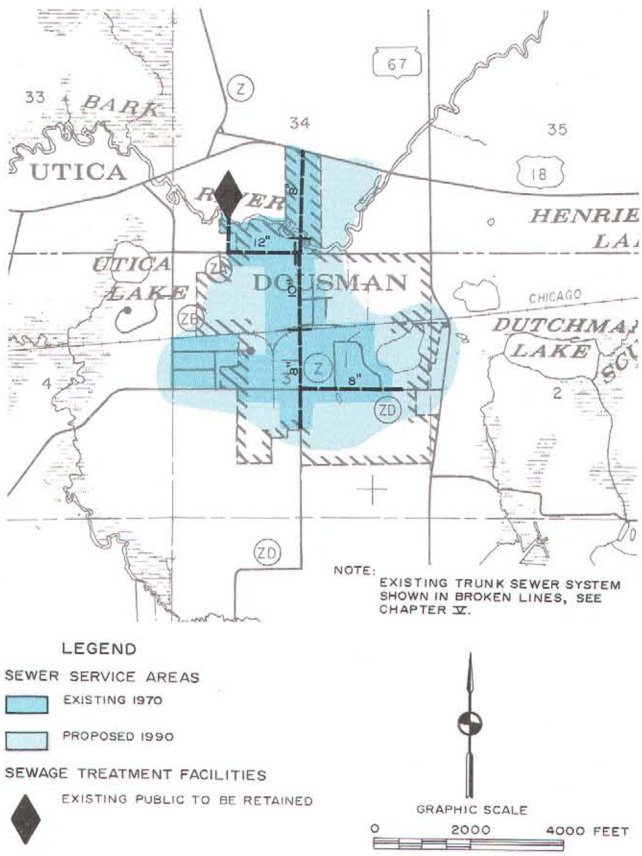
DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE DOUSMAN SEWER SERVICE AREA
MIDDLE ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Dousman							
Facilities (0.38 MGD)	$552,400	$498,100	$260,100	$758,200	$31,600	$16,500	$48,100
Land (2.6 Acres)	13,000	9,500	--	9,500	600	--	600
Subtotal	565,400	507,600	260,100	767,700	32,200	16,500	48,700
Trunk Sewers--None							
Total	$565,400	$507,600	$260,100	$767,700	$32,200	$16,500	$48,700

Source: SEWRPC.

Map 117

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE DOUSMAN SEWER SERVICE AREA
MIDDLE ROCK RIVER SUBREGIONAL AREA
1990



The sewerage system plan proposes the expansion of the existing Dousman sewage treatment facility to meet anticipated urban growth by 1990. In order to meet the water use objectives for the Bark River, it will be necessary for the Dousman facility to provide, in addition to the current secondary level of waste treatment, auxiliary waste treatment for effluent aeration and disinfection.

Source: SEWRPC.

advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection.

2. A new sewage treatment plant would be constructed near the outlet of Oconomowoc Lake and would provide for sewage generated in the Oconomowoc Lake, Okauchee Lake, and Pine Lake sewer service areas. Effluent from the new plant would be discharged to the Oconomowoc River. This sewage treatment facility would have a 1990 average hydraulic design capacity of 1.14 mgd and, in order to meet the established water use objectives for the Oconomowoc River, would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection.

3. A new sewage treatment plant would be constructed northwest of Silver Lake and would serve the Silver Lake sewer service area. Effluent from the new plant would be discharged to an unnamed tributary of the Oconomowoc River. This sewage treatment facility would have a 1990 average hydraulic design capacity of 0.13 mgd and, in order to meet the established water use objectives for the Oconomowoc River, would provide secondary waste treatment and auxiliary waste treatment for effluent aeration and disinfection. For cost analysis purposes, it was assumed that an aerated lagoon type of sewage treatment facility would be provided at this location.

4. A new sewage treatment plant would be constructed west of North Lake to serve the North Lake sewer service area. Effluent from this new plant would be discharged to the Oconomowoc River. This sewage treatment facility would have a 1990 average hydraulic design capacity of 0.23 mgd and, in order to meet the established water use objectives for the Oconomowoc River, would provide secondary waste treatment and auxiliary waste treatment for effluent aeration and disinfection. For cost analysis purposes, it was assumed that an aerated lagoon type of sewage treatment facility would be provided at this location.

5. A new sewage treatment plant would be constructed southeast of Beaver Lake and would serve the Beaver Lake sewer service area. Effluent from the new plant would be discharged to the Bark River. This sewage treatment facility would have a 1990 average hydraulic design capacity of 0.25 mgd and, in order to meet the established water use objectives for the

Bark River, would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. For cost analysis purposes it was assumed that this facility would also be an aerated lagoon type.

6. A new sewage treatment plant to serve the Hartland sewer service area would be constructed on the site of the existing Village of Hartland sewage treatment plant. Since the existing plant has less than one-third of the required 1990 average hydraulic design capacity, it was assumed for cost analysis purposes that an essentially new plant would be constructed to replace the existing plant. Effluent from the new plant would be discharged to the Bark River. This sewage treatment facility would have a 1990 average hydraulic design capacity of 1.95 mgd and, in order to meet the established water use objectives for the Bark River, would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection.

7. A new sewage treatment plant would be constructed at the western limits of the City of Delafield to serve the Delafield-Nashotah and Nashotah-Nemahbin Lakes sewer service areas. Effluent from the new plant would be discharged to the Bark River at a downstream point in the Town of Summit through an outfall sewer. This sewage treatment facility would have a 1990 average hydraulic design capacity of 1.85 mgd and, in order to meet the established water use objectives for the Bark River, would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection.

The location of each sewage treatment plant, together with its proposed 1990 service area, is shown on Map 118. Required sewage treatment levels and performance standards for each sewage treatment facility are set forth in Table 207.

In addition to the foregoing sewage treatment facilities, five intercommunity trunk sewers have been included in this alternative plan in order to provide for sewer service between municipalities within the same sewer service area or to interconnect sewer service areas. Two of the five intercommunity trunk sewers included as part of this alternative plan element provide for the extension of sewer service within the Oconomowoc-Lac LaBelle sewer service area. The third intercommunity trunk sewer provides for the interconnection of the Oconomowoc Lake, Okauchee Lake, and Pine Lake sewer service areas. The fourth intercommunity trunk sewer provides for sewer service within the Delafield-Nashotah sewer service area. Finally, the fifth intercommunity trunk sewer provides for interconnection of the Delafield-Nashotah and the Nashotah-Nemahbin Lakes sewer service areas. The location of these five intercommunity trunk sewers is shown on Map 118.

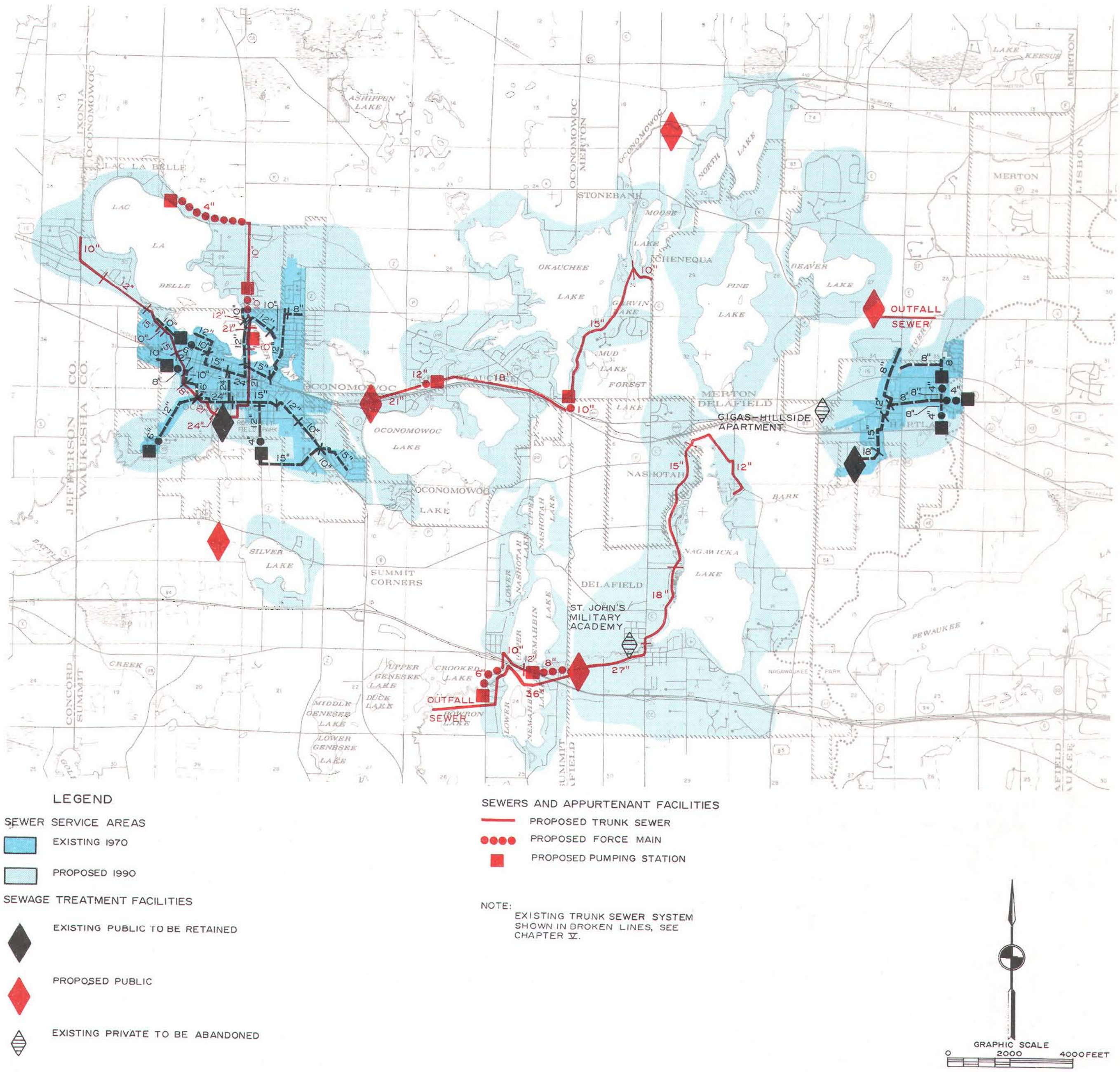
The total estimated capital cost of carrying out alternative plan 1 for the Oconomowoc-Delafield subarea is about \$16.7 million, with an equivalent annual cost of about \$1.4 million. Detailed cost estimates for this alternative plan are presented in Table 208.

Alternative Plan 2: The second alternative sanitary sewerage system plan considered for the Oconomowoc-Delafield subarea would provide for two sewage treatment facilities to serve the 10 identified contiguous sewer service analysis areas within the Middle Rock River subregional area. Under this alternative, sewage treatment facilities would be expanded or constructed as follows:

1. A new sewage treatment plant to serve the Oconomowoc-Lac LaBelle, Oconomowoc Lake, Okauchee Lake, Pine Lake, Beaver Lake, North Lake, and Silver Lake sewer service areas would be constructed at a site adjacent to the existing City of Oconomowoc trickling filter-type sewage treatment plant, which plant having reached the end of its useful life would be abandoned. Effluent from the new plant would be discharged to the Oconomowoc River. This sewage treatment facility would have a 1990 average hydraulic design capacity of 6.16 mgd and, in order to meet the established water use objectives for the Oconomowoc River, would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection.

Map 118

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
FOR THE OCONOMOWOC-DELAFIELD SUBAREA
MIDDLE ROCK RIVER SUBREGIONAL AREA
1990



One alternative sanitary sewerage system plan for the Oconomowoc-Delafield subarea is illustrated on the above map. This alternative would provide for seven individual sewage treatment facilities to serve the 10 identified sewer service analysis areas. Necessary trunk sewers to provide for intercommunity sewer service under this alternative are also shown on the map. While this alternative was found to be slightly less costly than the other two alternatives considered, implementation of this alternative would ignore the effects of a potential long-term accumulation of residual nutrients in the downstream lakes, as well as the potential problems created when water quality management responsibility is diffused among many individual communities.

Source: SEWRPC.

Table 207

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE OCONOMOWOC-DELAFIELD SUBAREA
MIDDLE ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Oconomowoc (4.41 MGD)	Oconomowoc-Lac LaBelle	21,000	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Oconomowoc Lake (1.14 MGD)	Oconomowoc Lake Okauchee Lake Pine Lake	5,400	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Silver Lake (0.13 MGD)	Silver Lake	600	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
North Lake (0.23 MGD)	North Lake	1,100	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Beaver Lake (0.25 MGD)	Beaver Lake	1,200	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration 200/100 ml
Hartland (1.95 MGD)	Hartland	9,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Delafield (1.85 MGD)	Delafield-Nashotah Nashotah-Nemahbin Lakes	8,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Oconomowoc (6.16 MGD)	Oconomowoc-Lac LaBelle Oconomowoc Lake Okauchee Lake North Lake Pine Lake Beaver Lake Silver Lake	29,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Delafield (3.80 MGD)	Hartland Delafield-Nashotah Nashotah-Nemahbin Lakes	18,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 3					
Oconomowoc (9.96 MGD)	Oconomowoc-Lac LaBelle Oconomowoc Lake Okauchee Lake North Lake Pine Lake Beaver Lake Hartland Delafield-Nashotah Nashotah-Nemahbin Lakes Silver Lake	47,400	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1] *See Map 117.*

Source: SEWRPC.

2. A new sewage treatment plant to serve the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes sewer service areas would be constructed at a site downstream from the Crooked Lake outlet in the Town of Summit. Effluent from the new plant would be discharged to the Bark River. The existing Village of Hartland sewage treatment plant would be abandoned under this alternative. This sewage treatment facility would have a 1990 average hydraulic design capacity of 3.80 mgd and, in order to meet the established water use objectives for the Bark River, would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection.

The location of both sewage treatment facilities, together with proposed 1990 sewer service areas, is shown on Map 119. The required sewage treatment levels and performance standards for each plant are set forth in Table 207.

Table 208

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE OCONOMOWOC-DELAFIELD SUBAREA
MIDDLE ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plants							
Oconomowoc							
Facilities (4.41 MGD)	$ 4,400,000	$ 3,970,000	$3,170,000	$ 7,140,000	$ 252,000	$201,500	$ 453,500
Land (5.8 Acres)	29,000	20,500	--	20,500	1,300	--	1,300
Subtotal	4,429,000	3,990,500	3,170,000	7,160,500	253,300	201,500	454,800
Oconomowoc Lake							
Facilities (1.14 MGD)	1,575,000	1,420,000	1,330,000	2,750,000	90,200	84,300	174,500
Land (3.5 Acres)	17,500	12,600	--	12,600	800	--	800
Subtotal	1,592,500	1,432,600	1,330,000	2,762,600	91,000	84,300	175,300
Silver Lake							
Facilities (0.13 MGD)	65,000	58,400	61,500	119,900	3,700	3,900	7,600
Land (7.2 Acres)	36,000	26,800	--	26,800	1,700	--	1,700
Subtotal	101,000	85,200	61,500	146,700	5,400	3,900	9,300
North Lake							
Facilities (0.23 MGD)	109,000	99,200	66,200	165,400	6,300	4,200	10,500
Land (8.2 Acres)	45,000	33,100	--	33,100	2,100	--	2,100
Subtotal	154,000	132,300	66,200	198,500	8,400	4,200	12,600
Beaver Lake							
Facilities (0.25 MGD)	173,000	155,900	165,500	321,400	9,900	10,500	20,400
Outfall Sewer	63,800	47,300	3,200	50,500	3,000	200	3,200
Land (9.7 Acres)	48,300	34,700	--	34,700	2,200	--	2,200
Subtotal	285,100	237,900	168,700	406,600	15,100	10,700	22,600
Hartland							
Facilities (1.95 MGD)	2,430,000	2,195,000	1,700,000	3,895,000	139,100	107,800	246,900
Land (4.1 Acres)	20,500	15,800	--	15,800	1,000	--	1,000
Subtotal	2,450,500	2,210,800	1,700,000	3,910,800	140,100	107,800	247,900
Delafield							
Facilities (1.85 MGD)	2,430,000	2,195,000	1,650,000	3,845,000	139,100	104,500	243,600
Outfall Sewer	915,000	670,000	9,500	679,500	42,500	600	43,100
Land (4.1 Acres)	20,500	15,800	--	15,800	1,000	--	1,000
Subtotal	3,365,500	2,880,800	1,659,500	4,540,300	182,600	105,100	287,700
Subtotal--Treatment Facilities	12,377,600	10,970,100	8,155,900	19,126,000	695,900	517,500	1,213,400
Trunk Sewers							
Oconomowoc-Lac Labelle (East)	738,000	597,000	186,000	783,000	37,900	11,800	49,700
Oconomowoc-Lac LaBelle (West)	415,200	304,000	7,900	311,900	19,300	500	19,800
Oconomowoc Lake, Okauchee Lake, Pine Lake	787,700	577,000	18,900	595,900	36,600	1,200	37,800
Delafield-Nashotah	1,977,800	1,448,500	15,800	1,464,300	91,900	1,000	92,900
Nashotah-Nemahbin Lakes	397,900	323,000	173,500	496,500	20,500	11,000	31,500
Subtotal--Trunk Sewers	4,316,600	3,249,500	402,100	3,651,600	206,200	22,500	231,900
Total	$16,694,200	$14,219,600	$8,558,000	$22,777,600	$ 902,100	$543,000	$1,445,100

Table 208 (continued)

Plan Subelement	Estimated Cost: Capital Construction	Present Worth (1970-2020): Construction	Present Worth (1970-2020): Operation and Maintenance	Present Worth (1970-2020): Total	Equivalent Annual (1970-2020): Construction	Equivalent Annual (1970-2020): Operation and Maintenance	Equivalent Annual (1970-2020): Total
ALTERNATIVE PLAN 2							
Sewage Treatment Plants							
Oconomowoc							
Facilities (6.16 MGD)	$ 5,731,000	$ 5,160,000	$4,640,000	$ 9,800,000	$ 327,300	$294,600	$ 621,900
Land (7.0 Acres)	35,000	25,200	--	25,200	1,600	--	1,600
Subtotal	5,766,000	5,185,200	4,640,000	9,825,200	328,900	294,600	623,500
Delafield							
Facilities (3.80 MGD)	4,010,000	3,620,000	3,140,000	6,760,000	230,000	199,000	429,000
Land (5.6 Acres)	28,000	20,500	--	20,500	1,300	--	1,300
Subtotal	4,038,000	3,640,500	3,140,000	6,780,500	231,300	199,000	430,300
Subtotal--Treatment Facilities	9,804,000	8,825,700	7,780,000	16,605,700	560,200	493,600	1,053,800
Trunk Sewers							
Oconomowoc-Lac LaBelle (East)	675,000	552,000	186,000	738,000	35,000	11,800	46,800
Oconomowoc-Lac LaBelle (West)	415,200	304,000	7,900	311,900	19,300	500	19,800
Oconomowoc Lake, Okauchee Lake, Pine Lake, North Lake, Beaver Lake	2,406,100	1,942,000	647,000	2,589,000	123,200	41,100	164,300
Silver Lake	327,000	250,100	60,000	310,100	15,900	3,800	19,700
Hartland, Delafield-Nashotah, Nashotah-Nemahbin Lakes	5,422,200	3,973,600	25,200	3,998,800	252,100	1,600	253,700
Subtotal--Trunk Sewers	9,245,500	7,021,700	926,100	7,947,800	445,500	58,800	504,300
Total	$19,049,500	$15,847,400	$8,706,100	$24,553,500	$1,005,700	$552,400	$1,558,100
ALTERNATIVE PLAN 3							
Sewage Treatment Plant							
Oconomowoc							
Facilities (9.96 MGD)	$ 9,840,000	$ 9,040,000	$6,650,000	$15,690,000	$ 574,000	$422,000	$ 996,000
Land (10 Acres)	50,000	36,300	--	36,300	2,300	--	2,300
Subtotal	9,890,000	9,076,300	6,650,000	15,726,300	576,300	422,000	998,300
Trunk Sewers							
Oconomowoc-Lac LaBelle (East)	675,000	552,000	186,000	738,000	35,000	11,800	46,800
Oconomowoc-Lac LaBelle (West)	415,200	304,000	7,900	311,900	19,300	500	19,800
Oconomowoc Lake, Okauchee Lake, Pine Lake, North Lake, Beaver Lake	3,110,600	2,810,000	775,000	3,585,000	178,200	49,100	227,300
Hartland, Delafield-Nashotah, Nashotah-Nemahbin Lakes	6,075,800	4,547,300	468,200	5,015,500	288,500	29,700	318,200
Silver Lake	327,000	250,100	60,000	310,100	15,900	3,800	19,700
Subtotal--Trunk Sewers	10,603,600	8,463,400	1,497,100	9,960,500	536,900	94,900	631,800
Total	$20,493,600	$17,539,700	$8,147,100	$25,686,800	$1,113,200	$516,900	$1,630,100

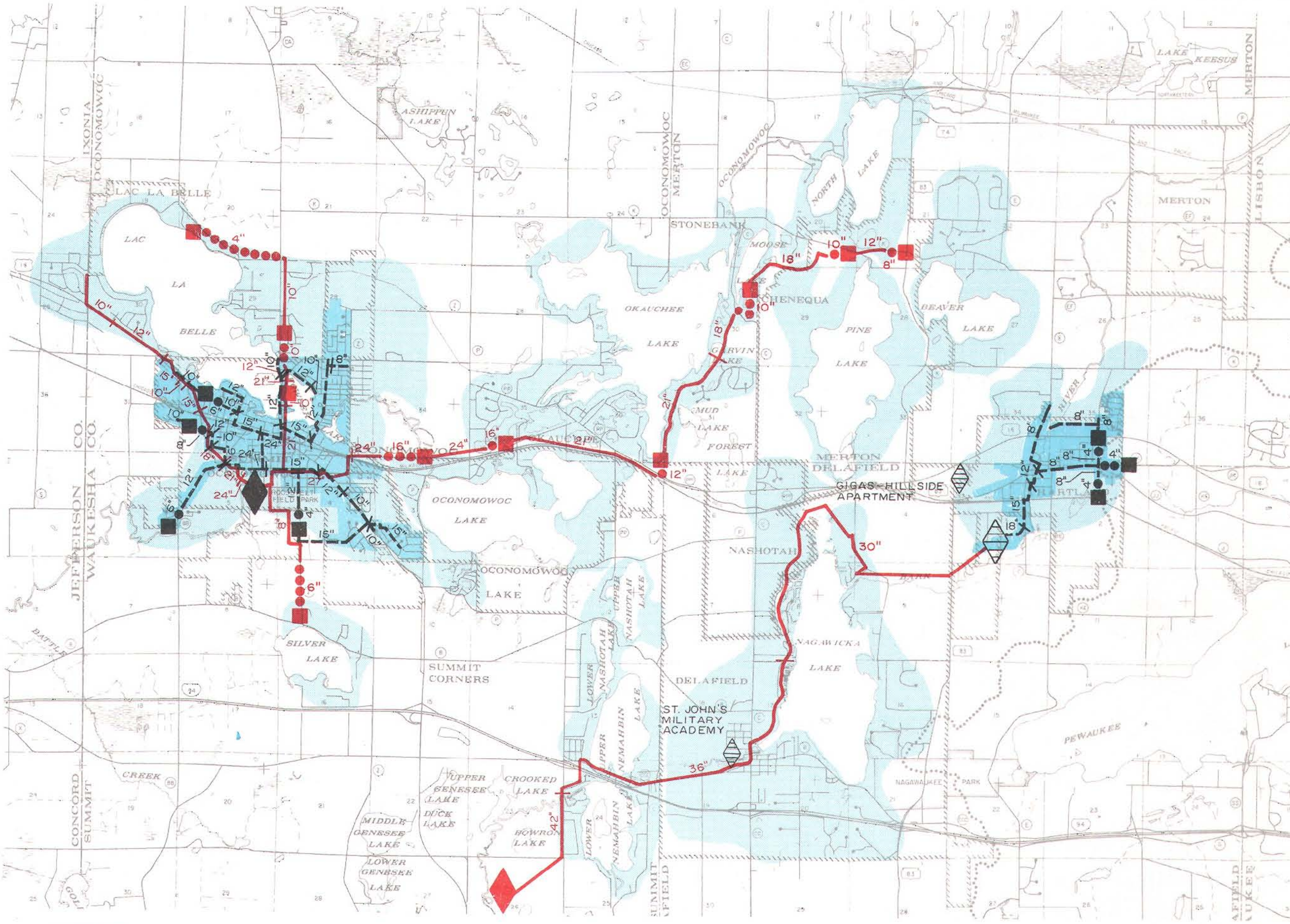
Source: SEWRPC.

In addition to the foregoing sewage treatment facilities, five intercommunity trunk sewers have been included in this alternative plan in order to provide for sewer service between municipalities within the same sewer service area or to interconnect sewer service areas. Two of the five intercommunity sewers included as part of this alternative plan element provide for the extension of sewer service within the Oconomowoc-Lac LaBelle sewer service area. The third intercommunity trunk sewer provides for the interconnection of the Oconomowoc Lake, Okauchee Lake, Pine Lake, North Lake, and Beaver Lake sewer service areas with the Oconomowoc-Lac LaBelle sewer service area. The fourth intercommunity trunk sewer provides for the interconnection of the Silver Lake sewer service area with the Oconomowoc-Lac LaBelle sewer service area. Finally, the fifth intercommunity trunk sewer provides for interconnection of the Hartland, Delafield—Nashotah, and Nashotah-Nemahbin Lakes sewer service areas. The location of these five intercommunity trunk sewers is shown on Map 119.

The total estimated capital cost of carrying out alternative plan 2 for the Oconomowoc-Delafield subarea is \$19.0 million, with an equivalent annual

Map 119

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE OCONOMOWOC-DELAFIELD SUBAREA
MIDDLE ROCK RIVER SUBREGIONAL AREA
1990



LEGEND

SEWER SERVICE AREAS

EXISTING 1970

PROPOSED 1990

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

EXISTING PUBLIC TO BE ABANDONED

PROPOSED PUBLIC

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

PROPOSED TRUNK SEWER

PROPOSED FORCE MAIN

PROPOSED PUMPING STATION

NOTE: EXISTING TRUNK SEWER SYSTEM SHOWN IN BROKEN LINES. SEE CHAPTER V.

GRAPHIC SCALE
0 2000 4000 FEET

A second alternative sanitary sewerage system plan for the Oconomowoc-Delafield subarea of the Rock River watershed would concentrate treatment of sewage at two major facilities--Oconomowoc and Delafield. The Delafield plant would be located on a site along the Bark River downstream from Crooked Lake in the Town of Summit. Both of these sewage treatment facilities would have to provide, in addition to secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. The necessary trunk sewers to implement this alternative are also shown on the above map. This alternative has the advantage of creating two relatively large centralized sanitary sewerage systems, one to serve the Bark River communities and one to serve the Oconomowoc River communities, and thus tends to take advantage of natural community interests in terms of water quality management. This alternative also most closely reflects local efforts to establish centralized sanitary sewerage systems in this portion of the Rock River watershed.

Source: SEWRPC.

cost of about $1. 6 million. Detailed cost estimates pertaining to this alternative plan are set forth in Table 208.

Alternative Plan 3: The third alternative sanitary sewerage system plan considered for the Oconomowoc-Delafield subarea would provide for sewage treatment at one centralized plant. This plant would serve all 10 contiguous sewer service analysis areas and would be constructed at a site adjacent to the existing City of Oconomowoc sewage treatment plant, which together with the existing Village of Hartland sewage treatment plant would be abandoned. Effluent from the new plant would be discharged to the Oconomowoc River. This sewage treatment facility would have a 1990 average hydraulic design capacity of 9. 96 mgd and, in order to meet the established water use objectives for the Oconomowoc River, would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The proposed 1990 service area for this facility is shown on Map 120. Required sewage treatment levels and performance standards for the plant are set forth in Table 207.

In addition to the centralized sewage treatment facility at Oconomowoc, five intercommunity trunk sewers have been included in this alternative plan in order to provide sewer service between municipalities within the same sewer service area or to interconnect sewer service areas. Two of the intercommunity trunk sewers included as part of this alternative plan element provide for the extension of sewer service within the Oconomowoc-Lac LaBelle sewer service area. The third intercommunity trunk sewer provides for the interconnection of the Oconomowoc Lake, Okauchee Lake, Pine Lake, North Lake, and Beaver Lake sewer service areas with the Oconomowoc-Lac LaBelle sewer service area. The fourth intercommunity trunk sewer provides for the interconnection of the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes sewer service areas with the Oconomowoc-Lac LaBelle sewer service area. The fifth intercommunity trunk sewer provides for the interconnection of the Silver Lake sewer service area with the Oconomowoc-Lac LaBelle sewer service area. The location of these five intercommunity trunk sewers is shown on Map 120.

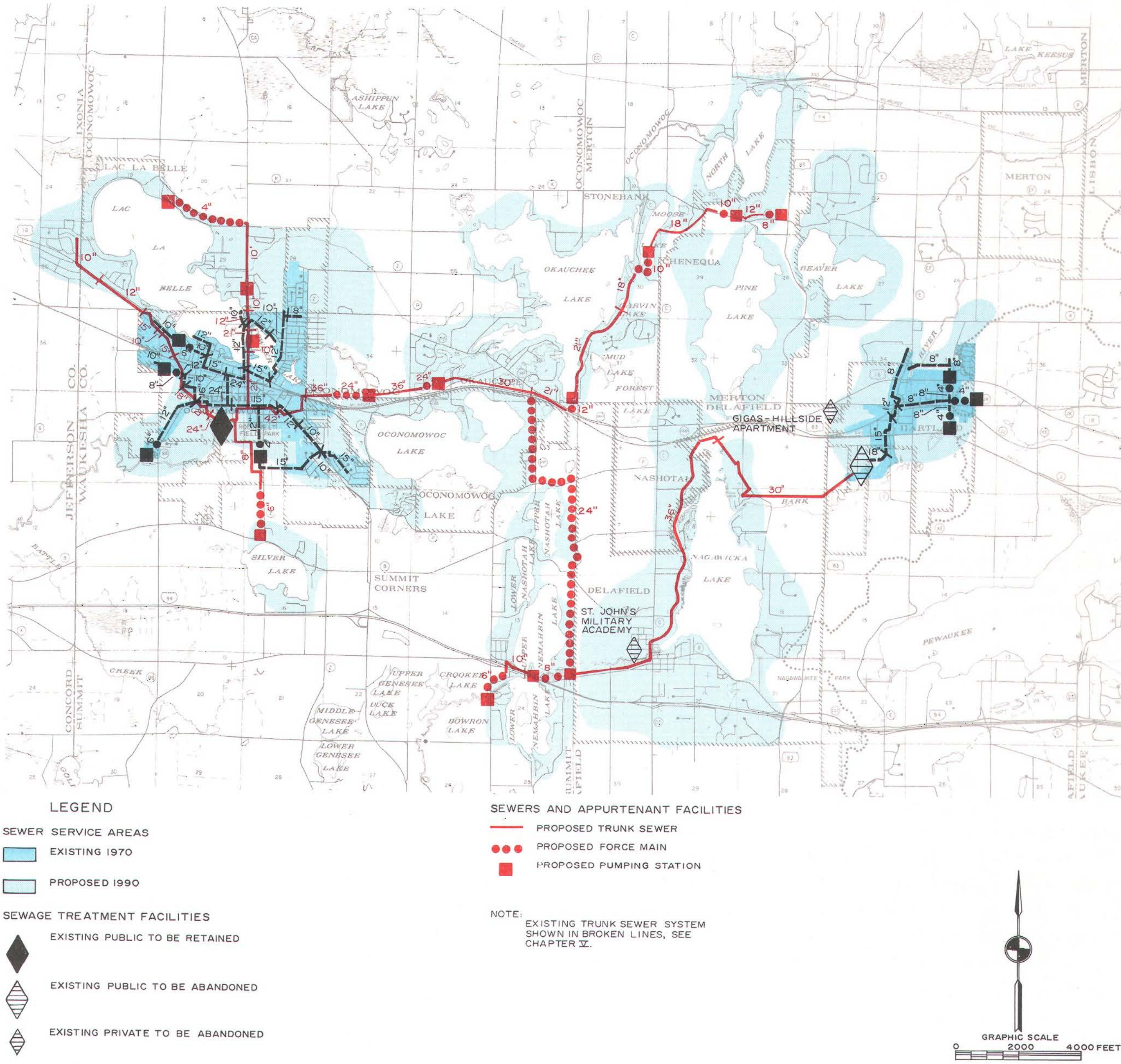
The total estimated capital cost of carrying out alternative plan 3 for the Oconomowoc-Delafield subarea is about $20. 5 million, with an equivalent annual cost of about $1. 6 million. Detailed cost estimates for this alternative plan are presented in Table 208.

Comparison of Alternative Plans: The analyses indicated that with respect to total annual cost, the alternative providing for a total of seven individual sewage treatment facilities in the Oconomowoc-Delafield subarea is slightly more economical than either the second or third alternatives, each of which provides for an increasing measure of consolidation of sewage treatment facilities. The difference in cost between the three alternatives based on equivalent annual cost, however, is only about 11 percent, within the range of precision with which the costs of each of the alternative plans can be estimated. It is important to consider other factors of the alternative plans presented, therefore, in order to provide a sound basis for ultimately selecting the best alternative to be included in the regional sanitary sewerage system plan.

Under the first alternative, responsibility for water quality management would be divided among seven individual entities consisting of either a single unit of government or, in some cases, two or three units of government. This type of approach to water quality management lends itself most readily to incremental implementation in that a given community which is desirous of proceeding with the installation of a sanitary sewer system does not, in most cases, have to wait until similar decisions are made in neighboring communities. Offsetting this advantage, however, are the long-range effects of discharging even highly treated effluent to streams just above lakes. For example, under alternative plan 1, sewage effluent would be discharged from the Beaver Lake and Hartland sewage treatment plants to the Bark River just upstream from Nagawicka Lake. In addition, sewage effluent from the North Lake treatment plant would be discharged to the Oconomowoc River just upstream from Okauchee Lake, and sewage effluent from the Oconomowoc Lake sewage treatment plant would be discharged into the Oconomowoc River just upstream from Fowler Lake and Lac LaBelle. While alternative plan 1 would provide for sewage treatment levels that would meet the stream water quality standards, the effects of a potential long-term accumulation of the residual nutrients, such as phosphorus, in

Map 120

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 3
FOR THE OCONOMOWOC-DELAFIELD SUBAREA
MIDDLE ROCK RIVER SUBREGIONAL AREA
1990



A third alternative sanitary sewerage system plan for the Oconomowoc-Delafield subarea of the watershed proposes centralized treatment of sewage at one major plant at Oconomowoc. The trunk sewers necessary to convey sewage from all 10 individual service areas under this alternative are also shown on the above map. In addition to being somewhat more costly in terms of equivalent annual cost than either the first or second alternatives considered, this alternative has the disadvantage of requiring interbasin diversion of water, of discharging a relatively large amount of sewage effluent to the Oconomowoc River, and does not utilize the natural waste assimilative capacity of the Bark River.

Source: SEWRPC.

the sewage treatment plant effluent in the various lakes could be highly detrimental. This factor, when combined with the diffusion of water quality management responsibility created by the construction, operation, and maintenance of seven sewage treatment facilities, may be deemed to outweigh the apparent slight cost advantage and assumed ready implementation potential for this alternative plan.

Alternative plan 2 would concentrate the treatment of sewage in the Oconomowoc-Delafield subarea at two sewage treatment facilities, with the treatment facility at Delafield discharging its effluent below Crooked Lake in the Town of Summit. In addition to meeting the stream water quality standards, this alternative has the advantage of discharging no sewage effluent upstream from the lakes, which are an important natural resource base element in the Middle Rock River subregional area. In addition, this alternative has the advantage of creating two relatively large centralized sanitary sewerage systems, one to serve the Bark River communities and the other to serve the Oconomowoc River communities, and thus tends to take advantage of a natural community of interest among such communities in terms of water quality management. Finally, this alternative most closely approximates the local sanitary sewerage system planning efforts which are currently underway in the Middle Rock River subregional area, and thus would seem to be capable of ready implementation.

The third alternative plan presented differs from the second only in that the Delafield and Oconomowoc sewage treatment plants would be combined, thus providing a further degree of centralization in the area. In addition to being somewhat more costly than the second plan, this alternative has the disadvantage of discharging a relatively large amount of sewage effluent—nearly 10 mgd—to the Oconomowoc River, unlike the second alternative which would divide the sewage effluent between the Bark and Oconomowoc Rivers and thus better utilize the natural waste assimilative capacities of the two streams.

Private Sewage Treatment Plants

Three private sewage treatment facilities currently discharge wastes in the Middle Rock River subregional area. These are: the St. John's Military Academy facility in the City of Delafield; the Hillside Apartments facility in the Town of Delafield; and the facility serving the Wisconsin School for Boys (Wales), also in the Town of Delafield. The St. John's and Hillside Apartments facilities lie within the proposed 1990 sewer service limits of the Delafield and Hartland sewer service areas, respectively, and would, accordingly, be abandoned and connected to the proposed local Delafield and Hartland sanitary sewerage systems upon implementation of any of the alternative plans presented above. The Wales Boys' School facility lies beyond the proposed 1990 sewer service area for the Village of Wales and environs. This facility has recently been rebuilt and is capable of adequately treating the anticipated 1990 sewage loading from the school. This facility can, therefore, continue in operation and should provide a level of waste treatment adequate to meet the water quality objectives and standards for the receiving stream. Should it become necessary at some future date to expand or reconstruct this private sewage treatment facility, the potential of abandoning this facility and connecting the school to the proposed Wales sanitary sewerage system should be carefully examined.

LOWER ROCK RIVER SUBREGIONAL AREA

The Lower Rock River subregional area consists of all that area of the Rock River watershed in Walworth County together with urban concentrations in the Fox River watershed at the western end of Geneva Lake. Several subwatersheds comprise the Lower Rock River subregional area, including the Whitewater Creek subwatershed, the Turtle Creek subwatershed, the Jackson Creek subwatershed, the Piscasaw Creek subwatershed, and the Sharon Creek subwatershed. Major concentrations of urban development are found in the Cities of Delavan, Elkhorn, and Whitewater; the Villages of Darien, Fontana, Sharon, Walworth, and Williams Bay, and the Delavan Lake area in the Town of Delavan.

As noted in Chapter V of this report, centralized sanitary sewer service in the Lower Rock River subregional area was provided by eight systems in 1970: those operated by the Cities of Delavan, Elkhorn, and Whitewater; and the Villages of Darien, Fontana, Sharon, Walworth, and Williams Bay. Together the service areas of these eight systems comprised an area of about 9.6 square miles and served an estimated resident population of about 28,200 persons. In 1970 there were about 12,600 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the eight existing systems are presented in Chapter V of this report.

Sewer Service Analysis Areas

A total of nine sewer service analysis areas may be identified within the Lower Rock River subregional area (see Table 209). These nine sewer service analysis areas are shown on Map 121 and may be described as follows:

1. Area A—This area consists of the City of Whitewater and environs, including existing and anticipated future urban development in that portion of the City of Whitewater lying in Jefferson County outside of the Southeastern Wisconsin Region. In 1970, sanitary sewer service was provided in this area to a total area of about 1.6 square miles, having a total resident population, including resident students attending the University of Wisconsin-Whitewater, of about 12,000 persons. By 1990 the total area anticipated to be served approximates 3.3 square miles, with a projected resident population of about 15,500 persons. This subarea is referenced as the "Whitewater" sewer service area in the ensuing discussion.

2. Area B—This area consists of the City of Elkhorn and environs. In 1970, sanitary sewer service was provided in this area to a total area of nearly two square miles, having a total resident population of about 4,000 persons. By 1990 the total area anticipated to be served approximates 2.8 square miles, with a projected population of about 8,000 persons. This subarea is referenced as the "Elkhorn" sewer service area in the ensuing discussion.

3. Area C—This area consists of the City of Delavan and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 2.4 square miles, having a total resident population of about 5,400 persons. By 1990 the total area anticipated to be served approximates 3.0 square miles, with a projected population of about 8,900 persons. This subarea is referenced as the "Delavan" sewer service area in the ensuing discussion.

4. Area D—This area consists of urban development along the shoreline of Delavan Lake in the Town of Delavan. About 2,700 persons resided in this area on a year-

Table 209

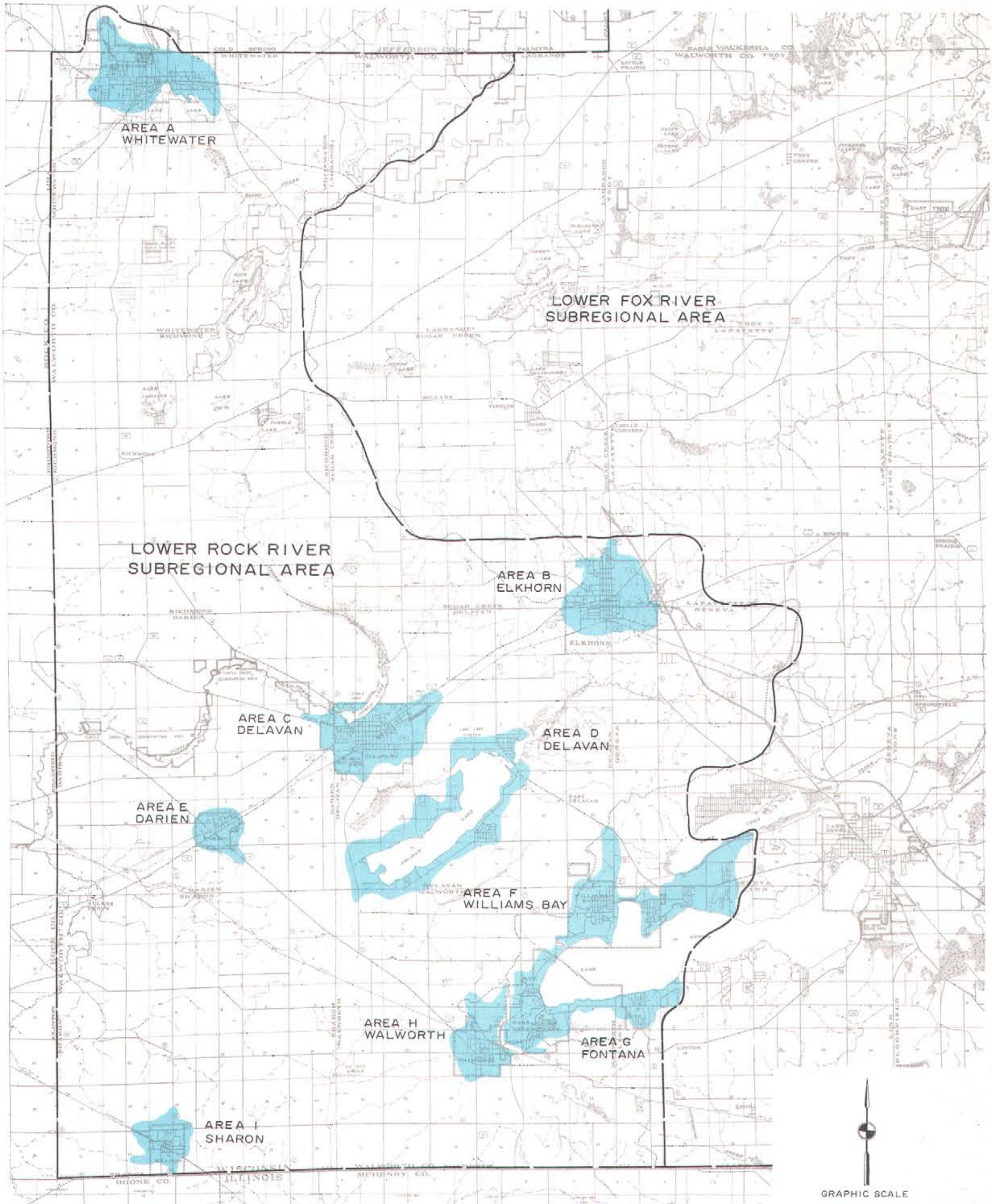
SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THE LOWER ROCK RIVER SUBREGIONAL AREA 1970 and 1990

Sewer Service Analysis Area[1] Letter	Name	Existing 1970 Area Served (Square Miles)	Existing 1970 Population Served	Existing 1970 Average Hydraulic Loading (MGD)	Existing 1970 Unserved Population Residing in Proposed 1990 Service Area	Planned 1990 Area Served (Square Miles)	Planned 1990 Population Served	Planned 1990 Average Hydraulic Loading (MGD)
A	Whitewater	1.64	12,000	1.51	100	3.31	15,500[2]	3.66[3]
B	Elkhorn	1.98	4,000	0.70	--	2.83	8,000	1.54
C	Delavan	2.43	5,400	0.70	400	3.06	8,900	1.41
D	Delavan Lake	--	--	--	2,700[4]	3.01	5,800[5]	1.22
E	Darien	0.41	900	N/A	--	0.86	2,800	0.59
F	Williams Bay	0.96	1,500[4]	0.36	900[4]	3.61	6,500[6]	1.40
G	Fontana	1.38	1,600[4]	0.50	300[4]	2.95	3,100[7]	0.82
H	Walworth	0.41	1,600	0.15	100	1.51	5,200	0.95
I	Sharon	0.43	1,200	0.04	100	1.11	2,600	0.55
Total		9.64	28,200	3.96	4,600	22.25	58,400	12.14

NOTE: N/A indicates data not available.
[1]See Map 121.
[2]Includes an estimated 6,000 students at the University of Wisconsin-Whitewater.
[3]Includes design sewage flow of 0.40 MGD from Hawthorn Mellody, Inc.
[4]Does not include seasonal resident population on Delavan and Geneva Lakes.
[5]Includes an estimated seasonal resident population of 2,900 persons.
[6]Includes an estimated seasonal resident population of 2,500 persons.
[7]Includes an estimated seasonal resident population of 1,000 persons.

Source: SEWRPC.

Map 121
SEWER SERVICE ANALYSIS AREAS
LOWER ROCK RIVER SUBREGIONAL AREA



Nine individual sewer service areas were identified within the Lower Rock River watershed. Except for a major concentration of urban development along the shoreline of Delavan Lake in the Town of Delavan Lake, these nine sewer service areas consist of incorporated cities and villages. In 1970 there were about 41,000 persons residing in this portion of the Rock River watershed, of which about 28,000 were served with centralized sanitary sewers and 13,000 by private septic tank sewage disposal systems. By 1990 it is anticipated that approximately 58,000 persons will be served by centralized sanitary sewers.

Source: SEWRPC.

round basis in 1970 but no centralized sanitary sewer service was provided. The Delavan Lake Sanitary District has been formed to provide centralized sanitary sewer service to this concentration of urban development. By 1990 the total area anticipated to be served with centralized sanitary sewer service approximates 3.0 square miles, with a projected population of about 5,800 persons, including an estimated seasonal resident population of about 2,900 persons. This subarea is referenced as the "Delavan Lake" sewer service area in the ensuing discussion.

5. Area E—This area consists of the Village of Darien and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.4 square mile, having a total resident population of about 900 persons. By 1990 the total area anticipated to be served approximates 0.9 square mile, with a projected population of about 2,800 persons. This subarea is referenced as the "Darien" sewer service area in the ensuing discussion.

6. Area F—This area consists of the Village of Williams Bay and environs, including urban development along the shorelines of Geneva Lake and Lake Como in the Towns of Geneva and Linn. In 1970, centralized sanitary sewer service was provided in this area to a total area of nearly 1.0 square mile, having a total resident population of about 1,500 persons. By 1990 the total area anticipated to be served approximates 3.6 square miles, with a projected population of about 6,500 persons, including an estimated seasonal resident population of about 2,500 persons. This subarea is referenced as the "Williams Bay" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Fontana and environs, including urban development along the shoreline of Geneva Lake in the Town of Linn. In 1970, sanitary sewer service was provided in this area to a total area of about 1.4 square miles, having a total resident population of about 1,600 persons. By 1990 the total area anticipated to be served approximates 2.9 square miles, with a projected population of about 3,100 persons, including an estimated seasonal resident population of about 1,000 persons. This subarea is referenced as the "Fontana" sewer service area in the ensuing discussion.

8. Area H—This area consists of the Village of Walworth and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.4 square mile, having a total resident population of about 1,600 persons. By 1990 the total area anticipated to be served approximates 1.5 square miles, with a projected population of about 5,200 persons. This subarea is referenced as the "Walworth" sewer service area in the ensuing discussion.

9. Area I—This area consists of the Village of Sharon and environs. In 1970, sanitary sewer service was provided in this area to a total area of about 0.4 square mile, having a total resident population of about 1,200 persons. By 1990 the total area anticipated to be served approximates 1.1 square miles, with a projected population of about 2,600 persons. This subarea is referenced as the "Sharon" sewer service area in the ensuing discussion.

Formulation of Alternatives

As discussed earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system planning program for the formulation of alternative plans. The first step in this process was to apply the Wisconsin Department of Natural Resources (DNR) guidelines relating distances between communities to the populations of both the "sending" and "receiving" communities in order to determine if potential interconnections between centralized sanitary sewerage systems should be investigated. The results of the application of these criteria to the communities within the Lower Rock River subregional sewerage system planning area are summarized in Table 210.

Two of the identified sewer service analysis areas—Delavan and Delavan Lake—were considered as one entity for interconnection analysis purposes, since the Delavan Lake Sanitary District has determined to locate its proposed sewage treatment facility on a site immediately adjacent to the existing City of Delavan sewage treatment facility, and since the DNR has determined that the two treatment plants should ultimately be integrated and operated as a single sewage treatment facility. Two additional areas—Whitewater and Sharon—were found to be too remote to be considered for interconnection analyses. Based on the DNR guidelines, the following interconnections between sanitary sewer service areas in the Lower Rock River subregional area were found to be potentially feasible:

1. Elkhorn to Delavan-Delavan Lake

2. Darien to Delavan-Delavan Lake

3. Williams Bay to Walworth

4. Fontana to Walworth

Conduct of preliminary economic analyses for these potential interconnections further revealed that a detailed economic analysis was warranted in each instance. Accordingly, it was determined that the following sanitary sewerage system plans for the Lower Rock River subregional area should be presented and evaluated.

1. A proposed plan for the Whitewater sewer service area.

2. A proposed plan for the Sharon sewer service area.

3. Two alternative plans for the Delavan-Delavan Lake and Elkhorn sewer service areas, including an alternative providing individual sewage treatment facilities at each of the two sewer service areas and an alternative providing for a single sewage treatment facility at the Delavan-Delavan Lake sewage treatment plant site.

4. Two alternative plans for the Delavan-Delavan Lake and Darien sewer service areas, including an alternative providing individual sewage treatment facilities at each of the two sewer service areas and an alternative providing for a single sewage treatment facility at the Delavan-Delavan Lake sewage treatment plant site.

5. Three alternative plans for the Fontana, Walworth, and Williams Bay sewer service areas, including an alternative providing individual sewage treatment facilities at each of the three sewer service areas; an alternative providing for two sewage treatment facilities, one at Williams Bay and the other at Walworth to serve Fontana and Walworth; and an alternative providing for a single sewage treatment facility at the Walworth sewage treatment site to serve all three sewer service areas.

Each of the sanitary sewerage system plan elements is described in the following paragraphs. Data pertaining to recommended treatment levels at each of the municipal sewage treatment plant sites considered in the preparation of these plan elements are presented in Table 211.

Table 210

RESULTS OF THE APPLICATION OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES INTERCONNECTION GUIDELINES AND PRELIMINARY ECONOMIC ANALYSES IN THE LOWER ROCK RIVER SUBREGIONAL AREA

Sewer Service Analysis Area(s)				Results of Application of DNR Guidelines		Results of Preliminary Economic Analysis			
Receiving		Sending				Total Equivalent Annual Cost			
Name	Estimated 1990 Population	Name	Estimated 1990 Population	Straight Line Distance Between Sewer Service Areas (Miles)	Proceed to Preliminary Economic Analysis (Yes or No)	Separate Plants (A)	Interconnection-One Plant (B)	Percent Difference (B-A)/(A)	Proceed to Detailed Economic Analysis[1] (Yes or No)
Delavan	14,700[2]	Elkhorn Darien	8,000 2,800	6.1 3.8	Yes Yes	$397,000 335,100	$455,800 329,200	14.6 - 1.8	Yes Yes
Walworth	5,200	Williams Bay Fontana	6,500 3,100	5.0 2.3	Yes Yes	228,100 235,000	238,700 220,000	4.7 - 6.4	Yes Yes

[1]*If the estimated equivalent annual cost of interconnection was no more than 20 percent greater than the cost of providing separate sewage treatment facilities, a detailed economic analysis was deemed to be required.*
[2]*Includes the Delavan Lake sewer service area population of 5,800.*

Source: SEWRPC.

Proposed Plan—Whitewater Subarea

In 1970 the sewage treatment facility serving the Whitewater sewer service area had an average hydraulic design capacity of about 2.5 mgd and provided a secondary level of waste treatment. Disposal of effluent is to Whitewater Creek. The existing plant consists of two parallel facilities, one a trickling filter type plant constructed in 1937, and the other an activated sludge type plant constructed in 1967. The plant in total may be considered as having nearly reached the end of its useful life and should be relocated to better serve existing and anticipated future urban development. In order to accommodate projected future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 3.7 mgd will be required for the Whitewater facility. Accordingly, it is proposed that a new sewage treatment facility be constructed at a site in Jefferson County north of the existing plant site and along Whitewater Creek. In order to meet the established water use objectives for Whitewater Creek, it will be necessary for this new facility to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Whitewater sewage treatment plant are set forth in Table 212.

The estimated capital cost of constructing the necessary treatment facilities at Whitewater,

Table 211

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THE LOWER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant Site	Receiving Water Body	Stream Low Flow and Dilution Ratio Data									Level of Treatment Required				
		7-Day, 10-Year Low Flow		Upstream Sewage Treatment Plant Flow-1990		Total Design Low Flow-1990		Total Design Sewage Flow-1990		Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Secondary	Advanced		Auxiliary	
		CFS	MGD	CFS	MGD	CFS	MGD	CFS	MGD			Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Whitewater	Whitewater Creek	4.90	3.17	0.62	0.40	5.52	3.57	5.67	3.66	0.97	Yes	Yes	Yes	Yes	Yes
Elkhorn[1]	Jackson Creek	0.39	0.25	--	--	0.39	0.25	2.38	1.54	0.16	Yes	Yes	Yes	Yes	Yes
Delavan[1,2]	Turtle Creek	8.90	5.75	2.09	1.35	10.99	7.10	4.07	2.63	2.70	Yes	Yes	Yes	Yes	Yes
Delavan[3]	Turtle Creek	8.90	5.75	2.09	1.35	10.99	7.10	4.98	3.22	2.21	Yes	Yes	Yes	Yes	Yes
Delavan[4]	Turtle Creek	8.90	5.75	2.09	1.35	10.99	7.10	6.46	4.17	2.64	Yes	Yes	Yes	Yes	Yes
Darien[2]	Seepage Lagoon	N/A	N/A	N/A	N/A	N/A	N/A	0.91	0.59	N/A	Yes	No	No	No	Yes
Williams Bay[5]	Seepage Lagoon	N/A	N/A	N/A	N/A	N/A	N/A	2.17	1.40	N/A	Yes	No	No	No	Yes
Fontana[6]	Seepage Lagoon	N/A	N/A	N/A	N/A	N/A	N/A	1.27	0.82	N/A	Yes	No	No	No	Yes
Walworth[6]	Piscasaw Creek	4.73	3.06	--	--	4.73	3.06	1.47	0.95	3.22	Yes	Yes	Yes	Yes	Yes
Walworth[7]	Piscasaw Creek	4.73	3.06	--	--	4.73	3.06	2.74	1.77	1.73	Yes	Yes	Yes	Yes	Yes
Walworth[8]	Piscasaw Creek	4.73	3.06	--	--	4.73	3.06	4.91	3.17	0.96	Yes	Yes	Yes	Yes	Yes
Sharon	Sharon Creek	0.57	0.37	--	--	0.57	0.37	0.85	0.55	0.67	Yes	Yes	Yes	Yes	Yes

NOTE: N/A indicates not applicable.

[1]Corresponds to Delavan, Delavan Lake, and Elkhorn alternative plan 1.

[2]Corresponds to Delavan, Delavan Lake, and Darien alternative plan 1.

[3]Corresponds to Delavan, Delavan Lake, and Darien alternative plan 2.

[4]Corresponds to Delavan, Delavan Lake, and Elkhorn alternative plan 2.

[5]Corresponds to Walworth, Fontana, and Williams Bay alternative plans 1 and 2.

[6]Corresponds to Walworth, Fontana, and Williams Bay alternative plan 1.

[7]Corresponds to Walworth, Fontana, and Williams Bay alternative plan 2.

[8]Corresponds to Walworth, Fontana, and Williams Bay alternative plan 3.

Source: SEWRPC.

Table 212

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WHITEWATER SEWER SERVICE AREA LOWER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Whitewater (3.66 MGD)	Whitewater	15,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 122.

Source: SEWRPC.

together with a trunk sewer to convey wastes from the existing plant to the proposed sewage treatment plant site, is about $4.3 million, with an equivalent annual cost of about $718,700 (see Table 213). The proposed 1990 service area for the City of Whitewater is shown on Map 122.

Proposed Plan—Sharon Subarea

In 1970 the sewage treatment facility serving the Sharon sewer service area had an average hydraulic design capacity of about 0.15 mgd and provided a secondary level of waste treatment. Disposal of effluent is to Sharon Creek, a tributary of the Rock River. The plant is a trickling filter type constructed in 1960. In order to accommodate projected future growth, it is anticipated that by 1990 an average hydraulic design capacity of 0.5 mgd will be required for this facility. In order to meet the established water use objectives for Sharon Creek, it will be necessary for this facility to provide, in addition to the current secondary level of waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The specific recommended performance standards for the Sharon sewage treatment plant are set forth in Table 214.

The estimated capital cost of constructing the necessary treatment facilities at Sharon is about $894,000, with an equivalent annual cost of about $95,900 (see Table 215). The proposed 1990 service area for the Village of Sharon is shown on Map 123.

Table 213

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WHITEWATER SEWER SERVICE AREA
LOWER ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Whitewater							
Facilities (3.66 MGD)	$3,911,000	$3,533,800	$3,177,600	$6,711,400	$224,200	$201,600	$425,800
Land (5.4 Acres)	27,000	20,500	--	20,500	1,300	--	1,300
Subtotal	3,938,000	3,554,300	3,177,600	6,731,900	225,500	201,600	427,100
Trunk Sewer							
Whitewater	392,900	288,400	3,200	291,600	288,400	3,200	291,600
Subtotal	392,900	288,400	3,200	291,600	288,400	3,200	291,600
Total	$4,330,900	$3,842,700	$3,180,800	$7,023,500	$513,900	$204,800	$718,700

Source: SEWRPC.

Table 214

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SHARON SEWER SERVICE AREA
LOWER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Sharon (0.55 MGD)	Sharon	2,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 123.

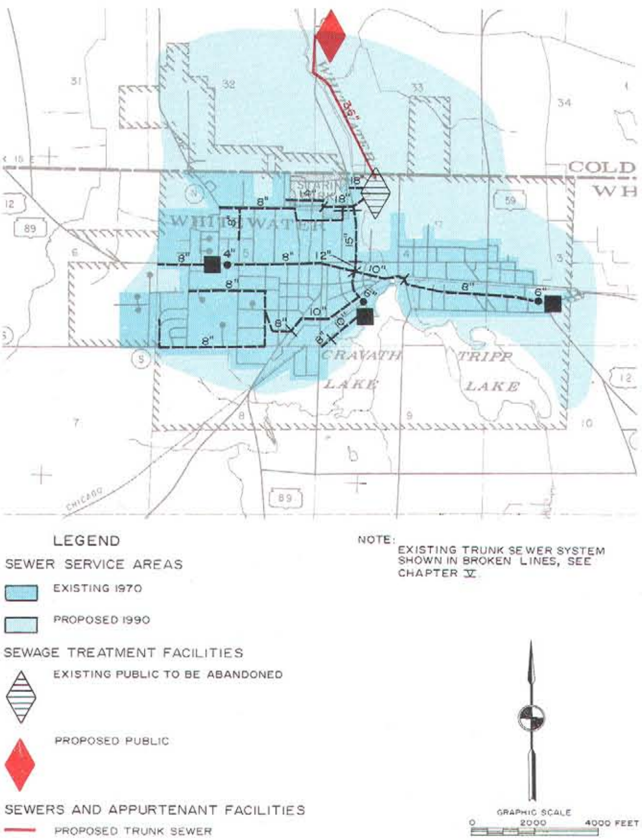
Source: SEWRPC.

Alternative Plans—Delavan-Delavan Lake—Elkhorn Subarea

As indicated above, preliminary economic analyses revealed a need to consider the interconnection of the Delavan-Delavan Lake and Elkhorn sewer service areas for sewage treatment purposes. Two basic alternative plans were formulated. The first alternative assumes the construction of a new sewage treatment facility to serve the Delavan-Delavan Lake sewer service areas at a site

Map 122

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE WHITEWATER SEWER SERVICE AREA
LOWER ROCK RIVER SUBREGIONAL AREA
1990

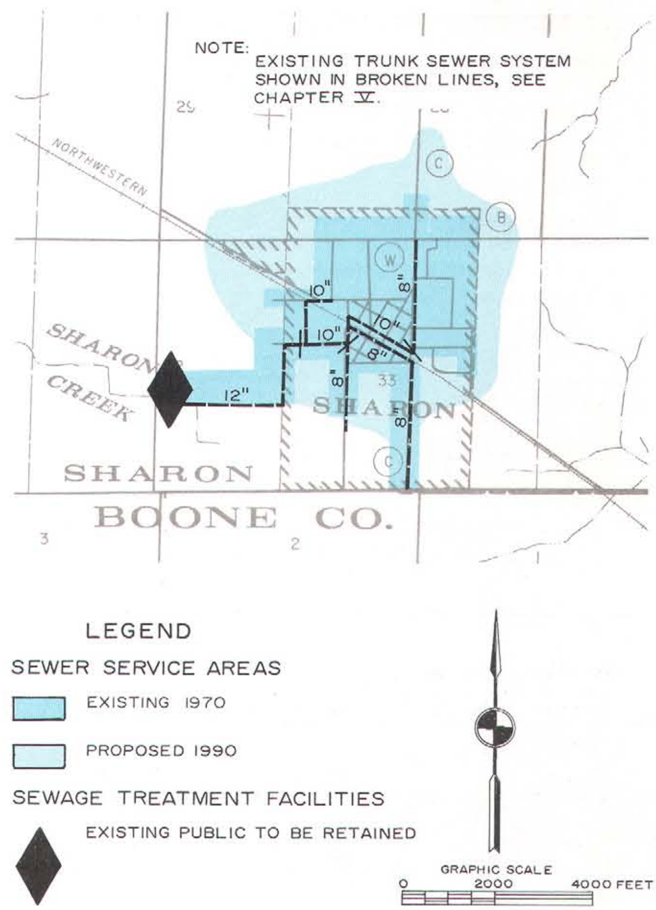


The existing Whitewater sewage treatment facility has nearly reached the end of its useful life and should be relocated to better serve existing and anticipated future development. Accordingly, the plan proposes construction of a new Whitewater sewage treatment facility on Whitewater Creek in Jefferson County. This new facility will need to provide, in addition to secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection if the established water use objectives for Whitewater Creek are to be met.

Source: *SEWRPC.*

Map 123

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE SHARON SEWER SERVICE AREA
LOWER ROCK RIVER SUBREGIONAL AREA
1990



The proposed service area for the Sharon sewage treatment facility is shown on the above map. In order to meet the established water use objectives for Sharon Creek, it will be essential for the Sharon sewage treatment facility to provide, in addition to the current secondary level of waste treatment, advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection.

Source: *SEWRPC.*

immediately adjacent to the existing City of Delavan sewage facility, together with the construction of a new treatment facility to serve the Elkhorn sewer service area. Both the existing City of Delavan and City of Elkhorn sewage treatment facilities are of the trickling filter type and have nearly reached the end of their useful lives. The second alternative provides for a single sewage treatment facility to serve the Delavan-Delavan Lake and Elkhorn sewer service areas, locating the single plant at the Delavan site. Required sewage treatment levels and performance standards under both alternatives considered are set forth in Table 216, while detailed cost estimates

Table 215

DETAILED COST ESTIMATES
PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE SHARON SEWER SERVICE AREA
LOWER ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Capital Construction	Estimated Cost: Present Worth (1970-2020) Construction	Estimated Cost: Present Worth (1970-2020) Operation and Maintenance	Estimated Cost: Present Worth (1970-2020) Total	Estimated Cost: Equivalent Annual (1970-2020) Construction	Estimated Cost: Equivalent Annual (1970-2020) Operation and Maintenance	Estimated Cost: Equivalent Annual (1970-2020) Total
Sewage Treatment Plant							
Sharon							
Facilities (0.55 MGD)	$880,000	$818,000	$680,000	$1,498,000	$52,000	$43,200	$95,200
Land (2.8 Acres)	14,000	11,000	--	11,000	700	--	700
Subtotal	894,000	829,000	680,000	1,509,000	52,700	43,200	95,900
Trunk Sewers--None							
Total	$894,000	$829,000	$680,000	$1,509,000	$52,700	$43,200	$95,900

Source: SEWRPC.

Table 216

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE DELAVAN, DELAVAN LAKE, AND ELKHORN SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Delavan (2.63 MGD)	Delavan Delavan Lake	14,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Elkhorn (1.54 MGD)	Elkhorn	8,000	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Delavan (4.17 MGD)	Delavan Delavan Lake Elkhorn	22,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]*See Map 124.*

Source: SEWRPC.

pertaining to the two alternatives are set forth in Table 217. The two proposals are shown on Maps 124 and 125.

Under alternative plan 1, a new Delavan-Delavan Lake sewage treatment plant would be constructed on a site immediately adjacent to the existing City of Delavan treatment facility. This site has already been selected for use by the Delavan Lake Sanitary District. In order to accommodate projected future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 2.6 mgd will be required for this facility under this alternative. In order to meet the established water use objectives for Turtle Creek, to which effluent would be discharged, it will be necessary for this facility to provide not only secondary waste treatment, but also advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. A trunk sewer to convey sewage from the Delavan Lake sewer service area to the new sewage treatment site is also included in this alternative plan. In addition, under alternative plan 1 a new sewage treatment facility would be constructed at or near the site of the existing Elkhorn treatment facility to serve the Elkhorn sewer service area. This facility would need to provide a 1990 average hydraulic design capacity of about 1.5 mgd. In order to meet the established water use objectives for Jackson Creek, to which effluent would be discharged, the proposed new Elkhorn facility would be required to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste

Table 217

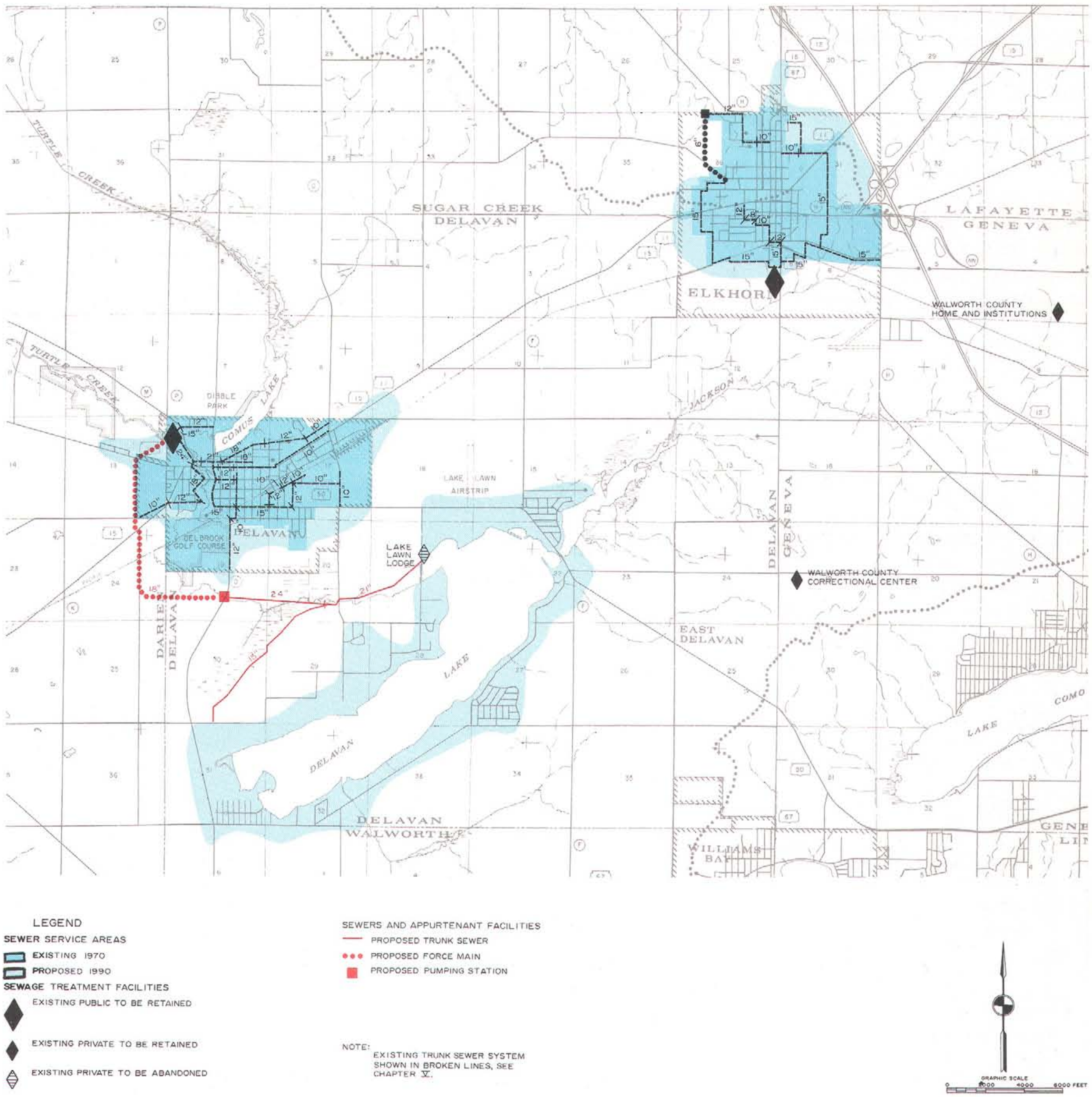
DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE DELAVAN, DELAVAN LAKE, AND ELKHORN SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plants							
Delavan							
Facilities (2.63 MGD)	$3,022,700	$2,692,100	$2,428,900	$ 5,121,000	$170,800	$154,100	$324,900
Land (4.6 Acres)	23,000	17,300	--	17,300	1,100	--	1,100
Subtotal	3,045,700	2,709,400	2,428,900	5,138,300	171,900	154,100	326,000
Elkhorn							
Facilities (1.54 MGD)	2,195,100	1,982,900	1,434,300	3,417,200	125,800	91,000	216,800
Land (3.8 Acres)	19,000	14,200	--	14,200	900	--	900
Subtotal	2,214,100	1,997,000	1,434,300	3,431,400	126,700	91,000	217,700
Subtotal--Treatment Facilities	5,259,800	4,706,400	3,863,200	8,569,700	298,600	245,100	543,700
Trunk Sewer							
Delavan Lake	1,536,200	1,163,300	173,600	1,336,900	73,800	11,000	84,800
Subtotal	1,536,200	1,163,300	173,600	1,336,900	73,800	11,000	84,800
Total	$6,796,000	$5,869,700	$4,036,800	$ 9,906,600	$372,400	$256,100	$628,500
ALTERNATIVE PLAN 2							
Sewage Treatment Plant							
Delavan							
Facilities (4.17 MGD)	$4,305,200	$3,890,100	$3,313,200	$ 7,203,300	$246,800	$210,200	$457,000
Land (5.7 Acres)	28,500	20,500	--	20,500	1,300	--	1,300
Subtotal	4,333,700	3,910,600	3,313,200	7,223,800	248,100	210,200	458,300
Trunk Sewers							
Delavan Lake	1,536,200	1,163,300	173,600	1,336,900	73,800	11,000	84,800
Elkhorn	1,577,000	1,258,000	326,000	1,584,000	79,800	20,700	100,500
Subtotal	3,113,200	2,421,300	499,600	2,920,900	153,600	31,700	185,300
Total	$7,446,900	$6,331,900	$3,812,800	$10,144,700	$401,700	$241,900	$643,600

Source: SEWRPC.

Map 124

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
FOR THE DELAVAN, DELAVAN LAKE, AND ELKHORN SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA
1990

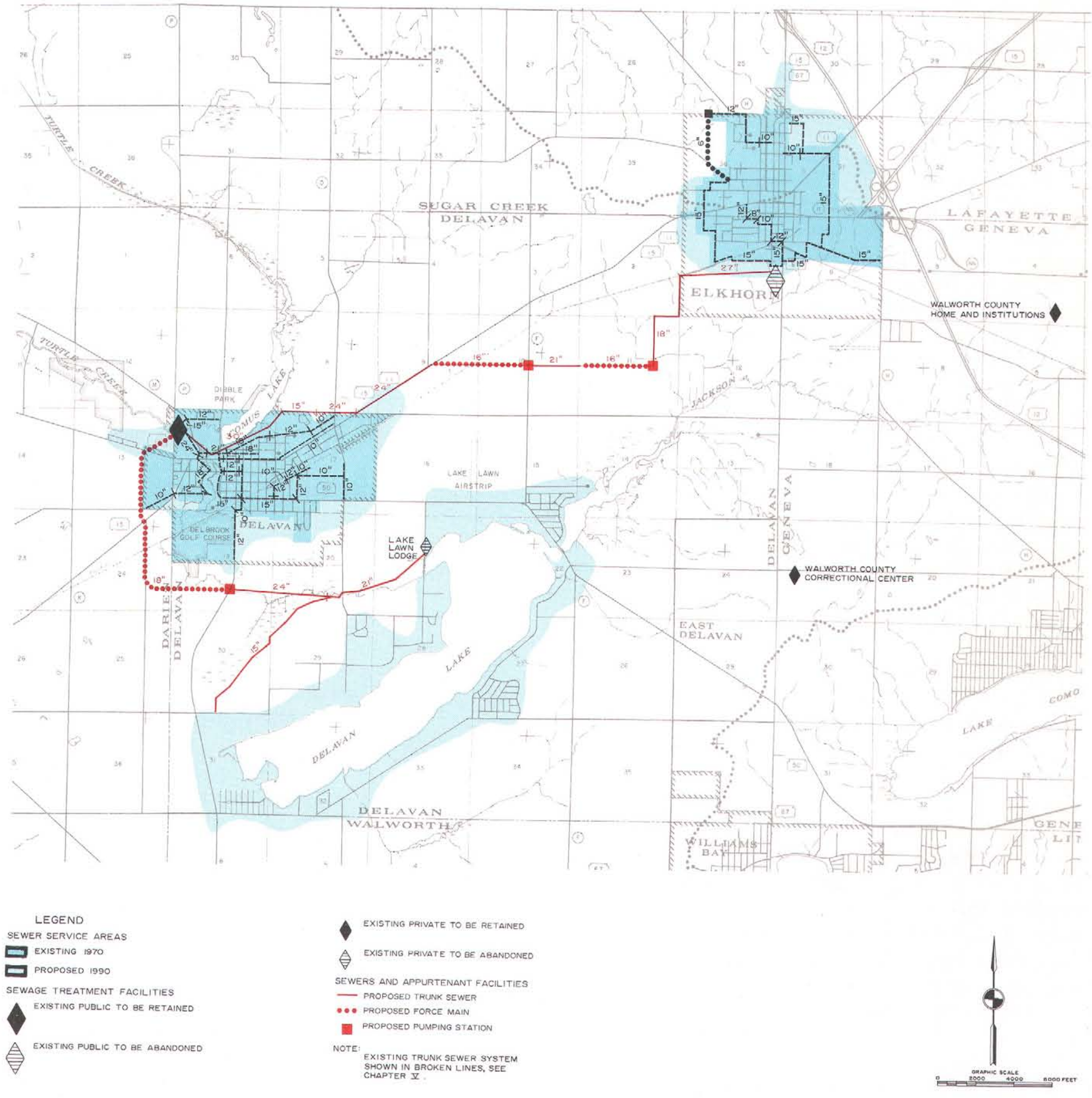


One alternative sanitary sewerage system plan for the Delavan, Delavan Lake, and Elkhorn sewer service areas would provide for construction of two new sewage treatment facilities, one to replace the existing Elkhorn facility and the other to replace the existing Delavan facility and to be sized to serve both the Delavan and Delavan Lake sewer service areas. Both facilities would be required to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. While this alternative and the other alternative considered for this area, as shown on Map 125, have about the same cost of implementation, this alternative has the disadvantage of continuing to discharge sewage effluent to Jackson Creek above Delavan Lake.

Source: SEWRPC.

Map 125

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE DELAVAN, DELAVAN LAKE, AND ELKHORN SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA
1990



Another alternative sanitary sewerage system plan for the Delavan, Delavan Lake, and Elkhorn sewer service areas proposes to consolidate treatment of sewage at the Delavan site on Turtle Creek. The trunk sewer system necessary to convey wastes from the Elkhorn area to the proposed new Delavan plant is shown on this map. This alternative was found to have approximately the same plan implementation cost as the other alternative considered, shown on Map 124, and has the advantage of eliminating any further discharge of sewage treatment plant effluent to Jackson Creek above Delavan Lake.

Source: SEWRPC.

treatment for effluent aeration and disinfection. The total estimated capital cost of carrying out alternative plan 1 for the Delavan-Delavan Lake and Elkhorn sewer service areas is about $6.8 million, with an equivalent annual cost of about $628,500.

As noted above, alternative plan 2 involves the provision of only one sewage treatment facility to serve the Delavan-Delavan Lake and Elkhorn sewer service areas. Under this alternative, a new Delavan-Delavan Lake treatment facility would be constructed on a site adjacent to the existing City of Delavan facility as in the first alternative presented, but would provide for an average hydraulic design capacity of nearly 4.2 mgd in order to accommodate sewage from both the Delavan-Delavan Lake and Elkhorn sewer service areas. In order to meet the established water use objectives for Turtle Creek, this facility would have to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. In addition to the new trunk sewer to convey sewage from the Delavan sewer service area to the proposed new plant included under alternative plan 1, alternative plan 2 provides for a trunk sewer from the existing Elkhorn sewage treatment facility to the proposed Delavan-Delavan Lake facility. The total estimated capital cost of carrying out alternative plan 2 for the Delavan-Delavan Lake and Elkhorn sewer service areas, including the construction of the necessary trunk sewers, is about $7.4 million, with an equivalent annual cost of about $643,600.

The cost of implementing the two alternative sanitary sewerage system plans considered for the Delavan-Delavan Lake and Elkhorn sewer service areas is within 2 percent on an equivalent annual cost basis, well within the accuracy with which such costs can be estimated. Consequently, the two plans may be considered to have approximately the same cost. It is necessary, therefore, to consider other intangible, but nevertheless very real, considerations in selecting a recommended plan from among the alternatives presented. The second alternative plan has the advantage of providing one sewage treatment facility to serve the Delavan-Delavan Lake and Elkhorn urban areas, which areas are tending to coalesce, and thus avoids proliferation of treatment plants and unnecessary duplication of staffs and related facilities. In addition, the second alternative has the advantage of not discharging any effluent to Jackson Creek above Delavan Lake, thus further contributing to efforts to improve water conditions in Delavan Lake. Also, since the Elkhorn sewage treatment facility must be replaced in the near future in any case, the opportunity to connect to the Delavan-Delavan Lake system is at hand and can readily be accommodated through joint intergovernmental action. Conversely, the first alternative would commit the construction of a new Elkhorn sewage treatment facility above Delavan Lake and thus commit the continued discharge of sewage effluent into the lake for a minimum of 15 to 20 years. On balance, therefore, while the two alternatives are approximately equal in terms of equivalent annual cost, the second alternative plan providing for one sewage treatment facility to serve the Delavan-Delavan Lake, and Elkhorn sewer service areas is more advantageous when other intangible considerations are taken into account.

Alternative Plans—Delavan-Delavan Lake—Darien Subarea

As indicated above, preliminary economic analyses revealed a need to consider the interconnection of the Delavan-Delavan Lake and Darien sewer service areas for sewage treatment purposes. Two basic alternative plans were formulated. The first alternative assumes the construction of a new sewage treatment facility to serve the Delavan and Delavan Lake sewer service areas at a site on Turtle Creek adjacent to the existing City of Delavan treatment facility, together with expansion of the existing Darien facility to accommodate anticipated future urban growth in the Darien sewer service area. The Darien facility under this alternative would continue to discharge effluent to the soil and ground water through a seepage lagoon. The second alternative provides for a single sewage treatment facility to serve both the Delavan-Delavan Lake and Darien sewer service areas, locating the single plant at the site of the proposed Delavan-Delavan Lake sewage treatment facility. The recommended sewage treatment levels and performance standards under both alternatives are set forth in Table 218, while detailed cost estimates pertaining to the two alternatives are set forth in Table 219. The two proposals are shown on Maps 126 and 127.

Under alternative plan 1, a new sewage treatment plant to serve the Delavan and Delavan Lake sewer service areas would be constructed on a site adjacent to the existing City of Delavan treatment facility. In order to accommodate projected future urban growth, it is anticipated that by 1990 an average hydraulic design capacity of about 2.6 mgd will be required for this facility. In order to meet the established water use objectives for Turtle Creek, to which effluent would be discharged, it will be necessary for this facility to provide not only secondary waste treatment but also advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. A new trunk sewer to convey sewage from the Delavan Lake sewer service area to the new treatment plant site is also included in this alternative plan. In addition, under alternative plan 1 the existing sewage treatment facility serving the Village of Darien would be expanded to provide a 1990 average hydraulic design capacity of about 0.6 mgd. This plant is proposed to continue to discharge effluent to a seepage lagoon with no overflow to a drainage course leading to Turtle Creek. It should be noted that the Darien seepage lagoon is located in a general area where soils data indicate sand and gravel deposits at or near the surface and, consequently, where the potential for pollution of the shallow aquifer is high (see Map 18). The continued operation of the Darien seepage lagoon, as proposed under this alternative, should, therefore, be carefully monitored. Should detailed engineering investigations conclude at some future date that soil absorption as a means of effluent disposal is no longer feasible and that discharge to the surface water system is necessary, this facility would need to provide a higher level of waste treatment than secondary waste treatment with auxiliary treatment for effluent disinfection. This alternative plan assumes, then, the continued viability of soil absorption for waste disposal in the Darien area and would have to be reevaluated at such time as this assumption may prove to be no longer valid. The total estimated capital cost of carrying out alternative plan 1 for the Delavan-Delavan Lake and Darien sewer service areas is about $5.5 million, with an equivalent annual cost of about $485,400.

As noted above, alternative plan 2 involves the provision of only one sewage treatment facility to serve the Delavan-Delavan Lake and Darien sewer service areas. Under this alternative, a new

Table 218

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE DELAVAN, DELAVAN LAKE, AND DARIEN SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Delavan (2.63 MGD)	Delavan Delavan Lake	14,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Darien (0.59 MGD)	Darien	2,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Delavan (3.22 MGD)	Delavan Delavan Lake Darien	17,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 126.
Source: SEWRPC.

Delavan-Delavan Lake treatment facility would be constructed on a site adjacent to the existing City of Delavan facility as in the first alternative presented, but would provide an average hydraulic design capacity of about 3.2 mgd in order to accommodate sewage from both the Delavan-Delavan Lake and Darien sewer service areas. In order to meet the established water use objectives for Turtle Creek, to which effluent would be discharged, this facility would have to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. In addition to the new trunk sewer to convey sewage from the Delavan Lake sewer service area to the proposed treatment plant included under alternative plan 1, alternative plan 2 provides for a trunk sewer to connect the Darien sewer service area to the proposed Delavan-Delavan Lake sewage treatment facility. The total estimated capital cost of carrying out alternative plan 2 for the Delavan-Delavan Lake and Darien sewer service areas, including the construction of the necessary trunk sewers, is about \$5.8 million, with an equivalent annual cost of about \$513,800.

The cost of implementing the two alternative sanitary sewerage system plans considered for the Delavan-Delavan Lake and Darien sewer service areas are within 5 percent on an equivalent annual cost basis, well within the accuracy with which such costs may be estimated. Consequently, the two plans may be considered to have approxi-

Table 219

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE DELAVAN, DELAVAN LAKE, AND DARIEN SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA

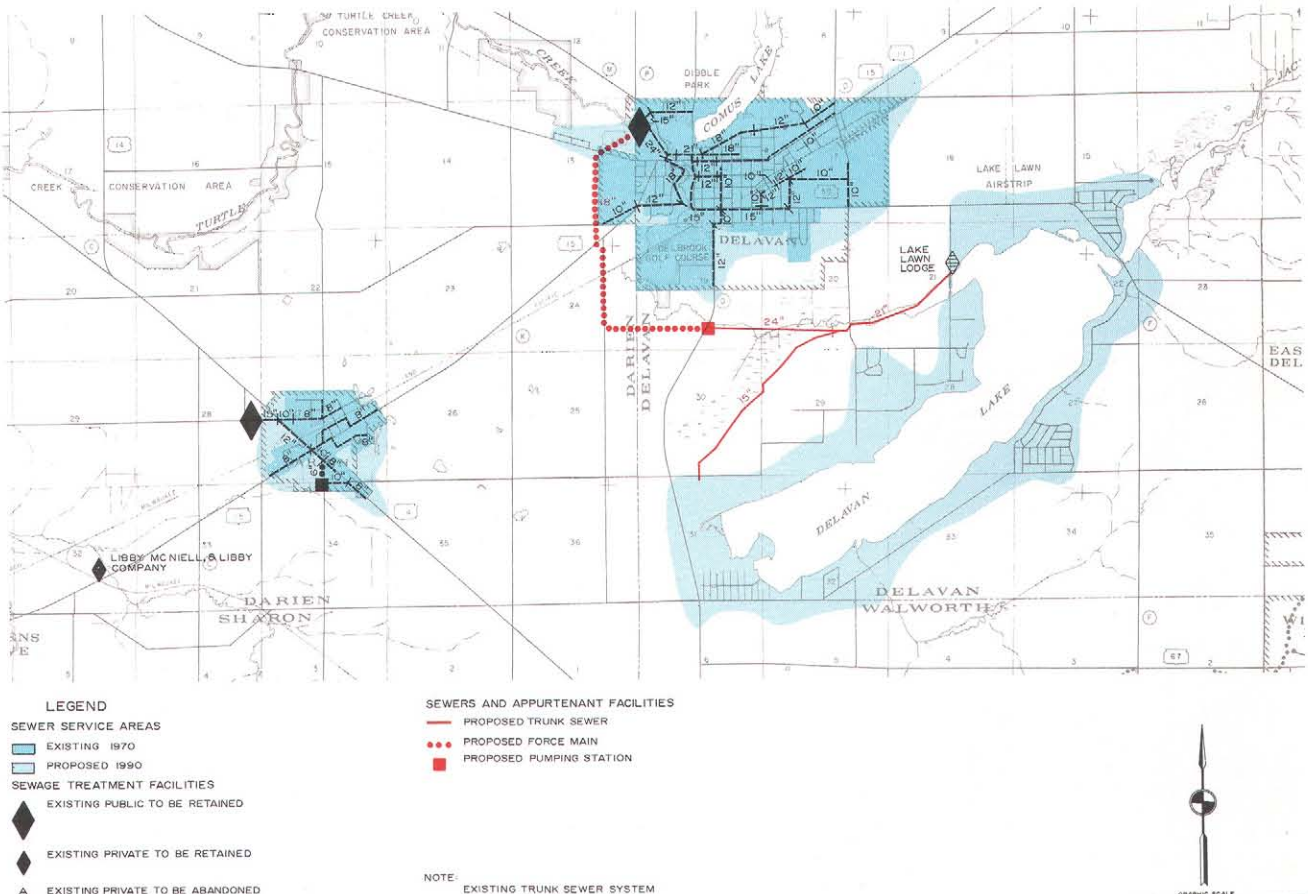
	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
Plan Subelement	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plants							
Delavan							
Facilities (2.63 MGD)	$3,022,700	$2,692,100	$2,428,900	$5,121,000	$170,800	$154,100	$324,900
Land (4.6 Acres)	23,000	17,300	--	17,300	1,100	--	1,100
Subtotal	3,045,700	2,709,400	2,428,900	5,138,300	171,900	154,100	326,000
Darien							
Facilities (0.59 MGD)	702,700	635,200	331,000	966,200	40,300	21,000	61,300
Seepage Lagoons (29.5 Acres)	101,300	91,400	--	91,400	5,800	--	5,800
Land (32.3 Acres)	161,500	118,200	--	118,200	7,500	--	7,500
Subtotal	965,500	844,800	331,000	1,175,800	53,600	21,000	74,600
Subtotal--Treatment Facilities	4,011,200	3,554,200	2,759,900	6,314,100	225,500	175,100	400,600
Trunk Sewer							
Delavan Lake	1,536,200	1,163,300	173,600	1,336,900	73,800	11,000	84,800
Subtotal	1,536,200	1,163,300	173,600	1,336,900	73,800	11,000	84,800
Total	$5,547,400	$4,717,500	$2,933,500	$7,651,000	$299,300	$186,100	$485,400
ALTERNATIVE PLAN 2							
Sewage Treatment Plant							
Delavan							
Facilities (3.22 MGD)	$3,418,200	$3,045,200	$2,794,600	$5,839,800	$193,200	$177,300	$370,500
Land (5.0 Acres)	25,000	18,900	--	18,900	1,200	--	1,200
Subtotal	3,443,200	3,064,100	2,794,600	5,858,700	194,400	177,300	371,700
Trunk Sewers							
Delavan Lake	1,555,900	1,177,500	173,600	1,351,100	74,700	11,000	85,700
Darien	842,300	224,000	665,000	889,000	14,200	42,200	56,400
Subtotal	2,398,200	1,401,500	838,600	2,240,100	88,900	53,200	142,100
Total	$5,841,400	$4,465,600	$3,633,200	$8,098,800	$283,300	$230,500	$513,800

Source: SEWRPC.

mately the same cost. It is necessary, therefore, to consider other intangible, but nevertheless real, considerations in selecting a recommended plan from among the alternatives presented. The second alternative plan has the advantage of providing only one sewage treatment facility to serve the Delavan-Delavan Lake and Darien urban areas, and thus avoids proliferation of treatment plants and unnecessary duplication of staffs and related facilities. This alternative would also eliminate the discharge of sewage effluent to the soil, thus eliminating the potential polluting effects that such effluent might have on the groundwater reservoir. On the other hand, the first alternative has certain advantages concerning the probability of implementation in that sewage treatment facilities would continue to be operated by the two units of government now providing sewer service.

Map 126

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
FOR THE DELAVAN, DELAVAN LAKE, AND DARIEN SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA
1990



One alternative plan for the Delavan, Delavan Lake, and Darien sewer service areas would provide for the construction of a new Delavan treatment facility to serve both the Delavan and Delavan Lake areas, together with the retention of the existing Darien facility, which now discharges effluent to the soil through a seepage lagoon. This alternative plan has a slight cost advantage over the other alternative plan considered, shown on Map 127, primarily because the treatment level requirements for the Darien facility are less stringent due to the utilization of the soil mantle for waste assimilation. Should detailed engineering investigations at some future date conclude that soil absorption as a means of effluent disposal is no longer feasible in the Darien area and conclude that discharge to the surface water system is necessary, the Darien facility would need to provide a higher level of waste treatment than secondary waste treatment.

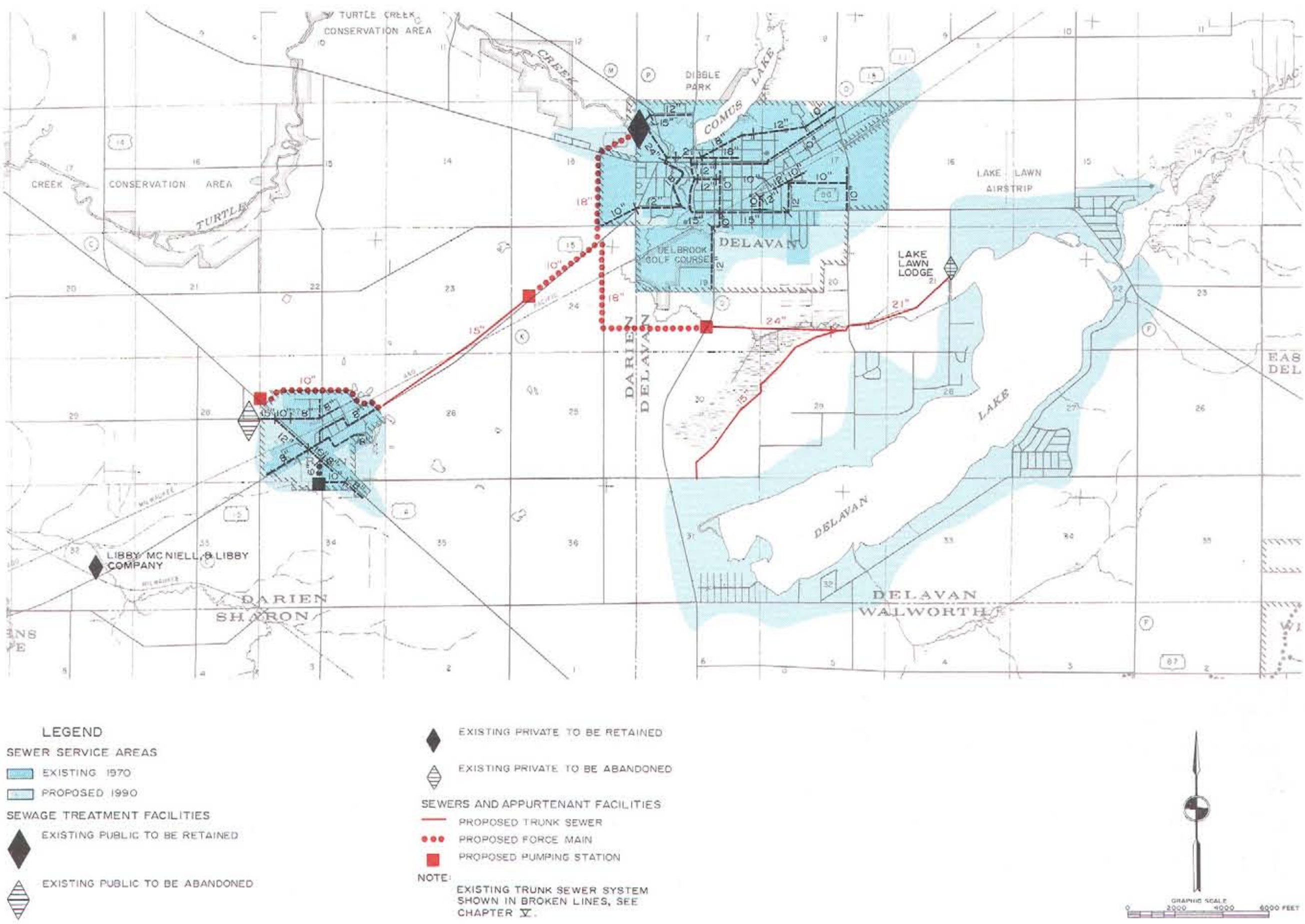
Source: SEWRPC.

Alternative Plans—Fontana-Walworth-Williams Bay Subarea

As indicated above, preliminary economic analyses revealed a need to consider the interconnection of the Fontana, Walworth, and Williams Bay sewer service areas for sewage treatment purposes. Three basic alternative plans were formulated. The first alternative assumes the provision of three individual sewage treatment facilities to serve the three sewer service areas, as is currently the case. The second alternative would provide for consolidation of the Walworth and Fontana treatment facilities at a new Walworth treatment plant site, together with the expansion of the Williams Bay treatment facility. The third alternative provides for a single sewage treatment facility at a new Walworth site to serve all three sewer service areas. The recommended sewage

Map 127

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE DELAVAN, DELAVAN LAKE, AND DARIEN SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA
1990



Another alternative sanitary sewerage system plan considered for the Delavan, Delavan Lake, and Darien sewer service areas provides for the consolidation of sewage treatment at a single new Delavan sewage treatment facility. The trunk sewer system necessary to convey wastes from the Darien sewer service area to the proposed Delavan plant site is shown on the above map. This alternative was found to be slightly more costly than the other alternative considered, as shown on Map 126, primarily because the Darien treatment requirements can be less stringent under the other alternative due to the utilization of the soil mantle for waste assimilation.

Source: SEWRPC.

treatment levels and performance standards under all three alternatives are set forth in Table 220, while detailed cost estimates pertaining to the three alternatives are set forth in Table 221. The three proposals are shown on Maps 128, 129, and 130.

Under alternative plan 1, a new sewage treatment plant to serve the Walworth sewer service area would be constructed on a site located on the Piscasaw Creek, a site already utilized by the Village of Walworth for final effluent treatment flow-through lagoons. As discussed in Chapter V of this report, these lagoons provide for a tertiary level of waste treatment, with secondary waste treatment being provided at a trickling filter-type plant located at the western village limits, which plant was constructed in 1952 and has reached the end of its useful life. In order to accommodate projected future urban growth in the Walworth area, it is anticipated that by 1990 an average hydraulic design capacity of nearly 1.0 mgd will be required for this facility. In order to meet the established water use objectives for Piscasaw Creek, it will be necessary for this facility to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. A new trunk sewer to convey sewage from the existing secondary

Table 220

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE WALWORTH, FONTANA, AND WILLIAMS BAY SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Levels	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
ALTERNATIVE PLAN 1					
Fontana (0.82 MGD)	Fontana	3,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Walworth (0.95 MGD)	Walworth	5,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Williams Bay (1.40 MGD)	Williams Bay	6,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 2					
Walworth (1.77 MGD)	Walworth Fontana	8,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Williams Bay (1.40 MGD)	Williams Bay	6,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ALTERNATIVE PLAN 3					
Walworth (3.17 MGD)	Walworth Fontana Williams Bay	14,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 15 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]See Map 128.

Source: SEWRPC.

Table 221

DETAILED COST ESTIMATES
ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE WALWORTH, FONTANA, AND WILLIAMS BAY SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA

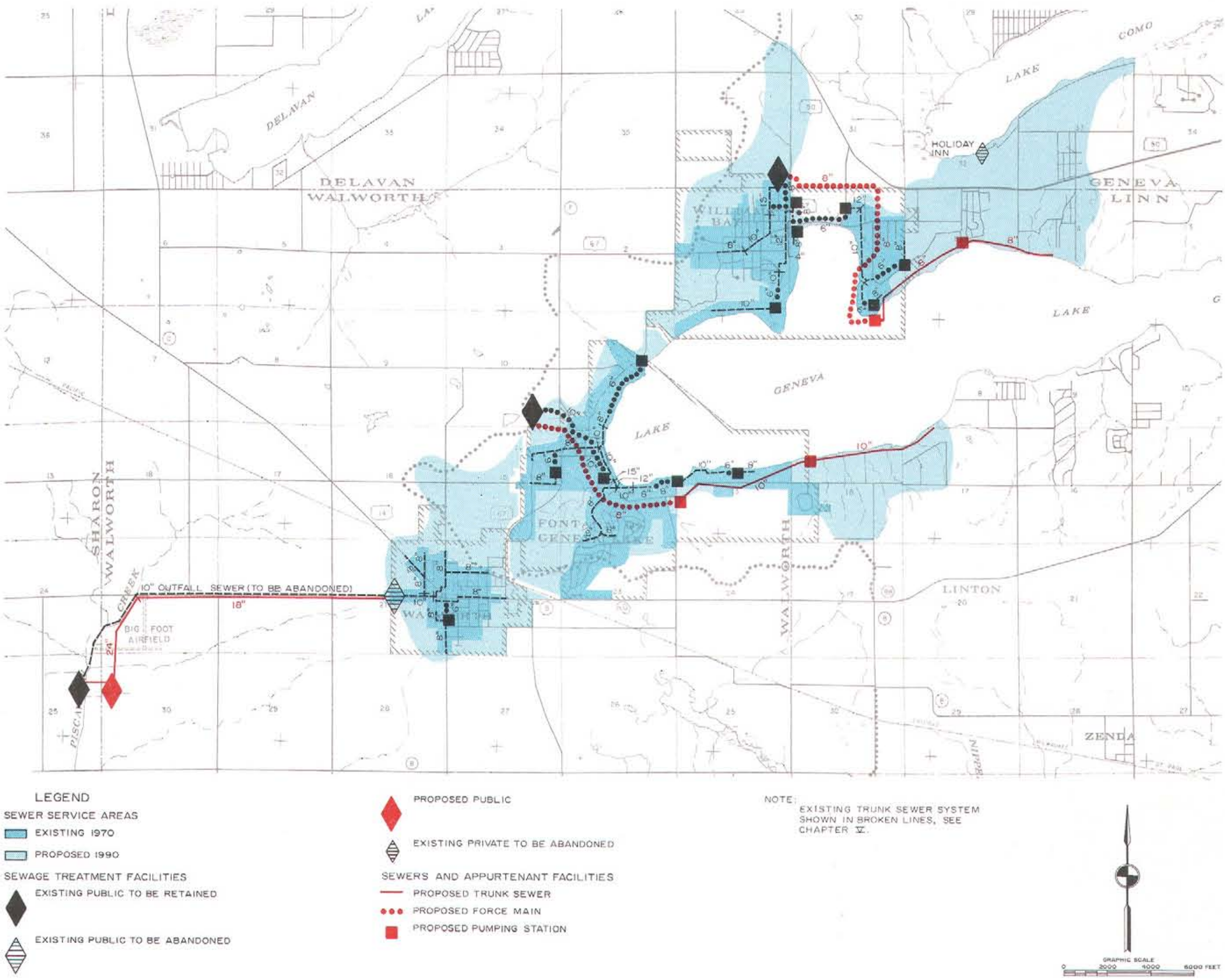
	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
Plan Subelement	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ALTERNATIVE PLAN 1							
Sewage Treatment Plants							
Fontana							
Facilities (0.82 MGD)	$ 895,100	$ 808,600	$ 428,700	$ 1,237,300	$ 51,300	$ 27,200	$ 78,500
Seepage Lagoons (41.0 Acres)	148,500	134,000	--	134,000	8,500	--	8,500
Land (44.2 Acres)	221,000	162,300	--	162,300	10,300	--	10,300
Subtotal	1,264,600	1,104,900	428,700	1,533,600	70,100	27,200	97,300
Walworth							
Facilities (0.95 MGD)	1,284,000	1,173,000	955,000	2,128,000	74,400	60,600	135,000
Land (3.2 Acres)	16,000	11,000	--	11,000	700	--	700
Subtotal	1,300,000	1,184,000	955,000	2,139,000	75,100	60,600	135,700
Williams Bay							
Facilities (1.40 MGD)	431,000	526,000	596,000	1,122,000	33,400	37,800	71,200
Seepage Lagoons (30.5 Acres)	101,300	91,400	--	91,400	5,800	--	5,800
Land (33.4 Acres)	167,000	122,900	--	122,900	7,800	--	7,800
Subtotal	699,300	740,300	596,000	1,336,300	47,000	37,800	84,800
Subtotal — Treatment Facilities	3,263,900	3,029,200	1,979,700	5,008,900	192,200	125,600	317,800
Trunk Sewers							
Fontana-Geneva Lake	2,276,500	1,551,000	9,500	1,560,500	98,400	600	99,000
Williams Bay-Geneva Lake	1,243,800	929,900	104,000	1,033,900	59,000	6,600	65,600
Walworth	296,800	217,500	7,900	225,400	13,800	500	14,300
Subtotal	3,817,100	2,698,400	121,400	2,819,800	171,200	7,700	178,900
Total	$7,081,000	$5,727,600	$2,101,100	$ 7,828,700	$363,400	$133,300	$496,700
ALTERNATIVE PLAN 2							
Sewage Treatment Plants							
Walworth							
Facilities (1.77 MGD)	$2,228,900	$2,014,400	$1,718,100	$ 3,732,500	$127,800	$109,000	$236,800
Land (4.0 Acres)	20,000	14,200	--	14,200	900	--	900
Subtotal	2,248,900	2,028,600	1,718,100	3,746,700	128,700	109,000	237,700
Williams Bay							
Facilities (1.40 MGD)	431,000	526,000	596,000	1,122,000	33,400	37,800	71,200
Seepage Lagoons (30.5 Acres)	101,300	91,400	--	91,400	5,800	--	5,800
Land (33.4 Acres)	167,000	122,900	--	122,900	7,800	--	7,800
Subtotal	699,300	740,300	596,000	1,336,300	47,000	37,800	84,800
Subtotal — Treatment Facilities	2,948,200	2,768,900	2,314,100	5,083,000	175,700	146,800	322,500
Trunk Sewers							
Fontana-Walworth	524,400	408,300	167,100	574,400	25,900	10,600	36,500
Fontana-Geneva Lake	2,259,400	1,681,900	173,400	1,855,300	106,700	11,000	117,700
Williams Bay-Geneva Lake	1,243,800	929,900	104,000	1,033,900	59,000	6,600	65,600
Walworth	364,000	266,000	7,900	273,900	16,900	500	17,400
Subtotal	4,391,600	3,286,100	452,400	3,737,500	208,500	28,700	237,200
Total	$7,339,800	$6,055,000	$2,766,500	$ 8,820,500	$384,200	$175,500	$559,700
ALTERNATIVE PLAN 3							
Sewage Treatment Plant							
Walworth							
Facilities (3.17 MGD)	$3,415,500	$3,086,200	$2,668,500	$ 5,754,700	$195,800	$169,300	$365,100
Land (5.0 Acres)	25,000	18,900	--	18,900	1,200	--	1,200
Subtotal	3,440,500	3,105,100	2,668,500	5,773,600	197,000	169,300	366,300
Trunk Sewers							
Williams Bay-Fontana-Walworth	1,909,600	1,524,200	611,600	2,135,800	96,700	38,800	135,500
Fontana-Geneva Lake	2,259,400	1,681,900	173,400	1,855,300	106,700	11,000	117,700
Williams Bay-Geneva Lake	1,243,800	929,900	104,000	1,033,900	59,000	6,600	65,600
Walworth	396,200	290,000	7,900	297,900	18,400	500	18,900
Subtotal	5,809,000	4,426,000	896,900	5,322,900	280,800	56,900	337,700
Total	$9,249,500	$7,531,100	$3,565,400	$11,096,500	$477,800	$226,200	$704,000

Source: SEWRPC.

level Walworth sewage treatment facility to the Piscasaw Creek site is also included in this alternative plan. In addition, the existing sewage treatment facilities serving the Villages of Fontana and Williams Bay would be expanded to provide for 1990 average hydraulic design capacities of about 0.8 mgd and 1.4 mgd, respectively. These two plants are proposed to continue to discharge effluent into seepage lagoons. It should be noted that the Fontana seepage lagoon is located in a general

Map 128

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN I
FOR THE WALWORTH, FONTANA, AND WILLIAMS BAY SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA
1990



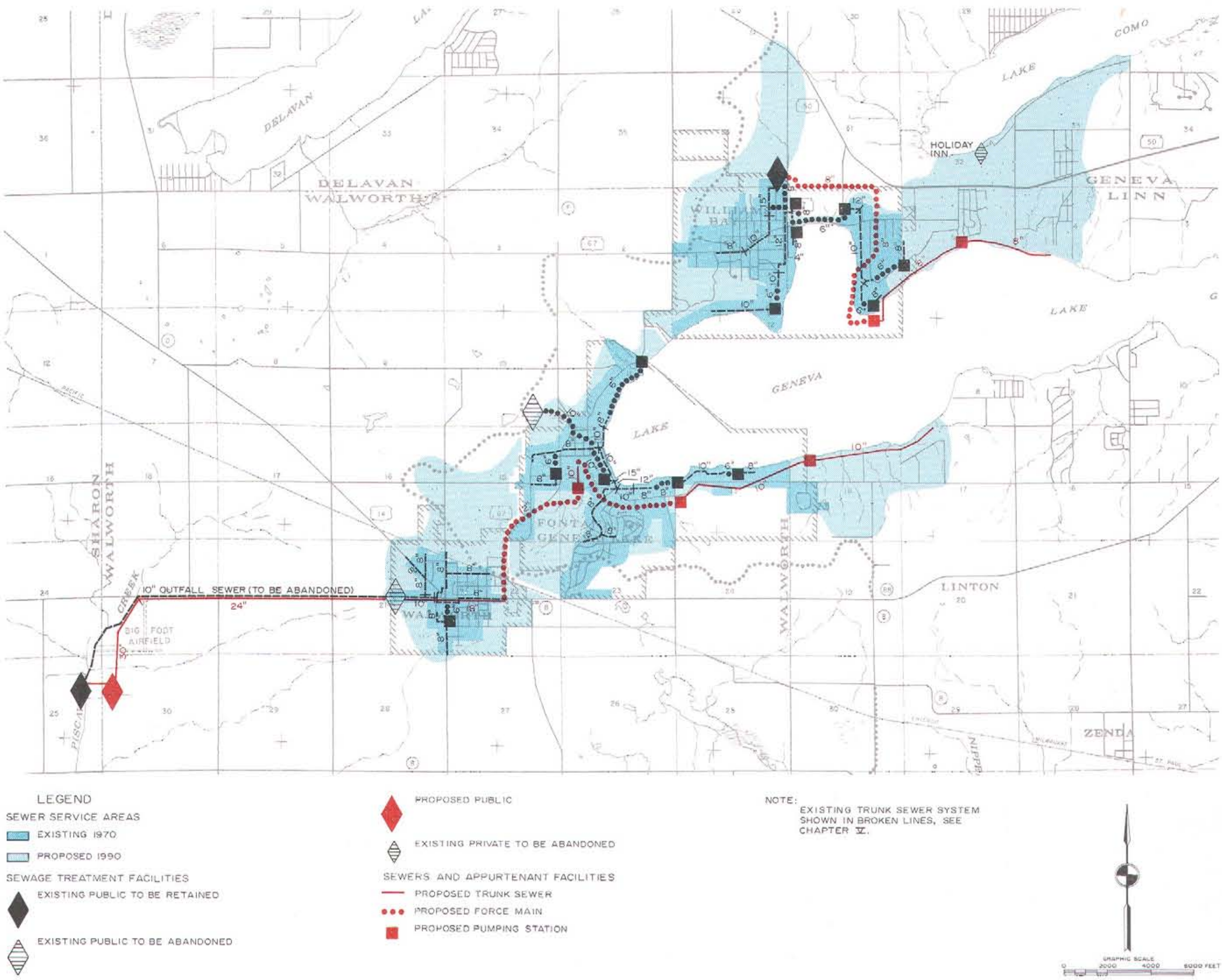
One alternative plan considered for the Walworth, Fontana, and Williams Bay sewer service areas would continue to provide for sewage treatment at three individual facilities as is currently the case. Under this alternative, a new sewage treatment plant would be constructed to serve the Walworth area on a site located on the Piscasaw Creek. The Fontana and Williams Bay facilities would continue to discharge effluent to the soil mantle. The above map shows the trunk sewers necessary to convey wastes from the old Walworth treatment plant site to the new site, as well as from the north and south shores of Lake Geneva to the Williams Bay and Fontana treatment facilities, respectively. This alternative was found to be the least costly alternative available to serve these three areas primarily because utilization of soil absorption for waste disposal precludes the need to provide advanced levels of waste treatment for discharge of effluent to the stream system.

Source: SEWRPC.

area where the potential for pollution of the shallow aquifer is high and that the Williams Bay seepage lagoon is located in a general area where the potential for pollution of the shallow aquifer ranges from high to low (see Map 18). The continued operation of these lagoons, as proposed under this alternative, should, therefore, be carefully monitored. This alternative plan assumes, then, the continued viability of soil absorption for waste disposal in the Fontana and Williams Bay areas, and would have to be reevaluated at such time as this assumption may prove

Map 129

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2
FOR THE WALWORTH, FONTANA, AND WILLIAMS BAY SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA
1990



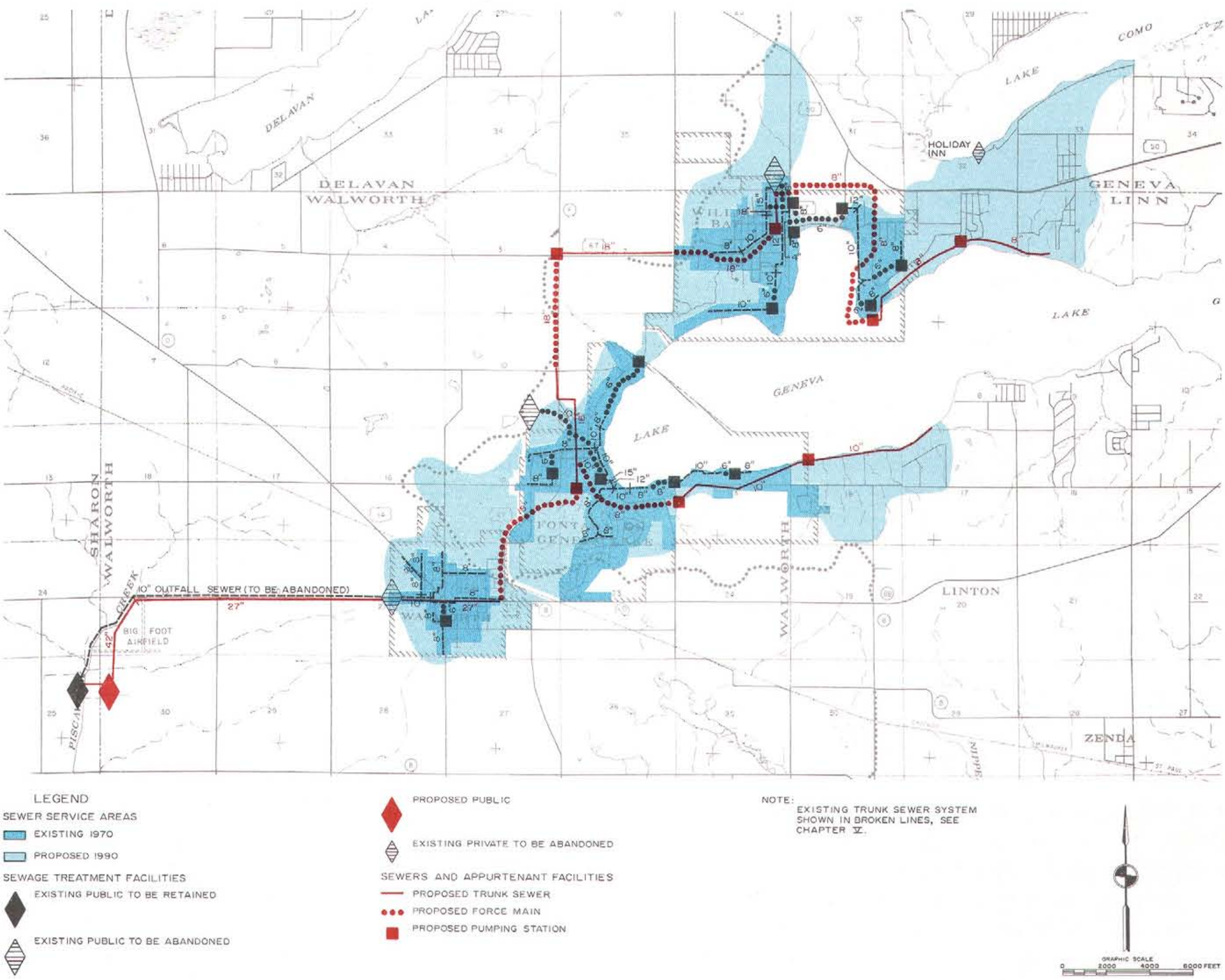
Another alternative considered for the Walworth, Fontana, and Williams Bay sewer service areas would provide partial consolidation of treatment at a proposed new Walworth treatment facility on Piscasaw Creek. Under this alternative the Fontana treatment facility would be abandoned; however, the Williams Bay treatment facility would continue to discharge effluent to the soil. As in the first alternative considered, shown on Map 128, trunk sewers would be provided along the north and south shores of Geneva Lake to serve existing urban development.

Source: SEWRPC.

to be no longer valid. In addition to the foregoing treatment facilities to serve Fontana and Williams Bay, this alternative provides for trunk sewers extending from the Fontana and Williams Bay plants to serve the south and north shores of Geneva Lake, respectively. The total estimated capital cost of carrying out alternative plan 1 for the Fontana, Walworth, and Williams Bay sewer service areas is about \$7.1 million, with an equivalent annual cost of about \$496,700.

Map 130

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 3
FOR THE WALWORTH, FONTANA, AND WILLIAMS BAY SEWER SERVICE AREAS
LOWER ROCK RIVER SUBREGIONAL AREA
1990



A third alternative sanitary sewerage system plan considered for the Walworth, Fontana, and Williams Bay areas provides for total consolidation of treatment in a new Walworth sewage treatment facility proposed to be located on the Piscasaw Creek. Under this alternative the existing Fontana and Williams Bay treatment facilities would be abandoned. All necessary trunk sewers to effect such abandonment and to provide for sewer service along the north and south shores of Lake Geneva are also shown on the map above. This alternative plan was the most costly of the three alternatives considered for this area, primarily because all sewage effluent would be discharged to the stream system and would, therefore, require advanced levels of waste treatment as opposed to the secondary level of waste treatment required under the other alternatives considered, which included effluent disposal to the soil. If at some future date effluent disposal through soil absorption is no longer a viable alternative for Fontana and Williams Bay, the alternative plan shown on the above map would be the most desirable course of action.

Source: SEWRPC.

Alternative plan 2 for the Fontana, Walworth, and Williams Bay sewer service areas is similar to alternative plan 1, except that the Fontana plant would be abandoned and its sewer service area connected to the new Walworth sewage treatment facility on Piscasaw Creek. Under this alternative, the Walworth treatment facility would provide an average hydraulic design capacity of about 1.8 mgd and would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. The Williams Bay facility would provide an average hydraulic design capacity of about 1.4 mgd and would continue to discharge effluent to the soil through a seepage lagoon. Trunk sewers to serve urban development along the shoreline of Geneva Lake and to connect the Fontana and Walworth sewer service areas to the new Piscasaw Creek plant site would also be provided under this alternative. The total estimated capital cost of carrying out alternative plan 2 for the Fontana, Walworth, and Williams Bay sewer service areas is about $7.3 million, with an equivalent annual cost of about $559,700.

The third alternative plan considered for the Fontana, Walworth, and Williams Bay sewer service areas would consolidate all sewage treatment at the proposed Piscasaw treatment plant site. Under this alternative, the Walworth treatment plant would provide an average hydraulic design capacity of about 3.2 mgd and would provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. Trunk sewers to serve urban development along the shorelines of Geneva Lake and to convey sewage from the Williams Bay, Fontana, and Walworth sewer service areas to the Piscasaw Creek plant site are also included under this alternative plan. The total estimated capital cost of carrying out alternative plan 3 for the Fontana, Walworth, and Williams Bay sewer service areas, including the construction of the necessary trunk sewers, is about $9.2 million, with an equivalent annual cost of about $704,000.

The three alternative plans considered thus range in total equivalent annual cost from nearly $497,000 for alternative plan 1, which alternative would provide for the continued operation of three sewage treatment facilities, to about $704,000 for alternative plan 3, which would consolidate treatment at one new facility, reflecting a difference of about 39 percent. This difference is largely due to the fact that treatment requirements under alternative plan 1 are substantially less than that under alternative plan 3 due to the utilization of soil absorption for much of the effluent disposal under alternative plan 1. Clearly, alternative plan 1 is the most cost effective plan for the Fontana, Walworth, and Williams Bay subarea. Should at some future date detailed engineering studies conclude that effluent disposal through soil absorption is no longer a viable alternative in the Fontana and Williams Bay sewer service areas, it would appear that alternative plan 3, providing for centralized sewage treatment at the Piscasaw Creek plant site, would be the most desirable plan available.

Private Sewage Treatment Plants

Four private sewage treatment plants were found in 1970 to discharge wastes in the Lower Rock River subregional area. These facilities serve the Lake Lawn Lodge in the Town of Delavan; the Libby, McNeill, and Libby, Inc., canning plant in the Town of Darien; and the Walworth County Correctional Center and Walworth County Institutions, both in the Town of Geneva. Since 1970 one additional private sewage treatment facility—that serving the Holiday Inn located on the shoreline of Lake Como in the Town of Geneva—has been established. Of these five facilities, two—the Lake Lawn Lodge and Holiday Inn facilities—lie within the proposed 1990 sewer service area and should accordingly be abandoned and connected to the Delavan Lake sanitary sewerage system in the case of the Lake Lawn Lodge facility, and the Williams Bay sanitary sewerage system in the case of the Holiday Inn facility, as trunk sewer service is extended. The remaining three facilities lie beyond the proposed 1990 sewer service areas in the subregional area and must, therefore, continue in operation. These facilities should provide a level of waste treatment adequate to meet the water quality objectives and standards for the receiving stream.

SUMMARY

Plan design, test, and evaluation comprise the very heart of the planning process. This chapter presents the results of the plan design, test, and evaluation phase of the regional sanitary sewerage system planning program in terms of alternative sanitary sewerage system plans for subareas of the seven counties of the Southeastern Wisconsin Region. The various alternative sanitary sewerage system plans considered were designed to meet the established water use objectives and supporting water quality standards set forth in Chapter VIII of this report, and, in addition, to contribute toward implementation of the adopted regional land use plan as presented in Chapter X of this report.

Based upon the state of the art of sanitary sewerage set forth in Chapter IX of this report, and upon previous sewerage system planning experience gained in Commission watershed studies for the Fox and Milwaukee Rivers, it was concluded that major emphasis in the formulation of alternative sanitary sewerage system plans for subareas of the Region should be based upon conventional centralized sanitary sewerage systems providing high degrees of treatment at sewage treatment facilities, with discharge of treated wastes primarily to surface waters. Thus, the basic alternatives considered centered on the provision of advanced waste treatment where necessary to achieve the established water use objectives, with the alternatives differing primarily with respect to the question of whether a given urban subarea of the Region should be served by a single sewage treatment facility or by multiple sewage treatment facilities. This required consideration of alternative trunk sewer arrangements to convey sewage to designated sewage treatment facilities.

While major emphasis was placed in this study on the basic alternative of providing advanced levels of waste treatment at varying treatment plant locations throughout the Region and on the alternative means of conveying sewage to these locations, other concepts of wastewater management, such as the diversion of effluent from one watershed to another, particularly across the subcontinental divide traversing the Southeastern Wisconsin Region, and land disposal of effluent as an alternative to high degrees of waste treatment, were also considered. None of these alternative conceptual solutions to the water quality management problems of the Region were, however, considered viable on a regionwide scale. For example, not only would total sewage effluent diversion within the Region from the Lake Michigan basin to the Mississippi River basin constitute a task of major proportions, involving over 90 percent of all sewage effluent currently discharged within the Region, the cost of diversion of such effluent would almost totally be an "add-on" cost to any of the alternative system plans considered, since the conveyance facilities required to effect such diversion represent an additional cost above and beyond what would be needed to provide sanitary sewer service and adequate sewage treatment if sewage effluent were continued to be discharged in the Lake Michigan basin. Such "add-on" costs were estimated to approximate $140.7 million. Similarly, land disposal of sewage effluent was found to be a waste management concept having many interrelated problems, not the least of which would be the extremely large amount of land needed to successfully dispose of the large volume of waste generated daily within the Region. Depending upon assumptions made for land requirements, the total area required for disposal of sewage effluent by land treatment in the Region varies from about 150 to about 360 square miles, or from about the combined area of four normal sized townships to an area somewhat larger than Racine County. Not only do such land requirements demonstrate the impracticality of applying land disposal of sewage effluent on a large scale throughout the Region, but the soil and geological conditions of the Region render only a small portion of the Region well suited for liquid waste disposal. This is not to say, however, that the waste management concepts of diversion and land disposal may not be practical and applicable for a small, individual community, particularly in the more rural areas of the Region.

In order to formulate alternative sanitary sewerage system plans, the Region was divided into 11 distinct subregional areas based upon natural major watershed divides, the external boundaries of the Region, existing and potential service areas of existing centralized sewerage systems, and existing and probable areas of urban concentration. Eleven such areas were designated (see Map 53): Milwaukee-Metropolitan, Upper Milwaukee River, Sauk Creek, Kenosha-Racine, Root River Canal, Des Plaines River, Upper Fox River, Lower Fox River, Upper Rock River, Middle Rock River, and Lower Rock River. A total of 92 individual sewer service analysis subareas were identified within the 11 designated subregional sewerage system planning areas. The adopted regional land use plan, together with those areas identified as committed to urban development since preparation of the land use plan, were used as the basis for the delineation of the 92 sewer service analysis areas. Once these areas were identified, the process of formulating alternative sewerage system plans could begin. While these 92 sewer service areas comprise the bulk of all existing and proposed urban development in the

Region, additional urban areas identified in the adopted regional land use plan were not included in the recommended sewer service areas. In most cases these areas are very small and consist of clusters of residential and commercial land uses located either along the shorelines of small lakes or at rural highway intersections. These areas were not recommended for sewer service by 1990 because they are very small and isolated from other urban development, because they consist in part of seasonal homes, are located in or adjacent to the Kettle Moraine State Forest where additional urban development should not be encouraged, or are located on soils fairly well suited for the use of onsite soil absorption sewage disposal systems. It is recognized that public health authorities may advise at some future date that centralized sanitary sewer service is needed in one or more of these areas, and it is accordingly recommended that analyses be made at such time of the alternatives that are then available for the provision of sewer service.

A systematic procedure was utilized to eliminate from consideration those alternative sanitary sewerage system plans that were clearly impractical. An initial screening of potential interconnections was made based upon Wisconsin Department of Natural Resources guidelines relating the sewer lengths required for interconnection to the populations of the communities involved. If a potential interconnection was found to be feasible based upon this initial screening, a preliminary economic analysis was performed to provide gross cost estimates of the alternatives available, generally the operation of two individual plants versus the operation of one centralized plant. Any potential interconnection which was found to be feasible after the preliminary economic analysis was included as an alternative plan set forth in this chapter and for which a detailed economic analysis was performed. It should be noted in this respect that both the preliminary screening and the preliminary economic analysis were intentionally biased toward interconnection, so that all practical alternative plans were fully evaluated.

A summary of the alternative sanitary sewerage system plans evaluated in this chapter is set forth in Table 222. A total of 38 alternative sanitary sewerage system plans were fully evaluated. In addition, 28 system plans were prepared for communities in the Region without any interconnection potential. Thus, a total of 66 sanitary sewerage system plans for various subareas of the Region were prepared, costed, and evaluated.

A summary of existing 1970 and planned 1990 sewer service characteristics for the Region are set forth in Table 223. This summary would be applicable no matter which of the alternative sanitary sewerage system plans set forth in this

Table 222

SUMMARY OF ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS PREPARED FOR THE REGION BY SUBREGIONAL AREA

Subregional Area	Number of Sewer Service Subareas Identified	Number of Proposed Sewerage System Plans for Subareas Without Interconnection Potential	Number of Alternative Sewerage System Plans for Subareas With Interconnection Potential
Milwaukee-Metropolitan	13	1[1]	2
Upper Milwaukee River	10	7	2
Sauk Creek	3	1	5
Kenosha-Racine	9	--	5
Root River Canal	2	--	2
Des Plaines River	6	4	2
Upper Fox River	5	--	3[2]
Lower Fox River	18	8	5
Upper Rock River	4	2	2
Middle Rock River	13	3	3
Lower Rock River	9	2	7
Region Total	92	28	38

[1]Represents areawide plan for the Milwaukee-Metropolitan Sewerage District and its contract communities.
[2]Represents alternative plans considered under the Fox River watershed study and incorporated by reference into the regional sanitary sewerage system planning program.

Source: SEWRPC.

chapter may ultimately be selected for the Region, since the population and area served is common to all alternatives. Assuming full implementation of such plans, it is estimated that about 2.6 million persons would be provided with centralized sanitary sewer service in the Region in 1990, or about 97 percent of the total anticipated 1990 regional population of nearly 2.7 million persons. The area proposed to be served by centralized sanitary sewer service is estimated to approximate 675 square miles, or about 25 percent of the 2,689 square mile area of the Region.

The total proposed 1990 sanitary sewer service area of about 675 square miles represents increases of about 458 square miles over the estimated 1963 sewer service area of 217 square miles, and of about 366 square miles over the estimated 1970 sewer service area of 309 square miles (see Chapter V). It is important to recognize that about 123 square miles of the 458 square mile increment in sewer service area proposed to be added between 1963 and 1990 represents urban development that existed in 1963, but was not served with public sewers. The remaining 335 square miles of incremental area is comprised of about 269 square miles of land recommended for urban development in the adopted regional land use plan and included, therefore, in the 1990 urban growth ring, and about 66 square miles of land area developed or committed for urban development during the period 1963 through 1973 and lying adjacent to or beyond the recommended 1990 urban development pattern as reflected in the adopted regional land use plan map (see Chapter V).

It should be further noted that the proposed increment of about 269 square miles in total area developed for urban purposes in the regional land use plan represents a conceptually different, but related, indicator of land proposed for conversion from rural to urban use over the 27-year planning period 1963 through 1990 than the 200 square mile land area increment referred to in Chapter X of this report in a discussion of the regional land use plan. The 200 square mile figure represents the estimated amount of land that would be actually converted from a specific rural to a specific urban land use. The 269 square mile figure refers to the incremental land area that would be included within the proposed 1990 urban growth ring under the adopted regional land use plan and, therefore, includes, in addition to the 200 square miles of actually converted land, about 69 square miles of open space type land—consisting of woodlands, wetlands, and other open lands—that would remain in essentially the same use as in 1963 but would be enveloped by lands actually converted to urban land uses.

Table 223

CENTRALIZED SANITARY SEWER SERVICE CHARACTERISTICS IN THE REGION BY SUBREGIONAL AREA 1970 and 1990

Subregional Area	Existing 1970				Planned 1990			
	Area Served (Square Miles)	Population Served[1]	Average Hydraulic Loading (MGD)	Population Unserved[1]	Area Served (Square Miles)	Population Served[1]	Average Hydraulic Loading (MGD)	Population Unserved[1]
Milwaukee-Metropolitan	207.50	1,096,300	192.00	72,800	347.23	1,730,900	236.16	7,100
Upper Milwaukee River	11.86	35,800	5.29	26,000	26.64	68,600	12.74	9,300
Sauk Creek	2.27	9,600	1.11	3,300	6.86	14,700	3.41	1,800
Kenosha-Racine	46.11	209,400	39.09	17,800	112.86	400,700	84.70	3,000
Root River Canal	0.74	2,800	0.43	7,100	1.73	7,700	1.43	4,800
Des Plaines River	1.95	3,600	0.35	7,600	8.37	8,200	2.41	4,500
Upper Fox River	16.24	58,700	10.69	34,700	72.98	174,800	36.60	2,100
Lower Fox River	7.61	22,800	3.00	52,000	37.57	73,600	13.76	31,900
Upper Rock River	2.23	8,500	1.39	12,600	8.50	15,200	3.99	7,200
Middle Rock River	3.31	13,000	1.97	22,800	29.97	52,400	11.03	6,400
Lower Rock River	9.64	28,200	3.96	10,600	22.25	52,000	12.14	1,600
Region Total	309.46	1,488,700	259.28	267,300	674.96	2,598,800	418.37	79,700

[1]*Does not include seasonal resident population or institutional population served by private sewage treatment facilities.*

Source: SEWRPC.

(This page intentionally left blank)

Chapter XII

RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN

INTRODUCTION

Previous chapters of this report have presented in summary form the basic data essential to sound areawide sanitary sewerage system planning. These have included data on climate; the hydrologic and hydraulic characteristics of the Region's lakes and streams; surface and ground water quality conditions; water use; soil capabilities; the kind, location, and intensity of existing and probable future land uses; population densities; economic activity; existing sanitary sewerage facilities; locally prepared sanitary sewerage facility development plans; and the state-of-the-art of sanitary sewage collection and treatment. Forecasts of future population and economic activity levels, land use, and sewage flows, along with regional sanitary sewerage development objectives, principles, and standards and related engineering design criteria, were also presented as a necessary basis for the preparation and evaluation of alternative sanitary sewerage system plans. The Region was divided into subregional areas for sanitary sewerage system planning purposes, these areas being delineated on the basis of the existing and probable future urban land use pattern and natural watershed boundaries. Finally, a series of alternative sanitary sewerage system plans were presented for public review and evaluation. These alternatives included such broad conceptual approaches as diversion of treated sewage effluent from one major watershed to another and land disposal of treated sewage effluent, in addition to the continued use of conventional centralized sanitary sewerage systems discharging treated effluent to surface waters. Particularly careful consideration was given in the preparation of the alternatives to the level of waste treatment required to achieve the established water use objectives and to the best means of sewering subareas of the Region. A particularly important question addressed with respect to the means of sewerage was whether each subarea of the Region considered could best be served by a single sewage treatment facility or by multiple sewage treatment facilities.

The selection of the best alternative for each subarea of the Region from among the various alternatives considered must be based upon a careful evaluation of many factors, both tangible and intangible. Considerable emphasis in the evaluation of the alternatives, however, was placed upon the accompanying costs, since all of the alternatives presented were designed to meet the established sanitary sewerage system development objectives and, particularly, the established water use objectives. Based upon the evaluations presented in the preceding chapter of this report, a recommended sanitary sewerage system plan for each subarea of the Region is herein recommended for adoption, the recommended plans for each subarea together constituting the recommended regional sanitary sewerage system plan. The final selection of the alternatives for each subarea to be included in the adopted regional sanitary sewerage system plan must ultimately be made by the responsible public officials and not by the planning technicians, although the latter may properly make recommendations based upon evaluation of the engineering, economic, and legal considerations involved. The final plan selection process must, therefore, involve the extensive use of advisory committees, public informational meetings, and formal public hearings as described in Chapter II of this report.

This chapter presents a description of the recommended regional sanitary sewerage system plan as synthesized from the various alternatives considered for each subarea. In addition, this chapter presents a description of certain auxiliary plan elements relating essentially to all of the recommended plan elements for each subarea of the Region, together with an analysis of the economic feasibility of plan implementation. Finally, the chapter analyzes the relationship of the recommended regional sanitary sewerage system plan to potential changes in population and to economic development trends within the Region, changes indicated by the revised year 1990 and new year 2000 population and employment forecasts prepared by the Commission, forecasts which became available as the regional sanitary sewerage system planning program was nearing completion.

It should be noted that the recommended sanitary sewerage system plan presented herein represents, in some cases, a refinement of the most cost effective alternative plan for the subarea as presented in the previous chapter of this report. These refinements consist solely of changes or additions to the trunk sewer networks originally proposed in the alternative plans. Such changes or additions resulted from a review of the best alternative for each subarea by the local public works officials concerned with the construction, maintenance, and operation of the sanitary sewerage system in each subarea.

SEWER SERVICE AREAS

The areas within the Region recommended for sanitary sewer service by the plan design year are shown in graphic form on Map 131. These service areas are based upon the adopted regional land use plan as refined to include certain areas committed to urban development since the preparation of the adopted land use plan which lay beyond the urban area limits originally delineated on the plan. This refinement was based upon analysis of new existing land use inventories conducted by the Commission in 1967 and 1970 since adoption of the regional land use plan.

The designated sanitary sewer service areas are designed to accommodate urban growth within the Region over the next two to three decades. The specific placement of future urban development in both time and space within the broad conceptual framework of the adopted regional land use and regional sanitary sewerage system plans is the responsibility of local public officials. Accordingly, a certain amount of flexibility has been incorporated into the designated sewer service areas to facilitate local implementation. This flexibility derives from the population density ranges, as well as from certain of the engineering design criteria utilized in the plan preparation, and generally permits a broad range of housing types and styles and, therefore, of population densities, and a reasonable range of commercial and industrial land use intensities to be accommodated within the areas designated for future urban use. In some cases, new urban development may be placed in certain areas beyond the limits oft the service areas shown on the recommended plan map and still meet the adopted land use and sanitary sewerage system development objectives, provided that such areas can be served by the rational outward extension of existing gravity drainage sanitary sewerage facilities.

The provision of centralized sanitary sewer service to all of the areas designated for such service on the recommended plan map (Map 131) would result in service being provided to a total area of about 675 square miles, or about 25 percent of the total area of the Region. In 1970 a total area of about 309 square miles, or about 11 percent of the total area of the Region, was served by centralized sanitary sewerage facilities. If the recommended plan is fully implemented, about 2.6 million persons would be provided with centralized sanitary sewer service in the Region by 1990, or about 97 percent of the total anticipated 1990 regional population of nearly 2.7 million persons (see Table 224). It should be noted that the incremental area recommended to be served by sanitary sewerage facilities totals about 366 square miles.[1] This is a considerably smaller area than the total of nearly 450 square miles into which locally proposed plans would extend service by the design year. This reduction in required sewer service area reflects the effect of proper consideration of areawide development objectives and areawide land use and sewerage system plans on the sewerage system planning process.

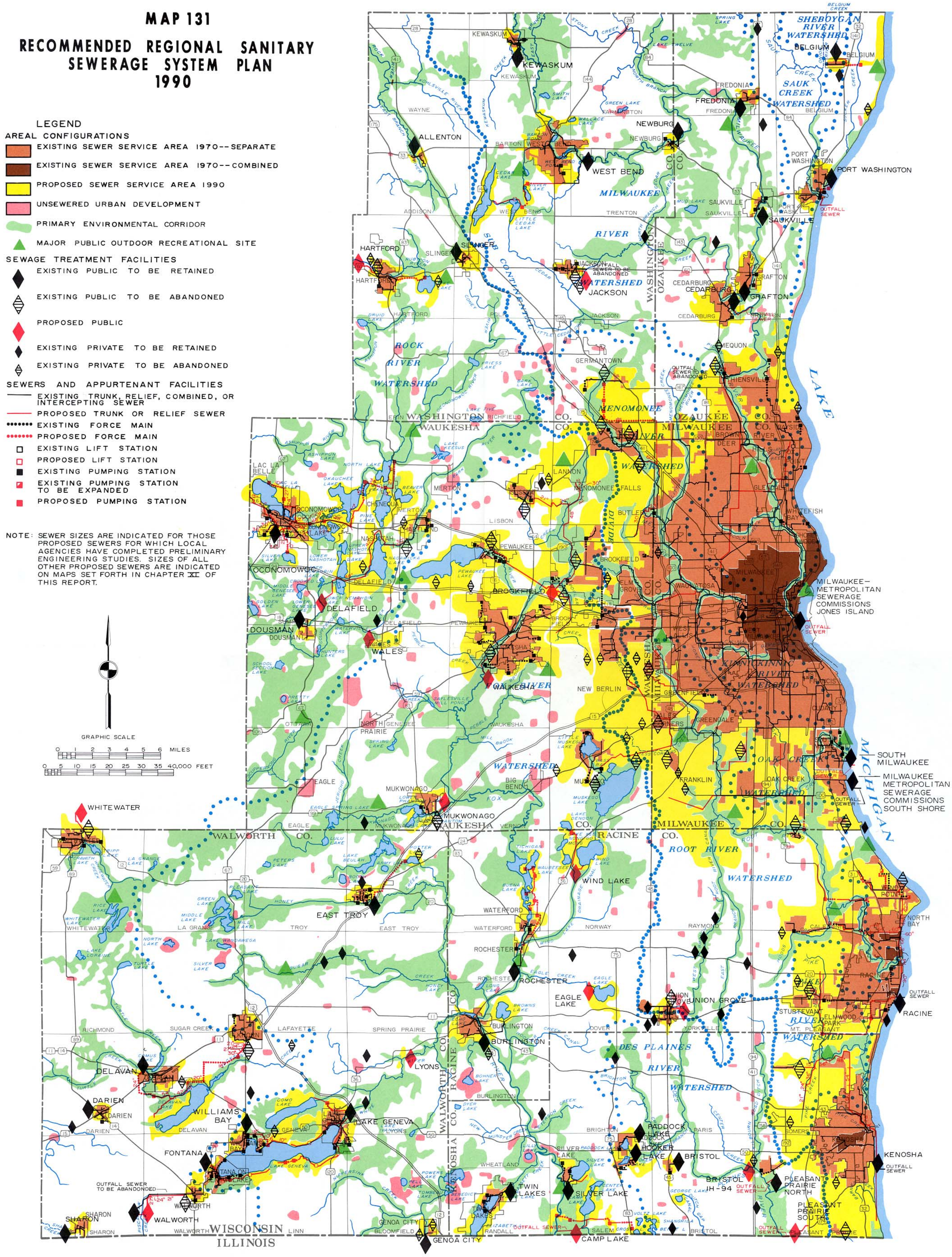
It is important to note that while the regional sanitary sewerage system plan recommends the provision of centralized sanitary sewer service to much of the urban land use pattern recommended in the adopted regional land use plan, some urban areas identified on the land use plan are not included within the recommended 1990 sewer service areas. In most cases these areas are very small, and consist of isolated enclaves of residential and commercial land uses located either along the shorelines of inland lakes or at rural highway intersections. Such areas were not included in a recommended sewer service area for a number of reasons, including the very small size and isolated nature of some of this development; the presence of a significant number of seasonal homes; location in or adjacent to the Kettle Moraine State Forest where additional urban development should not be encouraged; or location on soils generally well suited for the use of onsite soil absorption sewage disposal systems. Should serious public health hazards or a serious ground or surface water pollution problem develop

---

[1] *For a discussion relating this incremental sewer service area to the area recommended for incremental urban development in the regional land use plan, see the subsection of Chapter XI entitled "Summary."*

MAP 131

RECOMMENDED REGIONAL SANITARY SEWERAGE SYSTEM PLAN 1990



Source: SEWRPC.

(This page intentionally left blank)

in any of these areas at some future date and, as a result, centralized sanitary sewer service become necessary, it is recommended that careful engineering and economic analyses be made at that time of the alternatives available for the provision of such service, including careful consideration of connection to any existing sewerage systems located in proximity to the problem area.

SEWAGE TREATMENT FACILITIES

Public

The recommended regional sanitary sewerage system plan proposes to provide treatment for sewage generated in the recommended 1990 sanitary sewer service areas at a total of 52 public sewage treatment facilities. The recommended location of these 52 facilities is shown on Map 131.

In order to meet the established water use objectives and supporting water quality standards for the streams in the Southeastern Wisconsin Region, as well as to meet the recommendations set forth for Lake Michigan by the Lake Michigan Enforcement Conference,[2] the plan recommends that 41 of the 52 public sewage treatment facilities provide advanced waste treatment, and that the remaining 11 plants provide secondary waste treatment. Thus, the provision of advanced waste treatment to achieve the established water use objectives may be considered to constitute the basic water quality management recommendation in the regional sanitary sewerage system plan. In 1970, only three of the 64 existing public sewage treatment facilities provided a level of treatment beyond secondary. Of the remaining 61 facilities, three provided only a primary level of waste treatment, while 58 provided a secondary level of waste treatment.

Full implementation of the recommended regional sanitary sewerage system plan would permit the abandonment of 22 existing public sewage treatment facilities.[3,4] Implementation of the recommended plan would require the construction of 10 new sewage treatment plants within the Region.

[2] *For a discussion of the Lake Michigan Enforcement Conference recommendations, see pp. 302-303 of this report.*

[3] *Four of these 22 treatment facilities were abandoned prior to final publication of this report: the Oakview Subdivision facility in the City of Oak Creek (abandoned in 1971); the Mission Hills facility in the City of Franklin (abandoned in 1973); the County Line facility in the Village of Germantown (abandoned in 1973); and the old Fox River facility in the City of Brookfield (abandoned in 1973).*

[4] *One additional treatment facility--the Northeast District plant in the City of Muskego--has been placed into operation since the sewerage system inventory was completed in 1970. Implementation of the recommended plan will also permit abandonment of this plant.*

Table 224

PUBLIC SANITARY SEWER SERVICE CHARACTERISTICS IN THE REGION BY SUBREGIONAL AREA
EXISTING 1970 AND RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN: 1990

Subregional Area	Existing 1970								Recommended Plan 1990							
	Area Served (Square Miles)	Population						Average Hydraulic Loading (MGD)	Area Served (Square Miles)	Population						Average Hydraulic Loading (MGD)
		Served[1]		Unserved		Total				Served[1]		Unserved		Total		
		Number	Percent	Number	Percent	Number	Percent			Number	Percent	Number	Percent	Number	Percent	
Milwaukee-Metropolitan	207.50	1,096,300	93.8	72,800	6.2	1,169,100	100	192.00	347.23	1,730,900	99.6	7,100	0.4	1,738,000	100	236.16
Upper Milwaukee River	11.86	35,800	57.9	26,000	42.1	61,800	100	5.29	26.64	68,600	88.1	9,300	11.9	77,900	100	12.74
Sauk Creek	2.27	9,600	74.4	3,300	25.6	12,900	100	1.11	6.86	14,700	89.1	1,800	10.9	16,500	100	3.41
Kenosha-Racine	46.11	209,400	92.2	17,800	7.8	227,200	100	39.09	112.86	400,700	99.3	3,000	0.7	403,700	100	84.70
Root River Canal	0.74	2,800	28.3	7,100	71.7	9,900	100	0.43	1.73	7,700	61.6	4,800	38.4	12,500	100	1.43
Des Plaines River	1.95	3,600	32.1	7,600	67.9	11,200	100	0.35	8.37	8,200	64.6	4,500	35.4	12,700	100	2.41
Upper Fox River	16.24	58,700	63.0	34,700	37.0	93,400	100	10.69	72.98	174,800	99.0	2,100	1.0	176,900	100	36.60
Lower Fox River	7.61	22,800	30.5	52,000	69.5	74,800	100	3.00	37.57	73,600	70.0	31,900	30.0	105,500	100	13.76
Upper Rock River	2.23	8,500	40.3	12,600	59.7	21,100	100	1.39	8.50	15,200	68.0	7,200	32.0	22,400	100	3.99
Middle Rock River	3.31	13,000	36.3	22,800	63.7	35,800	100	1.97	29.97	52,400	89.1	6,400	10.9	58,800	100	11.03
Lower Rock River	9.64	28,200	73.0	10,600	27.0	38,800	100	3.96	22.25	52,000	97.0	1,600	3.0	53,600	100	12.14
Region Total	309.46	1,488,700	85.0	267,300	15.0	1,756,000	100	259.28	674.96	2,598,800	97.0	79,700	3.0	2,678,500	100	418.37

[1] *Does not include institutional population serviced by private sewage treatment facilities or seasonal resident population.*

Source: SEWRPC.

Thus, full implementation would result in a net decrease of 12 sewage treatment plants within the Region by the design year.

Recommended sewage treatment levels and performance standards, average hydraulic design capacities, and population levels to be served by 1990 for each of the 52 recommended public sewage treatment facilities in the Region are set forth in Table 225; detailed cost estimates for the recommended construction of new plants and for improvements at existing plants are set forth in Table 226; and a detailed listing of those 22 public sewage treatment facilities proposed to be abandoned upon full implementation of the plan is set forth in Table 227. The following discussion summarizes the public sewage treatment facility recommendations contained in the regional sanitary sewerage system plan by subregional area, as those areas were identified in Chapter XI of this report.

Milwaukee-Metropolitan Subregional Area: The recommended plan proposes that three public sewage treatment facilities serve the Milwaukee-Metropolitan subregional area by 1990. These three facilities are the Jones Island and South Shore treatment plants operated by the Milwaukee-Metropolitan Sewerage Commissions and the South Milwaukee plant operated by the City of South Milwaukee. All three plants are recommended to provide an advanced level of waste treatment for phosphorus removal. Together the three plants are anticipated to serve a total population of over 1.7 million persons by 1990, or about 99 percent of the anticipated 1990 population of this subregional area. The Milwaukee-metropolitan system would constitute by far the single largest and most significant sanitary sewerage system within the Region in 1990, as it did in 1970.

A total of 13 existing public sewage treatment facilities would be abandoned upon full implementation of the recommended sanitary sewerage system plan in the Milwaukee-Metropolitan subregional area. These include the Hales Corners facility, operated by the Milwaukee-Metropolitan Commissions; the Oakview Subdivision facility operated by the City of Oak Creek;[5] the Mission Hills facility in the City of Franklin operated by the Mission Hills Water and Sewer Trust;[6] the Rawson Homes facility in the City of Franklin operated by the Rawson Homes Sewer and Water Trust; the Thiensville facility operated by the Village of Thiensville; the Caddy Vista facility operated by the Caddy Vista Sanitary District in the Town of Caledonia; the Old Village facility operated by the Village of Germantown; the County Line facility operated by the Village of Germantown;[7] the Big Muskego Lake facility operated by the City of Muskego; the Greenridge facility operated by the City of New Berlin; the Regal Manors facility operated by the City of New Berlin; the Pilgrim Road facility operated by the Village of Menomonee Falls; and the Lilly Road facility operated by the Village of Menomonee Falls.[8]

Upper Milwaukee River Subregional Area: The recommended plan proposes that nine public sewage treatment facilities serve the Upper Milwaukee River subregional area by 1990. These nine facilities would be operated by the Cities of Cedarburg and West Bend; the Villages of Fredonia, Grafton, Jackson, Kewaskum, and Saukville; the Newburg Sanitary District in the Towns of Trenton and Saukville;[9] and a proposed sanitary or utility district in the Town of Farmington to serve urban development along the shoreline of Green Lake. The facilities operated by the City of West Bend and the Village of Jackson would be required to provide an advanced level of waste treatment for both phosphorus removal and nitrification; the facilities operated by the City of Cedarburg and the Villages of Grafton, Kewaskum, and Saukville would be required to provide an advanced level of waste treatment for phosphorus removal only; the facility proposed to serve the Green Lake urban area would be required to provide an advanced level of waste treatment for nitrification only; with the remaining facilities serving the Village of Fredonia and the Newburg Sanitary District required to provide a secondary level of waste treatment only. The recommendation to provide advanced waste treatment for

[5] *This facility was abandoned in 1971.*

[6] *This facility was abandoned in 1973.*

[7] *This facility was abandoned in 1973.*

[8] *One additional facility--the Northeast District plant operated by the City of Muskego--which was placed into operation after 1970, the base year of the plan, would also be abandoned.*

[9] *On November 5, 1973, the Newburg Sanitary District was incorporated as the Village of Newburg.*

Table 225

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE REGION
1990

Sewage Treatment Plant (By Subregional Area)	Area(s) Served	Estimated 1990 Average Hydraulic Design Capacity (MGD)	Estimated 1990 Population Served	Recommended Sewage Treatment Level(s)	Type of Sewage Treatment Assumed For Cost Analysis Purposes In Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA						
Milwaukee-Metropolitan Sewerage Commissions--Jones Island Plant	Milwaukee-Metropolitan Sewerage District Mequon Thiensville Germantown Menomonee Falls Butler Brookfield Elm Grove New Berlin Muskego Raymond Caddy Vista	200.0	1,701,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Milwaukee-Metropolitan Sewerage Commissions--South Shore Plant		120.0		Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
South Milwaukee	South Milwaukee	6.0	27,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
UPPER MILWAUKEE RIVER SUBREGIONAL AREA						
Kewaskum	Kewaskum	0.92	3,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
West Bend	West Bend Tri-Lakes	6.10	32,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Jackson	Jackson	0.50	1,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Newburg	Newburg	0.12	1,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Fredonia	Fredonia	0.23	1,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Grafton	Grafton	1.90	10,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Cedarburg[1]	Cedarburg	2.48	14,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Green Lake	Green Lake	0.09	700	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Saukville	Saukville	0.40	2,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

Sewage Treatment Plant (By Subregional Area)	Area(s) Served	Estimated 1990 Average Hydraulic Design Capacity (MGD)	Estimated 1990 Population Served	Recommended Sewage Treatment Level(s)	Type of Sewage Treatment Assumed For Cost Analysis Purposes In Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
SAUK CREEK SUBREGIONAL AREA						
Port Washington	Port Washington	2.60	12,400	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Belgium	Belgium Lake Church	0.81	2,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
KENOSHA-RACINE SUBREGIONAL AREA						
Racine	Racine Crestview-North Park Caledonia Sturtevant-Mt. Pleasant Sanders Park	48.5	220,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Kenosha	Kenosha Parkside Somers Carol Beach	36.2	180,400	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
ROOT RIVER CANAL SUBREGIONAL AREA						
Union Grove	Union Grove Wisconsin Southern Colony	1.88[2]	9,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Wisconsin Southern Colony	Wisconsin Southern Colony	0.40[2]	2,000[3]	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
DES PLAINES RIVER SUBREGIONAL AREA						
Bristol	Bristol-Lake George	0.32	1,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Bristol-IH 94	Bristol-IH 94	0.33	1,600[4]	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Pleasant Prairie-North	Pleasant Prairie-North	0.09	800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Pleasant Prairie-South	Pleasant Prairie-South	0.60	2,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Paddock Lake	Paddock Lake	0.80	3,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Hooker Lake	Hooker-Montgomery Lakes	0.27	1,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml

Table 225 (continued)

Sewage Treatment Plant (By Subregional Area)	Area(s) Served	Estimated 1990 Average Hydraulic Design Capacity (MGD)	Estimated 1990 Population Served	Recommended Sewage Treatment Level(s)	Type of Sewage Treatment Assumed For Cost Analysis Purposes In Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
UPPER FOX RIVER SUBREGIONAL AREA						
Brookfield	Brookfield-New Berlin Lannon-Menomonee Falls Sussex Pewaukee	19.10	91,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Waukesha	Waukesha	17.50	83,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
LOWER FOX RIVER SUBREGIONAL AREA						
Mukwonago	Mukwonago	1.39	7,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
East Troy	East Troy Potter Lake	0.93	4,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Lake Geneva	Lake Geneva Lake Como	2.70	14,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Lyons	Lyons	0.15	700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Genoa City	Genoa City	0.30	1,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Wind Lake	Wind Lake	1.45	6,900	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Eagle Lake	Eagle Lake	0.32	1,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Rochester[5]	Waterford-Rochester Tichigan Lake	1.50	8,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Burlington	Burlington	2.50	15,000	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Silver Lake	Silver Lake	0.71	3,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

Table 225 (continued)

Sewage Treatment Plant (By Subregional Area)	Area(s) Served	Estimated 1990 Average Hydraulic Design Capacity (MGD)	Estimated 1990 Population Served	Recommended Sewage Treatment Level(s)	Type of Sewage Treatment Assumed For Cost Analysis Purposes In Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
SUBREGIONAL AREA LOWER FOX RIVER (Continued)						
Twin Lakes	Twin Lakes	0.75	4,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Camp Lake	Camp-Center Lakes Wilmot Cross Lake Rock Lake	1.06	4,900	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
UPPER ROCK RIVER SUBREGIONAL AREA						
Allenton	Allenton	0.36	1,700	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Slinger	Slinger	0.67	3,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Hartford	Hartford Pike Lake	2.96	10,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
MIDDLE ROCK RIVER SUBREGIONAL AREA						
Merton	Merton	0.38	1,700	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Wales	Wales	0.23	1,100	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Dousman	Dousman	0.46	2,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Oconomowoc	Oconomowoc-Lac LaBelle Oconomowoc Lake Okauchee Lake North Lake Pine Lake Beaver Lake Silver Lake	6.16	29,300	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Delafield	Hartland Delafield-Nashotah Nashotah-Nemahbin Lakes	3.80	18,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml

Table 225 (continued)

Sewage Treatment Plant (By Subregional Area)	Area(s) Served	Estimated 1990 Average Hydraulic Design Capacity (MGD)	Estimated 1990 Population Served	Recommended Sewage Treatment Level(s)	Type of Sewage Treatment Assumed For Cost Analysis Purposes In Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
LOWER ROCK RIVER SUBREGIONAL AREA						
Whitewater	Whitewater	3.66	15,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Sharon	Sharon	0.55	2,600	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1.5 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Delavan	Delavan Delavan Lake Elkhorn	4.17	22,700	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Darien	Darien	0.59	2,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Fontana	Fontana	0.82	3,100	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Walworth	Walworth	0.95	5,200	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
					Phosphorus Removal	Phosphorus Discharge: 1 mg/l
				Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
					Disinfection	Fecal Coliform Concentration: 200/100 ml
Williams Bay	Williams Bay	1.40	6,500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
				Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml

[1]Assumes the construction of an outfall sewer from the existing Cedarburg sewage treatment plant to the Milwaukee River.

[2]Under the recommended plan, the Union Grove sewage treatment plant would provide secondary waste treatment and advanced waste treatment for phosphorus removal for the influent sewage from the Union Grove sewer service area (1.43 MGD) and advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection for the influent sewage from both the Union Grove and Wisconsin Southern Colony sewer service areas (1.88 MGD).

[3]Equivalent population based on projected institutional waste flow of 0.40 MGD.

[4]Population equivalent based on a projected industrial-commercial waste loading of 0.33 MGD.

[5]Plant operated by the Western Racine County Sewerage District.

Source: SEWRPC.

phosphorus removal at Cedarburg is coupled with a recommendation to construct an outfall sewer from the existing plant site to the Milwaukee River to avoid the need to provide for additional advanced waste treatment for nitrification at the Cedarburg plant site. The West Bend sewage treatment facility is recommended to serve not only the City of West Bend and environs but also urban development along the shorelines of Big Cedar, Little Cedar, and Silver Lakes as initially

Table 226

DETAILED COST ESTIMATES FOR SEWAGE TREATMENT PLANTS
RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE REGION
1990

Sewage Treatment Plant (By Subregional Area)	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA							
Milwaukee-Metropolitan Sewerage Commissions Jones Island Plant							
Facilities (200.0 MGD)	$ --	$ 8,689,600	$ 65,309,800	$ 73,999,400	$ 551,300	$ 4,143,500	$ 4,694,800
Outfall Sewer	2,632,500	1,929,300	--	1,929,300	122,400	--	122,400
Subtotal	2,632,500	10,618,900	65,309,800	75,928,700	673,700	4,143,500	4,817,200
Milwaukee Metropolitan Sewerage Commissions-- South Shore Plant							
Facilities (120.0 MGD)	26,865,000	25,805,500	40,057,500	65,863,000	1,637,200	2,541,400	4,178,600
South Milwaukee							
Facilities (6.0 MGD)	1,668,000	1,862,000	3,199,700	5,061,700	118,300	203,000	321,300
Outfall Sewer	270,000	198,600	--	198,600	12,600	--	12,600
Subtotal	1,938,000	2,060,600	3,199,700	5,260,300	130,900	203,000	333,900
Subregional Area Subtotal	$ 31,435,500	$ 38,485,000	$108,567,000	$147,052,000	$2,441,800	$ 6,887,900	$ 9,329,700
UPPER MILWAUKEE RIVER SUBREGIONAL AREA							
Kewaskum							
Facilities (0.92 MGD)	$ 1,037,000	$ 935,000	$ 872,000	1,807,000	$ 59,500	$ 55,500	$ 115,000
Land (3.3 Acres)	16,500	12,100	--	12,100	800	--	800
Subtotal	1,053,500	947,100	872,000	1,819,100	60,300	55,500	115,800
West Bend							
Facilities (6.10 MGD)	2,620,400	3,609,100	6,008,000	9,617,100	228,700	407,300	636,000
Land (5.4 Acres)	27,000	27,000	--	27,000	1,700	--	1,700
Subtotal	2,647,400	3,636,100	6,008,000	9,644,100	230,400	407,300	637,700
Jackson							
Facilities (0.50 MGD)	824,100	1,016,400	1,210,500	2,226,900	64,400	76,700	141,100
Land (2.8 Acres)	14,000	14,000	--	14,000	900	--	900
Subtotal	838,100	1,030,400	1,210,500	2,240,900	65,300	76,700	142,000
Newburg							
Facilities (0.12 MGD)	$ 98,400	$ 140,000	$ 229,000	$ 369,000	$ 8,900	$ 14,500	$ 23,400
Land (1.8 Acres)	9,000	9,000	--	9,000	600	--	600
Subtotal	107,400	149,000	229,000	378,000	9,500	14,500	24,000
Fredonia							
Facilities (0.23 MGD)	146,600	212,600	333,800	546,400	13,500	21,200	34,700
Land (2.1 Acres)	10,500	11,000	--	11,000	700	--	700
Subtotal	157,100	223,600	333,800	557,400	14,200	21,200	35,400
Grafton							
Facilities (1.90 MGD)	654,800	734,500	1,453,300	2,187,800	46,600	92,200	138,800
Land (3.2 Acres)	16,000	11,000	--	11,000	700	--	700
Subtotal	670,800	745,500	1,453,300	2,198,800	47,300	92,200	139,500
Cedarburg							
Facilities (2.48 MGD)	898,300	1,296,300	2,723,200	4,019,500	82,200	172,800	255,000
Outfall Sewer	261,100	261,400	8,500	269,900	16,600	500	17,100
Land (3.7 Acres)	18,500	18,500	--	18,500	1,200	--	1,200
Subtotal	1,177,900	1,576,200	2,731,700	4,307,900	100,000	173,300	273,300
Green Lake							
Facilities (0.09 MGD)	45,900	41,000	44,100	85,100	2,600	2,800	5,400
Land (6.6 Acres)	33,000	23,600	--	23,600	1,500	--	1,500
Subtotal	78,900	64,600	44,100	108,700	4,100	2,800	6,900
Saukville							
Facilities (0.40 MGD)	176,600	284,600	530,700	815,300	18,000	33,700	51,700
Land (2.2 Acres)	11,000	11,000	--	11,000	700	--	700
Subtotal	187,600	295,600	530,700	826,300	18,700	33,700	52,400
Subregional Area Subtotal	$ 6,918,700	$ 8,668,100	$ 13,413,100	$ 22,081,200	$ 549,800	$ 877,200	$ 1,427,000

Table 226 (continued)

Sewage Treatment Plant (By Subregional Area)	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
SAUK CREEK SUBREGIONAL AREA							
Port Washington							
Facilities (2.60 MGD)	$ 892,000	$ 999,300	$ 1,825,200	$ 2,824,500	$ 63,400	$ 115,800	$ 179,200
Outfall Sewer	908,000	848,000	157,600	1,005,600	53,800	10,000	63,800
Land (3.8 Acres)	19,000	14,000	--	14,000	900	--	900
Subtotal	1,819,000	1,861,300	1,982,800	3,844,100	118,100	125,800	243,900
Belgium							
Facilities (0.81 MGD)	1,282,500	1,158,500	586,300	1,744,800	73,500	37,200	110,700
Land (3.1 Acres)	15,500	11,000	--	11,000	600	--	600
Subtotal	1,298,000	1,169,500	586,300	1,755,800	74,100	37,200	111,300
Subregional Area Subtotal	$ 3,117,000	$ 3,030,800	$ 2,569,100	$ 5,599,900	$ 192,200	$ 163,000	$ 355,200
KENOSHA-RACINE SUBREGIONAL AREA							
Racine							
Facilities (48.5 MGD)	$ 11,600,000	$ 11,806,000	$ 22,619,000	$ 34,425,000	$ 749,000	$ 1,435,000	$ 2,184,000
Land (13 Acres)	975,000	728,000	--	728,000	46,200	--	46,200
Subtotal	12,575,000	12,534,000	22,619,000	35,153,000	795,200	1,435,000	2,230,200
Kenosha							
Facilities (36.2 MGD)	4,200,000	5,391,000	17,527,000	22,918,000	342,000	1,112,000	1,454,000
Land (14 Acres)	140,000	99,000	--	99,000	6,300	--	6,300
Subtotal	4,340,000	5,490,000	17,527,000	23,017,000	348,300	1,112,000	1,460,300
Subregional Area Subtotal	$ 16,915,000	$ 18,024,000	$ 40,146,000	$ 58,170,000	$1,143,500	$ 2,547,000	$ 3,690,500
ROOT RIVER CANAL SUBREGIONAL AREA							
Union Grove							
Facilities (1.43 MGD & 1.88 MGD)[1]	$ 2,092,500	$ 1,889,900	$ 1,435,900	$ 3,325,800	$ 119,900	$ 91,100	$ 211,000
Land (4 Acres)	20,000	14,200	--	14,200	900	--	900
Subtotal	2,112,500	1,904,100	1,435,900	3,340,000	120,800	91,100	211,900
Wisconsin Southern Colony							
Facilities (0.40 MGD)	--	85,100	285,300	370,400	5,400	18,100	23,500
Subtotal	--	85,100	285,300	370,400	5,400	18,100	23,500
Subregional Area Subtotal	$ 2,112,500	$ 1,989,200	$ 1,721,200	$ 3,710,400	$ 126,200	$ 109,200	$ 235,400
DES PLAINES RIVER SUBREGIONAL AREA							
Bristol							
Facilities (0.32 MGD)	$ 589,000	$ 545,000	$ 478,000	$ 1,023,000	$ 34,600	$ 30,300	$ 64,900
Land (2.4 Acres)	12,000	8,800	--	8,800	600	--	600
Subtotal	601,000	553,800	478,000	1,031,800	35,200	30,300	65,500
Bristol-IH 94							
Facilities (0.33 MGD)	496,100	448,300	276,200	724,500	28,400	17,500	45,900
Land (2.5 Acres)	12,500	9,500	--	9,500	600	--	600
Subtotal	508,600	457,800	276,200	734,000	29,000	17,500	46,500
Pleasant Prairie--North							
Facilities (0.09 MGD)	--	20,500	53,600	74,100	1,300	3,400	4,700
Outfall Sewer	87,100	63,000	1,600	64,600	4,000	100	4,100
Subtotal	87,100	83,500	55,200	138,700	5,300	3,500	8,800
Pleasant Prairie--South							
Facilities (0.60 MGD)	905,200	818,000	687,200	1,505,200	51,900	43,600	95,500
Land (3.0 Acres)	15,000	11,000	--	11,000	700	--	700
Outfall Sewer	70,900	52,000	3,200	55,200	3,300	200	3,500
Subtotal	991,100	881,000	690,400	1,571,400	55,900	43,800	99,700
Paddock Lake							
Facilities (0.80 MGD)	766,000	774,000	922,000	1,696,000	49,100	58,500	107,600
Land (2.9 Acres)	14,500	10,600	--	10,600	700	--	700
Subtotal	780,500	784,600	922,000	1,706,600	49,800	58,500	108,300
Hooker Lake							
Facilities (0.27 MGD)	204,000	249,000	308,000	557,0a0	15,800	19,400	35,200
Land (2.3 Acres)	11,500	8,400	--	8,400	500	--	500
Subtotal	215,500	257,400	308,000	565,400	16,300	19,400	35,700
Subregional Area Subtotal	$ 3,183,800	$ 3,018,100	$ 2,729,800	$ 5,747,900	$ 191,500	$ 173,000	$ 364,500

Sewage Treatment Plant (By Subregional Area)	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
UPPER FOX RIVER SUBREGIONAL AREA							
Brookfield							
Facilities (19.1 MGD)	$ 14,178,000	$ 10,482,000	$ 8,811,000	$ 19,293,000	$ 665,000	$ 559,000	$ 1,224,000
Land (17.0 Acres)	82,500	60,500	--	60,500	3,800	--	3,800
Subtotal	14,260,500	10,542,500	8,811,000	19,353,500	668,800	559,000	1,227,800
Waukesha							
Facilities (17.5 MGD)	12,990,300	9,602,200	8,073,300	17,675,500	609,200	512,200	1,121,400
Land (16.5 Acres)	85,000	62,300	--	62,300	4,000	--	4,000
Subtotal	13,075,300	9,664,500	8,073,300	17,737,800	613,200	512,200	1,125,400
Subregional Area Subtotal	$ 27,335,800	$ 20,207,000	$ 16,884,300	$ 37,091,300	$1,282,000	$ 1,071,200	$ 2,353,200

LOWER FOX RIVER SUBREGIONAL AREA							
Mukwonago							
Facilities (1.39 MGD)	$ 1,861,700	$ 1,681,800	$ 1,257,800	$ 2,939,600	$ 106,700	$ 79,800	$ 186,500
Land (3.6 Acres)	18,000	12,600	--	12,600	800	--	800
Subtotal	1,879,700	1,694,400	1,257,800	2,952,200	107,500	79,800	187,300
East Troy							
Facilities (0.93 MGD)	1,435,700	1,297,200	961,500	2,258,700	82,300	61,000	143,300
Land (3.2 Acres)	16,000	11,800	--	11,800	800	--	800
Subtotal	1,451,700	1,309,000	961,500	2,270,500	83,100	61,000	144,100
Lake Geneva							
Facilities (2.70 MGD)	3,119,900	2,818,200	2,211,400	5,029,600	178,800	140,300	319,100
Land (4.7 Acres)	23,500	17,300	--	17,300	1,100	--	1,100
Subtotal	3,143,400	2,835,500	2,211,400	5,046,900	179,900	140,300	320,200
Lyons							
Facilities (0.15 MGD)	71,600	64,600	67,800	132,400	4,100	3,200	7,300
Land (7.7 Acres)	38,500	28,400	--	28,400	1,800	--	1,800
Subtotal	110,100	93,000	67,800	160,800	5,900	3,200	9,100
Genoa City							
Facilities (0.30 MGD)	172,800	156,000	80,400	236,400	9,900	5,100	15,000
Land (2.2 Acres)	12,500	9,500	--	9,500	600	--	600
Subtotal	185,300	165,500	80,400	245,900	10,500	5,100	15,600
Wind Lake							
Facilities (1.45 MGD)	1,989,900	1,798,400	1,765,300	3,563,700	114,100	112,000	226,100
Land (3.7 Acres)	18,500	14,200	--	14,200	900	--	900
Subtotal	2,008,400	1,812,600	1,765,300	3,577,900	115,000	112,000	227,000
Eagle Lake							
Facilities (0.32 MGD)	135,000	122,200	64,600	186,800	7,750	4,100	11,850
Land (11.3 Acres)	56,500	41,000	--	41,000	2,600	--	2,600
Subtotal	191,500	163,200	64,600	227,800	10,350	4,100	14,450
Rochester[2]							
Facilities (1.50 MGD)	1,191,600	1,112,800	1,104,900	2,217,700	70,600	70,100	140,700
Land (3.3 Acres)	16,500	12,600	--	12,600	800	--	800
Subtotal	1,208,100	1,125,400	1,104,900	2,230,300	71,400	70,100	141,500
Burlington							
Facilities (2.50 MGD)	1,524,000	1,377,600	1,504,000	2,881,600	87,400	126,400	213,800
Land (3.8 Acres)	19,000	14,200	--	14,200	900	--	900
Subtotal	1,543,000	1,391,800	1,504,000	2,895,800	88,300	126,400	214,700
Silver Lake							
Facilities (0.71 MGD)	649,600	614,700	556,400	1,171,100	39,000	35,300	74,300
Land (3.0 Acres)	15,000	11,000	--	11,000	700	--	700
Subtotal	664,600	625,700	556,400	1,182,100	39,700	35,300	75,000
Twin Lakes							
Facilities (0.75 MGD)	743,900	698,300	126,100	824,400	44,300	8,000	52,300
Land (None)	--	--	--	--	--	--	--
Subtotal	743,900	698,300	126,100	824,400	44,300	8,000	52,300
Camp Lake							
Facilities (1.06 MGD)	1,107,700	1,000,900	1,018,200	2,019,100	63,500	64,600	128,100
Outfall Sewer	171,200	126,100	3,200	129,300	8,000	200	8,200
Land (3.3 Acres)	16,500	12,600	--	12,600	800	--	800
Subtotal	1,295,400	1,139,600	1,021,400	2,161,000	72,300	64,800	137,100
Subregional Area Subtotal	$ 14,425,100	$ 13,054,000	$ 10,721,600	$ 23,775,600	$ 828,250	$ 710,100	$ 1,538,350

Table 226 (continued)

Sewage Treatment Plant (By Subregional Area)	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
UPPER ROCK RIVER SUBREGIONAL AREA							
Allenton							
Facilities (0.36 MGD)	$ 166,500	$ 147,000	$ 73,000	$ 220,000	$ 9,300	$ 4,600	$ 13,900
Land (11 Acres)	55,000	40,300	--	40,300	2,600	--	2,600
Subtotal	221,500	187,300	73,000	260,300	11,900	4,600	16,500
Slinger							
Facilities (0.67 MGD)	1,095,000	999,000	749,000	1,748,000	63,400	47,500	110,900
Land (2.9 Acres)	14,500	10,600	--	10,600	700	--	700
Subtotal	1,109,500	1,009,600	749,000	1,758,600	64,100	47,500	111,600
Hartford							
Facilities (2.96 MGD)	3,318,300	2,997,900	2,572,400	5,570,300	190,200	163,200	353,400
Land (4.9 Acres)	24,500	17,300	--	17,300	1,100	--	1,100
Subtotal	3,342,800	3,015,200	2,572,400	5,587,600	191,300	163,200	354,500
Subregional Area Subtotal	$ 4,673,800	$ 4,212,100	$ 3,394,400	$ 7,606,500	$ 267,300	$ 215,300	$ 482,600
MIDDLE ROCK RIVER SUBREGIONAL AREA							
Merton							
Facilities (0.38 MGD)	$ 228,000	$ 207,000	$ 225,000	$ 432,000	$ 13,100	$ 14,300	$ 27,400
Land (12 Acres)	60,000	44,200	--	44,200	2,800	--	2,800
Subtotal	288,000	251,200	225,000	476,200	15,900	14,300	30,200
Wales							
Facilities (0.23 MGD)	152,000	137,000	167,000	304,000	8,700	10,600	19,300
Land (9.0 Acres)	45,000	33,100	--	33,100	2,100	--	2,100
Subtotal	197,000	170,100	167,000	337,100	10,800	10,600	21,400
Dousman							
Facilities (0.46 MGD)	552,400	498,100	260,100	758,200	31,600	16,500	48,100
Land (2.6 Acres)	13,000	9,500	--	9,500	600	--	600
Subtotal	565,400	507,600	260,100	767,700	32,200	16,500	48,700
Oconomowoc							
Facilities (6.16 MGD)	5,731,000	5,160,000	4,640,000	9,800,000	327,300	294,600	621,900
Land (7.0 Acres)	35,000	25,200	--	25,200	1,600	--	1,600
Subtotal	5,766,000	5,185,200	4,640,000	9,825,200	328,900	294,600	623,500
Delafield							
Facilities (3.80 MGD)	4,010,000	3,620,000	3,140,000	6,760,000	230,000	199,000	429,000
Land (5.6 Acres)	28,000	20,500	--	20,500	1,300	--	1,300
Subtotal	4,038,000	3,640,500	3,140,000	6,780,500	231,300	199,000	430,300
Subregional Area Subtotal	$ 10,854,400	$ 9,754,600	$ 8,432,100	$ 18,186,700	$ 619,100	$ 535,000	$ 1,154,100
LOWER ROCK RIVER SUBREGIONAL AREA							
Whitewater							
Facilities (3.66 MGD)	$ 3,911,000	$ 3,533,800	$ 3,177,600	$ 6,711,400	$ 224,200	$ 201,600	$ 425,800
Land (5.4 Acres)	27,000	20,500	--	20,500	1,300	--	1,300
Subtotal	3,938,000	3,554,300	3,177,600	6,731,900	225,500	201,600	427,100
Sharon							
Facilities (0.55 MGD)	880,000	818,000	680,000	1,498,000	52,000	43,200	95,200
Land (2.8 Acres)	14,000	11,000	--	11,000	700	--	700
Subtotal	894,000	829,000	680,000	1,509,000	52,700	43,200	95,900
Delavan							
Facilities (4.17 MGD)	4,305,200	3,890,100	3,313,200	7,203,300	246,800	210,200	457,000
Land (5.7 Acres)	28,500	20,500	--	20,500	1,300	--	1,300
Subtotal	4,333,700	3,910,600	3,313,200	7,223,800	248,100	210,200	458,300
Darien							
Facilities (0.59 MGD)	702,700	635,200	331,000	966,200	40,300	21,000	61,300
Seepage Lagoons (29.5 Acres)	101,300	91,400	--	91,400	5,800	--	5,800
Land (32.3 Acres)	161,500	118,200	--	118,200	7,500	--	7,500
Subtotal	965,500	844,800	331,000	1,175,800	53,600	21,000	74,600
Fontana							
Facilities (0.82 MGD)	895,100	808,600	428,700	1,237,300	51,300	27,200	78,500
Seepage Lagoons (41.0 Acres)	148,500	134,000	--	134,000	8,500	--	8,500
Land (44.2 Acres)	221,000	162,300	--	162,300	10,300	--	10,300
Subtotal	1,264,600	1,104,900	428,700	1,533,600	70,100	27,200	97,300

Table 226 (continued)

Sewage Treatment Plant (By Subregional Area)	Estimated Cost						
	Capital Construction	Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
		Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Walworth							
Facilities (0.95 MGD)	1,284,000	1,173,000	955,000	2,128,000	74,400	60,600	135,000
Land (3.2 Acres)	16,000	11,000	--	11,000	700	--	700
Subtotal	1,300,000	1,184,000	955,000	2,139,000	75,100	60,600	135,700
Williams Bay							
Facilities (1.40 MGD)	431,000	526,000	596,000	1,122,000	33,400	37,800	71,200
Seepage Lagoons (30.5 Acres)	101,300	91,400	--	91,400	5,800	--	5,800
Land (33.4 Acres)	167,000	122,900	--	122,900	7,800	--	7,800
Subtotal	699,300	740,300	596,000	1,336,300	47,000	37,800	84,800
Subregional Area Subtotal	$ 13,395,100	$ 12,167,900	$ 9,481,500	$ 21,649,400	$ 772,100	$ 601,600	$ 1,373,700
Regional Total	$134,366,700	$132,610,800	$218 060,100	$350,670,900	$8,413,750	$13,890,500	$22,304,250

[1]Secondary and advanced (phosphorus removal) treatment capacity 1.43 MGD; advanced (nitrification) and auxiliary (effluent aeration and disinfection) treatment capacity 1.88 MGD.

[2]Plant operated by the Western Racine County Sewerage District.

Source: SEWRPC.

Table 227

PUBLIC SEWAGE TREATMENT FACILITIES PROPOSED TO BE ABANDONED UPON FULL IMPLEMENTATION OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE REGION: 1990

Public Sewage Treatment Facility to be Abandoned (by Subregional Area)	Agency or Unit of Government Operating the Facility	Disposal of Effluent
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA		
Hales Corners	Milwaukee-Metropolitan Sewerage Commissions	Root River
Oakview Subdivision[1]	City of Oak Creek	Minor Tributary to Lake Michigan
Mission Hills[2]	Mission Hills Water and Sewer Trust	Minor Tributary to Root River
Rawson Homes	Rawson Homes Sewer and Water Trust	Minor Tributary to Root River
Thiensville	Village of Thiensville	Milwaukee River
Caddy Vista	Caddy Vista Sanitary District	Root River
Germantown--Old Village Plant	Village of Germantown	Menomonee River
Germantown--County Line Plant[2]	Village of Germantown	Menomonee River
Muskego--Big Muskego Lake Plant	City of Muskego	Big Muskego Lake
Muskego--Northeast District Plant[3]	City of Muskego	Seepage Lagoon--Overflow to Tess Corners Creek
New Berlin-Greenridge Plant	City of New Berlin	Root River
New Berlin-Regal Manors Plant	City of New Berlin	Deer Creek
Menomonee Falls--Pilgrim Road Plant	Village of Menomonee Falls	Menomonee River
Menomonee Falls--Lilly Road Plant	Village of Menomonee Falls	Menomonee River
UPPER MILWAUKEE RIVER SUBREGIONAL AREA		
None	--	--
SAUK CREEK SUBREGIONAL AREA		
None	--	--
KENOSHA-RACINE SUBREGIONAL AREA		
Pleasant Park	Pleasant Park Utility Co., Inc.	Ditch Tributary to Lake Michigan
Somers	Town of Somers Sanitary District No. 2	Pike River
Sturtevant	Village of Sturtevant	Minor Tributary to Pike River
North Park	North Park Sanitary District	Lake Michigan
ROOT RIVER CANAL SUBREGIONAL AREA		
None	--	--
DES PLAINES RIVER SUBREGIONAL AREA		
None	--	--
UPPER FOX RIVER SUBREGIONAL AREA		
Brookfield-Fox River Plant[2]	City of Brookfield	Fox River
Pewaukee	Village of Pewaukee	Pewaukee River
Sussex	Village of Sussex	Sussex Creek
LOWER FOX RIVER SUBREGIONAL AREA		
None	--	--
UPPER ROCK RIVER SUBREGIONAL AREA		
None	--	--
MIDDLE ROCK RIVER SUBREGIONAL AREA		
Hartland	Village of Hartland	Bark River
LOWER ROCK RIVER SUBREGIONAL AREA		
Elkhorn	City of Elkhorn	Jackson Creek

[1]Facility abandoned during 1971.
[2]Facility abandoned during 1973.

[3]Facility placed into operation during 1972 and is not reflected in the inventory of public sewage treatment plants reported in Chapter V.

Source: SEWRPC.

recommended in the adopted Milwaukee River watershed plan. Together these nine plants are anticipated to serve a total population of about 68,600 persons by 1990, or about 88 percent of the anticipated 1990 population of this subregional area.

Under the recommended plan for the Upper Milwaukee River subregional area, no existing public sewage treatment facilities would be abandoned. It should be noted, however, that the Jackson sewage treatment facility is recommended to be relocated to a new site on Cedar Creek downstream from the existing treatment plant site in order to provide better service to the Jackson urban area and to enable abandonment of the private sewage treatment facility operated by Libby, McNeill, and Libby, Inc.

Sauk Creek Subregional Area: The recommended plan proposes that two public sewage treatment facilities serve the Sauk Creek subregional area by 1990. These two facilities are the Port Washington treatment plant operated by the City of Port Washington, and the Belgium treatment plant operated by the Village of Belgium. The Belgium plant is recommended to serve, in addition to the Village of Belgium itself, the unincorporated village of Lake Church, urban development along the shoreline of Lake Michigan, and the newly established Harrington Beach State Park. The Port Washington facility is recommended to provice an advanced level of waste treatment for phosphorus removal. The Belgium treatment plant is recommended to provide an advanced level of waste treatment for nitrification. Together the two plants are anticipated to serve a total population of about 14,700 persons by 1990, or about 89 percent of the anticipated 1990 population of this subregional area. No existing public sewage treatment facilities would be abandoned upon implementation of the recommended plan for the Sauk Creek subregional area.

Kenosha-Racine Subregional Area: The recommended plan proposes that two public sewage treatment facilities serve the Kenosha-Racine subregional area by 1990. These two facilities are the treatment plants operated by the Cities of Racine and Kenosha. Both plants are recommended to provide an advanced level of waste treatment for phosphorus removal.[10] Together the two plants are anticipated to serve a total population of about 400,700 persons in 1990, or about 99 percent of the anticipated 1990 population of this subregional area.

A total of four existing public sewage treatment facilities would be abandoned upon full implementation of the recommended sanitary sewerage system plan in the Kenosha-Racine subregional area. These four facilities are the Pleasant Park facility in the Town of Pleasant Prairie operated by the Pleasant Park Utility Company, Inc.; the Somers facility operated by the Town of Somers Sanitary District No. 2; the Sturtevant facility operated by the Village of Sturtevant; and the North Park facility operated by the North Park Sanitary District in the Town of Caledonia and Village of Wind Point.

[10] *It should be noted that on October 16, 1973, officials of the Cities of Kenosha and Racine signed a settlement to a Lake Michigan pollution law suit brought by the State of Illinois which would commit the cities to provide higher levels of waste treatment at their sewage treatment facilities and eliminate pollution from combined sewer overflows. The agreement, which is binding on Racine and Kenosha only if all necessary federal and state funds are made available and if all other municipalities discharging effluent in Lake Michigan in the four states bordering Lake Michigan are also required to meet the treatment standards, provides for more stringent effluent limitations than those recommended in the regional sanitary sewerage system plan. The following table summarizes the effluent limitations agreed to by the Cities of Kenosha and Racine and compares these limitations with those recommended in the regional plan:*

COMPARISON OF EFFLUENT LIMITATIONS: KENOSHA-RACINE AGREEMENT AND REGIONAL SANITARY SEWERAGE SYSTEM PLAN

Effluent Limitation	Kenosha-Racine Agreement			Regional Plan
	By 12/31/76	By 12/31/77	By 7/1/79	
BOD_5	20 mg/l (monthly average)	10 mg/l (monthly average)	4 mg/l (monthly average)	15 mg/l (annual average)
Suspended Solids	20 mg/l (monthly average)	10 mg/l (monthly average)	5 mg/l (monthly average)	- -
Phosphorus	1 mg/l (monthly average)	1 mg/l (monthly average) 90 % Removal (annual average)	1 mg/l (monthly average) 90 % Removal (annual average)	1 mg/l (annual average)
Fecal Coliform	40/100 ml (Maximum at any time) 20/100 ml (annual average)	40/100 ml (Maximum at any time) 20/100 ml (annual average)	40/100 ml (Maximum at any time) 20/100 ml (annual average)	200/100 ml (annual average)

As reported in Chapter XI of this report, the alternative sanitary sewerage system plans for the Kenosha-Racine subregional area were initially evaluated by the Racine Urban Planning District Citizens Advisory Committee prior to consideration by the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning. After very lengthy and careful consideration, the Citizens Advisory Committee recommended adoption and implementation of Alternative Plan 3 for the Kenosha-Racine subregional area, described above as the recommended plan, with the understanding that the North Park sewage treatment facility be expanded on an interim basis during the early stages of the plan implementation period in order to meet pressing existing sewage treatment and pollution problems. Accordingly, it is recommended that as part of the regional sanitary sewerage system plan, the North Park sewage treatment facility be expanded to a capacity of about 2.0 mgd to serve as an interim facility while full implementation of the recommended plan, which includes construction of a considerable number of major trunk sewers, proceeds.

Root River Canal Subregional Area: The recommended plan proposes that one public sewage treatment facility serve urban development in the Root River Canal subregional area in 1990. This facility is proposed to be operated by the Village of Union Grove and would consist of a replacement facility for the existing plant now serving the village. The plan further recommends the integration of the existing sewage treatment facility serving the Wisconsin Southern Colony Institution adjacent to the village with the proposed new Union Grove sewage treatment facility in order to provide for advanced waste treatment for sewage generated in both the village and the Institution. Thus, it is recommended that the Union Grove sewage treatment facility provide secondary waste treatment and advanced waste treatment for phosphorus removal for the influent sewage from the Union Grove sewer service area, and advanced waste treatment for nitrification for the influent sewage from both the Union Grove and Wisconsin Southern Colony sewer service areas. The existing Wisconsin Southern Colony plant would be retained and continue to provide secondary and tertiary levels of waste treatment. The Union Grove plant is anticipated to serve a total population of about 7,700 persons, not including 1,400 persons residing at the Wisconsin Southern Colony Institution, or about 66 percent of the anticipated 1990 population of this subregional area. No public sewage treatment facilities would be abandoned upon implementation of the recommended plan for the Root River Canal subregional area.

Des Plaines River Subregional Area: The recommended plan proposes that six public sewage treatment facilities serve the Des Plaines River subregional area by 1990. These six facilities are the Bristol treatment plant operated by the Town of Bristol Utility District No. 1; a proposed plant to be operated by the Town of Bristol and to serve the Bristol-IH 94 sewer service area; the Pleasant Prairie treatment plant operated by the Town of Pleasant Prairie Sewer Utility District D to serve the Pleasant Prairie-North sewer service area; a proposed plant to be operated by the Town of Pleasant Prairie and to serve the Pleasant Prairie-South sewer service area near the Wisconsin-Illinois state line; the Paddock Lake treatment plant operated by the Village of Paddock Lake; and the Hooker Lake treatment plant operated by the Town of Salem Sewer Utility District No. 1.

The Paddock Lake treatment facility is recommended to provide an advanced level of treatment for phosphorus removal and nitrification; the Bristol and Hooker Lake treatment plants are recommended to provide an advanced level of treatment for nitrification only; with the proposed Bristol-IH 94 plant and the two Pleasant Prairie plants recommended to provide a secondary level of waste treatment. Together the six plants are anticipated to serve a total population of about 8,200 persons by 1990, or about 66 percent of the anticipated 1990 population of this subregional area. No existing public sewage treatment facilities would be abandoned under the recommended sanitary sewerage system plan in the Des Plaines River subregional area.

Upper Fox River Subregional Area: The recommended plan proposes that two public sewage treatment facilities serve urban development in the Upper Fox River subregional area in 1990. These two facilities are the Brookfield treatment plant, operated by the City of Brookfield,[11] and the Waukesha treatment plant, operated by the City of Waukesha. The Brookfield plant would be an areawide facility serving not only the western

[11] *This facility was placed into operation in 1973.*

portion of the City of Brookfield, but also the western portion of the City of New Berlin; the Villages of Lannon, Pewaukee, and Sussex; the western portion of the Village of Menomonee Falls; the Pewaukee Lake Sanitary District; and urban development in the Towns of Brookfield, Lisbon, and Pewaukee. The Waukesha facility would serve the City of Waukesha and environs, including urban development in the Towns of Waukesha and Pewaukee. Both treatment facilities are recommended to provide an advanced level of waste treatment for phosphorus removal and nitrification. Together the two plants are anticipated to serve a total population of about 174,800 persons by 1990, or about 99 percent of the anticipated 1990 population of this subregional area.

With respect to the Waukesha plant, two possible locations should be considered—the location of the existing plant and a new location approximately two miles downstream from the existing plant—with the ultimate location determined by local engineering studies. The site of the existing Waukesha sewage treatment plant has several disadvantages as the site for the proposed plant providing areawide service, including limited area for expansion and a location lying partially in the natural floodlands of the Fox River. In addition, new urban development in the Waukesha area is occurring in areas downstream from the existing facility, and sewage from such development will have to be pumped to the old plant site. The relocation of the plant would overcome the aforementioned problems, and would also provide greater flexibility by preserving the option of ultimately consolidating municipal waste treatment in the Upper Fox River watershed at a single location, as initially recommended in the adopted Fox River watershed plan, beyond the design year of the sewerage system plan. In order to provide a conservatively high estimate of plan implementation costs, it has been assumed in this report that the proposed plant will be located at the downstream site. It is recognized, however, that detailed engineering design studies may result in a recommendation to retain and perhaps expand the existing treatment facility to serve future urban growth in the Waukesha area through the plan design year of 1990.

A total of three existing public sewage treatment facilities would be abandoned upon full implementation of the regional sanitary sewerage system plan in the Upper Fox River subregional area. These are the Brookfield-Fox River plant operated by the City of Brookfield; the Pewaukee plant operated by the Village of Pewaukee; and the Sussex plant operated by the Village of Sussex. In addition, the existing facility operated by the City of Brookfield and known as the Poplar Creek Sewage Lagoons would be replaced with the proposed new Brookfield sewage treatment plant.

Lower Fox River Subregional Area: The recommended plan proposes that 12 public sewage treatment facilities serve the Lower Fox River subregional area by 1990. These facilities are the Mukwonago plant operated by the Village of Mukwonago; the East Troy plant operated by the Village of East Troy; the Lake Geneva plant operated by the City of Lake Geneva; a proposed plant to be operated by the Town of Lyons Sanitary District No. 2 to serve the unincorporated village of Lyons; the Genoa City plant operated by the Village of Genoa City; a proposed plant to be operated by the Town of Norway Sanitary District No. 1 to serve urban development in the Wind Lake area; a proposed plant to be operated by the Eagle Lake Sewer Utility District in the Town of Dover to serve urban development in the Eagle Lake area; the Rochester plant operated by the Western Racine County Sewerage District; the Burlington plant operated by the City of Burlington; the Silver Lake plant operated by the Village of Silver Lake; the Twin Lakes plant operated by the Village of Twin Lakes; and a proposed Camp Lake plant to be operated by the Town of Salem Sewer Utility District No. 2. The East Troy plant is proposed to serve not only the Village of East Troy but also urban development along the shoreline of Potter Lake in the Town of East Troy Sanitary District No. 2; the Lake Geneva plant is proposed to serve not only the City of Lake Geneva but also urban development along the northern shoreline of Lake Como in the Town of Geneva; the Rochester plant is proposed to serve not only the existing Western Racine County Sewerage District, including the Villages of Rochester and Waterford and the Town of Rochester Sewer Utility District No. 1, but also urban development along the Fox River and Tichigan Lake in the Town of Waterford Sanitary District No. 1; and the Camp Lake facility is proposed to provide service to nearly all existing urban development in the Town of Salem Sewer Utility District No. 2, including urban development along the shorelines of Camp, Center, Cross, Rock, Bennet, Voltz, and Shangrila Lakes and in the unincorporated villages of Trevor and Wilmot.

The Mukwonago, East Troy, Lake Geneva, Wind Lake, and Twin Lakes treatment facilities are recommended to provide an advanced level of waste treatment for both phosphorus removal and nitrification; the Rochester, Burlington, Silver Lake, and Camp Lake treatment facilities are recommended to provide an advanced level of waste treatment for phosphorus removal only; the Eagle Lake facility is recommended to provide an advanced level of waste treatment for nitrification only; with the Lyons and Genoa City treatment facilities recommended to provide a secondary level of waste treatment. Together the 12 plants are anticipated to serve a total population of about 74,000 persons by 1990, or about 70 percent of the total anticipated population of this subregional area. No existing public sewage treatment facilities would be abandoned under the recommended sanitary sewerage system plan in the Lower Fox River subregional area.

Upper Rock River Subregional Area: The recommended plan proposes that three sewage treatment facilities serve the Upper Rock River subregional area in 1990. These three facilities are the Allenton treatment plant operated by the Allenton Sanitary District in the Town of Addison; the Slinger treatment plant operated by the Village of Slinger; and the Hartford treatment plant operated by the City of Hartford. The Hartford treatment facility is proposed to serve, in addition to the City of Hartford, urban development along the shoreline of Pike Lake, including the newly established Pike Lake State Park, in the Town of Hartford. The Hartford plant is recommended to provide an advanced level of waste treatment for phosphorus removal and nitrification; while the Allenton and Slinger plants are recommended to provide an advanced level of waste treatment for nitrification only. Together the three plants are anticipated to serve a total population of about 15,200 persons by 1990, or about 68 percent of the total population of this subregional area. No existing public sewage treatment facilities are proposed to be abandoned under the recommended sanitary sewerage system plan for the Upper Rock River subregional area. The Hartford facility is, however, recommended to be relocated downstream from the existing treatment plant site.

Middle Rock River Subregional Area: The recommended plan proposes that five public sewage treatment facilities serve the Middle Rock River subregional area by 1990. These five facilities are a proposed treatment plant to serve the Village of Merton; a proposed treatment plant to serve the Village of Wales; the existing Dousman sewage treatment plant serving the Village of Dousman; the existing Oconomowoc sewage treatment plant serving the City of Oconomowoc; and a proposed Delafield sewage treatment plant to serve the City of Delafield, the Villages of Hartland and Nashotah, and urban development along the shorelines of the Nashotah and Nemahbin Lakes in the Town of Summit. The Oconomowoc facility would also be areawide in scope, serving in addition to the City of Oconomowoc the Villages of Lac LaBelle, Oconomowoc Lake, and Chenequa and urban development in the Towns of Ixonia, Oconomowoc, Summit, and Merton.

The Merton, Oconomowoc, and Delafield plants are recommended to provide an advanced level of waste treatment for both phosphorus removal and nitrification; the Wales plant is recommended to provide an advanced level of treatment for nitrification only; while the Dousman plant is recommended to provide a secondary level of waste treatment. Together the five plants are anticipated to serve a total population of about 52,400 persons by 1990, or about 89 percent of the total anticipated population of this subregional area.

One existing public sewage treatment facility—that serving the Village of Hartland—would be abandoned upon full implementation of the recommended sanitary sewerage system plan for the Middle Rock River subregional area. In addition the Oconomowoc facility is recommended to be relocated on a site downstream from and immediately adjacent to the existing sewage treatment facility site.

Lower Rock River Subregional Area: The recommended plan proposes that seven public sewage treatment facilities serve the Lower Rock River subregional area by 1990. These seven facilities are the Whitewater plant operated by the City of Whitewater; the Sharon plant operated by the Village of Sharon; a proposed Delavan plant to serve not only the City of Delavan but also the Delavan Lake Sanitary District and the City of Elkhorn; the Darien treatment plant operated by the Village of Darien; the Fontana treatment plant operated by the Village of Fontana; the Walworth treatment plant operated by the Village of Walworth; and the Williams Bay treatment plant operated by the Village of Williams Bay.

The Whitewater, Sharon, Delavan, and Walworth treatment plants are recommended to provide an advanced level of waste treatment for both phosphorus removal and nitrification; while the Darien, Fontana, and Williams Bay facilities are recommended to provide a secondary level of waste treatment. Together the seven plants are anticipated to serve a total population of about 52,000 persons by 1990, or about 97 percent of the anticipated population of this subregional area.

One existing public sewage treatment facility—that serving the City of Elkhorn—would be abandoned upon implementation of the recommended sanitary sewerage system plan for the Lower Rock River subregional area. In addition, the Whitewater sewage treatment plant would be relocated at a new site downstream from the existing sewage treatment plant site in the Town of Cold Spring, Jefferson County; the existing City of Delavan sewage treatment facility would be functionally integrated with the proposed new Delavan Lake sewage treatment facility on a site adjacent to the existing Delavan sewage treatment plant; and the existing secondary treatment component of the Walworth treatment facility would be abandoned and relocated to a site on the Piscasaw Creek at the site of the existing Walworth tertiary treatment lagoons.

It should also be noted that the recommended plan assumes the continued viability of soil absorption as a means of waste disposal of sewage generated in the Villages of Darien, Fontana, and Williams Bay. Should at some future date engineering studies conclude that soil absorption is no longer a feasible means of waste disposal in one or more of these three areas, reconsideration should be given to potential interconnections to other sewage treatment facilities. In particular, should such contingency come to pass in the case of Fontana or Williams Bay, careful consideration should be given to providing treatment to either or both of these communities at the proposed new Walworth sewage treatment plant site.

Private

As noted in Chapter V of this report, there were in 1970 a total of 59 private sewage treatment facilities generally serving isolated enclaves of urban land uses located throughout the Region. These isolated land uses include agricultural related industries, public and private recreational facilities, institutional facilities, and commercial service facilities.[12]

Under the recommended sanitary sewerage system plan for the Region, 29 of the 59 existing private sewage treatment facilities could be abandoned upon full implementation of the plan proposals (see Table 228). These 29 facilities all lie within the proposed 1990 sewer service areas and could be abandoned upon extension of sewer service.

Of the 29 private sewage treatment facilities that could be abandoned on plan implementation, 12 lie within the Milwaukee-Metropolitan subregional area and include the facilities serving the following land use complexes: the Highway 100 Drive-In Theater and the Pure Oil Truck Stop in the City of Franklin; the Chalet-on-the-Lake Restaurant, the Sisters of Notre Dame Academy, and the Federal Foods Company in the City of Mequon; the Brookfield Central High School in the City of Brookfield; the Cleveland Heights Grade School, the Highway 24 Drive-In Theater, and the New Berlin Memorial Hospital in the City of New Berlin; the Muskego Rendering Plant and the Tess Corners Grade School in the City of Muskego; and the S. K. Williams Company in the City of Wauwatosa.

The remaining 17 private sewage treatment facilities that should be abandoned upon full plan implementation are scattered throughout the Region and include those facilities serving the following land uses: within the Upper Milwaukee River subregional area the Libby, McNeill, and Libby, Inc. canning plant in the Town of Jackson; within the Kenosha-Racine subregional area the American Motors Truck Service plant in the Town of Somers, the Sienadale Motherhouse in the Town of Pleasant Prairie, the Frank Pure Food Company in the

[12] *Since 1970, five additional private sewage treatment facilities have been placed into operation: the Holiday Inn facility on the shoreline of Lake Como in the Town of Geneva; the Willow Springs Mobile Home Park facility in the Town of Lisbon; the Country Estates Mobile Home Park facility in the Town of Lyons; the STH 15 Rest Area facility in the Town of LaFayette; and the Wheatland Mobile Home Park in the Town of Wheatland. In addition, further checking of Department of Natural Resources records revealed the existence of two private sewage treatment facilities constructed before 1970 but not included in the 1970 inventory reported in Chapter V. These facilities serve the Port Country Club in the Town of Belgium and the Slovak Sokol Camp in the Town of East Troy. Four of these seven facilities should be abandoned upon implementation of the recommended regional sanitary sewerage system plan--the Holiday Inn facility lying within the proposed service area of the Village of Williams Bay, the Willow Springs Mobile Home Park facility lying within the proposed service area of the Village of Sussex, the Port Country Club facility lying within the proposed service area of the Town of Belgium, and the Slovak Sokol Camp facility lying within the proposed service area of the Town of East Troy Sanitary District No. 1.*

Towns of Caledonia and Mt. Pleasant, and the St. Bonaventure Seminary in the Town of Mt. Pleasant; within the Des Plaines River subregional area the Howard Johnson Motor Lodge in the Town of Bristol; within the Upper Fox River subregional area the Ramada Inn-Waukesha in the Town of Pewaukee, the New Berlin West High School in the City of New Berlin, and the Oakton Manor-Tumblebrook Golf Course in the Town of Delafield; within the Lower Fox River subregional area the Packaging Corporation of America in the Town of Burlington, the Pasier Produce Company in the Village of Genoa City, and the Genoa City Cooperative Milk Assoc. in the Village of Genoa City; within the Upper Rock River subregional area the Libby, McNeill, and Libby, Inc. canning plant in the City of Hartford and the Pike Lake State Park in the Town of Hartford; within the Middle Rock River subregional area the St. John's Military Academy in the City of Delafield and the Gigas-Hillside Apartments in the Town of Delafield; and within the Lower Rock River subregional area the Lake Lawn Lodge in the Town of Delavan.

The remaining 30 existing private sewage treatment facilities are scattered throughout the Region and are of various types (see Table 229). One facility—that serving the Wisconsin Southern Colony Institution in the Root River Canal subregional area—is recommended to be retained as a second-

Table 228

PRIVATE SEWAGE TREATMENT PLANTS PROPOSED TO BE ABANDONED UPON FULL IMPLEMENTATION OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE REGION: 1990

Private Sewage Treatment Facility to be Abandoned (by Subregional Area)	Civil Division Location	Disposal of Effluent
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA		
Highway 100 Drive-In Theater	City of Franklin	Root River
Pure Oil Truck Stop	City of Franklin	Root River
Chalet-on-the-Lake Restaurant	City of Mequon	Lake Michigan
Sisters of Notre Dame Academy	City of Mequon	Lake Michigan
Federal Food Company	City of Mequon	Soil Absorption
Brookfield Central High School	City of Brookfield	Soil Absorption
Cleveland Heights Grade School	City of New Berlin	Tributary to Poplar Creek
Hy. 24 Drive-In Theater	City of New Berlin	Soil Absorption
New Berlin Memorial Hospital	City of New Berlin	Tributary to Root River
Muskego Rendering Plant	City of Muskego	Soil Absorption
Tess Corners Grade School	City of Muskego	Tributary to Root River
S. K. Williams Company	City of Wauwatosa	Menomonee River
UPPER MILWAUKEE RIVER SUBREGIONAL AREA		
Libby, McNeill, and Libby, Inc.	Town of Jackson	Soil Absorption and Cedar Creek
SAUK CREEK SUBREGIONAL AREA		
Port Country Club[1]	Town of Belgium	Soil Absorption
KENOSHA-RACINE SUBREGIONAL AREA		
American Motors Truck Service	Town of Somers	Soil Absorption
Siennadale Motherhouse	Town of Pleasant Prairie	Soil Absorption
Frank Pure Food Company	Towns of Caledonia and Mount Pleasant	Hood Creek
St. Bonaventure Seminary	Town of Mount Pleasant	Minor Tributary to Pike River
DES PLAINES RIVER SUBREGIONAL AREA		
Howard Johnson Motor Lodge	Town of Bristol	Des Plaines River
UPPER FOX RIVER SUBREGIONAL AREA		
Ramada Inn-Waukesha	Town of Pewaukee	Soil Absorption
New Berlin West High School	City of New Berlin	Tributary to Poplar Creek
Oakton Manor-Tumblebrook Golf Course	Town of Delafield	Pewaukee Lake
Willow Springs Mobile Home Park[1]	Town of Lisbon	Minor Tributary to Fox River
LOWER FOX RIVER SUBREGIONAL AREA		
Packaging Corporation of America	Town of Burlington	Fox River
Pasier Produce Company	Village of Genoa City	Soil Absorption
Genoa City Cooperative Milk Association	Village of Genoa City	Nippersink Creek
Slovak Sokol Camp[1]	Town of East Troy	Soil Absorption
UPPER ROCK RIVER SUBREGIONAL AREA		
Libby, McNeill, and Libby, Inc.	City of Hartford	Rubicon River
Pike Lake State Park	Town of Hartford	Soil Absorption
MIDDLE ROCK RIVER SUBREGIONAL AREA		
St. John's Military Academy	City of Delafield	Bark River
Gigas Hillside Apartments	Town of Delafield	Soil Absorption
LOWER ROCK RIVER SUBREGIONAL AREA		
Lake Lawn Lodge	Town of Delavan	Jackson Creek
Holiday Inn[1]	Town of Geneva	Soil Absorption

[1]These facilities were placed into operation since 1970 or were reported by the Wisconsin Department of Natural Resources subsequent to the 1970 inventory and are not reflected in the inventory of private sewage treatment plants reported in Chapter V.

Source: SEWRPC.

ary waste treatment facility, but to be functionally integrated with the proposed new sewage treatment plant to serve the adjacent Village of Union Grove for the purposes of providing advanced waste treatment for nitrification. Thus, this private treatment facility would no longer constitute an individual waste source. Four of the 30 facilities—those serving the Wisconsin Electric Power Company and the Chicago, Milwaukee, St. Paul and Pacific Railroad Company in the Milwaukee-Metropolitan subregional area, the J. I. Case Company in the Kenosha-Racine subregional area, and the Trent Tube Company in the Lower Fox River subregional area—are special-purpose industrial waste treatment facilities providing such treatment as sedimentation and oil separation and discharging essentially clear water to the surface water system. These four facilities, while located within the 1990 sewer service areas, should be retained to accommodate the

Table 229

PRIVATE SEWAGE TREATMENT FACILITIES PROPOSED TO BE RETAINED UNDER THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE REGION: 1990

Private Sewage Treatment Facility to be Retained (by Subregional Area)	Civil Division Location	Disposal of Effluent
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA		
Wisconsin Electric Power Co.	City of Oak Creek	Lake Michigan
Chicago, Milwaukee, St. Paul and Pacific Railroad Co.	City of Milwaukee	Menomonee River
UPPER MILWAUKEE RIVER SUBREGIONAL AREA		
Level Valley Dairy	Town of Jackson	Cedar Creek
Justro Feed Corporation	Town of Cedarburg	Soil Absorption
River Road Cheese Factory	Town of Saukville	Soil Absorption
SAUK CREEK SUBREGIONAL AREA		
Hillar Cheese Company	Town of Fredonia	Sauk Creek
Krier Preserving Company	Town of Belgium	Soil Absorption
KENOSHA-RACINE SUBREGIONAL AREA		
J. I. Case Company	Town of Mount Pleasant	Lake Michigan
ROOT RIVER CANAL SUBREGIONAL AREA		
Fonk Mobile Homes, Park No. 1	Town of Yorkville	East Branch Root River Canal
Racine County Highway and Office Building	Town of Yorkville	East Branch Root River Canal
Wisconsin Southern Colony[1]	Town of Dover	--
Pekin Duck Farm	Town of Yorkville	Soil Absorption and West Branch Root River Canal
York Duck Farm	Town of Yorkville	West Branch Root River Canal
C & D Duck Farm	Town of Yorkville	Soil Absorption and West Branch Root River Canal
Grove Duck Farm	Town of Raymond	West Branch Root River
DES PLAINES RIVER SUBREGIONAL AREA		
Brightondale County Park	Town of Brighton	Brighton Creek
Paramski Mobile Home Park	Town of Bristol	Soil Absorption
Wisconsin Tourist Information Center	Town of Pleasant Prairie	Des Plaines River
Meeter Brothers Canning Company	Town of Yorkville	Tributary to Des Plaines River
Fonk Mobile Homes, Park No. 2	Town of Dover	Tributary to Des Plaines River
UPPER FOX RIVER SUBREGIONAL AREA		
Mammoth Springs Canning Company	Town of Lisbon	Soil Absorption
LOWER FOX RIVER SUBREGIONAL AREA		
Holy Redeemer College	Town of Dover	Tributary to Wind Lake Canal
Alpine Valley Lodge	Town of LaFayette	Soil Absorption
Trent Tube Company	Village of East Troy	Honey Creek
Playboy Club Hotel	Town of Lyons	White River
Rainbow Springs Resort	Town of Mukwonago	Tributary to Mukwonago River
Country Estates Mobile Home Park[2]	Town of Lyons	Tributary to Ore Creek
STH 15 Rest Area[2]	Town of LaFayette	Tributary to Sugar Creek
Wheatland Mobile Home Park[2]	Town of Wheatland	Minor Tributary to Fox River
MIDDLE ROCK RIVER SUBREGIONAL AREA		
Wisconsin School for Boys (Wales)	Town of Delafield	Soil Absorption
LOWER ROCK RIVER SUBREGIONAL AREA		
Libby, McNeill, and Libby, Inc.	Town of Darien	Spray Irrigation
Walworth County Correctional Center	Town of Geneva	Soil Absorption
Walworth County Institutions	Town of Geneva	Tributary to Jackson Creek

[1]Recommended to be functionally integrated with the Village of Union Grove treatment facility for advanced waste treatment purposes.
[2]These facilities were placed into operation since 1970 and are not reflected in the inventory of private sewage treatment plants reported in Chapter V.
Source: SEWRPC.

industrial wastes and should not discharge clear water[13] into the public sanitary sewerage system.

Twelve of the 30 existing private treatment facilities to be retained serve agricultural-related industries in the Region and discharge treated wastes either to the soil and groundwater system or the surface water system. These 12 facilities serve the Level Valley Dairy, the Justro Feed Corporation, and the River Road Cheese Factory in the Upper Milwaukee River subregional area; the Hiller Cheese Company and the Krier Preserving Company in the Sauk Creek subregional area; the Pekin Duck Farm, the York Duck Farm, the C & D Duck Farm, and the Grove Duck Farm in the Root River Canal subregional area; the Meeter Brothers Canning Company in the Des Plaines River subregional area; the Mammoth Springs Canning Company in the Upper Fox River subregional area; and the Libby, McNeill, and Libby, Inc. canning plant in the Lower Rock River subregional area.

The remaining 13 existing private to-be-retained sewage treatment facilities are domestic waste-oriented and serve institutional, residential, and recreational land uses beyond the proposed 1990 sewer service area limits. These 13 facilities serve the Fonk Mobile Homes Park No. 1 and the Racine County Highway and Office Building in the Root River Canal subregional area; the Brightondale County Park, the Paramski Mobile Home Park, the Wisconsin Tourist Information Center, and the Fonk Mobile Homes Park No. 2 in the Des Plaines River subregional area; the Holy Redeemer College, the Alpine Valley Lodge, the Playboy Club Hotel, and the Rainbow Springs Resort in the Lower Fox River subregional area; the Wisconsin School for Boys (Wales) in the Middle Rock River subregional area; and the Walworth County Correctional Center and the Walworth County Institutions in the Lower Rock River subregional area.

Since those private sewage treatment facilities recommended to be retained in the plan generally are unique in terms of the type of wastes to be treated, recommendations concerning the type and level of treatment to be provided must be formulated on a case-by-case basis during plan implementation. Accordingly, the recommended sanitary sewerage system plan does not include specific performance standards for each of the 30 private sewage treatment facilities that must be retained and continued in operation throughout the Region.

It is important to recognize, too, that additional private sewage treatment facilities will likely be needed during the plan implementation period to serve new enclaves of isolated land use development. Generally, such new facilities will lie beyond the planned 1990 sewer service areas, although it is possible that interim private sewage treatment facilities may be needed to accommodate urban development even within the recommended sewer service areas, until appropriate extensions of sanitary sewers can be fully effected. Each proposal for a new private sewage treatment facility must accordingly be individually evaluated on a case-by-case basis in light of the adopted plan and the objectives which that plan is intended to achieve.

Certain types of urban land use are properly and logically located in the more rural reaches of the Region and at times may require the provision of a sewage treatment facility, as opposed to the utilization of soil absorption septic tank systems for relatively minor installations. The types of urban land uses that must of necessity often be located in rural areas where public centralized sanitary sewer service is not available include highway-oriented commercial service facilities, such as motels and certain types of truck service stations and terminals; certain transportation facilities, such as airports; park and recreational facilities, both public and private; certain institutional facilities; and industrial facilities directly related to the agricultural land use base. It is not possible within the context of a regional planning effort to identify all such potential land uses in the rural areas. Accordingly, each proposal must be evaluated as it arises. Those additional private sewage treatment facilities found to be essential to accommodate such isolated urban land use enclaves must provide a type and level of treatment that is designed to achieve the established water use objectives and supporting standards. It should be recognized in this respect that while there are a number of different types of urban land uses which need to be located in the rural areas of the Region and which may, therefore, require individual sewage treatment facilities, such facilities should not be used to

[13] *Clear water in this respect shall be defined as any effluent which cannot be substantially improved by the available public sewage treatment facilities.*

accommodate new urban residential development or new urban commercial or industrial development that can more rationally and efficiently be accommodated within the recommended 1990 sewer service areas—areas where substantial public capital investment has in many cases already been made to accommodate future development.

TRUNK SEWERS

Intercommunity

The regional sanitary sewerage system plan for the Region includes proposals for those trunk sewers necessary to extend centralized sanitary sewer service to all of the proposed 1990 sewer service areas, to enable the abandonment of certain public sewage treatment facilities, and to provide for intermunicipal connections between sewer service areas. The general alignment and approximate size of these intercommunity trunk sewers is shown on the recommended plan map contained in the pocket attached to the back cover of this report. Cost estimates for all intercommunity trunk sewers included in the plan are set forth in Table 230.

Within the Milwaukee-metropolitan subregional area, the plan recommends completion of the long-range trunk, relief, and intercepting sewer plan of the Milwaukee-Metropolitan Sewerage Commissions. These sewer extensions are designed both to provide sewer service to existing and proposed contract service areas and to provide relief to portions of the trunk sewer system

Table 230

DETAILED COST ESTIMATES FOR INTERCOMMUNITY TRUNK SEWERS
RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE REGION: 1990

Intercommunity Trunk Sewer (By Subregional Area)	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA							
Milwaukee-Metropolitan Sewerage District	$126,401,300	$ 93,172,300	$ 398,800	$ 93,571,100	$5,911,200	$ 25,300	$5,936,500
Caddy Vista	151,200	116,100	28,400	144,500	7,400	1,800	9,200
Muskego	1,466,000	1,075,000	11,000	1,086,000	68,200	700	68,900
New Berlin	749,700	550,100	7,900	558,000	34,900	500	35,400
Greenfield-New Berlin	507,200	372,000	6,300	378,300	23,600	400	24,000
Brookfield-Menomonee Falls	480,600	351,800	4,800	356,600	22,300	300	22,600
Menomonee Falls	522,000	383,000	3,200	386,200	24,300	200	24,500
Germantown	1,067,900	941,700	878,000	1,819,700	59,800	55,700	115,500
Thiensville-Mequon	558,400	435,000	69,300	504,300	27,600	4,400	32,000
Subregional Area Subtotal	$131,904,300	$ 97,397,000	$1,407,700	$ 98,804,700	$6,179,300	$ 89,300	$6,268,600
UPPER MILWAUKEE RIVER SUBREGIONAL AREA							
Tri-Lakes-West Bend	$ 1,046,000	$ 1,063,000	$ 174,000	$ 1,237,000	$ 67,300	$ 11,000	$ 78,300
Jackson	91,800	67,800	1,600	69,400	4,300	100	4,400
Subregional Area Subtotal	$ 1,137,800	$ 1,130,800	$ 175,600	$ 1,306,400	$ 71,600	$ 11,100	$ 82,700
SAUK CREEK SUBREGIONAL AREA							
Lake Church-Belgium	$ 287,800	$ 230,100	$ 122,900	$ 353,000	$ 14,600	$ 7,800	$ 22,400
Subregional Area Subtotal	$ 287,800	$ 230,100	$ 122,900	$ 353,000	$ 14,600	$ 7,800	$ 22,400
KENOSHA-RACINE SUBREGIONAL AREA							
Caledonia (Improvements)	$ 965,000	$ 867,000	$ 594,000	$ 1,461,000	$ 55,000	$ 37,700	$ 92,700
Crestview-North Park (Improvements)	747,000	646,000	473,000	1,119,000	41,000	30,000	71,000
Caledonia (New)	983,000	772,000	142,000	914,000	49,000	9,000	58,000
Caledonia and Crestview-North Park-Racine (New)	5,104,000	4,461,000	205,000	4,666,000	283,000	13,000	296,000
Carol Beach-Kenosha	729,000	536,000	11,000	547,000	34,000	700	34,700
Sturtevant-Mt. Pleasant, and Sanders Park-Racine	4,631,000	3,494,000	706,000	4,200,000	221,700	44,800	266,500
Somers and Parkside-Kenosha	7,649,000	5,586,000	216,000	5,802,000	354,400	13,700	368,100
Subregional Area Subtotal	$ 20,808,000	$ 16,362,000	$2,347,000	$ 18,709,000	$1,038,100	$148,900	$1,187,000

Table 230 (continued)

Intercommunity Trunk Sewer (By Subregional Area)	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
ROOT RIVER CANAL SUBREGIONAL AREA							
Wisconsin Southern Colony	$ 87,800	$ 78,800	$ 47,300	$ 126,100	$ 5,000	$ 3,000	$ 8,000
Union Grove	158,000	115,100	3,200	118,300	7,300	200	7,500
Subregional Area Subtotal	$ 245,800	$ 193,900	$ 50,500	$ 244,400	$ 12,300	$ 3,200	$ 15,500
DES PLAINES RIVER SUBREGIONAL AREA							
Pleasant Prairie-South	$ 121,500	$ 88,300	$ 1,600	$ 89,900	$ 5,600	$ 100	$ 5,700
Subregional Area Subtotal	$ 121,500	$ 88,300	$ 1,600	$ 89,900	$ 5,600	$ 100	$ 5,700
UPPER FOX RIVER SUBREGIONAL AREA							
Sussex	$ 632,000	$ 461,700	$ 11,000	$ 472,700	$ 29,300	$ 700	$ 30,000
Pewaukee	629,000	460,300	15,800	476,100	29,200	1,000	30,200
Brookfield-Lannon	3,739,000	2,735,000	20,200	2,755,200	173,500	1,300	174,800
Waukesha	2,080,100	1,524,200	4,700	1,528,900	96,700	300	97,000
Brookfield-New Berlin	989,600	725,100	7,900	733,000	46,000	500	46,500
Subregional Area Subtotal	$ 8,069,700	$ 5,906,300	$ 59,600	$ 5,965,900	$ 374,700	$ 3,800	$ 378,500
LOWER FOX RIVER SUBREGIONAL AREA							
Mukwonago	$ 141,800	$ 104,000	$ 1,600	$ 105,600	$ 6,600	$ 100	$ 6,700
Potter Lake	445,900	340,400	17,400	357,800	21,600	1,100	22,700
Geneva Lake-North	2,989,100	2,211,400	126,100	2,337,500	140,300	8,000	148,300
Geneva Lake-South	4,836,000	3,603,200	269,500	3,872,700	228,600	17,100	245,700
Lake Como	587,100	450,900	121,400	572,300	28,600	7,700	36,300
Denoon Lake-Wind Lake	505,700	381,400	86,700	468,100	24,200	5,500	29,700
Tichigan Lake	2,517,300	1,986,000	617,900	2,603,900	126,000	39,200	165,200
Silver Lake	202,200	148,200	3,200	151,400	9,400	200	9,600
Wilmot	245,800	200,200	119,800	320,000	12,700	7,600	20,300
Cross-Rock Lakes	436,300	354,700	209,700	564,400	22,500	13,300	35,800
Camp Lake	393,900	288,400	6,300	294,700	18,300	400	18,700
Subregional Area Subtotal	$ 13,301,100	$ 10,068,800	$1,579,600	$ 11,648,400	$ 638,800	$100,200	$ 739,000
UPPER ROCK RIVER SUBREGIONAL AREA							
Hartford	$ 641,300	$ 469,700	$ 4,700	$ 474,400	$ 29,800	$ 300	$ 30,100
Pike Lake	237,700	187,600	85,200	272,800	11,900	5,400	17,300
Subregional Area Subtotal	$ 879,000	$ 657,300	$ 89,900	$ 747,200	$ 41,700	$ 5,700	$ 47,400
MIDDLE ROCK RIVER SUBREGIONAL AREA							
Oconomowoc-Lac LaBelle (East)	$ 675,000	$ 552,000	$ 186,000	$ 738,000	$ 35,000	$ 11,800	$ 46,800
Oconomowoc-Lac LaBelle (West)	415,200	304,000	7,900	311,900	19,300	500	19,800
Oconomowoc Lake, Okauchee Lake, Pine Lake, North Lake, Beaver Lake	2,406,100	1,942,000	647,000	2,589,000	123,200	41,100	164,300
Silver Lake	327,000	250,100	60,000	310,100	15,900	3,800	19,700
Hartland, Delafield-Nashotah, Nashotah-Nemahbin	5,422,200	3,973,600	25,200	3,998,800	252,100	1,600	253,700
Subregional Area Subtotal	$ 9,245,500	$ 7,021,700	$ 926,100	$ 7,947,800	$ 445,500	$ 58,800	$ 504,300
LOWER ROCK RIVER SUBREGIONAL AREA							
Whitewater	$ 392,900	$ 288,400	$ 3,200	$ 291,600	$ 288,400	$ 3,200	$ 291,600
Delavan Lake	1,536,200	1,163,300	173,600	1,336,900	73,800	11,000	84,800
Elkhorn	1,577,000	1,258,000	326,000	1,584,000	79,800	20,700	100,500
Fontana-Geneva Lake	2,276,500	1,551,000	9,500	1,560,500	98,400	600	99,000
Williams Bay-Geneva Lake	1,243,800	929,900	104,000	1,033,900	59,000	6,600	65,600
Walworth	296,800	217,500	7,900	225,400	13,800	500	14,300
Subregional Area Subtotal	$ 7,323,200	$ 5,408,100	$ 624,200	$ 6,032,300	$ 613,200	$ 42,600	$ 655,800
Regional Total	$193,323,700	$144,464,300	$7,384,700	$151,849,000	$9,435,400	$471,500	$9,906,900

Source: SEWRPC.

now experiencing periods of overloading. This Milwaukee-metropolitan trunk sewer system has been designed in part to provide for selective routing of sewage flows to the two major sewage treatment facilities—Jones Island and South Shore. The proposed extensions to the Milwaukee-metropolitan trunk sewer system are shown on Map 131 and have been identified by segment on Map 132. Two of the segments relate directly to the abandonment of public sewage treatment facilities within the Milwaukee-Metropolitan Sewerage District. Construction of Segment E will permit the abandonment of the Hales Corners sewage treatment facility, while construction of Segment Q will permit the abandonment of the Rawson Homes sewage treatment facility in the City of Franklin. Several other segments relate directly to the abandonment of public sewage treatment facilities within the existing and proposed contract service area. Construction of Segment J is essential to the abandonment of the Northeast District and Big Muskego Lake sewage treatment facilities in the City of Muskego. Construction of Segment E is essential to the abandonment of the Regal Manors sewage treatment facility in the City of New Berlin. Construction of Segments C and D is essential to the abandonment of the Lilly Road and Pilgrim Road sewage treatment facilities in the Village of Menomonee Falls. Construction of Segments C, D, and I is essential to the abandonment of the Old Village sewage treatment facility in the Village of Germantown. Finally, construction of segments A, G, L, and M is essential to the abandonment of the Thiensville sewage treatment plant in the Village of Thiensville.

In addition to the proposed trunk sewer extensions which lie under the jurisdiction of the Milwaukee-Metropolitan Sewerage Commissions, the recommended plan includes eight local trunk sewers in the Milwaukee-metropolitan subregional area that are of particular significance in providing intercommunity sewer service or enabling the abandonment of existing public sewage treatment facilities. These eight trunk sewers include the Caddy Vista sewer, which would enable the abandonment of the Caddy Vista Sanitary District sewage treatment facility; the Muskego sewer, which would enable the abandonment of both the Northeast District and Big Muskego Lake sewage treatment facilities operated by the Village of Muskego; the New Berlin sewer, which would enable the abandonment of the Regal Manors sewage treatment facility operated by the City of New Berlin; the Greenfield-New Berlin sewer, which would enable abandonment of the Greenridge sewage treatment facility operated by the City of New Berlin; the Brookfield-Menomonee Falls sewer, which would provide sewer service to major areas of both the City of Brookfield and the Village of Menomonee Falls; the Menomonee Falls sewer, which would enable abandonment of the Lilly Road and Pilgrim Road sewage treatment facilities operated by the Village of Menomonee Falls; the Germantown sewer, which would enable abandonment of the Old Village sewage treatment facility operated by the Village of Germantown; and the Thiensville-Mequon sewer, which would enable abandonment of the Thiensville sewage treatment facility.

Within the Upper Milwaukee River subregional area the plan proposes two trunk sewers. The first would provide for sewer service extension to the Big Cedar, Little Cedar, and Silver Lakes areas southwest of the City of West Bend and connect those areas to the West Bend sewage treatment facility. The second would permit the relocation of the Village of Jackson sewage treatment plant downstream to a new site.

Within the Sauk Creek subregional area, one trunk sewer is included in the recommended sanitary sewerage system plan. This sewer would connect the Lake Church sewer service area in the Town of Belgium to the Village of Belgium sewage treatment facility.

Within the Kenosha-Racine subregional area, seven individual components comprise the recommended trunk sewer plan. Two of the seven involve improvements to existing sewers in the Caledonia and Crestview-North Park sewer service areas which consist primarily of increased trunk sewer and pumping station capacities in order to provide for system extensions and service to the entire 1990 planned service area. The remaining five sewers are either extensions of existing sewers or proposed new sewers from the recommended sewage treatment facilities. These include a new sewer extending from the Racine sewage treatment facility to serve the Caledonia and Crestview-North Park service areas and would permit ultimate abandonment of the North Park sewage treatment facility operated by the North Park Sanitary District; an extension of a trunk sewer into the Caledonia sewer service area; a new sewer from the Racine sewage treatment plant to serve the Sturtevant-Mt. Pleasant area and which would permit abandonment of the

Sturtevant sewage treatment facility operated by the Village of Sturtevant; a new sewer extending from the Kenosha sewage treatment facility to serve the Town of Somers and the University of Wisconsin-Parkside area, and which would permit the abandonment of the Somers sewage treatment facility operated by the Town of Somers Sanitary District No. 2; and a new sewer from the Kenosha sewage treatment plant to the Carol Beach sewer service area in the Town of Pleasant Prairie, which would permit the abandonment of the Pleasant Park sewage treatment facility operated by the Pleasant Park Utility Company, Inc.

Within the Root River Canal subregional area, two trunk sewers are included in the recommended plan. The first would permit relocation of the Union Grove sewage treatment facility to a site downstream on the West Branch of the Root River Canal. The second—actually an outfall sewer—would connect the Wisconsin Southern Colony Institution facility with the new Union Grove facility in order to functionally integrate the two plants for advanced waste treatment purposes.

Within the Des Plaines River subregional area, one trunk sewer is included within the recommended plan. This sewer would provide service to the proposed new Pleasant Prairie-South sewer service area from a proposed sewage treatment facility to be located on the Des Plaines River.

Within the Upper Fox River subregional area, five trunk sewers are included within the recommended plan. Four of these sewers would extend from the new Brookfield sewage treatment facility located at the confluence of Poplar Creek and the Fox River. One of these four would extend from the treatment plant north to the Villages of Lannon and Menomonee Falls. The second would extend from the Lannon-Menomonee Falls sewer to the Village of Sussex and would permit abandonment of the existing Sussex treatment facility operated by the Village of Sussex. The third would extend from the new Brookfield plant to the Village of Pewaukee to provide service to the village and the Lake Pewaukee Sanitary District and would permit abandonment of the existing Village of Pewaukee sewage treatment facility. The fourth would extend from the new Brookfield plant south along Poplar Creek and would extend service to the Town of Brookfield and the City of New Berlin. The fifth sewer included in the recommended plan for the Upper Fox River subregional area would permit relocation of the existing Waukesha sewage treatment plant to a new site about two miles downstream on the Fox River.

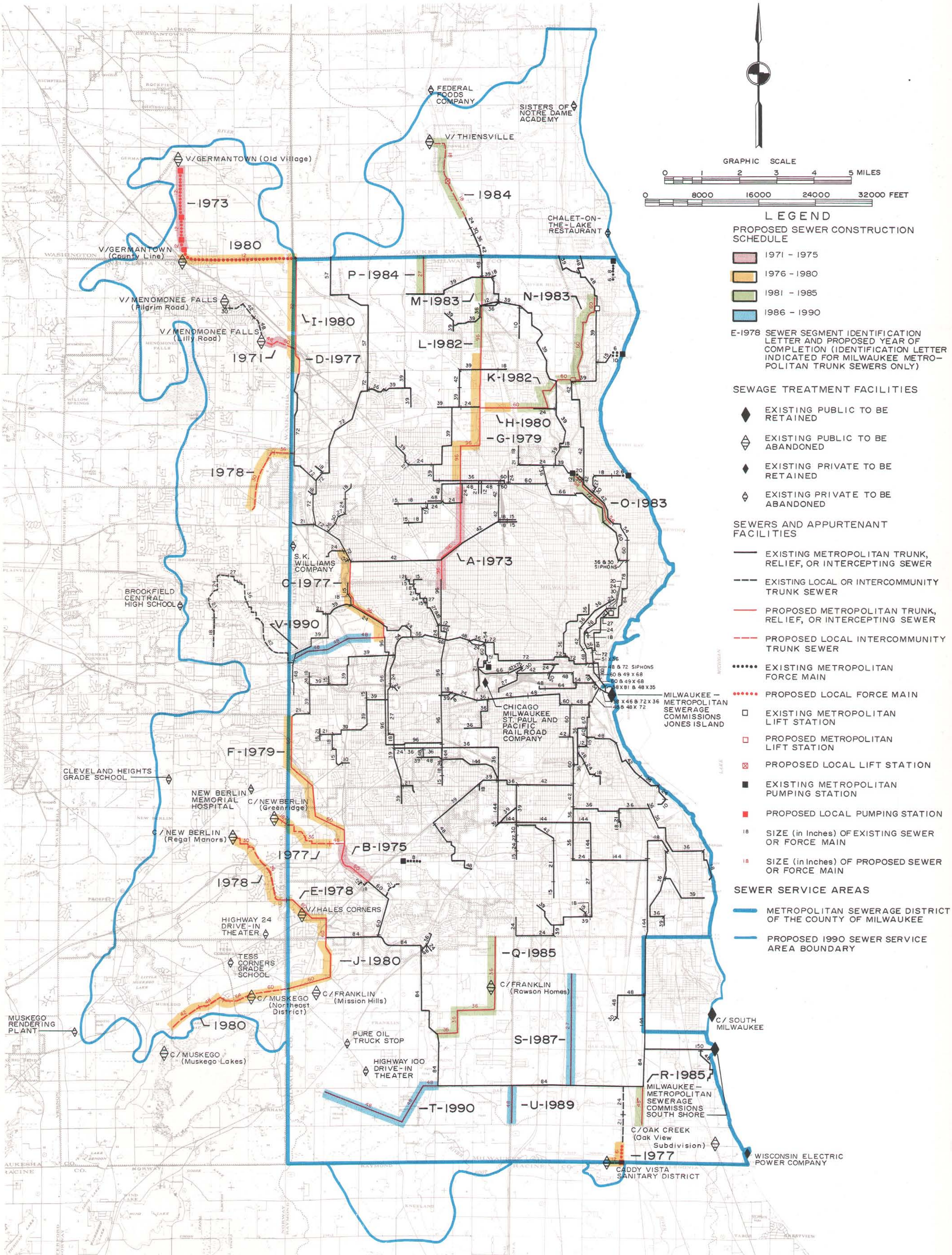
Within the Lower Fox River subregional area, 11 trunk sewers are included in the recommended plan. The first would permit relocation of the Mukwonago sewage treatment facility to a new site downstream on the Mukwonago River. The second would provide sewer service to the Potter Lake area in the Town of East Troy and would extend from the Village of East Troy sewage treatment facility to a point near Potter Lake. The third would extend sewer service from the City of Lake Geneva along the north shore of Geneva Lake in the Towns of Geneva and Linn. The fourth would extend sewer service from the City of Lake Geneva along the southern shoreline of Geneva Lake in the Town of Linn. The fifth would extend sewer service from the City of Lake Geneva to the urban development situated on the northern shoreline of Lake Como in the Town of Geneva. The sixth would provide for sewer service to urban development along the shoreline of Denoon Lake in the City of Muskego, connecting that area to the proposed Wind Lake sewage treatment plant in the Town of Norway. The seventh would extend sewer service from the Western Racine County Sewerage District to urban development along the shoreline of the Fox River and Tichigan Lake in the Town of Waterford Sanitary District No. 1. The eighth would extend sewer service from the Village of Silver Lake treatment facility to urban development along the shoreline of Silver Lake located within the Town of Salem Sewer Utility District No. 2. Finally, the ninth, tenth, and eleventh sewers would interconnect the Wilmot, Cross-Rock Lakes, and Camp and Center Lakes sewer service areas to a proposed Camp Lake treatment facility to be built and operated by the Town of Salem Sewer Utility District No. 2.

Within the Upper Rock River subregional area, two trunk sewers are included within the recommended plan. The first would permit relocation of the City of Hartford sewage treatment facility to a new site downstream on the Rubicon River. The second would interconnect the Hartford and Pike Lake sewer service areas, thus providing sewer service to urban development on the shoreline of Pike Lake and the Pike Lake State Park.

Within the Middle Rock River subregional area, five trunk sewers are included in the recommended plan. The first two sewers would extend from the proposed new Oconomowoc sewage treat-

Map 132

IDENTIFICATION BY SEGMENT OF RECOMMENDED SEWER CONSTRUCTION PROGRAM IN THE MILWAUKEE – METROPOLITAN SUBREGIONAL AREA



Source: SEWRPC

(This page intentionally left blank)

ment facility along the north and south shorelines of Lac LaBelle. The third sewer would extend easterly from the Oconomowoc facility and provide service to urban development along the shorelines of Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, and Beaver Lake. The fourth would extend from the Oconomowoc treatment facility southerly to serve urban development along the shoreline of Silver Lake. The fifth would extend from the proposed new Delafield sewage treatment facility to serve the Villages of Hartland and Nashotah and the Town of Summit, and would permit abandonment of the existing Village of Hartland treatment facility.

Within the Lower Rock River subregional area, six trunk sewers are included within the recommended plan. The first would permit relocation of the existing City of Whitewater sewage treatment facility to a new site downstream on Whitewater Creek. The second would extend sanitary sewer service from the proposed new Delavan sewage treatment facility to urban development along the shoreline of Delavan Lake. The third would provide for interconnection of the Delavan and Elkhorn sewer service areas and permit abandonment of the existing City of Elkhorn sewage treatment facility. The fourth would extend sewer service from the Village of Fontana along the shoreline of Geneva Lake in the Town of Linn. The fifth would extend sewer service from the Village of Williams Bay along the northerly shoreline of Geneva Lake and the southerly shoreline of Como Lake in the Towns of Linn and Geneva. Finally, the sixth would permit the relocation of the Village of Walworth sewage treatment facility to a new site on the Piscasaw Creek.

Local

The foregoing specific trunk sewer recommendations relate only to those trunk sewers which are of an intercommunity nature. Also of importance to the attainment of the basic plan recommendation to provide centralized sanitary sewer service to the recommended future sewer service areas are local trunk sewer extensions which generally involve only a single community and are not, therefore, of areawide significance. As part of the plan preparation process, data on the configuration and size of locally proposed trunk sewers were obtained directly from local officials. These data represent specific proposals set forth in official community development plans and related engineering studies. Map scale limitations preclude showing these locally proposed trunk sewers on the recommended plan map (see Map 131). Accordingly, based upon the data submitted by the local officials, larger scale, individual community maps identifying the locally proposed trunk sewers have been prepared by the Commission and are on file in the Commission offices. It should be clearly understood that these locally proposed trunk sewers, while not shown on the recommended plan map, or included in the plan cost estimates, represent an important adjunct to the recommended regional sanitary sewerage system plan and, as such, should be useful in plan implementation.

To illustrate the type of local community trunk sewer map prepared by the Commission from the data provided by the local officials, a representative example of such a map has been reproduced in this report (see Map 133). This map illustrates the locally proposed trunk sewer extensions to serve the recommended 1990 sewer service area in the Village of Germantown. A list of all cities, villages, and special districts for which local trunk sewer plans have been prepared and are on file in the Commission offices is set forth in Table 231. Since all local units of government and special-purpose districts were contacted in 1973 by the Commission and requested to provide information on locally proposed trunk sewer extensions, it may be assumed that at the time the regional sanitary sewerage system plan was prepared and evaluated, those local units of government and special-purpose districts not listed in Table 231 had no firm plans for local trunk sewer extensions.

ABATEMENT OF COMBINED SEWER OVERFLOWS

Studies carried out by the Regional Planning Commission under its comprehensive watershed planning programs have indicated that combined sewer overflows constitute a water pollution and environmental health problem only in the older, central portions of the three urbanized areas of the Region—the Milwaukee, Racine, and Kenosha urbanized areas. As discussed in Chapter XI of this report, previous Commission studies and ongoing local research and demonstration programs provide a basis for inclusion in the regional sanitary sewerage system plan of the following preliminary recommendations for resolution of the combined sewer overflow problem in these three areas.

Table 231

LIST OF CITY, VILLAGE, AND SPECIAL DISTRICT TRUNK SEWER PLANS ON FILE WITH THE SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

City Trunk Sewer Plans[1]		
Brookfield	Greenfield	Port Washington
Burlington	Kenosha	Racine
Cudahy	Mequon	St. Francis
Delafield	Milwaukee	South Milwaukee
Elkhorn	Muskego	Waukesha
Franklin	New Berlin	Wauwatosa
Glendale	Oak Creek	West Allis
Hartford	Oconomowoc	West Bend
Village Trunk Sewer Plans[1]		
Bayside	Grafton	Saukville
Belgium	Greendale	Shorewood
Brown Deer	Hales Corners	Slinger
Butler	Hartland	Sturtevant
Darien	Jackson	Twin Lakes
Dousman	Kewaskum	Union Grove
East Troy	Menomonee Falls	Walworth
Elm Grove	Mukwonago	Waterford
Fontana	Pewaukee	West Milwaukee
Fox Point	River Hills	Whitefish Bay
Fredonia	Rochester	Williams Bay
Germantown		
Special District Trunk Sewer Plans[1]		
Allenton Sanitary District		
Town of Bristol Sewer Utility District No. 1		
Browns Lake Sanitary District		
Town of Caledonia Sewer Utility District No. 1		
Crestview Sanitary District		
Delafield-Hartland Water Pollution Control Commission		
Delavan Lake Sanitary District		
Eagle Lake Sewer Utility District No. 1		
Town of Mount Pleasant Sewer Utility District No. 1		
Town of Norway Sanitary District No. 1		
North Park Sanitary District		
Town of Pleasant Prairie Sanitary Districts A, B, C, D, 1, and 2		
Town of Rochester Sewer Utility District No. 1		
Town of Salem Sewer Utility District No. 1		
Town of Somers Sanitary District No. 1		
Town of Somers Sanitary District No. 2		
Western Racine County Sewerage District		

[1]The following units of government did not submit local trunk sewer plans and may be presumed to have no firm plans for trunk sewer extensions at the time the regional plan was prepared and evaluated: Cities of Cedarburg, Delavan, Lake Geneva, and Whitewater; Villages of Genoa City, Paddock Lake, Sharon, Silver Lake, Sussex, and Thiensville; and the Caddy Vista and Newburg Sanitary Districts.

Source: SEWRPC.

Milwaukee Area

Combined sewer overflows as a water quality problem in the Milwaukee urbanized area was studied in detail as part of the Commission's Milwaukee River watershed study. The adopted Milwaukee River watershed plan recommends the construction of a combination deep tunnel mined storage/flow-through treatment system to collect, convey, and adequately treat all combined sewer overflows throughout the nearly 26.9 square mile combined sewer service area in Milwaukee County. The deep tunnel mined storage/flow-through treatment system was selected as the most cost effective solution after careful consideration of 15 alternatives including sewer separation. The watershed plan further recommends that the Milwaukee-Metropolitan Sewerage Commissions undertake a preliminary engineering study as the initial step toward implementing the watershed plan recommendation.

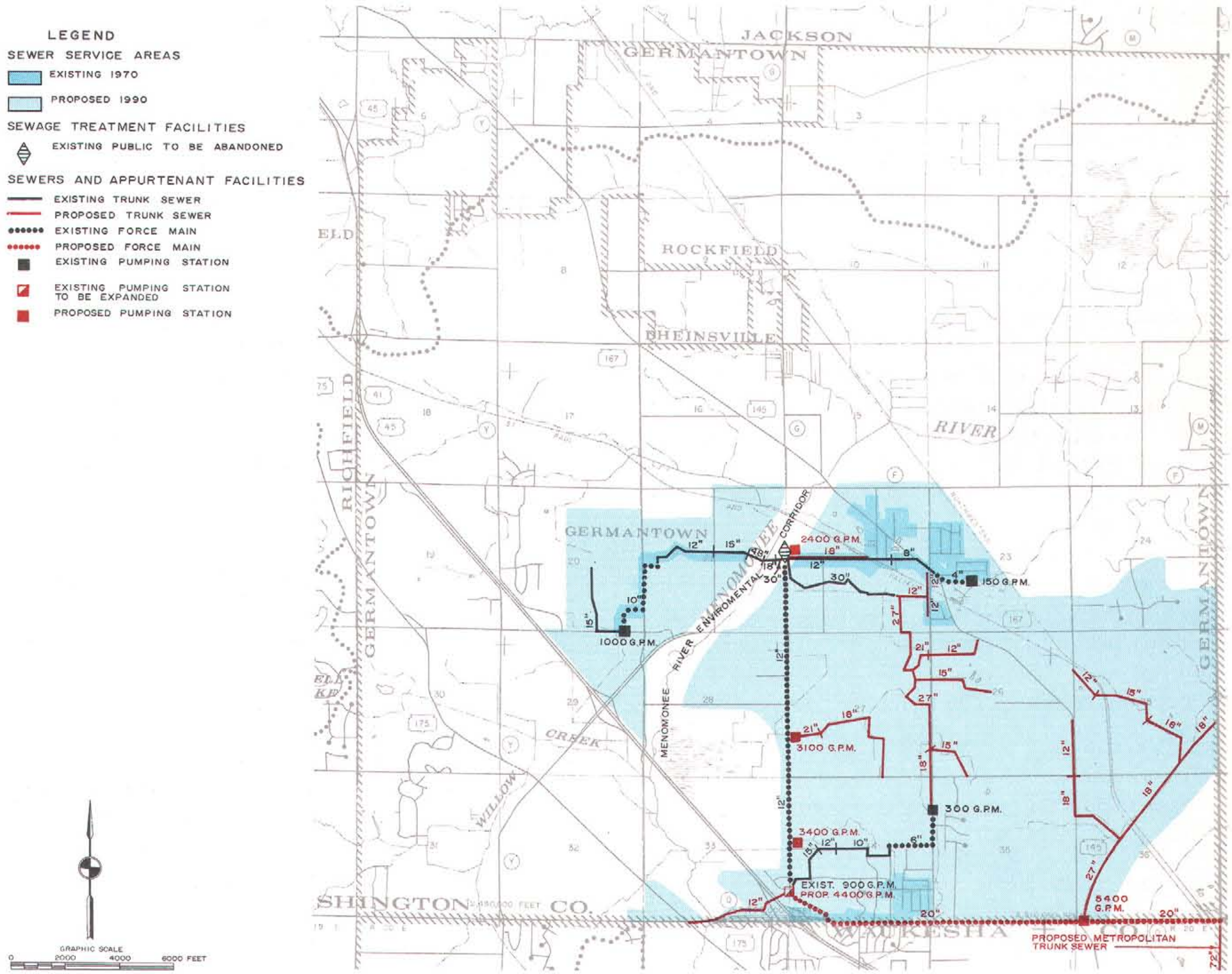
Toward this end the Milwaukee-Metropolitan Sewerage Commissions, by a formal resolution adopted on April 20, 1973, requested the Regional Planning Commission to prepare a prospectus documenting the need for and outlining the scope and content of the necessary preliminary engineering study, recommending the best means for its conduct, and presenting a budget for and means of financing the study. This prospectus was prepared under the direction of a Technical Advisory Committee of distinguished sanitary and public works engineers drawn from federal, state, and local agencies of government and from the major universities in the Region. It was published in July 1973 and adopted by the Commission and certified to implementing agencies on September 13, 1973.

The prospectus recommends that the preliminary engineering study begin with a careful review of the findings and recommendations of the adopted Milwaukee River watershed plan and, based upon a review of the findings of any new research and demonstration projects completed since preparation and adoption of the watershed plan, either reaffirm the basic validity of the combined sewer overflow abatement recommendations contained in the Milwaukee River watershed plan or provide alternative recommendations. Two of the most important purposes of the preliminary engineering study will be to determine an optimum combination of storage and flow-through treatment and to determine the practicality of the required tunnel and mined storage construction in the bedrock as a basis for the engineering design of the facilities necessary to carry out the plan recommendation.

Of particular importance will be a determination of the subsurface geophysical and geohydrologic conditions existing in the areas in which subsurface conveyance and storage facilities are proposed to be constructed. Subsurface explorations will be required to provide information on the bedrock conditions, including information on the type and location of the various strata of bedrock underlying the study area; the location of any faults that may affect the design of the required facilities; the chemical and physical characteris-

Map 133

TYPICAL MAP ILLUSTRATING LOCAL TRUNK SEWER PLANS
VILLAGE OF GERMANTOWN, WISCONSIN



As part of the regional sanitary sewerage system plan preparation process, data on the configuration and size of locally proposed trunk sewers were obtained from local public officials. These local trunk sewers are essential to the provision of sewer service to the recommended 1990 urban development area and, as such, constitute an important adjunct to the recommended regional sanitary sewerage system plan. Map scale limitations preclude showing these locally proposed trunk sewers on the recommended plan map (see Map 131). The above map of locally proposed trunk sewers in the Village of Germantown illustrates the type of local community trunk sewer map prepared by the Commission from the data provided by the local officials. Such maps are on file in the Commission offices for all cities, villages, and special districts listed in Table 231.

Source: SEWRPC.

tics of the rock, including its hardness, porosity, hydraulic conductivity, and structural stability and the suitability of the rock, if mined, for use as aggregate in construction within the Milwaukee area, including the construction of shoreline erosion protection structures; and groundwater conditions and their potential effect upon the location, design, and cost of the necessary facilities.

Also of particular importance will be the provision of a basis for selecting the type of conventional or flow-through treatment to be used, as well as to determine the balance between conveyance, storage, and treatment in the system design, including the establishment of the characteristics and treatability of the combined sewer overflows after variable periods and conditions of storage. It is anticipated that the necessary preliminary engineering study will begin in 1974 and will be conducted over a three-year period.[14]

Accordingly, the regional sanitary sewerage system plan recommends that the preliminary engineering study for the abatement of combined sewer overflows be mounted and completed as rapidly as possible, and that specific recommendations to resolve the combined sewer overflow pollution problem in the Milwaukee area be determined upon the findings of the preliminary engineering study, it being anticipated that the study will result in recommendations for an optimum combination of storage and flow-through treatment of combined sewer overflows. The estimated costs associated with conducting the engineering study and with implementing the basic recommendation contained in the Milwaukee River watershed plan are set forth in Table 232.

Racine Area

Combined sewers in the City of Racine currently serve an area of about 1.9 square miles. The city has underway a research and demonstration project to evaluate the practicality of "flow-through treatment" as an alternative to sewer separation. The regional sanitary sewerage system plan recommends that definitive recommendations concerning which of the remaining combined sewer areas in Racine should be separated and which should receive flow-through treatment facilities be held in abeyance until completion of the research and demonstration study and a determination as to which alternative is most cost effective. In order to provide an order of magnitude cost to include in the regional sanitary sewerage system plan, however, it has been assumed that the entire 1.9 square mile area will require complete sewer separation. These costs are set forth in Table 232 and, based upon studies for the Milwaukee area as documented in the Milwaukee River watershed plan, it may be conservatively assumed that such costs represent the maximum necessary to resolve the combined sewer overflow problem in the Racine area, it being likely that the research and demonstration project will provide a more cost effective solution than sewer separation.

Kenosha Area

Combined sewers in the City of Kenosha currently serve an area of about 1.6 square miles. The city has underway a research and demonstration project to determine the practicality of providing adequate conveyance capacity and standby treatment capacity at the Kenosha treatment facility rather than at outfall locations to treat the combined sewer overflows. The regional sanitary sewerage system plan recommends that definitive recommendations as to whether the remaining combined sewer areas in the City of Kenosha

[14] *For more detail concerning the proposed engineering study, see SEWRPC Prospectus Preliminary Engineering Study for the Abatement of Pollution From Combined Sewer Overflow in the Milwaukee Metropolitan Area, July 1973.*

Table 232

SUMMARY COST ESTIMATES FOR ABATEMENT OF COMBINED SEWER OVERFLOWS
RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE REGION: 1990

Combined Sewer Overflow Abatement Plan Element	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Milwaukee--Deep Tunnel Conveyance, Mined Storage, and Screening/ Dissolved Air Flotation System[1]	$130,005,000	$148,730,000	$24,610,000	$173,340,000	$ 9,416,000	$1,562,000	$10,978,000
Racine--Sewer Separation Program[2]	27,392,000	20,072,900	--	20,072,900	1,273,500	--	1,273,500
Kenosha--Sewer Separation Program[2]	21,913,600	16,058,300	--	16,058,300	1,018,800	--	1,018,800
Total	$179,310,600	$184,859,200	$24,610,000	$209,471,200	$11,708,300	$1,562,000	$13,270,300

[1] *Includes cost of conducting preliminary engineering study as recommended in Prospectus Preliminary Engineering Study for the Abatement of Pollution From Combined Sewer Overflow in the Milwaukee Metropolitan Area.*

[2] *It is recognized that current (1973) research and demonstration studies in the Cities of Racine and Kenosha and jointly funded by the U.S. Environmental Protection Agency and the Wisconsin Department of Natural Resources may result in finding more cost effective solutions to the combined sewer overflow problem than complete sewer separation.*

Source: SEWRPC.

should be separated or whether additional treatment plant capacity together with construction of necessary conveyance facilities—probably a single intercepting sewer along the Lake Michigan shoreline—should be provided, be held in abeyance until completion of the research and demonstration project. In order to provide a cost to include in the regional sanitary sewerage system plan, however, it has been assumed that the entire 1.6 square mile area will require sewer separation. These costs are set forth in Table 232 and may be conservatively assumed to represent the maximum necessary to resolve the combined sewer overflow problem in the Kenosha area, it being likely that the research and demonstration project will provide a more cost effective solution than complete sewer separation.

AUXILIARY PLAN ELEMENTS

The foregoing discussion describes the recommended regional sanitary sewerage system plan as it applies to the various subareas of the seven-county Southeastern Wisconsin Region. There are a number of additional factors and considerations which are important to the plan recommendations and which apply in general to all sanitary sewerage subsystems within the Region. These auxiliary plan elements include clear water elimination, elimination of sewage flow relief points, treatment plant operation, sludge disposal, flow metering, and water quality monitoring.

Clear Water Elimination

As noted in Chapter VI of this report, groundwater infiltration and storm water inflow into sanitary sewerage systems can create serious problems in both the conveyance and treatment components of such systems. Excessive clear water inflow[15] into sanitary sewers may result in local sewer surcharging and backflooding into streets and basements, not only creating costly nuisance conditions but at times a serious hazard to public health and safety. Excessive clear water inflow may also contribute to the discharge of raw sewage to streams and watercourses at flow relief points, with the creation of attendant water pollution and public health problems. Excess clear water inflow reduces the capacity of conveyance and treatment facilities to carry and treat domestic and industrial flows, and thereby increases both the capital and operational costs of sewerage systems. Finally, excessive clear water inflow may not only overload sewage treatment facilities but may so alter the character of the sewage to be treated as to upset the treatment plant operations. The latter is particularly true with biological sewage treatment plants where excessive clear water inflow during periods of wet weather may destroy the ability of the plant to provide the required level of treatment for some period of time following abatement of the high wet weather flows. For these reasons one of the requirements for the award of federal grants-in-aid for the construction of sewerage facilities is the conduct of an infiltration-inflow study in the local sewerage system in order to determine whether or not excessive clear water flows exist in the system and, if so, to determine the most cost effective method of abating such flows.

The terms "infiltration" and "clear water inflow" may be defined in two conceptually different ways. In the first way the two terms are distinguished on the basis of source, infiltration being defined as groundwater entering the separate sanitary sewers through defective pipes, joints, connections, and manhole walls; and inflow being defined as storm water and certain spent clear industrial cooling and process waters entering such sewers through roof leaders, yard drains, manhole covers, and cross connections from storm sewers, including inlets and catch basins. In the second way the two terms are distinguished on the basis of design objectives, infiltration being defined as that irreducible minimum of water entering separate sanitary sewers through defective sewer joints, broken or cracked sewer pipes, pervious connections, and manhole walls; and inflow being defined as water discharged into sewers from such sources as illegally connected roof downspouts and building foundation drains, illegally connected storm water inlets on public or private property, flooded manhole covers, and commer-

[15] *The term "excessive clear water inflow" may be defined as the total quantity of water from both infiltration and inflow--without distinction as to source--which can be economically eliminated from a sewer system by rehabilitation, as determined by cost effectiveness analyses that compare the cost of such rehabilitation with the cost of providing increased conveyance and treatment facility capacity to provide adequate treatment for the quantities of inflow.*

cial and industrial clear water discharges. It is clear under the second set of definitions that infiltration is not deliberately planned except for some defined tolerable irreducible minimum, while inflow is generally the result of deliberately planned or expeditiously devised connections of sources of extraneous clear water into sanitary sewer systems.

Correction of excessive infiltration and clear water inflow problems should involve both minimization of future extraneous flows through proper design and construction of new sewers and the correction of conditions contributing to excessive inflows in existing sewer systems. Good engineering design combined with proper inspection to assure good joints, proper bedding of pipe, and control of trench widths to restrict structural loads on pipe, as well as post-construction testing for infiltration, can greatly assist in minimizing clear water infiltration into new sewers. Good engineering design and proper inspection must include not only the public portions of the sewerage system, but must also extend to include the building sewers in order to avoid the improper connection of roof and foundation drains to the sanitary sewerage system.

Correction of excessive infiltration into existing sanitary sewerage systems involves detailed study and analysis of existing dry and wet weather sewage flow conditions to determine the source and extent of excessive extraneous water flows and the elimination of such flows through various corrective methods, including, as may be necessary, the repair and replacement of faulty sections of sewer and the disconnection of roof and foundation drains.

It is recommended that each local unit of government within the Southeastern Wisconsin Region responsible for the construction, operation, and maintenance of sanitary sewerage facilities conduct a study of the infiltration and inflow problems existing in the local system. It is further recommended that the engineering design criteria set forth in Chapter IX of this report be utilized in such studies as a basis for determining whether or not excessive infiltration or inflows are present in the system. In this respect, it is suggested that, if flow gagings at critical points in the system indicate that the actual wet weather flows are less than the recommended design flows, it would be concluded that no substantial infiltration-inflow problems exist in the area tributary to the gaging point.[16] Where such gaged flows are found to be in excess of the design criteria, it would be concluded that a substantial infiltration-inflow problem does exist requiring further detailed examinations of the sewerage system tributary to the gaging point in order to determine the source and amounts of the excessive flows, and the most cost effective means for their abatement.[17]

This recommended procedure is considered particularly appropriate for application to the areawide systems existing in the Kenosha, Milwaukee, and Racine areas, which systems are comprised of several subsystems, each the responsibility of a different governmental jurisdiction. With respect to such areawide systems, the required infiltration-inflow study could be accomplished in two stages, the first conducted by the agency responsible for the construction, maintenance, and operation of the intercommunity trunk sewers at which existing flows would be gaged at critical inflow points and compared to the design flow criteria set forth in this report to determine whether substantial infiltration-inflow problems exist in the areas tributary to these inflow points. Where a problem is determined to exist, the appropriate local jurisdiction would conduct the second stage study, a detailed inflow-infiltration study for the tributary sewerage system.

[16] *This recommended procedure corresponds to Infiltration/Inflow Analysis (STEP 1), "An Analysis Demonstrating the Existence or Nonexistence of Excessive Infiltration/Inflow in Each Sewer System Tributary to the Treatment Works," set forth in a preliminary draft report entitled Guidelines for Control of Infiltration/ Inflow in Sewer Systems, U. S. Environmental Protection Agency, September 19, 1973.*

[17] *This recommended procedure corresponds to "Sewer System Evaluation Survey" set forth in a preliminary draft report entitled Guidelines for Control of Infiltration/Inflow in Sewer Systems, U. S. Environmental Protection Agency, September 19, 1973. As conceived by the EPA, this survey would include the following major steps: study design, resulting in a sewer survey proposal to be submitted to and approved by the EPA; physical survey to determine the specific flow characteristics, groundwater levels, and physical conditions of the sewer system; rainfall simulation to identify sections of sewer lines which have infiltration/inflow conditions during periods of rainfall; sewer cleaning and television inspection; and analysis, including development of sewer rehabilitation program.*

Elimination of Flow Relief Points

As reported in Chapter V of this report, a total of 566 known points of sewage flow relief were identified in the inventories conducted under the sewerage system planning program. The inventories indicated that flow relief at these points were being effected by a number of different devices, all of which directly or indirectly result in the discharge of raw sewage to surface water bodies. Thirty of the 566 flow relief points consisted of gravity flow bypass conduits or relief pumping stations located at or directly ahead of existing sewage treatment plants; 148 consisted of combined sewer overflows of various types; 235 consisted of gravity flow crossovers from the separate sanitary sewer system to a storm sewer system; 75 consisted of gravity flow bypasses from the separate sewer system to the surface water courses; 18 consisted of stationary relief pumping stations discharging sewage from the separate sanitary sewer system directly to service water courses; and 60 consisted of portable pumping stations discharging sewage from the separate sewer system directly to surface water courses.

The recommended sanitary sewerage system plan as described in this chapter, if fully carried out, would directly eliminate 230 of these 566 known sewage flow relief points. Construction of new or expanded sewage treatment facilities as recommended would eliminate all of the 30 bypasses now located at sewage treatment plants. Similarly, abatement of the combined sewer overflows in Kenosha, Milwaukee, and Racine in the manner recommended in the plan would eliminate all of the 148 combined sewer overflow devices that now discharge raw sewage during periods of wet weather directly to surface watercourses. In addition, construction of trunk sewers contained in the recommended plan would eliminate an additional 52 points of flow relief, including 11 stationary relief pumping stations, 15 crossovers, and 26 bypasses. The remaining 336 known points of sewage flow relief included in the inventory presented in Chapter V of this report, as well as any other points of sewage flow relief that may exist within the local sanitary sewerage systems in the Region but which were not uncovered in the inventory, would not, however, be eliminated by construction of the sewerage facilities contained in the recommended plan.

Accordingly, it is recommended that each unit or agency of government responsible for the construction, operation, and maintenance of separate sanitary sewerage systems within the Region conduct a detailed study of the local sanitary sewerage system to identify all points of sewage flow relief and to determine the steps needed to assure the ultimate elimination of the 336 remaining flow relief points not eliminated through construction of the sewerage facilities contained in the recommended plan, as well as any other points of sewage flow relief which may be uncovered in such detailed studies. In part the problem is directly related to the infiltration-inflow problem discussed in the preceding section. To the extent that infiltration-inflow analyses and recommendations result in decreasing sewage flows, such steps in and of themselves may reduce or eliminate bypassing at points of sewage flow relief. It is important, however, that each individual point of sewage flow relief by ultimately identified and physically eliminated so as to preclude the possibility of the discharge of raw sewage ahead of the sewage treatment plant. In some cases this will require the construction of relief sewers in addition to efforts aimed at reducing infiltration and inflow. Detailed local engineering studies will be necessary in any case to determine the extent of the problem and to recommend specific solutions in specific instances.

Sewage Treatment Plant Operation

Of particular importance in achieving the established water use objectives, which formed an important basis for the preparation of the regional sanitary sewerage system plan, is the proper operation and maintenance of the existing and proposed sewage treatment plants within the Region. This factor becomes even more important when one considers the substantial upgrading of treatment necessary within the Region to provide for advanced waste treatment processes. In general it may be concluded that the commitment to meet the water use objectives will require a commitment on the part of the local units of government to provide for increased staffing and operational control of the recommended sewage treatment facilities.

Under current regulations, the Wisconsin Department of Natural Resources maintains a certification program for treatment plant operators. The program seeks to increase operator qualifications with increasing plant size. While the larger plants are certainly more important in terms of the volume of flow and perhaps in terms of the sophistication of the operations, it must be recognized that the smaller plants within the Region are generally located on very small streams and, therefore, like the large plants, must provide a consistently high level of waste treatment if the water use objectives are to be attained. Accordingly, it is recommended that the DNR review its certification program and determine if it is adequate to achieve the operating standards needed to carry out the plan recommendations.

In order to assist responsible local public officials in providing for proper staffing and operational procedures at sewage treatment plants, Table 233 sets forth for typical plant sizes the recommended staffing and operational standards, including minimum personnel required, hours when personnel should be present at the plant, laboratory control, and record keeping. Ideally, all municipal sewage treatment plants would be staffed on a 24-hour around-the-clock basis in order to provide continuous surveillance of the operation.

The laboratory tests and procedures set forth in Table 233 are designed to provide the data needed to adequately assess the treatment plant operation and determine whether or not the specific recommended performance standards set forth in the plan are being met. These data should be considered the minimum necessary in this respect.

Flow Metering

The inventory findings reported in Chapter V of this report revealed a lack of definitive knowledge concerning total sewage flows within the Region. This lack is caused by unmetered flows not only at points of sewage flow relief throughout local sewerage systems but also at bypasses located at sewage treatment plants. Effective design as well as operation and management of sanitary sewerage systems, and proper water quality management, require that all sewage flows be metered. Accordingly, it is recommended that the following steps be taken toward achieving complete metering of sewage flows:

1. All sewage treatment facilities should be provided with metering equipment providing continuous data on rates and volumes of sewage flows. Such equipment should be of an adequate size to measure peak rates of flow and should be installed to permit accurate measurement of all inflows, including flows which must for some reason bypass the treatment plant. In addition, metering within the sewage treatment plant shall be provided as necessary for proper process control. Except in cases where a sewage treatment facility is recommended in the plan to be rebuilt or relocated by 1980, existing bypasses or relief pumping stations located at or just ahead of sewage treatment facilities should have meters installed to record volume and duration of bypassed flows until such bypasses and relief pumping stations can be eliminated through the provision of adequate treatment capacity.

2. All pumping stations within a sanitary sewerage system should be provided with metering equipment to provide data on rates and volumes of sewage flow, either on a continuous or on an adequate sampling basis, to determine volume and duration of pumping and to provide a basis for systems analysis, design, and operation.

3. Major points of sewage flow relief within the sewer system should be provided with metering equipment to record volume and duration of bypassed flows, either on a continuous or on an adequate sampling basis, until such points are eliminated. A major point of sewage flow relief is defined as one which discharges flows to storm sewers or surface watercourses in excess of an equivalent rate of 10 percent of the total average hydraulic loading in the system or subsystem tributary to the point.

All of the foregoing recommendations are designed to provide adequate data on actual sewage flows and thereby to enable design and operating engineers to make better decisions as to system design and operation and maintenance.

Sludge Disposal

Disposal of sewage sludge has historically been one of the most neglected aspects of sewage treatment plant design and operation. In general, a great deal of effort has been concentrated on developing techniques and methods for sludge handling and sludge reduction, but very little has been directed at techniques and methods for final sludge disposal. The conditioning process presently in most common use within the Region consists of anaerobic digestion in heated tanks to stabilize the organic material in the sludge, fol-

Table 233

RECOMMENDED STAFFING AND OPERATIONAL PROCEDURES FOR SEWAGE TREATMENT PLANTS BY TYPICAL PLANT SIZE

Typical Plant Size	Minimum Personnel	Hours Personnel Are Present	Laboratory Control (As Applicable)	Records
10 MGD	Superintendent Chemist 6 Operators 1 Maintenance Man 2 Laborers	24 hours daily	Sludge settleability pH of raw waste and effluent DO of raw waste, effluent, and receiving stream BOD's of raw waste and effluent--24-hour composite samples Fixed and volatile suspended solids of raw wastes and effluents--24-hour composite samples pH of digested sludge where needed Total and volatile solids of digested sludge where needed Volatile acids of digested sludge where needed Chlorine residuals of effluent Nitrates--24-hour composite Sludge index where needed Mixed liquor DO where needed (each shift) Sludge depth in primary and final settling tanks (each shift) Fecal coliforms of raw sewage and effluent--daily Raw sewage temperature--hourly Return and waste sludge--suspended solids (fixed & volatile), total solids (fixed & volatile) (each shift) Anaerobic digested sludge--temperature, pH, CO_2, total alkalinity (each shift) Digester supernatant--BOD, total solids (fixed & volatile), suspended solids (fixed & volatile) (each shift) Aerobic digested sludge--temperature, BOD, total solids (fixed & volatile), suspended solids (fixed & volatile) (each shift) NOTE: Require all additional data and sampling of influent and effluent indicated in Table 20 of this report, total and soluble phosphorus, organic nitrogen, ammonia nitrogen, based on 24-hour composite samples weekly.	Keep daily records of all operations on a shift basis. Personnel should attend short schools, operators meetings, and have access to current literature. Typical records are: Weather Wind direction Adequate flow records Bypassing flow records Solids handled by weight Hours of primary and secondary settling tank cleanup Trickling filter maintenance, if needed Activated sludge operations, if needed Sludge handling operations
5 MGD	Superintendent 4 Operators 1 Maintenance Man 1 Laborer Laboratory Technician	24 hours daily	Same as 10 MGD	Same as 10 MGD
1 MGD	Superintendent & Laboratory Technician 2 Operators 1 Laborer	2 Shifts 16 hrs. per day 6 days per week	Fecal coliform--raw sewage and effluent--daily Raw sewage temperature--hourly Sludge setteability BOD - raw and effluent 3-hour composite taken at 11 a.m., 12 noon, and 1 p.m. Suspended solids - raw, mixed liquor and final effluent-3-hour composite, 11 a.m., 12 noon, and 1 p.m. pH digested sludge--also raw sludge pH Total solids - digested sludge Depth of sludge in primary and final settling tanks Sludge index DO receiving stream DO mixed liquor DO of raw waste & effluent Chlorine residual of effluent NOTE: Require all additional data and sampling of influent and effluent indicated in Table 20 of this report, total and soluble phosphorus, organic nitrogen, ammonia, nitrogen, based on 3-hour composites: 11 a.m., 12 noon, and 1 p.m.	Same as 10 MGD - 6 days per week.
0.5 MGD	Superintendent & Laboratory Technician 1 Operator 1 Laborer	6 days per week	Same as 1 MGD except Monday through Friday only.	Same as 10 MGD - 6 days per week.
0.25 MGD	1 Operator (part time)	5 days per week	Fecal coliform--raw sewage and effluent--daily Raw sewage temperature--hourly Sludge settleability Chlorine residual effluent - 5 days Sludge index tests - 5 days DO raw & effluent - 5 days + stream D.O. BOD raw & effluent - 3 times per week on 3-hour composite raw & final effluent SS raw & effluent - 3 times per week on 3-hour composite raw & final effluent (same as 1 MGD) NOTE: These tests should be made weekly pH digested sludge, total solids, digested sludge, total and soluble phosphorus, organic nitrogen, ammonia nitrogen of influent and effluent based on 3-hour composites, 11 a.m., 12 noon, and 1 p.m.	Keep records of all operation on a 5-day basis plus automatic flow records daily Operator should attend short schools, and operator meetings Typical records - 5 days are: Weather Wind direction Adequate flow records Bypass and flow records Hours of primary and secondary settling tank clean up All maintenance records as needed Activated sludge operation records, as needed

NOTE: The above recommendations for staffing sewage treatment plants assume the operation of a conventional sewage treatment plant and do not, therefore, reflect the potential effects of automation on plant staffing requirements. Even fully automated plants, however, require provision for surveillance and monitoring on a 24-hour basis.

Source: The Conference of State Sanitary Engineers, U.S. Public Health Service, and SEWRPC.

lowed by air drying beds or lagoons.[18] Vacuum dewatering of the sludge is practiced in some plants within the Region. All of the plants produce a final sludge residue requiring some form of disposal, either by incineration, land disposal, or recycling.

Within the Region, about half of the municipal sewage treatment plants use sludge drying beds or sludge lagoons to dewater sludge, with the dewatered residue being trucked to a sanitary landfill site, plowed into farm lands, or otherwise utilized for soil fertilization. Nearly a third of the plants, mostly very small ones located in rural areas, spread liquid sludge on adjoining farmlands. The remaining plants use miscellaneous sludge handling reduction and disposal techniques, such as commercial fertilization manufacturing and drying and incineration. Within this latter category is the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. The joint Commissions have long converted the raw, dewatered sewage sludge into a commercial fertilizer sold under the trade name "Milorganite," an early example of the desirable recycling of waste materials. Unfortunately, fertilizer manufacturing facilities have not been installed in the newer South Shore treatment facility operated by the joint Commissions, where sludge instead is being dewatered in lagoons for ultimate disposal by a means to be determined by an engineering study presently being conducted by the Metropolitan Sewerage District.

The particular method or technique for sludge handling, reduction, and disposal at a given municipal sewage treatment plant must be evaluated on a case-by-case basis as engineering studies for recommended plant improvements are completed. Since sludge reduction, handling, and disposal may range from 25 to 50 percent of the total treatment costs, including both capital and operation and maintenance costs, thorough engineering evaluation of all sludge handling, reduction, and disposal or utilization methods available at a particular site are warranted. It is likely that for the immediate future, final disposal of most sewage sludge residues in the Region will be handled through sanitary landfill operations or the spreading of liquid or air dried sludge on farmlands after stabilization by digestion. It should be noted in this connection that the State of Wisconsin Governors Recycling Task Force has recommended the establishment of solid waste recycling centers throughout the State,[19] and that it may be possible in the not too distant future to centralize the final disposal or utilization of dewatered sludge at a common regional solid waste disposal site where it could either be recycled, incinerated, or disposed of by landfill.

Water Quality Monitoring

Because of the interrelationship between sewage treatment and water quality enhancement and protection, data concerning long-term trends in stream water quality are particularly important to any continuing evaluation of the effectiveness of the regional sanitary sewerage system plan. Accordingly, the following discussion reviews the existing stream water quality monitoring program in the Region, and sets forth a procedure whereby data collected under this program will be analyzed to provide a basis for plan surveillance and reevaluation.

History of Water Quality Monitoring: In 1968 the Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources whereby the Department and the Commission undertook a continuing stream water quality monitoring program within the Region. The objective of the program is to provide, on a continuing basis, the water quality information necessary to assess the long-term trends in stream water quality within the rapidly urbanizing Region. The continuing monitoring program was designed to build upon the bench mark stream water quality data base established by the Commission in the initial regional stream water quality study, the findings of which were published in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, November 1966. The continuing stream water quality monitoring program during 1968 and 1969 involved operation of the 87 stream water quality sampling stations established by the Commission in the initial study of 43 streams and watercourses within the 11 major watersheds of the Region. Sampling was done twice yearly at all 87 sampling stations during the periods of high and low flow,

[18] *Sixty of the 64 public sewage treatment plants operating within the Region in 1970 were equipped with sludge digestion facilities.*

[19] *See Wisconsin Solid Waste Recycling--Predesign Report, Board of Engineering Consultants, Governor's Recycling Task Force, May 1973.*

with the samples being analyzed for dissolved oxygen, temperature, fecal and total coliform, nitrate nitrogen, nitrite nitrogen, dissolved phosphorus, pH, chloride, and specific conductance.

To provide additional information on the diurnal fluctuations of stream water quality in the Region, the monitoring program was revised in 1970 to provide for the collection of six stream water samples over a 24-hour period once yearly during a period of low streamflow at each sampling station, with each sample being analyzed for the following five parameters: dissolved oxygen, temperature, pH, chloride, and specific conductance. In addition, once during the 24-hour period the following four parameters would be analyzed: fecal coliform, nitrate nitrogen, nitrite nitrogen, and dissolved phosphorus.

In order to obtain regional information on additional water quality indicators, the Commission and the Wisconsin Department of Natural Resources agreed to a further modification of the program beginning with the 1972 survey. The overall continuity of the sampling program was maintained by continuing to monitor those parameters included in previous surveys with the following changes: a decrease from six to four per day in the frequency of dissolved oxygen, temperature, and specific conductance measurements; a decrease from six to two per day in the frequency of pH and chloride determinations; an increase from one to two per day in the frequency of fecal coliform, nitrate nitrogen, nitrite nitrogen, and dissolved phosphorus measurements; and the addition of two determinations per day of organic nitrogen, ammonia nitrogen, and total phosphorus. The addition of the three parameters was prompted by the need for more information on nutrients and increased interest in both oxygen demand exerted by ammonia nitrogen and the toxic effect of ammonia nitrogen. Thus, the stream water quality monitoring program, as revised in 1972, provides for four measurements over a 24-hour period once yearly. These are made during a period of low flow at each of the 87 stations for each of the following three parameters: dissolved oxygen, temperature, and specific conductance. Two determinations are made at each station over the same 24-hour period of each of the following nine parameters: pH, chloride, fecal coliform, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, organic nitrogen, dissolved phosphorus, and total phosphorus.

Current Review of Monitoring Program Data: Nearly 10 years have elapsed since the conduct in 1964 of the initial bench mark stream water quality survey by the Commission. The Commission is currently (1973) analyzing the data collected under the continuing program, and the findings of this analysis are to be set forth in a Commission technical report scheduled to be published in late 1974. The principal objectives of this analysis are to make a complete presentation of all the data collected to date; provide, based upon that data, an assessment of long-term trends in stream water quality in the Region; evaluate existing water quality against current adopted water use objectives and supporting standards, as well as anticipated upgraded State of Wisconsin water use objectives and supporting standards, to determine how well those objectives are being achieved; and consider alterations in the sampling program—revision to and expansion of the number of water quality indicators included in the program, modifications in the frequency of sampling, adjustments in the location of sampling stations, and more extensive flow measurements—in light of anticipated changes in Wisconsin water use objectives and standards, changing federal requirements, and data needs revealed by the analysis.

Implications for Regional Sanitary Sewerage System Planning Program: The Commission staff analysis of the SEWRPC-DNR surface water quality monitoring program and the findings and recommendations resulting from that analysis may be expected to be of particular significance to the implementation phase of the regional sanitary sewerage system planning program. Inasmuch as water quality enhancement and protection constitute a most important objective of the sanitary sewerage system planning program, this detailed examination of recent and current regional water quality levels will establish a base coincident with completion of the regional sanitary sewerage system plan against which sewerage study implementation efforts may be measured.

Furthermore, and as discussed in Chapter IX of this report, the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning concluded that the regional data with respect to instream nitrification were minimal. Accordingly, the Commission endorsed the recommendations concerning nitrification set forth in this report upon the condition that the Commission, as part of its continuing water resources planning programs and in cooperation with the Wisconsin Department of Natural Resources, undertake the collection and analysis of additional instream nitrification data and also do detailed water quality simulation for selected stream reaches to further the understanding of the relationship between sewage treatment, instream nitrification, and instream water quality.

Recommendations pertaining to acquisition of additional water quality data in general, and nitrification data in particular, and recommendations with respect to water quality modeling efforts will result from the current comprehensive examination of existing regional water quality data. The local units of government in cooperation with the federal, state, and regional agencies should examine those findings and recommendations when published and, inasmuch as they are judged to be consistent with the objectives of the regional sanitary sewerage system planning program, lend their active support to implementation of those recommendations.

Pollution Investigation Surveys: In order to complement the stream water quality monitoring program described above, it is recommended that the Wisconsin Department of Natural Resources continue to conduct periodic pollution investigation surveys of the river basins in the Region. Such surveys are essential to providing additional water quality information through the collection and analysis of water samples, as well as to uncover new sources of pollution. Such surveys, as continuing surveillance efforts, should be made for each basin in the Region at regular intervals of no more than five years. The conduct of such surveys is essential to providing data for continuing water quality management planning efforts, which efforts in turn provide the data necessary to enable the Wisconsin Department of Natural Resources to issue waste discharge permits under the federal water quality legislation.

COST ANALYSIS

In order to assist the responsible public officials concerned in evaluating the foregoing recommended regional sanitary sewerage system plan, a preliminary capital improvement program was prepared which, if followed, would result in total plan implementation over a 20-year period. This preliminary capital improvement program includes the staging of the necessary facility construction and the distribution of the attendant costs over the 20-year plan implementation period 1970-1990. This program is presented in summary form for the Region as a whole in Table 234 and is presented in more detailed form by subregional area in a series of tables in Chapter XIV of this report. The detailed tables set forth the construction costs and the estimated maintenance and operation costs associated with implementation of each of the individual recommended plan elements by year and by unit or units of government concerned. The ultimate adoption of capital improvement programs for implementation of the sanitary sewerage system plan will require determination by responsible public officials of not only those individual plan elements which are to be implemented, and the timing of such implementation, but also of the principal beneficiaries and the available means of financing. In addition to the summary capital improvement program set forth in Table 234, the plan costs for each major plan element by subregional area are presented in Table 235.

The full capital investment cost of implementing the recommended regional sanitary sewerage system plan is estimated at about \$507 million over the 20-year plan implementation period. Of this total cost, about \$134 million, or about 26 percent, is required to fully implement the recommended sewage treatment plan element of the regional plan; about \$194 million, or about 38 percent, is required to fully implement the intercommunity trunk sewer element of the recommended plan; and about \$179 million, or about 36 percent, is required to fully implement the combined sewer overflow abatement element of the recommended plan.

The average annual cost of the total capital investment required for plan implementation approximates \$25 million, or about \$12 per capita, the per capita cost being based on the anticipated regional population to be served with sanitary sewers in 1980. As reported in Chapter V, about \$23 per capita was expended in 1970 in the Region for sewerage facility capital improvements. The average annual capital costs and corresponding per capita costs of implementation of the sewage treatment plant, intercommunity trunk sewer, and combined sewer overflow abatement plan elements are, respectively, about \$6 million, or about \$2.90 per capita; \$10 million, or about \$4.90 per capita; and \$9 million, or about \$4.40 per capita.

It is anticipated that upon adoption of the plan by the concerned units and agencies of government, all of the components of the recommended regional sanitary sewerage system plan will be eligible for state and federal grants-in-aid. The possible sources of state and federal financial assistance are described in Chapter XIV of this report. Given adequate funding of such assistance programs at the state and federal levels of government, it is estimated that full utilization of these financial resources for local implementation of the recommended regional sanitary sewerage system plan could serve to reduce the local plan implementation cost with respect to capital investment by approximately 80 percent.

In order to assess the possible impact of implementation of the regional sanitary sewerage system plan on the public financial resources of the local units of government within the Region, an analysis was made of the public expenditures by all of the units of government in the Region for public sanitary sewerage facilities during the period 1960 to 1970. The source of data was audit reports filed by municipalities with the Wisconsin Department of Administration, Bureau of Municipal Audit. Data were obtained from the audit files for the years 1960, 1962, 1964, 1966, 1968, and 1970. The data obtained from the audit reports from 1970 were then compared with the results of the inventory of public sewerage expenditures set forth in Chapter V of this report. This comparison was made on a county-by-county basis, and indicated that the audit reports generally under-reported actual expenditures for sewerage purposes. Accordingly, factors were developed to adjust the audit report figures to those derived from the Commission's own inventory of expenditures during 1970, and such factors were then applied to the data for the years 1960 through 1968. These estimated expenditures for the Region as a whole, as adjusted, are set forth in Table 236.

As indicated in Table 236, local units of government in the Region expended an average annual

Table 234

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED REGIONAL SANITARY SEWERAGE SYSTEM PLAN BY MAJOR PLAN ELEMENT BY YEAR: 1971-1990

Calendar Year	Project Year	Sewage Treatment Plant Plan Element		Intercommunity Trunk Sewer Plan Element		Abatement of Combined Sewer Overflow Plan Element[1]		Total	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ 11,693,500	$ 9,081,900	$ 522,000	$ 1,300	$ --	$ --	$ 12,215,500	$ 9,083,200
1972	2	14,954,800	9,223,300	--	200	--	--	14,954,800	9,223,500
1973	3	12,307,800	9,422,100	12,072,000	950	--	--	24,379,800	9,423,050
1974	4	2,015,000	9,625,300	--	1,250	5,478,400	--	7,493,400	9,626,550
1975	5	5,875,000	9,672,300	11,558,000	1,900	14,609,000	--	32,042,000	9,674,200
1976	6	11,110,500	10,062,600	13,411,000	3,000	14,609,100	--	39,130,600	10,065,600
1977	7	31,150,600	10,607,000	18,814,900	45,700	23,714,100	--	73,679,600	10,652,700
1978	8	6,185,000	10,928,400	13,332,800	87,400	9,300,000	1,600,000	28,817,800	12,615,800
1979	9	1,555,400	12,354,200	30,449,300	20,161,100	9,300,000	1,600,000	41,304,700	34,115,300
1980	10	14,431,100	12,424,200	34,501,900	20,183,400	9,300,000	1,600,000	58,233,000	34,207,600
1981	11	11,328,600	13,038,500	1,000,000	20,395,900	9,300,000	1,600,000	21,628,600	35,034,400
1982	12	382,300	13,467,500	9,643,000	20,401,200	9,300,000	1,600,000	19,325,300	35,468,700
1983	13	--	13,483,200	15,225,300	20,402,500	9,300,000	1,600,000	24,525,300	35,485,700
1984	14	--	13,483,200	2,456,500	20,404,000	9,300,000	1,600,000	11,756,500	35,487,200
1985	15	8,744,600	13,483,200	9,920,600	20,409,400	9,300,000	1,600,000	27,965,200	35,492,600
1986	16	--	13,631,200	--	20,421,100	9,300,000	1,600,000	9,300,000	35,652,300
1987	17	--	13,631,200	3,499,200	20,421,900	9,300,000	1,600,000	12,799,200	35,653,100
1988	18	--	13,631,200	--	20,421,900	9,300,000	1,600,000	9,300,000	35,653,100
1989	19	--	13,631,200	3,060,600	20,422,900	9,300,000	1,600,000	12,360,600	35,654,100
1990	20	2,632,500	13,588,000	13,856,600	20,426,900	9,300,000	1,600,000	25,789,100	35,614,900
Total		$134,366,700	$238,469,700	$193,323,700	$244,613,900	$179,310,600	$20,800,000	$507,001,000	$503,883,600
Annual Average		$ 6,718,335	$ 11,923,485	$ 9,666,185	$ 12,230,695	$ 8,965,530	$ 1,040,000	$ 25,350,050	$ 25,194,180

NOTE: More detailed cost schedules are set forth by subregional area in Tables 249, 251, 253, 255, 257, 259, 261, 263, 265, 267, and 269.

[1]Does not include $2.3 million necessary to conduct the preliminary engineering study for the Milwaukee area deep tunnel/mined storage/flow-through treatment plan recommendation.

Source: SEWRPC.

Table 235

SUMMARY OF COST ESTIMATES FOR SEWAGE TREATMENT PLANTS, INTERCOMMUNITY TRUNK SEWERS, AND COMBINED SEWER OVERFLOW ABATEMENT PROGRAMS RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE REGION: 1990

Sanitary Sewerage System Plan Component (By Subregional Area)	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
MILWAUKEE-METROPOLITAN SUBREGIONAL AREA							
Sewage Treatment Plants	$ 31,435,500	$ 38,485,000	$108,567,000	$147,052,000	$ 2,441,800	$ 6,887,900	$ 9,329,700
Intercommunity Trunk Sewers	131,904,300	97,397,000	1,407,700	98,804,700	6,179,300	89,300	6,268,600
Abatement of Combined Sewer Overflows	130,005,000	148,730,000	24,610,000	173,340,000	9,416,000	1,562,000	10,978,000
Subtotal	293,344,800	284,612,000	134,584,700	419,196,700	18,037,100	8,539,200	26,576,300
UPPER MILWAUKEE RIVER SUBREGIONAL AREA							
Sewage Treatment Plants	6,918,700	8,668,100	13,413,100	22,081,200	549,800	877,200	1,427,000
Intercommunity Trunk Sewers	1,137,800	1,130,800	175,600	1,306,400	71,600	11,100	82,700
Subtotal	8,056,500	9,798,900	13,588,700	23,387,600	621,400	888,300	1,509,700
SAUK CREEK SUBREGIONAL AREA							
Sewage Treatment Plants	3,117,000	3,030,800	2,569,100	5,599,900	192,200	163,000	355,200
Intercommunity Trunk Sewers	287,800	230,100	122,900	353,000	14,600	7,800	22,400
Subtotal	3,404,800	3,260,900	2,692,000	5,952,900	206,800	170,800	377,600
KENOSHA-RACINE SUBREGIONAL AREA							
Sewage Treatment Plants	16,915,000	18,024,000	40,146,000	58,170,000	1,143,500	2,547,000	3,690,000
Intercommunity Trunk Sewers	20,808,000	16,362,000	2,347,000	18,709,000	1,038,100	148,900	1,187,000
Abatement of Combined Sewer Overflows--Kenosha	21,913,600	16,058,300	--	16,058,300	1,018,800	--	1,018,800
Abatement of Combined Sewer Overflows--Racine	27,392,000	20,072,900	--	20,072,900	1,273,500	--	1,273,500
Subtotal	87,028,600	70,517,200	42,493,000	113,010,200	4,473,900	2,695,900	7,169,300
ROOT RIVER CANAL SUBREGIONAL AREA							
Sewage Treatment Plants	2,112,500	1,989,200	1,721,200	3,710,400	126,200	109,200	235,400
Intercommunity Trunk Sewers	245,800	193,900	50,500	244,400	12,300	3,200	15,500
Subtotal	2,358,300	2,183,100	1,771,700	3,954,800	138,500	112,400	250,900
DES PLAINES RIVER SUBREGIONAL AREA							
Sewage Treatment Plants	3,183,800	3,018,100	2,729,800	5,747,900	191,500	173,000	364,500
Intercommunity Trunk Sewers	121,500	88,300	1,600	89,900	5,600	100	5,700
Subtotal	3,305,300	3,106,400	2,731,400	5,837,800	197,100	173,100	370,200
UPPER FOX RIVER SUBREGIONAL AREA							
Sewage Treatment Plants	27,335,800	20,207,000	16,884,300	37,091,300	1,282,000	1,071,200	2,353,200
Intercommunity Trunk Sewers	8,069,700	5,906,300	59,600	5,965,900	374,700	3,800	378,500
Subtotal	35,405,500	26,113,300	16,943,900	43,057,200	1,656,700	1,075,000	2,731,700
LOWER FOX RIVER SUBREGIONAL AREA							
Sewage Treatment Plants	14,425,100	13,054,000	10,721,600	23,775,600	828,250	710,100	1,538,350
Intercommunity Trunk Sewers	13,301,100	10,068,800	1,579,600	11,648,400	638,800	100,200	739,000
Subtotal	27,726,200	23,122,800	12,301,200	35,424,000	1,467,050	810,300	2,277,350
UPPER ROCK RIVER SUBREGIONAL AREA							
Sewage Treatment Plants	4,673,800	4,212,100	3,394,400	7,606,500	267,300	215,300	482,600
Intercommunity Trunk Sewers	879,000	657,300	89,900	747,200	41,700	5,700	47,400
Subtotal	5,552,800	4,869,400	3,484,300	8,353,700	309,000	221,000	530,000
MIDDLE ROCK RIVER SUBREGIONAL AREA							
Sewage Treatment Plants	10,854,400	9,754,600	8,432,100	18,186,700	619,100	535,000	1,154,100
Intercommunity Trunk Sewers	9,245,500	7,021,700	926,100	7,947,800	445,500	58,800	504,300
Subtotal	20,099,900	16,776,300	9,358,200	26,134,500	1,064,600	593,800	1,658,400
LOWER ROCK RIVER SUBREGIONAL AREA							
Sewage Treatment Plants	13,395,100	12,167,900	9,481,500	21,649,400	772,100	601,600	1,373,700
Intercommunity Trunk Sewers	7,323,200	5,408,100	624,200	6,032,300	613,200	42,600	655,800
Subtotal	20,718,300	17,576,000	10,105,700	27,681,700	1,385,300	644,200	2,029,500
SOUTHEASTERN WISCONSIN REGION							
Sewage Treatment Plants	134,366,700	132,610,800	218,060,100	350,670,900	8,413,750	13,890,500	22,304,250
Intercommunity Trunk Sewers	193,323,700	144,464,300	7,384,700	151,849,000	9,435,400	471,500	9,906,900
Abatement of Combined Sewer Overflows	179,310,600	184,861,200	24,610,000	209,471,200	11,708,300	1,562,000	13,270,300
Total	$507,001,000	$461,936,300	$250,054,800	$711,991,100	$29,557,450	$15,924,000	$45,481,450

Source: SEWRPC.

Table 236

EXPENDITURES FOR PUBLIC SANITARY SEWERAGE PURPOSES AND TOTAL RECEIPTS REPORTED BY LOCAL UNITS OF GOVERNMENT IN THE REGION: 1960, 1962, 1964, 1966, 1968, and 1970[a] (IN MILLIONS OF DOLLARS)

Year	Sanitary Sewerage Expenditures			Total Receipts[4]	Sanitary Sewerage Expenditures as a Percent of Total Receipts
	Capital Improvements[2]	Operation and Maintenance[3]	Total		
1960	$45.9	$3.0	$48.9	$ 586.5	8.3
1962	13.3	5.0	18.3	579.1	3.2
1964	20.8	2.8	23.6	632.8	3.7
1966	76.8	3.7	80.5	750.5	10.7
1968	72.5	6.5	79.0	949.6	8.3
1970	33.7	9.4	43.1	1,355.5	3.2
Average 1960-1970	43.8	5.1	48.9	809	6.0

[1]*As adjusted to compensate for underreporting on audit forms; see accompanying text.*

[2]*Items included in this category are sanitary sewer facility construction costs, and monies expended for debt retirement for sewage facilities, including special assessment bonds paid.*

[3]*Items included in this category are operation and maintenance expenditures for sewage treatment plants and pumping stations, contract payments for sewage treatment, and overhead.*

[4]*Includes all receipts reported by the municipal units of government minus agency and trust receipts.*

Source: Wisconsin Department of Administration, Bureau of Municipal Audit, and SEWRPC.

amount of nearly $49 million for the construction, maintenance, and operation of public sanitary sewerage facilities over the 1960-1970 period. This amount is equal to about 6 percent of the average annual public revenues received by the local units of government over the same period. The estimated average annual expenditure of about $49 million for sanitary sewerage purposes may be further broken down to estimates of $44 million for annual capital improvements, with the remaining $5 million for annual sewerage operation and maintenance purposes.

Based upon the data presented in Table 236, four alternative forecasts, each utilizing differing assumptions, were prepared to indicate the possible range of future expenditures by local units of government within the Region for public sanitary sewerage purposes (see Table 237 and Figure 131). The first alternative forecast assumed that the average annual rate of increase in expenditures which obtained over the 1960 to 1970 period could be expected to continue to the year 1990. Under this first assumption, nearly $1.9 billion would become available for sanitary sewerage purposes. The second alternative forecast assumed that the average per capita expenditures which obtained over the 1960 to 1970 period could be expected to continue to the year 1990. Under this assumption, about $1.4 billion would become available for sanitary sewerage purposes. The third alternative forecast assumed that the average proportion of sanitary sewerage expenditures to total annual receipts by the local units of government which obtained over the 1960 to 1970 period could be expected to continue to the year 1990. Under this assumption nearly $2.3 billion would become available for sanitary sewerage purposes. Finally, the fourth alternative forecast assumed that the average annual rate of increase of per capita expenditures which obtained over the 1960 to 1970 period could be expected to continue to the year 1990. Under this assumption about $2.6 billion would become available for sanitary sewerage purposes.

A review of past expenditure patterns, along with the range of possible future expenditure levels,

Table 237

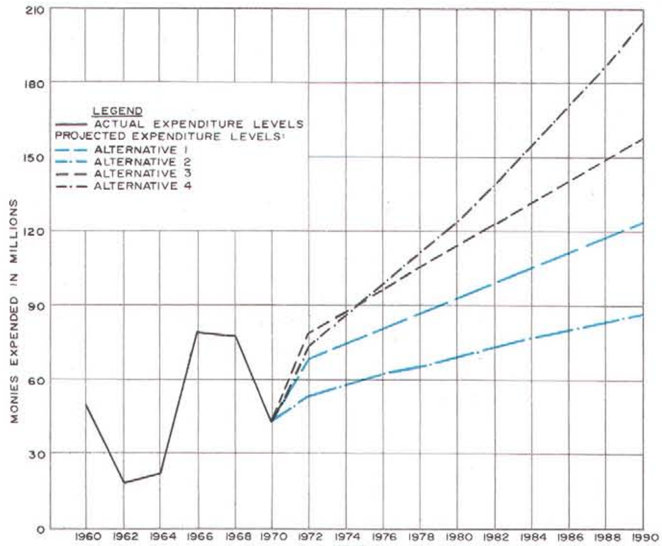
ALTERNATIVE FORECASTS OF EXPENDITURES FOR PUBLIC SANITARY SEWERAGE PURPOSES BY THE LOCAL UNITS OF GOVERNMENT IN THE REGION: 1971-1990

Alternative Forecast	Forecast Assumptions	Forecast Expenditure
1	Least squares linear projection of the 1960-1970 expenditures.	$1,896,176,000
2	Constant per capita expenditure	1,416,700,000
3	Constant proportion of total receipts	2,340,300,000
4	Increasing per capita expenditure--least squares linear projection of 1960-1970 per capita expenditure	2,622,100,000

Source: SEWRPC.

Figure 131

ACTUAL AND PROJECTED EXPENDITURE LEVELS FOR SANITARY SEWERAGE PURPOSES IN THE REGION: 1960-1990



NOTE: INCLUDES ALL EXPENDITURES FOR OPERATION, MAINTENANCE, AND CAPITAL IMPROVEMENTS.

thus indicates that between \$1.4 and \$2.6 billion may be expected to be expended by the local units of government within the Region for sanitary sewerage purposes by 1990. The forecast range does not represent any major departures from past expenditure levels or patterns and, therefore, may be considered conservative in nature.

The estimated total cost of implementing the entire recommended sanitary sewerage system plan for the Region, including capital and operation and maintenance costs, is about \$1.0 billion (see Table 234). This amount can be compared on a gross basis with a possible expenditure of about \$2.0 billion, the average of the four alternative forecasts of expenditures for sanitary sewerage system purposes as presented above. While such a comparison does indicate that the plan implementation costs are reasonable, it is important to note that the two figures are not comparable. The recommended plan does not include, for example, the cost of constructing lateral, common, branch, or local trunk sewers. Thus, expenditures can be expected for public sanitary sewerage purposes in addition to those provided for in the recommended plan. At least partially offsetting this factor are the following considerations: 1) implementation of the recommended plan would result in lower expenditures being made by homeowners for the installation and maintenance of private sewage disposal systems; 2) large portions of the cost of installing lateral and branch sewers can be recouped through application of appropriate financing techniques, such as special assessments, and through regulations requiring land developers to install sanitary sewerage facilities as an integral part of the land development process; and 3) it is reasonable to conclude that given the Federal Water Pollution Control Act Amendments of 1972, nonlocal expenditures for sanitary sewerage facilities in the form of state and federal aid will play an increasingly important role in future years.

From the foregoing discussion it is fair to conclude that sufficient monies to substantially implement the recommended regional sanitary sewerage system plan should become available without significant shifts in local expenditure patterns. The costs of the plan must also be viewed in terms of the substantial benefits, namely, achieving the established water use objectives and supporting water quality standards for the Region's surface waters, eliminating certain existing public health hazards through the extension of sewers, and avoidance of the creation of new public health hazards due to malfunctioning septic tank sewage disposal systems on soils poorly suited for the absorption of sewage effluent. In addition, implementation of the recommended regional sanitary sewerage system plan would substantially contribute toward achieving a land use pattern that not only can be effectively and economically provided with centralized public sanitary sewer service, but one that also lends itself to the efficient and economic provision of other essential public services. It is clear that if the adopted water uses and supporting water quality standards are to be met, the level of expenditures needed to implement the recommended regional sanitary sewerage system plan is necessary and warranted.

RELATIONSHIP OF PLAN TO REVISED 1990 AND NEW 2000 POPULATION FORECASTS

As discussed in Chapter X of this report, the Commission began in 1972 a major effort toward reevaluation of the adopted regional land use plan. As part of this effort, revised population forecasts were prepared for the year 1990, and such forecasts were extended to the year 2000. For the Region as a whole, the revised 1990 population is anticipated to be 2.3 million persons, with a 2000 regional population of about 2.6 million persons. On a regional basis, therefore, the population initially anticipated for the Region in 1990 at the time of the preparation of the regional land use plan appears most likely to be nearly reached in the year 2000.

On the basis of a county-by-county comparison of the initial and revised population forecasts, it was concluded that with respect to four counties—Ozaukee, Walworth, Washington, and Waukesha—greater rates of population growth than initially anticipated would likely result in a need for sewerage facilities in addition to those included in the recommended regional sanitary sewerage system plan to serve the population distribution as assumed in the adopted regional land use plan. With respect to Milwaukee County, it was concluded that the substantially lower rate of growth than initially anticipated will have little impact on the basic areawide sewerage system which is already substantially in place and which, for system continuity and water pollution abatement purposes, must be completed as initially planned. Within Racine and Kenosha Counties the picture was somewhat mixed, with greater than anticipated growth likely to occur in the western portions of the counties, coupled with less growth in the eastern portions of the counties, where the basic areawide sanitary sewerage system is already substantially in place.

The revised 1990 and new 2000 population forecasts have also been allocated to subareas of the Region designated as planning analysis areas as a part of the Commission's continuing land use-transportation planning program (see Map 134). It is possible, therefore, to make a more detailed comparison between initial and revised 1990 and new 2000 forecasts on a subcounty basis and determine what impact, if any, such forecasts are likely to have on the recommended regional sanitary sewerage system plan. The results of this comparison by selected subarea of the Region are set forth in Table 238.

Twenty-eight subareas of the Region may be identified which are comprised of one or more of the planning analysis areas and which generally correspond to one or more sewer service areas as utilized in the preparation of the recommended regional sanitary sewerage system plan. With respect to eight of these subareas—western Kenosha County, Belgium-Fredonia, Union Grove, Allenton, Waukesha, Elkhorn, Geneva Lake, and Delavan—it may be concluded that the new 1990 population forecasts are so close to the initial 1990 population forecasts as to have virtually no substantial impact upon the recommended regional sanitary sewerage system plan. In some instances with respect to these eight subareas, however, it is likely that additional sewerage facilities will be required to serve the anticipated 2000 population.

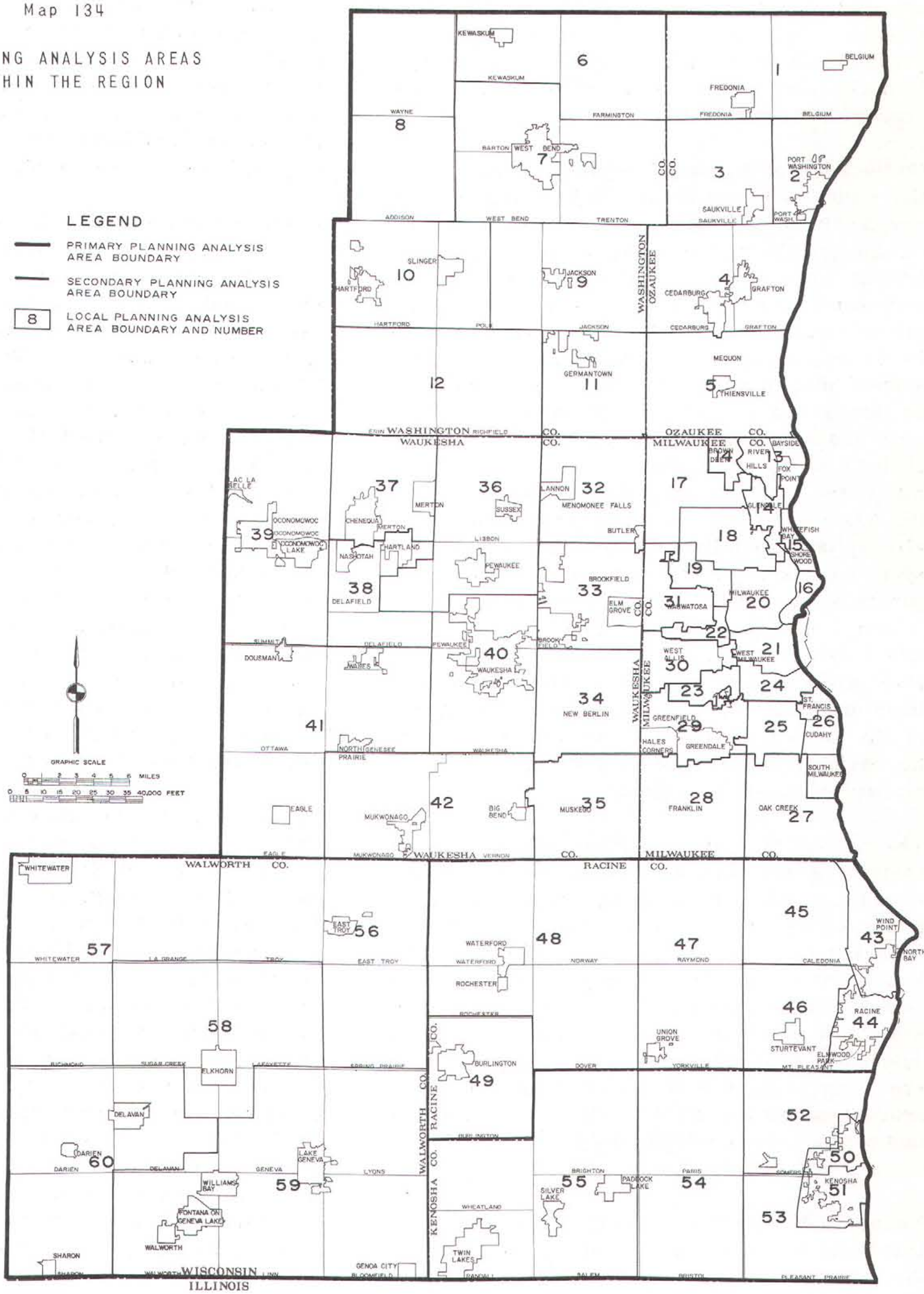
In one subarea—Erin-Richfield—the revised 1990 and new 2000 population forecasts indicate substantial growth beyond that initially anticipated in the adopted regional land use plan, which growth may require the installation of sanitary sewerage facilities not anticipated in the recommended plan. Whether or not such facilities will be needed will depend upon the density of development in the area and the continued ability of soils and the groundwater reservoir to safely absorb increasing amounts of septic tank effluent. This same conclusion is at least partially true of the southwest Waukesha County area designated as the Dousman-Wales-North Prairie-Eagle area in Table 238. In this area sewerage facilities were recommended in Dousman, Wales, and North Prairie to serve primarily existing and a modest amount of anticipated future development. It may be necessary to extend sewerage facilities to additional urban areas if urban growth continues and reaches the new forecast levels for 1990 and 2000.

In two subareas—the Kenosha Planning District and the Racine Urban Planning District consisting of all that area of Kenosha and Racine Counties east of IH 94, respectively—the revised population forecasts indicate a potential decrease in population growth. It is unlikely, however, that this decrease will have any significant impact on the recommended regional sanitary sewerage system plan for these two Districts, since in each case much of the areawide sewerage system has been completed and is already in place. A decrease in population growth may require somewhat less total treatment capacity than anticipated and, depending upon the spatial distribution of new urban development within the Districts, may preclude the need to extend trunk sewers as far as envisioned in the plan. Accordingly, careful staging of facility construction in these Districts will be required.

In the Milwaukee-Metropolitan Sewerage District and its contract areas, the revised 1990 and new 2000 population forecasts are also significantly less than the initial 1990 forecast. As concluded in Chapter X of this report, however, it is unlikely

Map 134

PLANNING ANALYSIS AREAS WITHIN THE REGION



In order to analyze the potential impact of revised Commission population forecasts on the recommended regional sanitary sewerage system plan, the initial 1990, revised 1990, and new 2000 population forecasts for various subareas of the Region were compared and analyzed. The subareas utilized in this comparison and analysis were the Commission standard planning analysis areas shown on this map. Comparative population data pertaining to each planning analysis area are set forth in Table 238. The analysis concluded that, despite a slowing down in the rate of population growth in the Region and a shifting population distribution pattern in the Region, the adopted regional land use plan remains a sound basis for the design of the recommended regional sanitary sewerage system plan. Careful attention durtng the plan implementation period should be given to the trends of change in life styles and activity patterns as reflected in land use development patterns and in daytime-nighttime and weekday-weekend population differentials within subareas of the Region, however, if the plan is to continue to remain a viable tool against which to evaluate land use and sewerage facility development proposals as they arise on a day-to-day basis. Departures of land use development from the pattern envisioned in the adopted regional land use plan may result in the need for more sanitary sewerage facilities to serve outlying areas of the Region by the year 2000, even though total resident population levels at the regional scale approximate or even fall below the initially forecast 1990 forecast levels.

Source: SEWRPC.

Table 238

COMPARISON BETWEEN INITIAL 1990 SEWRPC POPULATION FORECASTS AS USED IN PREPARATION OF THE RECOMMENDED REGIONAL SANITARY SEWERAGE SYSTEM PLAN AND REVISED SEWRPC 1990 AND NEW SEWRPC 2000 POPULATION FORECASTS BY SELECTED SUBAREA OF THE REGION

Subarea		Initial SEWRPC 1990 Population Forecast[2]			Revised SEWRPC 1990 Population Forecast	New SEWRPC 2000 Population Forecast
Name	Planning Analysis Area Designation(s)[1]	Served in Regional Sanitary Sewerage System Plan	Unserved in Regional Sanitary Sewerage System Plan	Total		
Kenosha Planning District	50-53	181,490	1,130	182,620	126,520	139,280
Bristol-Paris	54	1,790	3,340	5,130	6,475	7,380
Western Kenosha County	55	14,300	4,940	19,240	19,406	21,741
Milwaukee-Metropolitan District and Contract Area	5,11 13-35	1,783,440	9,430	1,792,870	1,394,020	1,519,196
Cedarburg-Grafton	4	24,980	2,640	27,620	36,907	50,824
Saukville	3	2,620	1,050	3,670	5,617	7,223
Port Washington	2	12,370	580	12,950	14,962	17,902
Belgium-Fredonia	1	3,770	3,000	6,770	7,021	8,183
Racine Urban Planning District	43-46	222,070	2,780	224,850	173,931	198,557
Union Grove	47	15,990	3,940	19,930	14,994	17,956
Western Racine County	48	16,110	4,690	20,800	24,808	30,549
Burlington	49	14,960	2,540	17,500	19,367	23,538
Kewaskum	6	3,280	2,130	5,410	6,653	7,708
West Bend	7	27,040	3,450	30,490	42,380	54,473
Allenton	8	1,670	2,510	4,180	4,236	4,561
Jackson	9	1,770	2,650	4,420	7,795	9,796
Hartford-Slinger	10	13,290	1,380	14,670	16,878	19,774
Erin-Richfield	12	--	6,080	6,080	12,354	16,575
Sussex-Pewaukee	36	29,530	2,630	32,160	37,324	58,431
Oconomowoc-Hartland-Delafield	37-39	50,050	4,510	54,560	70,656	98,585
Waukesha	40	77,270	2,400	79,670	80,810	107,064
Dousman-Wales-North Prairie-Eagle	41	3,110	8,160	11,270	17,679	23,740
Mukwonago-Big Bend	42	7,800	6,880	14,680	28,202	40,065
East Troy	56	4,550	3,880	8,430	12,946	16,103
Whitewater	57	9,550	4,740	14,290	17,029	18,833
Elkhorn	58	7,950	3,560	11,510	12,760	15,306
Geneva Lake Area	59	27,060	6,290	33,350	31,708	36,832
Delavan	60	17,280	2,190	19,470	17,657	19,926

[1]*See Map 134.*

[2]*Based on distribution of forecast county population as recommended in the adopted regional land use plan.*

Source: SEWRPC.

that this change in population trends will have any impact on the recommended regional sanitary sewerage system plan, since much of the areawide sewerage system has been completed and is in place, with most remaining trunk sewer extensions essential to provide sewage flow relief and to extend service to committed contract areas.

In all remaining areas of the Region as identified in Table 238, the revised 1990 population forecast exceeds the initial 1990 population forecast and it may be assumed, therefore, that the facilities included in the recommended regional sanitary sewerage system plan will be the minimum necessary to accommodate future development. Design engineers involved in engineering studies relating to the improvements included in the recommended plan will need to carefully review the revised forecast to determine what modifications may be warranted in the sizing or location of major recommended sewerage facilities.

Based upon the foregoing, it may be concluded that the regional land use plan remains a sound basis for the design of the recommended regional sanitary sewerage system plan. It must be recognized, however, that both the land use and sewerage systems plans—like all plans—are intended only as points of departure against which land use and sewerage facility development proposals can be evaluated as they arise on a day-to-day basis. If they are to continue to serve as valid and useful points of departure, the plans must be maintained current, being revised as newly discovered evidence may require. Careful attention in plan maintenance will have to be given to trends of change in life styles and activity patterns, as reflected in land use development patterns and in daytime-nighttime and weekday-weekend population differentials within subareas of the Region. Departures of land use development from the pattern envisioned in the adopted regional land use plan may result in the need for more sanitary sewerage facilities to serve outlying areas of the Region by the year 2000, even though total resident population levels at the regional scale approximate or even fall below forecast levels.

PUBLIC REACTION TO RECOMMENDED PLAN

It was noted in Chapter II of this report that the general approach utilized by the Commission in the selection of a recommended plan from among alternatives is to proceed through the use of advisory committees, interagency meetings, informational meetings, and public hearings to a final decision and plan adoption by the Commission in accordance with the provisions of the State enabling legislation. Because plan selection and adoption necessarily involve both technical and nontechnical policy determinations, such selection and adoption must involve the various governmental bodies, technical agencies, and private interest groups concerned. Such involvement is particularly important in light of the advisory role of the Commission in shaping regional development. The use of advisory committees, public informational meetings, and public hearings appears to be the most practical and effective procedure available for attaining the necessary involvement of elected and appointed public officials and interested citizens in the planning process, and of openly arriving at agreement on development plans which can be jointly adopted and cooperatively implemented.

As an integral part of the regional sanitary sewerage system planning program, a series of informal public informational meetings and a formal public hearing were held within the Region. The meetings and hearing were conducted by the Commission itself, with either the Chairman of the Commission or county board-appointed Commissioners presiding. The purpose of these meetings and hearing was to more fully inform public officials and interested citizens about the findings and preliminary recommendations of the sewerage system planning program and to obtain the reaction of the officials and citizens to the regional sanitary sewerage system plan recommended by the staff and by the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning together with the alternatives thereto. The meetings and hearing were preceded by an extensive program of notification, including letters to local, state, and federal public officials; citizen groups; librarians; and to about 3,500 individuals and organizations included on the SEWRPC mailing list. In addition, news releases were issued to all daily and weekly newspapers and radio and television stations serving the Region. A summary of the inventory, analysis, and forecast findings; of the sewerage system development objectives and standards; of the alternative sewerage system plans considered; and of the recommended preliminary regional sanitary sewerage system plan was presented at each of the informational meetings and again at the public hearing, together with data on the costs and means for implementation of the recommended plan. The public informational meetings and hearing were held in accordance with the schedule listed below, and minutes of both the informational meetings and the public hearing, together with documentation of the notification procedures utilized by the Commission, totaling 370 pages in length, were published on February 1, 1974, and transmitted to the Regional Planning Commission for review and consideration prior to final adoption of the recommended plan.

General Informational Meetings

Presiding Agency	Place of Meeting	Date of Meeting
Southeastern Wisconsin Regional Planning Commission	Racine County Highway and Office Building Sturtevant, Wisconsin	November 5, 1973 7:35 p. m. - 9:05 p. m.
Southeastern Wisconsin Regional Planning Commission	Washington County Courthouse West Bend, Wisconsin	November 8, 1973 7:30 p. m. - 8:55 p. m.
Southeastern Wisconsin Regional Planning Commission	Walworth County Courthouse Elkhorn, Wisconsin	November 14, 1973 7:40 p. m. - 9:45 p. m.
Southeastern Wisconsin Regional Planning Commission	Pleasant Prairie Town Hall Pleasant Prairie, Wisconsin	November 15, 1973 7:40 p. m. - 8:45 p. m.
Southeastern Wisconsin Regional Planning Commission	Waukesha County Technical Institute, Pewaukee	November 19, 1973 7:35 p. m. - 10:05 p. m.
Southeastern Wisconsin Regional Planning Commission	Ozaukee County Courthouse Port Washington, Wisconsin	November 26, 1973 7:30 p. m. - 9:15 p. m.

Public Hearing

Southeastern Wisconsin Regional Planning Commission	Milwaukee County Courthouse Milwaukee, Wisconsin	December 5, 1973 7:30 p. m. - 9:00 p. m.

In addition to the foregoing general public informational meetings and the public hearing, four special public informational meetings were held at the request of local governmental officials and concerned citizens to, provide more detailed briefings on the preliminary recommended plan:

Special Informational Meetings

Governmental Unit or Group Requesting Meeting	Place of Meeting	Date of Meeting
Towns of Polk and West Bend Big Cedar Lake Sanitary District Little Cedar Lake Sanitary District Silver Lake Sanitary District	Town Hall Town of Polk	November 27, 1973 7:30 p. m. - 10:30 p. m.
City of Elkhorn Common Council	City Hall City of Elkhorn	November 28, 1973 7:30 p. m. - 10:00 p. m.

Delafield-Hartland Water Pollution Control Commission City of Delafield Common Council Village of Hartland Board	SEWRPC Offices City of Waukesha	December 3, 1973 4:00 p. m. - 6:00 p. m.
City of Lake Geneva Common Council and Plan Commission	City Hall City of Lake Geneva	December 3, 1973 7:00 p. m. - 8:30 p. m.
Mill Road Area Residents City of Delafield	SEWRPC Offices City of Waukesha	December 19, 1973 7:30 p. m. - 9:00 p. m.

In addition to the foregoing general and special public informational meetings and the public hearing, the following three special intergovernmental meetings were called by the Commission in response to concerns expressed at the public hearing:

Special Intergovernmental Meetings

Governmental Units and Other Groups Represented at Meeting	Place of Meeting	Date of Meeting
Delafield-Hartland Water Pollution Control Commission City of Delafield Village of Hartland Village of Nashotah Town of Summit Delafield Homeowners Association U. S. Environmental Protection Agency Wisconsin Department of Natural Resources SEWRPC	SEWRPC Offices City of Waukesha	January 14, 1974 7:30 p. m. - 9:30 p. m.
Walworth County City of Delavan City of Elkhorn Delavan Lake Sanitary District U. S. Environmental Protection Agency Wisconsin Department of Natural Resources SEWRPC	City Hall City of Elkhorn	January 16, 1974 1:30 p. m. - 3:00 p. m.
Washington County City of West Bend Town of Polk Town of West Bend Silver Lake Sanitary District Silver Lake Property Owners Association Little Cedar Lake Sanitary District Little Cedar Lake Property Owners Association Big Cedar Lake Sanitary District Big Cedar Lake Property Owners Association SEWRPC	Washington County Courthouse City of West Bend	January 16, 1974 7:30 p. m. - 10:00 p. m.

A total of 610 persons attended the general public informational meetings and the public hearing. The record of the proceedings indicates that public reaction to the plan recommendations, including the water use objectives, the waste treatment levels required to meet these objectives throughout the Region, the sewer service areas, and the trunk sewer and treatment facilities required to serve these areas, all met with a very favorable response. The meetings and hearing indicated that significant controversy existed with respect to the plan recommendations in only five geographic subareas of the Region: 1) the Lake Church area of Ozaukee County; 2) the Green Lake area of Washington County; 3) the Tri-Lakes area of Washington County; 4) the Delafield-Hartland area of Waukesha County; and 5) the Elkhorn-Delavan area of Walworth County.

Lake Church Sewer Service Area—Ozaukee County

Some citizens who reside along the shoreline of Lake Michigan in the Town of Belgium both north and south of the Harrington Beach State Park questioned the need to provide centralized sanitary sewer service to the shoreline development as recommended in the preliminary plan. In general, these citizens recognized that centralized sewer service was required for the unincorporated village of Lake Church, about one mile west of the shoreline urban development, and to the newly-established Harrington Beach State Park. They indicated, however, that in their opinion, utilization of onsite soil absorption septic tank systems to serve the approximately 130 homes along the Lake Michigan shoreline in the proposed service area remains a satisfactory long-term solution to the problem of handling sanitary wastes in this area.

After careful consideration of this matter, the Commission determined that the plan should continue to recommend the provision of centralized sanitary sewer service to the Lake Michigan shoreline development in the Town of Belgium. In its determination of this matter, the Commission reviewed not only the comments made by the citizens at the public informational meetings and hearing but also the findings that such service was essential to resolving existing and potential water pollution and public health hazards at both Lake Church and Harrington Beach State Park, the latter being contiguous to the existing shoreline development, and the fact that the soils in this area are generally poorly suited for the application of onsite sewage disposal systems. The Commission also took note of preliminary proposals advanced by the Town of Belgium through its consulting engineer, which proposals also would extend sewer service to the shoreline development in question. Finally, the Commission also noted that provision of sewer service to the shoreline area would also enable the abandonment of the private sewage treatment facility serving the Port Country Club.

Green Lake Sewer Service Area—Washington County

The adopted Milwaukee River watershed plan initially recommended that a centralized sanitary sewerage system be provided in the Town of Farmington to serve existing urban development, including campgrounds, on the shoreline of Green Lake. The record of the public hearing with respect to the Milwaukee River watershed plan reveals no opposition to or comment on the plan recommendation at that time. Accordingly, this recommendation was carried over into the preparation of the preliminary regional sanitary sewerage system plan. At the public hearing on the preliminary plan, both the Town of Farmington and the Washington County Park and Planning Commission requested this recommendation be deleted from the plan. The local officials expressed concern that the establishment of such a system would serve to induce further urban development and destroy the generally rural character of the surrounding area. Furthermore, they indicated steps would be taken with respect to the enactment of sound zoning and other land use control ordinances to ensure that urban development would not take place in this area. Finally, they indicated that alternative solutions to any existing problems, perhaps including the installation of holding tanks where necessary, would be superior to the establishment of a new sewerage system that would be costly to the small number of permanent residents on the lake.

After careful consideration of the information presented by the local public officials in this area, the Commission determined to delete from the recommended plan the proposal to provide for a new centralized sanitary sewer system to serve urban development on the shorelines of Green Lake. In so determining, the Commission noted that should at some future date problems related to the handling of sanitary wastes in the Green Lake area become more severe, a recommendation to provide a centralized sanitary sewerage service could be again reconsidered.

Tri-Lakes Sewer Service Area—
Washington County

The adopted Milwaukee River watershed plan initially recommended that centralized sanitary sewer service be provided for existing urban development along the shorelines of Big Cedar Lake, Little Cedar Lake, and Silver Lake, commonly known as the Tri-Lakes area, in the Towns of West Bend and Polk, with sewage treatment to be provided at the City of West Bend treatment facility. The public hearing record for the Milwaukee River watershed plan reveals no objection to or comment on this plan recommendation. The City of West Bend Common Council endorsed in principle the proposal to provide sewage treatment to the Tri-Lakes area and authorized necessary studies to expand the City of West Bend treatment facility to include capacity for Tri-Lakes sewage. Accordingly, the concept of centralized sewerage service to the Tri-Lakes area, with treatment provided at West Bend, was included in the preliminary regional sanitary sewerage system plan.

The public hearing record for the regional sanitary sewerage system plan reveals substantial concern over and objection to the proposed sewerage system on the part of some citizens and local public officials in the Tri-Lakes area. These citizens and officials held that the need for such service had not been adequately shown, that the costs for such service had been greatly understated, and that the provision of such service conflicted with local desires to retain in open space land uses those undeveloped lands within the lake subwatersheds, but away from the lake shore, and the generally low density, semi-rural character of the lake community. Certain public officials indicated that before they would be willing to commit themselves to endorsing the plan recommendation, further studies concerning the need for and cost of sewers in this area and, particularly, the impact that such sewers would have on lake water quality would be required. These concerns were jointly expressed by the Washington County Park and Planning Commission and by appropriate officials of the sanitary districts and property owners associations in the Tri-Lakes area.

In response to the expressed concern at the public hearing and in documents filed soon thereafter, the Commission held an intergovernmental meeting on January 16, 1974, at the Washington County Courthouse. Appropriate officials of the sanitary districts, property owners associations, the City of West Bend, and the Washington County Park and Planning Commission were present at this meeting. The various problems associated with providing centralized sanitary sewer service to the Tri-Lakes area were discussed at length at this meeting. Of particular concern was the continued eutrophication of the three inland lakes concerned, and the continued viability of using onsite sewage disposal and private water supply systems to serve the intensive urban development already existing around the shorelines of the three lakes. In addition, recent growth trends in the West Bend area have indicated a tendency toward urban development in the intervening areas between the City and the lake communities, raising the possibility of the lake communities eventually become contiguous to urban development in West Bend. A general consensus was arrived at the meeting to the effect that, while more detailed studies would be desirable to determine the precise impact on water quality of the installation of sanitary sewers, and while financial impact analyses should be made, the proposal contained in the preliminary regional sanitary sewerage system plan should remain in the plan as adopted by the Regional Planning Commission and certified to appropriate local, state, and federal agencies. Subsequently, the Washington County Park and Planning Commission submitted a supplementary statement to that included in the public hearing document indicating their agreement with this consensus and their support for retaining the recommendation in the final regional sanitary sewerage system plan. The County Park and Planning Commission further indicated that the three lake-oriented sanitary districts and property owner associations involved are desirous of proceeding with a local preliminary engineering study to more precisely determine the costs and benefits associated with the sewerage plan recommendation and thereby assist the local agencies concerned in arriving at a decision as to the desirability and timing of plan implementation. Based upon that supplementary statement, the Tri-Lakes sewer service recommendation, including treatment at the City of West Bend facility, was retained in the plan as recommended for adoption by the Commission.

Delafield-Hartland Sewer Service Area—
Waukesha County

A number of residents in the Bark River watershed area of Waukesha County expressed concerns over the plan recommendations for provision of sanitary sewer service to the City of Delafield; the Villages of Hartland, Merton, and Nashotah; and a portion of the Town of Summit adjacent to the City of Delafield, and more particularly about the location of the areawide sewage treatment plant proposed to serve this area. The preliminary plan recommendation as set forth earlier in this chapter was to provide centralized sanitary sewer service to the City of Delafield, the Villages of Hartland, Merton, and Nashotah, and the Nemahbin and Nashotah Lakes area of the Town of Summit. A major new areawide sewage treatment facility was proposed to be located on the Bark River in the Town of Summit. In addition, a new sewage treatment facility was proposed to serve the Village of Merton and environs. Under these plan recommendations the existing Village of Hartland sewage treatment facility would be abandoned. These plan recommendations generally coincided with the early proposals of the Delafield-Hartland Water Pollution Control Commission formed jointly by the City of Delafield and Village of Hartland to provide for areawide sewerage service in this portion of the county.

Coinciding with the completion of the regional sanitary sewerage system plan and the holdings of hearings thereon, the Delafield-Hartland Water Pollution Control Commission was in the process of selecting an alternate sewage treatment site, since the Town Board of the Town of Summit, acting after a vote of town residents during a special town meeting, had refused to cooperate in the location of the proposed areawide treatment facility below Crooked Lake in the Town of Summit.

Citizen comments made at the public informational meetings and public hearing, therefore, were directed both at the initial Commission staff and Technical Coordinating and Advisory Committee recommendation to build an areawide treatment facility downstream of Crooked Lake in the Town of Summit, and at the current Delafield-Hartland Water Pollution Control Commission proposal to place the areawide treatment facility on an alternate site in the City of Delafield, with discharge of effluent to the Bark River above the Nemahbin Lakes. In general, those citizens from the Town of Summit strenuously opposed the establishment of an areawide sewage treatment facility within the town, while recognizing, however, a need to provide sewer service to urban development in the Nemahbin and Nashotah Lakes area of the town. Those citizens of Delafield expressed support for the preliminary Commission plan recommendation, while strenuously opposing the location of the sewage treatment facility in the City of Delafield. In addition, the City of Oconomowoc, by Common Council resolution, expressed its opposition at the public hearing to selection of another alternative investigated under the study that would divert all sewage from the Bark River basin to the Oconomowoc River basin, with treatment to be provided at an expanded Oconomowoc treatment facility.

In an attempt to resolve this matter, the Commission held a special intergovernmental meeting on January 14, 1974, attended by appropriate officials representing the Delafield-Hartland Water Pollution Control Commission, the City of Delafield, the Villages of Nashotah and Hartland, the Town of Summit, the Wisconsin Department of Natural Resources, the U. S. Environmental Protection Agency, and interested citizens from the City of Delafield. At this meeting all of the parties concerned expressed again their individual positions, with a general consensus found on the need to provide an areawide sanitary sewer system to serve urban development in the Bark River basin, but with disagreement as to where specifically the areawide sewage treatment facility should be located. Discussion initially centered around three alternative treatment plant locations. One of the alternative locations—Oconomowoc—was opposed by Department of Natural Resources officials on the basis of unsound interbasin diversions of water, and note was also taken to the previously expressed official opposition to this alternative by the City of Oconomowoc. A second alternative location, consisting of two subalternatives, one that would locate the areawide plant in the Town of Summit downstream of Crooked Lake and another that would locate the plant in the City of Delafield with an outfall sewer through the Town of Summit to the Bark River below Crooked Lake, was objected to by the Town of Summit officials, who reiterated the position of the town residents, taken at a special town meeting, in opposition to these two proposals. A third alternative location, that selected by the Delafield-Hartland Water Pollution Control Commission in the City of Delafield, was opposed by residents of the city in light of potential land use conflicts.

Further discussion at the meeting centered on two additional alternative treatment plant locations, one which would locate the areawide sewage treatment plant in the northwest portion of the City of Delafield adjacent to the Village of Nashotah, with disposal of effluent primarily to the groundwater reservoir; the other involving location of the areawide treatment plant at or near the site of the existing Dousman sewage treatment facility, together with abandonment of the existing Dousman plant. Village of Nashotah officials opposed the first additional alternative indicating that, in their opinion, this alternative represented a poor solution to the problem in light of potential ground and surface water contamination and land use conflicts. The second additional alternative was favored primarily by those officials representing the Town of Summit since it would minimize the potential land use conflicts involved in the siting of the treatment plant and would enable the abandonment of the existing Dousman plant as well.

The cost of transporting the sewage from the treatment plant site located in the Town of Summit below Crooked Lake to the proposed Dousman site, a distance of about two miles, would entail additional capital and operating costs that would be difficult to justify on the basis of surface water quality considerations alone. Moreover, the construction of a gravity trunk sewer from Delafield to Dousman would have serious land use development ramifications in that it would tend to encourage intensive urban development over a large area of the Town of Summit, the very kind of development that the objecting Town of Summit residents did not favor.

In summary, it was recognized by all concerned at the meeting that absent the full cooperation of the Town of Summit, it will be very difficult to fully implement the preliminary regional plan recommendation to construct an areawide sewage treatment facility in the Town of Summit below Crooked Lake. While all present at the meeting agreed that the recommended location for the plant was the best possible location because it would provide the fullest measure of protection for the lakes in the area, the Town of Summit officials indicated that they could not cooperate in this matter because of the official Town policy adopted by the electorate at a special Town meeting held in 1972.

Following this interagency meeting and further discussions with public officials representing the Delafield-Hartland Water Pollution Control Commission and the Town of Summit, the Commission determined to explore in greater detail two of the suggested additional alternatives for locating the proposed areawide Delafield treatment facility. These two additional alternatives included locating the areawide sewage treatment plant in the northwest corner of the City of Delafield and disposing of the treated effluent primarily through discharge to the groundwater reservoir; and locating the areawide plant at Dousman together with abandonment of the existing Dousman treatment facility. These two post-public hearing alternative plans are shown in graphic forms on Maps 134A and 134B, while detailed cost estimates pertaining to the two additional alternative plans and comparisons of such cost estimates with recommended plan equivalents are set forth in Table 238A.

Under the first post-public hearing sewerage alternative considered for the Delafield subarea, the proposed Delafield treatment plant would be located in Section 6, Town 7 North, Range 18 East, in the City of Delafield, just adjacent to the Village of Nashotah. Three basic assumptions were made in the development of this alternative, namely:

1. That the same level of treatment would be provided at the proposed plant as that recommended to be provided at the treatment plants proposed in the alternatives considered in the preparation of the regional sanitary sewerage system plan;

2. That the proposed seepage ponds would be constructed and designed like stabilization ponds; and

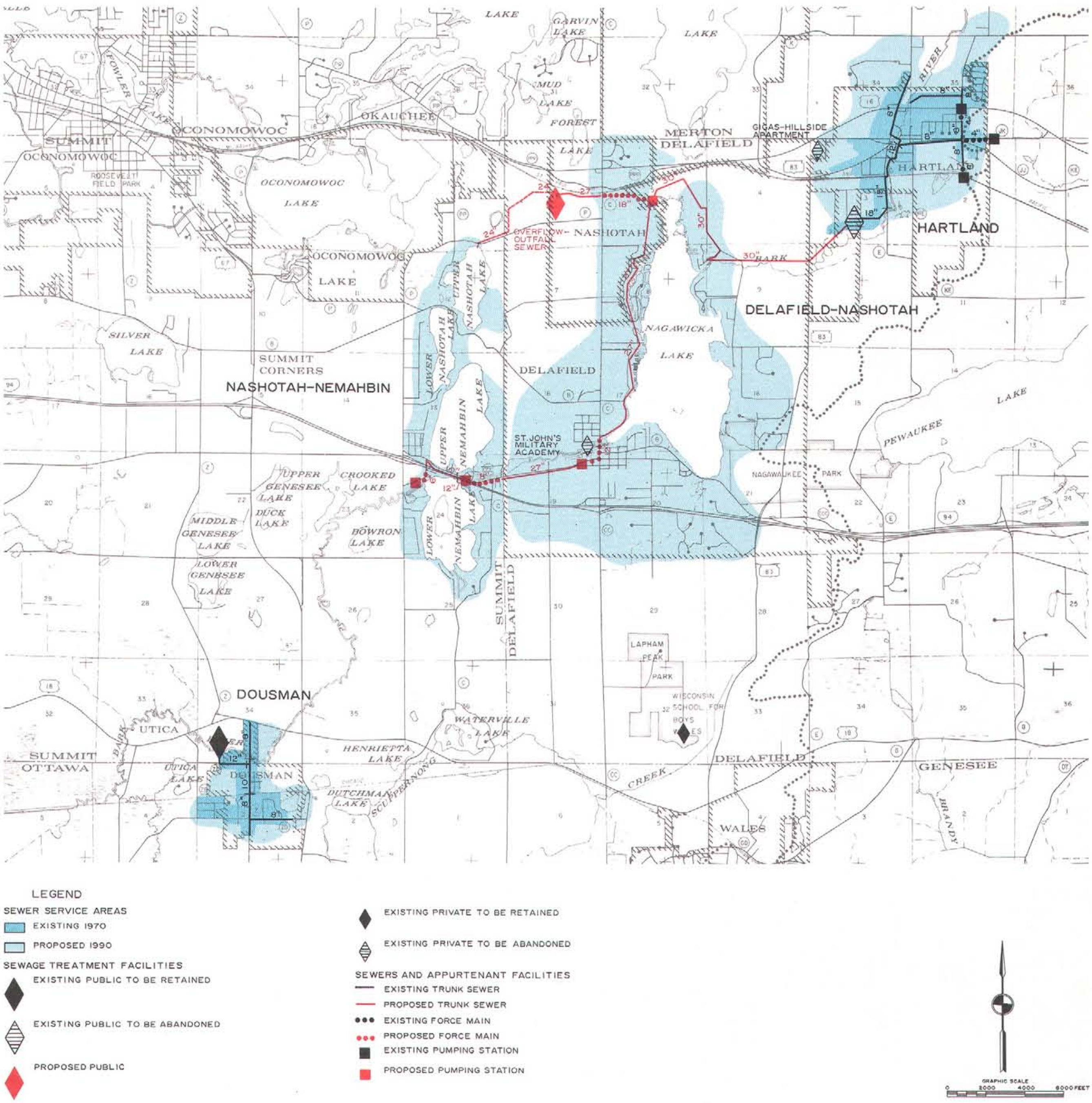
3. That an overflow outfall sewer discharging to upper Nashotah Lake would need to be provided in order to maintain the system in operating condition during excessive periods of flow or during periods of plant breakdown.

The proposed treatment plant location and the trunk sewer configuration necessary to carry out this alternative for the Delafield subarea is shown on Map 134A.

The total capital cost of this alternative plan is estimated at about $13.3 million, with a total equivalent annual cost of $939,000 (see Table 238A). It is important to note that while this

Map 134A

POST-PUBLIC HEARING ALTERNATIVE PLAN I
HARTLAND-NASHOTAH-DELAFIELD-SUMMIT-DOUSMAN SUBAREA
MIDDLE ROCK RIVER SUBREGIONAL AREA

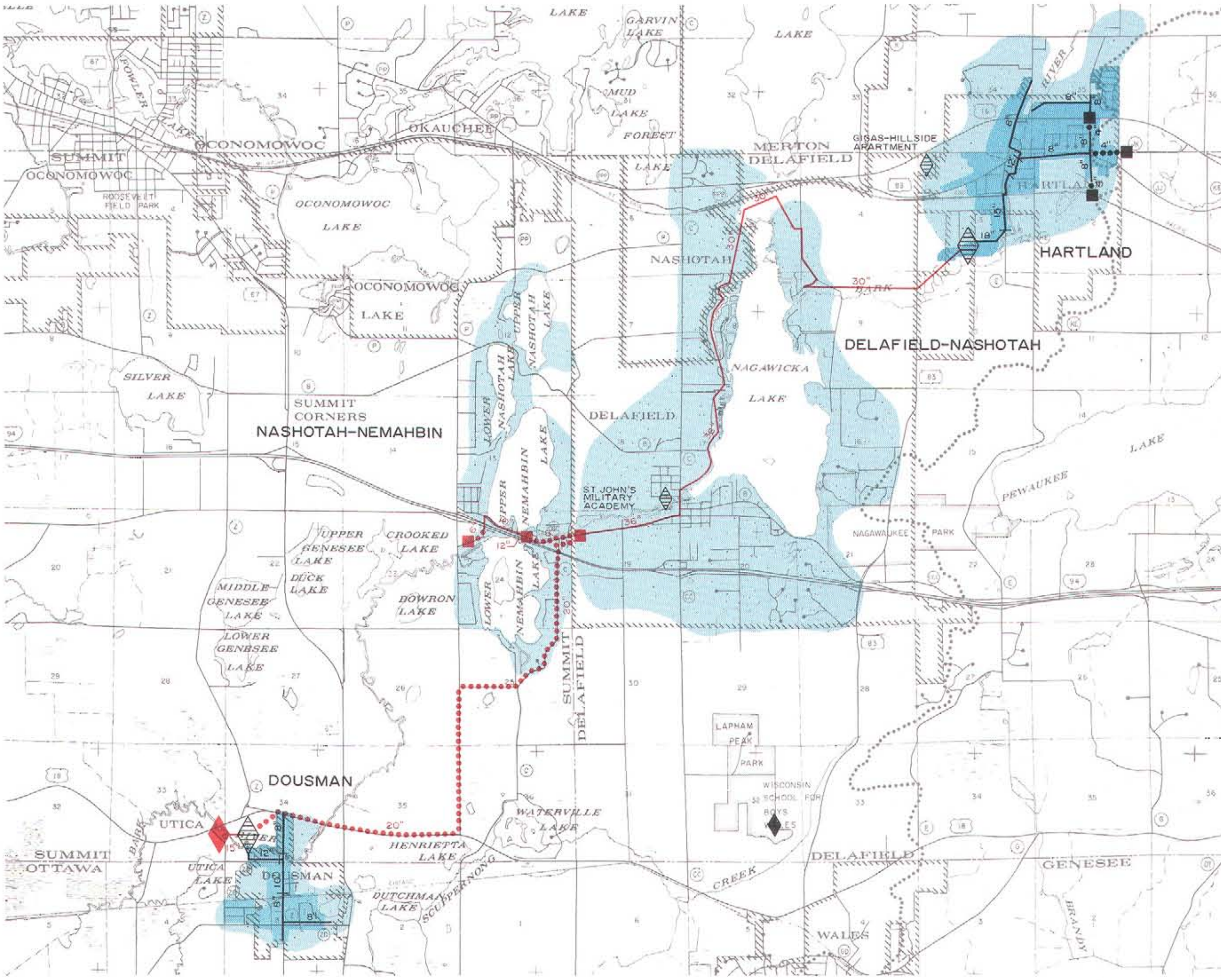


Following the public hearing on the regional sanitary sewerage system plan, the Commission held several intergovernmental meetings to consider difficulties encountered by the Delafield-Hartland Water Pollution Control Commission in locating a specific site for the proposed areawide sewage treatment plant to serve the Villages of Hartland and Nashotah, the City of Delafield, and portions of the Town of Summit. Considerable citizen opposition was expressed at the hearing to both the plant site proposed by the Regional Planning Commission below Crooked Lake in the Town of Summit and to an alternate site in the City of Delafield proposed by the Delafield-Hartland Water Pollution Control Commission. Acting on suggestions set forth during these meetings, the Commission evaluated two additional alternative treatment plant locations. The first alternative location is shown on the above map, and would place the proposed treatment facility in the northwest section of the City of Delafield adjacent to the Village of Nashotah. Under this alternative the plant would discharge effluent directly to seepage ponds for disposal to the groundwater reservoir with an emergency overflow outfall sewer constructed that would discharge directly to upper Nashotah Lake. This alternative was found to be substantially less cost effective than the recommended plan due primarily to the significant land area requirements necessary to accommodate the seepage ponds. Because of the existence of thick sand and gravel deposits at or near the land surface in this area, this alternative would also tend to result in the rapid dispersal of contaminants and, hence, have a very high potential for pollution of the shallow groundwater aquifer.

Source: SEWRPC.

Map 134B

POST-PUBLIC HEARING ALTERNATIVE PLAN 2
HARTLAND-NASHOTAH-DELAFIELD-SUMMIT-DOUSMAN SUBAREA
MIDDLE ROCK RIVER SUBREGIONAL AREA



LEGEND

SEWER SERVICE AREAS
- EXISTING 1970
- PROPOSED 1990

SEWAGE TREATMENT FACILITIES
- EXISTING PUBLIC TO BE RETAINED
- EXISTING PUBLIC TO BE ABANDONED
- PROPOSED PUBLIC
- EXISTING PRIVATE TO BE RETAINED
- EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES
- EXISTING TRUNK SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- EXISTING PUMPING STATION
- PROPOSED PUMPING STATION

GRAPHIC SCALE 0 2000 4000 6000 FEET

A second alternative sanitary sewerage system plan considered by the Commission for the Bark River communities after the public hearing on the recommended regional sanitary sewerage system plan would locate the needed areawide sewage treatment plant at a site on the Bark River in the Town of Summit just below the site of the existing Village of Dousman sewage treatment facility. This alternative would permit abandonment of the existing Dousman plant. Sewage would be conveyed from the Hartland-Delafield-Summit urban area to the Dousman treatment plant site via a force main. The cost of this alternative was found to be modestly higher than the recommended plan, with the additional cost increment due entirely to the sewage conveyance costs from the recommended plant site to the proposed alternative plant site. With respect to achievement of water quality objectives, this alternative would be as effective as the recommended plan. Since this alternative is less cost effective than the recommended plan, however, the Commission determined not to recommend it for implementation. Clearly, however, this alternative treatment plant site would be superior to all the other alternative sites considered or proposed by local officials, except that site included in the recommended plan.

Source: SEWRPC.

Table 238A

DETAILED COST ESTIMATES
POST-PUBLIC HEARING CONSIDERATION OF ADDITIONAL ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS
FOR THE DELAFIELD-NASHOTAH-HARTLAND-SUMMIT-DOUSMAN SUBAREA
MIDDLE ROCK RIVER SUBREGIONAL AREA

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
POST-PUBLIC HEARING ALTERNATIVE PLAN 1--TREATMENT FACILITY LOCATION IN NORTHWEST CORNER OF CITY OF DELAFIELD							
Sewage Treatment Plant							
Delafield							
Facilities (3.80 MGD)	$ 4,010,000	$ 3,620,000	$3,140,000	$ 6,760,000	$230,000	$199,000	$429,000
Seepage Lagoon	2,872,800	2,596,000	--	2,596,000	164,700	--	164,700
Land (385 Acres)	1,928,000	1,412,300	--	1,412,300	89,600	--	89,600
Overflow-Outfall Sewer	130,100	94,600	1,600	96,200	6,000	100	6,100
Subtotal	8,940,900	7,722,900	3,141,600	10,864,500	490,300	199,100	689,400
Trunk Sewers							
Delafield-Nashotah-Hartland and Nashotah-Nemahbin Lakes	4,400,800	3,355,700	580,100	3,935,800	212,900	36,800	249,700
Subtotal	4,400,800	3,355,700	580,100	3,935,800	212,900	36,800	249,700
Total	$13,341,700	$11,078,600	$3,721,700	$14,800,300	$703,200	$235,900	$939,100
RECOMMENDED PLAN COMPARABLE TO POST-PUBLIC HEARING ALTERNATIVE PLAN 1							
Sewage Treatment Plant							
Delafield							
Facilities (3.80 MGD)	$ 4,010,000	$ 3,620,000	$3,140,000	$ 6,760,000	$230,000	$199,000	$429,000
Land (5.6 Acres)	28,000	20,500	--	20,500	1,300	--	1,300
Subtotal	4,038,000	3,640,500	3,140,000	6,780,500	231,300	199,000	430,300
Trunk Sewers							
Delafield-Nashotah-Hartland and Nashotah-Nemahbin Lakes	5,422,200	3,973,600	25,200	3,998,800	252,100	1,600	253,700
Subtotal	5,422,200	3,973,600	25,200	3,998,800	252,100	1,600	253,700
Total	$ 9,460,200	$ 7,614,100	$3,165,200	$10,779,300	$483,400	$200,600	$684,000
POST PUBLIC HEARING ALTERNATIVE PLAN 2--CONSOLIDATED TREATMENT FACILITY AT DOUSMAN							
Sewage Treatment Plant							
Dousman							
Facilities (4.18 MGD)	$ 4,210,700	$ 3,804,900	$3,188,700	$ 6,993,600	$241,400	$202,300	$443,700
Land (6.4 Acres)	32,000	23,600	--	23,600	1,500	--	1,500
Subtotal	4,242,700	3,828,500	3,188,700	7,017,200	242,900	202,300	445,200
Trunk Sewers							
Delafield-Nashotah-Hartland	4,466,900	3,273,800	18,900	3,292,700	207,700	1,200	208,900
Nashotah-Nemahbin Lakes	397,900	323,000	173,500	496,500	20,500	11,000	31,500
Delafield-Dousman	1,270,700	991,400	327,800	1,319,200	62,900	20,800	83,700
Dousman	25,200	25,200	--	25,200	1,600	--	1,600
Subtotal	6,160,700	4,613,400	520,200	5,133,600	292,700	33,000	325,700
Total	$10,403,400	$ 8,441,900	$3,708,900	$12,150,800	$535,600	$235,300	$770,900
RECOMMENDED PLAN COMPARABLE TO POST-PUBLIC HEARING ALTERNATIVE PLAN 2							
Sewage Treatment Plants							
Delafield							
Facilities (3.80 MGD)	$ 4,010,000	$ 3,620,000	$3,140,000	$ 6,760,000	$230,000	$199,000	$429,000
Land (5.6 Acres)	28,000	20,500	--	20,500	1,300	--	1,300
Subtotal	4,038,000	3,640,500	3,140,000	6,780,500	231,300	199,000	430,300
Dousman							
Facilities (0.38 MGD)	552,400	498,100	260,100	758,200	31,600	16,500	48,100
Land (2.6 Acres)	13,000	9,500	--	9,500	600	--	600
Subtotal	565,400	507,600	260,100	767,700	32,200	16,500	48,700
Subtotal-Treatment Facilities	4,603,400	4,148,100	3,400,100	7,548,200	263,500	215,500	479,000
Trunk Sewers							
Delafield-Nashotah-Hartland and Nashotah-Nemahbin Lakes	5,422,200	3,973,600	25,200	3,998,800	252,100	1,600	253,700
Subtotal	5,422,200	3,973,600	25,200	3,998,800	252,100	1,600	253,700
Total	$10,025,600	$ 8,121,700	$3,425,300	$11,547,000	$515,600	$217,100	$732,700

Source: SEWRPC.

alternative has a capital cost for the trunk sewer system of nearly $1 million less than the trunk sewer system proposed in the recommended regional sanitary sewerage system plan, the overall total cost of carrying out this alternative is substantially higher, with the added treatment costs necessary to purchase land and construct the required seepage lagoons and to construct the overflow outfall sewer more than offsetting the trunk sewer savings. The estimated equivalent annual cost of the recommended plan as shown in Table 238A is $684,000, which is significantly greater than the aforementioned equivalent annual cost of this proposed alternative.

In addition to added costs, a major disadvantage of the proposed alternative plan is its dependence upon seepage lagoons in order to avoid the discharge of sewage wastes to the surface water system. As shown on Map 18, p. 78, of this report, the entire Delafield-Nashotah area is classified as being of questionable suitability for liquid waste disposal since predominate areas of thick sand and gravel deposits are at or near the surface and dispersion of contaminants may take place rapidly, resulting in a very high potential for pollution of the shallow groundwater aquifer. In addition, experience with existing seepage lagoon systems in the Region has shown that such lagoons have serious operating problems and provide at best an unreliable long-term solution to effluent disposal. In summary, there would be little advantage in locating the proposed areawide Delafield sewage treatment plant in the northwest portion of the City of Delafield as proposed in this first post-public hearing alternative plan.

The second post-public hearing alternative plan considered by the Commission in making a final determination on the recommended plan for the Delafield area involves transmission of sewage from the Delafield-Hartland-Summit area through a force main to a proposed areawide sewage treatment plant site located on the Bark River in the Town of Summit just below the site of the existing Village of Dousman sewage treatment facility (see Map 134B). This alternative would enable the abandonment of the existing Dousman plant and would thus result in having one less sewage treatment facility discharging wastes to the Bark River. The total estimated capital cost of carrying out this post-public hearing alternative plan is estimated at about $10.4 million, with a total equivalent annual cost of nearly $771,000 (see Table 238A). This cost can be compared with the recommended plan capital construction cost of about $10.0 million and a total equivalent annual cost of about $733,000.

Since the service being provided is identical under this alternative to that provided under the recommended plan, the additional costs may be attributed solely to the costs of transmitting the sewage from the proposed sewage treatment plant site at Delafield to the proposed site at Dousman, a distance of about two miles. The utilization of force main conveyance of the Delafield-Hartland sewage to the Dousman site would avoid the land use development problem noted above that would be created if a large gravity trunk sewer were constructed along the Bark River to the Dousman site, and would thus serve to carry out not only the regional land use plan recommendations but also the expressed objectives of the Town of Summit residents. The major disadvantage of this alternative is that it would involve yet another municipality in implementation—the Village of Dousman—and would require a commitment to a greater capital outlay and a greater annual operating cost. These disadvantages may be outweighed by the advantage of overcoming the expressed objection by the Town of Summit residents to locating a treatment facility in the Town upstream of the Village of Dousman. No additional water quality benefits may be attributed to the alternative of locating the proposed areawide Delafield plant below Dousman.

After reviewing all of the materials and comments presented and made at the public hearing, after further consideration of all of the discussion at the interagency meeting held on January 14, 1974, and after carefully considering the two additional post-public hearing alternatives, the Commission determined that the initial plan recommendation to locate the areawide sewage treatment facility serving the Delafield-Hartland area in the Town of Summit below Crooked Lake was a sound recommendation and should be maintained in the regional plan as adopted despite the admittedly difficult circumstances that may be encountered during plan implementation. In the judgment of the Commission, any solution other than the recommended plan, the alternatives thereto as presented in Chapter XI of this report, or the more costly Dousman alternative, would result in a permanent commitment either to the discharge of sewage effluent to the Bark River above the lakes in the Town of Summit or to the groundwater reservoir. Either of these two alternatives would represent, in the opinion of the Commission, poor public policy toward resource preservation and enhancement, since they represent positions that cannot be defended in light of the consensus already achieved to abandon the existing Hartland sewage treatment facility and in light of the reliance of urban development in this area on the shallow groundwater reservoir for public water supply. With respect to water quality, the Dousman alternative would be equal to the recommended plan. Since that alternative was less cost-effective than the recommended plan, however, the Commission determined not to specifically recommend it. Clearly, however, the Dousman alternative would be preferable to any alternative other than the recommended plan, and would represent an acceptable solution to the difficult problems encountered, so long as all parties concerned realize that a modest additional cost would be involved.

In addition, the Commission after reviewing the information presented at the public hearing, determined to delete the recommendation to provide an individual sewage treatment facility to serve the Village of Merton and environs. Rather, the Commission determined that no recommendation for sewer service for the Village of Merton should be made at this time, and that should public sewers become necessary to serve the Merton area, consideration be given at that time to either providing a separate treatment plant with discharge of the treated effluent to the groundwater reservoir or conveyance of the sewage to the proposed areawide treatment facility.

Elkhorn-Delavan-Delavan Lake Sewer Service Area—Walworth County

Public officials representing the Cities of Elkhorn and Delavan expressed concern at the public hearing over the plan recommendation to provide one areawide sewage treatment facility to serve the Cities of Delavan and Elkhorn and the Delavan Lake Sanitary District in the Town of Delavan. The City of Elkhorn officials in particular were concerned over the amount of money already expended and committed for engineering studies relating to a proposed new sewage treatment facility for Elkhorn, a facility which would continue to discharge effluent to Jackson Creek above Delavan Lake. The City of Delavan officials generally recognized the need to provide sanitary sewer service to the Delavan Lake area, but expressed reservations about joining an areawide system at this point in time. On the other hand, officials of the Delavan Lake Sanitary District expressed their full support for the preliminary plan recommendation.

In an effort to seek a consensus on this matter, two special intergovernmental meetings were held on November 28, 1973, and January 16, 1974, at the Elkhorn City Hall. In attendance at these meetings were officials of the Cities of Elkhorn and Delavan, the Delavan Lake Sanitary District, the Walworth County Park and Planning Commission, the Wisconsin Department of Natural Resources, and the U. S. Environmental Protection Agency. Discussion at the meeting centered around the advantages and disadvantages of the preliminary Commission plan recommendation, with emphasis on the desirability of completely eliminating sewage effluent from tributary water courses to Delavan Lake. All of the local public officials expressed concern over the specific financial analyses that would be a necessary part of the plan implementation process. Discussion was centered around relative timing in terms of the availability of federal grants-in-aid with respect to construction of the locally proposed Elkhorn sewage treatment facility, it being concluded that the low availability of federal funds precludes immediate construction of the proposed Elkhorn facility and, hence, there being no reason to believe that full implementation of the proposed areawide system could not be accomplished as rapidly as the individual Elkhorn facility.

After careful consideration of the comments made at and the materials submitted as part of the public hearing and at the discussion held at the public interagency meeting held on January 18, 1973, the Commission determined that the preliminary plan recommendation to construct an areawide sewage treatment facility below Delavan Lake to serve the Cities of Elkhorn and Delavan and the Delavan Lake Sanitary District was sound and represents the best and most effective course of action that could be taken. The Commission's decision was based primarily upon the desirability of removing all sewage effluent from tributary streams to Delavan Lake. In keeping with this recognition, the Commission further recommended that the small sewage treatment facility serving the Walworth County Institutions and Lakeland Hospital be abandoned and connected to the City of Elkhorn system, even though it lies beyond the proposed 1990 sewer service area.

Other Concerns Expressed at Hearings

A single item of concern not relating to the substance of the proposed plan recommendations but only to the timing of plan implementation was raised at the public hearing. This item concerned the timing of the plan implementation for the metropolitan trunk and relief sewers in the Milwaukee area (see Map 132). In particular, public officials from the Cities of Franklin, Glendale, and Oak Creek, noting the pressing need to resolve existing public health hazards, including the backup of sewage into basements, and further noting the desirability of eliminating as rapidly as possible existing temporary sewage treatment facilities, requested that the proposed construction schedule as it effects their communities be advanced to reflect more rapid completion of key trunk and relief sewers. It should be noted that, as discussed in Chapter XIV of this report, the proposed construction timetable was based upon a weighing of several factors, including most importantly, anticipated availability of state and federal grants-in-aid, previous construction schedules as prepared by the Milwaukee-Metropolitan Sewerage Commissions, the provision of relief trunk sewer capacity to resolve pressing existing public health hazards and water pollution problems, and contract commitments.

The Commission directed that the staff review the proposed construction schedule for major trunk sewers in the Milwaukee metropolitan area, considering in that review the comments made at the public hearing by the public officials representing the Cities of Franklin, Glendale, and Oak Creek. Upon completion of this review, the Commission staff reported that the key constraint inhibiting an advancement of the proposed construction schedule was the forecast availability of state and federal funding in partial support of the proposed sewer construction. It was noted that the point of departure used by the Commission staff in developing the major trunk sewer construction schedule for the Milwaukee metropolitan area, as proposed to be included in the regional sanitary sewerage system plan, was such a schedule developed by the Milwaukee-Metropolitan Sewerage Commission in 1972 when the primary source of funding for the construction of the trunk sewers were monies raised through the issuance by Milwaukee County of general obligation bonds for this purpose and state and federal grants-in-aid under the Wisconsin Water Pollution Prevention and Abatement Program (Section 144.21 Wisconsin Statutes) and the federal Waste Treatment Works Construction Program (35 U. S. Code 466). As a result of the public policy decision made by the Finance Committee of the Milwaukee County Board of Supervisors, the County Executive, and the Milwaukee-Metropolitan Sewerage Commissions in 1973 to relate the rate of major trunk sewer construction directly to the availability of state and federal grants-in-aid, the original construction schedule was "stretched out" to adjust it to the forecast availabiltty of such state and federal grants. In so doing, the order of priority originally established for the construction of the various projects was essentially maintained. The proposed completion dates of the various projects were revised, however, to reflect the new funding limitations, so that the total improvement program, which originally had completion dates ranging from 1972 through 1978, was assigned new completion dates ranging from 1973 through 1990 (see Chapter XIV).

If a level of federal and state funding becomes available which is substantially higher than that forecast and if the Milwaukee-Metropolitan Sewerage Commissions are able and willing to provide the necessary matching funds at the increased rate—or if a public policy decision is made to rely more heavily on local funding—then the trunk sewer construction schedule proposed herein could be advanced substantially and the problems cited by the local officials at the public hearing resolved more rapidly. In view of the serious public health, water pollution, and urban service problems involved and in view of the fact that delays in the construction of certain trunk sewer segments could result in undesirable aberrations in the spatial location and timing of urban development within Milwaukee County, the Commission recommends that every effort be made by the federal, state, and local units of government concerned to increase the level of funding for, and to thereby accelerate, the proposed trunk sewer construction schedule set forth in this report.

Concluding Remarks—Public Reaction

In summary, it may be concluded that public reaction to the plan recommendations, including the water use objectives, the waste treatment levels required to meet these objectives throughout the Region, the sewer service areas, and the trunk sewers and treatment facilities required to serve these areas, all met a very favorable response at the public informational meetings and hearing. In reviewing all of the comments, opinions, and data presented at these meetings and hearing and in the series of intergovernmental meetings held subsequently to the public hearing, the Commission determined to change the plan recommendations made by the Commission staff and Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System

Planning for three specific geographic subareas of the Region. The Commission acted to delete the recommendation to establish new sanitary sewerage systems and accompanying sewage treatment facilities to serve the Green Lake area in the Town of Farmington, Washington County, and to serve the Village of Merton and environs in Waukesha County. The Commission acted to add a recommendation to abandon the small sewage treatment facility serving the Walworth County Institutions and Lakeland Hospital in the Town of Geneva and to connect these institutions to the City of Elkhorn sanitary sewerage system. These actions by the Commission affect the summary data presented in Chapters XII and XV of this report by deleting two of the 52 recommended public sewage treatment plants and one of the private treatment plants and by reducing the total sewer service area within the Region by one square mile. These changes also affect the plan implementation costs. Thus, the plan as adopted recommends a total of 50 public sewage treatment facilities to serve the Region through the plan design year, with a total service area of about 674 square miles. The population proposed to be served by centralized sanitary sewers, initially estimated at about 2.6 million persons, was reduced by about 2,400 persons, while the total estimated capital cost of implementing the plan was reduced by about $367,000.

RELATIONSHIP BETWEEN SEWER SERVICE AREAS AND ENVIRONMENTAL CORRIDORS

The environmental corridor concept and its application in the Southeastern Wisconsin Region were discussed in Chapter IV of this report. Because of the importance of the primary environmental corridors of the Region to the overall quality of the environment, the identification and delineation of these corridors was one of the most important tasks completed under the initial regional land use planning effort. The primary environmental corridors encompass almost all of the best remaining elements of the natural resource base–the critical resource areas—which are so essential to the maintenance of the ecological balance, environmental quality, and the natural beauty of the Region. These elements include the lakes and streams and associated floodlands and shorelands; prime woodlands and wetlands; prime wildlife habitat areas; rugged terrain and high relief topography; significant geological formations and physiographic features; and areas covered by organic soils. These primary environmental corridors also include the best remaining potential park and related outdoor recreation sites within the Region, frequently include historic sites and structures, and provide the most attractive scenic areas and vistas within the Region. All of these natural resource and natural resource-related elements tend to occur within the Region in an essentially lineal pattern; hence, the term "environmental corridors." The environmental corridors in the Region were found to encompass approximately 486 square miles of land and inland lake area, or about 18 percent of the total area of the Region.

Urban development trends within the Region, particularly since 1950, have resulted in encroachment of urban development into some of the primary environmental corridors. If the density of the development is maintained below 0.5 persons per gross acre, and the soils are suitable for the use of onsite sewage disposal systems, such intrusion may be compatible with preservation of the corridors. If, however, the density of the development is excessive, or if the soils are poorly suited to the use of onsite sewage disposal systems, such intrusion may destroy the corridor and thereby the very resources and resource-related amenities sought by the development. Such unplanned or poorly planned intrusion may also contribute toward the creation of environmental problems having areawide effects. Accordingly, as discussed in Chapter VIII of this report, one of the recommended sanitary sewerage system development standards provides that lands designated as primary environmental corridors on the regional land use plan should generally not be served by sanitary sewers. Development which is incidental to the preservation and protection of the corridors, such as park and related outdoor recreation areas, and existing clusters of urban development within such corridors which, because of soil limitations, cannot continue to rely on private onsite soil absorption sewage disposal facilities, however, may have to be provided with centralized sanitary sewer service. In such cases, however, the engineering analyses relating to the sizing of the required sanitary sewerage facilities should assume the permanent preservation of all undeveloped primary environmental corridor lands in natural open space uses.

One of the most difficult tasks faced in determining recommended future sanitary sewer service areas for the regional sanitary sewerage system plan involved properly relating such areas to the delineated primary environmental corridors in the Region in those situations where significant concentrations of existing urban development already exist within the corridors. Any recommendation to extend sanitary sewer service into primary environmental corridors in order to serve small clusters of existing urban development could tend to induce additional urban development, and thereby destroy the corridor. Particularly difficult situations are encountered in lakeshore areas where existing summer cottages and, increasingly, permanent residences, are improperly located on soils having severe or very severe limitations for the safe absorption of septic tank effluent. In the determination as to whether or not centralized sanitary sewer service should be provided in the corridors, reliance was placed on analyses conducted by the Commission under the comprehensive watershed studies and upon any additional local planning and engineering studies which may have resulted in findings that centralized sanitary sewer service is essential in order to avoid a serious public health hazard or water pollution problem.

In those situations where decisions were made to extend centralized sanitary sewer service into the primary environmental corridors, it must be clearly understood that such proposals are intended to serve only the existing urban development, accommodating only a very modest increment of new urban development on already platted but vacant lots, and is in no way intended to constitute a recommendation for the creation of substantial amounts of additional urban development within the environmental corridor areas. Very careful attention will have to be given in the design of the specific sewerage facilities to the objective of resolving existing problems relating to onsite soil absorption of sewage effluent while at the same time being careful not to induce new development that would tend to destroy the character of the primary environmental corridor lands. In the last analysis, whether or not extension of required centralized sanitary sewer service into primary environmental corridors under these circumstances will, in fact, contribute toward preserving or destroying the fundamental, critical resource values found in such corridors will depend to a very large extent on the care exercised in the design of the facilities and upon the specific land use development policies pursued in this respect by the local unit of government concerned.

SUMMARY

The recommended sanitary sewerage system plan for the Southeastern Wisconsin Region is based upon the provision of conventional centralized sanitary sewerage systems providing high levels of treatment at sewage treatment facilities, with discharge of treated wastes primarily to surface waters. The plan recommends that sewage treatment be provided at a total of 52 public sewage treatment facilities. In order to meet the established water use objectives and supporting water quality standards for the surface waters in the Region, the plan recommends that 41 of the 52 public sewage treatment facilities provide advanced waste treatment, with the remaining 11 plants recommended to provide a secondary level of waste treatment. Full implementation of the recommended plan will enable the abandonment of 22 existing public sewage treatment facilities, 13 of which are currently located in Milwaukee County and the existing and proposed contract areas of the Milwaukee-Metropolitan Sewerage Commissions in Ozaukee, Racine, Washington, and Waukesha Counties. Implementation of the plan would further permit the abandonment of 29 of the existing 59 private sewage treatment facilities in the Region. Such facilities currently serve isolated urban land use enclaves.

The plan recommends that centralized sanitary sewer service be extended to a total area of about 675 square miles, or about 25 percent of the total area of the Region. It is anticipated that about 2.6 million persons would reside in this area and be provided with centralized sanitary sewer service in the Region by 1900, representing nearly 97 percent of the total anticipated 1990 regional population of nearly 2.7 million persons. The incremental sewer service area recommended in the plan totals about 366 square miles, considerably less than the locally proposed future sewer service area of nearly 450 additional square miles, thus reflecting the effect of proper consideration of areawide development objectives and areawide land use and sewerage system plans on the sewerage system planning process.

The recommended regional sanitary sewerage system plan includes proposals for those trunk sewers necessary to extend centralized sanitary sewer service to all of the proposed 1990 sewer service areas, to enable the abandonment of

22 existing public sewage treatment facilities, and to provide for intermunicipal connections between sewer service areas. The general alignment and approximate size of these intercommunity trunk sewers is shown on Map 131. In addition, locally proposed trunk sewer extensions which generally involve only a single community and which are important to the attainment of the basic plan recommendation to provide sewer service to the recommended future service areas were submitted by local officials as important adjuncts to the recommended plan. These plan proposals are on file in the Commission offices.

The plan further proposes to abate combined sewer overflows in the Milwaukee, Racine, and Kenosha areas of the Region. In the Milwaukee area the plan recommends proceeding with full implementation of the recommendations contained in the adopted Milwaukee River watershed plan to construct a combination deep tunnel mined storage/flow-through treatment system to collect, convey, and adequately treat all combined sewer overflows throughout the approximately 27-square mile combined sewer service area in Milwaukee County. The plan further recommends that, based on a Prospectus completed in July 1973, the Milwaukee-Metropolitan Sewerage Commissions undertake a preliminary engineering study as the initial step toward implementing the watershed plan recommendation. The Prospectus recommends that the preliminary engineering study begin with a careful review of the findings and recommendations of the adopted Milwaukee River watershed plan and, based upon a review of the findings of any new research and demonstration projects completed since preparation and adoption of the watershed plan, either reaffirm the basic validity of the combined sewer overflow abatement recommendations contained in the watershed plan or provide alternative recommendations. Three of the most important purposes of the preliminary engineering study will be to determine an optimum combination of storage and flow-through treatment, the practicality of the required tunnel and mined storage construction in the bedrock, and the practicality of utilizing either conventional or flow-through treatment for the highly diluted combined sewer overflows. In the Racine area, the plan recommends that definitive recommendations concerning which of the remaining combined sewer areas should be separated and which should receive flow-through treatment facilities be held in abeyance until completion of a current research and demonstration study and a determination as to the most cost effective method of resolving the combined sewer overflow problem. Similarly, in the Kenosha area the plan recommends awaiting the results of a research and demonstration project aimed at determining the feasibility of providing standby treatment capacity before proceeding with completion of a long-proposed sewer separation program.

In addition to the foregoing specific recommendations concerning the construction of sewerage facilities, the plan includes several auxiliary elements applicable in general to all sanitary sewerage systems. The plan recommends that clear water elimination efforts be mounted in all communities and that the design criteria utilized to prepare the plan become a standard for determining whether or not a substantial infiltration-inflow problem exists within a system or subsystem. The plan further recommends that steps be taken to eliminate all of the nearly 600 points of sewage flow relief found to exist in 1970 throughout the Region. In addition, the plan recognizes the need to substantially upgrade the operation and maintenance of sewage treatment plants in order to provide for the higher levels of waste treatment that will be necessary to implement the plan and achieve the water use objectives. Toward this end the plan sets forth recommended staffing and operational standards for typical plant sizes. To overcome problems uncovered in sewerage system inventories concerning a lack of definitive knowledge of total sewage flow, the plan recommends that steps be taken to provide for full metering of all flows, including metering at major bypass points. With respect to sludge disposal, the plan recommends that individual case-by-case engineering studies be undertaken to determine the most cost effective method of sludge handling, reduction, disposal, or utilization at individual municipal treatment plants. Finally, the plan recommends that the data obtained under the joint Commission-DNR stream water quality monitoring program be reviewed and that such review serve as a basis for the formulation of definitive recommendations as to any changes in the monitoring program needed to properly assess the status of plan implementation and achievement of the established water use objectives over time.

The full capital investment cost of implementing the recommended regional sanitary sewerage system plan is estimated at about $507 million over the 20-year plan implementation period 1970-1990. Of this total cost, about $134 million, or about 26 percent, is required to fully implement the recommended sewage treatment plant element of the plan; about $194 million, or about 38 percent, is required to fully implement the intercommunity trunk sewer element of the plan; with the remaining $179 million, or about 36 percent, required to fully implement the combined sewer overflow abatement element of the plan. The average annual cost of the total capital investment required for plan implementation approximates $25 million, or about $12 per capita. It is anticipated that all of the components of the recommended plan will be eligible for federal and state grants-in-aid and that full utilization of these financial resources could serve to reduce the local plan implementation cost with respect to capital investment by as much as 80 percent.

An analysis was conducted of the expenditure trends for public sanitary sewerage purposes in the Region during the period 1960 to 1970. This analysis revealed an average annual expenditure over that period of about $49 million for sanitary sewerage purposes, representing about 6 percent of the average annual public revenues received by the local units of government over the same period. Based upon historical data, four alternative forecasts were prepared to indicate the possible range of future expenditures by local governments in the Region for public sanitary sewerage purposes. These forecasts ranged from a low of about $1.4 billion, based upon an assumption that the average per capita expenditures which obtained over the 1960 to 1970 period would continue to the year 1990; to a high of about $2.6 billion, based upon an assumption that the average annual rate of increase of per capita expenditures which obtained over the 1960 to 1970 period would continue to the year 1990. An average of the four forecasts indicates that a total expenditure for public sewerage purposes of about $2.0 billion may be anticipated over the 20-year period. This amount can be compared on a gross basis with the estimated total cost of implementing the entire recommended regional sanitary sewerage system plan for the Region, including operation and maintenance as well as capital costs, of about $1.0 billion. Based upon this analysis, it was concluded that sufficient monies to substantially implement the recommended regional sanitary sewerage system plan should become available without significant shifts in local expenditure patterns. It is clear that if the adopted water uses and supporting water quality standards are to be met for the Region, the level of expenditures needed to implement the plan is necessary and fully warranted.

A comparison between the initial 1990 population forecasts used as a basis for preparation of the regional sanitary sewerage system plan and recently available revised population forecasts indicates that in most areas of the Region the sewerage facilities included in the recommended plan will represent a minimum necessary to serve anticipated urban development growth. In the three central area cities of the Region—Milwaukee, Kenosha, and Racine—the population forecasts have been significantly revised downward. In these instances, however, the basic areawide sewerage systems are already in place and the planned system expansions are essential to providing relief to overloaded areas, to carrying out contract commitments, to serve shifting land use development patterns, and to upgrading levels of treatment.

As an integral part of the regional sanitary sewerage system planning program, a series of informal public informational meetings and a formal public hearing were held within the Region. The purpose of these meetings and hearing was to more fully inform public officials and interested citizens about the findings and preliminary recommendations of the sewerage system planning program, and to obtain the reaction of the officials and citizens to the regional sanitary sewerage system plan recommended by the Commission staff and by the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning, together with the alternatives thereto. The meetings and hearing were preceded by an extensive program of notification, including letters to concerned local, state, and federal public officials; to citizen groups; librarians; and to about 3,500 individuals and organizations included on the Commission Newsletter mailing list. In addition, a series of news releases was issued to all media in the Region. Minutes of the informational meetings and public hearing and documentation of the notification procedures utilized were published on December 31, 1973.

The preliminary plan recommendations, including the water use objectives, the waste treatment levels required to meet these objectives throughout the Region, the sewer service areas, and the trunk sewers and treatment facilities required to serve these areas, met a very favorable response at the meetings and hearing. The meetings and hearing indicate that significant controversy existed with respect to the plan recommendations in only five geographic subareas of the Region: the Lake Church area in Ozaukee County, the Green Lake area in Washington County, the Tri-Lakes area in Washington County, the Delafield-Hartland area in Waukesha County, and the Elkhorn-Delavan area in Walworth County. The Commission held a series of additional intergovernmental meetings between the parties concerned in an effort to arrive at a consensus with respect to the final recommendations to be contained in the adopted regional sanitary sewerage system plan. After holding these meetings and after reviewing all of the comments, opinions, and data presented during these meetings and at the public informational meetings and hearing, the Commission determined to change the recommended regional sanitary sewerage system plan in three specific goegraphic subareas of the Region. The Commission acted to delete from the plan the recommendations to establish new sanitary sewerage systems and accompanying treatment facilities to serve the Green Lake area of Washington County and the Village of Merton in Waukesha County, and acted to add to the plan the recommendation to abandon the small sewage treatment facility serving the Walworth County Institutions and Lakeland Hospital in the Town of Geneva, connected these institutions to the City of Elkhorn sewerage system.

(This page intentionally left blank)

Chapter XIII

THE UNPLANNED ALTERNATIVE

INTRODUCTION

The preceding chapter of this report has set forth a recommended regional sanitary sewerage system plan related to and based upon the adopted regional land use plan. Both the recommended regional sanitary sewerage system plan and the adopted regional land use plan were selected after careful test and evaluation of the alternatives available and after presentation of these alternatives to broadly based technical and intergovernmental coordinating and advisory committees established by the Commission to provide technical and policy guidance in the conduct of both the regional land use and regional sanitary sewerage system planning programs. With respect to both planning programs, the plan test, evaluation, and review processes indicated that implementation of the recommended plans would best meet the recommended regional land use and sewerage system development objectives formulated as part of the comprehensive planning process.

As part of the regional land use planning program, an unplanned land use development alternative consisting of continued existing trend development in the absence of any attempt to guide such development on an areawide basis in the public interest was examined. It was recognized that such unplanned development could result in a number of greatly differing regional land use patterns, depending upon the degree to which community plans and land development policies and controls, together with the availability of areawide planning and engineering data, such as the detailed soil surveys, actually influenced the operation of the urban land market and historic development trends over time. In order to assess the possible impact of such unplanned regional land use development upon the future environment of the Region, one of many regional land use patterns which might result from such unplanned development assumptions was presented. The unplanned land use alternative was intended to serve not as a recommendation, but as a basis of comparison for the evaluation of the potential benefits of the adopted regional land use plan and of the workability of the complementary regional transportation plan being recommended for implementation as part of the comprehensive plan for the development of the Region. In general, the unplanned land use alternative would require the least amount of effort toward public regulation of development on an areawide basis in the public interest and would require few restraints on the operation of the urban land market in determining the future character, intensity, and spatial distribution of land use development in the Region. The unplanned alternative would, however, provide the people of the Region with no assurance that the future regional development pattern would meet the recommended regional development objectives.[1]

Since one of the important reasons for preparing the regional sanitary sewerage system plan was to assist in implementing the adopted regional land use plan, no attempt was made in the regional sanitary sewerage system planning program to develop a sewerage system plan that would serve the land use pattern projected under the unplanned land use alternative. The implications of the unplanned land use alternative for sanitary sewerage service within the Region was, however, investigated by analyzing the sewerage system development costs attendant to unplanned land use development within a selected subarea of the Region. Three different means of providing for sanitary waste disposal in the study area were considered: 1) reliance on onsite soil absorption sewage disposal systems; 2) provision of centralized sanitary sewer service with treatment provided at a number of small "package" sewage treatment plants; and 3) provision of centralized sanitary sewer service with treatment at a single centralized treatment facility. The costs attendant to each of these three alternative means of handling sanitary wastes were estimated, and compared with the costs attendant to the regional sanitary sewerage system plan. This chapter presents the results of this analysis.

[1] *For a detailed description of the unplanned alternative, see SEWRPC Planning Report No. 7, The Regional Land Use-Transportation Study, Volume Three, Recommended Regional Land Use-Transportation Plans--1990, Chapter V.*

UNPLANNED LAND USE ALTERNATIVE

Under the unplanned land use alternative selected for analysis in the initial regional land use-transportation planning program, historical growth trends in the Region were assumed to be altered only by the aggregate effects of local community plans and plan implementation policies. The need to restrict intensive urban development to those areas of the Region having both soils suitable for such development and gravity sewer service readily available was not recognized, as it would be in implementation of the adopted regional land use plan. The allocation of the various future land uses to each county of the Region was such as to approximate, to the extent possible, the proposals contained in existing community development plans and zoning documents. The total county employment and population levels consequently were varied somewhat from the forecast levels. The unplanned land use alternative for the Region as a whole is shown in graphic form on Map 135. Data pertaining to urban and rural land use in the Region under the unplanned alternative, and as compared to the adopted regional land use plan, are set forth in Table 239. Under the unplanned alternative, a total of 418 square miles of land would be converted from rural to urban use over the next two to three decades, or about two times the total of 200 square miles of land which would have to be converted under the adopted plan to accommodate the same incremental increase in population of about one million persons.

Residential Development

Under the unplanned alternative, future residential development in the Region would occur primarily at low densities, as contrasted with the primary reliance upon medium-density development recommended in the adopted regional land use plan. As shown in Table 239, almost two and one-half times as much new residential development would be added to the existing stock of residential land within the Region under the unplanned land use alternative than under the adopted land use plan. Nearly 90 percent of this additional residential development would be developed at low densities with lot sizes ranging from one-half to five acres per dwelling unit, in sharp contrast to the adopted plan where nearly three-fourths of the residential acreage would be developed at medium densities with lot sizes ranging from about 6,300 square feet to nearly one-half acre per dwelling unit. Under the unplanned land use alternative, future population levels within Ozaukee, Walworth, Washington, and Waukesha Counties would be significantly greater than the forecast population levels utilized in the preparation of the regional land use plan. The three urbanized counties of Kenosha, Milwaukee, and Racine would each experience significantly smaller population increases (see Table 240). It is important to note that, based on 1970 land use and population data, actual population levels on a county-by-county basis more closely approximate levels anticipated under the unplanned alternative than under the recommended plan (see discussion in Chapter X of this report). Under the unplanned alternative, urban population densities within the Region would decrease from a 1963 level of about 4,800 persons per square mile, to a 1970 level of about 4,300 persons per square mile, to a 1990 level of about 2,700 persons per square mile. In contrast, the adopted regional land use plan would provide an overall population density of about 4,400 persons per square mile within the Region by 1990 (see Table 241).

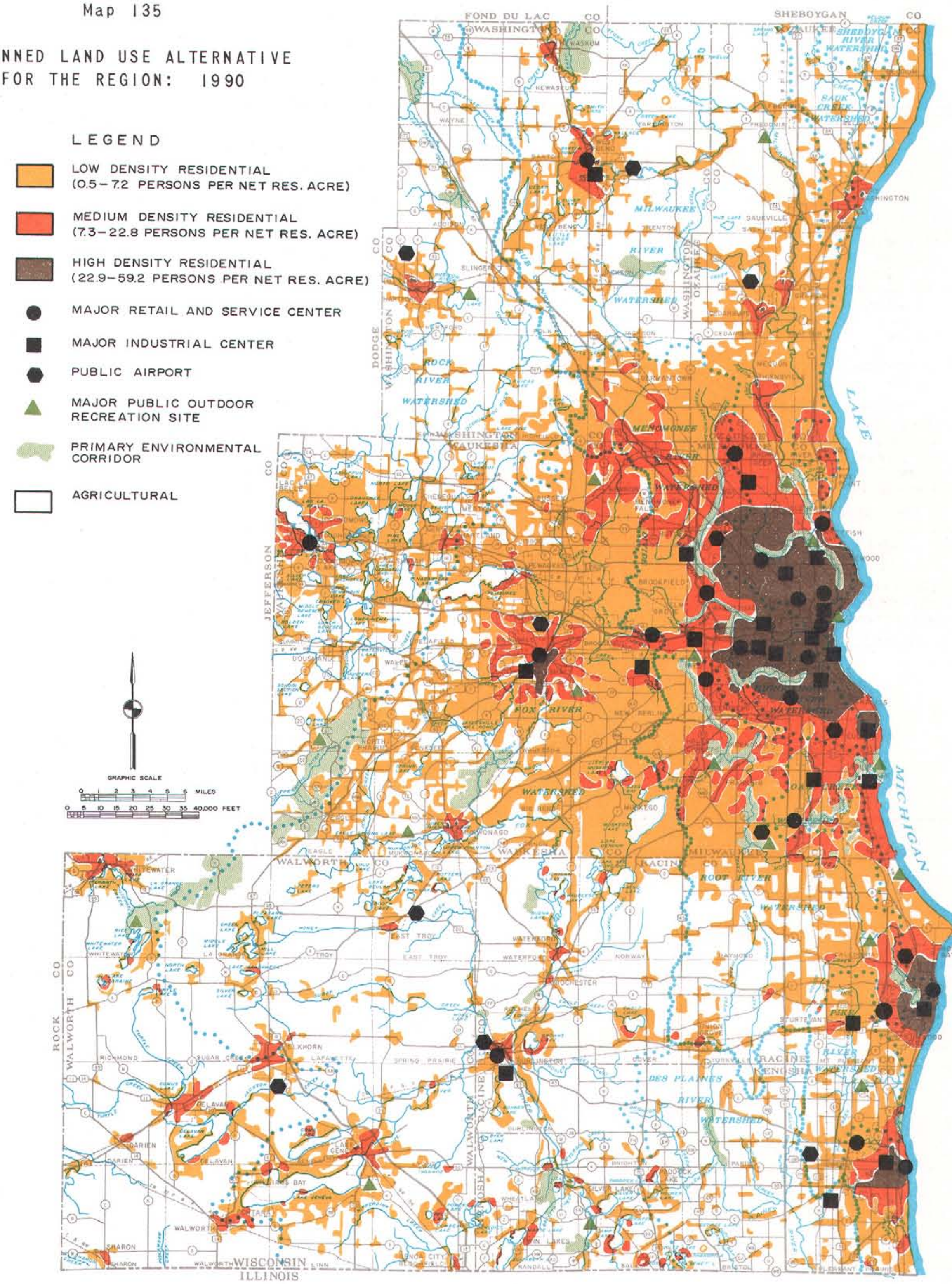
It should be noted that should historic trends in land use development within the Region continue, local governments within the Region would continue to be presented with all of the many problems attendant to highly dispersed low-density development, including incomplete neighborhoods requiring extensive urban services which can only be provided inefficiently and at a high cost. Under the unplanned land use alternative, the continued abandonment of working farm units could be expected, leaving a residual of scattered undeveloped and underdeveloped areas of land which lack potential for either good rural or urban development. In addition, the continued deterioration and destruction of the natural resource base could be expected, with incompatible urban land uses intruding into the floodlands, wetlands, woodlands, and wildlife habitat areas of the primary environmental corridors.

Sewer and Water Service

As already noted, the unplanned land use alternative would require the conversion of more than 400 square miles of land from rural to urban use. Only about 55 percent of the total developed area of the Region in 1990 under the unplanned alternative could be readily provided with public sanitary sewer service facilities tributary to existing and locally proposed systems (see Table 242), since

Map 135

UNPLANNED LAND USE ALTERNATIVE FOR THE REGION: 1990



One possible end result of continued existing trend land use development within the Region is shown on the above map. Under a continuation of existing trends, future residential development in the Region could be expected to occur in a highly diffused pattern and primarily at low densities. In contrast, the adopted regional land use plan seeks to encourage more compact residential development, primarily at medium densities (see Map 51). Under this unplanned alternative, urban population densities within the Region could be expected to decrease from a 1963 level of about 4,800 persons per square mile to a 1990 level of about 2,700 persons per square mile. In contrast, the adopted regional land use plan seeks to achieve an overall population density of about 4,400 persons per square mile within the Region by 1990. Should historic trends in land use development within the Region continue and result in a regional settlement pattern similar to that above, local governments within the Region would continue to be presented with all of the problems attendant to highly dispersed low density development, including incomplete neighborhoods requiring extensive urban services which can only be provided inefficiently and at high cost. Continued abandonment of working farm units could be expected, leaving a residual of scattered undeveloped areas of land which lack potential for either good rural or good urban development. In addition, the continued deterioration and destruction of the natural resource base could be expected, with incompatible urban land uses permanently intruding into the wetlands, woodlands, and wildlife habitat areas of the Region's primary environmental corridors.

Source: SEWRPC.

Table 239

URBAN AND RURAL LAND USE IN THE REGION: 1963 AND 1970 RECOMMENDED LAND USE PLAN AND 1990 UNPLANNED ALTERNATIVE

Land Use Category	Existing (1963)		Increment 1963 - 1990			
			Planned		Unplanned	
	Acres	Percent of Major Category	Acres	Percent Change	Acres	Percent Change
Urban Land Use						
Residential	*129,358*	*44.6*	*71,187*	*55.0*	*171,818*	*132.8*
High-Density	34,463	11.9	2,790	8.0	466	1.3
Medium-Density	24,748	8.5	53,784	217.3	18,851	76.1
Low-Density	70,147	24.2	14,613	20.8	152,503	217.4
Commercial[1]	6,706	2.3	5,048	75.2	5,950	88.7
Industrial[1]	9,746	3.4	5,123	52.5	4,812	49.3
Governmental[2]	14,722	5.1	9,573	65.0	8,904	60.4
Transportation[3]	96,117	33.1	28,623	29.7	70,215	73.0
Recreation	33,262[4]	11.5	8,718[5]	26.2	5,762[5]	17.3
Total Urban Use	289,911	100.0	128,272	44.2	267,461	92.2
Rural Land Use						
Agriculture	*1,085,144*	*75.8*	*-102,837*	*- 9.4*	*-238,328*	*-21.9*
Prime Agriculture	443,952	31.0	- 21,267	- 4.7	- 68,591	-15.4
Other Agriculture	641,192	44.8	- 81,570	-12.7	-169,737	-26.4
Other Open Lands[6]	345,951	24.2	- 25,435	- 7.3	- 29,133	- 8.4
Total Rural Land Use	1,431,095	100.0	-128,272	- 8.9	-267,461	-18.6
Total	1,721,006	--	--	--	--	--

[1]*Includes on-site parking.*
[2]*Includes institutional uses and on-site parking.*
[3]*Includes communications and utilities uses.*
[4]*Includes the entire site areas of public and nonpublic recreation sites.*
[5]*Includes only that increment recommended for public recreation uses.*
[6]*Includes woodlands, water, wetlands, and quarries.*

Source: SEWRPC.

Note: Figures in italics indicate subtotals.

Table 240

POPULATION DISTRIBUTION IN THE REGION BY COUNTY: 1963 AND 1990 RECOMMENDED LAND USE PLAN AND 1990 UNPLANNED ALTERNATIVE (POPULATION IN THOUSANDS)

County	Existing (1963)		Increment 1963-1990				Total 1990			
			Planned		Unplanned		Planned		Unplanned	
	Number	Percent of Total	Number	Percent Change	Number	Percent Change	Number	Percent of Total	Number	Percent of Total
Kenosha	106.7	6.4	95.3	89.3	34.1	31.9	202.0	7.5	140.8	5.2
Milwaukee	1,086.3	64.9	359.7	33.1	138.5	12.7	1,446.0	54.0	1,224.8	45.7
Ozaukee	41.6	2.5	64.4	154.8	118.4	284.6	106.0	4.0	160.0	6.0
Racine	150.6	9.0	132.4	87.9	105.4	69.6	283.0	10.6	256.0	9.6
Walworth	55.5	3.3	31.5	56.7	77.3	139.2	87.0	3.2	132.8	5.0
Washington	49.5	2.9	46.5	93.9	76.3	154.1	96.0	3.6	125.8	4.7
Waukesha	184.2	11.0	273.8	148.6	453.6	246.2	450.0	17.1	637.8	23.8
Regional Total	1,674.4	100.0	1,003.6	59.9	1,003.6	59.9	2,678.0	100.0	2,678.0	100.0

Source: SEWRPC.

Table 241

DEVELOPED AREA AND POPULATION DENSITY IN THE REGION: 1963 AND 1990 RECOMMENDED LAND USE PLAN AND 1990 UNPLANNED ALTERNATIVE

	Existing (1963)	Increment 1963-1990				Total 1990	
		Planned		Unplanned			
		Number	Percent	Number	Percent	Planned	Unplanned
Square Miles of Developed Area[1]	340	269	79.1	653	191.7	609	993
Urban Population	1,634,200	1,017,220	62.2	1,017,220	62.2	2,651,220	2,651,220
Population Per Square Miles of Developed Area	4,807	3,782	78.6	1,560	32.4	4,353	2,673

[1]*Determined by measuring the extent of uninterrupted urban development (see footnote 1, Chapter V, Volume 1, SEWRPC Planning Report No. 7).*

Source: SEWRPC.

Table 242

DEVELOPED AREA AND POPULATION SERVED BY PUBLIC SANITARY SEWER SERVICE AND PUBLIC WATER SUPPLY IN THE REGION: 1963 AND 1990 RECOMMENDED LAND USE PLAN AND 1990 UNPLANNED ALTERNATIVE

Extent of Service	Existing (1963)		Increment 1963 - 1990			
			Planned		Unplanned	
	Public Sewer Service	Public Water Supply	Public Sewer Service	Public Water Supply	Public Sewer Service	Public Water Supply
Developed Area:						
Total Square Miles	339.7	339.7	269.3	269.3	653.2	653.2
Square Miles Served	217.0	200.0	362.9	379.9	331.5	348.5
Percent of Total Served	63.9	58.8	--	--	--	--
Population:						
Total Population	1,674,400	1,674,400	1,003,600	1,003,600	1,003,600	1,003,600
Population Served	1,419,025	1,372,480	1,127,645	1,174,190	570,175	616,720
Percent of Total Served	84.7	81.9	--	--	--	--

Extent of Service	Existing (1963)		Total 1990			
			Planned		Unplanned	
	Public Sewer Service	Public Water Supply	Public Sewer Service	Public Water Supply	Public Sewer Service	Public Water Supply
Developed Area:						
Total Square Miles	339.7	339.7	609.0	609.0	992.9	992.9
Square Miles Served	217.0	200.0	579.9	579.9	548.5	548.5
Percent of Total Served	63.9	58.8	95.2	95.2	55.2	55.2
Population:						
Total Population	1,674,400	1,674,400	2,678,000	2,678,000	2,678,000	2,678,000
Population Served	1,419,025	1,372,480	2,546,670	2,546,670	1,989,200	1,989,200
Percent of Total Served	84.7	81.9	95.0	95.0	74.3	74.3

Source: SEWRPC.

the highly dispersed low-density characteristics of the residential development would place many new developments beyond the logical or feasible extensions of such existing or proposed systems. Accordingly, the unplanned alternative would result in an increased emphasis upon the utilization of onsite septic tank sewage disposal systems rather than centralized sanitary sewerage facilities. The continued widespread use of such septic tank sewage disposal systems could be expected under the unplanned land use alternative to subject the surface water system and the shallow groundwater aquifers to pollution in numerous locations within the Region, involving ever large areas and with serious potential attendant public health problems. Odor, public health, and water pollution problems could be expected to continue to develop in areas where intensive residential development is located on soils poorly suited for septic tank filter field utilization. As discussed in Chapter IV of this report, about 61 percent of the total area of the Region is covered with soils poorly suited for residential development without sanitary sewer service on lots of one acre or less in size, with nearly 45 percent of the total area of the Region unsuitable for residential development with septic tank systems even on lots larger than one acre in size.

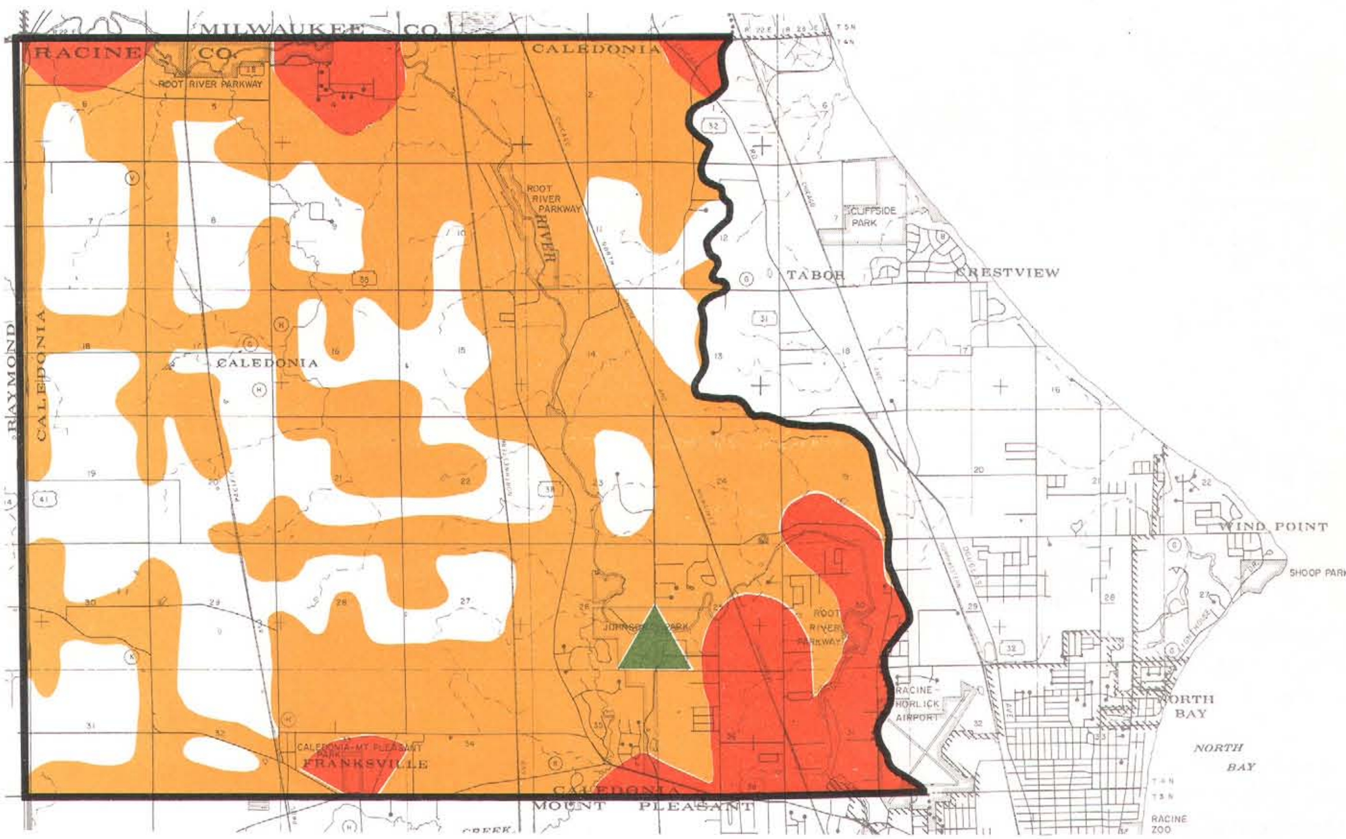
APPLICATION OF SANITARY SEWERAGE ALTERNATIVES TO A SELECTED STUDY AREA UNDER THE UNPLANNED ALTERNATIVE

As noted above, it was considered impractical under the regional sanitary sewerage system planning program to prepare an alternative sanitary sewerage system plan for the unplanned regional land use pattern—which pattern represents only one possible pattern of a very large number of such patterns which could result from continued existing trend development within the Region. In order to demonstrate the costs of providing centralized sanitary sewer service under the unplanned land use alternative, and to compare such costs with those applicable to development in accordance with the regional land use plan, as well as to costs associated with a typical land use development utilizing onsite septic tank sewage disposal systems, however, it was determined to select a small study area for comparative analysis.

The area selected for study for such analysis lies in that portion of the Town of Caledonia in the Root River watershed, generally in the path of outward urban expansion from both the Racine and Milwaukee urbanized areas. At the present time, this portion of the Town of Caledonia already exhibits a land use development pattern tending toward that envisioned under the unplanned land use alternative, with highly scattered residential development located along section and quarter-section line roads and in scattered, isolated small subdivisions. Disposal of sanitary wastes presently is by use either of septic tanks and onsite absorption of septic tank effluent or through centralized sanitary sewer service with treatment provided by contract with the City of Racine. In addition, one small subdivision is served by the Caddy Vista Sanitary District which operates its own sewage treatment facility. The land use pattern assumed under the unplanned alternative for this portion of the Region is shown on Map 136, while for comparison purposes the recommended regional land use plan for the area is shown on Map 137.

Map 136

UNPLANNED LAND USE ALTERNATIVE FOR THE CALEDONIA STUDY AREA: 1990



LEGEND

- LOW DENSITY RESIDENTIAL (0.5–7.2 PERSONS PER NET RESIDENTIAL ACRE)
- MEDIUM DENSITY RESIDENTIAL (7.3–22.8 PERSONS PER NET RESIDENTIAL ACRE)
- MAJOR PUBLIC OUTDOOR RECREATION SITE
- AGRICULTURAL AND VACANT
- STUDY AREA BOUNDARY

GRAPHIC SCALE 0 2000 4000 FEET

In order to investigate the costs of providing centralized sanitary sewer service to urban development under the unplanned land use alternative, to compare such costs with those applicable to development in accordance with the regional land use plan, and to further compare such costs to those associated with development utilizing septic tank sewage disposal systems, a small study area was selected for comparative analysis. This study area is located in the Root River watershed portion of the Town of Caledonia, Racine County. As indicated on the above map, under the unplanned alternative all new urban development in this portion of the Town of Caledonia would occur at densities of less than 7.3 persons per net residential acre, (5.5 persons per gross acre, or 3,500 persons per square mile) and would likely occur in scattered, strip development fashion along already existing section and quarter-section line town and county roads. At the present time all but a small portion of this area of the Town of Caledonia is served by onsite, septic tank sewage disposal systems.

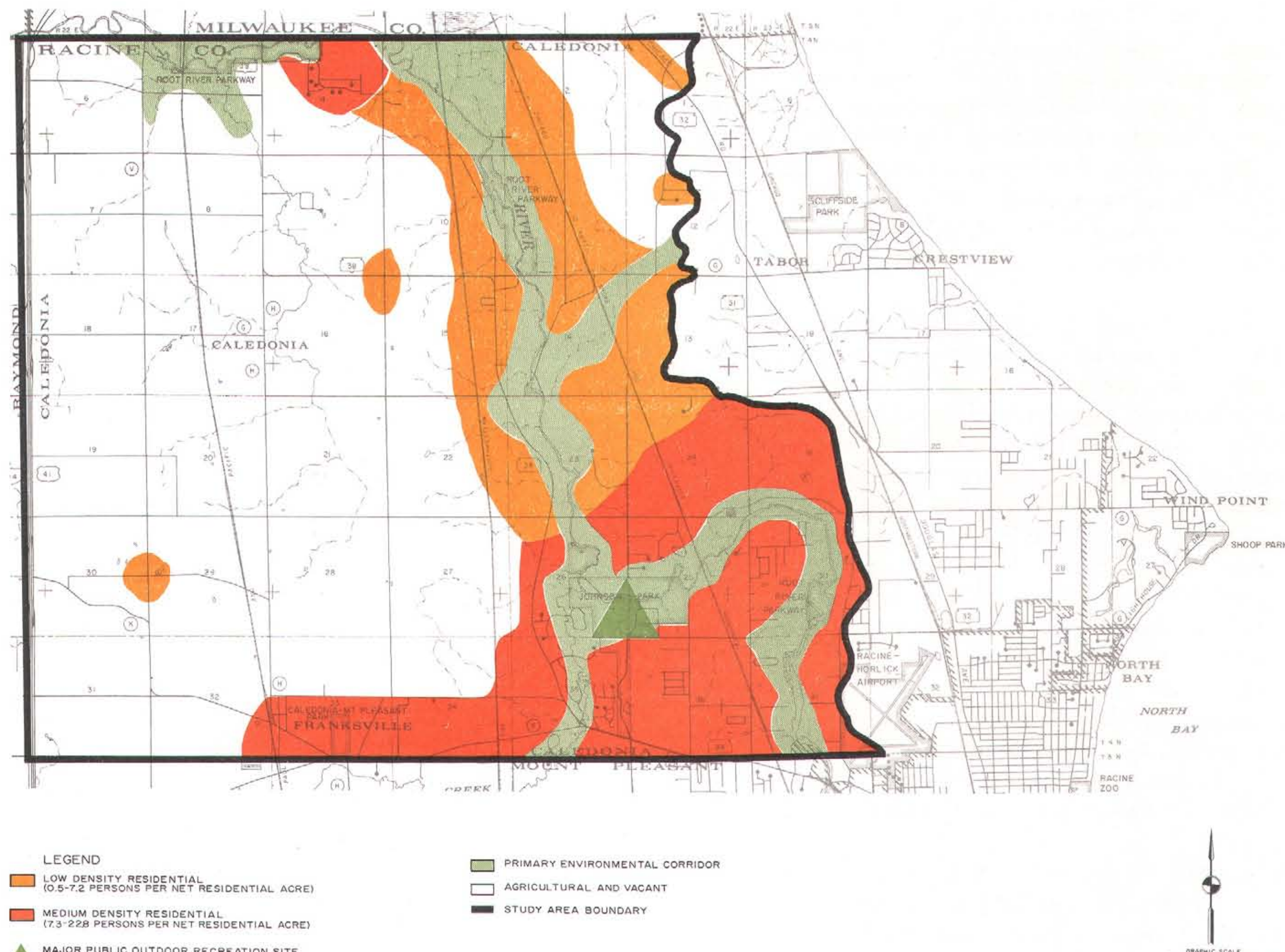
Source: SEWRPC.

In 1970 the resident population in the study area was estimated at about 9,100 persons, of which about 4,500 persons resided in areas already provided with centralized sanitary sewer service. Under the unplanned 1990 land use alternative (see Map 136), it is estimated that about 49,000 persons would reside in the study area, while under the adopted 1990 regional land use plan (see Map 137), it is estimated that the study area resident population would approximate 39,000 persons. In general, development in the study area under the unplanned land use alternatives would consist of diffused, low-density residential development, while development under the adopted regional land use plan in the study area would occur in a more compact pattern at predominantly medium densities.

In the analysis, three alternative ways of providing the necessary sanitary waste disposal services were examined with respect to the unplanned alternative for the study area: septic tank systems with onsite soil absorption of effluent (unplanned alternative 1A); centralized sanitary sewer ser-

Map 137

ADOPTED REGIONAL LAND USE PLAN FOR THE CALEDONIA STUDY AREA: 1990



The adopted regional land use plan for the Caledonia study area is shown on this map and may be contrasted with the unplanned alternative land development pattern for the same area shown on Map 136. Under the adopted regional land use plan, the majority of new development in this portion of the Town of Caledonia would occur at medium densities, ranging from 7.3 to 22.8 persons per net residential acre, (5.6 to 15.6 persons per gross acre, or 3,500 to 10,000 persons per square mile) with typical single-family home lot sizes averaging about one-third of an acre. The regional land use plan further recommends that centralized sanitary sewer and water supply services be extended to serve all new urban development as shown on the map, and that such development further be planned to form cohesive neighborhood units. Finally, the adopted regional land use plan recommends that the primary environmental corridor along the main stem of the Root River through the Town of Caledonia be preserved and protected from intrusions of incompatible development. It should be noted that the adopted Root River watershed plan recommends that this environmental corridor be purchased by Racine County for park and parkway purposes, and that the County Board has already begun the recommended acquisition program.

Source: SEWRPC.

vice with treatment provided at a number of small pre-engineered or "package" sewage treatment plants (unplanned alternative 1B); and centralized sanitary sewer service with treatment provided at the City of Racine sewage treatment facility (unplanned alternative 1C). In addition, the costs of implementing each of the three foregoing unplanned alternatives were compared on a per capita basis with the cost of implementing the recommended regional sanitary sewerage system plan, which plan is based upon the adopted regional land use plan for the study area.

For analysis purposes, it was assumed that of the total estimated 1990 study area population of about 49,000 under the unplanned alternative, an estimated 17,000 persons would be served with public sanitary sewers in those portions of the study area already served either through extensions of trunk sewers from the City of Racine system or by the Caddy Vista system. Thus, under each of the three unplanned alternatives considered, an incremental population of about 32,000 persons was utilized in order to provide a common basis for analysis and comparison.

Unplanned Alternative 1A—Septic Tank Systems

The first unplanned alternative considered assumed the provision of individual onsite septic tank sewage disposal systems to serve the 1990 study area population of about 32,000 persons (see Map 138). This alternative was considered even though it is recognized that such an alternative would clearly be an unsatisfactory one for the study area, an area which is generally covered by soils having severe or very severe limitations for the absorption of septic tank effluent. The alternative was developed, however, primarily to demonstrate the direct cost of sewering low-density urban development with septic tanks without regard to the economic and social costs attendant to the use of a system of sewage disposal which could eventually be expected to malfunction.

The analysis assumed an average of 3.8 persons per residential dwelling unit, which resulted in a need to provide approximately 7,100 new individual septic tank systems to serve the assumed population increment of about 27,000 persons in the study area, since 4,600 persons already reside in the study area and are already served with septic tank systems. Based upon an average hydraulic loading of 125 gallons per capita per day and a need to provide for retention capacity, it was assumed each residence would need a standard 1,000-gallon septic tank, one service line connecting the tank to the building, and one drain tile field. Using the design criteria set forth in the U. S. Public Health Service Manual of Septic Tank Practice, and assuming a percolation rate of 1 inch in 45 minutes,[2] the necessary soil absorption field would consist of 320 feet of drain tile. The service life for the septic tank was assumed at 50 years, while the soil absorption field was assumed to have a service life of 15 years, and would thus be periodically replaced in the economic analysis. The total capital cost of installing the necessary septic tank system was estimated at $1,220 per residence. Operation and maintenance costs were estimated at $10 per septic tank per year.

Detailed cost estimates for implementing unplanned alternative 1A for the study area are set forth in Table 243. The total estimated capital cost for the needed 7,100 new septic tank systems is estimated at about $8.7 million. The estimated equivalent annual cost, including both capital costs for the new systems and operation and maintenance costs for both the existing and new systems, is estimated at about $480,000. The estimated per capita equivalent annual cost, based upon an estimated 1980 resident population of 18,200 persons, is about $26.

Unplanned Alternative 1B—
Pre-Engineered Treatment Systems

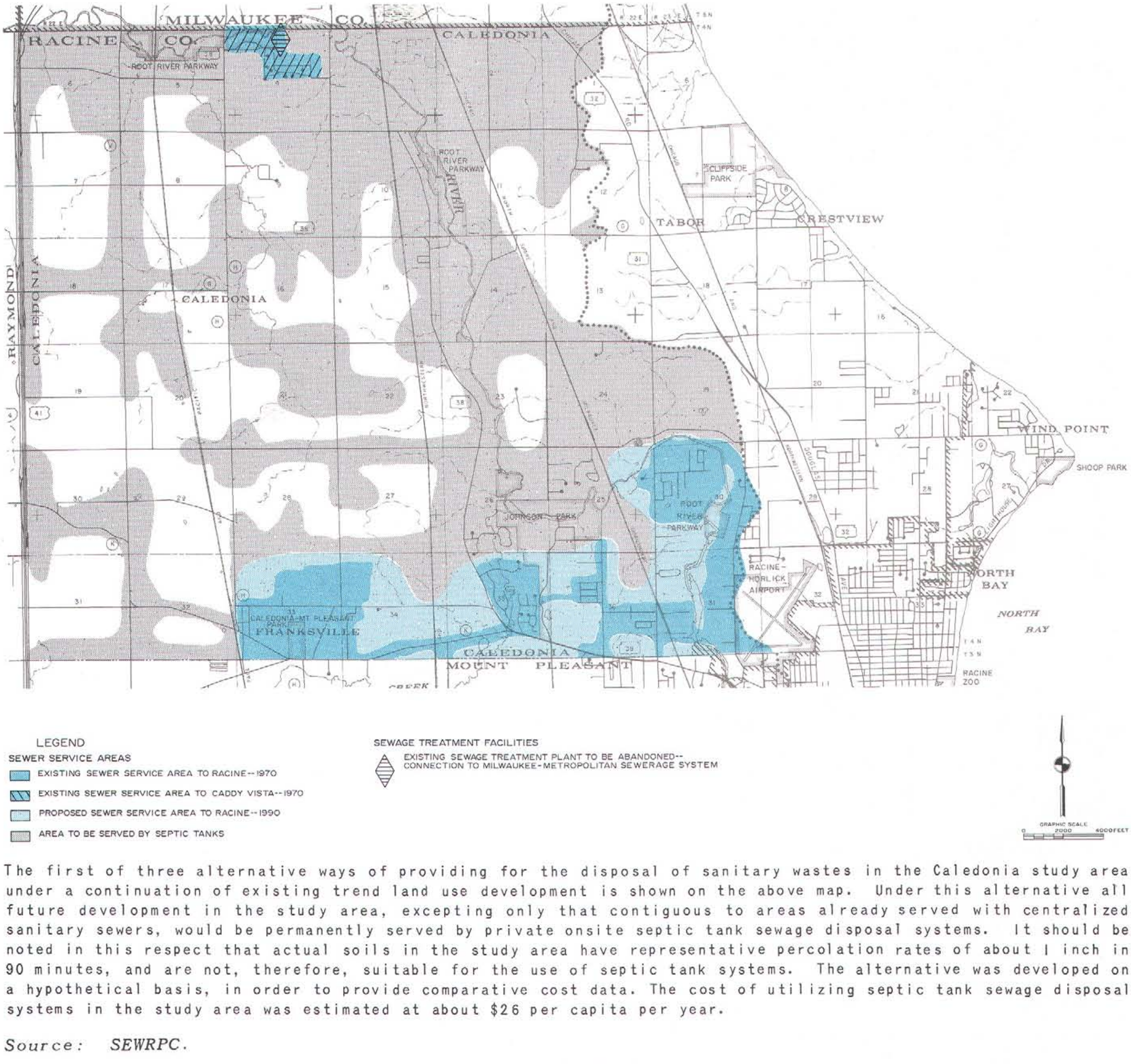
The second unplanned alternative considered to provide sanitary sewer service to the study area assumes the utilization of a number of small pre-engineered or "package" sewage treatment plants. This unplanned alternative would require not only the installation of the sewage treatment plants, but also trunk sewers to the treatment plant sites, lateral and branch sewers, and building sewers. This unplanned alternative is shown in graphic form on Map 139. Nine individual "package" treatment plants would be required to serve the unplanned land use pattern in the study area. These plants would range in size from about 0.36 mgd to about 1.03 mgd, and would serve resident populations ranging from 1,700 to 4,900 persons.

---

[2] *The percolation rate selected is typical of soils within the Region which are rated as suitable for the use of septic tank systems. It is important to note that the actual soils in the selected study area have representative percolation rates of about 1 inch in 90 minutes and are not suitable for septic tank systems. Any comparison of septic tanks to sewerage systems in this particular area is, therefore, hypothetical.*

Map 138

UNPLANNED SEWERAGE ALTERNATIVE IA FOR THE CALEDONIA STUDY AREA
SEWER SERVICE BY SEPTIC TANK SYSTEMS



The first of three alternative ways of providing for the disposal of sanitary wastes in the Caledonia study area under a continuation of existing trend land use development is shown on the above map. Under this alternative all future development in the study area, excepting only that contiguous to areas already served with centralized sanitary sewers, would be permanently served by private onsite septic tank sewage disposal systems. It should be noted in this respect that actual soils in the study area have representative percolation rates of about 1 inch in 90 minutes, and are not, therefore, suitable for the use of septic tank systems. The alternative was developed on a hypothetical basis, in order to provide comparative cost data. The cost of utilizing septic tank sewage disposal systems in the study area was estimated at about $26 per capita per year.

Source: SEWRPC.

Table 243

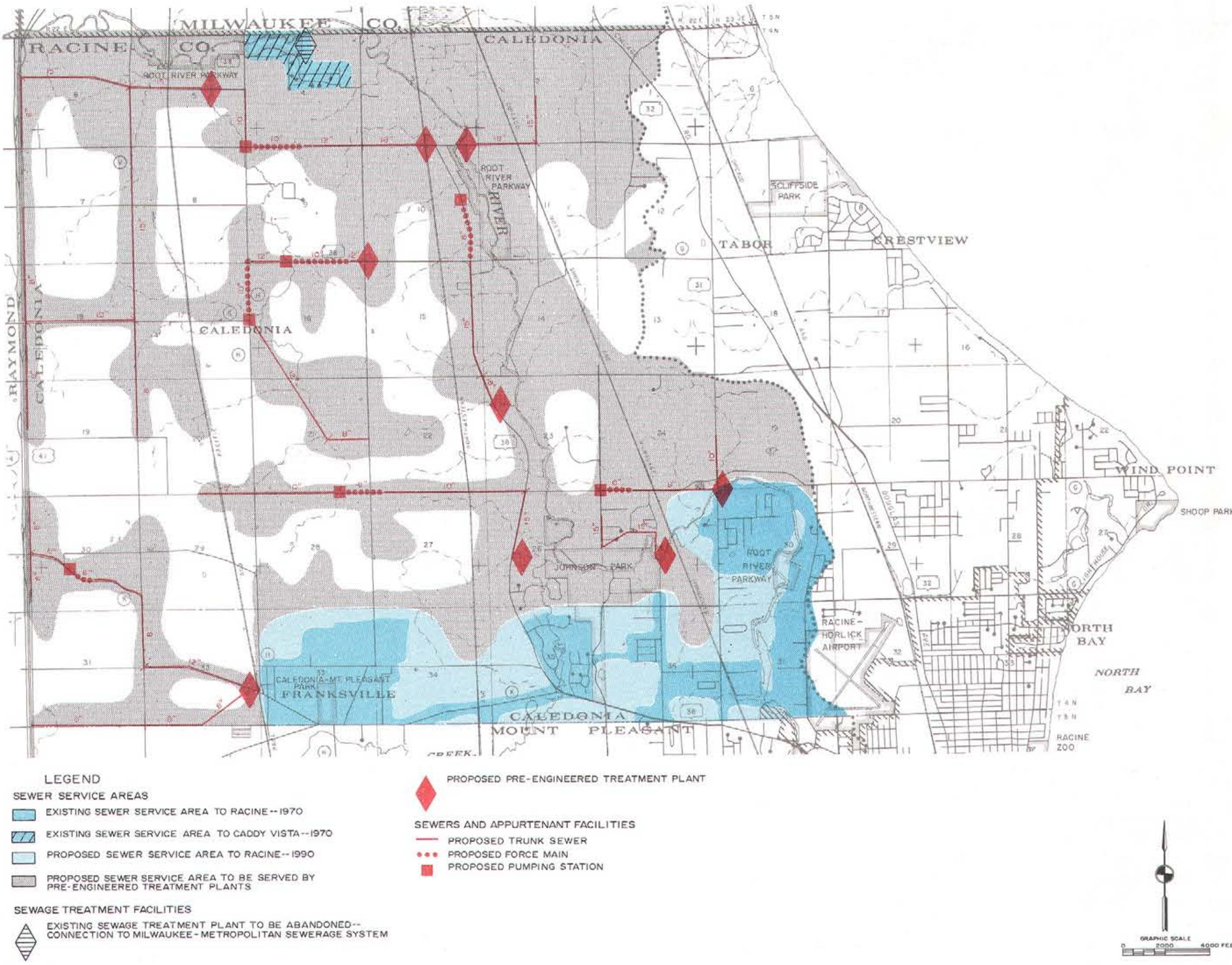
DETAILED COST ESTIMATES
CALEDONIA STUDY AREA UNPLANNED SEWERAGE ALTERNATIVE IA
SEWER SERVICE BY SEPTIC TANK SYSTEMS

Plan Element	Estimated Cost: Capital Construction	Present Worth (1970-2020): Construction	Present Worth (1970-2020): Operation and Maintenance	Present Worth (1970-2020): Total	Equivalent Annual (1970-2020): Construction	Equivalent Annual (1970-2020): Operation and Maintenance	Equivalent Annual (1970-2020): Total
Septic Tanks and Effluent Absorption Systems	$8,701,000	$6,925,200	$650,200	$7,575,400	$439,100	$41,200	$480,300
Total	$8,701,000	$6,925,200	$650,200	$7,575,400	$439,100	$41,200	$480,300

Source: SEWRPC.

Map 139

UNPLANNED SEWERAGE ALTERNATIVE 1B FOR THE CALEDONIA STUDY AREA
SEWER SERVICE BY PRE-ENGINEERED TREATMENT PLANTS



The second of three alternative ways of providing for the disposal of sanitary wastes in the Caledonia study area under a continuation of existing trend land use development provides sanitary sewer service with treatment of the sewage provided at a number of pre-engineered or "package" sewage treatment plants. As shown above, nine individual treatment plants would be required to serve the unplanned land use pattern in the study area by 1990. Such plants would range in size from about 0.4 to about 1.0 mgd, and would serve populations ranging from 1,700 to 4,900 persons. The cost of this alternative was estimated at about $102 per capita per year, or more than either the septic tank development alternative, as illustrated on Map 138, or the centralized sewer service alternative, as illustrated on Map 140.

Source: SEWRPC.

Detailed cost estimates for implementing unplanned alternative 1B for the study area are shown in Table 244. The capital costs for the necessary sewage treatment facilities is estimated at about $10.4 million, with the cost of the trunk sewers estimated at about $6.3 million. In addition, the estimated capital cost of necessary lateral and branch sewers is about $6.4 million, with the building sewers having an estimated capital cost of about $2.0 million. Thus, the total estimated capital cost of providing sewer service under this unplanned alternative is estimated at about $25.1 million, with a total equivalent annual cost of about $1.8 million. The estimated per capita equivalent annual cost, based upon an assumed 1980 population of 18,200 persons, is about $102.

Table 244

DETAILED COST ESTIMATES
CALEDONIA STUDY AREA UNPLANNED SEWERAGE ALTERNATIVE IB
SEWER SERVICE BY PRE-ENGINEERED TREATMENT PLANTS

Plan Element	Capital Construction	Estimated Worth: Present Worth (1970-2020): Construction	Operation and Maintenance	Total	Equivalent Annual (1970-2020): Construction	Operation and Maintenance	Total
Pre-Engineered Sewage Treatment Plants (9)	$10,431,500	$ 9,424,100	$6,843,900	$16,268,000	$ 597,900	$434,200	$1,032,100
Trunk Sewers	6,250,900	4,733,400	737,800	5,471,200	300,300	46,800	347,100
Subtotal	16,682,400	14,157,500	7,581,700	21,739,200	898,200	481,000	1,379,200
Lateral and Branch Sewers	6,437,900	4,717,600	238,000	4,955,600	299,300	15,100	314,400
Building Sewers	2,027,300	1,484,800	964,600	2,449,400	94,200	61,200	155,400
Subtotal	8,465,200	6,202,400	1,202,600	7,405,000	393,500	76,300	469,800
Total	$25,147,600	$20,359,900	$8,784,300	$29,144,200	$1,291,700	$557,300	$1,849,000

Source: SEWRPC.

Unplanned Alternative 1C—
Centralized Treatment System

The third unplanned alternative considered to provide sanitary sewer service to the study area assumes provision of centralized sanitary sewer service with conveyance of sewage to the City of Racine sewage treatment facility. This alternative is shown in graphic form on Map 140.

Detailed cost estimates for implementing unplanned alternative 1C are presented in Table 245. The estimated capital cost of providing incremental capacity at the Racine sewage treatment facility is $1.5 million, while the necessary trunk sewers to collect sewage from throughout the study area and to convey sewage to the Racine plant have an estimated capital cost of about $14.0 million. The estimated capital cost for lateral and branch sewers is about $6.1 million, while the capital cost of the necessary building sewers is estimated at about $2.0 million. Thus, the total capital cost for implementing unplanned alternative 1C is estimated at about $23.6 million, with an equivalent annual cost of about $1.6 million. The estimated per capita equivalent annual cost, based upon an assumed 1980 population of 18,200 persons, is about $87.

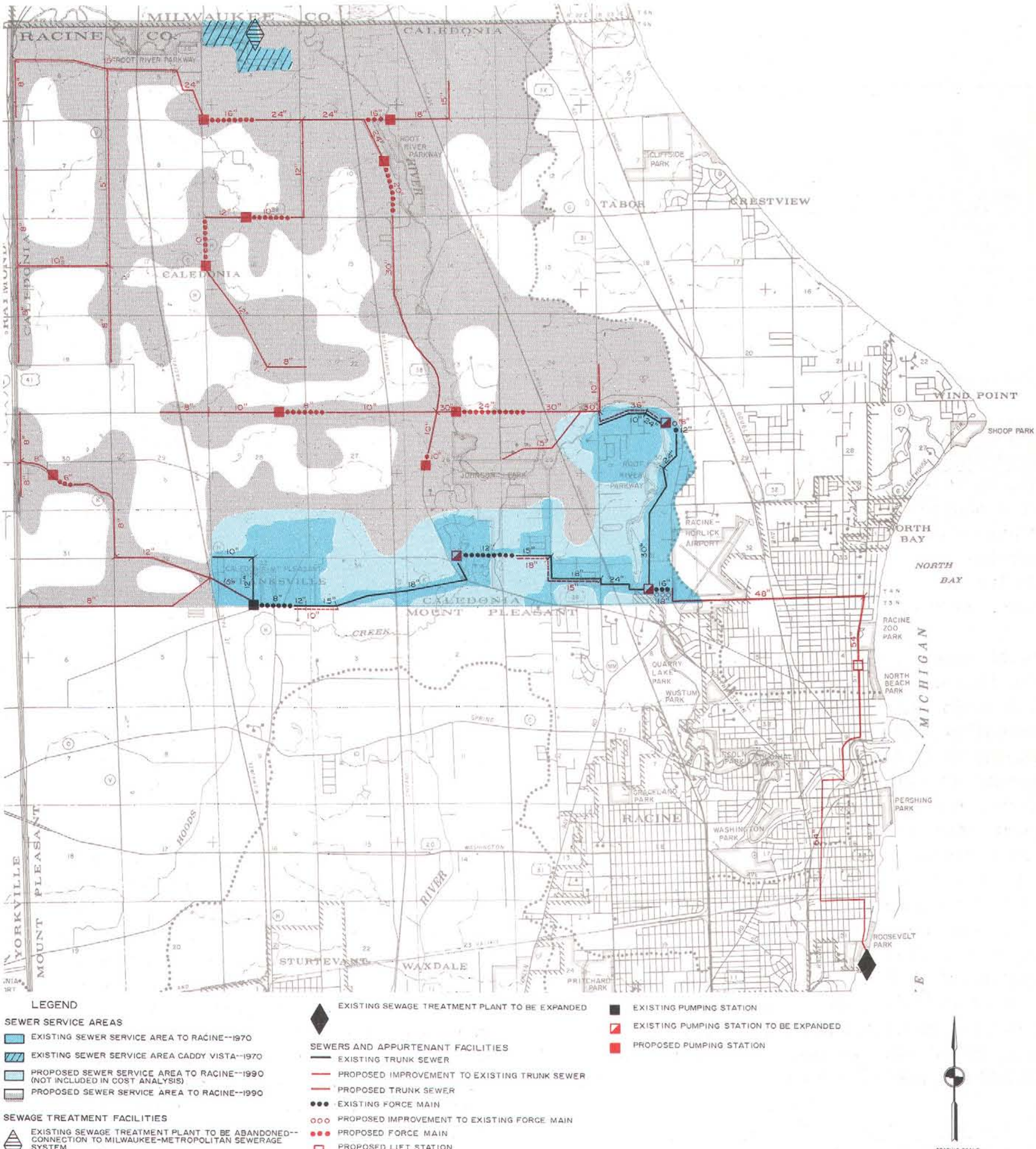
Comparison of Unplanned Alternatives
With Recommended Plan

The costs of providing centralized sanitary sewer service to urban development in the Caledonia study area under the recommended regional sanitary sewerage system plan are set forth in Table 246. It is important to note that the data shown in Table 246 represent the cost of serving the entire 1990 planned population in the study area of about 39,000 persons and, therefore, are not comparable, except on a per capita basis, with the costs presented for each of the three unplanned sanitary sewerage alternatives set forth above. It should also be noted that the costs set forth in Table 246 do include an increment beyond a strict apportionment of the recommended plan costs for the study area set forth in Chapter XII of this report, since lateral, branch, and building sewer costs had to be included so as to provide a basis for comparing, on a per capita cost basis, the recommended plan with the foregoing unplanned alternatives. The recommended sanitary sewerage system plan for the study area is shown on Map 141.

The estimated capital and equivalent annual costs for the three unplanned sewerage alternatives and for the recommended regional sanitary sewerage system plan to serve the study area are set forth in Table 247. Among the three unplanned sewerage alternatives considered, the septic tank alternative is the least costly, with an estimated equivalent annual per capita cost of about $26, compared to per capita costs of $102 for the unplanned sewerage alternative utilizing "package" sewage treatment plants, and about $87 for the unplanned sewerage alternative providing for conveyance and treatment of sewage at the Racine sewage treatment facility. As noted earlier, however, the use of septic tanks as a permanent means of sewage disposal is not a feasible alternative in the study area due to severe soil limitations, a situation generally existing throughout much of the Southeastern Wisconsin Region.

Map 140

UNPLANNED SEWERAGE ALTERNATIVE 1C FOR THE CALEDONIA STUDY AREA
SEWER SERVICE BY CONNECTION TO RACINE TREATMENT PLANT



The third of three alternative ways of providing for the disposal of sanitary wastes in the Caledonia study area under a continuation of existing trend land use development would provide a centralized sanitary sewerage system with treatment of the sewage from throughout the study area provided at the City of Racine sewage treatment plant. The necessary trunk sewers under this alternative, including a conveyance sewer to the Racine sewage treatment plant, are shown on this map. The cost of this alternative was estimated at about $87 per capita per year, significantly less than that of the "package" treatment plant alternative as shown on Map 139, but substantially more than the hypothetical septic tank development alternative, as shown on Map 138.

Source: SEWRPC.

Table 245

DETAILED COST ESTIMATES
CALEDONIA STUDY AREA UNPLANNED SEWERAGE ALTERNATIVE IC
SEWER SERVICE BY CONNECTION TO RACINE TREATMENT PLANT

Plan Element	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Apportioned Capacity at Racine Sewage Treatment Plant	$ 1,479,500	$ 1,532,900	$3,445,000	$ 4,977,900	$ 97,300	$218,600	$ 315,900
Trunk Sewers	13,981,900	10,772,700	2,088,200	12,860,900	683,400	132,500	815,900
Subtotal	15,461,400	12,305,600	5,533,200	17,838,800	780,700	351,100	1,131,800
Lateral and Branch Sewers	6,092,800	4,465,400	223,800	4,689,200	283,300	14,200	297,500
Building Sewers	2,027,300	1,484,800	964,600	2,449,400	94,200	61,200	155,400
Subtotal	8,120,100	5,950,200	1,188,400	7,138,600	377,500	75,400	452,900
Total	$23,581,500	$18,255,800	$6,721,600	$24,977,400	$1,158,200	$426,500	$1,584,700

Source: SEWRPC.

Table 246

DETAILED COST ESTIMATES
CALEDONIA STUDY AREA RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN
SEWER SERVICE BY CONNECTION TO RACINE SEWAGE TREATMENT PLANT

Plan Element	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Apportioned Capacity at Racine Sewage Treatment Plant	$ 1,507,500	$ 1,562,000	$3,510,200	$ 5,072,200	$ 99,100	$222,700	$ 321,800
Trunk Sewers	5,693,000	4,453,000	897,000	5,350,000	282,500	56,900	339,400
Subtotal	7,200,500	6,015,000	4,407,200	10,422,200	381,600	279,600	661,200
Lateral and Branch Sewers	8,987,800	6,585,400	178,100	6,763,500	417,800	11,300	429,100
Building Sewers	2,059,200	1,508,400	978,800	2,487,200	95,700	62,100	157,800
Subtotal	11,047,000	8,093,800	1,156,900	9,250,700	513,500	73,400	586,900
Total	$18,247,500	$14,108,800	$5,564,100	$19,672,900	$895,100	$353,000	$1,248,100

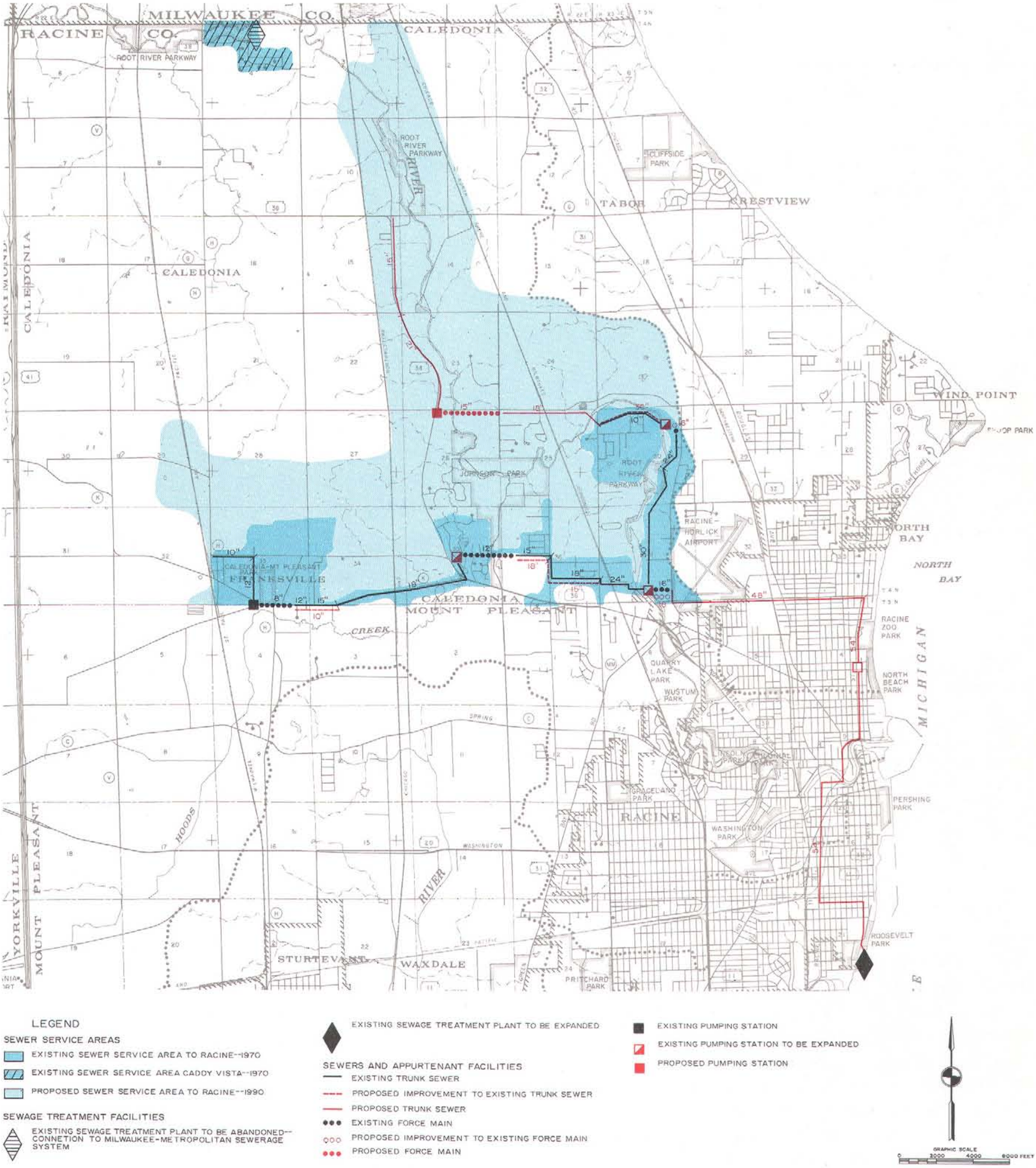
Source: SEWRPC.

Among the feasible alternatives for sewering unplanned urban development in the study area, then, the alternative of providing centralized sanitary sewer service at a single large sewage treatment plant has a significant cost advantage over the provision of centralized sanitary sewer service at several small sewage treatment facilities. Significantly, however, both the latter alternatives, when considered on an equivalent annual cost per capita basis, are more costly than the provision of centralized sanitary sewer service to a more compact planned urban development pattern as recommended in the regional land use and sanitary sewerage system plans, which cost is estimated at $67 per capita. This analysis demonstrates, then, the advantages of directing urban development in accordance with the adopted regional land use plan, rather than allowing development to occur in scattered fashion as depicted under the unplanned land use alternative. The analysis further demonstrates, however, that in those instances where soils clearly are suitable to safely absorb septic tank effluent, it would be possible to accommodate low-density urban development more economically through septic tank systems than through the provision of centralized sanitary sewer service.

While the foregoing analysis concludes that it is more economical to accommodate low-density urban development through septic tank systems than through the provision of centralized sanitary sewer service when such development is located on soils clearly suitable for the use of onsite

Map 141

RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE CALEDONIA STUDY AREA
SEWER SERVICE BY CONNECTION TO RACINE TREATMENT PLANT



The recommended regional sanitary sewerage system plan as it applies to the Caledonia study area is shown on the above map. Under this alternative, land use development is assumed to occur in a more compact, urban development pattern, with treatment of sewage to be provided through continued expansion of the existing Racine sewerage system and treatment of the sewage at the City of Racine treatment plant. All necessary trunk sewers to carry out this recommended plan are shown on the above map. The cost of this alternative was estimated at about $67 per capita per year, or substantially less than the estimated per capita costs for either of the two feasible alternatives examined previously with respect to the unplanned land use pattern, as shown on Maps 139 and 140. It is important to recognize that the cost savings found under this plan reflect primarily the more compact urban development pattern as recommended in the regional land use plan, as opposed to the more scattered and less dense urban development pattern as assumed under the unplanned regional land use alternative.

Source: SEWRPC.

Table 247

COMPARISON OF DETAILED COST ESTIMATES
UNPLANNED SEWERAGE ALTERNATIVES AND RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN
CALEDONIA STUDY AREA

Alternative	Estimated Cost: Capital Construction	Estimated Cost: Equivalent Annual (1970-2020): Construction	Estimated Cost: Equivalent Annual (1970-2020): Operation and Maintenance	Estimated Cost: Equivalent Annual (1970-2020): Total	Estimated 1980 Population Served	Equivalent Annual Cost Per Capita: Total	Equivalent Annual Cost Per Capita: Less Lateral, Branch, and Building Sewers
Unplanned Alternatives							
1A--Septic Tanks	$ 8,701,000	$ 439,100	$ 41,200	$ 480,300	18,200	$ 26	$--
1B--Pre-Engineered Treatment Plants	25,147,600	1,291,700	557,300	1,849,000	18,200	102	76
1C--Connection to Racine	23,581,500	1,158,200	426,500	1,584,700	18,200	87	62
Recommended Sewerage System Plan	18,247,500	895,100	353,000	1,248,000	18,700	67	35

Source: SEWRPC.

sewage disposal systems, it does not necessarily follow that such low-density septic tank urban development represents a desirable development pattern that should be pursued in those areas of the Region where suitable soils may be found. With respect to the septic tank system itself, such systems have been known to be highly irregular in performance, reflecting inadequate design, installation, and maintenance practices. Dangerous concentrations of bacteriological and chemical contaminants may develop in the groundwater reservoir underlying high intensity septic tank development areas. Septic tank sewage disposal systems also have a limited life and must be maintained and periodically replaced. Improperly maintained and operated systems may be subject to clogging "barriers" in the disposal field which keep effluent from filtering through. These types of failures would tend to cause the discharge of untreated wastes onto the ground surface, and may cause public health and water pollution problems, as well as an aesthetic nuisance. Many homeowners simply do not understand that the septic tank in any system must be cleaned from time-to-time, and that lack of such maintenance tends to force the system into failure.

Apart from the problems involved in locating, operating, and maintaining septic tank systems, however, there are other concerns of a broader nature which should be taken into account before it is concluded that urban development served by septic tanks represents a desirable form of urban land use. There are many other costs associated with widespread low-density urban development, the kind of urban development that would be needed to properly utilize onsite soil absorption septic tank sewage disposal systems. Such costs occur both in the public and private sectors of the economy. In the public sector, there are invariably additional costs involved in the provision of public facilities and services, such as transportation, police and fire protection, solid waste collection, storm water drainage, and water supply. To accurately assess such incremental costs would require the preparation of a full complement of alternative areawide public facilities plans. To date the Commission has completed and adopted only one such facility plan—a regional transportation plan, initially adopted by the Commission in 1966 and amended by Commission adoption of the Milwaukee area transit plan in 1972.

Analyses conducted by the Commission as part of the preparation of the regional land use and transportation and Milwaukee area transit plans indicate that the capital costs necessary for public transportation facilities, including highway, parking, and transit facilities, could be expected to increase from an estimated total of about $2.34 billion under the adopted plans to an estimated total of about $2.42 billion under the unplanned land use alternative, assuming that a minimal level of transit service could be maintained in the Region under the latter alternative. This represents an increase in capital facility costs of about 7 percent. The analyses further indicate that total operating costs over the 23-year plan implementation period 1967 to 1990 could be expected to increase from about $23.6 billion under the adopted plans to about $26.2 billion under the unplanned alternative, an increase of about 11 percent. These increases in costs are due primarily to the more dispersed, highly scattered urban development pattern assumed under the unplanned alternative, and reflect the inability to maintain, much less increase, transit utilization, as well as the increased travel costs occasioned by greater separation distances between residences and places of employment, shopping, and recreation.

The impact upon transit service of not implementing the recommended regional land use and transportation plans is evidenced by the fact that under the unplanned alternative the total revenue passengers carried by transit is estimated at about 82 million annually, as opposed to about 157 million revenue passengers under the adopted regional land use plan. Concomitantly, travel on the arterial network could be expected to increase from about 10 billion vehicle miles annually under the adopted regional land use plan to nearly 12 billion vehicle miles annually under the unplanned alternative, an increase of about 20 percent.

The foregoing estimates of increased travel and related costs under the unplanned alternative do not fully recognize the additional school bus route miles that would be needed to accommodate urban development if it occurred in accordance with the unplanned alternative. Under the adopted regional land use and transportation plans, a total of about 335,000 person trips per day could be expected to be made within the Region for school purposes by 1990. Of this total, an estimated 144,000 trips could be made by public transit, 63,000 by school bus, and 24,000 as auto drivers, with the remaining 104,000 trips made either as auto passengers or by walking. Under the unplanned alternative, while the total number of school trips could be expected to remain at about 335,000 in 1990, the number of trips made by transit could be expected to decrease to about 86,000, a loss of nearly 58,000. It may be conservatively assumed that these 58,000 trips would have to be accommodated by special school bussing, as would additional trips previously made by walking in the predominantly medium-density urban residential neighborhoods recommended under the adopted regional land use plan. Thus, school bussing costs could be expected to be increased significantly under the unplanned alternative.

The impact of the unplanned alternative in terms of fuel consumption and pollutants discharged from vehicles can also be estimated. Total fuel consumption based upon assumptions underlying the adopted regional land use and transportation plans is estimated at about 832 million gallons per year, whereas such consumption under the unplanned alternative is estimated at about 952 million gallons per year, an increase of about 14 percent. Similarly, the pollutants from vehicles as measured in terms of carbon monoxide, hydrocarbons, and oxides of nitrogen emitted could be expected to be increased significantly. Carbon monoxide emitted from vehicles could be expected to increase from an estimated 105,000 tons per year under the adopted regional land use and transportation plans to about 116,000 tons per year under the unplanned alternative, an increase of about 10 percent. Hydrocarbons emitted from vehicles could be expected to increase from about 17,000 tons per year under the adopted plans to about 20,000 tons per year under the unplanned alternative, an increase of about 18 percent. Oxides of nitrogen emitted could be expected to increase from about 22,000 tons per year under the adopted plans to about 25,000 tons per year under the unplanned alternative, an increase of about 14 percent.

While the foregoing analyses relate to some of the incremental costs to be expected in transportation through continued dispersion of urban development within the Region, similar incremental costs may be expected in other municipal governmental functions. To adequately assess added incremental costs would require the preparation of additional plan elements and accompanying interpretive analyses. Based upon the foregoing analyses, however, it may be concluded that while the utilization of septic tanks to provide for sanitary sewer service in low-density urban areas may be cost effective from a single purpose point of view, any conclusions that low-density urban development served by septic tank systems represents a desirable land use pattern should be tempered with the realization that other not insubstantial costs are involved in both the public and private sectors. In particular the increased transportation costs could be severe even assuming the availability of an adequate fuel supply. Given restriction on the utilization of fuels, it becomes even more clear that the type of urban land development pattern depicted in the unplanned land use alternative is one that should be pursued by local governmental officials only after very careful analyses.

SUMMARY

The regional sanitary sewerage system plan as set forth in Chapter XII of this report is related to and based upon the adopted regional land use plan.

As part of the regional land use planning program, an unplanned land use development alternative was examined. This alternative assumed the continuation of existing trends in land use development in the absence of any attempt to guide such development on an areawide basis in the public interest. Under the unplanned alternative, with its emphasis upon low-density development, about two times as much land would have to be converted from rural to urban use over the next two-to-three decades than under the adopted regional land use plan. Whereas nearly three-fourths of all new residential development under the adopted regional land use plan would be developed at medium densities, about 90 percent of new residential development under the unplanned alternative would be developed at low densities. Overall urban population densities in the Region could be expected to decrease under the unplanned alternative to a level of about 2,700 persons per square mile, as compared to an overall urban population density of about 4,400 persons per square mile under the adopted plan.

It was considered impractical under the regional sanitary sewerage system planning program to prepare an alternative plan for providing sanitary sewage disposal to the unplanned regional land use alternative. An analysis was made, however, of the cost of providing sewer service to a selected subarea of the Region utilizing the unplanned alternative as a basis for the analysis. The selected subarea is located in the Town of Caledonia, Racine County. Three alternative methods of providing sewer service to the unplanned land use alternative development pattern in this area were examined: septic tank systems; provision of centralized sewer service with treatment at a series of small pre-engineered or "package" treatment plants; and provision of centralized sewer service with treatment at a single sewage treatment facility. The analysis revealed that the per capita costs of providing sewer service for the three alternatives were \$26, \$102, and \$87, respectively. The per capita cost of implementing the recommended sewerage system plan for the same study area is estimated at \$67. Since about 60 percent of the Region is covered by soils unsuited or poorly suited to septic tank utilization, it may be concluded that the provision of centralized sanitary sewer service to the urban development pattern recommended in the adopted regional land use plan is not only the most cost effective way of accommodating future urban development in the Region, but would also serve to most effectively protect the underlying and sustaining natural resource base. Even in those instances where it may be concluded that soils are suitable to support septic tank development, analyses conducted by the Commission under other planning programs reveal substantial additional costs generated by a low-density urban development pattern, particularly with respect to transportation costs. Such additional costs must of necessity temper any conclusion that widespread low-density urban development on septic tanks represents a desirable urban development pattern.

(This page intentionally left blank)

Chapter XIV

PLAN IMPLEMENTATION

INTRODUCTION

The recommended sanitary sewerage system plan for the seven-county Southeastern Wisconsin Region, as described in Chapter XII of this report, provides a design for the attainment of the specific land use, water use and quality, and sewerage system development objectives formulated under the regional sanitary sewerage system planning program and related Commission planning programs in cooperation with the local, state, and federal units and agencies of government concerned. The recommended plan, moreover, is the most cost effective design of the many alternatives considered.

The recommended regional sanitary sewerage system plan emphasizes three primary aspects of sewerage system development within the Region: 1) the delineation of rational, centralized sanitary sewer service areas as required to support existing and proposed urban land use patterns and to resolve existing and avoid potential public health hazards and aesthetic nuisances; 2) the identification of the sewage treatment and conveyance facilities required to actually extend sewer service into the delineated service areas in an orderly, efficient manner; and 3) the provision of the level of sewage treatment required to meet the established water use objectives and supporting water quality standards for the surface waters in the Region and to abate the continued pollution of these waters by both treated and untreated sewage. In addition, the plan includes recommendations directed at the abatement of surface water pollution from combined sewer overflows; the abatement of excessive clear water inflows to sanitary sewerage systems; the elimination of points of sewage flow relief and attendant discharge of raw sewage to receiving surface waters; the proper operation of sewage treatment facilities, including the metering of sewage flows; the disposal of sewage sludge; and continuing efforts at stream water quality monitoring in order to assess the effects of plan implementation on long-term trends in surface water quality.

In a practical sense, however, the recommended regional sanitary sewerage system plan is not complete until the steps required to implement the plan—that is, to convert the plan into action policies and programs—are specified. This chapter is, therefore, intended to constitute a guide for use in the implementation of the regional sanitary sewerage system plan. Basically, it outlines the actions which must be taken by the various levels and agencies of government concerned if the recommended regional sanitary sewerage system plan is to be fully carried out over the 20-year plan implementation period. Those units and agencies of government which have plan adoption and plan implementation powers applicable to the regional sanitary sewerage system plan are identified; necessary or desirable formal plan adoption actions specified; and specific implementation actions and schedules presented with respect to each major element of the regional sanitary sewerage system plan and directed at each of the units and agencies of government concerned. In addition, financial and technical assistance programs available to such units and agencies of government in the implementation of the regional sanitary sewerage system plan are discussed.

The plan implementation recommendations contained in this chapter are, to the maximum extent possible, based upon and related to the existing governmental structure and programs and are predicated upon existing enabling legislation. Because of the ever present possibility of unforeseen changes in economic conditions, state and federal legislation, case law decisions, governmental organization, and tax and fiscal policies, it is not possible to declare once and for all time exactly how a process as complex as regional sanitary sewerage system plan implementation should be administered and financed. In the continuing regional planning program for southeastern Wisconsin, it will be necessary, therefore, to periodically update not only the elements included within the regional sanitary sewerage system plan, together with the data and forecasts on which these plan elements are based, but also the recommendations contained herein for plan implementation.

BASIC CONCEPTS AND PRINCIPLES

It is important to recognize that plan implementation measures must not only grow out of formally adopted plans, but must also be based upon a full understanding of the objectives underlying the recommendations contained in those plans. Thus, action policies and programs must not only be preceded by formal plan adoption, and following such adoption, should not only be consistent with the adopted plans, but should also emphasize implementation of the most important and essential elements of the plan and those areas of action which will have the greatest impact on guiding and shaping development in accordance with the objectives underlying the plan. Of particular importance in this respect is an understanding of the relationships that exist between the regional sanitary sewerage system plan and the land use objectives expressed in the adopted regional land use plan, and the water use objectives and supporting water quality standards expressed not only in the regional sanitary sewerage system plan but in the related Commission watershed plans.

Fundamental to implementation of the regional sanitary sewerage system plan is an understanding of the underlying regional land use plan upon which the sewerage system plan is based. To the extent that urban land use development in the Region proceeds in accordance with the regional land use plan, implementation of the regional sanitary sewerage system plan will provide the necessary sewer service. The specific placement of future urban development in both time and space within the broad, general framework of the adopted regional land use plan, however, is the important responsibility of the local units of government comprising the Region. In order to provide latitude for the proper exercise of this local responsibility in light of local needs, desires, and preferences, as well as areawide needs, a certain amount of flexibility has been incorporated into both the regional land use plan and into the designated sanitary sewer service areas. Thus, in some cases, new urban development or redevelopment may in some areas vary somewhat in type and density from that generally proposed, while in other areas new development may be placed beyond the limits of the general service areas shown on the recommended plan map and still meet the adopted land use and sanitary sewerage system development objectives, provided that overall urban development densities fall within the three broad density categories proposed in the land use plan and that new urban development is located in time and space so that it can be readily and economically served by the rational outward extension of existing gravity drainage sanitary sewerage facilities.

While the regional land use plan provides the fundamental basis for the determination of areas to which centralized sanitary sewer service should be provided, the established water use objectives and supporting water quality standards provide the essential basis for the specification of performance standards for sewage treatment. In this respect it is important in plan implementation to distinguish between the recommended performance standards set forth in the plan and the specific types and levels of treatment which may be utilized to achieve these standards. For example, in order to achieve consistency in the necessary economic and engineering analyses in the preparation of the plan, it was assumed that all new and replacement sewage treatment facilities would be either of the activated sludge type or of the waste stabilization lagoon type. During the preliminary engineering phase of plan implementation, other types of sewage treatment should be considered and may, in some applications, be found to constitute a better approach to the actual design of a particular individual sewage treatment plant. Technological alternatives range from other types of sewage treatment, such as physical-chemical plants, to other methods of waste disposal, such as spray irrigation. The particular type of treatment or disposal which is ultimately selected for construction and operation at a given location is not important to plan implementation; the specific performance standard of that plant is, however, of central importance.

The relationship of the regional sanitary sewerage system plan to other types and levels of planning is another important factor which must be understood for proper plan implementation. As discussed in Chapter VII of this report, federal legislation envisions the use of basically three levels, or types, of plans at the state and local levels of government for assuring that established water use objectives are met in the most cost effective manner. At the most general level are the basin plans, which are essentially water quality management plans designed to assess existing water quality conditions over the entire natural drainage basins; to determine the relative magnitude of the existing and probable future water pollution sources, including both point and nonpoint sources; and to recommend means by which pollution from such sources may be abated and established water use objectives attained. Although more comprehensive in scope, the Commission's watershed plans correspond to these basin plans.

At the most detailed level of planning are the facilities plans, directly related to the construction of specific sewage treatment facilities and sewerage systems. Such plans are designed to determine the specific waste treatment technology to be applied in order to effectively implement the basin plans at a given location within a basin. Such plans must also recommend the means to be applied in reducing excessive clear water infiltration and inflow, as well as the means to be used for sludge reduction, handling, and recycling or disposal. The preparation of these plans is primarily the responsibility of the implementing agencies.

The third type of plan, the regional or metropolitan water quality management plan, is essentially a bridge between the basin plan and the facilities plan, and is required only in areas of major urban and industrial concentrations such as southeastern Wisconsin. These areawide water quality management plans are intended to be urban development-oriented and are to recommend the specific sewerage facilities necessary to permit sound urban development within a metropolitan area governed by a multiplicity of jurisdictions. As such, the areawide plans should contain recommendations relating to intermunicipal connection, as well as general sewer service areas and anticipated sewage flows. While more detailed than a basin plan, the areawide plan is not as detailed as a facilities plan, particularly with respect to the specific waste treatment technologies to be applied at a given treatment plant location. The regional sanitary sewerage system plan presented in this report is intended to constitute the areawide water quality management plan for the seven-county Southeastern Wisconsin Region. Thus, as envisioned by the Commission, the adopted watershed plans should meet the requirements of the basin plans, with particular emphasis upon the attainment of water use objectives and standards, and the abatement of nonpoint as well as point sources of pollution; while the regional sanitary sewerage system plan should meet the requirements of the areawide water quality management plan, with particular emphasis on sanitary sewer service areas and on the location and capacity of conveyance as well as treatment facilities. The preparation of the detailed facilities plans is envisioned as the responsibility of the local unit of government and represents an extension of, and expansion upon, the preliminary and final engineering studies that have historically been conducted at the local level. It is anticipated that the watershed and regional sanitary sewerage system plans, taken together, will provide important inputs to the facilities plans that must be prepared at the local level. It is through these local planning efforts that the adopted areawide plan elements will be carried into greater depth and detail for sound implementation. More specifically, detailed preliminary engineering plans will be needed with respect to the recommended treatment plants, trunk sewers, and combined sewer overflow abatement projects. In some cases, detailed preliminary engineering plans must be prepared to abate excessive infiltration and inflow, as well as for the ultimate elimination of all points of sewage flow relief. The preparation of such preliminary engineering plans and accompanying detailed engineering studies will require the development of continuing, close working relationships between the Commission, the local and areawide units and agencies of government concerned, and key state and federal agencies, in particular the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency.

In this respect it will be highly desirable, although not absolutely essential, to achieve the highest degree of plan implementation through fulfillment of the Commission's function as a center for coordination of local, areawide, state, and federal planning and plan implementation activities within the Region. The Commission's work program includes the continuing provision of assistance to the local units of government, particularly in terms of extending the data and recommendations contained in the plans and integrating the local plans with the areawide plans, and adjusting the details of the former to the broader framework of the latter. In addition, the Commission serves as a clearinghouse for all applications for federal grants-in-aid, including the construction of sewerage facilities. Pursuant to long-standing Commission policy, all comments and recommendations on such applications relate the proposed project to the comprehensive planning program for the Region, and in particular the extent to which a particular project contributes to the fulfillment of plans produced under such programs.

Indeed, federal legislation requires that all federally aided sewerage facility projects be in conformance with duly prepared, adopted, and approved basin and areawide water quality management plans.

Finally, it is extremely important that all public officials and interested citizens recognize that failure by a local unit of government to implement any one element of the recommended areawide plan may adversely affect many other units and agencies of government and detract from the ability of the entire Region, or large parts of the Region, to serve as a pleasant, safe, and healthful place in which to live. With particular respect to water quality, it will do little good for one municipality to fully implement the plan and thus contribute to achieving the water use objectives if another municipality fails to take appropriate steps to similarly implement the plan. It is essential, too, that the state and federal implementing agencies recognize, particularly when funds are apportioned and priorities established, the needs of the Southeastern Wisconsin Region in terms of water quality management, for the Region is that part of the State of Wisconsin wherein reside the largest concentration of people, where the degree of water quality degradation has often been the greatest, and where existing demands on water use are the highest.

PLAN IMPLEMENTATION ORGANIZATIONS

Although the Regional Planning Commission can promote and encourage plan implementation in various ways, the completely advisory role of the Commission makes actual implementation of the recommended regional sanitary sewerage system plan entirely dependent upon action by certain local, areawide, state, and federal agencies of government. These agencies include general-purpose local units of government, such as cities and villages; special-purpose districts, such as metropolitan sewerage districts; state agencies, such as the Wisconsin Department of Natural Resources; and federal agencies, such as the U. S. Environmental Protection Agency. Because of the many and varied agencies in existence, it becomes exceedingly important to identify those agencies having the legal authority and financial capability to most effectively implement the recommended plan elements. Accordingly, those agencies whose action will have a significant effect either directly or indirectly upon the successful implementation of the recommended regional sanitary sewerage system plan and whose full cooperation in plan implementation will be essential are listed and discussed below. The agencies are, for convenience, discussed by level of government; however, the interdependence between the various levels, as well as between agencies, of government, and the need for close intergovernmental cooperation cannot be overemphasized. Most of the agencies needed for implementation of the recommended regional sanitary sewerage system plan are already in existence within the Region. In some cases, however, it may be considered desirable to create new agencies; in such cases the creation of the new agencies should be in such form as to complement and supplement most effectively the plan implementation activities of the agencies already in existence.

Technical Coordinating and Advisory Committee

Since planning at its best is a continuing function, a public body should remain on the scene to coordinate and advise on the execution of the regional sanitary sewerage system plan and should undertake plan updating and renovation as necessitated by changing events. Although the Regional Planning Commission is charged by state statute with and will perform this continuing areawide planning function under a continuing environmental engineering planning program, it cannot properly do so without the active participation and support of local governmental officials through an appropriate advisory committee structure. It is, therefore, recommended that the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning be reconstituted as a continuing intergovernmental advisory committee to provide a focus for the coordination of the actions of all levels of government in the execution of the regional sanitary sewerage system plan. The Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning would thus continue to be a creature of the Southeastern Wisconsin Regional Planning Commission pursuant to Section 66.945(7) of the Wisconsin Statutes and would report directly to the Commission. It is recommended that all agency representatives and individuals currently serving on the Committee remain as members of the continuing Committee, and that the question of Committee membership be left open so that additional members could be added to the Committee as appropriate. It is anticipated that the primary focus of the Committee will appropriately be upon the technical aspects of plan implementation, particularly with respect to the extension of sewer service into rational service areas; with respect to the recommended performance standards for individual sewage treatment facilities, as those standards relate to attainment of the water use objectives and supporting water quality standards; and with respect to the design criteria utilized in preparation of the plan, as such criteria may from time to time be reflected in detailed planning and engineering studies throughout the Region. It is further anticipated that this Committee may from time to time be faced with considerations relating to provision of interim sewerage facilities as part of larger questions relating to staging of implementation of the recommended plan.

Local Level Agencies

As discussed in detail in Chapter VII in this report, there are several different local level agencies which, under the provisions of the Wisconsin Statutes, may become involved in the provision of centralized sanitary sewer service. These local level agencies are cities, villages, towns, sanitary districts, and utility districts.

Cities: In addition to its general grant of home rule power, cities have specific authority under Section 62.18 of the Wisconsin Statutes to provide for sewer service and to construct, operate, and maintain a sanitary sewerage system. Cities are allowed to establish within the city limits special sewerage districts and levy special sewerage district taxes therein for improvements. Twenty-seven of the 28 cities in the Region currently exercise this authority and provide centralized sanitary sewer service.

Villages: By direct reference in Section 61.39 of the Wisconsin Statutes, villages are given identical powers to cities with respect to establishing, operating, and maintaining sanitary sewerage systems and special sewerage districts. Forty-two of the 53 villages in the Region currently exercise this authority and provide centralized sanitary sewer service.

Towns: Towns generally do not have specific authority to provide for sanitary sewerage systems except through the establishment of special town sanitary or utility districts. Under Section 60.29(19) of the Wisconsin Statutes, however, town boards may, upon petition, build and construct sewers and assess benefited property. In addition, under Section 60.29(30) of the Wisconsin Statutes, town boards may provide municipal improvements—presumably including sanitary sewer service—in any properly designated unincorporated village in the town. In general, town boards in the Region have chosen to form sanitary and utility districts to provide for centralized sanitary sewer service to urban portions of towns.

Sanitary Districts: Town sanitary districts may be created under Section 60.30 of the Wisconsin Statutes to plan, construct, and maintain centralized sanitary sewerage systems. Nine of 27 existing town sanitary districts in the Region currently provide centralized sanitary sewer service.

Utility Districts: Section 66.072 of the Wisconsin Statutes permits towns, villages, and cities of the third and fourth class to establish utility districts for a number of functions, including the provision of centralized sanitary sewer service. Utility districts within the Region have been formed primarily within towns. Eleven of 14 existing town utility districts currently provide centralized sanitary sewer service. In addition, the Village of Elm Grove is divided into two separate utility districts for sanitary sewer purposes.

Areawide Level Agencies

Except as noted below, statutory provisions exist for the creation of the following areawide agencies which may have specific planning and plan implementation powers important to implementation of the regional sanitary sewerage system plan. These agencies include counties, the Milwaukee-Metropolitan Sewerage District, other metropolitan sewerage districts, joint sewerage commissions, cooperative contract commissions, comprehensive river basin districts, and the Regional Planning Commission itself.

Counties: There are only three methods by which county units of government in Wisconsin may provide sanitary sewer service, other than providing service to county-owned institutions. Two of these three methods involve county participation in metropolitan sewerage districts and are discussed below. The third method is set forth in Section 59.03 of the Wisconsin Statutes and is a limited grant of home rule power to the county board of any county with a population of 250,000 or more. While initially directed at Milwaukee County, this statute has potential application within the Southeastern Wisconsin Region by the design year of the plan in both Racine and Waukesha Counties. Under this statute the county board may provide many municipal services, including sanitary sewer service, and may carry out these powers in districts which it may create for such a purpose. Such powers may be exercised by the county board, however, only upon request of the towns, cities, and villages which may desire to have the county board act in such a manner.

Milwaukee-Metropolitan Sewerage District: The Milwaukee-Metropolitan Sewerage District of the County of Milwaukee operates under the provisions of Section 59.96 of the Wisconsin Statutes and through the joint agency of the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee. The sanitary sewerage system operated by the District, by its constituent municipalities, and by its contract municipalities constitutes by far the largest and most significant sanitary sewerage system in the Region. The financing and organizational details of the Milwaukee-Metropolitan Sewerage District have been discussed in detail in Chapters V and VII in this report, respectively, and will not be repeated here. Because the system operated by and under the control of the District serves a great majority of the Region's population, it may be expected that the District will play an extremely important role in the implementation of the recommended regional sanitary sewerage system plan.

Other Metropolitan Sewerage Districts: Section 66.20 to 66.26 of the Wisconsin Statutes provide for the creation of metropolitan sewerage districts outside of Milwaukee County. Proceedings to create such a district may be initiated by a resolution by the governing body of any municipality. Upon receipt of such a resolution, the Department of Natural Resources is required to schedule a public hearing on the matter and, based upon statutory criteria, either order or deny the creation of the proposed district. Such districts are to be governed by five-member commissions appointed by the county board of supervisors. One such metropolitan sewerage district has been created in the Region, but under legislation which preceded the current legislation. This district is the Western Racine County Sewerage District serving the Villages of Rochester and Waterford and a portion of the Town of Rochester. The areawide nature of many of the recommended sanitary sewerage systems in the Region lends itself to the formation of potential additional metropolitan sewerage districts.

Joint Sewerage Commissions: Section 144.07 of the Wisconsin Statutes provides authority for a group of governmental units to construct and operate a joint sewerage system following hearing and approval by the Wisconsin Department of Natural Resources. Under this statute the jointly acting governmental units may create an areawide sewerage system and may choose to provide for a sewerage commission to conduct the affairs of the system in much the same manner as a metropolitan sewerage commission is created to carry out areawide sewerage functions under a metropolitan sewerage district. The key difference between a joint sewerage system and a metropolitan sewerage district is that under a joint sewerage system all of the governing bodies of the local units of government which initially formed the system must annually approve budgets and appropriations, whereas in the case of a metropolitan sewerage district a special unit of government with its own taxing and appropriations powers is created. To date no such joint sewerage commissions have been created in the Southeastern Wisconsin Region.

Cooperative Contract Commissions: Section 66.30 of the Wisconsin Statutes permits the joint exercise by municipalities of any power or duty required of, or authorized to, such municipalities by statute. Hence, local units of government with equivalent powers may contract on a cooperative basis to provide jointly what each unit of government can provide individually. The exercise of this cooperative power may or may not include the formation of a separate commission to conduct the municipal activities. This power has significant potential for use in the Southeastern Wisconsin Region with respect to implementation of the regional sanitary sewerage system plan. Three formal cooperative contract commissions have been created to date in the Region for purposes of constructing areawide sewerage facilities, including the Underwood Sewerage Commission jointly created by contract between the City of Brookfield and the Village of Elm Grove, the Menomonee South Sewerage Commission jointly created by contract between the City of Brookfield and the Village of Menomonee Falls, and the Delafield-Hartland Water Pollution Control Commission jointly formed by contract between the City of Delafield and the Village of Hartland. In addition to the foregoing formal cooperative contract commissions, there are numerous intergovernmental contracts within the Region that provide for the conveyance and treatment of sewage by one municipality for sewage generated in another municipality.

Comprehensive River Basin Districts: One possibility for areawide water quality management plan implementation is the creation of a special comprehensive river basin district embracing an entire watershed and capable of raising revenues through taxation and bonding, as well as constructing and operating any necessary water quality management facilities. Many attempts to create such special river basin districts have been made, usually including proposals for broad powers beyond water quality management to include land acquisition, park and open space development, and flood control functions. Such legislation has not to date been adopted, and thus this form of special-purpose areawide district is not presently available as a means of dealing with the regional sanitary sewerage system plan implementation problem.[1]

Regional Planning Commission: Although not a plan implementation agency itself, one other areawide agency—the Regional Planning Commission—warrants comment. As noted, the Commission has no statutory plan implementation powers. In its role as a coordinating agency for planning and development activities within the Southeastern Wisconsin Region, however, the Commission may, through community assistance planning services and through the review of federal and state grants-in-aid using adopted plan elements as a basis for this review, promote plan implementation. In addition, the Commission provides a basis for the creation and continued functioning of the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning, which Committee, as noted above, is recommended to remain as an important continuing public planning organization in the Region.

State Level Agencies

There exists at the state level the following agencies that either have general or specific planning authority and certain plan implementation powers important to the adoption and implementation of the regional sanitary sewerage system plan.

Wisconsin Department of Natural Resources: As discussed in detail in Chapter VII of this report, the responsibility for water pollution control in Wisconsin is centered in the Department of Natural Resources. The basic authority and accompanying responsibilities relating to the water pollution control function of the Department are set forth in Chapter 144 of the Wisconsin Statutes. Under this chapter the Department is given broad authority to prepare water quality management plans; to establish water use objectives and supporting water quality standards; to issue general and specific orders relating to water pollution abatement; to review and approve all plans and specifications for components of sanitary sewerage systems; to conduct research and demonstration projects on sewerage and waste treatment matters; to operate an examining program for the certification of sewage treatment plant operators; to order the installation of centralized sanitary sewerage systems; to review and approve the creation of joint sewerage systems and metropolitan sewerage districts; and to administer a financial assistance program for the construction of pollution prevention and abatement facilities. In addition, under recent legislation[2] the Department is given broad authority to establish and carry out a pollution discharge elimination program in accordance with the policy guidelines set forth by the U. S. Congress under the Federal Water Pollution Control Act Amendments of 1972. This recent legislation establishes a new waste discharge permit system and provides that no permit may be issued by the Department for any discharge from a point source of pollution which is in conflict with any areawide waste treatment management plan approved by the Department. Also under this new legislation, the Department is given rule-making authority to establish effluent limitations, water quality related limitations, performance standards related to classes or categories of pollution, and toxic and pretreatment effluent standards. All permits issued by the Department must include conditions that waste discharges will meet, as applicable; and all effluent limitations, performance standards, effluent prohibitions, pretreatment standards, and any other limitations needed to meet the established water use objectives and supporting water quality standards as developed under areawide waste treatment management planning programs. As

---

[1] *Assembly Bill 351 (1973) introduced into the Wisconsin Legislature on February 6, 1973, represents the latest attempt to create enabling legislation authorizing comprehensive river basin authorities.*

[2] *Chapter 74 Wisconsin Laws of 1973. This law created Chapter 147 of the Wisconsin Statutes.*

appropriate, the permits may include a timetable for appropriate action on the part of the owner or operator of any point waste discharge. It is anticipated that this new legislation and accompanying procedures will become the primary enforcement tool of the Wisconsin Department of Natural Resources in achieving the established water use objectives and supporting water quality standards and in, therefore, implementing the regional sanitary sewerage system plan.

Although not feasible under current legislation and state constitutional constraints, it is conceivable that the state itself could assume responsibility for the construction, operation, and maintenance of areawide sewage treatment facilities and major intercommunity trunk sewer systems. Such authority would constitute an important departure from historical practice and tradition in Wisconsin, but would be very similar in concept to the state's role in the transportation field where the Wisconsin Department of Transportation, operating through the State Highway Commission since the early part of this century, has designed, constructed, and maintained those trunk highways essential to provide for intercommunity movement of people and goods.

Wisconsin Department of Health and Social Services, Division of Health: In performing its functions relating to the maintenance and promotion of public health, the Wisconsin Division of Health is charged with the responsibility of regulating the installation and operation of private septic tank sewage disposal systems. The Division reviews plats of all land subdivisions not served by public sanitary sewerage systems and may object to such plats if onsite sanitary waste disposal facilities are not properly provided for in the plat layout.

Wisconsin Department of Local Affairs and Development: This Department has limited authority to review subdivision plats; to review proposed municipal incorporations, consolidations, and annexations; and to provide technical assistance to local units of government in planning and planning-related matters.

Wisconsin Department of Administration: This Department performs many state level planning functions, including the integration of functional plans prepared by state agencies, and serves as the state clearinghouse under U. S. Office of Management and Budget (OMB) Circular A-95 with respect to all applications for federal grants and related approvals as set forth in OMB Circular No. A-95.

Federal Level Agencies

There exist at the federal level the following agencies which administer federal programs that can have important effects upon implementation of the recommended regional sanitary sewerage system plan.

U. S. Environmental Protection Agency: As discussed in detail in Chapter VII of this report, the U. S. Environmental Protection Agency has broad powers under the Federal Water Pollution Control Act, as amended, to administer federal grants-in-aid for the construction of publicly owned waste treatment works and related sewerage facilities; to promote and fund areawide waste treatment planning and management; to set and enforce water quality standards, including effluent limitations, the establishment of water use objectives and supporting water quality standards, and the conduct of water quality inventories and inspection and monitoring programs; and to establish a national pollutant discharge elimination system. The Environmental Protection Agency thus acts as the key federal water pollution control agency and must approve all basin and areawide waste treatment management plans as certified to it by appropriate state agencies.

U. S. Department of Housing and Urban Development: This agency administers a grant program related to development of local sewerage facilities and also must certify the adequacy of comprehensive areawide planning in metropolitan areas, pursuant to federal legislation. Maintenance of the certificate of planning adequacy for an urban area is essential for maintaining the eligibility of local units of government to receive federal grants-in-aid for sewerage purposes, not only under the grant program administered by the Department of Housing and Urban Development but also the more significant grant program administered by the U. S. Environmental Protection Agency.

U. S. Department of the Interior, Geological Survey: This agency conducts continuing programs with respect to water resources appraisal and monitoring. The programs of the U. S. Geological Survey are particularly important to carrying out continuing stream gauging efforts which provide a necessary input to the low streamflow analyses so essential to the design of the regional sanitary sewerage system plan.

U. S. Department of Agriculture, Farmers Home Administration: This agency administers programs providing for waste disposal construction grants and loans in rural areas. Such grants can be important to implementation of the regional sanitary sewerage system plan, particularly with respect to provision of centralized sanitary sewer service to small villages and lake-oriented communities in the more rural reaches of the Region.

U. S. Department of the Army, Corps of Engineers: While the Federal Water Pollution Control Act Amendments of 1972 transferred all federal water quality authority to the U. S. Environmental Protection Agency, including the waste discharge permit authority under the Federal Refuse Disposal Act of 1899, the Army Corps of Engineers continues to review all permits for waste outfalls discharging to navigable waters. The scope of the Corps of Engineers review is one relating to the interference of such outfalls with anchorage and navigation in and on navigable waters. The Corps of Engineers also has authority under Section 208 of the Federal Water Pollution Control Act, as amended, to consult with and provide technical assistance to states and areawide planning agencies in the development of areawide waste treatment management plans for urban areas.

PLAN ADOPTION AND INTEGRATION

Upon adoption of the regional sanitary sewerage system plan by formal resolution of the Southeastern Wisconsin Regional Planning Commission, in accordance with Section 66.945(10) of the Wisconsin Statutes, the Commission will transmit a certified copy of the resolution adopting the plan, together with a copy of the plan itself, to all local legislative bodies within the Southeastern Wisconsin Region and to all of the aforesaid existing local, areawide, state, and federal agencies that have potential plan implementation functions.

Adoption, endorsement, or formal acknowledgement of the regional sanitary sewerage system plan by the local legislative bodies and the existing local, areawide, state, and federal level agencies concerned is highly desirable to assure a common understanding between the several governmental levels and to enable their staffs to program the necessary plan implementation work, and is, in some cases, required by the Wisconsin Statutes before certain planning actions can proceed, as in the case of city, village, and town plan commissions created pursuant to Section 66.23 of the Wisconsin Statutes. In addition, formal plan adoption may also be required for state and federal financial aid eligibility. It is extremely important to understand that adoption of the recommended regional sanitary sewerage system plan by any unit or agency of government pertains only to the statutory duties and functions of the adopting agencies, and such adoption does not and cannot in any way preempt or commit action by another unit or agency of government acting within its own area of functional and geographic jurisdiction.

Upon adoption or endorsement of the regional sanitary sewerage system plan by a unit or agency of government, it is recommended that the policy-making body of the unit or agency direct its staff to review in detail the elements of the plan. Once such review is completed, the staff can propose to the policy-making body for its consideration and approval the steps necessary to fully integrate the regional sanitary sewerage system plan elements into the plans and programs of the unit or agency of government.

Local Level Agencies

1. It is recommended that the governing bodies of all cities, villages, and towns within the Region formally adopt the regional sanitary sewerage system plan by resolution pursuant to Section 66.945(12) of the Wisconsin Statutes after a report and recommendation by appropriate committees and local plan commissions.

2. It is recommended that the governing bodies of all town sanitary and utility districts in the Region formally adopt the regional sanitary sewerage system plan by resolution pursuant to Section 66.945(12) of the Wisconsin Statutes and inform their respective town boards of such action.

3. It is recommended that the plan commissions of all cities, villages, and towns in the Region formally adopt the regional sanitary sewerage system plan, as it affects them, by resolution pursuant to Section 66.945(12) and 62.23(3)(b) of the Wisconsin Statutes and certify such adoption to their respective governing body.

Areawide Level Agencies

1. It is recommended that the Milwaukee County Board of Supervisors formally adopt the regional sanitary sewerage system plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes, after review and recommendation by the County Park Commission and the County Planning Commission.

2. It is recommended that the Kenosha, Ozaukee, and Racine County Boards of Supervisors formally adopt the regional sanitary sewerage system plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes, after review and recommendation by their respective county planning and zoning committees.

3. It is recommended that the Walworth, Washington, and Waukesha County Boards of Supervisors formally adopt the regional sanitary sewerage system plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes, after review and recommendation by their respective county park and planning commissions.

4. It is recommended that the Metropolitan Sewerage Commission of the County of Milwaukee and the Sewerage Commission of the City of Milwaukee, acting jointly on behalf of the Metropolitan Sewerage District of the County of Milwaukee, adopt the recommended regional sanitary sewerage system plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes, and inform its constituent and contract municipalities of such action.

5. It is recommended that the Western Racine County Sewerage Commission and any other metropolitan sewerage commission which may be created in the future adopt the recommended regional sanitary sewerage system plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes, and inform their constituent municipalities of such action.

6. It is recommended that the Underwood Sewer Commission, the Menomonee South Sewerage Commission, the Delafield-Hartland Water Pollution Control Commission, and any other joint sewerage commission or cooperative contract commission formed for sewerage purposes in the future formally adopt the recommended regional sanitary sewerage system plan by resolution, pursuant to Section 66.945(12) of the Wisconsin Statutes, and inform their respective creating governing bodies of such action.

State Level Agencies

1. It is recommended that the Wisconsin Natural Resources Board endorse the recommended regional sanitary sewerage system plan, certify the plan as the official areawide water quality management plan for the seven-county Southeastern Wisconsin Region to the U. S. Environmental Protection Agency, and direct its staff in the Wisconsin Department of Natural Resources to integrate the recommended sewerage system plan elements into its broad range of water pollution control agency responsibilities, as well as to assist in coordinating plan implementation activities over the next 20 years.

2. It is recommended that the Wisconsin Board of Health and Social Services endorse the recommended regional sanitary sewerage system plan and direct its staff in the Wisconsin Division of Health to utilize the plan recommendations as appropriate in the exercise of its septic tank regulation and subdivision plat review and approval powers authorized under the Wisconsin Statutes.

3. It is recommended that the Wisconsin Department of Local Affairs and Development endorse the recommended regional sanitary sewerage system plan and integrate the plan into its activities with respect to the provision of technical assistance to local units of government, with respect to reviewing subdivision plats, and with respect to administering any appropriate state and federal grant-in-aid programs.

4. It is recommended that the Wisconsin Department of Administration endorse the recommended regional sanitary sewerage system plan and utilize the plan recom-

mendations as appropriate in the exercise of its state planning and state A-95 Clearinghouse functions.

Federal Level Agencies

1. It is recommended that the U. S. Environmental Protection Agency formally accept and endorse the recommended regional sanitary sewerage system plan upon State of Wisconsin certification and utilize the plan recommendations in its broad range of agency responsibilities relating to water quality management.

2. It is recommended that the U. S. Department of Housing and Urban Development formally acknowledge the recommended regional sanitary sewerage system plan and utilize the plan recommendations as appropriate in the administration of its broad range of grant and loan programs and in its areawide planning certification process.

3. It is recommended that the U. S. Department of the Interior, Geological Survey, formally acknowledge the recommended regional sanitary sewerage system plan and continue, in cooperation with the various agencies concerned, its entire water resources investigation program.

4. It is recommended that the U. S. Department of Agriculture, Farmers Home Administration, formally acknowledge the recommended regional sanitary sewerage system plan and utilize the plan recommendations in its administration and granting of loans and grants-in-aid for rural waste disposal facilities.

5. It is recommended that the U. S. Department of the Army, Corps of Engineers, formally acknowledge the recommended regional sanitary sewerage system plan and utilize the plan recommendations in carrying out its responsibilities relating to the issuance of permits for waste outfalls in navigable waters.

SUBSEQUENT ADJUSTMENT OF THE PLAN

No plan can be permanent in all of its aspects or precise in all of its elements. The very definition and characteristics of areawide planning suggest that an areawide plan, such as the regional sanitary sewerage system plan, to be viable and of use to local, areawide, state, and federal units and agencies of government, be continually adjusted through formal amendments, extensions, additions, and refinements to reflect changing conditions. The Wisconsin Legislature clearly foresaw this when it gave the regional planning commissions the power to "...amend, extend, or add to the master plan or carry any part or subject matter into greater detail..." in Section 66.945(9) of the Wisconsin Statutes.

Amendments, extensions, and additions to the regional sanitary sewerage system plan will be forthcoming not only from the work of the Commission under the continuing regional planning programs but also from local and areawide agencies as they prepare more detailed facilities plans; from state agencies as they adjust and refine statewide plans; and from federal agencies as national policies are established or modified, as new programs are created, or as existing programs are expanded or curtailed. Areawide adjustments may also come from subsequent regional or state planning programs, which may include additional comprehensive or special-purpose planning efforts such as the preparation of additional watershed and basin plans.

All of these adjustments or refinements will require the utmost cooperation by the local, areawide, state, and federal agencies of government, as well as coordination by the Southeastern Wisconsin Regional Planning Commission, which has been empowered under Section 66.945(8) of the Wisconsin Statutes to act as a coordinating agency for programs and activities of the local units of government. To achieve this coordination between the local, state, and federal programs most effectively and efficiently and, therefore, to assure the timely adjustments of the regional sanitary sewerage system plan, it is recommended that all of the aforesaid local, areawide, state, and federal agencies having various plan and plan implementation powers advise and transmit all subsequent planning studies, plan proposals and amendments, and plan implementation devices to the Southeastern Wisconsin Regional Planning Commission for consideration as to integration into, and adjustment of, the recommended regional sanitary sewerage system plan. Of particular importance in this respect will be the continuing role of the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning in intergovernmental coordination, and the role of the Regional Planning Commission itself under the review authority set forth in the U. S. Office of Management and Budget Circular A-95.

IMPLEMENTATION SCHEDULES—SEWAGE TREATMENT PLANTS, TRUNK SEWERS, AND ABATEMENT OF COMBINED SEWER OVERFLOWS

In order to provide a point of departure for intergovernmental discussions and negotiations involving the development of necessary areawide sanitary sewerage systems, and to further provide a basis for tentative federal and state agency programming, including the issuance of waste discharge permits and the disposition of grant-in-aid monies, a series of implementation schedules relating to the facility recommendations contained in the recommended regional sanitary sewerage system plan were prepared, one schedule for each subregional area as those areas were identified in Chapter XI of this report. These schedules include proposed dates for the implementation of each individual plan element, including those relating to sewage treatment plant construction, trunk sewer extensions, and abatement of combined sewer overflows. While these schedules contain specific dates for the completion of each individual recommended plan component, it should be recognized that the actual timing of implementation may be expected to vary somewhat from the schedule depending upon the rate of urban growth and development in various subareas of the Region and upon the availability of sufficient federal and state grant-in-aid monies.

It is accordingly recommended that each named unit or agency of government in the implementation schedules utilize the timetable provided in the schedule in the programming of facility construction. It is further recommended that the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency, after careful review, utilize the timetable set forth in the implementation schedule in preparing schedules of compliance for each owner and operator of a waste source seeking a waste discharge permit under Chapter 74 of the Wisconsin Laws of 1973 and the Federal Water Pollution Control Act Amendments of 1972. The essential elements of each implementation schedule are summarized by subregional area in the following discussion.

Milwaukee-Metropolitan Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Milwaukee-metropolitan subregional area is set forth in Table 248. With respect to sewage treatment plants, the schedule recommends that the Milwaukee-Metropolitan Sewerage Commissions complete the addition of secondary and advanced waste treatment facilities at the South Shore sewage treatment plant by 1974. No additional major sewage treatment plant facility improvements, other than for maintenance purposes and for the abatement of pollution from combined sewer overflows, are anticipated to be required in this subregional area by 1990

The proposed time schedule for completion of the long-range metropolitan district trunk, relief, and intercepting sewer construction program is shown in Table 248 and on Map 132. The metropolitan district trunk sewers have been broken down into segments and identified by the letters A through V. Local intercommunity trunk sewers needed to fully implement the plan recommendations are also included in Table 248 and on Map 132. Based upon this implementation schedule, it is anticipated that abandonment of existing public sewage treatment plants will occur as follows: Menomonee Falls Pilgrim Road plant and Lilly Road plant—1977; New Berlin Greenridge plant—1977; Caddy Vista Sanitary District plant—1977; Hales Corners plant—1978; New Berlin Regal Manors plant—1978; Muskego Northeast District plant and Big Muskego Lake plant—1980; Germantown Old Village plant—1980; Thiensville plant—1984; and Franklin Rawson Homes plant—1985. The foregoing schedule of sewage treatment plant abandonment reflects the phased construction of trunk sewers in the manner set forth in the implementation schedule. This proposed timetable was based upon considerations related to several factors, including anticipated availability of federal grants-in-aid during the 1974-1976 period; previous construction schedules as prepared by the Milwaukee-Metropolitan Sewerage Commissions; contract commitments; and the provision of relief trunk sewer capacity to resolve pressing existing water pollution problems and public health hazards. Given increased availability of federal funds and a willingness to provide necessary local matching funds, there is no reason why this schedule could not be advanced.[3]

[3] *See also the discussion set forth in Chapter XII, p. 691, under the heading "Other Concerns Expressed at Hearings."*

Table 248

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE MILWAUKEE-METROPOLITAN SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]	Combined Sewer Overflow Abatement Plan Element
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment			
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection		
Milwaukee-Metropolitan Sewerage District and Constituent Municipalities; Cities of Brookfield, Mequon, Muskego, and New Berlin; Villages of Butler, Elm Grove, Germantown, Menomonee Falls, and Thiensville; Town of Raymond; and Caddy Vista Sanitary District (Expanded Plants)	South Shore-1974	Not Applicable	Jones Island--Already Provided South Shore--1974	Not Applicable	Already Provided	Metropolitan District Trunk Sewers (By segment--see Map 132) A-1973[3] B-1975 C-1977 D-1977 (Abandon Menomonee Falls STPs) E-1978 (Abandon Hales Corners STP) F-1979 G-1979 H-1980 I-1980 J-1980 K-1982 L-1982 M-1983 N-1983 O-1983 P-1984 Q-1985 (Abandon Franklin-Rawson Homes STP) R-1985 S-1987 T-1990 U-1989 V-1990 Local Trunk Sewers (By Segment--See Map 132) Menomonee Falls--1971 Greenfield-New Berlin--1977 (Abandon New Berlin-Greenridge STP) Caddy Vista--1977 (Abandon Caddy Vista STP) New Berlin--1978 (Abandon New Berlin-Regal Manors STP) Brookfield-Menomonee Falls--1978 Muskego--1980 (Abandon Muskego STPs) Germantown--1980 (Abandon Germantown STP) Thiensville-Mequon--1984 (Abandon Thiensville STP)	Complete Preliminary Engineering Study for Abatement of Combined Sewer Overflows as Recommended in Milwaukee River Watershed Plan--1977 Implement Recommendations Coming Out of Preliminary Engineering Study--by 1990
City of South Milwaukee (Expanded Plant)	Already Provided	Not Applicable	Already Provided	Not Applicable	Already Provided	Not Applicable	Not Applicable

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1] *Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.*

[2] *See Map 131.*

[3] *This sewer completed in 1973.*

With respect to the abatement of combined sewer overflows in the Milwaukee urbanized area, the proposed implementation schedule recommends that the preliminary engineering study for the abatement of combined sewer overflows, as outlined in a Prospectus published by the Regional Planning Commission for and on behalf of the joint Sewerage Commissions, be mounted as rapidly as possible and completed during 1977. The implementation schedule also tentatively calls for complete implementation of the recommendations to be forthcoming from the preliminary engineering study by 1990.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Milwaukee-metropolitan subregional area is set forth in Table 249. It is important to recognize that this cost schedule is directly

Table 249

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE MILWAUKEE-METROPOLITAN SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

Calendar Year	Project Year	Sewage Treatment Plant Plan Element							
		Milwaukee Metropolitan Sewerage Commissions-- Jones Island Plant		Milwaukee Metropolitan Sewerage Commissions-- South Shore Plant		South Milwaukee		Subtotal	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 4,000,000	$ 10,000,000	$ 2,500,000	$ --	$ 100,000	$ 10,000,000	$ 6,600,000
1972	2	--	4,000,000	10,000,000	2,500,000	1,938,000	203,000	11,938,000	6,703,000
1973	3	--	4,000,000	6,865,000	2,500,000	--	203,000	6,865,000	6,703,000
1974	4	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1975	5	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1976	6	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1977	7	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1978	8	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1979	9	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1980	10	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1981	11	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1982	12	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1983	13	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1984	14	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1985	15	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1986	16	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1987	17	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1988	18	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1989	19	--	4,000,000	--	2,500,000	--	203,000	--	6,703,000
1990	20	2,632,500	4,000,000	--	2,500,000	--	203,000	2,632,500	6,703,000
Total		$ 2,632,500	$80,000,000	$ 26,865,000	$50,000,000	$ 1,938,000	$ 3,957,000	$ 31,435,500	$133,957,000
Annual Average		$ 131,625	$ 4,000,000	$ 1,343,250	$ 2,500,000	$ 96,900	$ 197,850	$ 1,571,775	$ 6,697,850

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element							
		Milwaukee Metropolitan Sewerage District		Caddy Vista		Muskego		New Berlin	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --
1972	2	--	--	--	--	--	--	--	--
1973	3	11,430,700	750	--	--	--	--	--	--
1974	4	--	750	--	--	--	--	--	--
1975	5	3,307,500	1,400	--	--	--	--	--	--
1976	6	--	1,400	151,200	--	--	--	--	--
1977	7	12,209,400	2,400	--	1,800	--	--	--	--
1978	8	4,617,000	2,900	--	1,800	--	--	749,700	--
1979	9	26,126,800	5,700	--	1,800	--	--	--	500
1980	10	18,454,500	8,200	--	1,800	1,466,000	--	--	500
1981	11	--	8,200	--	1,800	--	700	--	500
1982	12	8,316,000	9,700	--	1,800	--	700	--	500
1983	13	14,225,300	11,000	--	1,800	--	700	--	500
1984	14	1,159,100	11,500	--	1,800	--	700	--	500
1985	15	8,242,600	12,200	--	1,800	--	700	--	500
1986	16	--	12,200	--	1,800	--	700	--	500
1987	17	3,499,200	13,000	--	1,800	--	700	--	500
1988	18	--	13,000	--	1,800	--	700	--	500
1989	19	2,060,600	14,000	--	1,800	--	700	--	500
1990	20	12,752,600	15,000	--	1,800	--	700	--	500
Total		$126,401,300	$ 143,300	$ 151,200	$ 25,200	$ 1,466,000	$ 7,000	$ 749,700	$ 6,000
Annual Average		$ 6,320,065	$ 7,165	$ 7,560	$ 1,260	$ 73,300	$ 350	$ 37,485	$ 300

related to the proposed implementation schedule set forth in Table 248. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 249.

Upper Milwaukee River Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Upper Milwaukee River subregional area is set forth in Table 250. With respect to sewage treatment plants, the plan recommends that the Village of Jackson complete construction of its new sewage treatment facility during 1977. All other sewage treatment facilities are recommended to be expanded or constructed as may be required from time to time by 1990 to meet grow-

Table 249 (continued)

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Greenfield-New Berlin: Facility Construction	Greenfield-New Berlin: Operation and Maintenance	Brookfield-Menomonee Falls: Facility Construction	Brookfield-Menomonee Falls: Operation and Maintenance	Menomonee Falls: Facility Construction	Menomonee Falls: Operation and Maintenance	Germantown: Facility Construction	Germantown: Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ 522,000	$ 200	$ --	$ --
1972	2	--	--	--	--	--	200	--	--
1973	3	--	--	--	--	--	200	--	--
1974	4	--	--	--	--	--	200	--	--
1975	5	--	--	--	--	--	200	--	--
1976	6	--	--	--	--	--	200	--	--
1977	7	507,200	--	--	--	--	200	--	--
1978	8	--	400	480,600	--	--	200	--	--
1979	9	--	400	--	300	--	200	--	--
1980	10	--	400	--	300	--	200	1,067,900	--
1981	11	--	400	--	300	--	200	--	55,700
1982	12	--	400	--	300	--	200	--	55,700
1983	13	--	400	--	300	--	200	--	55,700
1984	14	--	400	--	300	--	200	--	55,700
1985	15	--	400	--	300	--	200	--	55,700
1986	16	--	400	--	300	--	200	--	55,700
1987	17	--	400	--	300	--	200	--	55,700
1988	18	--	400	--	300	--	200	--	55,700
1989	19	--	400	--	300	--	200	--	55,700
1990	20	--	400	--	300	--	200	--	55,700
Total		$ 507,200	$ 5,200	$ 480,600	$ 3,600	$ 522,000	$ 4,000	$ 1,067,900	$ 557,000
Annual Average		$ 25,360	$ 260	$ 24,030	$ 180	$ 26,100	$ 200	$ 53,395	$ 27,850

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Thiensville-Mequon: Facility Construction	Thiensville-Mequon: Operation and Maintenance	Subtotal: Facility Construction	Subtotal: Operation and Maintenance	Combined Sewer Overflow Abatement Plan Element: Facility Construction	Combined Sewer Overflow Abatement Plan Element: Operation and Maintenance	Subregional Area Total: Facility Construction	Subregional Area Total: Operation and Maintenance
1971	1	$ --	$ --	$ 522,000	$ 200	$ --	$ --	$ 10,522,000	$ 6,600,200
1972	2	--	--	--	200	--	--	11,938,000	6,703,200
1973	3	--	--	11,430,700	950	--	--	18,295,700	6,703,950
1974	4	--	--	--	950	766,700	--	766,700	6,703,950
1975	5	--	--	3,307,500	1,600	766,700	--	4,074,200	6,704,600
1976	6	--	--	151,200	1,600	766,700	--	917,800	6,704,600
1977	7	--	--	12,716,600	4,400	9,105,000	--	21,821,600	6,707,400
1978	8	--	--	5,847,300	5,300	9,300,000	1,600,000	15,147,300	8,308,300
1979	9	--	--	26,126,800	8,900	9,300,000	1,600,000	35,426,800	8,311,900
1980	10	--	--	20,988,400	11,400	9,300,000	1,600,000	30,288,400	8,314,400
1981	11	--	--	--	67,800	9,300,000	1,600,000	9,300,000	8,370,800
1982	12	--	--	8,316,000	69,300	9,300,000	1,600,000	17,616,000	8,372,300
1983	13	--	--	14,225,300	70,600	9,300,000	1,600,000	23,525,300	8,373,600
1984	14	558,400	--	1,717,500	71,100	9,300,000	1,600,000	11,017,500	8,374,100
1985	15	--	4,400	8,242,600	76,200	9,300,000	1,600,000	17,542,600	8,379,200
1986	16	--	4,400	--	76,200	9,300,000	1,600,000	9,300,000	8,379,200
1987	17	--	4,400	3,499,200	77,000	9,300,000	1,600,000	12,799,200	8,380,000
1988	18	--	4,400	--	77,000	9,300,000	1,600,000	9,300,000	8,380,000
1989	19	--	4,400	2,060,600	78,000	9,300,000	1,600,000	11,360,600	8,381,000
1990	20	--	4,400	12,752,600	79,000	9,300,000	1,600,000	24,685,100	8,382,000
Total		$ 558,400	$ 26,400	$131,904,300	$ 777,700	$132,305,000	$20,800,000	$295,644,800	$155,534,700
Annual Average		$ 27,920	$ 1,320	$ 6,595,215	$ 38,885	$ 6,615,250	$ 1,040,000	$ 14,782,240	$ 7,776,735

Source: SEWRPC.

ing demands. With respect to trunk sewers, the implementation schedule recommends that the trunk sewer to serve the Village of Jackson and convey wastes from the old treatment plant site to the new treatment plant site be constructed during 1977, that trunk sewer service be extended in the manner recommended in the plan from the City of West Bend to the Tri-Lakes urban area southwest of the city by 1985, and that the recommended outfall sewer from the City of Cedarburg sewage treatment facility to the Milwaukee River be completed by 1983.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Upper Milwaukee River subregional area is set forth in Table 251. It is important

Table 250

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE UPPER MILWAUKEE RIVER SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment		
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection	
Village of Kewaskum (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Already Provided	Not Applicable	Already Provided	Not Applicable
City of West Bend and Big Cedar Lake, Little Cedar Lake, Silver Lake, and Wallace Lake Sanitary District (Expanded Plant)	Expansion as Required by 1990	By 1983	Already Provided	Not Applicable	Already Provided	Tri-Lakes--by 1985
Village of Jackson (Relocated Plant)	Relocation by 1977 and Expansion as Required by 1990	By 1983	By 1977	Not Applicable	By 1977	Old STP site to new STP site--by 1977
Newburg Sanitary District (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Not Applicable	Not Applicable	Already Provided	Not Applicable
Village of Fredonia (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Not Applicable	Not Applicable	Already Provided	Not Applicable
Village of Grafton (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Already Provided	Not Applicable	Already Provided	Not Applicable
City of Cedarburg (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Already Provided	Not Applicable	Already Provided	Outfall sewer to Milwaukee River--by 1983
Village of Saukville (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Already Provided	Not Applicable	Already Provided	Not Applicable

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1] *Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.*

[2] *See Map 131.*

to recognize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 250. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 251.

Sauk Creek Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Sauk Creek subregional area is set forth in Table 252. With respect to sewage treatment plants, the schedule recommends that the City of Port Washington provide additional treatment capacity as may be required from time to time by 1990, and that the Village of Belgium provide additional treatment capacity to serve the Lake Church area in the Town of Belgium by 1977, with additional capacity to be provided as may be required from time to time by 1990. With respect to trunk sewers, the schedule recommends that the proposed Lake Church trunk sewer be completed during 1977.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Sauk Creek subregional area is set forth in Table 253. It is important to recognize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 252. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 253.

Table 251

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE UPPER MILWAUKEE RIVER SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

Calendar Year	Project Year	Sewage Treatment Plant Plan Element									
		Kewaskum		West Bend		Jackson		Newburg		Fredonia	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ 953,500	$ 16,600	$ --	$ 92,000	$ --	$ 10,000	$ --	$ 7,900	$ --	$ 8,000
1972	2	--	45,000	--	92,000	--	10,000	--	7,900	--	8,000
1973	3	100,000	55,500	--	92,000	--	10,000	--	7,900	--	8,000
1974	4	--	55,500	--	92,000	--	10,000	--	7,900	--	8,000
1975	5	--	55,500	--	92,000	--	10,000	--	7,900	--	8,000
1976	6	--	55,500	--	100,000	--	10,000	--	7,900	--	8,000
1977	7	--	55,500	1,000,000	100,000	500,000	10,000	--	7,900	157,100	8,000
1978	8	--	55,500	1,000,000	200,000	338,100	50,000	--	7,900	--	21,200
1979	9	--	55,500	647,400	300,000	--	76,700	--	7,900	--	21,200
1980	10	--	55,500	--	350,000	--	76,700	--	7,900	--	21,200
1981	11	--	55,500	--	407,300	--	76,700	--	7,900	--	21,200
1982	12	--	55,500	--	407,300	--	76,700	--	7,900	--	21,200
1983	13	--	55,500	--	407,300	--	76,700	--	7,900	--	21,200
1984	14	--	55,500	--	407,300	--	76,700	--	7,900	--	21,200
1985	15	--	55,500	--	407,300	--	76,700	107,400	7,900	--	21,200
1986	16	--	55,500	--	407,300	--	76,700	--	14,500	--	21,200
1987	17	--	55,500	--	407,300	--	76,700	--	14,500	--	21,200
1988	18	--	55,500	--	407,300	--	76,700	--	14,500	--	21,200
1989	19	--	55,500	--	407,300	--	76,700	--	14,500	--	21,200
1990	20	--	55,500	--	407,300	--	76,700	--	14,500	--	21,200
Total		$1,053,500	$1,060,600	$2,647,400	$5,583,000	$838,100	$1,040,400	$107,400	$191,000	$157,100	$331,600
Annual Average		$ 52,030	$ 53,030	$ 132,370	$ 279,150	$ 41,905	$ 52,020	$ 5,370	$ 9,550	$ 7,855	$ 16,580

Calendar Year	Project Year	Sewage Treatment Plant Plan Element							
		Grafton		Cedarburg		Saukville		Subtotal	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 40,000	$ --	$ 37,500	$ --	$ 17,000	$ 953,500	$ 229,000
1972	2	--	40,000	916,800	37,500	--	17,000	916,800	257,400
1973	3	--	40,000	--	172,800	--	17,000	100,000	403,200
1974	4	--	40,000	--	172,800	--	17,000	--	403,200
1975	5	--	40,000	--	172,800	187,600	17,000	187,600	403,200
1976	6	--	40,000	--	172,800	--	33,700	--	427,900
1977	7	--	40,000	--	172,800	--	33,700	1,657,100	427,900
1978	8	--	40,000	--	172,800	--	33,700	1,338,100	581,100
1979	9	--	40,000	--	172,800	--	33,700	647,400	707,800
1980	10	670,800	40,000	261,100	172,800	--	33,700	931,900	757,800
1981	11	--	92,200	--	173,300	--	33,700	--	867,800
1982	12	--	92,200	--	173,300	--	33,700	--	867,800
1983	13	--	92,200	--	173,300	--	33,700	--	867,800
1984	14	--	92,200	--	173,300	--	33,700	--	867,800
1985	15	--	92,200	--	173,300	--	33,700	107,400	867,800
1986	16	--	92,200	--	173,300	--	33,700	--	874,400
1987	17	--	92,200	--	173,300	--	33,700	--	874,400
1988	18	--	92,200	--	173,300	--	33,700	--	874,400
1989	19	--	92,200	--	173,300	--	33,700	--	874,400
1990	20	--	92,200	--	173,300	--	33,700	--	874,400
Total		$670,800	$1,322,000	$1,177,900	$3,190,400	$187,600	$590,500	$6,839,800	$13,309,500
Annual Average		$ 33,540	$ 66,100	$ 58,895	$ 159,520	$ 9,380	$ 29,525	$ 341,990	$ 665,475

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element						Subregional Area Total	
		Jackson		Tri-Lakes-West Bend		Subtotal			
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation• and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ 953,500	$ 229,000
1972	2	--	--	--	--	--	--	916,800	257,400
1973	3	--	--	--	--	--	--	100,000	403,200
1974	4	--	--	--	--	--	--	--	403,200
1975	5	--	--	--	--	--	--	187,600	403,200
1976	6	--	--	--	--	--	--	--	427,900
1977	7	91,800	--	--	--	91,800	--	1,748,900	427,900
1978	8	--	100	--	--	--	100	1,338,100	581,200
1979	9	--	100	--	--	--	100	647,400	707,900
1980	10	--	100	--	--	--	100	931,900	757,900
1981	11	--	100	--	--	--	100	--	867,900
1982	12	--	100	--	--	--	100	--	867,900
1983	13	--	100	--	--	--	100	--	867,900
1984	14	--	100	--	--	--	100	--	867,900
1985	15	--	100	1,046,000	--	1,046,000	100	1,153,400	867,900
1986	16	--	100	--	11,000	--	11,100	--	885,500
1987	17	--	100	--	11,000	--	11,100	--	885,500
1988	18	--	100	--	11,000	--	11,100	--	885,500
1989	19	--	100	--	11,000	--	11,100	--	885,500
1990	20	--	100	--	11,000	--	11,100	--	885,500
Total		$91,800	$1,300	$1,046,000	$55,000	$1,137,800	$56,300	$7,977,600	$13,365,800
Annual Average		$ 4,590	$ 65	$ 52,300	$ 2,750	$ 56,890	$ 2,815	$ 398,880	$ 668,290

Source: SEWRPC.

Table 252

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE SAUK CREEK SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]: Secondary Waste Treatment	Advanced Waste Treatment: Nitrification	Advanced Waste Treatment: Phosphorus Removal	Auxiliary Waste Treatment: Effluent Aeration	Auxiliary Waste Treatment: Effluent Disinfection	Trunk Sewer Plan Element[2]
City of Port Washington (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Already Provided	Not Applicable	Already Provided	Not Applicable
Village of Belgium and Town of Belgium (Expanded Plant)	Service to Lake Church by 1977 and Expansion as Required by 1990	By 1983	Not Applicable	By 1977	Already Provided	Lake Church--by 1977

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1]*Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.*

[2]*See Map 131.*

Table 253

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE SAUK CREEK SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

		Sewage Treatment Plant Plan Element						Intercommunity Trunk Sewer Plan Element			
		Port Washington		Belgium		Subtotal		Lake Church-Belgium		Subregional Area Total	
Calendar Year	Project Year	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 25,000	$ --	$ 8,000	$ --	$ 33,000	$ --	$ --	$ --	$ 33,000
1972	2	100,000	35,000	--	8,000	100,000	43,000	--	--	100,000	43,000
1973	3	--	35,000	--	8,000	--	43,000	--	--	--	43,000
1974	4	--	35,000	--	8,000	--	43,000	--	--	--	43,000
1975	5	--	35,000	--	8,000	--	43,000	--	--	--	43,000
1976	6	--	35,000	1,298,000	8,000	1,298,000	43,000	--	--	1,298,000	43,000
1977	7	--	35,000	--	37,200	--	72,200	287,800	--	287,800	72,200
1978	8	811,000	35,000	--	37,200	811,000	72,200	--	7,800	811,000	80,000
1979	9	908,000	115,800	--	37,200	908,000	153,000	--	7,800	908,000	160,800
1980	10	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1981	11	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1982	12	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1983	13	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1984	14	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1985	15	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1986	16	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1987	17	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1988	18	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1989	19	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
1990	20	--	125,800	--	37,200	--	163,000	--	7,800	--	170,800
Total		$1,819,000	$1,769,600	$1,298,000	$568,800	$3,117,000	$2,338,400	$287,800	$101,400	$3,404,800	$2,439,800
Annual Average		$ 90,950	$ 88,480	$ 64,900	$ 28,440	$ 155,850	$ 116,920	$ 14,390	$ 5,070	$ 170,240	$ 121,990

Source: SEWRPC.

Kenosha-Racine Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Kenosha-Racine subregional area is set forth in Table 254. With respect to sewage treatment plants, the schedule recommends that the Cities of Kenosha and Racine provide additional treatment capacity as may be required from time to time by 1990. In addition the schedule recommends that the North Park Sanitary

Table 254

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE KENOSHA-RACINE SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]	Combined Sewer Overflow Abatement Plan Element
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment			
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection		
City of Racine; Villages of Elmwood Park, Sturtevant, and North Bay; Town of Mt. Pleasant Sewer Utility District; Town of Caledonia Sewer Utility District No. 1; Crestview Sanitary District; and North Park Sanitary District (Expanded Plant)	Expansion as Required by 1990 Interim Expansion of North Park STP by 1977	Not Applicable	Already Provided	Not Applicable	Already Provided	Sturtevant-Mt. Pleasant-Sanders Park (Abandon Sturtevant STP)--by 1976 Caledonia and Portions of Caledonia and Crestview-North Park--by 1980 Remaining Portion of Caledonia and Crestview-North Park (Abandon North Park STP) --by 1990 Caledonia (Improvements)--As Required by 1990 Crestview-North Park (Improvements)--As Required by 1990	Conclude Research and Demonstration Study and Determine Most Cost Effective Solution to Problem--by 1975 Implement Most Cost Effective Solution--by 1977
City of Kenosha; Town of Pleasant Prairie Sewer Utility District Nos. 1 and 2 and A, B, and C; Town of Somers Sanitary Districts Nos. 1 and 2; and Pleasant Park Utility Company, Inc. (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Already Provided	Not Applicable	Already Provided	Portions of Somers and Parkside--by 1978 Remaining Portion of Somers and Parkside (Abandon Somers STP)--by 1980 Carol Beach (Abandon Pleasant Park STP)--by 1980	Conclude Research and Demonstration Study and Determine Most Cost Effective Solution to Problem--by 1974 Implement Most Cost Effective Solution--by 1977

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1]Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.

[2]See Map 131.

District undertake an interim expansion program at its treatment facility to be completed during 1977. With respect to trunk sewers in the Racine portion of the subregional area, the schedule recommends that the Sturtevant-Mt. Pleasant-Sanders Park trunk sewer be constructed during 1976, thus permitting abandonment of the Sturtevant sewage treatment plant; that the Caledonia trunk sewer and the initial portion of the Caledonia-Crestview-North Park trunk sewer be constructed by 1980; and that the remaining portion of the Caledonia-Crestview-North Park trunk sewer be constructed by 1990, thus permitting abandonment of the North Park sewage treatment facility. In addition, the schedule recommends that the planned improvements to existing sewers in Caledonia and Crestview-North Park be undertaken as may be required from time to time by 1990. With respect to the Kenosha portion of the subregional area, the schedule recommends construction of the initial phase of the Somers-Parkside trunk sewer by 1978; construction of the remaining portion of the Somers-Parkside trunk sewer by 1980, thus permitting abandonment of the Somers sewage treatment facility; and construction of the Carol Beach trunk sewer by 1980, thus permitting the abandonment of the Pleasant Park sewage treatment facility.

With respect to the abatement of combined sewer overflows in the Kenosha urbanized area, the proposed implementation schedule recommends that the current research and demonstration study be concluded and a determination made of the most cost effective solution to the combined sewer overflow problem during 1974, with complete implementation of the most cost effective solution to be completed during 1977. Similarly, in the Racine urbanized area, the proposed implementation schedule recommends that the current research and demonstration study and a determination of the most cost effective solution to the combined sewer overflow problem in that area be completed in 1975, with implementation of the most cost effective solution to be completed during 1977.

A schedule of the construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Kenosha-Racine subregional area is set forth in Table 255. It is important to recognize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 254. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 255.

Table 255

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE KENOSHA-RACINE SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

Calendar Year	Project Year	Sewage Treatment Plant Plan Element: Racine: Facility Construction	Racine: Operation and Maintenance	Kenosha: Facility Construction	Kenosha: Operation and Maintenance	Subtotal: Facility Construction	Subtotal: Operation and Maintenance	Intercommunity Trunk Sewer Plan Element: Caledonia (Improvements): Facility Construction	Caledonia (Improvements): Operation and Maintenance
1971	1	$ 400,000	$ 800,000	$ 340,000	$ 600,000	$ 740,000	$ 1,400,000	$ --	$ --
1972	2	--	800,000	--	600,000	--	1,400,000	--	--
1973	3	--	800,000	--	600,000	--	1,400,000	--	--
1974	4	--	800,000	--	600,000	--	1,400,000	--	--
1975	5	4,000,000	800,000	--	600,000	4,000,000	1,400,000	--	--
1976	6	--	1,000,000	--	600,000	--	1,600,000	--	--
1977	7	4,000,000	1,200,000	4,000,000	600,000	8,000,000	1,800,000	--	--
1978	8	--	1,200,000	--	--	--	1,200,000	--	--
1979	9	--	1,200,000	--	1,112,000	--	2,312,000	--	--
1980	10	4,175,000	1,200,000	--	1,112,000	4,175,000	2,312,000	965,000	--
1981	11	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1982	12	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1983	13	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1984	14	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1985	15	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1986	16	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1987	17	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1988	18	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1989	19	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
1990	20	--	1,435,000	--	1,112,000	--	2,547,000	--	37,700
Total		$12,575,000	$24,150,000	$ 4,340,000	$17,544,000	$16,915,000	$41,694,000	$ 965,000	$ 377,000
Annual Average		$ 628,750	$ 1,207,500	$ 217,000	$ 877,200	$ 845,750	$ 2,084,700	$ 48,250	$ 18,850

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Crestview-North Park (Improvements): Facility Construction	Crestview-North Park (Improvements): Operation and Maintenance	Caledonia (New): Facility Construction	Caledonia (New): Operation and Maintenance	Caledonia and Crestview-North Park-Racine (New): Facility Construction	Caledonia and Crestview-North Park-Racine (New): Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --
1972	2	--	--	--	--	--	--
1973	3	--	--	--	--	--	--
1974	4	--	--	--	--	--	--
1975	5	--	--	--	--	--	--
1976	6	--	--	--	--	--	--
1977	7	--	--	--	--	--	--
1978	8	--	--	--	--	--	--
1979	9	--	--	--	--	1,500,000	--
1980	10	747,000	--	983,000	--	1,500,000	4,000
1981	11	--	30,000	--	9,000	--	8,000
1982	12	--	30,000	--	9,000	--	8,000
1983	13	--	30,000	--	9,000	--	8,000
1984	14	--	30,000	--	9,000	--	8,000
1985	15	--	30,000	--	9,000	--	8,000
1986	16	--	30,000	--	9,000	--	8,000
1987	17	--	30,000	--	9,000	--	8,000
1988	18	--	30,000	--	9,000	--	8,000
1989	19	--	30,000	--	9,000	1,000,000	8,000
1990	20	--	30,000	--	9,000	1,104,000	11,000
Total		$ 747,000	$ 300,000	$ 983,000	$ 90,000	$ 5,104,000	$ 87,000
Annual Average		$ 37,350	$ 15,000	$ 49,150	$ 4,500	$ 255,200	$ 4,350

Table 255 (continued)

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Carol Beach-Kenosha: Facility Construction	Operation and Maintenance	Sturtevant-Mt. Pleasant and Sanders Park-Racine: Facility Construction	Operation and Maintenance	Somers and Parkside-Kenosha: Facility Construction	Operation and Maintenance	Subtotal: Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --
1972	2	--	--	--	--	--	--	--	--
1973	3	--	--	--	--	--	--	--	--
1974	4	--	--	--	--	--	--	--	--
1975	5	--	--	2,500,000	--	3,000,000	--	5,500,000	--
1976	6	--	--	2,131,000	--	2,000,000	--	4,131,000	--
1977	7	--	--	--	--	2,649,000	--	2,649,000	--
1978	8	--	--	--	13,000	--	13,700	--	26,700
1979	9	--	--	--	13,000	--	13,700	1,500,000	26,700
1980	10	729,000	--	--	13,000	--	13,700	4,924,000	30,700
1981	11	--	700	--	13,000	--	13,700	--	112,100
1982	12	--	700	--	13,000	--	13,700	--	112,100
1983	13	--	700	--	13,000	--	13,700	--	112,100
1984	14	--	700	--	13,000	--	13,700	--	112,100
1985	15	--	700	--	13,000	--	13,700	--	112,100
1986	16	--	700	--	13,000	--	13,700	--	112,100
1987	17	--	700	--	13,000	--	13,700	--	112,100
1988	18	--	700	--	13,000	--	13,700	--	112,100
1989	19	--	700	--	13,000	--	13,700	1,000,000	112,100
1990	20	--	700	--	13,000	--	13,700	1,104,000	115,100
Total		$ 729,000	$ 7,000	$ 4,631,000	$ 169,000	$ 7,649,000	$ 178,100	$20,808,000	$ 1,208,100
Annual Average		$ 36,450	$ 350	$ 231,550	$ 8,450	$ 382,450	$ 8,905	$ 1,040,400	$ 60,405

Calendar Year	Project Year	Abatement of Combined Sewer Overflow Plan Element: Racine: Facility Construction	Operation and Maintenance	Kenosha: Facility Construction	Operation and Maintenance	Subtotal: Facility Construction	Operation and Maintenance	Subregional Area Total: Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ 740,000	$ 1,400,000
1972	2	--	--	--	--	--	--	--	1,400,000
1973	3	--	--	--	--	--	--	--	1,400,000
1974	4	--	--	5,478,400	--	5,478,400	--	5,478,400	1,400,000
1975	5	9,130,600	--	5,478,400	--	14,609,000	--	24,109,000	1,400,000
1976	6	9,130,700	--	5,478,400	--	14,609,100	--	18,740,100	1,600,000
1977	7	9,130,700	--	5,478,400	--	14,609,100	--	25,258,100	1,800,000
1978	8	--	--	--	--	--	--	--	1,226,700
1979	9	--	--	--	--	--	--	1,500,000	2,338,700
1980	10	--	--	--	--	--	--	9,099,000	2,342,700
1981	11	--	--	--	--	--	--	--	2,659,100
1982	12	--	--	--	--	--	--	--	2,659,100
1983	13	--	--	--	--	--	--	--	2,659,100
1984	14	--	--	--	--	--	--	--	2,659,100
1985	15	--	--	--	--	--	--	--	2,659,100
1986	16	--	--	--	--	--	--	--	2,659,100
1987	17	--	--	--	--	--	--	--	2,659,100
1988	18	--	--	--	--	--	--	--	2,659,100
1989	19	--	--	--	--	--	--	1,000,000	2,659,100
1990	20	--	--	--	--	--	--	1,104,000	2,662,100
Total		$27,392,000	$ --	$21,913,600	$ --	$49,305,600	$ --	$87,028,600	$42,902,100
Annual Average		$ 1,369,600	$ --	$ 1,095,680	$ --	$ 2,465,280	$ --	$ 4,351,430	$ 2,145,105

Source: SEWRPC.

Root River Canal Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Root River Canal subregional area is set forth in Table 256. The schedule recommends that the Village of Union Grove complete construction of a new sewage treatment facility, including a new trunk sewer from the old treatment plant site to the new treatment plant site, by 1976. In addition the schedule recommends that the proposed functional integration of the Wisconsin Southern Colony and the new Union Grove sewage treatment facility be completed through the construction of a new trunk sewer from the Southern Colony Institution to the new Union Grove treatment plant site by 1983.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Root River Canal subregional area is set forth in Table 257. It is important to recog-

Table 256

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE ROOT RIVER CANAL SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment		
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection	
Village of Union Grove and Wisconsin Department of Health and Social Services--Southern Colony (Relocated Plant)	Relocation by 1976 and Expansion as Required by 1990	By 1983	By 1976	By 1976	By 1976	Old Union Grove STP site to new STP site--by 1976 Southern Colony (to integrate facilities for nitrification)--by 1983

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1] *Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.*

[2] *See Map 131.*

Table 257

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE ROOT RIVER CANAL SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

Calendar Year	Project Year	Sewage Treatment Plant Plan Element						Intercommunity Trunk Sewer Plan Element	
		Union Grove		Wisconsin Southern Colony		Subtotal		Wisconsin Southern Colony	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 37,500	$ --	$ --	$ --	$ 37,500	$ --	$ --
1972	2	--	37,500	--	--	--	37,500	--	--
1973	3	--	37,500	--	--	--	37,500	--	--
1974	4	--	37,500	--	--	--	37,500	--	--
1975	5	--	37,500	--	--	--	37,500	--	--
1976	6	2,112,500	37,500	--	18,100	2,112,500	55,600	87,800	--
1977	7	--	91,100	--	18,100	--	109,200	--	200
1978	8	--	91,100	--	18,100	--	109,200	--	200
1979	9	--	91,100	--	18,100	--	109,200	--	200
1980	10	--	91,100	--	18,100	--	109,200	--	200
1981	11	--	91,100	--	18,100	--	109,200	--	200
1982	12	--	91,100	--	18,100	--	109,200	--	200
1983	13	--	91,100	--	18,100	--	109,200	--	200
1984	14	--	91,100	--	18,100	--	109,200	--	200
1985	15	--	91,100	--	18,100	--	109,200	--	200
1986	16	--	91,100	--	18,100	--	109,200	--	200
1987	17	--	91,100	--	18,100	--	109,200	--	200
1988	18	--	91,100	--	18,100	--	109,200	--	200
1989	19	--	91,100	--	18,100	--	109,200	--	200
1990	20	--	91,100	--	18,100	--	109,200	--	200
Total		$2,112,500	$1,500,400	$ --	$271,500	$2,112,500	$1,771,900	$87,800	$2,800
Annual Average		$ 105,625	$ 75,020	$ --	$ 13,575	$ 105,625	$ 88,595	$ 4,390	$ 140

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element				Subregional Area Total	
		Union Grove		Subtotal			
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ 37,500
1972	2	--	--	--	--	--	37,500
1973	3	--	--	--	--	--	37,500
1974	4	--	--	--	--	--	37,500
1975	5	--	--	--	--	--	37,500
1976	6	158,000	--	245,800	--	2,358,300	55,600
1977	7	--	3,000	--	3,200	--	112,400
1978	8	--	3,000	--	3,200	--	112,400
1979	9	--	3,000	--	3,200	--	112,400
1980	10	--	3,000	--	3,200	--	112,400
1981	11	--	3,000	--	3,200	--	112,400
1982	12	--	3,000	--	3,200	--	112,400
1983	13	--	3,000	--	3,200	--	112,400
1984	14	--	3,000	--	3,200	--	112,400
1985	15	--	3,000	--	3,200	--	112,400
1986	16	--	3,000	--	3,200	--	112,400
1987	17	--	3,000	--	3,200	--	112,400
1988	18	--	3,000	--	3,200	--	112,400
1989	19	--	3,000	--	3,200	--	112,400
1990	20	--	3,000	--	3,200	--	112,400
Total		$158,000	$42,000	$245,800	$44,800	$2,358,300	$1,816,700
Annual Average		$ 7,900	$ 2,100	$ 12,290	$ 2,240	$ 117,915	$ 90,835

Source: SEWRPC.

nize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 256. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 257.

Des Plaines River Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Des Plaines River subregional area is set forth in Table 258. With respect to sewage treatment plants, the schedule recommends that all of the six recommended facilities provide treatment capacity as may be required from time to time by 1990. With respect to the single new trunk sewer recommended to serve the south area of the Town of Pleasant Prairie, the schedule recommends that such trunk sewer be provided at such time as the new sewage treatment facility is constructed.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Des Plaines River subregional area is set forth in Table 259. It is important to recognize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 258. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 259.

Upper Fox River Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Upper Fox River subregional area is set forth in Table 260. With respect to sewage treatment plants, the schedule recommends that the City of Brookfield place into operation its new sewage treatment facility in 1973 and construct such additions as may be required from time to time by 1990; that the City of Waukesha provide for expansion or relocation of its plant and such additions in capacity as may be required from time to time by 1990; and that an interim expansion of the Sussex sewage treatment plant be completed by 1975. With respect to trunk sewers, the schedule recommends that the Pewaukee trunk

Table 258

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE DES PLAINES RIVER SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment		
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection	
Town of Bristol Utility District No. 1 (Expanded Plant)	Expansion as Required by 1990	By 1983	Not Applicable	By 1977	Already Provided	Not Applicable
Town of Bristol--IH 94 Area[3] (New Plant)	New Plant as Required by 1990	Not Applicable	Not Applicable	By 1990	By 1990	Not Applicable
Town of Pleasant Prairie Sewer Utility District D (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Not Applicable	Not Applicable	Already Provided	Not Applicable
Town of Pleasant Prairie--South Area[3] (New Plant)	New Plant as Required by 1990	Not Applicable	Not Applicable	By 1990	By 1990	To new STP--by 1990
Village of Paddock Lake (Expanded Plant)	Expansion as Required by 1990	By 1983	By 1983	By 1977	Already Provided	Not Applicable
Town of Salem Sewer Utility District No. 1 (Expanded Plant)	Expansion as Required by 1990	By 1983	Not Applicable	By 1977	Already Provided	Not Applicable

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1]*Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.*

[2]*See Map 131.*

[3]*Plant should be designed to meet 1990 treatment level requirements at time of initial construction.*

Table 259

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE DES PLAINES RIVER SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

		Sewage Treatment Plant Plan Element									
		Bristol		Bristol-IH 94		Pleasant Prairie-North		Pleasant Prairie-South		Paddock Lake	
Calendar Year	Project Year	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 5,000	$ --	$ --	$ --	$ 3,400	$ --	$ --	$ --	$ 20,000
1972	2	--	5,000	--	--	--	3,400	--	--	--	20,000
1973	3	--	5,000	--	--	--	3,400	--	--	--	20,000
1974	4	--	5,000	--	--	--	3,400	--	--	--	--
1975	5	--	5,000	508,600	--	--	3,400	590,000	--	--	--
1976	6	--	5,000	--	17,500	--	3,400	--	30,000	--	30,000
1977	7	300,000	5,000	--	17,500	87,100	--	--	30,000	200,000	30,000
1978	8	301,000	15,000	--	17,500	--	3,500	--	30,000	--	30,000
1979	9	--	30,300	--	17,500	--	3,500	--	30,000	--	30,000
1980	10	--	30,300	--	17,500	--	3,500	401,100	40,000	--	30,000
1981	11	--	30,300	--	17,500	--	3,500	--	43,800	580,500	40,000
1982	12	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
1983	13	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
1984	14	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
1985	15	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
1986	16	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
1987	17	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
1988	18	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
1989	19	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
1990	20	--	30,300	--	17,500	--	3,500	--	43,800	--	58,500
Total		$601,000	$413,600	$508,600	$262,500	$87,100	$65,900	$991,100	$598,000	$780,500	$776,500
Annual Average		$ 30,050	$ 20,680	$ 25,430	$ 13,125	$ 4,355	$ 3,295	$ 49,555	$ 29,900	$ 39,025	$ 38,825

		Sewage Treatment Plant Plan Element				Intercommunity Trunk Sewer Plan Element					
		Hooker Lake		Subtotal		Pleasant Prairie-South		Subtotal		Subregional Area Total	
Calendar Year	Project Year	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 10,000	$ --	$ 38,400	$ --	$ --	$ --	$ --	$ --	$ 38,400
1972	2	--	10,000	--	38,400	--	--	--	--	--	38,400
1973	3	--	10,000	--	38,400	--	--	--	--	--	38,400
1974	4	--	10,000	--	18,400	--	--	--	--	--	18,400
1975	5	--	10,000	1,098,600	18,400	121,500	--	121,500	--	1,220,100	18,400
1976	6	--	12,000	--	97,900	--	100	--	100	--	98,000
1977	7	215,500	12,000	802,600	94,500	--	100	--	100	802,600	94,600
1978	8	--	19,400	301,000	115,400	--	100	--	100	301,000	115,500
1979	9	--	19,400	--	130,700	--	100	--	100	--	130,800
1980	10	--	19,400	401,100	140,700	--	100	--	100	401,100	140,800
1981	11	--	19,400	580,500	154,500	--	100	--	100	580,500	154,600
1982	12	--	19,400	--	173,000	--	100	--	100	--	173,100
1983	13	--	19,400	--	173,000	--	100	--	100	--	173,100
1984	14	--	19,400	--	173,000	--	100	--	100	--	173,100
1985	15	--	19,400	--	173,000	--	100	--	100	--	173,100
1986	16	--	19,400	--	173,000	--	100	--	100	--	173,100
1987	17	--	19,400	--	173,000	--	100	--	100	--	173,100
1988	18	--	19,400	--	173,000	--	100	--	100	--	173,100
1989	19	--	19,400	--	173,000	--	100	--	100	--	173,100
1990	20	--	19,400	--	173,000	--	100	--	100	--	173,100
Total		$215,500	$326,200	$3,183,800	$2,442,700	$121,500	$1,500	$121,500	$1,500	$3,305,300	$2,444,200
Annual Average		$ 10,775	$ 16,310	$ 159,190	$ 122,135	$ 6,075	$ 75	$ 6,075	$ 75	$ 165,265	$ 122,210

Source: SEWRPC.

sewer be completed by 1977, thus permitting abandonment of the Pewaukee sewage treatment facility; that the New Berlin trunk sewer be completed by 1978; that the Lannon trunk sewer be completed by 1985; and that the Sussex trunk sewer be completed by 1985, thus permitting abandonment of the Sussex sewage treatment facility. In addition the schedule recommends that Waukesha provide a trunk sewer from the old sewage treatment plant site to the new sewage treatment plant site at such time as the initial phase of a relocated plant is constructed.

Table 260

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEMPPLAN IN THE UPPER FOX RIVER SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment		
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection	
Cities of Brookfield and New Berlin; Villages of Lannon, Menomonee Falls, Pewaukee, and Sussex; Towns of Brookfield, Delafield, Lisbon, and Pewaukee; and the Lake Pewaukee Sanitary District (New Plant)	New Plant by 1973 and Expansion as Required by 1990 Interim Expansion of Sussex STP by 1975	By 1983	By 1975	Not Applicable	By 1973	Pewaukee (Abandon Pewaukee STP)--by 1977 New Berlin--by 1978 Lannon--by 1983-85 Sussex (Abandon Sussex STP)--by 1985
City of Waukesha and Towns of Pewaukee and Waukesha (Expanded or Relocated Plant)	New or Expanded Plant as Required by 1990	By 1983	By 1975	Not Applicable	Already Provided	Old STP site to new STP site--if required, by 1990

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1]*Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.*

[2]*See Map 131.*

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Upper Fox River subregional area is set forth in Table 261. It is important to recognize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 260. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 261.

Lower Fox River Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Lower Fox River subregional area is set forth in Table 262. With respect to sewage treatment plants, the schedule recommends that the Village of Mukwonago complete construction of a relocated plant by 1977; that the Town of Lyons Sanitary District No. 2, the Town of Norway Sanitary District No. 1, and the Eagle Lake Sewer Utility District each complete construction of new sewage treatment facilities during 1977; that the Town of Salem Sewer Utility District No. 2 complete construction of a new treatment facility by 1978; and that all other treatment facilities be expanded as may be required from time to time by 1990.

With respect to trunk sewers, the schedule recommends that the Mukwonago trunk sewer from the old sewage treatment plant site to the new sewage treatment plant site be completed by 1977; that the Potter Lake trunk sewer extending from the Village of East Troy to the Town of East Troy Sanitary District No. 2 be completed by 1978; that the Lake Como trunk sewer extending from the City of Lake Geneva to the unincorporated village of Lake Como in the Town of Geneva be completed by 1980; that the Geneva Lake-North and Geneva Lake-South trunk sewers from the City of Lake Geneva to the Town of Linn be completed by 1980; that the Denoon Lake trunk sewer from the Town of Norway Sanitary District No. 1 to urban development around Denoon Lake in the City of Muskego be completed by 1977; that the Tichigan Lake trunk sewer from the Western Racine County Sewerage District to the Town of Waterford Sanitary District No. 1 be completed by 1978; that the Silver Lake trunk sewer in the Village of Silver Lake to the Town of Salem Sewer Utility District No. 2 be completed by 1978; that the Camp Lake trunk sewer in the Town of Salem Sewer Utility District No. 2 be completed by 1978; that the Wilmot trunk sewer in the Town of Salem Sewer Utility District No. 2 be completed by 1979; and that the Cross-Rock Lakes trunk sewer in the Town of Salem Sewer Utility District No. 2 be completed by 1980.

Table 261

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE UPPER FOX RIVER SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

Calendar Year	Project Year	Sewage Treatment Plant Plan Element						Intercommunity Trunk Sewer Plan Element			
		Brookfield		Waukesha		Subtotal		Sussex		Pewaukee	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ 200,000	$ --	$ 200,000	$ --	$ --	$ --	$ --
1972	2	--	--	--	200,000	--	200,000	--	--	--	--
1973	3	4,000,000	--	--	200,000	4,000,000	200,000	--	--	--	--
1974	4	--	160,000	--	200,000	--	360,000	--	--	--	--
1975	5	--	160,000	--	200,000	--	360,000	--	--	629,000	--
1976	6	--	160,000	4,000,000	200,000	4,000,000	360,000	--	--	--	1,000
1977	7	4,000,000	160,000	--	360,000	4,000,000	520,000	--	--	--	1,000
1978	8	--	320,000	--	360,000	--	680,000	--	--	--	1,000
1979	9	--	320,000	--	360,000	--	680,000	--	--	--	1,000
1980	10	--	320,000	4,000,000	360,000	4,000,000	680,000	--	--	--	1,000
1981	11	6,260,500	320,000	--	520,000	6,260,500	840,000	--	--	--	1,000
1982	12	--	559,000	--	520,000	--	1,079,000	--	--	--	1,000
1983	13	--	559,000	--	520,000	--	1,079,000	--	--	--	1,000
1984	14	--	559,000	--	520,000	--	1,079,000	--	--	--	1,000
1985	15	--	559,000	5,075,300	520,000	5,075,300	1,079,000	632,000	--	--	1,000
1986	16	--	559,000	--	512,200	--	1,071,200	--	700	--	1,000
1987	17	--	559,000	--	512,200	--	1,071,200	--	700	--	1,000
1988	18	--	559,000	--	512,200	--	1,071,200	--	700	--	1,000
1989	19	--	559,000	--	512,200	--	1,071,200	--	700	--	1,000
1990	20	--	559,000	--	512,200	--	1,071,200	--	700	--	1,000
Total		$14,260,500	$6,951,000	$13,075,300	$7,801,000	$27,335,800	$14,752,000	$632,000	$3,500	$629,000	$15,000
Annual Average		$ 713,025	$ 347,550	$ 653,765	$ 390,050	$ 1,366,790	$ 737,600	$ 31,600	$ 175	$ 31,450	$ 750

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element								Subregional Area Total	
		Brookfield-Lannon		Brookfield-New Berlin		Waukesha		Subtotal			
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ 200,000
1972	2	--	--	--	--	--	--	--	--	--	200,000
1973	3	--	--	--	--	--	--	--	--	4,000,000	200,000
1974	4	--	--	--	--	--	--	--	--	--	360,000
1975	5	--	--	--	--	--	--	629,000	--	629,000	360,000
1976	6	--	--	--	--	2,080,100	--	2,080,100	1,000	6,080,100	361,000
1977	7	--	--	--	--	--	300	--	1,300	4,000,000	521,300
1978	8	--	--	--	--	--	300	--	1,300	--	681,300
1979	9	--	--	989,600	--	--	300	989,600	1,300	989,600	681,300
1980	10	--	--	--	500	--	300	--	1,800	4,000,000	681,800
1981	11	1,000,000	--	--	500	--	300	1,000,000	1,800	7,260,500	841,800
1982	12	1,000,000	--	--	500	--	300	1,000,000	1,800	1,000,000	1,080,800
1983	13	1,000,000	--	--	500	--	300	1,000,000	1,800	1,000,000	1,080,800
1984	14	739,000	1,000	--	500	--	300	739,000	2,800	739,000	1,081,800
1985	15	--	1,300	--	500	--	300	632,000	3,100	5,707,300	1,082,100
1986	16	--	1,300	--	500	--	300	--	3,800	--	1,075,000
1987	17	--	1,300	--	500	--	300	--	3,800	--	1,075,000
1988	18	--	1,300	--	500	--	300	--	3,800	--	1,075,000
1989	19	--	1,300	--	500	--	300	--	3,800	--	1,075,000
1990	20	--	1,300	--	500	--	300	--	3,800	--	1,075,000
Total		$3,739,000	$8,800	$989,600	$5,500	$2,080,100	$4,200	$8,069,700	$37,000	$35,405,500	$14,789,000
Annual Average		$ 186,950	$ 440	$ 49,480	$ 275	$ 104,005	$ 210	$ 403,485	$ 1,850	$ 1,770,275	$ 739,450

Source: SEWRPC.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Lower Fox River subregional area is set forth in Table 263. It is important to recognize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 262. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 263.

Upper Rock River Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Upper Rock River subregional area is set forth in Table 264. With respect to sewage

Table 262

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE LOWER FOX RIVER SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment		
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection	
Village of Mukwonago (Relocated Plant)	Relocation by 1977 and Expansion as Required by 1990	By 1983	By 1977	Not Applicable	By 1977	Old STP site to new STP site--by 1977
Village of East Troy and Town of East Troy Sanitary District No. 2 (Expanded Plant)	Expansion as Required by 1990	By 1983	By 1975	By 1977	By 1974	Potter Lake--by 1978
City of Lake Geneva and Towns of Geneva and Linn (Expanded Plant)	Expansion as Required by 1990	By 1983	By 1975	By 1977	By 1974	Lake Como--by 1980 Geneva Lake-North--by 1980 Geneva Lake-South--by 1980
Town of Lyons Sanitary District No. 2 (New Plant)	New Plant by 1977 and Expansion as Required by 1990	Not Applicable	Not Applicable	Not Applicable	By 1977	Not Applicable
Village of Genoa City (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Not Applicable	Not Applicable	Already Provided	Not Applicable
Town of Norway Sanitary District No. 1 (New Plant)	New Plant by 1977 and Expansion as Required by 1990	By 1983	By 1977	By 1977	By 1977	Denoon Lake--by 1977
Eagle Lake Sewer Utility District (New Plant)	New Plant by 1977 and Expansion as Required by 1990	By 1983	Not Applicable	By 1977	By 1977	Not Applicable
Western Racine County Sewerage District, Villages of Rochester and Waterford, Town of Rochester Sewer Utility District No. 1, Town of Waterford Sanitary District No. 1 (Expanded Plant)	Expansion as Required by 1990	Not Applicable	By 1975	Not Applicable	Already Provided	Tichigan Lake--by 1978
City of Burlington and Browns Lake Sanitary District (Expanded Plant)	Expansion as Required by 1990	Not Applicable	By 1975	Not Applicable	Already Provided	Not Applicable
Village of Silver Lake and Town of Salem Sewer Utility District No. 2 (Expanded Plant)	Expansion as Required by 1990	Not Applicable	By 1975	Not Applicable	Already Provided	Silver Lake--by 1978
Village of Twin Lakes (Expanded Plant)	Expansion as Required by 1990	By 1983	By 1975	By 1977	Already Provided	Not Applicable
Town of Salem Sewer Utility District No. 2 (New Plant)	New Plant by 1978 and Expansion as Required by 1990	Not Applicable	By 1978	Not Applicable	By 1978	Camp Lake--by 1978 Wilmot--by 1979 Cross-Rock Lakes--by 1980

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1] *Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.*

[2] *See Map 131.*

Table 263

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE LOWER FOX RIVER SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

		Sewage Treatment Plant Plan Element									
		Mukwonago		East Troy		Lake Geneva		Lyons		Genoa City	
Calendar Year	Project Year	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 8,000	$ --	$ 12,000	$ --	$ 45,000	$ --	$ --	$ --	$ 10,000
1972	2	--	8,000	--	12,000	--	45,000	--	--	--	10,000
1973	3	--	8,000	--	12,000	--	45,000	--	--	--	10,000
1974	4	--	8,000	15,000	12,000	2,000,000	45,000	--	--	--	10,000
1975	5	--	8,000	436,700	14,000	--	90,000	--	--	--	10,000
1976	6	--	10,000	--	30,000	--	90,000	--	--	--	10,000
1977	7	1,879,700	10,000	--	30,000	--	95,000	110,100	--	--	10,000
1978	8	--	79,800	--	30,000	--	95,000	--	3,200	--	10,000
1979	9	--	79,800	--	30,000	--	95,000	--	3,200	--	10,000
1980	10	--	79,800	--	30,000	1,143,400	95,000	--	3,200	--	10,000
1981	11	--	79,800	1,000,000	30,000	--	140,300	--	3,200	--	10,000
1982	12	--	79,800	--	61,000	--	140,300	--	3,200	185,300	10,000
1983	13	--	79,800	--	61,000	--	140,300	--	3,200	--	15,100
1984	14	--	79,800	--	61,000	--	140,300	--	3,200	--	15,100
1985	15	--	79,800	--	61,000	--	140,300	--	3,200	--	15,100
1986	16	--	79,800	--	61,000	--	140,300	--	3,200	--	15,100
1987	17	--	79,800	--	61,000	--	140,300	--	3,200	--	15,100
1988	18	--	79,800	--	61,000	--	140,300	--	3,200	--	15,100
1989	19	--	79,800	--	61,000	--	140,300	--	3,200	--	15,100
1990	20	--	79,800	--	61,000	--	140,300	--	3,200	--	15,100
Total		$1,879,700	$1,097,400	$1,451,700	$791,000	$3,143,400	$2,143,000	$110,100	$41,600	$185,300	$240,800
Annual Average		$ 93,985	$ 54,870	$ 72,585	$ 39,550	$ 157,170	$ 107,150	$ 5,505	$ 2,080	$ 9,265	$ 12,040

		Sewage Treatment Plant Plan Element									
		Wind Lake		Eagle Lake		Rochester		Burlington		Silver Lake	
Calendar Year	Project Year	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ 50,000	$ --	$ 45,000	$ --	$ 15,000
1972	2	--	--	--	--	--	50,000	--	45,000	--	15,000
1973	3	--	--	--	--	--	50,000	--	50,000	--	15,000
1974	4	--	--	--	--	--	50,000	--	50,000	--	15,000
1975	5	--	--	--	--	43,100	50,000	60,000	50,000	21,000	15,000
1976	6	1,000,000	--	--	--	--	60,000	--	70,000	--	20,000
1977	7	1,008,400	--	191,500	--	--	60,000	--	70,000	--	20,000
1978	8	--	12,000	--	4,100	--	60,000	--	70,000	--	20,000
1979	9	--	12,000	--	4,100	--	60,000	--	70,000	--	20,000
1980	10	--	12,000	--	4,100	1,165,000	60,000	--	70,000	--	20,000
1981	11	--	12,000	--	4,100	--	70,100	--	80,000	643,600	20,000
1982	12	--	12,000	--	4,100	--	70,100	--	80,000	--	35,300
1983	13	--	12,000	--	4,100	--	70,100	--	80,000	--	35,300
1984	14	--	12,000	--	4,100	--	70,100	--	80,000	--	35,300
1985	15	--	12,000	--	4,100	--	70,100	1,483,000	80,000	--	35,300
1986	16	--	12,000	--	4,100	--	70,100	--	126,400	--	35,300
1987	17	--	12,000	--	4,100	--	70,100	--	126,400	--	35,300
1988	18	--	12,000	--	4,100	--	70,100	--	126,400	--	35,300
1989	19	--	12,000	--	4,100	--	70,100	--	126,400	--	35,300
1990	20	--	12,000	--	4,100	--	70,100	--	126,400	--	35,300
Total		$2,008,400	$156,000	$191,500	$53,300	$1,208,100	$1,251,000	$1,543,000	$1,622,000	$664,600	$512,700
Annual Average		$ 100,420	$ 7,800	$ 9,575	$ 2,665	$ 60,405	$ 62,550	$ 77,150	$ 81,100	$ 33,230	$ 25,635

		Sewage Treatment Plant Plan Element						Intercommunity Trunk Sewer Plan Element	
		Twin Lakes		Camp Lake		Subtotal		Mukwonago	
Calendar Year	Project Year	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 15,000	$ --	$ --	$ --	$ 200,000	$ --	$ --
1972	2	--	15,000	--	--	--	200,000	--	--
1973	3	--	15,000	--	--	--	205,000	--	--
1974	4	--	15,000	--	--	2,015,000	205,000	--	--
1975	5	28,000	15,000	--	--	588,800	252,000	--	--
1976	6	--	17,000	--	--	1,000,000	307,000	--	--
1977	7	54,000	17,000	--	--	3,243,700	312,000	141,800	--
1978	8	--	18,000	1,295,400	--	1,295,400	402,100	--	100
1979	9	--	18,000	--	64,800	--	466,900	--	100
1980	10	661,900	18,000	--	64,800	2,970,300	466,900	--	100
1981	11	--	20,000	--	64,800	1,643,600	534,300	--	100
1982	12	--	20,000	--	64,800	185,300	580,600	--	100
1983	13	--	20,000	--	64,800	--	585,700	--	100
1984	14	--	20,000	--	64,800	--	585,700	--	100
1985	15	--	20,000	--	64,800	1,483,000	585,700	--	100
1986	16	--	20,000	--	64,800	--	632,100	--	100
1987	17	--	20,000	--	64,800	--	632,100	--	100
1988	18	--	20,000	--	64,800	--	632,100	--	100
1989	19	--	20,000	--	64,800	--	632,100	--	100
1990	20	--	20,000	--	64,800	--	632,100	--	100
Total		$743,900	$363,000	$1,295,400	$777,600	$14,425,100	$9,049,400	$141,800	$1,300
Annual Average		$ 37,195	$ 18,150	$ 64,770	$ 38,880	$ 721,255	$ 452,470	$ 7,090	$ 65

Table 263 (continued)

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Potter Lake Facility Construction	Potter Lake Operation and Maintenance	Geneva Lake-North Facility Construction	Geneva Lake-North Operation and Maintenance	Geneva Lake-South Facility Construction	Geneva Lake-South Operation and Maintenance	Lake Como Facility Construction	Lake Como Operation and Maintenance
1971	1	$ --	$ --	$ --	$ 1,100	$ --	$ --	$ --	$ --
1972	2	--	--	--	--	--	--	--	--
1973	3	--	--	--	--	--	--	--	--
1974	4	--	--	--	--	--	--	--	--
1975	5	--	--	--	--	--	--	--	--
1976	6	--	--	--	--	--	--	--	--
1977	7	--	--	--	--	--	--	--	--
1978	8	445,900	--	--	--	4,836,000	--	--	--
1979	9	--	1,100	--	--	--	17,100	587,100	--
1980	10	--	1,100	2,989,100	--	--	17,100	--	7,700
1981	11	--	1,100	--	8,000	--	17,100	--	7,700
1982	12	--	1,100	--	8,000	--	17,100	--	7,700
1983	13	--	1,100	--	8,000	--	17,100	--	7,700
1984	14	--	1,100	--	8,000	--	17,100	--	7,700
1985	15	--	1,100	--	8,000	--	17,100	--	7,700
1986	16	--	1,100	--	8,000	--	17,100	--	7,700
1987	17	--	1,100	--	8,000	--	17,100	--	7,700
1988	18	--	1,100	--	8,000	--	17,100	--	7,700
1989	19	--	1,100	--	8,000	--	17,100	--	7,700
1990	20	--	1,100	--	8,000	--	17,100	--	7,700
Total		$445,900	$13,200	$2,989,100	$81,100	$4,836,000	$205,200	$587,100	$84,700
Annual Average		$ 22,295	$ 660	$ 149,455	$ 4,055	$ 241,800	$ 10,260	$ 29,355	$ 4,235

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Denoon Lake-Wind Lake Facility Construction	Denoon Lake-Wind Lake Operation and Maintenance	Tichigan Lake Facility Construction	Tichigan Lake Operation and Maintenance	Silver Lake Facility Construction	Silver Lake Operation and Maintenance	Wilmot Facility Construction	Wilmot Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --
1972	2	--	--	--	--	--	--	--	--
1973	3	--	--	--	--	--	--	--	--
1974	4	--	--	--	--	--	--	--	--
1975	5	--	--	--	--	--	--	--	--
1976	6	--	--	1,000,000	--	--	--	--	--
1977	7	505,700	--	1,000,000	--	--	--	--	--
1978	8	--	5,500	517,300	--	202,200	--	--	--
1979	9	--	5,500	--	39,200	--	20,000,000	245,800	--
1980	10	--	5,500	--	39,200	--	20,000,000	--	7,600
1981	11	--	5,500	--	39,200	--	20,000,000	--	7,600
1982	12	--	5,500	--	39,200	--	20,000,000	--	7,600
1983	13	--	5,500	--	39,200	--	20,000,000	--	7,600
1984	14	--	5,500	--	39,200	--	20,000,000	--	7,600
1985	15	--	5,500	--	39,200	--	20,000,000	--	7,600
1986	16	--	5,500	--	39,200	--	20,000,000	--	7,600
1987	17	--	5,500	--	39,200	--	20,000,000	--	7,600
1988	18	--	5,500	--	39,200	--	20,000,000	--	7,600
1989	19	--	5,500	--	39,200	--	20,000,000	--	7,600
1990	20	--	5,500	--	39,200	--	20,000,000	--	7,600
Total		$505,700	$71,500	$2,517,300	$470,400	$202,200	$240,000,000	$245,800	$83,600
Annual Average		$ 25,285	$ 3,575	$ 125,865	$ 23,520	$ 10,110	$ 12,000,000	$ 12,290	$ 4,180

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Cross-Rock Lakes Facility Construction	Cross-Rock Lakes Operation and Maintenance	Camp Lake Facility Construction	Camp Lake Operation and Maintenance	Subtotal Facility Construction	Subtotal Operation and Maintenance	Subregional Area Total Facility Construction	Subregional Area Total Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ 1,100	$ --	$ 201,100
1972	2	--	--	--	--	--	--	--	200,000
1973	3	--	--	--	--	--	--	--	205,000
1974	4	--	--	--	--	--	--	2,015,000	205,000
1975	5	--	--	--	--	--	--	588,800	252,000
1976	6	--	--	--	--	1,000,000	--	2,000,000	307,000
1977	7	--	--	--	--	1,647,500	--	4,891,200	312,000
1978	8	--	--	393,900	--	6,395,300	5,600	7,690,700	407,700
1979	9	--	--	--	400	832,900	20,063,400	832,900	20,530,300
1980	10	436,300	--	--	400	3,425,400	20,078,700	6,395,700	20,545,600
1981	11	--	13,300	--	400	--	20,100,000	1,643,600	20,634,300
1982	12	--	13,300	--	400	--	20,100,000	185,300	20,680,600
1983	13	--	13,300	--	400	--	20,100,000	--	20,685,700
1984	14	--	13,300	--	400	--	20,100,000	--	20,685,700
1985	15	--	13,300	--	400	--	20,100,000	1,483,000	20,685,700
1986	16	--	13,300	--	400	--	20,100,000	--	20,732,100
1987	17	--	13,300	--	400	--	20,100,000	--	20,732,100
1988	18	--	13,300	--	400	--	20,100,000	--	20,732,100
1989	19	--	13,300	--	400	--	20,100,000	--	20,732,100
1990	20	--	13,300	--	400	--	20,100,000	--	20,732,100
Total		$436,300	$133,000	$393,900	$4,800	$13,301,100	$241,148,800	$27,726,200	$250,198,200
Annual Average		$ 21,815	$ 6,650	$ 19,695	$ 240	$ 665,055	$ 12,057,440	$ 1,386,310	$ 12,509,910

Source: SEWRPC.

Table 264

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE UPPER ROCK RIVER SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment		
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection	
Allenton Sanitary District (Expanded Plant)	Expansion by 1977 and as Required by 1990	By 1983	Not Applicable	By 1977	Already Provided	Not Applicable
Village of Slinger (Expanded Plant)	Expansion by 1977 and as Required by 1990	By 1983	Not Applicable	By 1977	Already Provided	Not Applicable
City of Hartford and Town of Hartford (Relocated Plant)	Relocation by 1973 and Expansion as Required by 1990	By 1983	By 1973	By 1977	By 1973	Old STP site to new STP site--by 1973 Pike Lake--by 1980

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1]Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.

[2]See Map 131.

treatment plants, the schedule recommends that the City of Hartford place into operation its new sewage treatment facility during 1973 and provide such additional capacity as may be required from time to time by 1990; and that the Allenton Sanitary District and the Village of Slinger each provide additional capacity by 1977 and as may be required from time to time by 1990. With respect to trunk sewers, the schedule recommends that the City of Hartford provide a trunk sewer from the old sewage treatment plant site to the new sewage treatment site by 1973, and that the Pike Lake trunk sewer from the City of Hartford to the Town of Hartford be completed by 1980.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Upper Rock River subregional area is set forth in Table 265. It is important to recognize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 264. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 265.

Middle Rock River Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Middle Rock River subregional area is set forth in Table 266. With respect to sewage treatment plants, the schedule recommends that the City of Oconomowoc complete construction of its new plant by 1977 and provide such additional capacity as may be required from time to time by 1990; that the Delafield-Hartland Water Pollution Control Commission complete construction of its proposed new sewage treatment facility by 1977; and that the Village of Wales and the Village of Dousman each provide new or expanded capacity as may be required from time to time by 1990. With respect to trunk sewers, the schedule recommends that the Hartland-Delafield-Nashotah and Nashotah-Nemahbin trunk sewers be completed by 1977, thus permitting abandonment of the Hartland sewage treatment facility; that the Lac LaBelle-East and Lac LaBelle-West trunk sewers be completed by 1978; that the Oconomowoc Lake, Okauchee Lake, Pine Lake, North Lake, and Beaver Lake trunk sewer be completed by 1980; and that the Silver Lake trunk sewer be completed by 1982.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Middle Rock River subregional area is set forth in Table 267. It is important to recognize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 266. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 267.

Table 265

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE UPPER ROCK RIVER SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

		Sewage Treatment Plant Plan Element							
		Allenton		Slinger		Hartford		Subtotal	
Calendar Year	Project Year	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 10,000	$ --	$ 20,000	$ --	$ 52,000	$ --	$ 82,000
1972	2	--	10,000	--	20,000	2,000,000	52,000	2,000,000	82,000
1973	3	--	10,000	--	20,000	1,342,800	100,000	1,342,800	130,000
1974	4	--	10,000	--	20,000	--	163,200	--	193,200
1975	5	--	10,000	--	20,000	--	163,200	--	193,200
1976	6	--	10,000	--	30,000	--	163,200	--	203,200
1977	7	221,500	10,000	500,000	30,000	--	163,200	721,500	203,200
1978	8	--	4,600	609,500	30,000	--	163,200	609,500	197,800
1979	9	--	4,600	--	47,500	--	163,200	--	215,300
1980	10	--	4,600	--	47,500	--	163,200	--	215,300
1981	11	--	4,600	--	47,500	--	163,200	--	215,300
1982	12	--	4,600	--	47,500	--	163,200	--	215,300
1983	13	--	4,600	--	47,500	--	163,200	--	215,300
1984	14	--	4,600	--	47,500	--	163,200	--	215,300
1985	15	--	4,600	--	47,500	--	163,200	--	215,300
1986	16	--	4,600	--	47,500	--	163,200	--	215,300
1987	17	--	4,600	--	47,500	--	163,200	--	215,300
1988	18	--	4,600	--	47,500	--	163,200	--	215,300
1989	19	--	4,600	--	47,500	--	163,200	--	215,300
1990	20	--	4,600	--	47,500	--	163,200	--	215,300
Total		$221,500	$129,800	$1,109,500	$760,000	$3,342,800	$2,978,400	$4,673,800	$3,868,200
Annual Average		$ 11,075	$ 6,490	$ 55,475	$ 38,000	$ 167,140	$ 148,920	$ 233,690	$ 193,410

		Intercommunity Trunk Sewer Plan Element							
		Hartford		Pike Lake		Subtotal		Subregional Area Total	
Calendar Year	Project Year	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ 82,000
1972	2	--	--	--	--	--	--	2,000,000	82,000
1973	3	641,300	--	--	--	641,300	--	1,984,100	130,000
1974	4	--	300	--	--	--	300	--	193,500
1975	5	--	300	--	--	--	300	--	193,500
1976	6	--	300	--	--	--	300	--	203,500
1977	7	--	300	--	--	--	300	721,500	203,500
1978	8	--	300	--	--	--	300	609,500	198,100
1979	9	--	300	--	--	--	300	--	215,600
1980	10	--	300	237,700	--	237,700	300	237,700	215,600
1981	11	--	5,400	--	5,100	--	5,400	--	220,700
1982	12	--	5,400	--	5,100	--	5,400	--	220,700
1983	13	--	5,400	--	5,100	--	5,400	--	220,700
1984	14	--	5,400	--	5,100	--	5,400	--	220,700
1985	15	--	5,400	--	5,100	--	5,400	--	220,700
1986	16	--	5,400	--	5,100	--	5,400	--	220,700
1987	17	--	5,400	--	5,100	--	5,400	--	220,700
1988	18	--	5,400	--	5,100	--	5,400	--	220,700
1989	19	--	5,400	--	5,100	--	5,400	--	220,700
1990	20	--	5,400	--	5,100	--	5,400	--	220,700
Total		$641,300	$5,100	$237,700	$51,000	$879,000	$56,100	$5,552,800	$3,924,300
Annual Average		$ 32,065	$ 255	$ 11,885	$ 2,550	$ 43,950	$ 2,805	$ 277,640	$ 196,215

Source: SEWRPC.

Table 266

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE MIDDLE ROCK RIVER SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment		
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection	
Village of Wales[3] (New Plant)	New Plant as Required by 1990	By 1990	Not Applicable	By 1990	By 1990	Not Applicable
Village of Dousman (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Not Applicable	By 1990	Already Provided	Not Applicable
City of Oconomowoc; Villages of Chenequa, Lac LaBelle, and Oconomowoc Lake; Towns of Ixonia, Merton, Oconomowoc, and Summit (Relocated Plant)	Relocation by 1977 and Expansion as Required by 1990	By 1983	By 1977	By 1977	By 1977	Lac LaBelle (East)--by 1978 Lac LaBelle (West)--by 1978 Oconomowoc Lake, Okauchee Lake, Pine Lake, North Lake, Beaver Lake--by 1980 Silver Lake--by 1982
City of Delafield, Villages of Hartland and Nashotah, and Town of Summit (New Plant)	New Plant by 1977 and Expansion as Required by 1990	By 1983	By 1977	By 1977	By 1977	Hartland, Delafield-Nashotah, Nashotah-Nemahbin (Abandon Hartland STP)--by 1977

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1] *Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.*

[2] *See Map 131.*

[3] *Plant should be designed to meet 1990 treatment level requirements at time of initial construction.*

Table 267

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE MIDDLE ROCK RIVER SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

Calendar Year	Project Year	Sewage Treatment Plant Plan Element							
		Wales		Dousman		Oconomowoc		Delafield	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ 15,000	$ --	$ 50,000	$ --	$ --
1972	2	--	--	--	15,000	--	50,000	--	--
1973	3	--	--	--	15,000	--	50,000	--	--
1974	4	--	--	--	15,000	--	50,000	--	--
1975	5	--	--	--	15,000	--	50,000	--	--
1976	6	--	--	--	15,000	2,000,000	50,000	--	--
1977	7	--	--	--	15,000	3,766,000	150,000	2,038,000	--
1978	8	--	--	565,400	15,000	--	294,600	--	100,000
1979	9	--	--	--	16,500	--	294,600	--	100,000
1980	10	--	--	--	16,500	--	294,600	--	100,000
1981	11	--	--	--	16,500	--	294,600	2,000,000	100,000
1982	12	197,000	--	--	16,500	--	294,600	--	199,000
1983	13	--	10,600	--	16,500	--	294,600	--	199,000
1984	14	--	10,600	--	16,500	--	294,600	--	199,000
1985	15	--	10,600	--	16,500	--	294,600	--	199,000
1986	16	--	10,600	--	16,500	--	294,600	--	199,000
1987	17	--	10,600	--	16,500	--	294,600	--	199,000
1988	18	--	10,600	--	16,500	--	294,600	--	199,000
1989	19	--	10,600	--	16,500	--	294,600	--	199,000
1990	20	--	10,600	--	16,500	--	294,600	--	199,000
Total		$197,000	$84,800	$565,400	$318,000	$5,766,000	$4,279,800	$4,038,000	$2,191,000
Annual Average		$ 9,850	$ 4,240	$ 28,270	$ 15,900	$ 288,300	$ 213,990	$ 201,900	$ 109,550

Table 267 (continued)

Calendar Year	Project Year	Sewage Treatment Plant Plan Element: Subtotal		Intercommunity Trunk Sewer Plan Element: Oconomowoc-Lac La Belle (East)		Oconomowoc-Lac La Belle (West)		Oconomowoc Lake, Okauchee Lake, Pine Lake, North Lake, and Beaver Lake	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 65,000	$ --	$ --	$ --	$ --	$ --	$ --
1972	2	--	65,000	--	--	--	--	--	--
1973	3	--	65,000	--	--	--	--	--	--
1974	4	--	65,000	--	--	--	--	--	--
1975	5	--	65,000	--	--	--	--	--	--
1976	6	2,000,000	65,000	--	--	--	--	--	--
1977	7	5,804,000	165,000	--	--	--	--	--	--
1978	8	565,400	409,600	675,000	--	415,200	--	--	--
1979	9	--	411,100	--	11,800	--	500	1,000,000	--
1980	10	--	411,100	--	11,800	--	500	1,406,100	--
1981	11	2,000,000	411,100	--	11,800	--	500	--	41,100
1982	12	197,000	510,100	--	11,800	--	500	--	41,100
1983	13	--	520,700	--	11,800	--	500	--	41,100
1984	14	--	520,700	--	11,800	--	500	--	41,100
1985	15	--	520,700	--	11,800	--	500	--	41,100
1986	16	--	520,700	--	11,800	--	500	--	41,100
1987	17	--	520,700	--	11,800	--	500	--	41,100
1988	18	--	520,700	--	11,800	--	500	--	41,100
1989	19	--	520,700	--	11,800	--	500	--	41,100
1990	20	--	520,700	--	11,800	--	500	--	41,100
Total		$10,566,400	$6,873,600	$675,000	$141,600	$415,200	$6,000	$2,406,100	$411,000
Annual Average		$ 528,320	$ 343,680	$ 33,750	$ 7,080	$ 20,760	$ 300	$ 120,305	$ 20,550

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Silver Lake		Hartland, Delafield-Nashotah, and Nashotah-Nemahbin		Subtotal		Subregional Area Total	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ 65,000
1972	2	--	--	--	--	--	--	--	65,000
1973	3	--	--	--	--	--	--	--	65,000
1974	4	--	--	--	--	--	--	--	65,000
1975	5	--	--	2,000,000	--	2,000,000	--	2,000,000	65,000
1976	6	--	--	2,000,000	--	2,000,000	--	4,000,000	65,000
1977	7	--	--	1,422,200	1,000	1,422,200	1,000	7,226,200	166,000
1978	8	--	--	--	1,600	1,090,200	1,600	1,655,600	411,200
1979	9	--	--	--	1,600	1,000,000	13,900	1,000,000	425,000
1980	10	--	--	--	1,600	1,406,100	13,900	1,406,100	425,000
1981	11	--	--	--	1,600	--	55,000	2,000,000	466,100
1982	12	327,000	3,800	--	1,600	327,000	58,800	524,000	568,900
1983	13	--	3,800	--	1,600	--	58,800	--	579,500
1984	14	--	3,800	--	1,600	--	58,800	--	579,500
1985	15	--	3,800	--	1,600	--	58,800	--	579,500
1986	16	--	3,800	--	1,600	--	58,800	--	579,500
1987	17	--	3,800	--	1,600	--	58,800	--	579,500
1988	18	--	3,800	--	1,600	--	58,800	--	579,500
1989	19	--	3,800	--	1,600	--	58,800	--	579,500
1990	20	--	3,800	--	1,600	--	58,800	--	579,500
Total		$327,000	$34,200	$5,422,200	$21,800	$9,245,500	$614,600	$19,811,900	$7,488,200
Annual Average		$ 16,350	$ 1,710	$ 271,110	$ 1,090	$ 462,275	$ 30,730	$ 990,595	$ 374,410

Source: SEWRPC.

Lower Rock River Subregional Area

The proposed implementation schedule for the recommended regional sanitary sewerage system plan in the Lower Rock River subregional area is set forth in Table 268. With respect to sewage treatment plants, the schedule recommends that the City of Whitewater complete construction of its new plant by 1977 and provide such additional capacity as may be required from time to time by 1990; that the City of Delavan, City of Elkhorn, and Delavan Lake Sanitary District complete construction of a new joint sewage treatment facility by 1977 and provide such additional capacity as may be required from time to time by 1990; that the Village of Walworth complete construction of its new plant by 1977 and provide such additional capacity as may be required from time to time by 1990; and that the Villages of Sharon, Darien, Fontana, and Williams Bay provide additional capacity at their treatment facilities as may be required from time to time by 1990.

With respect to trunk sewers, the schedule recommends that the City of Whitewater provide a

Table 268

PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN IN THE LOWER ROCK RIVER SUBREGIONAL AREA

Unit(s) of Government	Sewage Treatment Plant Plan Element[1]					Trunk Sewer Plan Element[2]
	Secondary Waste Treatment	Advanced Waste Treatment		Auxiliary Waste Treatment		
		Nitrification	Phosphorus Removal	Effluent Aeration	Effluent Disinfection	
City of Whitewater (Relocated Plant)	Relocation by 1977 and Expansion as Required by 1990	By 1983	By 1977	By 1977	By 1977	Old STP site to new STP site--by 1977
Village of Sharon (Expanded Plant)	Expansion as Required by 1990	By 1983	By 1990	By 1977	Already Provided	Not Awplicable
City of Delavan, City of Elkhorn, and Delavan Lake Sanitary District (New Plant)	New Plant by 1977 and Expansion as Required by 1990	By 1983	By 1977	By 1977	By 1977	Elkhorn - Delavan (Abandon Elkhorn STP)--by 1977 Delavan Lake--by 1977
Village of Darien (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Not Applicable	Not Applicable	Already Provided	Not Tpplicable
Village of Fontana and Town of Linn (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Not Applicable	Not Applicable	Already Provided	Geneva Lake--by 1980
Village of Williams Bay, Town of Geneva, and Town of Linn (Expanded Plant)	Expansion as Required by 1990	Not Applicable	Not Applicable	Not Applicable	Already Provided	Geneva Lake--by 1980
Village of Walworth (Relocated Plant)	Relocation by 1977 and Expansion as Required by 1990	By 1983	By 1977	By 1977	By 1977	Old STP site to new STP site--by 1977

NOTE: This proposed implementation schedule represents a point of departure for intergovernmental negotiations and tentative federal and state agency programming, including the issuance of pollution abatement orders and waste discharge permits and the disposition of grants-in-aid.

Source: SEWRPC.

[1]Specific recommended performance standards for each sewage treatment plant are set forth in Table 225.

[2]See Map 131.

trunk sewer from the old sewage treatment plant site to the new sewage treatment plant site by 1977; that the Village of Walworth provide a new trunk sewer from the old sewage treatment plant site to the new sewage treatment plant site by 1977; that the Elkhorn-Delavan trunk sewer be constructed by 1977, thus permitting abandonment of the Elkhorn sewage treatment plant; that the Delavan Lake trunk sewer be constructed by 1977; that the Geneva Lake trunk sewer extending to the Village of Fontana be constructed by 1980; and that the Geneva Lake trunk sewer extending from the Village of Williams Bay be constructed by 1980.

A schedule of construction and operation and maintenance costs for implementation of the recommended regional sanitary sewerage system plan in the Lower Rock River subregional area is set forth in Table 269. It is important to recog-

Table 269

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THE LOWER ROCK RIVER SUBREGIONAL AREA BY PLAN ELEMENT BY YEAR: 1971-1990

Calendar Year	Project Year	Sewage Treatment Plant Plan Element							
		Whitewater		Sharon		Delavan		Darien	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 50,000	$ --	$ 12,000	$ --	$ 50,000	$ --	$ 15,000
1972	2	--	50,000	--	12,000	--	50,000	--	15,000
1973	3	-	50,000	--	12,000	--	50,000	--	15,000
1974	4	--	50,000	--	12,000	--	50,000	--	15,000
1975	5	--	50,000	--	12,000	--	50,000	--	15,000
1976	6	--	50,000	--	15,000	--	50,000	--	15,000
1977	7	3,938,000	50,000	50,000	15,000	2,333,700	50,000	--	15,000
1978	8	--	204,800	--	17,000	--	110,200	--	15,000
1979	9	--	204,800	--	17,000	--	110,200	--	15,000
1980	10	--	204,800	--	17,000	--	110,200	965,500	15,000
1981	11	--	204,800	844,000	17,000	--	110,200	--	21,000
1982	12	--	204,800	--	43,200	--	110,200	--	21,000
1983	13	--	204,800	--	43,200	--	110,200	--	21,000
1984	14	--	204,800	--	43,200	--	110,200	--	21,000
1985	15	--	204,800	--	43,200	2,000,000	110,200	--	21,000
1986	16	--	204,800	--	43,200	--	210,200	--	21,000
1987	17	--	204,800	--	43,200	--	210,200	--	21,000
1988	18	--	204,800	--	43,200	--	210,200	--	21,000
1989	19	--	204,800	--	43,200	--	210,200	--	21,000
1990	20	--	204,800	--	--	--	210,200	--	21,000
Total		$3,938,000	$3,012,400	$894,000	$503,600	$4,333,700	$2,282,600	$965,500	$360,000
Annual Average		$ 196,900	$ 150,620	$ 44,700	$ 25,180	$ 216,685	$ 114,130	$ 48,275	$ 18,000

Calendar Year	Project Year	Sewage Treatment Plant Plan Element							
		Fontana		Walworth		Williams Bay		Subtotal	
		Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance	Facility Construction	Operation and Maintenance
1971	1	$ --	$ 20,000	$ --	$ 20,000	$ --	$ 30,000	$ --	$ 197,000
1972	2	--	20,000	--	20,000	--	30,000	--	197,000
1973	3	--	20,000	--	20,000	--	30,000	--	197,000
1974	4	--	20,000	--	20,000	--	30,000	--	197,000
1975	5	--	20,000	--	20,000	--	30,000	--	197,000
1976	6	--	20,000	700,000	20,000	--	30,000	700,000	200,000
1977	7	--	20,000	600,000	20,000	--	30,000	6,921,700	200,000
1978	8	1,264,600	20,000	--	61,000	--	30,000	1,264,600	458,000
1979	9	--	27,200	--	61,000	--	30,000	--	465,200
1980	10	--	27,200	--	61,000	699,300	30,000	1,664,800	465,200
1981	11	--	27,200	--	61,000	--	37,800	844,000	479,000
1982	12	--	27,200	--	61,000	--	37,800	--	505,200
1983	13	--	27,200	--	61,000	--	37,800	--	505,200
1984	14	--	27,200	--	61,000	--	37,800	--	505,200
1985	15	--	27,200	--	61,000	--	37,800	2,000,000	505,200
1986	16	--	27,200	--	61,000	--	37,800	--	605,200
1987	17	--	27,200	--	61,000	--	37,800	--	605,200
1988	18	--	27,200	--	61,000	--	37,800	--	605,200
1989	19	--	27,200	--	61,000	--	37,800	--	605,200
1990	20	--	27,200	--	61,000	--	37,800	--	562,000
Total		$1,264,600	$486,400	$1,300,000	$933,000	$699,300	$678,000	$13,395,100	$8,256,000
Annual Average		$ 63,230	$ 24,320	$ 65,000	$ 46,650	$ 34,965	$ 33,900	$ 699,755	$ 412,800

Table 269 (continued)

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Whitewater – Facility Construction	Whitewater – Operation and Maintenance	Delavan Lake – Facility Construction	Delavan Lake – Operation and Maintenance	Elkhorn – Facility Construction	Elkhorn – Operation and Maintenance	Fontana-Geneva Lake – Facility Construction	Fontana-Geneva Lake – Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ --
1972	2	--	--	--	--	--	--	--	--
1973	3	--	--	--	--	--	--	--	--
1974	4	--	--	--	--	--	--	--	--
1975	5	--	--	--	--	--	--	--	--
1976	6	392,900	--	1,536,200	--	1,577,000	--	--	--
1977	7	--	3,200	--	11,000	--	20,700	--	--
1978	8	--	3,200	--	11,000	--	20,700	--	--
1979	9	--	3,200	--	11,000	--	20,700	--	--
1980	10	--	3,200	--	11,000	--	20,700	2,276,500	--
1981	11	--	3,200	--	11,000	--	20,700	--	600
1982	12	--	3,200	--	11,000	--	20,700	--	600
1983	13	--	3,200	--	11,000	--	20,700	--	600
1984	14	--	3,200	--	11,000	--	20,700	--	600
1985	15	--	3,200	--	11,000	--	20,700	--	600
1986	16	--	3,200	--	11,000	--	20,700	--	600
1987	17	--	3,200	--	11,000	--	20,700	--	600
1988	18	--	3,200	--	11,000	--	20,700	--	600
1989	19	--	3,200	--	11,000	--	20,700	--	600
1990	20	--	3,200	--	11,000	--	20,700	--	600
Total		$392,900	$44,800	$1,536,200	$154,000	$1,577,000	$289,800	$2,276,500	$6,000
Annual Average		$ 19,645	$ 2,240	$ 76,810	$ 7,700	$ 78,850	$ 14,490	$ 113,825	$ 300

Calendar Year	Project Year	Intercommunity Trunk Sewer Plan Element: Williams Bay-Geneva Lake – Facility Construction	Williams Bay-Geneva Lake – Operation and Maintenance	Walworth – Facility Construction	Walworth – Operation and Maintenance	Subtotal – Facility Construction	Subtotal – Operation and Maintenance	Subregional Area Total – Facility Construction	Subregional Area Total – Operation and Maintenance
1971	1	$ --	$ --	$ --	$ --	$ --	$ --	$ --	$ 197,000
1972	2	--	--	--	--	--	--	--	197,000
1973	3	--	--	--	--	--	--	--	197,000
1974	4	--	--	--	--	--	--	--	197,000
1975	5	--	--	--	--	--	--	--	197,000
1976	6	--	--	296,800	--	3,802,900	--	4,502,900	200,000
1977	7	--	--	--	500	--	35,400	6,921,700	235,400
1978	8	--	--	--	500	--	35,400	1,264,600	493,400
1979	9	--	--	--	500	--	35,400	--	500,600
1980	10	1,243,800	--	--	500	3,520,300	35,400	5,185,100	500,600
1981	11	--	6,600	--	500	--	42,600	844,000	521,600
1982	12	--	6,600	--	500	--	42,600	--	547,800
1983	13	--	6,600	--	500	--	42,600	--	547,800
1984	14	--	6,600	--	500	--	42,600	--	547,800
1985	15	--	6,600	--	500	--	42,600	2,000,000	547,800
1986	16	--	6,600	--	500	--	42,600	--	647,800
1987	17	--	6,600	--	500	--	42,600	--	647,800
1988	18	--	6,600	--	500	--	42,600	--	647,800
1989	19	--	6,600	--	500	--	42,600	--	647,800
1990	20	--	6,600	--	500	--	42,600	--	604,600
Total		$1,243,800	$66,000	$296,800	$7,000	$7,323,200	$567,600	$20,718,300	$8,823,600
Annual Average		$ 62,190	$ 3,300	$ 14,840	$ 350	$ 366,160	$ 28,380	$ 1,035,915	$ 441,180

Source: SEWRPC.

nize that this cost schedule is directly related to the proposed implementation schedule set forth in Table 268. Any deviations from the implementation schedule would, accordingly, affect the cost schedule set forth in Table 269.

IMPLEMENTATION OF AUXILIARY PLAN ELEMENTS

As discussed in Chapter XII of this report, there are a number of additional factors and considerations which relate to the basic sewerage facility plan recommendations and which apply in general to the entire Region. These factors and considerations have been termed auxiliary plan elements and are not included in the foregoing specific implementation schedules. They are, however, essential to full implementation of the plan and to attaining the established water use objectives and supporting water quality standards for the surface waters in the Region.

Clear Water Elimination

It is recommended that each local unit of government within the Region responsible for the construction, operation, and maintenance of sanitary sewerage facilities conduct a study of the infiltration and inflow problems existing in the local system. Such infiltration and inflow studies should utilize, in the manner recommended in Chapter XII of this report, the engineering design criteria set forth in Chapter IX of this report as a basis for determining whether or not excessive infiltration or inflows are present in the system. In the metropolitan sewerage systems currently existing in the Kenosha, Racine, and Milwaukee areas, which systems are comprised of several subsystems, each the responsibility of a different governmental jurisdiction, it is recommended that the required infiltration/inflow study be accomplished in two stages. The first stage would be conducted by the agency responsible for the construction, operation, and maintenance of the metropolitan or intercommunity trunk sewers. Where an infiltration/inflow problem is determined to exist in areas tributary to critical inflow points on the metropolitan trunk sewer system, the appropriate local unit of government would conduct the necessary detailed inflow-infiltration study for the tributary sewerage system. Such studies should determine the most cost effective method of resolving the problem, comparing the costs of full or partial flow abatement with the costs of conveyance and treatment.

As discussed in Chapter XII of this report, two of the major sources of clear water inflow into the sanitary sewerage systems are roof downspout and building foundation drain connections to the separate sanitary sewerage system. These connections may be classified as either "legal"—that is connections made prior to the enactment of local ordinances prohibiting such connections—or "illegal"—that is, connections made after the enactment of such ordinances. Local units of government in the Region are generally under state orders to eliminate these sources of clear water—whether in the form of "legal" or "illegal" connections—as a first step in the reduction of clear water flows in separate sanitary sewerage systems.

One community's approach to the problem of eliminating clear water inflows from roof downspouts and building foundation drains is illustrated in Figure 132. By ordinance, the City of Oak Creek has prohibited the discharge of clear water into the sanitary system and further declares it to be the public policy to eliminate all discharge of clear water now occurring in the sanitary sewer system. The ordinance relating to this matter, as well as a diagram illustrating a recommended arrangement for eliminating clear water discharge from foundation drains to the sanitary sewer system, are shown on Figure 132. Under the ordinance, and in accordance with Section 66.22 of the Wisconsin Statutes, the city has the authority to impose special assessments against real property for all or part of the cost of abating, correcting, or eliminating clear water connections to the sewer system. In this connection, it should be recognized that with respect to those problem situations created before local ordinances were enacted to prohibit the discharge of clear water to sanitary sewer systems, there may well be a public responsibility to assist financially in correcting such problems. Clearly no such public responsibility exists for correcting such problems created by illegal connections.

Elimination of Flow Relief Points

It is recommended that each unit or agency of government responsible for the construction, operation, and maintenance of sanitary sewerage systems in the Region conduct a detailed study of the local sanitary sewerage system to identify all existing points of sewage flow relief and to determine the steps necessary to assure the ultimate elimination of those flow relief points not eliminated through the construction of the sewerage facilities contained in the recommended regional sanitary sewerage system plan. Each individual point of sewage flow relief must be identified and physically eliminated so as to preclude the possibility of the discharge of raw sewage ahead of the sewage treatment plant. It is recognized that in many cases this will require the construction of local relief sewers.

Sewage Treatment Plant Operation

It is recommended that the Wisconsin Department of Natural Resources review its sewage treatment plant operator certification program and make such changes as may be deemed necessary in order to improve the operation and maintenance of sewage treatment plants so as to achieve the operating standards needed to carry out the plan recommendations. It is further recommended that each local unit of government responsible for the construction, operation, and maintenance of a sewage treatment facility consider staffing and operation in accordance with the minimum stand-

Figure 132

CLEAR WATER PROHIBITION AND ELIMINATION ORDINANCE AND RECOMMENDED ARRANGEMENT FOR CORRECTING EXISTING SITUATIONS WHERE FOUNDATION DRAINS DISCHARGE TO THE SANITARY SEWER SYSTEM

CITY OF OAK CREEK, WISCONSIN

CITY OF OAK CREEK

Official Notice

ORDINANCE NO. 493
By Ald. Martens

An Ordinance to Prohibit the Discharge of Clear Water into the Sanitary Sewer System and to Authorize Inspection of Connections, Providing for Notice, Hearing, Appeal, Assessment and Penalty.

WHEREAS, the Department of Natural Resources of the state of Wisconsin has issued an order, 4B-70-5-4, directing the city of Oak Creek to eliminate clear water that reaches sanitary, main and intercepting sewers; this, to improve the capacity and efficiency of overtaxed sewerage treatment facilities, and reduce pollution, and

WHEREAS, all sewers installed in Oak Creek since 1959 have been designed as separate sanitary sewers and no sources of clear water have been allowed to be connected to the sanitary sewer system; however, clear water sources do exist in areas where sewers and buildings were constructed prior to the enactment of Ordinance No. 99 in 1959; also, some structures have a valving system to be manually operated by the homeowner to direct the flow of waste water into the sanitary sewers, and clear water into the sump system; however, said systems are not properly used by the owners, and clear water is pumped into the sanitary system; further, some property owners have physically altered sanitary sewer systems originally properly installed, to direct sump pump clear water discharge into the sanitary sewer system, and

WHEREAS, the public health, safety, and welfare requires all such clear water discharges into the sanitary sewer system to be eliminated.

NOW, THEREFORE, the common council of the city of Oak Creek do hereby ordain as follows:

Section 1. The discharge of clear water into the sanitary sewer system is prohibited.

Section 2. The discharge of clear water into the sanitary sewer system is to be eliminated.

Section 3. The inspection officers of the city of Oak Creek are hereby authorized and directed to make such inspections as are necessary to determine where clear water connections, or clear water infiltration, exists. In making such inspections, they are authorized and directed to obtain special inspection warrants under the provisions of Sections 66.122 and 66.123 of the Wisconsin statutes.

Section 4. Upon determining that a clear water connection, or clear water infiltration exists, city inspection officers are authorized and directed to issue appropriate orders to abate, correct, or eliminate such connection of infiltration within a reasonable time, not to exceed 90 days. This order shall be sent to the owner by certified mail, at the address shown on the tax roll. The owner shall have the right to appeal the said order to the common council within 10 days from the date of mailing. The council shall hold a public hearing on the said appeal, within 10 days from receipt of the appeal. The owner shall have the right to appear in person, or by an attorney. The council shall have the authority to affirm, modify, or reverse the order appealed from. The owner shall have the right to appeal the council's decision by certiorari commenced within 10 days of the council order. If no such appeal is taken, the council's order shall be final, and may be implemented by mandatory injunction or other appropriate legal means.

Section 5. In accordance with the provisions of Section 66.62 Wisconsin statutes, the council shall have the authority to impose special assessments against the property for all or part of the cost of abating, correcting, or eliminating clear water connections or infiltration, including the manual valving system described in the preamble hereof. Prior to the imposition of such assessment, the council shall conduct a public hearing, preceded by a Class 1 notice published in the official city newspaper, and a mailed notice to each owner at the address shown on the last tax roll. Any special assessment imposed shall be by a final resolution as provided in Section 66.60 of the Wisconsin statutes, and shall constitute a lien on the property. Payment shall be made as the council provides in said resolution. The council may provide for installment payments not to exceed five (5) years, with 6 percent interest on the unpaid balance. The owner shall have the right to appeal the said special assessment in the manner provided in Section 66.60 (12) within 40 days of the publication of the final resolution.

Section 6. City officers and contractors retained by the city are authorized to enter upon property for the purpose of performing the work necessary to abate, correct, or eliminate such clear water connections or infiltration. No person shall refuse such entry, or interfere with such city officer or contractor in the performance of such work. In addition to the penalties herein provided, any person who so refuses or interferes, shall be subject to injunction or restraining order of a court or competent jurisdiction.

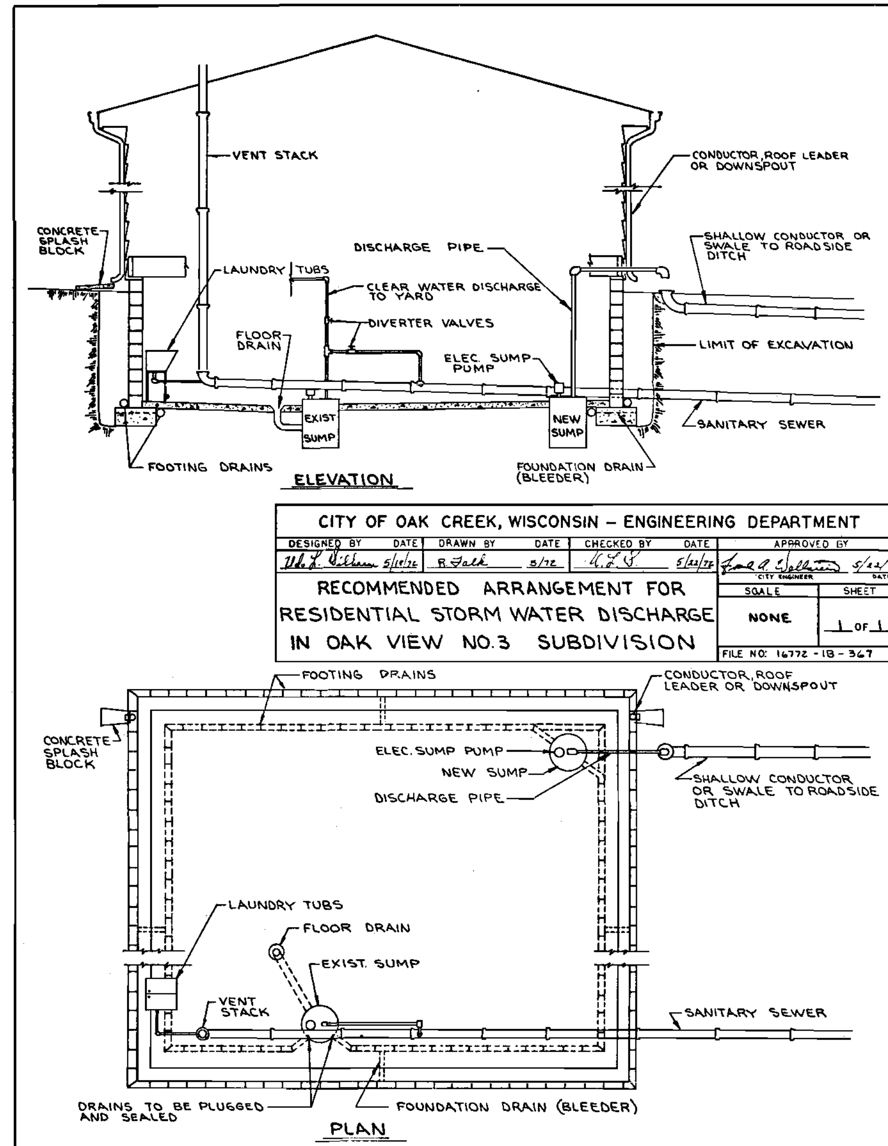
Section 7. Any person, firm, or corporation violating any of the provisions of this ordinance, shall forfeit not less than $10 nor more than $200 or in default of payment thereof, be imprisoned in the county jail for a period not to exceed 60 days. Each day of violation shall constitute a separate offense.

Section 8. All ordinances or parts of ordinances contravening the provisions of this ordinance are hereby repealed.

Section 9. This ordinance shall take effect and be in force from and after its passage and publication.

Passed and adopted this 21st day of November, 1972.
/s/Allen H. Windschanz,
President, Common Council

Approved this 22nd day of November, 1972.
/s/Elroy C. Honadel, Mayor
Attest:
/s/La Verne C. Gutknecht
City Clerk
Vote: Ayes 5 Noes 0



ards set forth in Table 233. Wherever possible all municipal sewage treatment plants should be staffed on a 24-hour around-the-clock basis in order to provide continuous surveillance of the operation. It should be recognized that the recommendations for staffing sewage treatment plants set forth in Table 233 assume the operation of a conventional sewage treatment plant and do not, therefore, reflect the potential effects of automation on plant staffing requirements. Even fully automated plants, however, require provision for surveillance and monitoring on a 24-hour basis. Such surveillance and monitoring could be effected either through a greatly reduced operating staff during certain hours of the day or by remote data transmission and alarm systems. It is further recommended that each local unit of government provide the proper laboratory and related facilities needed to adequately assess the treatment plant operation and determine whether or not the specific recommended performance standards set forth in the plan are being met. In this respect, it is further recommended that the Wisconsin Department of Natural Resources require that all facilities plans and related engineering studies prepared in support of applications to construct sewage treatment facilities include design data related to effluent quality on an average annual basis. Finally, it is recommended that the Department of Natural Resources review its requirements for sewage treatment plant operational reporting to ensure that all the data described in Table 233 and those additional data which may be necessary to determine whether or not the treatment level performance standards are being met are included in the reports submitted to the Department of Natural Resources by individual treatment plant operators.

Flow Metering

It is recommended that each local unit of government constructing, operating, and maintaining a sanitary sewerage system take steps to achieve complete metering of sewage flows in accordance with the metering recommendations set forth in Chapter XII of this report. Metering equipment providing continuous data on rates and volumes of sewage flow should be provided at all sewage treatment facilities and pumping stations, as well as at major points of sewage flow relief.

Sludge Disposal

It is recommended that as part of facilities planning and engineering efforts, each local unit of government in the Region responsible for the construction, operation, and maintenance of sewage treatment facility include as a specific component of such plans and studies a cost effectiveness determination with respect to the best method of sludge handling, reduction, and final disposal or recycling. It is further recommended that such plans and studies include investigations relating to the recycling of sludge wastes.

Water Quality Monitoring

It is recommended that the Regional Planning Commission and the Wisconsin Department of Natural Resources review the current stream water quality monitoring program and, based upon such a review and analysis, determine whether changes are needed in the program concerning the frequency of sampling, the location of sampling stations, and the need for more extensive flow measurements. Such review should be made in light of the sewage treatment plant location recommendations included in the regional sanitary sewerage system plan and in light of changing state and federal requirements with respect to changing water use objectives and supporting water quality standards. It is further recommended that the Wisconsin Department of Natural Resources continue to conduct periodic field pollution investigation surveys of the river basins in the Region. Such surveys, as continuing field surveillance efforts, should be made for each basin in the Region at regular intervals of no more than five years.

FINANCIAL AND TECHNICAL ASSISTANCE

Upon adoption of the regional sanitary sewerage system plan and any necessary implementation schedules and schedules of capital costs, it becomes necessary for the governmental units and agencies concerned to utilize effectively all sources of financial and technical assistance available for the timely execution of the recommended plan. In addition to current tax revenue sources such as property taxes, fees, fines, and public utility earnings, and other sources such as shared taxes, the agencies and units of government concerned can also make use of other revenue sources such as borrowing, special assessments, sewer service charges, and state and federal grants-in-aid. Various types of technical assistance useful in plan implementation are also available from regional, state, and federal agencies.

Financial Assistance

Financial assistance includes borrowing, special assessments, sewer service charges, and state and federal grants-in-aid.

Borrowing: Areawide agencies and local units of government are normally authorized to borrow so as to discharge their duties and responsibilities. Chapter 67 of the Wisconsin Statutes generally empowers counties, cities, villages, and towns to borrow money and to issue municipal obligations not to exceed 5 percent of the equalized assessed evaluation of its taxable property with certain exceptions, including school bonds and revenue bonds. Such borrowing powers are important to local units of government in the construction of sewerage facilities to implement the recommended plan. Section 60.307 of the Wisconsin Statutes specifically authorizes town sanitary districts to borrow money and to issue bonds for the construction or extension of sanitary sewerage systems. Section 66.202 and 59.96(7) of the Wisconsin Statutes authorize metropolitan sewerage districts to borrow money and to issue bonds for the construction of sanitary sewerage facilities. In addition, the powers of cooperative contract commissions under Section 66.30 of the Wisconsin Statutes include borrowing by the contracting bodies of such commissions for acquiring, constructing, and equipping areawide sewerage projects.

Rural sewer development loans are available to rural units of government from the U. S. Farmers Home Administration for developing waste disposal systems. To qualify, such rural units of government must have less than 5,500 population, lie beyond the metropolitan area, and be unable to obtain financial assistance elsewhere. Finally, in an effort to ensure that inability to borrow necessary funds at reasonable terms does not prevent local public agencies from carrying out necessary sewerage facility construction programs, the U. S. Congress, as part of the Federal Water Pollution Control Act Amendments of 1972, created an Environmental Financing Authority, which Authority is empowered to make commitments to purchase and to purchase, on terms and conditions to be determined by the Authority, any obligation which is issued by a state or local public body to finance the nonfederal share of any sewerage facility project. It is the intent of Congress that this authority should not provide financial assistance to a community that can borrow money on the open market at reasonable rates.

Special Assessments: Most governmental units which have authority to provide for sanitary sewerage facilities have special assessment powers under various provisions of the Wisconsin Statutes. Cities and villages have such special assessment powers under Sections 62.18(16) and 61.39 of the Statutes; metropolitan sewerage districts have special assessment powers under Sections 59.96(9) and 66.25 of the Statutes; and town sanitary and utility districts have such special assessment powers under Sections 60.309 and 66.072 of the Wisconsin Statutes. It is recognized that such special assessment powers and revenues would be utilized primarily for local sewerage system improvements needed to extend sewer service to the areas recommended in the regional sanitary sewerage system plan, as opposed to the areawide facilities actually included in the plan itself.

Sewer Service Charges: Section 66.076 of the Wisconsin Statutes provides that municipalities may establish sewer service charges. The revenue from such charges may be pledged as security for mortgage bonds or mortgage certificates. For the purpose of making equitable charges for all services rendered by the sewerage system, the property benefited may be classified, taking into consideration the volume of water, the character of the sewage or waste disposed, and the nature of the use made of the sewerage system. It is anticipated that the user charge requirements set forth in the Federal Water Pollution Control Act Amendments of 1972 as a condition to obtaining federal grants-in-aid will result in the establishment of sewer service charges throughout most of southeastern Wisconsin in those principalities now relying primarily on the general property tax levy to finance sewerage improvements and operation and maintenance costs.

Grant-in-Aid Programs: One state and several federal grant programs are available to local units of government for the financing of sewerage facility improvements. These include the following programs:

1. State Water Pollution Prevention and Abatement Program: This program, administered by the Wisconsin Department of Natural Resources pursuant to the rules set forth in Chapter NR 125 of the Wisconsin Administrative Code, provides financial assistance to local governments for the cost of approved pollution abatement and prevention projects. Eligible projects include waste treatment facilities; trunk, relief, and intercepting sewers; outfall sewers; certain sewage collection systems; and other appurtenances. It is anticipated

that all facility recommendations included in the regional sanitary sewerage system plan would be eligible for state financial assistance. For nonfederally aided projects, the state grant is 25 percent of the total cost. For projects receiving federal aid, the state grant offer may amount to 25 percent or less in order to provide combined state and federal assistance not in excess of 85 percent of the cost of the project, except that combined state and federal assistance may extend to 90 percent of the cost of that part of the project consisting of advanced or tertiary sewage treatment components.

2. Federal Waste Treatment Works Construction Program: This program, administered by the U. S. Environmental Protection Agency, provides federal financial assistance in an amount of 75 percent of the total cost of approved projects. Projects must be found to be in conformance with an approved facility plan and areawide water quality management or Section 303 basin plan, as applicable. It is anticipated that all facilities included in the recommended regional sanitary sewerage system plan will be eligible for 75 percent federal assistance under this program.

3. Federal Water and Sewer Facilities Program: This program, administered by the U. S. Department of Housing and Urban Development, provides grants up to 50 percent to local units of government toward the cost of constructing sewerage collection, conveyance, and transmission systems. At the present time the funding status of this program is somewhat clouded by an administration proposal to abandon the program in favor of special federal revenue sharing.

4. Federal Rural Waste Disposal Facilities Program: This program, administered by the U. S. Department of Agriculture, Farmers Home Administration, provides grants in amounts up to 50 percent toward the cost of developing rural waste collection and disposal systems to rural units of government up to 5,500 population and located outside of metropolitan areas. At the present time the funding status of this program is also clouded by the proposal to institute special federal revenue sharing for categorical grant programs.

Technical Assistance

Those agencies directly involved in water quality management normally provide various levels and types of technical assistance which may be useful in implementation of the regional sanitary sewerage system plan. Limited guidance and assistance is usually provided without cost. In some cases the local unit of government may contract with the agency for more extensive technical assistance and services. At the federal level the U. S. Environmental Protection Agency provides technical assistance and advice on request at no cost to state and local units of government and to private firms relative to water quality management problems. At the state level, the Wisconsin Department of Natural Resources is authorized under Section 144.025(2)(h), upon request and without charge, to consult with and advise owners and operators of sewage facilities as to the best method of sewage disposal. The Department is not required, however, to prepare specific facility plans. In addition, the Department provides continuing technical assistance services to treatment plant operators regarding the proper operational procedures to be followed in achieving the necessary treatment levels and maintaining the performance standards recommended in areawide water quality management plans. Recently, the Department has made available one full-time staff member in its district office to provide such technical assistance at no cost to the local units of government in the seven-county Southeastern Wisconsin Region. At the regional level, the Regional Planning Commission staff as part of its continuing environmental engineering planning program stands ready and willing to provide whatever technical assistance it can to the implementing agencies in securing and assuring continued compliance with the plan recommendations in the design of sewerage facilities, thereby also assuring that such facilities will be eligible to receive maximum federal and state grants-in-aid.

SUMMARY

This chapter has described the various means available and has recommended specific procedures for implementation of the regional sanitary sewerage system plan. The most important recommended plan implementation actions are summarized in the following paragraphs by level and responsible agency or unit of government.

Local Level

Common Councils, Village Boards, and Town Boards: It is recommended that, upon referral to and upon recommendation of the local plan commissions, each common council, village board, and town board within the Region, as appropriate:

1. Adopt the recommended regional sanitary sewerage system plan as a guide to future sewerage facility development in the community as that plan affects each community.

2. Review and adopt the appropriate sewerage facility implementation schedule and accompanying schedule of capital and operation and maintenance costs, and direct its staff and consulting engineers to utilize such schedules in the preparation of detailed facilities plans and in the conduct of engineering studies.

3. Conduct an infiltration and inflow study to determine whether or not an infiltration/inflow problem exists and, if so, the remedial action needed to resolve such problem.

4. Conduct a detailed study relating to the identification of all existing points of sewage flow relief and a determination of the steps necessary to ultimately eliminate such points.

5. Review the operational characteristics of each sewage treatment plant to determine if the facility is properly staffed and operated in accordance with the standards set forth in the plan and, if not, to ensure compliance with such standards.

6. Take such steps as are necessary to achieve complete metering of sewage flows in accordance with the metering recommendations set forth in the plan.

Sanitary and Utility Districts: It is recommended that the governing body of each sanitary and utility district in the Region, as appropriate:

1. Adopt the recommended regional sanitary sewerage system plan as a guide to future sewerage facility development in the district as the plan affects the district, and inform its respective general-purpose local unit of government of such action.

2. Review and adopt the appropriate sewerage facility implementation schedule and accompanying schedule of capital and operation and maintenance costs, and direct its staff and consulting engineers to utilize such schedules in the preparation of detailed facilities plans and in the conduct of engineering studies.

3. Conduct an infiltration and inflow study to determine whether or not an infiltration/inflow problem exists and, if so, the remedial action needed to resolve such problem.

4. Conduct a detailed study relating to the identification of all existing points of sewage flow relief and a determination of the steps necessary to ultimately eliminate such points.

5. Review the operational characteristics of each sewage treatment plant to determine if the facility is properly staffed and operated in accordance with the standards set forth in the plan and, if not, to ensure compliance with such standards.

6. Take such steps as are necessary to achieve complete metering of sewage flows in accordance with the metering recommendations set forth in the plan.

Plan Commissions of Cities, Villages, and Towns: It is recommended that the plan commissions of all cities, villages, and towns within the Region:

1. Adopt the regional sanitary sewerage system plan as a guide to future sewerage facility development in the community and certify such adoption to the local governing body.

2. Integrate the sewerage facility and sewer service area recommendations in the plan into local master plans.

Areawide Level

County Boards of Supervisors: It is recommended that the county boards of supervisors of the seven counties in the Region, upon recommendation of the appropriate agencies and committees:

1. Adopt the regional sanitary sewerage system plan, as it applies to each county, as a guide to the future urban development in the county.

2. Adopt the recommended implementation schedules and schedules of construction and operating and maintenance costs set forth in the plan and appropriate annually the monies so scheduled (Milwaukee County).[4]

3. As appropriate, assist in the creation of metropolitan sewerage districts, joint sewerage commissions, or cooperative contract commissions with respect to those portions of the recommended plan proposing the creation of areawide sanitary sewerage systems (Kenosha, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties).

4. Consider establishment of county grant-in-aid programs designed to encourage the preparation of detailed facilities plans and the conduct of engineering studies that will tend to implement and carry out the recommended regional sanitary sewerage system plan.

Metropolitan Sewerage District of the County of Milwaukee: It is recommended that the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee, acting as agents of the Milwaukee-Metropolitan Sewerage District of the County of Milwaukee:

1. Adopt the recommended regional sanitary sewerage system plan as a guide to future sewerage facility development in the District.

2. Adopt the appropriate implementation schedule and accompanying schedule of capital and operation and maintenance costs.

3. Undertake the initial step of a proposed two-step infiltration/inflow study throughout the District.

4. Undertake responsibility for implementation of the plan recommendation dealing with the abatement of pollution caused by combined sewer overflows in the Milwaukee urbanized area.

5. Conduct a detailed study relating to the identification of all existing points of sewage flow relief in the metropolitan trunk sewer system and a determination of the steps necessary to ultimately eliminate such points.

6. Review the operational characteristics of each sewage treatment plant to determine if the facility is properly staffed and operated in accordance with the standards set forth in the plan and, if not, to ensure compliance with such standards.

7. Take such steps as are necessary to achieve complete metering of sewage flows in accordance with the metering recommendations set forth in the plan.

Other Metropolitan Sewerage Commissions: It is recommended that the Western Racine County Sewerage Commission and any future metropolitan sewerage commissions:

1. Adopt the recommended regional sanitary sewerage system plan as a guide to future sewerage facility development in the metropolitan district.

2. Adopt the appropriate implementation schedule and accompanying schedule of capital and operation and maintenance costs.

3. Undertake in cooperation with its constituent municipalities the infiltration/inflow analyses as recommended in the plan.

4. Conduct a detailed study relating to the identification of all existing points of sewage flow relief and a determination of the steps necessary to ultimately eliminate such points.

5. Review the operational characteristics of each sewage treatment plant to determine if the facility is properly staffed and operated in accordance with the standards set forth in the plan and, if not, to ensure compliance with such standards.

---

[4] *Parentheses indicate that the recommended action is applicable only to the named unit or units of government.*

6. Take such steps as are necessary to achieve complete metering of sewage flows in accordance with the metering recommendations set forth in the plan.

Other Areawide Agencies: It is recommended that the Delafield-Hartland Water Pollution Control Commission, the Underwood Sewer Commission, the Menomonee-South Sewerage Commission, and any other future joint sewerage commission or cooperative contract sewerage commission:

1. Adopt the recommended regional sanitary sewerage system plan as a guide to future sewerage facility development in its jurisdictional area.

2. Adopt the appropriate implementation schedule and accompanying schedule of capital and operation and maintenance costs.

3. Undertake in cooperation with its constituent municipalities the infiltration/inflow analyses as recommended in the plan.

4. Conduct a detailed study relating to the identification of all existing points of sewage flow relief and a determination of the steps necessary to ultimately eliminate such points.

5. Review the operational characteristics of each sewage treatment plant to determine if the facility is properly staffed and operated in accordance with the standards set forth in the plan and, if not, to ensure compliance with such standards.

6. Take such steps as are necessary to achieve complete metering of sewage flows in accordance with the metering recommendations set forth in the plan.

State Level

Wisconsin Department of Natural Resources: It is recommended that the State Natural Resources Board and the Department of Natural Resources:

1. Endorse the recommended regional sanitary sewerage system plan and direct its integration into the water quality management functions and programs conducted by the Division of Environmental Protection.

2. Certify the regional sanitary sewerage system plan to the U. S. Environmental Protection Agency as the official water quality management plan for the seven-county Southeastern Wisconsin Region.

3. Utilize the implementation schedules included in the plan, after careful review and analysis, in the issuance of pollution abatement orders and waste discharge permits and in the disposition of state and federal grant-in-aid monies.

4. Review the sewage treatment plant operator certification program and determine whether or not changes are necessary to assist in upgrading the operation of sewage treatment plants so as to achieve the operating standards needed to carry out the plan recommendations.

5. Require all facilities plans and related engineering studies to include design data related to effluent quality on an average annual basis.

6. Review sewage treatment plant operational reporting requirements to ensure that all of the data necessary to determine whether or not the treatment level performance standards are being met are included in treatment plant operator reports submitted to the department.

7. Cooperate with the Regional Planning Commission in reviewing the joint SEWRPC/DNR water quality monitoring program to determine if changes are desirable in light of plan recommendations.

8. Continue to conduct periodic field pollution investigation surveys of river basins in the Region.

Wisconsin Board of Health and Social Services: It is recommended that the Wisconsin Board of Health and Social Services:

1. Endorse the regional sanitary sewerage system plan.

2. Direct the staff in the Division of Health to utilize the plan recommendations as appropriate in the exercise of the septic

tank regulation and subdivision plat review and approval powers.

Wisconsin Department of Local Affairs and Development: It is recommended that the Wisconsin Department of Local Affairs and Development:

1. Endorse the recommended regional sanitary sewerage system plan.

2. Utilize as appropriate the plan recommendations in the provision of technical assistance to local units of government, in reviewing subdivision plats, and in administering appropriate state and federal grant programs.

Wisconsin Department of Administration: It is recommended that the Wisconsin Department of Administration:

1. Endorse the recommended regional sanitary sewerage system plan.

2. Utilize as appropriate the plan recommendations in the exercise of its state planning and State A-95 Clearinghouse functions.

Federal Level

U. S. Environmental Protection Agency: It is recommended that the U. S. Environmental Protection Agency:

1. Accept and endorse the regional sanitary sewerage system plan upon certification from the Wisconsin Natural Resources Board.

2. Utilize as appropriate the plan recommendations in the approval of waste discharge permits and in the disposition of federal grants-in-aid.

U. S. Department of Housing and Urban Development: It is recommended that the U. S. Department of Housing and Urban Development:

1. Endorse the recommended regional sanitary sewerage system plan.

2. Utilize the plan recommendations in the administration of grants-in-aid and loan programs.

3. Certify that the areawide planning requirements for sewerage purposes in the Southeastern Wisconsin Region have been met.

U. S. Department of the Interior, Geological Survey: It is recommended that the U. S. Department of the Interior, Geological Survey:

1. Formally acknowledge the recommended regional sanitary sewerage system plan.

2. Continue its water resources investigation program, including the provision of low streamflow data.

U. S. Department of Agriculture, Farmers Home Administration: It is recommended that the U. S. Department of Agriculture, Farmers Home Administration:

1. Formally acknowledge the regional sanitary sewerage system plan.

2. Utilize as appropriate the plan recommendations in the administration of its rural waste disposal grant-in-aid and loan programs.

U. S. Department of the Army, Corps of Engineers: It is recommended that the U. S. Department of the Army, Corps of Engineers:

1. Formally acknowledge the regional sanitary sewerage system plan.

2. Utilize as appropriate the plan recommendations in issuing permits for waste outfalls in navigable waters.

(This page intentionally left blank)

Chapter XV

SUMMARY AND CONCLUSIONS

INTRODUCTION

Upon completion and adoption of the regional land use and transportation plans late in 1966, the Regional Planning Commission decided that a regional sanitary sewerage system plan should constitute the next region-wide element of the comprehensive plan for the physical development of the Region to be prepared. Several factors contributed to the recognition of the need to prepare such a plan, namely: inadequate sewer service, particularly in newly developed areas of the Region; forecast population growth and population redistribution, together with concomitant conversion of land within the Region from rural to urban use; deteriorating surface water quality accompanied by increasing conflicts over water use and increasing public demand for water pollution abatement; the widespread occurrence within the Region of soils unsuited to the disposal of sewage through onsite septic tank systems; the increasing use of small, isolated sewage treatment plants and tributary sanitary sewerage systems on an uncoordinated, individual basis, without regard for the effect on areawide land use and sewerage system development or on surface water quality; the importance of the orderly extension of sanitary sewerage service throughout the Region to implementation of the adopted regional land use plan; and a mounting need to meet the areawide planning prerequisites of state and federal sanitary sewerage facility grant-in-aid programs.

These factors were fully explored by a 24-member Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning in a Regional Sanitary Sewerage System Planning Program Prospectus published in December 1968. The Prospectus provided the basis for undertaking the regional sanitary sewerage system planning program, with the cost of the program shared by the seven county boards in the Region and the U. S. Department of Housing and Urban Development. The program was conducted by the Commission staff, supplemented by the contractual services of the Harza Engineering Company, Chicago, Illinois, and was conducted under the continuing technical and policy guidance of the Technical Coordinating and Advisory Committee. The Committee was comprised of the most experienced and distinguished sanitary and municipal engineers working within the Region, including representation from agencies with long experience in the development of sanitary sewerage systems and in the operation and maintenance of sewage treatment facilities, as well as from the Region's major universities.

Next to transportation facilities, sanitary sewerage facilities are the singularly most important public works influencing the development of an urbanizing Region. The location and adequacy of these facilities greatly affect the public health, safety, and welfare; the overall quality of the environment; recreational activity; industrial productivity; and the value and use to which land may be put. If not properly tended to, sewerage system development will inevitably emerge as a major obstacle in the sound growth of the Region, and will become a major policy issue facing public officials, citizen leaders, and technicians.

Sanitary sewerage facility planning cannot be accomplished successfully within the context of a single municipality or county if the municipality or county is part of a larger urban complex. The urbanizing Region must form the geographic unit for sanitary sewerage system planning in order to assure coordination of related subsystems and to assure coordination with areawide land use development.

The regional sanitary sewerage system planning program is directly related to the Commission's series of more broadly oriented land and water resources planning programs conducted on a watershed basis. The Commission's comprehensive watershed planning programs may be thought of as natural resource conservation oriented planning efforts which provide a broad approach to water control facility and related land and water use planning and development. The sanitary sewerage system planning program, on the other hand, may be thought of as an urban development oriented planning effort which seeks to provide the facilities necessary to permit sound urban development within the Region while protecting the underlying and sustaining natural resource base.

The watershed and sanitary sewerage plan elements, together with a land use plan element, must be carefully coordinated and must comprise integrated elements of a single comprehensive areawide development plan.

The purpose of the regional sanitary sewerage system planning program is two-fold:

1. To permit, within a comprehensive framework, public evaluation and choice of alternative sanitary sewerage system development policies and plans.

2. To provide, through an agreed-upon areawide, long-range plan for sanitary sewerage facility development, for the efficient and coordinated development of sanitary sewerage facilities within the Region and for the coordination of such facility development with land use development.

Through the regional sanitary sewerage system planning process several goals are to be attained, including protection of the public health; the abatement of water pollution; the sound investment of public funds in efficient and effective sanitary sewerage systems; the more effective guidance of land use development into a sound areawide pattern; and the wise use of limited land and water resources.

Five basic principles were formulated which formed the basis for the planning process as applied in the regional sanitary sewerage system planning program. These five principles are:

1. Sanitary sewerage system planning must be regional in scope, but must recognize subregional planning areas related to natural watershed boundaries and urban concentrations with well-developed sewerage systems.

2. Sanitary sewerage system planning must be conducted concurrently with land use planning.

3. Both land use and sanitary sewerage facility planning must recognize the existence of a limited natural resource base to which rural and urban development must be adjusted to ensure a pleasant and habitable environment.

4. Sanitary sewerage facilities must be planned as integrated systems or coordinated subsystems.

5. Primary emphasis should be placed on solutions within the natural watershed to sanitary sewerage system development problems related to water pollution abatement.

The major findings and recommendations of the regional sanitary sewerage system planning program are documented and presented in this report. This report is intended to allow careful, critical review of the alternative plan elements by public officials, agency staff personnel, and citizen leaders within the Region, and to provide the basis for plan adoption and implementation by the local, areawide, state, and federal agencies of government concerned. The report can only summarize in brief fashion the information assembled in the extensive data collection, analysis, forecasting, and plan design phases of the program. Although the reproduction of all information assembled in the study in report form is impractical due to its magnitude and complexity, all of the basic data are on file in the Commission offices and are available to member units and agencies of government and to the public in general upon specific request.

INVENTORY AND ANALYSIS FINDINGS

Socioeconomic Base

The seven-county Southeastern Wisconsin Region is an interrelated complex of natural and manmade features, which together form a rapidly changing environment for human life. Important manmade features of the Region include its land use pattern, its public utility networks, and its transportation system. Together with the population residing in the Region and the economic activities taking place within the Region, these features may be thought of as the socioeconomic base of the Region.

The Region consists of a seven-county area encompassing 2,689 square miles of land and inland water area, or about 5 percent of the total area of the State of Wisconsin. About 40 percent of the state's population, however, resides within the seven counties, which employ about 38 percent of the total work force of the state, and which contain about half of all the tangible wealth of the state as measured by equalized assessed valuation. The Region contains 153 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 major watersheds.

The population of the Region has been increasing at an average rate of about 18,000 persons per year from 1960 to 1970, and as of 1970 totaled 1,756,100 persons. This rate of population growth, although higher than state and national rates, is considerably lower than the approximately 33,000 persons per year growth rate experienced within the Region from 1950 to 1960. The composition of the population is becoming increasingly urban, and at the present time only about 12 percent of the total regional population is classified as rural. Moreover, of that 12 percent, about 10 percent is classed as rural nonfarm and only 2 percent is rural farm.

Employment opportunities have increased at a rate of approximately 9,370 jobs per year over the last decade, with a current level of approximately 741,600 jobs within the Region. The economic factors which promote population growth and urbanization within the Region are largely centered in and around the major urban centers of Milwaukee, Racine, and Kenosha, although a diffusion of economic activity into the outlying areas of the Region is occurring.

Land within the Region has been undergoing conversion from rural to urban use at the rate of about 14 square miles per year. Recent urban development within the Region has been discontinuous and highly diffused, consisting primarily of many scattered, low-density, isolated enclaves of residential development located away from established urban centers. Overall urban population densities within the Region, which peaked in 1920 at a level of about 11,000 persons per square mile, have been steadily declining since then to a level of about 4,300 persons per square mile in 1970. The highly diffused nature of recent urban development and a sharp decline in urban population density have intensified many long-standing environmental problems within the Region and have created new environmental and developmental problems of an unprecedented scale and complexity, including problems relating to sanitary sewerage system development.

Natural Resource Base

The importance of considering natural resource base elements in sanitary sewerage system planning cannot be overemphasized, since sanitary sewerage system development, by its impacts on that base, has the potential to either significantly degrade or to protect and enhance the natural heritage and environmental quality of the Region. Furthermore, the monetary costs attendant to the planning, design, construction, and operation of sanitary sewerage systems are, in part, a function of how well such systems are adjusted to the supporting capabilities of the natural resource base. Certain elements of the natural resource base have particular significance to the regional sanitary sewerage system planning program, including temperature, precipitation, prevailing winds, surface drainage patterns, bedrock, soil types, vegetational patterns, and surface waters.

The Region has a climate characterized primarily by a continuous progression of markedly different seasons and a large range in annual temperature, onto which is superimposed frequent, distinct changes in weather conditions which, particularly in winter and spring, normally occur once every two or three days. The annual temperature range, which is based on monthly means for six geographically representative observation stations, extends from a January low of 20.7°F to a July high of 71.0°F. Extreme high temperatures within the Region have ranged from 104°F in the extreme eastern portion of Racine County to slightly more than 110°F in western Walworth, Waukesha, and Washington Counties, whereas extreme low temperatures have ranged from about -20°F along the entire Lake Michigan shoreline to -33°F in the northwestern corner of Washington County. Temperature affects the amount of heat energy needed for sludge digestion at sewage treatment plants and, because of freezing problems, places restrictions on those sewage treatment effluent disposal methods which involve application to the soil in lieu of discharge to surface waters. More importantly, however, temperature markedly affects the reaction rates of aerobic and anaerobic processes which are fundamental to the operation of conventional activated sludge trickling filter sewage treatment processes, as well as self-purification processes occurring naturally in lakes and streams. Aerobic biochemical processes at sewage treatment plants and in natural waters are also influenced by temperature in that these processes require an ample supply of oxygen, the solubility of which decreases markedly with increasing temperatures.

The annual total precipitation in the Region is 30.3 inches, expressed as water equivalent, with monthly averages ranging from a February low of 1.32 inches to a high of 3.86 inches in June. The maximum 24-hour precipitation recorded in the Region was 7.58 inches in the West Bend area on August 4, 1924, and the greatest 24-hour snowfall recorded was 30.0 inches at Racine in February 1898. Precipitation is relevant to the development and operation of sanitary sewerage systems primarily because it is a major causative factor in combined sewer and separate sewer overflows and sewage treatment plant bypasses, all of which can cause serious pollution of the surface water resources.

Prevailing winds follow a clockwise pattern in terms of the prevailing direction over the seasons of the year, being northwesterly in the late fall and in winter, northeasterly in the spring, and southwesterly in the summer and early fall. Beneficial effects of wind include the increased rate of oxygen absorption that occurs in lakes and streams as well as at wastewater treatment units open to the atmosphere, and accelerated evaporation from sludge drying beds.

The regional surface drainage system is characterized by a disordered and dendritic pattern, primarily because of the heterogenous nature of the glacial drift. There is a preponderance of ponds and lakes, and much of the Region is covered by wetlands with many streams being mere threads of water through these wetlands. A major subcontinental divide traverses the Region such that 1,685 square miles, or 63 percent of the Region, drain toward the Mississippi River, while 1,004 square miles, or 37 percent of the Region, are tributary to the Great Lakes-St. Lawrence River drainage basin. The subcontinental divide thus determines the gross surface water drainage pattern and, in addition, poses considerable constraints on water use and sewerage system development. The surface water drainage pattern of the Region may be further subdivided so as to identify 11 individual watersheds and numerous small catchment areas contiguous to Lake Michigan, which may be considered as comprising a twelfth watershed. The surface water drainage pattern and the location of watershed boundaries are pertinent to the regional sanitary sewerage system plan since emphasis on in-watershed solutions is one of the five basic principles formulated under the regional sanitary sewerage system planning program.

The bedrock of the Region is for the most part covered by unconsolidated glacial deposits that are over 500 feet thick in some buried preglacial valleys. In contrast, there are approximately 150 square miles of southeastern Wisconsin, generally east of and parallel to the Kettle Moraine area, where bedrock lies within 20 feet of the ground surface, and a few localized areas where bedrock is actually exposed. Outcrop areas in those portions of the Region having less than 20 feet of glacial drift overlying the bedrock constitute an important consideration in the design and construction of private onsite septic tank sewage disposal systems and public sanitary sewerage systems, since the operation of the former is dependent on favorable soil characteristics while the latter involves extensive trenching and excavation.

A wide variety of soil types have developed in southeastern Wisconsin as the result of the interaction of parent glacial deposits covering the Region, topography, climate, plants, animals, and time. As a result of a detailed soil survey for the Region, all the diverse soil types have been mapped; the physical, chemical, and biological properties have been identified; and interpretations made for planning purposes. Such data and interpretations reveal that approximately 716 square miles, or about 27 percent of the Region, are covered by soils that are poorly suited for residential development with public sanitary sewer service; approximately 1,637 square miles, or about 61 percent of the Region, are poorly suited for residential development without sanitary sewer service on lots smaller than one acre in size; and about 1,181 square miles, or approximately 44 percent of the Region, are poorly suited for residential development without public sanitary sewer service on lots one acre or larger in size.

Woodlands comprise about 133,000 acres, or about 8 percent of land area, while wetlands comprise about 179,000 acres, or about 10 percent of the area of the Region. The proper planning and development of public sanitary sewerage systems, combined with control of private onsite sewage disposal systems, is necessary if the best remaining woodlands and wetlands are to be protected and managed.

Lakes, streams and their associated floodlands, and groundwater comprise the water resources of the Region. The Region contains 1,148 lineal miles of major streams and 100 major lakes, the latter having a total surface area of about 57 square miles, or about 2 percent of the area of the Region, and a total shoreline length of 448 miles. These surface water resources are very vulnerable to man's activities in that their quality can easily degenerate as a result of excessive nutrient and organic pollution loadings from malfunctioning or improperly placed private onsite sewage disposal systems, combined sewer and separate sanitary sewer overflows, and inadequate waste treatment facilities.

Commission studies have indicated that many of the major lakes and many miles of major streams in the Region are being degraded as a result of man's activities to the point where they now have, or soon will have, little or no value for recreational purposes, as desirable locations for controlled water-oriented residential development, or as aesthetic assets of southeastern Wisconsin. Of the 43 major streams in the Region, 21 were found to be essentially unsuitable for the preservation and enhancement of aquatic life, and 33 were found to be essentially unsuitable for recreational use. In general, the surface waters of the Region may be characterized as highly polluted. Surface water degradation is primarily attributable to mismanagement of human wastes, and therefore the regional sanitary sewerage system planning program has important potential to protect the Region's surface water resources.

Analyses indicate the most important remaining elements of the natural resources of the Region are concentrated in narrow elongated areas which have been termed primary environmental corridors. Such corridors occupy approximately 486 square miles, or about 18 percent of the area of the Region, and contain almost all of the remaining high-value wildlife habitat areas and woodlands within the Region; most of the wetlands, lakes, and streams, and associated floodlands; as well as many significant physiographic features and historic sites. Preservation of these primary environmental corridors in their natural state or in related open space uses is essential to maintaining a high level of environmental quality in the Region and to the protection of its natural beauty, and as such is one of the principal objectives of the adopted regional land use plan upon which the regional sanitary sewerage system plan has been based.

Existing Sanitary Sewerage Systems

One of the initial steps in the regional sanitary sewerage system planning program was an inventory of all existing sanitary and combined sewerage systems within the Region, whether publicly or privately owned. Such an inventory is essential to the evaluation of the adequacy of the existing network of sanitary sewers presently serving urban land use development within the Region; an analysis of the deficiencies in the existing systems in meeting present needs; and to a determination of the capabilities of the existing systems to be expanded to meet probable future needs. In addition, an inventory was conducted of all locally prepared sanitary sewerage system plans and engineering reports.

The inventory found that there are a total of 91 existing public sanitary sewerage systems operating within the Region which provide public sanitary sewer service to various subareas of the Region. Together these 91 systems serve a total area of about 309 square miles, or about 11 percent of the total area of the Region, and a total population of about 1.5 million, or nearly 85 percent of the total population of the Region. The remaining 15 percent of the population, or about 268,000 persons, are served by onsite sewage disposal facilities. The percent of the total area of a county served by sewers ranges from a high of 74 percent in highly urbanized Milwaukee County to a low of 2 percent in largely rural Walworth County. The percent of total county population served ranges from a high of 98 percent in Milwaukee County to a low of 47 percent in Washington County.

Of the total 309 square miles of area served by public sanitary sewers in the Region, about 31 square miles, or nearly 10 percent, consist of combined sewer service areas where, by design, sanitary sewage and storm water are collected and conveyed in a single sewer system. About 26 of the 30 square miles of combined sewer service area are in the City of Milwaukee, about one square mile is in the Village of Shorewood, and about two square miles each are in the Cities of Kenosha and Racine.

Treatment for sewage generated in the 91 centralized sanitary sewerage systems is provided at 64 sewage treatment facilities throughout the Region, indicating that many of the systems are actually subsystems of larger systems that provide sewage treatment on an intergovernmental contract or special-purpose district basis. All but three of these 64 sewage treatment facilities discharged treated wastes to the surface waters of the Region. The remaining three treatment plants—those serving the Villages of Darien, Fontana, and Williams Bay—discharge treated wastes to the groundwater reservoir through seepage lagoons. The sewage treatment facilities range in size, as measured by average hydraulic design capacity, from 30,000 gallons per day at the facilities serving the Town of Somers Sanitary District No. 2 in Kenosha County and the Village of Jackson in Washington County to 200 mgd at the Jones Island sewage treatment plant operated by the Milwaukee-Metropolitan Sewerage Commissions. Of the 64 sewage treatment facilities, three, as of 1970, were equipped to provide only a primary level of waste treatment; 58 were equipped to provide a secondary level of waste treatment; two were equipped to provide a tertiary level of waste treatment; and one was equipped to provide an advanced level of waste treatment. Cf the 64 sewage treatment facilities in the Region, 20 were found to be operating at or over their average hydraulic design capacity in 1970, providing an important indication of existing or potential problems associated with sewage treatment facilities.

The total effluent discharged from municipal treatment plants in the Region during 1970 was about 265 mgd. Of this total, 233 mgd, or nearly 88 percent, were discharged directly to Lake Michigan, while an additional 10 mgd, or an additional 4 percent, were discharged to streams draining directly to Lake Michigan. Clearly, the waters in the Lake Michigan basin bear the greatest burden of wastewater assimilation in the Region. The total sewage treatment plant effluent discharged to streams west of the subcontinental divide and, therefore, in the Mississippi River basin, was about 21 mgd, or only about 8 percent of the total sewage effluent discharged in 1970 in the Region. The remaining 1 mgd, or less than 1 percent, were discharged to the groundwater reservoir.

In addition to the 64 facilities providing treatment for wastes generated in the 91 centralized sanitary sewerage systems in the Region, there are a total of 59 private sewage treatment facilities generally serving isolated enclaves of urban land use development. Of these 59 small private treatment plants, 30 are located in the Lake Michigan basin and 29 in the Mississippi River basin. Thus, there are a total of 123 sewage treatment facilities in the Southeastern Wisconsin Region, of which all but 22 discharge wastes to the surface waters of the Region.

An attempt was made in the sanitary sewerage system inventory to identify all known sewage overflow, or relief, points located on either the separate or combined sewerage systems in order to determine the number of points at which raw sewage is presently discharged to surface waters in the Region, particularly during periods of wet weather and peak sewage flows. Thirty of the 64 public sewage treatment facilities serving the Region were found to have a flow relief device located at or just ahead of the sewage treatment plant that would allow the direct bypass of raw sewage at times when the plant capacity is exceeded or the plant is not operable for some reason. In addition, a total of 536 additional flow relief devices are known to exist in the sanitary sewerage systems tributary to the sewage treatment plants within the Region, of which 428 are located in Milwaukee County. Of the 536 known flow relief devices in the Region, not including bypasses or relief pumping stations at sewage treatment plants, 148 are combined sewer outfalls located in the Cities of Kenosha, Milwaukee, and Racine and the Village of Shorewood; 235 are gravity crossovers from the separate sanitary sewer system to a storm sewer system; 75 are gravity bypasses from the separate sewer system directly to surface watercourses; 18 are stationary relief pumping stations, pumping sewage from the separate sanitary sewer system directly to surface watercourses; and 60 are portable relief pumping stations also utilized to pump sewage from the separate sewer system directly to surface watercourses. It is important to note that the foregoing data represent only those flow relief devices that are actually known to exist in the Region and that local officials willingly reported in the inventories conducted under the sewerage system planning program. Consequently, the foregoing data cannot be assumed to constitute an accurate inventory of all such devices within the Region, but rather represent an approximation of the total number of such devices.

An important aspect of the inventory of existing sanitary sewerage systems in the Region related to sewerage system expenditures. Total expenditures during 1970 for operation, maintenance, and capital improvements, including debt retirement, for the sanitary sewerage systems in the Region were found to approximate $43.1 million, or about

$29 per capita, such per capita cost based upon the estimated total population within the Region served by sanitary sewers. Of this total, about $9.4 million, or about $6 per capita, was expended for operation and maintenance, and about $33.7 million, or about $23 per capita, was expended for capital improvements. Total expenditures during 1970 on a per capita served basis ranged from a low of $4 per capita in the Village of Mukwonago to a high of $463 per capita in the City of Franklin. Capital expenditures during 1970 on a per capita served basis ranged from a low of $1 per capita in the Village of Mukwonago to a high of $462 per capita in the City of Franklin. Operation and maintenance expenditures during 1970 on a per capita served basis ranged from a low of $1 per capita in the Cities of Franklin and Muskego to a high of $45 per capita in the Village of Dousman. In general, it was found that operation and maintenance costs for sanitary sewerage systems decreased with increasing system size.

As already noted, about 15 percent of the total regional population, or about 268,000 persons, rely on septic tank sewage disposal systems for domestic sewage disposal. Only about 27,000 of these persons actually reside on farms. The remaining 241,000 persons constitute urban dwellers generally living in a scattered fashion throughout the suburban and rural-urban fringe areas of the Region. Of this total, about 139,000 persons, or about 8 percent of the total regional population, reside in significant concentrations of urban development. These scattered urban concentrations total about 61 square miles of urban land use, or slightly over one-fifth of the area of the Region.

Local units of government in the Region have proposed the extension of sanitary sewer service to about an additional 447 square miles of land throughout the Region. This can be compared to the approximately 309 square miles of area in the Region now served by centralized sanitary sewers. It is assumed that urban development would take place throughout the locally proposed sewer service area at an average overall population density equal to 5,000 persons per square mile, the average population density for new development as recommended in the adopted regional land use plan, the locally proposed sewer service area could be expected to accommodate an incremental population growth of about 2.2 million persons. Thus, locally proposed sewer service areas in the Region already contain enough area to more than double the population of the Region. Since even the most optimistic population forecasts indicate an increase in the population of the Region over the next two to three decades of no more than one million persons, there is a need to better coordinate land use development with sewerage system planning and development within the Region. The most appropriate vehicle for providing such coordination is the adopted regional land use plan.

Sewage Characteristics

Of particular importance in the planning and design of sanitary sewerage systems are the characteristics of the sewage to be collected and treated, including the rate and volume of flow and the concentration of contaminants. Several investigations were made under the regional sanitary sewerage system planning program to determine the flow and strength characteristics of sewage generated in the Region. Such characteristics were then utilized, together with widely accepted engineering standards and experienced engineering judgment, as a basis for the selection of sewerage system design criteria.

The principal sources of sanitary sewage are spent municipal water supply, groundwater infiltration, and storm water inflow. Analyses conducted under the program indicated that, with respect to sewage flows, the average amount of domestic sewage flow contributed by all urban land uses except major industrial and commercial concentrations was 88 gallons per capita per day; the average amount of sewage flow contributed by major concentrations of industrial land uses was 12,270 gallons per acre per day; the average amount of sewage flow contributed by major concentrations of commercial land uses was 7,640 gallons per acre per day; the average infiltration rate was 0.24 gallons per minute per gross developed acre; the average storm water inflow rate was 0.57 gallons per minute per gross developed acre; the average peak-to-average flow rate for trunk sewers was 3.72 to 1; and the average peak-to-average flow rate for sewage treatment plants was 1.87 to 1 (see Table 87).

While variation in sewage strengths is not as critical a consideration in regional sanitary sewerage system planning as variation in sewage flow rates, a knowledge of sewage strength characteristics is required to determine the necessary type and level of treatment to be provided and the potential effects of effluent discharges on the quality of the receiving streams. Analyses conducted under the program indicated that, with respect to sewage strength characteristics, the average five-day carbonaceous biochemical oxygen demand in municipal sewage was equivalent to a contribution of 0.259 pound per capita per day; the average suspended solids value was 0.219 pound per capita per day; the average total phosphorus value was 0.0138 pound per capita per day; the average organic nitrogen value was 0.011 pound per capita per day; and the average ammonia nitrogen value was 0.0143 pound per capita per day. Actual average sewage strength values found were 195.9 mg/l of $CBOD_5$; 170.9 mg/l of suspended solids; 11.9 mg/l of total phosphorus; 10.5 mg/l of organic nitrogen; and 15.4 mg/l of ammonia nitrogen.

Sewerage Law

Sewerage related law consists primarily of water pollution control legislation and administrative machinery at the federal, state, and local levels of government. With the passage of the Federal Water Pollution Control Act Amendments of 1972, the U. S. Congress set in motion a series of actions which will have many ramifications for sewerage system planning and development within the Region. Water use objectives and supporting water quality standards are now required for all navigable waters in the United States. It is a national goal to eliminate the discharge of pollutants into navigable waters of the United States by 1985, and to achieve an interim goal of suitable water quality for the maintenance of fish life and for use for human recreational activities in and on the waters by 1983. To meet these goals the Act requires, in addition to water use objectives and water quality standards, the enactment of specific effluent limitations for all point sources of water pollution. If economically and technically feasible, such effluent limitations could include a complete discharge prohibition. For certain categories of polluters, national standards of performance with respect to the discharge of pollutants are to be formulated and applied to any newly established source within the categories. Thus, no matter what the assimilative capacity may be of a receiving water body, a newly established industrial firm anywhere in the nation will have to meet the national standard.

The new federal Act also establishes a pollutant discharge permit system under which the federal Environmental Protection Agency (EPA), or a state upon approval of the EPA, is to issue permits for the discharge of any pollutants, subject to the conditions that the discharge will meet all applicable effluent limitations and contribute toward achieving the established water use objectives and supporting water quality standards. This new system supercedes the established but little utilized waste discharge permit system under the federal Refuse Act of 1899.

Each state must have a continuing water quality management planning process designed to achieve the overall water quality objectives in the Act. This state planning process is to be designed to result in the preparation of comprehensive development plans for natural basins and watersheds and must incorporate metropolitan or regional sanitary sewer system plans. In order to provide a firm basis upon which to expend federal monies in metropolitan areas for public waste treatment works construction, the new Act requires the development and implementation of areawide waste treatment management plans. The regional sanitary sewerage system plan for southeastern Wisconsin is intended to constitute the first step in meeting this requirement. The EPA administrator can only make federal grants for waste treatment works construction to such management agencies and only for treatment works and related sewerage facilities found to be in accordance with the officially adopted plan. In addition, no permits may be issued for any point sources of water pollution found to be in conflict with an adopted areawide waste treatment management plan.

Federal funding for waste treatment works construction, including related sewerage facilities, has been set at 75 percent of construction costs. In addition to meeting planning requirements, any federal grant recipient must establish a system of sewer service charges to assure that each recipient of waste treatment services pays its proportionate share of the operation, maintenance, and replacement costs of the waste treatment services provided.

Responsibility for water pollution control in Wisconsin is centered in the Department of Natural Resources. The Department is given the authority to prepare long-range water resources plans, to set standards of water quality applicable to all waters of the state, to issue pollution abatement orders to certify sewage treatment plant operators, to review and approve plans for sewerage facilities, to order the installation of sanitary sewerage systems, and to administer financial assistance programs for the construction of pollution abatement facilities. In addition, recent legislation has given the Department the authority to set up a waste discharge permit system designed to implement the national pollutant discharge system established under the aforementioned federal Water Pollution Control Act Amendments of 1972. Water use objectives and supporting water quality standards have been adopted by the Wisconsin Natural Resources Board for all waters in the state, and provide a basic input to the formulation of the regional sanitary sewerage system plan.

Local water pollution control machinery generally centers around specific methods of organizing to provide for sanitary sewer service. Cities and villages under the home rule power can take all steps necessary to effectively establish, operate, and maintain sanitary sewerage systems, including the adoption of rules regulating the discharge of substances into such systems. Counties and towns do not have such broad authority. Towns, however, may form sanitary or utility districts to provide such sewerage service to portions of the town.

Several ways exist to provide for areawide sanitary sewerage systems. In addition to the long-established Metropolitan Sewerage District of the County of Milwaukee, other metropolitan sewerage districts, which must include at least one city or village in its entirety, may be established under state law. In addition, adjacent communities can establish joint sewerage commissions to operate areawide facilities upon approval of the Department of Natural Resources. The general grant of intergovernmental cooperation powers set forth in Section 66.30 of the Wisconsin Statutes also is available to establish areawide sewerage systems.

DEVELOPMENT OBJECTIVES

The task of formulating objectives and standards to be used in plan design and evaluation is a difficult but necessary part of the planning process. Regional plan elements must advance development proposals which are physically feasible, economically sound, aesthetically pleasing, and conducive to the promotion of public health and safety. Agreement on development objectives beyond such generalities, however, becomes more difficult to achieve because the definition of specific development objectives and supporting standards inevitably involves value judgments. Nevertheless it is essential to state such objectives for the development of regional sanitary sewerage systems and to quantify them insofar as possible through standards in order to provide a framework through which the regional sanitary sewerage system plan can be prepared. Moreover, so that the regional sanitary sewerage system plan will form an integral part of the overall framework of long-range plans for the development of the Region, the regional sanitary sewerage system objectives must be compatible with and dependent upon other regional development objectives. Therefore, the regional sanitary sewerage system development objectives and supporting principles and standards set forth in this report are based upon previously adopted regional development objectives as established under the regional land use and watershed planning programs, supplemented as required to meet the specific needs of the regional sanitary sewerage system planning program.

Four new development objectives, together with supporting principles and standards, were formulated under the regional sanitary sewerage system planning program. These four new development objectives are:

1. The development of sanitary sewerage systems which will effectively serve the existing regional urban development pattern and promote implementation of the regional land use plan, meeting the anticipated sanitary waste disposal demand generated by the existing and proposed land uses.

2. The development of sanitary sewerage systems so as to meet established water use objectives and supporting water quality standards (see Map 49).

3. The development of sanitary sewerage systems that are properly related to and will enhance the overall quality of the natural and manmade environments.

4. The development of sanitary sewerage systems that are both economical and efficient, meeting all other objectives at the lowest cost possible.

Together with the land use and related water control facility development objectives previously established under related Commission work programs, these new development objectives and their supporting principles and standards provided the basic framework within which alternative regional sanitary sewerage system plans were formulated and a recommended regional sanitary sewerage system plan synthesized.

DESIGN CRITERIA

A very important part of the regional sanitary sewerage system planning program was the selection of engineering design criteria and analytic procedures utilized in the design of alternative sewerage system plans and in the essential economic comparisons between such plans. While the design criteria in general are widely accepted and firmly based in current civil and sanitary engineering practice, it was nevertheless deemed important to document the criteria as part of the planning program report. Such criteria were based upon and related to a discussion of the state of the art of sanitary sewerage.

It was determined as part of the review of the state of the art of sanitary sewerage that the system of using water carriage for domestic wastes to central locations for treatment can be expected to remain the normal sewerage practice within the Region for at least the next several decades. Despite the seemingly high capital costs of the sewerage systems necessary to collect and convey the sewage to central locations, it was concluded that the water carriage system of sewage disposal has fewer and less serious disadvantages than the practically available alternatives. The disadvantages of available alternatives, which consist of various onsite disposal systems, include higher unit costs, inability to dispose of kitchen wastes and wash water, maintenance problems, and lack of demonstrated technical feasibility. The review of the state of the art also concluded that the current policy of building separate sanitary and storm sewerage systems is sound and there is no reason to question the validity of continued reliance on separate sewerage systems. This conclusion was reached even though it was conceded that treatment of storm water may eventually be required in some areas for sound water quality management.

The engineering design criteria and analytic procedure set forth in this report were applied in the analysis of the existing sanitary sewerage systems, in the synthesis and testing of alternative plans, and in the making of economic comparisons between those plans. With respect to sewer design, the criteria relate to sewage flows, hydraulic friction, pipe capacity, flow velocity, depths of flow, minimum sewer slopes, and construction practices. After analyzing inventory data relating to actual sewage flows in the Region and comparing such data with generally recommended sewage flow design standards, criteria were developed relating average daily and instantaneous peak sewage flows to the major land use categories identified on the adopted regional land use plan and to allowances for normal groundwater infiltration and storm water inflow.

An average daily sewage flow contribution of 125 gallons per capita per day was utilized for sizing sewerage system components, including all domestic, commercial, and industrial sewage contributions exclusive of inflow and infiltration. For major industrial and retail land use concentrations, a peak daily sewage flow contribution of 7,500 gallons per acre was utilized. A variable peak-to-average ratio for sanitary sewage, excluding infiltration and storm water inflow, was utilized to design trunk sewers, with the ratio varying from a low of 2.5 to 1 to a high of 5.0 to 1 depending upon the population of the service area tributary to the given sewer. A total peak infiltration flow allowance of 0.6 gallon per minute per acre was established, which allowance was intended to be added to the peak flow rate derived by appropriately factoring the base flow of 125 gallons per capita per day. In addition, a peak storm water inflow allowance of an additional 0.6 gallon per minute per acre was established, which, like the infiltration allowance, was intended to be added to the peak flow rate derived by factoring the base flow. Based on the foregoing sewage flow criteria, design curves were prepared related to each of the three urban density categories utilized in the regional land use plan—low, medium, and high density.

With respect to sewer hydraulics, the Manning formula was utilized for calculations of sewer flow velocities, discharges, and slopes. A Manning roughness coefficient, or "n value", of 0.013 was used in hydraulic calculations for all sewers, with the exception of cement-lined cast iron force mains where an "n value" of 0.015 was used. All sewers were designed to flow full at a maximum velocity of 15 feet per second and at a minimum velocity of 2 feet per second under peak design flow conditions.

With respect to the design of pumping and lift stations, such stations were sized in the program to handle the peak flow rates from the tributary sewer service area discharging to the station.

Wet wells in the stations were assumed to have sufficient capacity to eliminate surcharging of influent sewers under design loadings. A minimum of two pumping units was assumed for each station, with sufficient pump capacity to meet the peak flow demand with the largest unit out of service.

The design criteria with respect to sewage treatment plants involved such factors as hydraulic loadings, pollution loadings, receiving streamflows, receiving stream waste assimilative capacities, and the kind and level of treatment to be provided. In the regional sanitary sewerage system plan the design capacity of sewage treatment plants was established by calculating the estimated average daily sewage flow from the entire tributary sewer service area, based on a flow rate of 125 gallons per capita per day. In addition, a constant rate of infiltration of 0.6 gallon per minute per acre was assumed, with the acreage being computed by dividing the forecast 1990 population by a medium population density of 10.2 persons per acre. This procedure results in an equivalent infiltration flow of 85 gallons per capita per day which, when added to the sanitary sewage flow of 125 gallons per capita per day, resulted in a design flow of 210 gallons per capita per day. Design flows for sewage treatment plants were, therefore, computed as the product of 210 gallons per capita per day and the forecast 1990 population of the service area, except where 1970 sewage treatment plant flows were known, in which case the design flow was calculated as the 1970 flow plus the product of 210 gallons per capita per day and the forecast 1990 population increment.

With respect to pollution loadings, the following criteria were utilized: suspended solids—0.21 pound per capita per day; carbonaceous biochemical oxygen demand ($CBOD_5$)—0.21 pound per capita per day; nitrogen—0.054 pound per capita per day as a total nitrogen, 0.027 pound per capita per day of the nitrogen as ammonia; and phosphorus—0.01 pound per capita per day. Equivalent influent sewage strengths were 120 mg/l of suspended solids, 120 mg/l of $CBOD_5$, 31 mg/l of total nitrogen, 15.5 mg/l of ammonia nitrogen, and 5.7 mg/l total phosphorus.

Each sewage treatment facility was designed based on an assumed streamflow at the discharge point equivalent to the lowest average flow over seven consecutive days in the last decade. The forecast 1990 seven day-ten year low flows were estimated for all existing and potential sewage treatment plant locations as the sum of the natural low flow plus the forecast 1990 flow from upstream sewage treatment plants. An oxygen sag curve model was developed to determine for each sewage treatment plant location the treatment levels required in order to assure adequate dissolved oxygen in the receiving stream so as to meet the water quality standards that support the water use objectives. Based on the application of the model, design curves were prepared for use in determining the level and type of treatment required at a potential sewage treatment plant site. Consideration was also given in establishing the level of treatment required to the steps necessary to avoid ammonia toxicity in the receiving streams.

Criteria utilized to make economic comparisons between alternative sanitary sewerage system plan elements were also developed. For purposes of the economic analysis, an interest rate of 6 percent was used and sewers and land were assumed to have an economic life of 50 years, whereas treatment facilities and pumping and lift stations were assigned a 25-year economic life. Although the plan design period is for the 20-year period from 1970 to 1990, the economic analysis period was taken as the 50-year period from 1970 to 2020. Cost computations assumed that construction of major sewerage system plan elements will commence in 1975. All construction costs and all equivalent annual costs expressed in the plan are expressed as 1970 values.

ANTICIPATED GROWTH AND CHANGE

In the preparation of a sanitary sewerage system plan for the Region, future population and economic activity levels must be forecast. These forecasts, when combined with the engineering design criteria discussed above, can then be converted to future demand for sewage treatment facilities within the Region, and a sewerage system plan and alternatives thereto prepared to meet the demand.

The regional land use plan was an essential input into the design of the regional sanitary sewerage system plan, since sewerage system planning must assume some anticipated distribution of future urban land uses in order to properly size and locate sewage conveyance and treatment facilities, and must further assume anticipated population and economic activity levels in order to determine future waste loadings on sewerage systems. The adopted regional land use plan was based upon an initial 1990 forecast population level of about 2.7 million persons, representing an increase of nearly one million persons over the 1963 population level. Employment in the Region was expected to reach nearly the one million job level by 1990, an increase of nearly 350,000 jobs over the 1963 level. This anticipated growth in population and employment was to be accommodated in the plan through the conversion of about 200 square miles of land from rural to urban use over the 27-year period 1963-1990. The regional land use plan contained specific recommendations for the amount and spatial location of future residential development, as well as the establishment of major commercial, industrial, and recreational centers. The plan recommended that the majority of new residential land uses within the Region be developed at medium densities and be provided with public sanitary sewer and water supply services. By 1990 the plan envisioned about 580 square miles, or 95 percent of the developed urban area, and about 2.5 million persons, or 95 percent of the total forecast population, being served by both public sanitary sewer and water supply facilities.

While the regional sanitary sewerage system plan was designed to serve the adopted regional land use plan, the dynamic nature of development trends in the Southeastern Wisconsin Region required that attention be given to potential changes in the development trends with respect to land use and population distribution reflected in the regional land use plan. Accordingly, the probable impact upon the regional sanitary sewerage system plan of revised population forecasts that became available as the regional sanitary sewerage system plan was nearing completion and which were prepared as part of the Commission's continuing comprehensive planning effort were evaluated. This evaluation indicated that the population was tending to grow at a somewhat slower rate than originally forecast, and that the design year population level for the adopted regional land use plan—and therefore, for the recommended sewerage system plan—of about 2.7 million persons would probably not be reached until the year 2000, or about a decade later than originally envisioned. More importantly, this evaluation indicated that population was tending to grow more rapidly than originally anticipated in the outlying areas of the Region and less rapidly than originally anticipated in the three major central urban areas of the Region—Milwaukee, Racine, and Kenosha. It was concluded that such changing development trends would, however, have little impact upon the regional sanitary sewerage system plan since, with respect to those areas of the Region growing more rapidly than originally anticipated, the sewerage system plan recommendations would be the minimum necessary to handle anticipated future urban growth, while with respect to the three central city metropolitan areas in the Region, the basic areawide sanitary sewage systems are already substantially in place and for system continuity and water pollution abatement purposes must be completed.

ALTERNATIVE PLANS

Plan design, test, and evaluation comprise the very heart of the planning process. The various alternative sanitary sewerage system plans considered were designed to meet the established water use objectives and supporting water quality standards and, in addition, to contribute toward implementation of the adopted regional land use plan. Based upon the state of the art of sanitary sewerage and upon previous sewerage system planning experience gained in Commission watershed studies for the Fox and Milwaukee Rivers, it was concluded that major emphasis in the formulation of alternative sanitary sewerage system plans for subareas of the Region should be based upon conventional centralized sanitary sewerage systems providing high degrees of treatment at sewage treatment facilities, with discharge of treated wastes primarily to surface waters. Thus, the basic alternatives considered centered upon the provision of advanced waste treatment where necessary to achieve the established water use objectives, with the alternatives differing primarily with respect to the question of whether a given subarea of the Region should be served by a single sewage treatment facility or by multiple sewage treatment facilities. This required consideration of alternative trunk sewer arrangements to convey sewage to designated sewage treatment facilities.

While major emphasis was placed in the study on the basic alternative of providing advanced levels of waste treatment at varying treatment plant locations throughout the Region and on alternative means of conveying sewage to these locations, other concepts of waste management, such as the diversion of effluent from one watershed to another, particularly across the subcontinental divide traversing the Southeastern Wisconsin Region, and land disposal of effluent as alternatives to high degrees of waste treatment were considered. None of these alternative conceptual solutions to the water quality management problems of the Region were, however, considered viable on a region-wide scale. For example, not only would total sewage effluent diversion within the Region from the Lake Michigan basin to the Mississippi River basin constitute a task of major proportions, involving over 90 percent of all sewage effluent currently discharged within the Region, but the cost of diversion of such effluent would almost totally be an "add on" cost to any of the alternative system plans considered, since the conveyance facilities required to effect such diversion represent an additional cost beyond what would be needed to provide sanitary sewer service and adequate sewage treatment if sewage effluent were continued to be discharged into the Lake Michigan basin. Such "add on" costs were estimated to approximate $136 million. Similarly, land disposal of sewage effluent was found to be a waste management concept having many interrelated problems, not the least of which would be the extremely large amount of land needed to successfully dispose of the large volume of waste generated daily within the Region. Depending upon assumptions made for land requirements for liquid waste disposal, the total area required for disposal of sewage effluent by land treatment in the Region would vary from about 150 to 360 square miles, or from about the combined area of four normal-sized townships to an area somewhat larger than Racine County. This is not to say, however, that the waste management concepts of diversion and land disposal may not be practical and applicable for a small individual community, particularly in the more rural areas of the Region.

In order to formulate alternative sanitary sewerage system plans, the Region was divided into 11 distinct subregional areas based upon natural major watershed divides, the external boundaries of the Region, existing and potential service areas of existing centralized sanitary sewerage systems, and existing and probable areas of urban concentration. Eleven such areas were designated: Milwaukee-metropolitan, Upper Milwaukee River, Sauk Creek, Kenosha-Racine, Root River Canal, Des Plaines River, Upper Fox River, Lower Fox River, Upper Rock River, Middle Rock River, and Lower Rock River. A total of 91 individual sewer service analysis subareas were identified within the 11 designated subregional sewerage system planning areas. Alternative sewerage system plans were then prepared to provide for centralized sanitary sewer service to these 91 sewer service analysis subareas.

A systematic procedure was utilized to eliminate from consideration those alternative sanitary sewerage system plans that were clearly impractical. An initial screening of potential interconnections was made based upon Wisconsin Department of Natural Resources guidelines relating the sewer lengths required for interconnection to the populations of the communities involved. If a potential interconnection was found to be feasible based upon this initial screening, a preliminary economic analysis was performed to provide gross cost estimates of the alternative available. Any potential interconnection which was found to be feasible after the preliminary economic analysis was included as an alternative plan set forth in the report and for which a detailed economic analysis was performed. Both the preliminary screening and the preliminary economic analysis steps were intentionally biased toward interconnection, so that all practical alternative plans were fully evaluated.

A total of 38 alternative sanitary sewerage system plans were prepared and fully evaluated. In addition, 28 system plans were prepared for communities in the Region without any interconnection potential. Thus, a total of 66 sanitary sewerage system plans for various subareas of the Region were prepared, costed, and evaluated. Each of the alternative plans included recommendations concerning the location, capacity, level of treatment, and performance standards for sewage treatment facilities, as well as proposed configurations and sizes of necessary intercommunity trunk sewers. Detailed cost estimates for all alternative plans are presented in the report.

RECOMMENDED PLAN

The recommended regional sanitary sewerage system plan for southeastern Wisconsin is comprised of five major elements: sewer service areas, sewage treatment facilities, trunk sewers, abatement of combined sewer overflows, and auxiliary elements applicable in general to all sanitary sewerage systems.

Sewer Service Areas

The plan recommends that centralized sanitary sewer service be extended to a total area of about

675 square miles, or about 25 percent of the total area of the Region. It is anticipated that about 2.6 million persons would reside in this area and be provided with centralized sanitary sewer service in the Region by 1990, representing nearly 97 percent of the total anticipated 1990 regional population of nearly 2.7 million persons. The incremental sewer service area recommended in the plan totals about 366 square miles, considerably less than the locally proposed incremental sewer service area of nearly 450 additional square miles, thus reflecting the effect of proper consideration of areawide development objectives and areawide land use and sewerage system plans on the sewerage system planning process.

Sewage Treatment Facilities

The recommended sanitary sewerage system plan for the Region is based upon the provision of conventional centralized sanitary sewerage systems providing high levels of treatment at sewage treatment facilities with discharge of treated wastes primarily to surface waters. The plan recommends that sewage treatment be provided at a total of 52 public sewage treatment facilities. In order to meet the established water use objectives and supporting water quality standards for the surface waters in the Region, the plan recommends that 41 of the 52 public sewage treatment facilities provide advanced waste treatment, with the remaining 11 plants recommended to provide a secondary level of waste treatment. Full implementation of the recommended plan will enable the abandonment of 22 existing public sewage treatment facilities, 13 of which are currently located in Milwaukee County and in the existing and proposed contract areas of the Milwaukee-Metropolitan Sewerage Commissions and Ozaukee, Racine, Washington, and Waukesha Counties. Implementation of the plan would further permit the abandonment of 29 of the existing 59 private sewage treatment facilities now serving isolated urban land use enclaves in the Region.

Trunk Sewers

The recommended plan includes proposals for those trunk sewers necessary to extend centralized sanitary sewer service to all of the proposed 1990 sewer service area, to enable the abandonment of 22 existing public sewage treatment facilities, and to provide for intermunicipal connections between sewer service areas. The general alignment and the approximate size of these intercommunity trunk sewers is shown on the recommended plan map (see Map 131). In addition, locally proposed trunk sewer extensions, which generally involve only a single community and which are important to the attainment of the basic plan recommendation to provide sewer service to the recommended future service areas, were submitted by local officials as important adjuncts to the recommended plan. These plan proposals are on file in the Commission offices.

Abatement of Combined Sewer Overflows

The plan further proposes to abate combined sewer overflows in the Milwaukee, Racine, and Kenosha areas of the Region. In the Milwaukee area the plan recommends proceeding with full implementation of the recommendations contained in the adopted Milwaukee River watershed plan to construct a combination deep tunnel mined storage/flow-through treatment system to collect, convey, and adequately treat all combined sewer overflows throughout the approximately 27 square mile combined sewer service area in Milwaukee County. The plan further recommends that, based upon a prospectus completed in July 1973, the Milwaukee-Metropolitan Sewerage Commissions undertake a preliminary engineering study as the initial step toward implementing the watershed plan recommendation. The prospectus recommends that the preliminary engineering study begin with a careful review of the findings and recommendations of the adopted Milwaukee River watershed plan and, based upon a review of the findings of any new research and demonstration projects completed since preparation and adoption of the watershed plan, either reaffirm the basic validity of the combined sewer overflow abatement recommendations contained in the watershed plan or provide alternative recommendations. Three of the most important purposes of the preliminary engineering study will be to determine an optimum combination of storage and flow-through treatment, the practicality of the required tunnel and mined storage construction in the bedrock, and the practicality of utilizing either conventional or flow-through treatment for the highly diluted combined sewer overflows. In the Racine area the plan recommends that definitive recommendations concerning which of the remaining combined sewer area should be separated and which should receive flow-through treatment facilities be held in abeyance until completion of the current research and demonstration study and a determination of the most cost effective method of resolving the combined sewer overflow problem. Similarly, in the Kenosha area the plan recommends awaiting the results of a research and demonstration project aimed at determining the feasibility of providing standby treatment capacity before proceeding with completion of a long-proposed sewer separation program.

Auxiliary Plan Elements

In addition to the foregoing specific recommendations concerning the construction of sewerage facilities, the plan includes several auxiliary elements applicable in general to all sanitary sewerage systems. The plan recommends that clear water elimination efforts be mounted in all communities and that the design criteria utilized to prepare the plan become the standard for determining whether or not excessive clear water inflows exist within the existing systems or subsystems. The plan further recommends that steps be taken to eliminate all of the nearly 600 points of sewage flow relief found to exist in 1970 throughout the Region. In addition, the plan recognizes the need to substantially upgrade the operation and maintenance of sewage treatment plants in order to provide for the higher levels of waste treatment that will be necessary to implement the plan and achieve the established water use objectives. Toward this end, this plan sets forth recommended staffing and operational standards for typical plant sizes. To overcome problems uncovered in sewerage system inventories concerning a lack of definitive knowledge of total sewage flow, the plan recommends that steps be taken to provide for full metering of all flows, including metering at major bypass points. With respect to sludge disposal, the plan recommends that individual case-by-case engineering studies be undertaken to determine the most cost effective method of sludge handling, reduction, and disposal or recycling at individual municipal treatment plants. Finally, the plan recommends that the data obtained under the joint Commission-Department of Natural Resources stream water quality monitoring program be reviewed, and that such review serve as a basis for the formulation of definitive recommendations as to any needed changes in the monitoring program needed to properly assess the status and effect of plan implementation and the achievement of the established water use objectives over time.

PUBLIC REACTION TO RECOMMENDED PLAN

As an integral part of the regional sanitary sewerage system planning program, a series of informal public informational meetings and a formal public hearing were held within the Region. The purpose of these meetings and hearing was to more fully inform public officials and interested citizens about the findings and preliminary recommendations of the sewerage system planning program, and to obtain the reaction of the officials and citizens to the regional sanitary sewerage system plan recommended by the Commission staff and by the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning, together with the alternatives thereto. The meetings and hearing were preceded by an extensive program of notification, including letters to concerned local, state, and federal public officials; to citizen groups; librarians; and to about 3,500 individuals and organizations included on the Commission Newsletter mailing list. In addition, a series of news releases was issued to all media in the Region. Minutes of the informational meetings and public hearing and documentation of the notification procedures utilized were published on December 31, 1973.

The preliminary plan recommendations, including the water use objectives, the waste treatment levels required to meet these objectives throughout the Region, the sewer service areas, and the trunk sewers and treatment facilities required to serve these areas, met a very favorable response at the meetings and hearing. The meetings and hearing indicate that significant controversy existed with respect to the plan recommendations in only five geographic subareas of the Region: the Lake Church area in Ozaukee County, the Green Lake area in Washington County, the Tri-Lakes area in Washington County, the Delafield-Hartland area in Waukesha County, and the Elkhorn-Delavan area in Walworth County. The Commission held a series of additional intergovernmental meetings between the parties concerned in an effort to arrive at a consensus with respect to the final recommendations to be contained in the adopted regional sanitary sewerage system plan. After holding these meetings and after reviewing all of the comments, opinions, and data presented during these meetings and at the public informational meetings and hearing, the Commission determined to change the recommended regional sanitary sewerage system plan in three specific geographic subareas of the Region. The Commission acted to delete from the plan the recommendations to establish new sanitary sewerage systems and accompanying treatment facilities to serve the Green Lake area of Washington County and the Village of Merton in Waukesha County, and acted to add to the plan the recommendation to abandon the small sewage treatment facility serving the Walworth County institutions and Lakeland Hospital in the Town of Geneva and connect these institutions to the City of Elkhorn sewerage system.

COST ANALYSIS

The full capital investment cost of implementing the recommended regional sanitary sewerage system plan is estimated at about $507 million over the 20-year plan implementation period 1970-1990. Of this total cost, about $134 million, or about 26 percent, is required to fully implement the recommended sewage treatment plant element of the plan; about $194 million, or about 38 percent, is required to fully implement the intercommunity trunk sewer element of the plan; with the remaining $179 million, or about 36 percent, required to fully implement the combined sewer overflow abatement element of the plan. The average annual cost of the total capital investment required for plan implementation approximates $25 million, or about $12 per capita, while the average annual operation and maintenance cost associated with the plan also approximates $25 million, or about $12 per capita. It is anticipated that all of the components of the recommended plan requiring capital investment will be eligible for federal and state grants-in-aid and that full utilization of these financial resources could serve to reduce the local plan implementation costs with respect to capital investment by as much as 80 percent.

An analysis was conducted of the expenditure trends for public sanitary sewerage purposes in the Region during the period 1960 to 1970. This analysis revealed an average annual expenditure over that period of about $49 million for sanitary sewerage purposes, representing about 6 percent of the average annual public revenues received by the local units of government over the same period. Based upon the historical data, four alternative forecasts were prepared to indicate the possible range of future expenditures by local governments in the Region for public sanitary sewerage purposes. These forecasts range from a low of about $1.4 billion, based upon an assumption that the average per capita expenditures which obtained over the 1960 to 1970 period would continue to the year 1990, to a high of about $2.6 billion, based upon an assumption that the average annual rate of increase of per capita expenditures which obtained over the 1960 to 1970 period would continue to the year 1990. An average of these four forecasts indicates that a total expenditure for public sewerage purposes of about $2.0 billion may be anticipated over the 20-year period. This amount can be compared on a gross basis with the estimated total cost of implementing the entire recommended regional sanitary sewerage system plan for the Region, including operation and maintenance as well as capital costs, of about $1.0 billion. Based upon this analysis, it was concluded that sufficient monies to substantially implement the recommended regional sanitary sewerage system plan should become available without significant shifts in local expenditure patterns.

THE UNPLANNED ALTERNATIVE

As part of the regional land use planning program, an unplanned land use development alternative was examined. This alternative assumed the continuation of existing trends in land use development in the absence of any attempt to guide such development on an areawide basis in the public interest. It was considered impractical under the regional sanitary sewerage system planning program to prepare an alternative plan for providing sanitary sewerage to the unplanned regional land use alternative. An analysis was made, however, of the cost of providing sewer service to a selected subarea of the Region utilizing the unplanned alternative as a basis for the analysis. The selected subarea is located in the Town of Caledonia, Racine County.

Three alternative methods of providing sewer service to the unplanned land use alternative development pattern in the study area were examined: septic tank systems; provision of centralized sewer service with treatment at a series of small pre-engineered or "package" treatment plants; and provision of centralized sewer service with treatment at a single sewage treatment facility. The analysis revealed that per capita costs of providing sewer service for the three unplanned alternatives were $26, $102, and $87, respectively. The per capita cost of implementing the recommended regional sanitary sewerage system plan for the same study area is estimated at $67. Since about 60 percent of the Region is covered by soils unsuited or poorly suited to septic tank utilization, it may be concluded that the provision of centralized sanitary sewer service to the urban development pattern recommended in the adopted regional land use plan is not only the most cost effective way of accommodating future urban development in the Region, but would also serve to most effectively protect the underlying and sustaining natural resource base. Even in those instances where it may be concluded that soils are suitable to support septic tank development, analyses conducted by the Commission under other planning programs reveal substantial additional costs generated by a low density urban development pattern, particularly with respect to transportation costs. Such additional costs must of necessity temper any conclusion that widespread low density urban development on septic tanks represents a desirable regional settlement pattern.

IMPLEMENTATION

The legal and governmental framework existing in the Southeastern Wisconsin Region is such that the existing local, areawide, county, and state units and agencies of government can readily implement all of the major recommendations contained in the regional sanitary sewerage system plan. In Chapter XIV of this report, a comprehensive, cooperative, intergovernmental plan implementation program is set forth which indicates the specific actions which will be required at each level, agency, and unit of government operating within the Region if the recommended sewerage system plan is to be fully implemented. These levels, agencies, and units of government include, at the local level, the governing bodies of the cities, villages, towns, and sanitary and utility districts within the Region; at the areawide level, the governing bodies of the counties, metropolitan sewerage commissions, joint sewerage commissions, and cooperative contract sewerage commissions; at the state level, the Wisconsin Department of Natural Resources; the Wisconsin Department of Health and Social Services, Division of Health; the Wisconsin Department of Local Affairs and Development; and the Wisconsin Department of Administration; and at the federal level, the U. S. Environmental Protection Agency; the U. S. Department of Housing and Urban Development; the U. S. Department of the Interior, Geological Survey; the U. S. Department of Agriculture, Farmers Home Administration; and the U. S. Department of the Army, Corps of Engineers.

Primary emphasis in the regional sanitary sewerage system plan implementation is based upon actions by the U. S. Environmental Protection Agency; the Wisconsin Department of Natural Resources; the governing bodies of the metropolitan sewerage commissions and cooperative contract sewerage commissions; and each individual local municipal unit of government that now operates or is recommended in the future to construct and operate a centralized sanitary sewerage system. It is recommended that the U. S. Environmental Protection Agency utilize the plan recommendations in achieving the U. S. Congressional objectives expressed in the federal Water Pollution Control Act Amendments of 1972, particularly with respect to the areawide waste treatment management planning required under the Act; the achievement of the established water use objectives and supporting water quality standards also required under the Act; and in the disposition of essential federal grants-in-aid for the construction of sanitary sewerage facilities. It is recommended that the Wisconsin Natural Resource Board endorse the recommended regional sanitary sewerage system plan and certify the plan as the official areawide water quality management plan for the seven-county Southeastern Wisconsin Region to the federal Environmental Protection Agency. It is further recommended that the Department of Natural Resources utilize the implementation schedules set forth in the plan, after careful review and analysis, in the issuance of pollution abatement orders and waste discharge permits and in the disposition of state and federal grant-in-aid monies. It is recommended that the governing bodies of all metropolitan sewerage commissions, cooperative contract sewerage commissions, and local municipal units of government which operate or are recommended to operate centralized sanitary sewerage systems adopt the recommended regional sanitary sewerage system plan as a guide to future sewerage facility development, and further adopt the appropriate implementation schedule and accompanying schedule of capital and operation and maintenance costs and appropriate monies as necessary to fully implement the plan recommendations. All units and agencies of government responsible for the construction, operation, and maintenance of centralized sanitary sewerage systems are recommended, in addition, to conduct detailed studies relating to the identification and ultimate elimination of all existing points of sewage flow relief, to conduct detailed studies relating to the reduction of infiltration and inflow, to review the operational characteristics of each sewage treatment plant and provide for proper staffing and operation in accordance with the standards recommended in the plan, and to take such steps as are necessary to achieve complete metering of sewage flows.

The foregoing enumeration of certain recommended plan implementation activities for summary purposes does not mean that the other plan implementation actions recommended in Chapter XIV of this report and not repeated here may be neglected. In the final analysis, the implementation of the recommended regional sanitary sewerage system plan must proceed in a comprehensive, fully coordinated fashion, with the assistance and cooperation of all affected levels, units, and agencies of government within the Region.

CONCLUSION

The regional sanitary sewerage system plan provides another extremely important element of the evolving comprehensive plan for the physical development of the seven-county Southeastern Wisconsin Region. Together with the regional land use plan and the series of comprehensive watershed plans, the sanitary sewerage system plan provides the Region, its public officials, and its citizens with a sound, coordinated guide to water pollution abatement and sewerage facility development. The plan is based upon extensive inventories and analyses of the Region's socioeconomic and natural resource base, its existing sewerage facilities and sewage characteristics, and its sewerage-related laws and regulations, and has been carefully selected from among many alternatives. The plan has been endorsed by a committee comprised of knowledgeable and experienced sanitary and municipal public works engineers, including representatives from public agencies involved in the provision of sanitary sewer service within the Region for over half a century, as well as from the Region's leading universities. The recommended plan and the alternatives thereto were, moreover, subject to extensive public review at a series of six public informational meetings and a formal public hearing, the results of which are documented in a published transcript of the meetings and hearing.

The regional sanitary sewerage system plan includes definitive recommendations for the establishment of sewer service areas; for the configuration and sizing of major trunk sewers; for the location of sewage treatment plants; for treatment levels and standards of performance at sewage treatment plants; and for the abatement of combined sewer overflows. Within the context of the overall regional planning program, the recommended regional sanitary sewerage system plan should meet all applicable federal and state planning requirements and thereby should be able to serve as the official water quality management plan for the Region and, as such, a sound basis for the approval of waste discharge permits and federal grants-in-aid. It is recognized that the plan recommendations will need to be further refined and detailed through the preparation at the local level of specific facilities plans. In this respect, the plan should serve as a sound point of departure for the necessary engineering studies.

Based upon an analysis of available alternatives, the plan is the most cost-effective way to provide sanitary sewer service to the designated sewer service areas of the Region, while abating the serious water pollution problems of the Region. The plan should, therefore, provide a sound basis for future public capital investment in sewerage facilities. Implementation of the plan should not only serve to reduce total costs but also ensure the most effective and efficient utilization of the public monies which will have to be expended for sewerage purposes over the next two to three decades within the Region in any case. Most importantly, implementation of the plan will contribute toward enhancing the overall quality of the natural environment in the Region and thereby contribute toward making the Region a safer, more healthful, and more attractive area in which to live and work.

APPENDICES

(This page intentionally left blank)

Appendix A

TECHNICAL COORDINATING AND ADVISORY COMMITTEE ON REGIONAL SANITARY SEWERAGE SYSTEM PLANNING

Ray D. Leary, Chairman	Chief Engineer and General Manager, Milwaukee-Metropolitan Sewerage Commissions
Lester Hoganson, Vice-Chairman	City Engineer, City of Racine
William D. McElwee, Secretary	Chief Environmental Planner, SEWRPC
Vinton W. Bacon	Professor, College of Applied Science and Engineering, University of Wisconsin-Milwaukee
Anthony F. Balestrieri	Consulting Engineer, Elkhorn, Wisconsin; Commissioner, SEWRPC
Kurt W. Bauer	Executive Director, SEWRPC
Richard C. Dess	Engineering Administrator, City of Wauwatosa
Thomas G. Frangos	Administrator, Division of Environmental Protection, Wisconsin Department of Natural Resources
Herbert A. Goetsch	Commissioner of Public Works, City of Milwaukee
Harlan D. Hirt	Chief, Planning Branch, Region V, U. S. Environmental Protection Agency
Donald K. Holland	Director of Public Works, City of Kenosha
George A. James	Acting Director, Bureau of Local and Regional Planning, Wisconsin Department of Local Affairs and Development
Raymond J. Kipp	Dean, College of Engineering, Marquette University
Thomas A. Kroehn	District Director, Southeast District, Wisconsin Department of Natural Resources
Theodore W. Meilahn	County Surveyor, Washington County
Melvin Noth	Director of Public Works, Village of Menomonee Falls
John W. Peters	Assistant Director, Planning and Relocation Branch, U. S. Department of Housing and Urban Development, Milwaukee
Herbert E. Ripley	Director of Environmental Health Services, Waukesha County Department of Health
Donald A. Roensch	Director of Public Works, City of Mequon
Rodney M. Vanden Noven	Director of Public Works, City of Waukesha
Frank A. Wellstein	City Engineer, City of Oak Creek
Henry B. Wildschut	County Highway Commissioner and Director of Public Works, Milwaukee County
James F. Wilson	District Supervisor, Farmers Home Administration, U. S. Department of Agriculture
Harvey E. Wirth	State Sanitary Engineer, Division of Health, Wisconsin Department of Health and Social Services

The following individuals also participated actively in the work of the Committee: John Cain, Chief, Water Resources Planning Section, Wisconsin Department of Natural Resources; Lawrence A. Ernest, Plant Superintendent, Milwaukee-Metropolitan Sewerage Commissions; Donald W. Hook, Chief, Water Quality Monitoring Section, Planning Branch, Region V, U. S. Environmental Protection Agency; Robert M. Krill, Chief, Municipal Wastewater Section, Wisconsin Department of Natural Resources; William Manske, Sewer Research Engineer, Department of Public Works, City of Milwaukee; Jerry McKersie, Chief, Water Quality Evaluation Section, Wisconsin Department of Natural Resources; Duane H. Schuettpelz, Water Quality Evaluation Specialist, Wisconsin Department of Natural Resources; Bernard G. Schultz, Assistant District Director, Southeast District, Wisconsin Department of Natural Resources; Gilbert Vosswinkel, Chief Sewer Design Engineer, Department of Public Works, City of Milwaukee; Donald G. Wieland, Division Engineer, Milwaukee-Metropolitan Sewerage Commissions; and Eugene F. Wojcik, Water Resources Planner, Region V, U. S. Environmental Protection Agency.

(This page intentionally left blank)

APPENDIX B

KNOWN FLOW RELIEF DEVICES IN THE REGION: 1970

Table B-1

KNOWN COMBINED SEWER OUTFALLS IN KENOSHA COUNTY: 1970

Combined Sewer Outfall Location[1]	Receiving Water Body
City of Kenosha	
1. 40th Place and Lake Michigan	Lake Michigan
2. 57th Street and Lake Michigan	Lake Michigan
3. 59th Street and Lake Michigan	Lake Michigan
4. 66th Street and Lake Michigan	Lake Michigan
5. 75th Street and Lake Michigan	Lake Michigan
6. 80th Street and Lake Michigan	Lake Michigan

[1]The number beside each listed combined sewer outfall corresponds to a code number on Map 31.
Source: SEWRPC.

Table B-2

KNOWN BYPASSES IN KENOSHA COUNTY: 1970

Bypass Location[1]	Receiving Water Body
City of Kenosha	
1. At Sewage Treatment Plant	Lake Michigan
Village of Paddock Lake	
2. At Sewage Treatment Plant	Brighton Creek
3. Parkview Boulevard and Chestnut Lane	Paddock Lake
Village of Twin Lakes	
4. At Sewage Treatment Plant	Bassett Creek
Town of Bristol Utility District No. 1	
5. At Sewage Treatment Plant	Des Plaines River
Town of Pleasant Prairie Sewer Utility District D	
6. At Sewage Treatment Plant	Des Plaines River
Town of Somers Sanitary District No. 2	
7. At Sewage Treatment Plant	Pike Creek

[1]The number beside each listed bypass corresponds to a code number on Map 31.
Source: SEWRPC.

Table B-3

KNOWN CROSSOVERS IN KENOSHA COUNTY: 1970

Crossover Location[1]	Receiving Water Body
City of Kenosha	
1. Alford Drive and 18th Street	Pike River
2. North Pershing Boulevard and 19th Avenue	Pike River
3. 20th Place and 22nd Avenue	Pike River
4. 25th Avenue and 33rd Street	Pike Creek
5. 31st Street and 14th Avenue (200' East of 14th Avenue)	Pike River
6. 33rd Street and 14th Avenue (200' East of 14th Avenue)	Pike River
7. 50th Street and 10th Avenue	Pike Creek
8. Sheridan Road and 51st Place	Pike Creek
9. 14th Avenue and 59th Street	Lake Michigan
10. 63rd Street and 12th Avenue	Lake Michigan
11. 65th Street and 22nd Avenue (150' West of 22nd Avenue)	Lake Michigan
12. Roosevelt Road and 64th Street	Lake Michigan
13. Pershing Boulevard and Taft Road	Lake Michigan
14. 75th Street and 18th Avenue	Lake Michigan
15. Sheridan Road and 76th Street	Lake Michigan
16. 78th Street and 20th Avenue	Lake Michigan
17. 79th Street and 24th Avenue	Lake Michigan
18. 79th Street and Johnson Road	Lake Michigan
19. 79th Street and Lincoln Road	Lake Michigan
20. 78th Street and 43rd Avenue	Lake Michigan

[1]The number beside each listed crossover corresponds to a code number on Map 31.
Source: SEWRPC.

Table B-4

KNOWN COMBINED SEWER OUTFALLS IN MILWAUKEE COUNTY: 1970

Combined Sewer Outfall Location[1]	Receiving Water Body
City of Milwaukee	
1. E. Bruce Street	Milwaukee River
2. E. Harbor Place	Milwaukee River
3. E. Florida Street	Milwaukee River
4. E. Polk Street	Milwaukee River
5. S. of E. Oregon Street	Milwaukee River
6. E. Pittsburgh Avenue	Milwaukee River
7. N. Broadway	Milwaukee River
8. S. Water Street	Milwaukee River
9. S. 1st Street	Milwaukee River
10. E. Erie Street	Milwaukee River
11. E. Chicago Street	Milwaukee River
12. E. Buffalo Street	Milwaukee River
13. W. St. Paul Avenue	Milwaukee River
14. E. St. Paul Avenue	Milwaukee River
15. N. of W. St. Paul Avenue	Milwaukee River
16. W. Clybourn Street	Milwaukee River
17. E. Clybourn Street	Milwaukee River
18. N. of W. Clybourn Street	Milwaukee River
19. W. Michigan Street	Milwaukee River
20. E. Michigan Street	Milwaukee River
21. N. of W. Michigan Street	Milwaukee River
22. E. Wisconsin Avenue	Milwaukee River
23. W. Wisconsin Avenue	Milwaukee River
24. N. of W. Wisconsin Avenue	Milwaukee River
25. E. Wells Street	Milwaukee River
26. W. Wells Street	Milwaukee River
27. N. of W. Wells Street	Milwaukee River
28. W. Kilbourn Avenue	Milwaukee River
29. W. Kilbourn Avenue	Milwaukee River
30. E. Kilbourn Avenue	Milwaukee River
31. W. State Street	Milwaukee River
32. E. State Street	Milwaukee River
33. W. Highland Avenue	Milwaukee River
34. E. Highland Avenue	Milwaukee River
35. W. Juneau Avenue	Milwaukee River
36. E. Juneau Avenue	Milwaukee River
37. N. of W. Juneau Avenue	Milwaukee River
38. W. McKinley Avenue	Milwaukee River
39. E. Ogden Avenue	Milwaukee River
40. W. Cherry Street	Milwaukee River
41. N. of W. Cherry Street	Milwaukee River
42. E. Lyon Street	Milwaukee River
43. E. Pleasant Street	Milwaukee River
44. E. Walnut Street	Milwaukee River
45. N. of E. Walnut Street	Milwaukee River
46. E. Brady Street	Milwaukee River
47. N. Holton Street	Milwaukee River
48. N. Marshall Street	Milwaukee River
49. N. Pulaski Street	Milwaukee River
50. N. Humboldt Avenue	Milwaukee River
51. E. Tunnel Place	Milwaukee River
52. E. Boylston Street	Milwaukee River
53. E. Bradford Avenue	Milwaukee River
54. E. Park Place	Milwaukee River
55. E. Locust Street	Milwaukee River
56. E. Chambers Street	Milwaukee River
57. E. Burleigh Street	Milwaukee River
58. E. Hampshire Street	Milwaukee River
59. E. Auer Avenue	Milwaukee River
60. E. Auer Avenue	Milwaukee River
61. E. Keefe Avenue	Milwaukee River
62. E. Edgewood Avenue	Milwaukee River
63. E. National Avenue	Kinnickinnic River
64. E. Walker Street	Kinnickinnic River
65. S. of E. Walker Street	Kinnickinnic River
66. S. of E. Washington Street	Kinnickinnic River
67. E. Greenfield Avenue	Kinnickinnic River
68. S. Kinnickinnic Avenue	Kinnickinnic River
69. S. Kinnickinnic Avenue	Kinnickinnic River
70. S. 1st Street	Kinnickinnic River
71. S. 1st Street	Kinnickinnic River
72. S. 2nd Street	Kinnickinnic River
73. W. Rogers Street	Kinnickinnic River
74. W. Becher Street	Kinnickinnic River
75. W. Becher Street	Kinnickinnic River
76. W. Lincoln Avenue	Kinnickinnic River
77. W. Lincoln Avenue	Kinnickinnic River
78. S. Chase Avenue	Kinnickinnic River
79. S. Chase Avenue	Kinnickinnic River
80. W. Cleveland Avenue	Kinnickinnic River
81. W. Cleveland Avenue	Kinnickinnic River
82. S. 8th Street	Kinnickinnic River
83. S. 14th Street	Kinnickinnic River
84. S. 27th Street	Kinnickinnic River
85. S. 2nd Street	Menomonee River
86. W. of N. 8th Street	Menomonee River
87. S. Muskego Avenue	Menomonee River
88. S. Muskego Avenue	Menomonee River
89. N. 15th Street	Menomonee River
90. N. 15th Street	Menomonee River
91. N. 17th Street	Menomonee River
92. N. 25th Street	Menomonee River
93. N. 26th Street	Menomonee River
94. S. 27th Street	Menomonee River
95. S. 27th Street	Menomonee River
96. S. 35th Street	Menomonee River
97. W. Wisconsin Avenue	Menomonee River

Table B-4 (continued)

Combined Sewer Outfall Location[1]	Receiving Water Body
98. W. Wisconsin Avenue	Menomonee River
99. N. 43rd Street	Menomonee River
100. N. 45th Street	Menomonee River
101. N. 46th Street	Menomonee River
102. N. Hawley Road	Menomonee River
103. S. 4th Street	South Menomonee Canal
104. S. 6th Street	South Menomonee Canal
105. S. 9th Street	Menomonee River — Burnham's Canal
106. S. 9th Street	Menomonee River — Burnham's Canal
107. S. 11th Street	Menomonee River — Burnham's Canal
108. S. 13th Street	Menomonee River — Burnham's Canal
109. S. 13th Street	Menomonee River — Burnham's Canal
110. S. Muskego Avenue	Menomonee River — Burnham's Canal
111. E. Bay Street	Lake Michigan
112. E. Russell Avenue	Lake Michigan
Village of Shorewood	
113. E. Edgewood Avenue	Milwaukee River

[1]The number beside each listed combined sewer outfall corresponds to a code number on Map 34.

Source: SEWRPC.

Table B-5

KNOWN BYPASSES IN IN MILWAUKEE COUNTY: 1970

Bypass Location[1]	Receiving Water Body
Milwaukee-Metropolitan Sewerage Commissions	
1. N. Marshall Street and the Milwaukee River	Milwaukee River
2. E. Brady Street and N. Van Buren Street	Milwaukee River
3. N. Commerce Street and W. Vliet Street	Milwaukee River
4. S. 11th Street and W. Canal Street	Menomonee River
5. S. 8th Street and W. Canal Street	Menomonee River
6. S. 1st Street and Kinnickinnic River	Kinnickinnic River
7. S. Water Street and E. Bruce Street	Milwaukee River
8. N. 2nd Street and W. Hampton Avenue	Milwaukee River
9. E. Fairmount and N. Lake Drive	Lake Michigan
10. N. Lake Drive near E. Ravine Lane	Lake Michigan
11. N. 31st Street, 480' North of W. Hampton Avenue	Lincoln Creek
12. N. 35th Street and W. Congress Street	Lincoln Creek
13. 300' East of N. 68th Street and River Parkway	Menomonee River
14. Honey Creek Parkway and W. Portland Avenue	Honey Creek
15. S. 43rd Street and W. Lincoln Avenue	Kinnickinnic River
16. 500' West of 4125 W. Mt. Vernon Avenue	Menomonee River
17. S. 60th Street and the Kinnickinnic River	Kinnickinnic River
18. S. 80th Street extended and W. Dickinson Street extended	Honey Creek
19. W. State Street and N. 46th Street	Menomonee River
20. 8506 N. Manor Road	Milwaukee River
21. E. Bruce Street at Milwaukee River	Milwaukee River
22. E. Erie Street at Milwaukee River	Milwaukee River
City of Cudahy	
23. E. Allerton Avenue and S. Lake Drive	Lake Michigan
24. E. Van Norman Boulevard and S. Hatley Avenue	Lake Michigan
25. E. Squire Avenue and S. Swift Avenue	Lake Michigan
26. E. Barnard Avenue and S. Kirkwood Avenue	Lake Michigan
27. E. Hammond Avenue and S. Kirkwood Avenue	Lake Michigan
City of Franklin	
28. At the Rawson Homes Sewer and Water Trust Sewage Treatment Plant	Root River
City of South Milwaukee	
29. Edgewood Avenue and 3rd Avenue	Lake Michigan
30. Marquette Avenue and Oak Creek	Oak Creek
31. N. Chicago Avenue and Oak Creek	Oak Creek
32. Brookdale Drive and Lake Drive	Lake Michigan
Village of Bayside	
33. N. Lake Drive extended at E. Sheridan Circle	Lake Michigan
Village of Fox Point	
34. Cherokee Circle, ½ Block South of E. Spoonek Road	Indian Creek
Village of Hales Corners	
35. W. Forest Home Avenue and S. 108th Street	Root River
36. Sewage Treatment Plant Site	Root River
37. W. Janesville Road and S. 115th Street	Root River
38. S. 103rd Street and W. Edgerton Avenue (East of S. 104th Street)	Root River

[1]The number beside each listed bypass corresponds to a code number on Map 34.

Source: SEWRPC.

Table B-6

KNOWN CROSSOVERS IN MILWAUKEE COUNTY: 1970

Crossover Location[1]	Receiving Water Body
Milwaukee-Metropolitan Sewerage Commissions	
1. N. 13th Street, North of W. Clybourn Street	Menomonee River
2. Roosevelt Drive and W. Scranton Place	Lincoln Creek
3. N. Green Bay Avenue and W. Hampton Avenue, East	Milwaukee River
4. N. Green Bay Avenue and W. Hampton Avenue, West	Milwaukee River
5. N. Lydell Avenue and W. Lancaster Avenue	Milwaukee River

Table B-6 (continued)

Crossover Location[1]	Receiving Water Body
6. N. Lydell Avenue and W. Montclaire Avenue	Lake Michigan
7. N. 27th Street and W. Silver Spring Drive	Lincoln Creek
8. N. 31st Street and W. Fairmount Avenue	Lincoln Creek
9. N. 51st Street, 800' North of W. Congress Street	Lincoln Creek
10. N. 51st Street and W. Congress Street	Lincoln Creek
11. Martha Washington Drive, South of Milwaukee Avenue	Menomonee River
12. Easement Parallel to C.N.W.RR., 500' South of Ozaukee County Line and West of Regent Road and North Shore Estates	Lake Michigan
13. N. Richard Street and the Milwaukee River	Milwaukee River
14. S. Kinnickinnic Avenue and E. St. Francis Avenue	Lake Michigan
15. S. 12th Street and W. National Avenue	Menomonee River
City of Cudahy	
16. E. Allerton Avenue and S. Hatley Avenue	Lake Michigan
17. E. Armour Avenue and S. Kirkwood Avenue	Lake Michigan
18. E. Armour Avenue and S. Packard Avenue	Lake Michigan
19. E. Layton Avenue and S. Packard Avenue	Lake Michigan
20. E. Squire Avenue and S. Lake Drive	Lake Michigan
21. E. Munkwitz Avenue and S. Swift Drive	Lake Michigan
22. E. Somers Avenue and S. Lake Drive	Lake Michigan
23. E. Holmes Avenue and S. Kirkwood Avenue	Lake Michigan
24. E. Martin Avenue and S. Lake Drive	Lake Michigan
25. E. Pulaski Avenue and S. Lake Drive	Lake Michigan
26. E. Hammond Avenue and S. Packard Avenue	Lake Michigan
27. E. Hammond Avenue and S. Lake Drive	Lake Michigan
28. E. Morris Avenue and S. Kirkwood Avenue	Lake Michigan
City of Milwaukee	
29. E. Grange Avenue at S. Howell Avenue	Kinnickinnic River
30. N. 24th Street and W. Hope Avenue	Lincoln Creek
31. N. 25th Street and W. Hope Avenue	Lincoln Creek
32. N. 27th Street and W. Fiebrantz Avenue	Lincoln Creek
33. N. 30th Street and W. Hope Avenue	Lincoln Creek
34. N. 31st Street extended and W. Hope Avenue extended	Lincoln Creek
35. N. 31st Street and W. Villard Avenue	Lincoln Creek
36. N. 31st Street and W. Villard Avenue	Lincoln Creek
37. N. 41st Street and W. Congress Street	Lincoln Creek
38. N. 47th Street and W. Concordia Avenue	Lincoln Creek
39. N. 47th Street and W. Congress Street	Lincoln Creek
40. N. 49th Street and W. Concordia Avenue	Lincoln Creek
41. N. 68th Street and W. Center Street	Menomonee River
42. N. 20th Street at W. Fairmount Avenue	Lincoln Creek
43. S. 3rd Street at W. Saveland Avenue	Kinnickinnic River
44. N. 51st Boulevard and W. Auer Avenue	Lincoln Creek
45. N. 51st Boulevard and W. Concordia Avenue	Lincoln Creek
46. N. 51st Boulevard and Roosevelt Drive	Lincoln Creek
47. N. 51st Street and W. Burleigh Street	Lincoln Creek
48. N. 54th Street and W. Burleigh Street	Lincoln Creek
49. N. 55th Street and W. Burleigh Street	Lincoln Creek
50. N. 56th Street and W. Burleigh Street	Lincoln Creek
51. N. 76th Street, Point 200' North of W. Hadley Street	Menomonee River
52. N. 79th Street and W. Locust Street	Menomonee River
53. W. Capitol Drive and N. 31st Street	Lincoln Creek
54. W. Capitol Drive and N. 31st Street	Lincoln Creek
55. N. Sherman Boulevard and W. Ruby Avenue	Lincoln Creek
56. N. Sherman Boulevard and W. Fond du Lac Avenue	Lincoln Creek
57. S. Whitnall Avenue and E. Howard Avenue	Kinnickinnic River
58. N. 36th Street Between W. Carmen Avenue and W. Florist Avenue	Lincoln Creek
59. E. Howard Avenue at S. Pine Avenue	Kinnickinnic River
60. W. Center Street at N. 86th Street	Menomonee River
61. N. 35th Street at a Point 40' North of W. Oriole Drive	Lincoln Creek
62. S. 35th Street at W. Lakefield Drive	Kinnickinnic River
63. W. Center Street at N. 88th Street	Menomonee River
64. W. Ruskin Street at S. 38th Street	Kinnickinnic River
65. W. Silver Spring Drive at N. 38th Street	Lincoln Creek
66. W. Silver Spring Drive at N. 37th Street	Lincoln Creek
67. W. Silver Spring Drive at N. 36th Street	Lincoln Creek
68. W. Silver Spring Drive at N. 35th Street	Lincoln Creek
69. N. Humboldt Avenue and E. Capitol Drive	Milwaukee River
70. N. 89th Street at W. Townsend Street	Menomonee River
71. N. 90th Street at W. Townsend Street	Menomonee River
72. W. Dickinson Street and S. 62nd Street	Menomonee River
73. W. Hope Avenue and N. 47th Street	Lincoln Creek
74. W. Silver Spring Drive and N. 39th Street	Lincoln Creek
75. W. Silver Spring Drive and N. 41st Street	Lincoln Creek
76. W. Stevenson Street and N. 71st Street	Menomonee River
77. W. Mt. Vernon Avenue and N. 69th Street	Menomonee River
78. W. Morgan Avenue at S. 57th Street	Kinnickinnic River
79. W. Hadley Street at N. 80th Street	Menomonee River
80. W. Mt. Vernon Avenue at Point 75' East of N. 91st Street	Lincoln Creek
81. N. 41st Street and W. Congress Street	Lincoln Creek
82. N. 66th Street ½ Block Between W. Congress Street and W. Ruby Avenue	Lincoln Creek
83. N. 94th Street and W. Townsend Street	Menomonee River
84. N. 95th Street and W. Metcalf Place	Menomonee River
85. E. Armour Avenue at a Point 69' West of S. Austin Street	Kinnickinnic River
86. N. 89th Street and W. Center Street	Menomonee River
87. N. 87th Street and W. Center Street	Menomonee River
88. N. 44th Street at a Point 285' South of W. Burleigh Street	Lincoln Creek
89. N. 53rd Street at W. Glendale Avenue	Lincoln Creek
90. N. 53rd Street at W. Courtland Avenue extended	Lincoln Creek
91. S. Austin Street at W. Dakota Street	Kinnickinnic River
92. N. 27th Street, 404' South of W. Hope Avenue	Lincoln Creek
93. W. Oklahoma Avenue and S. 22nd Street	Kinnickinnic River
94. E. Ohio Street and S. Quincy Avenue	Kinnickinnic River
95. S. 43rd Street and W. Morgan Avenue	Kinnickinnic River
96. N. 26th Street and W. Vienna (From a Point 120' North of W. Vienna Avenue to a Point 176' North of W. Vienna Avenue)	Lincoln Creek
97. N. 37th Street at a Point 145' North of W. Mt. Vernon Avenue	Menomonee River
98. N. 38th Street and W. Mt. Vernon Avenue	Menomonee River
99. N. 51st Street and W. Wisconsin Avenue	Menomonee River
100. N. 46th Street and W. State Street	Menomonee River
101. N. 49th Street and W. Wisconsin Avenue	Menomonee River
102. N. 48th Street and W. Wisconsin Avenue	Menomonee River
103. N. 48th Street and W. Wisconsin Avenue	Menomonee River
104. N. 50th Street and W. Wisconsin Avenue	Menomonee River
105. N. 51st Street and W. Wisconsin Avenue	Menomonee River
106. E. Meinecke Avenue and N. Gordon Place	Milwaukee River
107. N. Story Parkway and W. Bluemound Road	Menomonee River
108. W. Woodlawn Court and W. Wisconsin Avenue	Menomonee River
109. W. Hilda Place and S. 38th Street	Menomonee River
110. N. Sherman Boulevard at W. Burleigh Street	Lincoln Creek
111. E. Lincoln Avenue at S. Burrell Street	Kinnickinnic River

Table B-6 (continued)

Crossover Location[1]	Receiving Water Body
112. E. Lincoln Avenue at a Point 150' West of S. Greeley Street	Kinnickinnic River
113. E. Lincoln Avenue at a Point 450' West of S. Greeley Street	Kinnickinnic River
114. N. 55th Street at W. Vine Street	Milwaukee River
115. N. Hi Mount Boulevard at W. Lloyd Street	Milwaukee River
116. N. 37th Street, 11' North of W. Mt. Vernon Avenue	Menomonee River
117. W. Mt. Vernon Avenue, 10' West of N. 37th Street	Menomonee River
118. E. Chambers Street and West Bank of the Milwaukee River	Milwaukee River
City of Oak Creek	
119. 5th Avenue and High Street	Lake Michigan
City of Wauwatosa	
120. Ridge Place and Harding Boulevard	Menomonee River
121. W. North Avenue and Menomonee River	Menomonee River
122. Jackson Park Boulevard and Swan Boulevard	Menomonee River
123. Jackson Park Boulevard and N. 90th Street	Menomonee River
124. Jackson Park Boulevard and N. 85th Street	Menomonee River
125. W. North Avenue and N. 82nd Street	Menomonee River
126. W. Meinecke Avenue and N. 83rd Street	Menomonee River
127. Stickney Avenue and N. 85th Street	Menomonee River
128. Stickney Avenue and N. 90th Street	Menomonee River
129. Swan Boulevard and Menomonee River Parkway	Menomonee River
130. N. 90th Street and Menomonee River Parkway	Menomonee River
131. Ludington Avenue and Hoyt Park	Menomonee River
132. Hillcrest Drive and N. 85th Street	Menomonee River
133. Milwaukee Avenue and N. 72nd Street	Menomonee River
134. Martin Drive and N. 62nd Street	Menomonee River
135. N. 62nd Street and Western Metal Company	Menomonee River
136. End of Hillside Lane	Menomonee River
137. Glenview Avenue and Currie	Honey Creek
138. Ravenswood Circle and N. 89th Street	Honey Creek
139. Glenwood Avenue and Hawthorne Avenue	Honey Creek
140. Honey Creek and W. Wisconsin Avenue	Honey Creek
141. East Side of Glenview Avenue at Hill Court	Honey Creek
142. N. 65th Street and W. Wisconsin Avenue	Menomonee River
143. N. 68th Street and W. Wisconsin Avenue	Menomonee River
144. N. 70th Street and W. Center Street	Menomonee River
145. N. 105th Street and W. Ruby Avenue	Menomonee River
146. W. Concordia Avenue and Menomonee River Parkway	Menomonee River
147. N. 106th Street and W. Fisher Parkway	Underwood Creek
148. Ravenswood Circle and Glenco Place	Honey Creek
149. N. 67th Street and W. Wells Street	Menomonee River
150. N. 85th Street Between Hill Court and Ravenswood Circle	Honey Creek
151. N. 86th Street and W. Meinecke Avenue	Menomonee River
152. N. 63rd Street and W. North Avenue	Menomonee River
153. N. 64th Street and W. North Avenue	Menomonee River
City of West Allis	
154. S. 70th Street and W. Arthur Avenue	Kinnickinnic River
155. S. 70th Street and W. Burnham Street	Kinnickinnic River
156. S. 77th Street and W. Walker Street	Honey Creek
157. S. 78th Street and W. Arthur Avenue	Honey Creek
158. S. 84th Street and W. Orchard Street	Honey Creek
159. S. 73rd Street and W. Burnham Street	Kinnickinnic River
160. S. 60th Street and W. Mobile Avenue	Kinnickinnic River
161. W. Madison Street, 1 Block West of S. 77th Street	Honey Creek
162. S. 64th Street and W. Arthur Avenue	Kinnickinnic River
Village of Fox Point	
163. E. Club Circle, 3rd Manhole East of N. Lake Drive	Lake Michigan
164. E. Goodrich Lane, 1st Manhole East of N. Lake Drive	Lake Michigan
165. N. Lake Drive, 1st Manhole North of N. Links Circle	Lake Michigan
166. N. Lake Drive and E. Fox Lane	Lake Michigan
167. E. Fox Lane, 225' East of N. Lake Drive	Lake Michigan
168. N. Lake Drive and E. Apple Tree Road	Lake Michigan
169. N. Lake Drive and E. Daphne Road	Lake Michigan
170. E. View Place and N. Barnett Lane	Lake Michigan
Village of Shorewood	
171. E. Edgewood Avenue and N. Oakland Avenue	Milwaukee River
172. E. Glendale Avenue and N. Larkin Street	Milwaukee River
173. E. Glendale Avenue and N. Morris Boulevard	Milwaukee River
174. N. Morris Boulevard and E. Lake Bluff Boulevard	Milwaukee River
175. E. Olive Street and N. Wilson Drive	Milwaukee River
176. N. Woodburn Street and E. Olive Street	Milwaukee River
177. E. Kensington Boulevard and N. Murray Avenue	Lake Michigan
178. E. Kinsington Boulevard and N. Farwell Avenue	Lake Michigan
179. E. Kinsington Boulevard and N. Maryland Avenue	Lake Michigan
180. E. Kinsington Boulevard and N. Cramer Street	Lake Michigan
Village of Whitefish Bay	
181. E. Hampton Avenue and N. Idlewild Avenue	Milwaukee River
182. E. Hampton Avenue and N. Sheffield Avenue	Milwaukee River
183. E. Lancaster Avenue and N. Diversey Boulevard	Milwaukee River
184. N. Bayridge Avenue and E. Monrovia Avenue	Lake Michigan
185. N. Berkley Boulevard, 500' North of E. Montlair Avenue	Lake Michigan
186. N. Lake Drive and E. Monrovia Avenue	Lake Michigan
187. N. Lake Drive, 200' South of E. Monrovia Avenue	Lake Michigan
188. W. Montclair Avenue and N. Bayridge Avenue	Lake Michigan
189. E. Montclair Avenue and N. Berkeley Boulevard	Lake Michigan
190. E. Montclair Avenue and N. Kent Avenue	Lake Michigan
191. E. Montclair Avenue and N. Lake Drive	Lake Michigan
192. E. Montclair Avenue and N. Santa Monica Boulevard	Lake Michigan
193. E. Montclair Avenue and N. Shoreland Avenue	Lake Michigan
194. N. Santa Monica Boulevard and E. Monrovia Avenue	Lake Michigan
195. E. Chateau Place and N. Newhall Street	Lake Michigan
196. E. Fairmont Avenue and N. Larkin Street	Lake Michigan
197. E. Fairmont Avenue and N. Newhall Street	Lake Michigan
198. E. Glendale Avenue and N. Cramer Street	Lake Michigan
199. E. Glendale Avenue and N. Murray Avenue	Lake Michigan
200. E. Henry Clay Street, Just East of N. Lake Drive	Lake Michigan
201. N. Lake Drive, 250' North of E. Birch Avenue	Lake Michigan
202. N. Lake Drive at E. Circle Drive	Lake Michigan
203. N. Lake Drive at E. Circle Drive	Lake Michigan
204. N. Lake Drive, 200' North of E. Fairmont Avenue	Lake Michigan
205. N. Lake Drive, 400' North of E. Fairmont Avenue	Lake Michigan
206. N. Lake Drive, 700' North of E. Fairmont Avenue	Lake Michigan
207. N. Lake Drive, Just North of E. Henry Clay Street	Lake Michigan
208. N. Lake Drive at E. Lexington Boulevard	Lake Michigan
209. N. Lake Drive at E. Lexington Boulevard	Lake Michigan
210. N. Lake Drive at E. Sylvan Avenue	Lake Michigan
211. N. Lake Drive at E. Sylvan Avenue	Lake Michigan
212. N. Wilshire Road at E. Cumberland Boulevard	Lake Michigan
213. N. Woodburn Street and E. Henry Clay Street	Lake Michigan
214. E. Circle Drive at W. End of Drive	Lake Michigan
215. N. Lake Drive and E. Lake View Avenue	Lake Michigan

[1]*The number beside each listed crossover corresponds to a code number on Map 34.*

Source: SEWRPC.

Table B-7

KNOWN PORTABLE PUMPING STATIONS IN MILWAUKEE COUNTY: 1970

Portable Pumping Station Location[1]	Receiving Water Body
City of Milwaukee	
1. N. 20th Street and W. Hampton Avenue	Milwaukee River
2. N. 47th Street and W. Hampton Avenue	Lincoln Creek
3. N. 47th Street and W. Eggert Place	Lincoln Creek
4. N. 49th Street and W. Luscher Avenue	Lincoln Creek
5. N. 57th Street and W. Sheridan Avenue	Lincoln Creek
6. N. 61st Street and W. Lawn Avenue	Lincoln Creek
7. N. 63rd Street and W. Fairmount Avenue	Lincoln Creek
8. N. 64th Street and W. Stark Street	Lincoln Creek
9. N. 66th Street and W. Ruby Avenue	Lincoln Creek
10. N. 66th Street North of W. Marion Street	Lincoln Creek
11. N. 67th Street North of W. Marion Street	Lincoln Creek
12. S. 60th Street and W. Adler Street	Menomonee River
13. S. 79th Street and W. O'Connor Street	Honey Creek
14. N. 90th Street and W. Mt. Vernon Avenue	Honey Creek
15. N. 107th Street and W. Lawn Avenue	Little Menomonee River
16. W. Monrovia Avenue and W. Crossfield Avenue	Little Menomonee River
17. E. Armour Avenue West of S. Austin Street	Kinnickinnic River
18. S. Burrel Street and E. Van Norman Avenue	Kinnickinnic River
19. S. Howell Avenue, South of E. Layton Avenue	Kinnickinnic River
20. S. 15th Place and W. Howard Avenue	Kinnickinnic River
21. S. 20th Street and W. Howard Avenue	Kinnickinnic River
22. S. 31st Street and W. Manitoba Street	Kinnickinnic River
23. S. 37th Street and W. Lincoln Avenue	Kinnickinnic River
24. S. 46th Street and W. Cleveland Avenue	Kinnickinnic River
25. S. 54th Street and W. Midland Drive	Kinnickinnic River
26. S. 57th Street and W. Euclid Avenue	Kinnickinnic River
27. S. 58th Street and W. Stack Drive	Kinnickinnic River
28. S. 72nd Street and W. Honey Creek Drive	Honey Creek
29. S. 77th Street, South of W. Oklahoma Avenue	Honey Creek
30. S. 84th Street and W. Morgan Avenue	Honey Creek
31. S. 92nd Street and W. Howard Avenue	Root River
32. S. 44th Street and W. Kinnickinnic River Parkway	Kinnickinnic River
33. S. Howell Avenue and W. Ramsey Avenue extended	Oak Creek
34. S. 1st Street and W. Layton Avenue	Kinnickinnic River
35. S. Howell Avenue and W. Edgerton Avenue	Kinnickinnic River
36. N. 48th Street and W. Luscher Avenue	Lincoln Creek
37. N. 55th Street and North of W. Fairmount Avenue	Lincoln Creek
City of South Milwaukee	
38. Brooklawn Circle in the Circle	Lake Michigan
39. 7th Avenue and Lakeview Avenue	Lake Michigan
City of West Allis	
40. S. 93rd Street and W. Orchard Street	Honey Creek
41. S. 81st Street and W. Rogers Street	Honey Creek
42. S. 74th Street and W. Dakota Street	Honey Creek
43. S. 102nd Street and W. National Avenue	Root River
Village of Brown Deer	
44. N. Green Bay Road and W. Fairy Chasm Road	Milwaukee River
45. W. Brown Deer Road, 300' West of the Milwaukee River	Milwaukee River
Village of Hales Corners	
46. S. 111th Street and Janesville Road	Root River

[1]*The number beside each listed portable pumping station location corresponds to a code number on Map 34.*

Source: SEWRPC.

Table B-8

KNOWN RELIEF PUMPING STATIONS IN MILWAUKEE COUNTY: 1970

Relief Pumping Station Location[1]	Receiving Water Body
Milwaukee-Metropolitan Sewerage Commissions	
1. N. 27th Street and W. Villard Avenue	Lincoln Creek
2. N. 32nd Street and W. Hampton Avenue	Lincoln Creek
3. Menomonee River Parkway and W. Center Street	Menomonee River
4. Menomonee River, South of W. North Avenue	Menomonee River
5. N. 63rd Street and W. Hampton Avenue	Lincoln Creek
6. N. 35th Street and Roosevelt Drive	Lincoln Creek
7. W. Wisconsin Avenue and Honey Creek	Honey Creek
8. S. 84th Street and W. Adler	Honey Creek
9. S. 35th Street and W. Manitoba	Kinnickinnic River
10. Range Line Road and the Milwaukee River	Milwaukee River
City of Greenfield	
11. S. 44th Street and W. St. Francis Avenue	Kinnickinnic River
City of West Allis	
12. S. 112th Street and W. Cleveland Avenue	Root River
13. Root River Parkway (North Side) and S. 116th Street extended	Root River
14. Root River Parkway and Rust Court extended	Root River
15. W. Morgan Avenue at S. 115th Street extended	Root River
Village of Fox Point	
16. Santa Monica Boulevard and Willow Road	Indian Creek
17. Mall Road and Crossway Road	Indian Creek

[1]*The number beside each listed relief pumping station corresponds to a code number on Map 34.*

Source: SEWRPC.

Table B-9

KNOWN BYPASSES IN OZAUKEE COUNTY: 1970

Bypass Location[1]	Receiving Water Body
City of Cedarburg	
1. At Sewage Treatment Plant	Cedar Creek
2. Water Street and Main Street	Cedar Creek
3. Highland Drive and Cedar Creek	Cedar Creek
City of Port Washington	
4. At Sewage Treatment Plant	Lake Michigan
5. Grand Avenue and Franklin Street	Lake Michigan
6. S. Wisconsin Street Near River Drive	Lake Michigan
7. Lake Street and Jackson Avenue	Lake Michigan
8. S. Wisconsin Street and River Drive	Lake Michigan
9. Grand Avenue and Webster Street	Sauk Creek
Village of Belgium	
10. At Sewage Treatment Plant	Onion River
Village of Fredonia	
11. At Sewage Treatment Plant	Milwaukee River
Village of Grafton	
12. At Sewage Treatment Plant	Milwaukee River
13. Bridge Street and the Milwaukee River	Milwaukee River
14. 12th Avenue One Block South of Falls Street	Milwaukee River
Village of Thiensville	
15. Riverview Drive and Madero Street	Milwaukee River

[1]*The number beside each listed bypass corresponds to a code number on Map 36.*

Source: SEWRPC.

Table B-10

KNOWN PORTABLE PUMPING STATIONS IN OZAUKEE COUNTY: 1970

Portable Pumping Station Location[1]	Receiving Water Body
City of Mequon	
1. Riverside Drive and the Milwaukee County Line	Milwaukee River
Village of Thiensville	
2. Firemans Park Near the Milwaukee River	Milwaukee River

[1]*The number beside each listed portable pumping station location corresponds to a code number on Map 36.*

Source: SEWRPC.

Table B-11

KNOWN RELIEF PUMPING STATIONS IN OZAUKEE COUNTY: 1970

Relief Pumping Station Location[1]	Receiving Water Body
Village of Thiensville	
1. STH 57 Near Friestadt Road	Pigeon Creek
Village of Saukville	
2. Across the Milwaukee River From the Sewage Treatment Plant	Milwaukee River

[1]*The number beside each listed relief pumping station corresponds to a code number on Map 36.*

Source: SEWRPC.

Table B-12

KNOWN COMBINED SEWER OUTFALLS IN RACINE COUNTY: 1970

Combined Sewer Outfall Location[1]	Receiving Water Body
City of Racine	
1. 21st Street and Lake Michigan	Lake Michigan
2. 3rd Street and Lake Michigan	Lake Michigan
3. Augusta Street and Lake Michigan	Lake Michigan
4. Michigan Avenue and the Root River	Root River
5. Chatham Street and the Root River	Root River
6. N. Main Street and the Root River	Root River
7. N. Wisconsin Street and the Root River	Root River
8. Lake Avenue and the Root River	Root River
9. Main Street and the Root River	Root River
10. 2nd Street and Water Street	Root River
11. State Street and the Root River	Root River
12. Ontario Street and 3rd Street extended	Root River
13. 4th Street and Water Street	Root River
14. Ontario Street and 4th Street extended	Root River
15. Root River (South Bank), 600' East of Marquette Street	Root River
16. Marquette Street and the Root River	Root River
17. South of Bank Street and the Root River	Root River
18. 6th Street and the Root River	Root River
19. 8th Street and the Root River	Root River
20. N. Memorial Drive and the Root River	Root River
21. S. Memorial Drive and the Root River	Root River
22. Harrison Street and the Root River	Root River
23. Southeast of Clayton Avenue and Howland on Clayton Avenue extended	Root River
24. Cedarbend Avenue and the Root River	Root River
25. W. 6th Street and the Root River	Root River
26. W. 6th Street and the Root River	Root River
27. Parkview Drive and the Root River	Root River
28. Liberty Street and the Root River	Root River
29. Domanick Drive, 200' East of Fairchild Street	Root River

[1]*The number beside each listed combined sewer outfall location corresponds to a code number on Map 38.*

Source: SEWRPC.

Table B-13

KNOWN BYPASSES IN RACINE COUNTY: 1970

Bypass Location[1]	Receiving Water Body
City of Racine	
1. 16th Street and Lake Michigan	Lake Michigan
2. 14th Street and Lake Michigan	Lake Michigan
3. 11th Street and Lake Michigan	Lake Michigan
4. Hamilton Street extended and Lake Michigan	Lake Michigan
5. Root River (South Bank), 400' East of Marquette Street	Root River
6. Harrison Street and the Root River	Root River
7. Old Spring Street Bridge and Luedtke Avenue	Root River
8. Frances Street and Harrington Drive	Root River
9. South 38th Street and Rapids Drive	Root River
10. At Sewage Treatment Plant	Lake Michigan
Village of Sturtevant	
11. At Sewage Treatment Plant	Pike River
Village of Union Grove	
12. At Sewage Treatment Plant	West Branch Root River
Town of Caledonia, Caddy Vista Sanitary District	
13. At Sewage Treatment Plant	Root River
Town of Caledonia, Crestview Sanitary District	
14. Novak Road, 1,000' North of 5½ Mile Road	Lake Michigan
Town of Caledonia, North Park Sanitary District	
15. STH 32, 1,300' North of 5 Mile Road	Lake Michigan
16. Erie Street and 4½ Mile Road	Lake Michigan
17. Valley Trail Road, 1,400' North of 4 Mile Road	Lake Michigan
18. 4 Mile Road, 400' West of Hunt Club Road	Lake Michigan
19. Tower Circle and Lake Michigan	Lake Michigan
20. Johnson Foundation Road, 1,700' South of 4 Mile Road	Lake Michigan
Town of Caledonia Sewer Utility District No. 1	
21. Root River and Johnson Drive (600' North of) extended	Root River
22. South Lane and Gifford Road	Hoods Creek
23. Birch Drive extended and the Root River (500' East)	Root River
24. CTH K and Kraut Road	Hoods Creek
Town of Mt. Pleasant Sewer Utility District	
25. Meadow Lane Road, 1,100' South of Hwy. 20	Pike River
26. Racine Avenue and Pine River Drive	Pike River

[1]*The number beside each listed bypass corresponds to a code number on Map 38.*

Source: SEWRPC.

Table B-14

KNOWN PORTABLE PUMPING STATIONS IN RACINE COUNTY: 1970

Portable Pumping Station Location[1]	Receiving Water Body
Town of Caledonia, Crestview Sanitary District	
1. Elm Drive and Six Mile Road	Lake Michigan

[1]*The number beside each listed portable pumping station corresponds to a code number on Map 38.*

Source: SEWRPC.

Table B-15

KNOWN BYPASSES
IN WALWORTH COUNTY: 1970

Bypass Location[1]	Receiving Water Body
City of Delavan	
1. At Sewage Treatment Plant	Turtle Creek
City of Elkhorn	
2. At Sewage Treatment Plant	Jackson Creek
City of Lake Geneva	
3. At Sewage Treatment Plant	White River
City of Whitewater	
4. Main Street Bridge Over Whitewater Creek	Whitewater Creek
Village of East Troy	
5. Trent Tube Company Pumping Station	Honey Creek
Village of Sharon	
6. At Sewage Treatment Plant	Sharon Creek
Village of Walworth	
7. At Sewage Treatment Plant	Piscasaw Creek

[1]*The number beside each listed bypass corresponds to a code number on Map 40.*
Source: SEWRPC.

Table B-16

KNOWN PORTABLE PUMPING STATIONS
IN WALWORTH COUNTY: 1970

Portable Pumping Station Location[1]	Receiving Water Body
Village of Sharon	
1. West End of George Street	Sharon Creek

[1]*The number beside each listed portable pumping station corresponds to a code number on Map 40.*
Source: SEWRPC.

Table B-17

KNOWN BYPASSES
IN WASHINGTON COUNTY: 1970

Bypass Location[1]	Receiving Water Body
City of West Bend	
1. Manhole Near Sewage Treatment Plant	Milwaukee River

[1]*The number beside each listed bypass corresponds to a code number on Map 42.*
Source: SEWRPC.

Table B-18

KNOWN PORTABLE PUMPING STATIONS
IN WASHINGTON COUNTY: 1970

Portable Pumping Station Location[1]	Receiving Water Body
Village of Germantown	
1. STH 145 and Pilgrim Road	Menomonee River

[1]*The number beside each listed portable pumping station corresponds to a code number on Map 42.*
Source: SEWRPC.

Table B-19

KNOWN BYPASSES
IN WAUKESHA COUNTY: 1970

Bypass Location[1]	Receiving Water Body
City of Brookfield	
1. At Fox River Sewage Treatment Plant	Fox River
City of Oconomowoc	
2. Gated Manhole Near Sewage Treatment Plant	Oconomowoc River
3. Gated Manhole Near Sewage Treatment Plant	Oconomowoc River
City of Waukesha	
4. At Sewage Treatment Plant	Fox River
Village of Butler	
5. N. 124th Street Near W. Villard Avenue, extended	Menomonee River
Village of Dousman	
6. Manhole Ahead of Sewage Treatment Plant	Bark River
Village of Hartland	
7. At Sewage Treatment Plant	Bark River
Village of Menomonee Falls	
8. At the Sewage Treatment Plant No. 1	Menomonee River

[1]*The number beside each listed bypass corresponds to a code number on Map 44.*
Source: SEWRPC.

Table B-20

KNOWN PORTABLE PUMPING STATIONS
IN WAUKESHA COUNTY: 1970

Portable Pumping Station Location[1]	Receiving Water Body
City of Brookfield	
1. Barker Road and Glenn-Oaks Drive	Fox River
2. Riverview Drive and Fox River Sewage Treatment Plant	Fox River
3. N. Brookfield Road North of Hoffman Avenue	Fox River
4. N. Brookfield Road Near Carol Drive	Fox River
5. W. Greenfield Avenue Near Ridgeway Road	Poplar Creek
6. Deer Park Drive East of Betty Lane	Deer Creek
7. W. Bluemound Road Near Lynnwood Lane	Underwood Creek
8. S. 124th Street Near Robinwood Street	Underwood Creek
9. W. Center Street Near Arbor Drive	Underwood Creek
Village of Sussex	
10. Manhole Near Sewage Treatment Plant	Sussex Creek

[1]*The number beside each portable pumping station corresponds to a code number on Map 44.*
Source: SEWRPC.

(This page intentionally left blank)

Appendix C

WATER QUALITY PARAMETERS—DEFINITIONS AND SIGNIFICANCE

INTRODUCTION

The regional sanitary sewerage system planning report contains numerous references to water and wastewater quality and the parameters—or indicators—used to quantitatively measure and describe that quality. The report includes, for example, a review of existing surface water and groundwater quality in the Southeastern Wisconsin Region (Chapter IV), a presentation of data on the quality of municipal sewage treatment plant influent and effluent (Chapters V and VI), a summary of adopted water use objectives and supporting water quality standards (Chapters VII and VIII), a discussion of the anticipated impact of municipal sewage treatment plant discharges on water quality in the receiving stream—as determined by water quality modeling (Chapter IX), and a presentation of recommended performance standards for municipal sewage treatment plants (Chapter XI).

The entire sanitary sewerage system planning program is, by its very nature, water quality oriented inasmuch as it is based on the premise that the activities of man in an urbanizing area affect, and are affected by, water quality in that area. Furthermore, planning efforts in general, and the regional sanitary sewerage system planning program in particular, must include an evaluation of present and anticipated future conditions of water quality and of the relationship of water quality to existing and probable future land and water uses.

This Appendix, which is referenced at numerous places in the report, is intended to provide a self-contained, concise discussion of water and wastewater quality parameters that complements and supports the main body of the regional sanitary sewerage system planning report. Brief discussions of all significant water quality parameters mentioned in the report are included in this Appendix. This Appendix is more than a glossary of water quality parameters inasmuch as it not only defines each parameter but also discusses its significance to water use.

WATER QUALITY AND POLLUTION

The term "water quality" refers to the physical, chemical, and biological characteristics of water. Water quality is determined both by the natural environment and by the activities of man. The uses which can be made of a particular water are significantly affected by its quality, and each potential use requires a certain level or range of water quality.

Definition of Pollution

Pure water, in a chemical sense, is not known to exist in nature in that foreign substances, originating from the natural environment or the activities of man, will always be present. Water is said to be polluted when those foreign substances are in such a form and concentration so as to render the water unsuitable for any desired beneficial uses such as the following: preservation and enhancement of fish and other aquatic life, water-based recreation, public water supply, industrial water supply and cooling water, and aesthetic enjoyment.

This definition of pollution does not explicitly consider the source of the polluting substance which may significantly affect the meaning and use of the term. For the purpose of this report, the causes of pollution are considered to be exclusively related to human activity. Examples of potentially polluting discharges to the surface waters that are related to human activities include discharges from municipal sewerage systems and from commercial and industrial facilities, runoff from urban areas and from agricultural lands, and effluent from onsite sewage disposal systems. Any substance present in such quantities as to adversely affect certain beneficial water uses but derived from natural sources would not be herein defined as pollution but would constitute a natural condition that impairs the usefulness of the water.

The Relative Nature of Pollution

The determination of whether or not a particular stream or lake is polluted is a function of the intended use of the water resource in that the water may be polluted with respect to some uses and not polluted with respect to others. For example, a stream that contains a low dissolved oxygen level would be classified as polluted with respect to its use for sport fishing since the survival and propagation of fish is contingent upon an ample supply of dissolved oxygen. That same stream, however, would not necessarily be polluted with respect to its use for aesthetic enjoyment, since its use for this purpose is dependent on the appearance of the stream and adjacent land area. Water pollution, therefore, is a relative term, depending on the uses or needs that the water is to satisfy and the quality of the water relative to the minimum requirements established for those uses or needs.

WATER QUALITY PARAMETERS

There are literally hundreds of water quality parameters, or indicators, available for measuring and describing water quality, that is, its physical, chemical, and biological characteristics. A list of these parameters would include all of the physical and chemical substances in solution or suspension in water, all the macroscopic and microscopic organisms in water, and the physical characteristics of the water itself. Only a few of these hundreds of parameters, however, are normally useful in the evaluation of wastewater quality and natural surface water quality and as indicators of pollution. Twelve parameters were selected in the regional sanitary sewerage system planning program for use in the evaluation of lake and stream water quality and in comparing it to supporting adopted water use standards, for describing the quality of municipal sewage treatment plant effluents, and for determining the effect of those effluents on receiving streams. These parameters in the order of discussion—physical, chemical, biological—are: temperature, dissolved solids, undissolved solids or suspended solids, pH, chloride, dissolved oxygen, carbonaceous biochemical oxygen demand, nitrogenous biochemical oxygen demand, ammonia, coliform bacteria, nutrients, and aquatic flora and fauna.

With the exception of one parameter—nitrogenous biochemical oxygen demand—the water quality indicators referred to in this report and the uses that were made of those indicators during preparation of the regional sanitary sewerage system plan generally conform to accepted, traditional usage and, therefore, require only brief discussions and minimal documentation. Inasmuch as the consideration of nitrogenous biochemical oxygen demand and its relationship to ammonia and to carbonaceous biochemical oxygen demand—particularly as these three indicators relate to the oxygen budget of a flowing stream—is a fairly recent development, the discussion of water quality parameters incorporates an expanded treatment of nitrogenous and carbonaceous biochemical oxygen demand and of ammonia and also includes literature references.

Temperature

Temperature levels in surface waters are determined by the natural environment, primarily solar radiation and atmospheric temperatures, and from wastewaters that are discharged to the surface waters at a temperature different than the ambient temperature. In southeastern Wisconsin, natural climatic temperature conditions do not raise water temperatures sufficiently high to significantly affect most uses of the water. Waste discharges such as spent cooling water, however, can raise the temperature of surface waters sufficiently high to preclude other water uses.

Water temperature is important for many uses. It affects the taste of water and the value of water for certain industrial processes. More importantly, however, aerobic and anaerobic biochemical processes fundamental to the operation of conventional activated sludge and trickling filter units at sewage treatment plants, as well as similar processes occurring in stabilization lagoons and naturally in surface waters, are temperature dependent, since reaction rates approximately double with each $20^{o}F$ rise in temperature within the temperature range normally encountered. Furthermore, an ample supply of oxygen is critical to aerobic sewage treatment processes as well as aerobic natural self-purification processes. That supply of oxygen available for such processes is a function of oxygen solubility in water which is, in turn, highly dependent on temperature.

Dissolved Solids

The dissolved solids content of water and wastewater consists of all inorganic and organic substances that occur dissolved in the water regardless of source. Excluded by this definition are suspended organic or inorganic materials, floating organisms, and dissolved gases.

The concentration of dissolved solids in natural surface waters normally exhibits a wider variation than does the dissolved solids content of sanitary sewage. For example, the Commission's 1964-65 regional surface water quality survey found concentrations of dissolved solids in the streams of southeastern Wisconsin ranging from a minimum of about 200 mg/l to a maximum of approximately 2,500 mg/l. This study, which was based on analyses of 539 samples collected at 87 regional water quality sampling stations, found an average dissolved solids concentration of 570 mg/l. Sanitary sewage composed primarily of domestic wastes may be expected to have a dissolved solids concentration of about 500 mg/l—a concentration that approximates the average dissolved solids level of the Region's surface waters.

The dissolved solids content of surface water has an important bearing upon its suitability for several water uses. Water quality standards supporting adopted State of Wisconsin water use objectives specify that surface waters used for municipal water supply should contain a monthly average of 500 mg/l or less of dissolved solids and shall not exceed 750 mg/l at any time. Quality standards with respect to dissolved solids content of water used for carbonated beverages, food canning, food equipment washing, and general processing are generally higher than for overall industrial and cooling water use and even higher than for drinking water use. Many factors are interrelated in determining the suitability of water for irrigation, important among which are the type of crop, the soil composition, drainage conditions, and climate. It would appear that water containing not more than 2,000 mg/l of dissolved solids is probably suitable for irrigation purposes in southeastern Wisconsin.

Undissolved Solids

Undissolved solids—also commonly referred to as suspended solids—consist of all the settleable and colloidal materials present in water and wastewater. These solids are either volatile (organic) or fixed (mineral) and their concentration generally increases with the degree of pollution. Sanitary sewage composed primarily of domestic waste may be expected to contain about 200 mg/l of undissolved solids.

Some of the volatile and fixed solids in sanitary sewage are settleable and are removed in first-stage sedimentation. In subsequent biological treatment, undissolved organic matter is available as food for bacteria, protozoa, and fungi either in the undissolved state or after conversion to soluble forms. These bacteria, protozoa, and fungi grow either on trickling filter media or in suspension in the activated sludge process. A cumulative suspended solids removal in excess of 90 percent is possible in a well-operated secondary sewage treatment plant.

With respect to sewage treatment plant operation, the undissolved solids content of the influent is important since it is a measure of the quantity of solid material that will ultimately be accumulated as sludge in the treatment process. The undissolved solids present in sewage treatment plant effluent are of concern because of the potential adverse impact on the receiving stream. The volatile or organic component may produce excessive oxygen demand on the receiving waters, thereby producing fish kills, odors, and generally noxious conditions. Both the volatile and fixed components of the undissolved solids in sewage treatment plant effluent may result in excessive color and turbidity in the receiving stream and may be detrimental to fish by causing abrasive injuries, obstructing respiratory passages, and covering and thereby damaging eggs in spawning areas.

Hydrogen Ion Concentration

The hydrogen ion concentration or hydrogen ion activity of a solution is expressed in pH units which are equal to the common (base 10) logarithm of the reciprocal of the hydrogen ion concentration. This system of denotation was devised to avoid negative coefficients and numbers with many decimals. The p stands for potenz, which is German for power, and H is the chemical symbol for hydrogen. Thus a pH value of 7.0 is equivalent to a hydrogen ion concentration of 0.0000001 in grams per liter of solution. The pH scale ranges from 0 to 14, with 7.0 identifying the neutral point separating acids with values of less than 7.0 from bases or alkaline substances with values of more than 7.0.

The hydrogen ion concentration of water or wastewater is dependent upon the dissolved substances, both solids and gases, that occur in the water. The streams of the seven-county planning region, which generally exhibit pH values near or slightly above 7.0, are characteristically calcium bicarbonate waters that act as chemical buffers tending to neutralize acids or bases. Most domestic sewage is neutral or slightly basic, whereas many industrial wastes are markedly acid or basic. Such municipal and industrial waste discharges can alter the pH of the stream depending on the complex of chemical, physical, and biological conditions that exist separately in the receiving water and in the waste discharge, and that combine to interact upon blending of these waters.

A pH range of 5.0 to 9.0 for the stream-wastewater mixture is generally favorable for the biological decomposition of organic substances. Water quality standards supporting adopted State of Wisconsin water use objectives specify that surface waters should have a pH in the range of 6.0 to 9.0 to be suitable for public water supply and fish and aquatic life uses.

In cases where municipal and industrial waste treatment utilize biological processes, pH must be controlled within a range favorable to the particular biological organisms involved. In addition, chemical processes used to coagulate municipal or industrial wastes, dewater sludge, or oxidize certain substances require that the pH be controlled within very narrow limits. The normal pH range of domestic sewage varies from 7.3 to 7.8, which is slightly alkaline. If the pH is significantly below 7.0, the sewage may corrode unprotected metal and concrete and usually indicates that industrial wastes in significant amounts are being discharged to the municipal sewer system without adequate pretreatment.

Chlorides

Chlorides are present in practically all surface water and groundwater, since the chlorides of calcium, magnesium, potassium, and sodium are readily soluble in water. The source can be the natural environment, specifically the leaching of minerals by groundwater movement and surface runoff, or induced through human activities including domestic and industrial waste discharges, agricultural drainage, and urban runoff containing, for example, salts applied to roads for winter maintenance.

During that period of time when streamflow is sustained exclusively by discharge from groundwater reservoir, the prevailing chloride concentration is usually referred to as the background concentration. This background concentration of chloride in southeastern Wisconsin streams is about 10 mg/l. Occasional or persistent concentrations higher than the background chloride concentration indicate the influence of human activities on water quality, and thus chloride data provides a means of detecting possible pollution of lakes and streams.

Chlorides in surface waters are not generally harmful to humans unless high concentrations—in excess of 1,000 mg/l—are reached. Concentrations of 250 to 400 mg/l, however, impart a salty taste to water, render it unsuitable for many industrial uses, and inhibit growth of certain aquatic plants. Certain industrial uses may be affected by chloride concentrations as low as 30 mg/l.

Dissolved Oxygen

The dissolved oxygen (DO) concentration is often considered to be the single most important indicator of surface water quality. Low dissolved oxygen concentrations in surface waters contribute to an unsuitable environment for fish and other desirable forms of aquatic life, and the absence of dissolved oxygen leads to a septic condition with its associated foul odors and unpleasant appearance.

Major sources of dissolved oxygen in surface waters are the atmosphere and aquatic plant life. Large reductions in dissolved oxygen content are caused by bacteria utilizing oxygen in the process of decomposing carbonaceous and nitrogenous compounds, thereby converting them to simpler, more stable inorganic compounds. In addition, algae and other aquatic plants may cause large daily increases and decreases in the dissolved oxygen concentrations of surface waters, as these plants produce oxygen through photosynthesis during the daylight hours and consume oxygen by respiration at night. Such diurnal dissolved oxygen variations often produce unfavorable effects on desirable forms of aquatic animal life, especially during the low phase of the daily cycle.

As already noted, oxygen solubility is temperature dependent, varying inversely with the water temperature. The highest saturation level is 14.6 milligrams per liter which occurs at 32°F (0°C). The saturation concentration decreases to 8.4 mg/l at 77°F (25°C)—representative of summer streamflow conditions—and to even lower levels at still higher temperatures.

The minimum dissolved oxygen concentration that should be maintained in a stream is dependent upon the desired uses of the stream. In order to prevent the development of anaerobic conditions in a stream, a dissolved oxygen concentration of at least 1.0 mg/l should be maintained. For a stream to support a varied and healthy fishery, the dissolved oxygen concentration under average conditions should remain at or above 5.0 mg/l. Fish life cannot generally be maintained at sustained dissolved oxygen concentrations of less than 3.0 mg/l.

It is, of course, possible to have surface water dissolved oxygen levels in excess of the saturation concentration—a condition referred to as supersaturation—which occurs when the rate of photosynthetic oxygen production temporarily exceeds the rate at which oxygen is either consumed by biochemical processes in the water or diffused into the atmosphere. Supersaturation is, however, a transient condition that does not occur with regularity and, therefore, the incremental oxygen represented by possible occasional supersaturated conditions should not be considered in evaluating the waste assimilative capacity of a stream or lake.

Carbonaceous and Nitrogenous Biochemical Oxygen Demand Biodegradation of Organic Substances[1,2] : Untreated sanitary sewage, biologically treated sanitary sewage, and the treated sewage-receiving water mixture normally contain organic material, that is, compounds containing carbon in combination with one or more elements. This organic material, which is discharged primarily by human beings into sanitary sewerage systems in the form of unused food and discarded body cells, consists primarily of carbohydrates, fats, and proteins.

These organic materials—waste products from man's perspective—constitute food for bacteria. Utilizing a process called biodegradation, or oxidation, these biological agents degrade, or oxidize, the organic material so as to both derive energy and to replace cell structure. Under aerobic conditions, these bacteria utilize free oxygen with the end products of the biodegradation consisting of carbon dioxide and water produced as a result of the oxidation of carbon to obtain energy, simpler and stabler inorganic end products, and residual organic matter having a lower energy level.

The bacterial conversion under controlled aerobic conditions of most of the potentially noxious and troublesome organic materials to innocuous substances is one of the primary functions of a conventional secondary municipal sewage treatment plant employing biological processes. It should be emphasized, however, that the control and treatment of sanitary sewage must, in many cases, include measures in addition to secondary treatment because the biodegradation occurring in that treatment does not eliminate all organic material, thereby resulting in the possibility of continuing adverse biodegradation occurring in the receiving waters. Furthermore, the stable compounds that are produced as a result of secondary treatment contain nutrients that may, in the absence of advanced treatment intended to remove such nutrients, produce troublesome growths of algae and aquatic plants.

Certain critical differences occur in the biodegradation of organic substances depending on the nature of the medium. More particularly, and as discussed below, biodegradation of untreated sanitary sewage such as is normally received at a municipal sewage treatment plant may be distinctly different from the point of view of sewage treatment plant operation and surface water quality management than the biodegradation process occurring in both the treated sewage discharged from that plant and in the mixture of that treated sewage and the receiving waters.

CBOD and NBOD in Untreated Sewage: In untreated sanitary sewage, composed primarily of domestic wastewater, the process whereby bacteria utilize oxygen and convert some of the organic matter to stable compounds is normally divided into two distinct stages: a first stage lasting 5 to 15 days during which bacteria biodegrade or oxidize carbonaceous substances, and a second stage—nitrification—lasting up to six months and during which nitrifying bacteria oxidize ammonia to nitrites and then nitrates.

For the purpose of this report, carbonaceous biochemical oxygen demand (CBOD) is intended to refer only to the first stage and the extrapolation of that stage, and does not include the additional oxygen required during nitrification to oxidize ammonia. The later oxygen demand is treated separately and quantified using the concept of nitrogenous biochemical oxygen demand (NBOD). The 5- to 15-day lag in the initiation of the NBOD process relative to the CBOD process is attributable to the relatively small population of bacteria in untreated sewage that is capable of oxidizing nitrogenous compounds.

Figure C-1 illustrates CBOD and NBOD exertion as a function of time as these processes typically occur in untreated sanitary sewage. In particular, Figure C-1 depicts initiation of the NBOD process well after the initial appearance of the CBOD process—about 10 days—and also demonstrates how the rates of exertion of both CBOD and NBOD eventually decrease and asymptotically approach ultimate values.

The ultimate carbonaceous biochemical oxygen demand ($CBOD_{ult}$) of untreated sanitary sewage is, for the purpose of this report, defined as the quantity of oxygen required by bacteria under aerobic conditions to degrade the carbonaceous organic material to carbon dioxide and water. Similarly, the ultimate nitrogenous oxygen demand ($NBOD_{ult}$) is, for the purposes of this report, defined as the quantity of oxygen required by bacteria under aerobic conditions to oxidize ammonia to nitrates and water. The magnitude of both the $CBOD_{ult}$ and $NBOD_{ult}$ is important to sewerage system planning, since the removal of varying proportions of each of these demands in the influent sewage may be necessary and should be considered to meet established water use objectives.

---

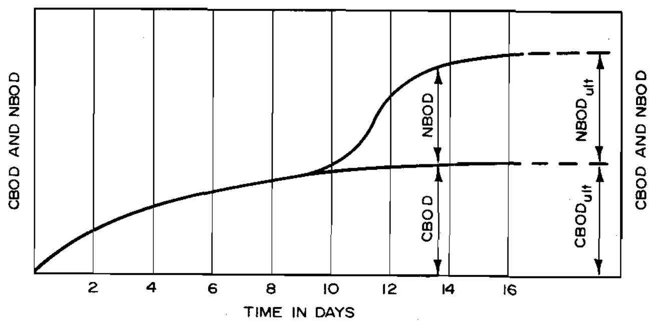
[1] *P. H. McGauhey, Engineering Management of Water Quality, Chapter 2, "Some Fundamental Concepts," McGraw-Hill Book Company, New York, 1968.*

[2] *C. N. Sawyer, Chemistry for Sanitary Engineers, Chapter 5, "Basic Concepts from Organic Chemistry" and Chapter 23, "Biochemical Oxygen Demand," McGraw-Hill, New York, 1960.*

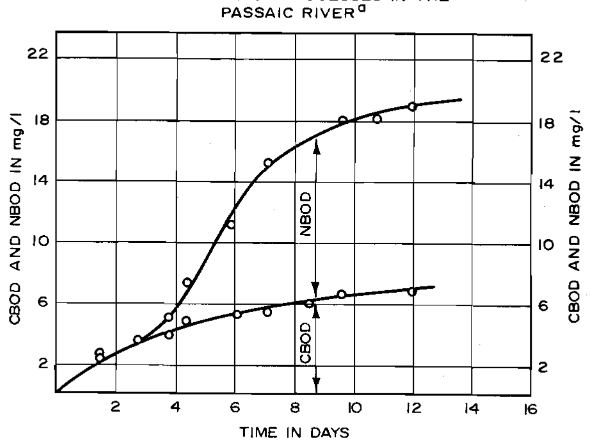
Figure C-1

CARBONACEOUS AND NITROGENOUS BIOCHEMICAL OXYGEN DEMAND

CBOD AND NBOD PROCESSES IN UNTREATED SANITARY SEWERAGE (GENERALIZED)



CBOD AND NBOD PROCESSES IN THE PASSAIC RIVER[a]



[a] WHIPPLE, W., ET. AL, INSTREAM AERATION OF POLLUTED RIVERS, CHAPTER 3, "DISSOLVED OXYGEN DYNAMICS AND ANALYTIC PROCEDURES", WATER RESOURCES RESEARCH INSTITUTE, RUTGERS UNIV., AUG. 1969.

Although laboratory tests are available for determining the $CBOD_{ult}$ and the $NBOD_{ult}$ of a sanitary sewage sample, these tests are not commonly used in connection with sewage treatment plant management because of the long time required to conduct the tests. In the operation of such a facility, for example, influent and effluent $CBOD_{ult}$ determination made for the purpose of adjusting the plant operation so as to optimize the treatment efficiency must be completed within a time period approximating that over which major changes in hydraulic loads or sewage quality may occur. That time period would typically be on the order of several days rather than several months.

Consequently, a five-day carbonaceous biochemical oxygen demand test conducted at 20°C (68°F) has been developed, standardized, and adopted by engineers to provide a practical indicator of the oxygen demand of sanitary sewage or at least that component—carbonaceous—of the ultimate biochemical oxygen demand normally satisfied in a secondary sewage treatment plant. The five-day, 20°C CBOD test ($CBOD_5$) is defined as the amount of dissolved oxygen used by aerobic bacteria to biodegrade or oxidize carbonaceous organic material during a five-day period at a temperature of 20°C expressed in milligrams per liter (mg/l) of dissolved oxygen or in pounds of dissolved oxygen for a given quantity of sanitary sewage. A typical value of $CBOD_5$ for domestic wastewater is 200 mg/l. If, for example, the average daily sewage flow were one million gallons, the $CBOD_5$ of 200 mg/l would be equivalent to, and could be expressed as, 1,668 pounds of $CBOD_5$ per day.

The five-day period required for the standard $CBOD_5$ test is short enough to facilitate practical application of the test results in water quality management in general, and sewage treatment plant operation in particular. Laboratory experience indicates that the five-day test is reliable in that there is relatively low scatter of test data at five days. The five-day period is advantageous in that it is prior to the onset of the NBOD process in untreated sanitary sewage and therefore may be expected to reflect only the CBOD processes, even if steps are not taken to inhibit the NBOD process. A temperature standard is necessary if test results are to be comparable because the rate of oxygen utilization during the first five days of CBOD exertion is markedly dependent on temperature.

Based on theoretical analyses of the CBOD process and laboratory studies of the process, an equation has been derived for the purpose of computing $CBOD_{ult}$ as a function of $CBOD_5$ and a constant—the CBOD deoxygenation rate constant. For example, a $CBOD_5$ value of 200 mg/l and a laboratory condition CBOD process deoxygenation rate constant of 0.30 per day (base e computations) would yield. using the aforementioned equation, a $CBOD_{ult}$ of 258 mg/l. Using the same value of the deoxygenation rate constant, each pound of $CBOD_5$ entering the sewage treatment plant would require 1.29 pounds of oxygen for complete degradation of the carbonaceous organic material.

CBOD and NBOD in Treated Sewage and in the Treated Sewage-Receiving Water Mixture: In sewage subjected to conventional secondary treatment and in mixtures of such treated sewage and receiving waters, the CBOD process and the NBOD process may be expected to occur simultaneously or the initiation of NBOD may lag slightly by a few days as illustrated in Figure C-1. That is, the 5- to 15-day lag of the NBOD process behind the CBOD process, as exhibited in the case of untreated sanitary sewage, is not expected in either biologically treated sanitary sewage or in the receiving waters downstream of the point at which the treatment plant discharge enters the stream.

This conclusion is supported by field data in the sense that in those river reaches receiving effluent from biological treatment plants where instream nitrification has been demonstrated or deduced, the NBOD and CBOD processes were observed to occur simultaneously or the NBOD process began within a few days of the initiation of CBOD. Furthermore, these studies have concluded that the NBOD process as well as the CBOD process may be important and should be taken into account in streams receiving discharges from biological treatment plants.[3,4,5,6,7]

Several explanations are given for the distinctly different CBOD and NBOD processes in untreated sanitary sewage relative to the CBOD and NBOD process in biologically treated sewage or in the mixture of treated sewage and the receiving waters. After secondary treatment, not only are there more nitrifying bacteria present, but the biological treatment process will partially decompose some of the complex organic nitrogen forms into the simpler form of ammonia nitrogen, thereby providing a large supply of ammonia in the effluent to be oxidized in the flowing stream. Secondary sewage treatment plant effluent contains 10 to 20 mg/l ammonia nitrogen where "ammonia nitrogen" is defined as ammonia, NH_3, expressed as nitrogen, N. If one assumes that all of this will be oxidized to nitrate, a considerable oxygen demand will be imposed on the receiving stream, since 4.6 pounds of oxygen are required to oxidize one pound of ammonia nitrogen. In the summer, a well-developed population of nitrogen-oxidizing bacteria often exists in the stream immediately downstream of an effluent discharge point and ammonia in the effluent may, under these conditions, result in the exertion of a heavy, immediate oxygen demand on the receiving stream waters, reducing dissolved oxygen levels below those required to sustain aquatic life and meet water use objectives.

It should be noted that high ammonia levels in secondary sewage treatment plant effluents are an important consideration in water quality management, not only because of the potential for generating instream nitrification and commensurate oxygen depletion, but also because of the potential toxic effect on fish life. Ammonia is considered toxic to fish life at concentrations ranging from about 1.50 to 3.0 mg/l ammonia nitrogen under natural stream conditions. The allowable ammonia concentration increases with increasing alkalinity but decreases with increasing pH.[8,9,10,11] For purposes of this report, and in light of the alkalinity and pH levels common to the Region's surface waters, ammonia was assumed to be potentially toxic at concentrations in excess of 2.5 mg/l expressed as ammonia nitrogen.

The five-day, 20°C carbonaceous biochemical oxygen demand ($CBOD_5$), the ultimate carbonaceous oxygen demand ($CBOD_{ult}$), and the ultimate nitrogenous biochemical oxygen demand ($NBOD_{ult}$) of treated sanitary sewage or of surface waters receiving treated sanitary sewage are all defined exactly as above for untreated sewage. And, as was the case for untreated sewage, only the $CBOD_5$ test is routinely made on effluent samples or stream samples, which results are mathematically extrapolated to estimate $CBOD_{ult}$. Procedures are, however, available for determination of $NBOD_{ult}$, one of which consists of parallel continuous analyses of the CBOD process and the NBOD process on a divided sample. Such analyses, which last for a period in excess of 10 to 20 days depending on the observed behavior of the particular samples, discriminate between the CBOD process and the NBOD process suppressing the occurrence of the latter in one of the two analyses.[12]

The $CBOD_{ult}$ and $NBOD_{ult}$ of a sewage treatment plant effluent are a primary determinant of the potential decrease in dissolved oxygen concentrations that will result if that wastewater is discharged into a stream. The actual decrease in dissolved oxygen downstream of the wastewater discharge is dependent upon many factors, including the ratio of streamflow to effluent discharge, the $CBOD_{ult}$ and $NBOD_{ult}$ of the effluent, the $CBOD_{ult}$ and $NBOD_{ult}$ of the stream, the rate at which the CBOD and NBOD processes occur, and the dissolved oxygen content and reaeration characteristics of the wastewater-stream mixture. A knowledge of these factors is important in water quality studies in order to determine whether a waste discharge will deplete surface water oxygen levels to such an extent that the suitability of the water for certain uses will be impaired.

---

[3] *R. L. O'Connell and N. A. Thomas, "Effect of Benthic Algae on Stream Dissolved Oxygen," Journal of the Sanitary Engineering Division, ASCE, June 1965.*

[4] *C. T. Wezernak and J. J. Gannon, "Evaluation of Nitrification in Streams," Journal of the Sanitary Engineering Division, ASCE, October 1968.*

[5] *W. Whipple, et al, Instream Aeration of Polluted Rivers, Chapter III, "Dissolved Oxygen Dynamics and Analytic Procedures," Water Resources Research Institute, Rutgers University, August 1969.*

[6] *D. J. O'Connor and D. M. DiToro, "Photosynthesis and Oxygen Balance in Streams," Journal of the Sanitary Engineering Division, ASCE, April 1970.*

[7] *R. C. Mt. Pleasant and W. Schlickenrieder, "Implications of Nitrogenous BOD in Treatment Plant Design," Journal of the Sanitary Engineering Division, ASCE, October 1971.*

[8] *Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C., April 1968. Reprinted by the U. S. Environmental Protection Agency, 1972.*

[9] *P. H. McGauhey, Engineering Management of Water Quality, McGraw-Hill, New York, 1968, p. 148.*

[10] *G. E. Hutchinson, A Treatise on Limnology, Volume I, Wiley, New York, 1957, p. 850.*

[11] *Mt. Pleasant and Schlickenrieder, op. cit.*

[12] *W. Whipple, et al, op cit.*

Factors Influencing the Nitrification Process in Streams[13]: Numerous factors determine both the occurrence of nitrification in flowing streams receiving discharges from municipal sewage treatment plants and the rate and manner in which that nitrification proceeds. Of particular importance to this report is the conclusion that most of the nitrification-suppressing factors would simply not be applicable during the critical summer low-flow period and under the stream water quality conditions and wastewater treatment conditions—a relatively high quality stream receiving effluent from a biological treatment plant—assumed in the stream water quality modeling under the regional sanitary sewerage system study. Considering the few remaining potential nitrification-suppressing factors that could occasionally occur under the assumed sewerage study conditions, it is likely that instream nitrification will occur with sufficient severity in stream reaches downstream of secondary sewage treatment plants to merit consideration of it in water quality management.

Dissolved oxygen levels below approximately 1.5 mg/l suppress instream nitrification. This concentration is well below the minimum required for the maintenance of a fishery and, in keeping with that requirement, the analyses described in this report assume receiving stream oxygen levels well above the nitrification inhibiting range.

Water temperatures below about 50°F (10°C) may be expected to inhibit instream nitrification. This factor would not prevent instream nitrification under the conditions assumed in the regional sanitary sewerage system planning program. Sewerage study analyses are concerned primarily with the critical summer low-flow period during which stream temperatures are well above the aforementioned lower limit of 50°F and are, therefore, favorable for the occurrence of nitrification.

Instream nitrification is affected by pH, with the optimum range appearing to be between about 7.0 and 9.0, a pH range that is very likely to exist throughout most of the seven-county planning region during the critical summer low-flow period as noted earlier in this Appendix. Thus, the instream pH range implicit in the sewerage study analyses, which range is in turn intended to reflect regional conditions, is conducive to the occurrence of nitrification.

Free bicarbonate ions or carbon dioxide are required by nitrifying bacteria as the source of carbon for new cell growth. In southeastern Wisconsin, these substances may be expected to be generally available in concentrations exceeding that required by the nitrifying bacteria, and these favorable conditions are implicit in the sanitary sewerage study water quality analyses.

Under conditions of high organic carbon content, carbon oxidizing bacteria may predominate over nitrogen oxidizing bacteria, thus inhibiting the activity of the latter and thereby suppressing nitrification. While this condition would be expected in untreated sewage or streams subjected to a high degree of organic pollution, it would not be expected in surface waters receiving discharges from municipal sewage treatment plants providing at least secondary treatment as assumed under the sanitary sewerage study. If sufficient quantities of phytoplankton are present, they may utilize ammonia directly as a nutrient source, thereby possibly inhibiting nitrification, that is, the oxidation of ammonia nitrogen to nitrates.

Coliform Bacteria

The number of coliform bacteria in water is the most widely used indicator of the possible presence of disease-producing organisms. Coliform bacteria are easily detected and apparently harmless microorganisms which occur in extremely large concentrations in the intestinal tracts of man and warm-blooded animals, along with pathogenic (disease-producing) bacteria. Therefore, the presence of large numbers of coliform bacteria in a water is used as an indicator of the possible presence of enteric pathogens in that water, while the absence of coliform bacteria is used as an indicator of the probable absence of pathogenic bacteria. Coliform bacteria are also present in the soil, however, and therefore may originate from sources other than the human intestinal tract, so that a high coliform count is not necessarily indicative of fecal pollution. Tests have been developed to determine the number of actual fecal coliform organisms present in water, and such tests are considered a better indicator of the probable presence of disease-producing organisms than total coliform tests. A high degree of correlation has been established between high coliform counts in drinking water and epidemics of water-borne diseases such as typhoid, but in waters used for recreational purposes, the correlation between high coliform counts and disease is not as well established.

The Drinking Water Standards of 1962 of the U. S. Public Health Service limit the average monthly coliform concentration in treated drinking water to one colony per 100 ml or a membrane filter coliform count (MFCC) of one per 100 ml. In water used for recreational purposes, State of Wisconsin standards specify a monthly geometric mean membrane filter fecal coliform count (MFFCC) based on a minimum of five samples per month of not more than 200 colonies per 100 ml, and a maximum count not exceeding 400 colonies per 100 ml for more than 10 percent of the samples during any month.

Nutrients

Nutrients may be defined as those chemical elements necessary for the growth of plant life. While a limited amount of fertilization is desirable to produce a balanced aquatic flora and fauna, excessive fertilization produces large growths of algae, aquatic plants, and organisms which inhibit desirable forms of aquatic life including fish, limit recreational activities, and create an aesthetic nuisance. Aesthetic nuisances include unsightly algae accumulations and masses of floating aquatic plants and the noxious conditions—primarily odor—associated with massive, rapid die-offs of algae and aquatic plants.

---

[13] *See the following for a literature review of factors reviewing instream nitrification: Addendum to Simplified Mathematical Modeling of Water Quality, prepared by Hydroscience, Inc., for the U. S. Environmental Protection Agency, Washington, D. C., May 1972.*

Many different nutrients are essential to plant growth. Some, termed micronutrients, must be present in only very small or trace quantities. These include iron, maganese, copper, zinc, molybdenum, vanadium, chlorine, boron, cobalt, and silicon. Others, termed macronutrients, must be present in large amounts and include phosphorus, nitrogen, carbon, hydrogen, oxygen, potassium, magnesium, calcium, and sulphur.

The nutrients most often cited as causing problems of overfertilization are nitrogen and phosphorus compounds. Lake studies,[14,15] including some studies conducted in southern Wisconsin, have indicated that the approximate threshold concentrations for algae blooms in these lakes are 0.3 mg/l inorganic nitrogen and 0.010-0.015 mg/l dissolved phosphorus. Growth of algae is inhibited when available dissolved phosphorus concentrations are less than 0.010-0.015 mg/l. At a concentration higher than 0.05 mg/l, nuisance algal blooms can be anticipated. These values are not necessarily applicable to all lakes, however, since the occurrence of nuisance growths of algae and other aquatic plants depends on the physical characteristics and general environment of a lake, as well as on the concentrations of nutrients present in the lake. In lakes that stratify, a measurable increase in the nutrient phosphorus content may occur in the hypolimnion in late summer, and that phosphorus may be brought to the surface during fall turnover of the lake and result in an autumnal algae bloom. Under bloom conditions, high total phosphorus levels are frequently associated with very low dissolved phosphate levels.

A recent report on water quality criteria[16] contained guideline values of a maximum of 0.10 mg/l total phosphorus in flowing streams and 0.05 mg/l in streams entering lakes or reservoirs to prevent nuisance growths of aquatic plants in streams and lakes. Similar criteria for nitrogen levels in streams are not available.

With respect to controlling algae and aquatic plant growths in surface waters by limiting the influx of a critical nutrient, contemporary water management practice is to place emphasis on phosphorus control rather than on the control of nitrogen or other necessary nutrients and elements. The most important sources of phosphorus are municipal sewage treatment plant effluent and runoff from rural and urban land surfaces, each of which is subject to a substantial degree of control. That is, the quantity, timing, and entry point of most of the phosphorus entering the surface water system is subject to management. In contrast, a large quantity of nitrogen is present in the atmosphere and can be removed from that reservoir by nitrogen-fixing algae—a process that is not readily subject to control.

Aquatic Fauna

A biological assay of a stream, lake, or impoundment provides a good indication of the prevailing level of water quality. Unpolluted waters usually support a large number of species of animal organisms but relatively few individuals of any particular species because of predation and competition for food and living space. In contrast, surface waters subjected to excessive loads of oxygen-demanding substances and processes are characterized by relatively large numbers of organisms of a few pollution tolerant species.

Typical animal organisms found in polluted water are flatworms (Turbellaria), threadworms (Nematodes), midges and wheel animalcules (Rotifera), and sometimes tubifex worms, if dead organic matter is available for food. The clean-water, or less tolerant, aquatic fauna are the Crustacea and moss animalcules (Bryozoa) and are usually found in the cleaner or recovery zones of a stream or lake. Thus, a biological survey and analyses of aquatic fauna will indicate those reaches of a stream which are relatively unpolluted, those which are polluted, and those which serve as intermediate recovery zones.

---

[14] *Sawyer, "Fertilization of Lakes by Agricultural and Urban Drainage," Journal New England Water Works Association, Vol. 61, 1947.*

[15] *Eutrophication--A Review, State of California Publication No. 34, State Water Quality Control Board, 1967, p. 30.*

[16] *Water Quality Criteria, op. cit.*

APPENDIX D

SANITARY SEWERAGE FACILITY DEVELOPMENT RECOMMENDATIONS FOR THAT PORTION OF THE MILWAUKEE RIVER WATERSHED LYING IN FOND DU LAC AND SHEBOYGAN COUNTIES

INTRODUCTION

As discussed in Chapter XI of this report, the Regional Planning Commission adopted in March 1972 a comprehensive plan for the Milwaukee River watershed. This plan contained a series of specific recommendations pertaining to sewerage facility development not only for that portion of the Milwaukee River watershed lying within the seven-county Southeastern Wisconsin Region, but also for that portion of the Milwaukee River watershed lying outside the Region in Fond du Lac ans Sheboygan Counties. The specific sewerage facility development recommendations for the in-Region portion of the watershed were reevaluated under the regional sanitary sewerage system planning program and the results of that reevaluation are presented on pages 461 through 477 of this report. Wisconsin Department of Natural Resources officials who served on the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning also requested that those sewerage facility recommendations pertaining to urban areas in that portion of the watershed lying in Fond du Lac and Sheboygan Counties be reevaluated and updated as necessary as a part of the regional sanitary sewerage system planning program. Accordingly, such a reevaluation was undertaken and the results are presented in this appendix.

SUMMARY OF MILWAUKEE RIVER WATERSHED PLAN RECOMMENDATIONS

With respect to that portion of the Milwaukee River watershed lying in Fond du Lac and Sheboygan Counties, the sewerage facility recommendations contained in the Milwaukee River watershed plan may be summarized as follows:

1. The provision of secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection at the sewage treatment facility serving the Village of Campbellsport, Fond du Lac County.

2. The provision of secondary waste treatment, tertiary waste treatment, and auxiliary waste treatment for effluent disinfection at the municipal sewage treatment facility serving the Village of Random Lake, Sheboygan County, together with extension of the Random Lake sanitary sewerage system to serve existing urban development along the shoreline of Random Lake in the Town of Sherman.

3. The provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection and low-flow augmentation at a proposed sewage treatment facility to serve the Village of Cascade, Sheboygan County, and contiguous urban development along the shoreline of Lake Ellen in the Town of Lyndon.

4. The provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection at the existing sewage treatment facility serving the Village of Adell, Sheboygan County, and at proposed sewage treatment facilities to serve urban development along the shorelines of Forest Lake in the Town of Auburn, Fond du Lac County, and Kettle Moraine Lake in the Town of Osceola, Fond du Lac County.

As discussed in Chapter XI of this report, a development relating to the state of the art of water quality management has taken place since the preparation and adoption of the Milwaukee River watershed plan. This development pertains to the observed toxic effect of ammonia in sewage treatment plant effluent on fish and other aquatic life in receiving streams. As discussed in Chapter IX of this report, such ammonia toxicity has just recently received increased attention and was deemed to be of enough significance to warrant its specific consideration in the reevaluation of the sewerage facility development recommendations for the Milwaukee River watershed as contained in the adopted Milwaukee River watershed plan. As discussed below, with respect to individual sewage treatment facilities, this reevaluation resulted in a decision to modify slightly certain of the sewage treatment plant recommendations contained in the adopted watershed plan.

SEWER SERVICE AREAS

A total of six sewer service analysis areas may be identified within that portion of the Milwaukee River watershed lying in Fond du Lac and Sheboygan Counties (see Table D-1). These six sewer service analysis areas are shown on Map D-1 and may be described as follows:

1. Area A—This area consists of the Village of Campbellsport and environs. In 1967, the base year for the Milwaukee River watershed plan, sewer service was provided in this area to about 0.4 square mile, having a total resident population of about 1,600 persons. By 1990 the total area anticipated to be served approximates 0.8 square mile, with a projected population of about 2,000 persons.

2. Area B—This area consists of the Village of Random Lake, including recently annexed (1973) urban development lying along the shoreline of Random Lake formerly in the Town of Sherman. In 1970 sewer service was provided in this area to about 0.4 square mile, having a total resident

Table D-1

SELECTED CHARACTERISTICS OF SEWER SERVICE ANALYSIS AREAS IN THAT PORTION OF THE MILWAUKEE RIVER WATERSHED LYING IN FOND DU LAC AND SHEBOYGAN COUNTIES 1967 AND 1990

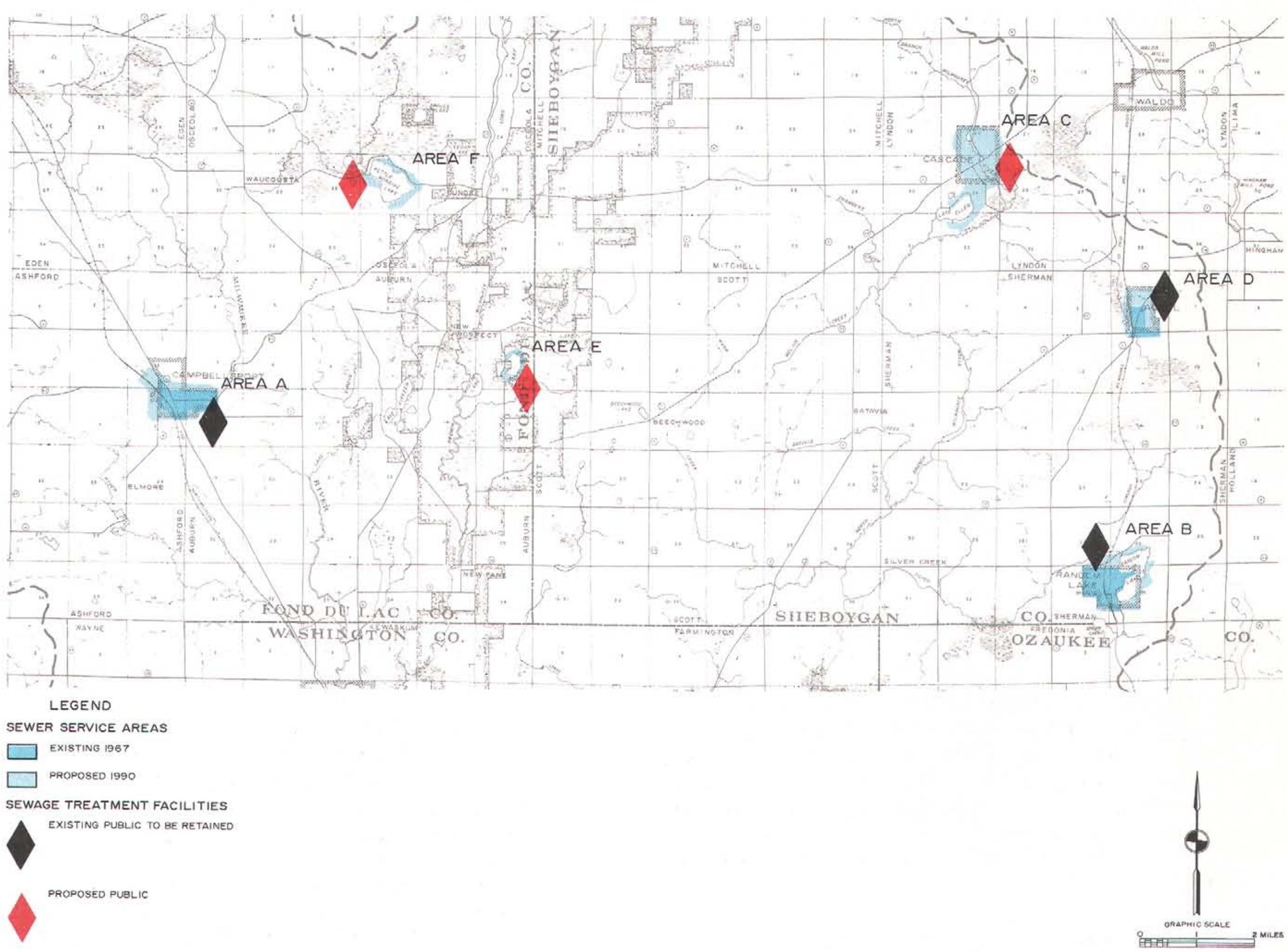
Sewer Service Analysis Area[1]		Existing 1967				Planned 1990		
Letter	Name	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)	Unserved Population Residing in Proposed 1990 Service Area	Area Served (Square Miles)	Population Served	Average Hydraulic Loading (MGD)
A	Campbellsport	0.42	1,600	0.25	--	0.78	2,000	0.40
B	Random Lake	0.43	1,000	0.07	400	0.71	1,900	0.30
C	Cascade-Lake Ellen	--	--	--	600	0.87	1,800	0.26
D	Adell	0.16	400	0.06	--	0.44	500	0.07
E	Forest Lake	--	--	--	80	0.08	600	0.08
F	Kettle Moraine Lake	--	--	--	60	0.19	800	0.10
	Total	1.01	3,000	0.38	1,140	3.07	7,600	1.21

[1]See Map D-1.

Source: SEWRPC.

Map D-1

RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN FOR THAT PORTION OF THE MILWAUKEE RIVER WATERSHED LYING IN FOND DU LAC AND SHEBOYGAN COUNTIES 1990



Source: SEWRPC.

population of about 1,000 persons. By 1990 the total area anticipated to be served approximates 0.7 square mile, with a projected population of about 1,900 persons.

3. Area C—This area consists of the Village of Cascade and contiguous urban development along the shoreline of Lake Ellen in the Town of Lyndon. No sewer service was provided in this area in 1967. By 1990 the total area anticipated to be served approximates 0.9 square mile, with a projected population of about 1,800 persons.

4. Area D—This area consists of the Village of Adell and environs. In 1967 sewer service was provided in this area to about 0.2 square mile, having a total resident population of about 400 persons. By 1990 the total area anticipated to be served approximates 0.4 square mile, with a projected population of about 500 persons.

5. Area E—This area consists of urban development along the shoreline of Forest Lake in the Town of Auburn. No sewer service was provided in this area in 1970. By 1990 the total area anticipated to be served approximates 0.1 square mile, with a projected population of about 600 persons.

6. Area F—This area consists of urban development along the shoreline of Kettle Moraine Lake in the Town of Osceola. No sewer service was provided in this area in 1967. By 1990 the total area anticipated to be served approximates 0.2 square mile, with a projected population of about 800 persons.

RECOMMENDED SEWERAGE FACILITY DEVELOPMENT PLAN

As noted earlier, the factor of ammonia toxicity required a reevaluation of the sewerage facility development recommendations contained in the adopted Milwaukee River watershed plan. Basic data utilized in formulating recommended levels of sewage treatment are presented in Table D-2. The recommended sewage treatment levels and performance standards for each sewage treatment facility are summarized in Table D-3, while detailed cost estimates for sewerage facility development, updated to the base year 1970, are presented in Table D-4.

The sewerage facility development recommendations for this portion of the Milwaukee River watershed, as revised pursuant to the reevaluation process followed under the regional sanitary sewerage system planning program, may be summarized as follows:

1. The provision of secondary waste treatment, advanced waste treatment for both phosphorus removal and nitrification, and auxiliary waste treatment for effluent disinfection at the municipal sewage treatment facility serving the Village of Campbellsport. The reevaluation determined that the ammonia toxicity factor required the addition of advanced waste treatment for nitrification at this plant in order to meet the established water use objectives and supporting water quality standards for the Milwaukee River.

Table D-2

REQUIRED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANT SITES IN THAT PORTION OF THE MILWAUKEE RIVER WATERSHED LYING IN FOND DU LAC AND SHEBOYGAN COUNTIES

Sewage Treatment Plant Site	Receiving Stream	Stream Low Flow and Dilution Ratio Data: 7-Day, 10-Year Low Flow CFS	7-Day, 10-Year Low Flow MGD	Upstream Sewage Treatment Plant Flow-1990 CFS	Upstream Sewage Treatment Plant Flow-1990 MGD	Total Design Low Flow-1990 CFS	Total Design Low Flow-1990 MGD	Total Design Sewage Flow-1990 CFS	Total Design Sewage Flow-1990 MGD	Dilution Ratio (Ratio of Design Low Flow to Design Sewage Flow-1990)	Level of Treatment Required: Secondary	Advanced: Phosphorus Removal	Advanced: Nitrification	Auxiliary: Effluent Aeration	Auxiliary: Disinfection	Auxiliary: Low-Flow Augmentation
Campbellsport	Milwaukee River	1.80	1.16	0.15	0.10	1.95	1.26	0.62	0.40	3.15	Yes	Yes	Yes	No	Yes	No
Random Lake	Tributary to Silver Creek	0.35	0.23	--	--	0.35	0.23	0.46	0.30	0.76	Yes	No	Yes	Yes	Yes	No
Cascade-Lake Ellen	Nichols Creek	0.90	0.58	0.50[1]	0.32[1]	1.40	0.90	0.40	0.26	3.50	Yes	No	No	No	Yes	Yes
Adell	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.11	0.07	N/A	Yes	No	No	No	Yes	No
Forest Lake	Tributary to East Branch Milwaukee River	0.00	0.00	--	--	--	--	0.12	0.08	--	Yes	No	Yes	Yes	Yes	No
Kettle Moraine Lake	Tributary to Milwaukee River	0.00	0.00	--	--	--	--	0.15	0.10	--	Yes	No	Yes	Yes	Yes	No

NOTE: N/A indicates not applicable.

[1]Assumes Low flow augmentation by a 0.5 cfs well.

Source: SEWRPC.

2. The provision of secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection at the municipal sewage treatment facility serving the Village of Random Lake. The reevaluation determined that the ammonia toxicity factor required the addition of advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration at this plant in order to meet the established water use objectives and supporting water quality standards for Silver Creek. The addition of these levels of waste treatment further eliminates the need to provide a tertiary level of waste treatment, as initially recommended in the Milwaukee River watershed plan.

3. The provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection and low-flow augmentation at the municipal sewage treatment facility proposed to serve the Village of Cascade and environs. This represents no change from the watershed plan recommendation.

4. The provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection at the municipal sewage treatment facility serving the Village of Adell and environs. This represents no change from the watershed plan recommendation.

5. The provision of secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection at the proposed municipal sewage treatment facility to serve urban development along the shoreline of Forest Lake. The reevaluation determined that the ammonia toxicity factor required the addition of advanced waste treatment for nitri-

Table D-3

SEWAGE TREATMENT LEVELS AND PERFORMANCE STANDARDS
RECOMMENDED SEWERAGE SYSTEM PLAN FOR THAT
PORTION OF THE MILWAUKEE RIVER WATERSHED
LYING IN FOND DU LAC AND SHEBOYGAN COUNTIES

Sewage Treatment Plant and Estimated 1990 Average Hydraulic Design Capacity	Sewer Service Analysis Areas Served[1]	Estimated 1990 Population	Recommended Sewage Treatment Level(s)	Type of Sewage Treatment Assumed for Cost Analysis Purposes in Plan Preparation	Recommended Performance Standards in Terms of Effluent Quality (All Numbers Represent Annual Averages)
Campbellsport (0.40 MGD)	Campbellsport	2,000	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
				Phosphorus Removal	Phosphorus Discharge: 1 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Random Lake (0.30 MGD)	Random Lake	1,900	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Cascade (0.26 MGD)	Cascade-Lake Ellen	1,800	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
				Low-Flow Augmentation (0.5 cfs well)	Not Applicable
Adell (0.07 MGD)	Adell	500	Secondary	Activated Sludge	$CBOD_5$ Discharge: 15 mg/l
			Auxiliary	Disinfection	Fecal Coliform Concentration: 200/100 ml
Forest Lake (0.08 MGD)	Forest Lake	600	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml
Kettle Moraine Lake (0.10 MGD)	Kettle Moraine Lake	800	Secondary	Aerated Lagoon	$CBOD_5$ Discharge: 15 mg/l
			Advanced	Nitrification	NH_3-N Discharge: 1.5 mg/l
			Auxiliary	Effluent Aeration	DO in Effluent: 6 mg/l
				Disinfection	Fecal Coliform Concentration: 200/100 ml

[1] *See Map D-1.*

Source: SEWRPC.

fication at this plant in order to meet the established water use objectives and supporting water quality standards for the East Branch of the Milwaukee River.

6. The provision of secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection at the proposed municipal sewage treatment facility to serve urban development along the shoreline of Kettle Moraine Lake. The reevaluation determined that the ammonia toxicity factor required the addition of advanced waste treatment for nitrification at this plant in order to meet the established water use objectives and supporting water quality standards for the Milwaukee River.

CONCLUDING REMARKS

A comparison between the recommended treatment levels at existing and proposed sewage treatment plants in that portion of the Milwaukee River watershed lying in Fond du Lac and Sheboygan Counties as initially set forth in the adopted Milwaukee River watershed plan and as modified under the regional sanitary sewerage system planning program is set forth in Table D-5. In two instances—Cascade and Adell—no changes in the watershed plan recommendations have been made. In the remaining four instances—Campbellsport, Random Lake, Forest Lake, and Kettle Moraine Lake—the watershed plan recommendations have been modified slightly to provide for the additional advanced waste treatment process of nitrification because ammonia toxicity was found to be a significant factor in the water quality management of the particular stream involved.

Table D-4

DETAILED COST ESTIMATES
RECOMMENDED SANITARY SEWERAGE SYSTEM PLAN
FOR THAT PORTION OF THE MILWAUKEE RIVER WATERSHED
LYING IN FOND DU LAC AND SHEBOYGAN COUNTIES
1990

Plan Subelement	Estimated Cost						
		Present Worth (1970-2020)			Equivalent Annual (1970-2020)		
	Capital Construction	Construction	Operation and Maintenance	Total	Construction	Operation and Maintenance	Total
Sewage Treatment Plant							
Campbellsport							
Facilities (0.40 MGD)	$ 543,000	$ 626,500	$ 854,700	$1,481,200	$ 39,600	$ 54,300	$ 93,900
Land (2.2 Acres)	4,400	3,200	--	3,200	200	--	200
Subtotal	547,400	629,700	854,700	$1,484,400	39,800	54,300	94,100
Random Lake							
Facilities (0.30 MGD)	635,000	565,900	301,100	867,000	35,900	19,100	55,000
Land (2.3 Acres)	4,600	3,200	--	3,200	200	--	200
Subtotal	639,600	569,100	301,100	870,200	36,100	19,100	55,000
Cascade							
Facilities (0.26 MGD)	313,500	386,600	430,100	816,700	24,500	27,300	51,800
Flow augmentation Well (0.5 cfs)	13,900	23,100	16,800	39,900	1,500	1,100	2,600
Land (2.4 Acres)	4,800	3,200	--	3,200	200	--	200
Subtotal	332,200	412,900	446,900	859,800	26,200	28,400	54,600
Adell[1]							
Facilities (0.07 MGD)	--	--	--	--	--	--	--
Forest Lake							
Facilities (0.08 MGD)	58,100	52,000	66,200	118,200	3,300	4,200	7,500
Land (6.4 Acres)	12,800	9,500	--	9,500	600	--	600
Subtotal	70,900	61,500	66,200	127,700	3,900	4,200	8,100
Kettle Moraine Lake							
Facilities (0.10 MGD)	70,200	63,000	75,700	138,700	4,000	4,800	8,800
Land (6.8 Acres)	13,600	9,500	--	9,500	600	--	600
Subtotal	83,800	72,500	75,700	148,200	4,600	4,800	9,400
Total	$1,673,900	$1,745,700	$1,744,600	$3,490,300	$110,600	$110,800	$221,200

[1]*No costs have been estimated for this sewage treatment facility since the existing plant has adequate average hydraulic design capacity to meet the anticipated 1990 demand.*

Source: SEWRPC.

Table D-5

COMPARISON BETWEEN RECOMMENDED TREATMENT LEVELS AT MUNICIPAL SEWAGE TREATMENT PLANTS IN THAT PORTION OF THE MILWAUKEE RIVER WATERSHED LYING IN FOND DU LAC AND SHEBOYGAN COUNTIES: MILWAUKEE RIVER WATERSHED PLAN AND REGIONAL SANITARY SEWERAGE SYSTEM PLAN

Sewage Treatment Plant	Milwaukee River Watershed Plan							Regional Sanitary Sewerage System Plan							Rationale for Change in Treatment Level Recommendations
			Advanced		Auxiliary					Advanced		Auxiliary			
	Secondary	Tertiary	Phosphorus Removal	Nitrification	Effluent Aeration	Effluent Disinfection	Low-Flow Augmentation	Secondary	Tertiary	Phosphorus Removal	Nitrification	Effluent Aeration	Effluent Disinfection	Low-Flow Augmentation	
Campbellsport ...	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Ammonia toxicity factor requires provision of nitrification
Random Lake	Yes	Yes	No	No	No	Yes	No	Yes	No	No	Yes	Yes	Yes	No	Ammonia toxicity factor requires provision of nitrification; nitrification and effluent aeration together eliminate the need for tertiary treatment
Cascade	Yes	No	No	No	No	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No change
Adell	Yes	No	No	No	No	No	Yes	Yes	No	No	No	No	Yes	No	No change
Forest Lake	Yes	No	No	No	No	Yes	No	Yes	No	No	Yes	Yes	Yes	No	Ammonia toxicity factor requires provision of nitrification
Kettle Moraine ... Lake	Yes	No	No	No	No	Yes	No	Yes	No	No	Yes	Yes	Yes	No	Ammonia toxicity factor requires provision of nitrification

Source: SEWRPC.

APPENDIX E

COMPARISON OF SEWRPC AND DNR-USGS LOW FLOWS AND ANALYSIS OF EFFECT ON RECOMMENDED TREATMENT LEVELS

INTRODUCTION

As described in Chapter IX of this report, consideration of the levels of sewage treatment to be provided under alternative sewerage system plans required that estimates be developed of the 7 day-10 year low flow at each potential site for a new or an expanded sewage treatment plant. Stream low flows were used to compute dilution ratios—stream low flow divided by sewage treatment plant design flow—which were in turn, as described in Chapter IX, a key factor in the establishment of the required treatment levels.

Two actions related to stream low flows, and, therefore, to dilution ratios and required treatment levels, were taken during the course of the Commission's regional sanitary sewerage system planning program but after alternative plans had been formulated. First, the Wisconsin Department of Natural Resources revised its definition of the term "low flow." The new definition uses a recurrence interval concept and defines the 7 day-10 year low flow as the minimum 7-day mean flow that may be expected to occur on the average of once every 10 years. There is, under this definition, a 10 percent probability that the actual 7-day low flow in any given year will be equal to or less than the 7 day-10 year low flow. Second, the Wisconsin Department of Natural Resources (DNR) with the technical assistance of the U. S. Geological Survey (USGS) initiated a statewide low-flow study. The objective of this study was to develop stream low-flow estimates at sewage treatment plant outfalls and other points of interest.

Inasmuch as both of the above actions—the revision in the definition of 7 day-10 year low flow and the DNR-USGS low-flow study—could result in low-flow estimates for the Southeastern Wisconsin Planning Region somewhat different from those obtained under the sanitary sewerage system planning program, the Commission staff undertook a comparative analysis of sewerage study low flows and preliminary DNR-USGS low flows. The primary concern was not the differences between the low flows per se but rather the probable impact of those differences on recommended treatment levels.

DATA PRESENTATION

Regional sanitary sewerage study low-flow estimates, sewage treatment plant design flows, and computed dilution ratios are presented in the left side of Table E-1 for the 45 recommended sewage treatment plant sites at which treated effluent is or would be discharged to streams. Tabulated dilution ratios range from 0.0 to 112.0, and have a median value of 1.38 and a mean value of 14.03. Table E-1 also shows the treatment levels commensurate with the aforementioned dilution ratios. Nitrification, a form of advanced treatment utilized for low dilution ratio situations, is required at about two-thirds of the recommended sewage treatment plants, thus illustrating the overall sewerage study conclusion that high treatment levels are required because of insufficient natural dilution water.

Provisional DNR-USGS natural 7 day-10 year low-flow estimates are also included in Table E-1. This provisional data is for the DNR-USGS project as of March 1973 and was transmitted to SEWRPC from DNR in September 1973. DNR-USGS low-flow estimates are available for 31 of the 45 recommended sewage treatment plant sites. In order to permit comparison to sewerage study dilution ratios, these natural low flows were adjusted for upstream 1970 and 1990 sewage treatment plant flows, and dilution ratios were computed. As shown in Table E-1, the resulting dilution ratios range from about 0.0 to 93.0, and have a median value of 0.91 and a mean value of 10.67. Sanitary sewerage study dilution ratios for the same 31 locations range from 0.0 to 112.0, and have a median value of 2.22 and a mean value of 15.15.

DATA ANALYSIS

Considering only the 31 recommended sewage treatment plant locations for which both sewerage study and DNR-USGS low-flow data and dilution ratios are available, the sewerage study dilution ratios are generally larger than the DNR-USGS dilution ratios in that the median and average of the former are 2.22 and 15.15, respectively, while the median and average of the latter are 0.91 and 10.67, respectively. Similarily, on a one-to-one comparison, sanitary sewerage study dilution ratios are larger for 23 of the 31 common locations.

The right hand column of Table E-1 summarizes the analysis by indicating the effect of the aforementioned differences in sewerage study and DNR-USGS low flows on recommended treatment levels. Of the 31 recommended sewage treatment plants for which both sewerage study and DNR-USGS low-flow estimates—and, therefore, dilution ratios—are available, the recommended treatment level is affected in only one instance—the Village of Kewaskum. The dilution ratio obtained under the sewerage study is larger than the DNR-USGS value and, as a result, the nitrification is not recommended in the regional sanitary sewerage system plan but would be required if the lower DNR-USGS dilution ratio were used.

CONCLUSION

Dilution ratios developed under the sanitary sewerage study are generally larger than DNR-USGS estimates for 31 common recommended sewage treatment plants in southeastern Wisconsin. These dilution ratio differences were found to have an insignificant effect on recommended treatment levels.

Table E-1

COMPARISON OF SEWRPC AND USGS-DNR LOW FLOWS AND CORRESPONDING REQUIRED TREATMENT LEVELS AT SEWAGE TREATMENT PLANTS RECOMMENDED IN THE REGIONAL SANITARY SEWERAGE SYSTEM PLAN

Sewage Treatment Plant Site (By Subregional Area)	Receiving Stream	Southeastern Wisconsin Regional Planning Commission									
		Stream Low Flow and Dilution Ratio Data					Level of Treatment Required				
								Advanced		Auxiliary	
		Natural 7-Day, 10-Year Low Flow (cfs)	Upstream Sewage Treatment Plant Flow-1990[1] (cfs)	Total Design Flow-1990 (cfs)	Total Design Sewage Flow-1990 (cfs)	Dilution Ratio-1990[2] (cfs)	Secondary	Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection
Upper Milwaukee River											
Kewaskum	Milwaukee River	5.30[3]	0.69[4]	5.99	1.42[5]	4.22	Yes	Yes	No	No	Yes
West Bend	Milwaukee River	8.40[3]	2.16	10.56	9.45	1.12	Yes	Yes	Yes	No	Yes
Jackson	Cedar Creek	1.90[3]	0.00[4]	1.90	0.77	2.47	Yes	Yes	Yes	No	Yes
Newburg	Milwaukee River	9.00[3]	11.60[4]	20.60	0.19	108.50	Yes	No	No	No	Yes
Fredonia	Milwaukee River	15.20[3]	12.65[4]	27.85	0.36	77.50	Yes	No	No	No	Yes
Grafton	Milwaukee River	16.50[3]	13.23[4]	29.83	2.94	10.15	Yes	Yes	No	No	Yes
Cedarburg	Milwaukee River	16.60[3]	16.17[4]	32.77	3.84	8.53	Yes	Yes	No	No	Yes
Saukville	Milwaukee River	15.80[3]	13.01[4]	28.81	0.62	46.40	Yes	Yes	No	No	Yes
Sauk Creek											
Belgium-Lake Church	Onion River	0.00	0.00	0.00	1.21	0.00	Yes	No	Yes	Yes	Yes
Port Washington	Lake Michigan	N/A	N/A	N/A	4.02	N/A	Yes	Yes	No	No	Yes
Racine-Kenosha											
Racine	Lake Michigan	N/A	N/A	N/A	75.08	N/A	Yes	Yes	No	No	Yes
Kenosha	Lake Michigan	N/A	N/A	N/A	56.04	N/A	Yes	Yes	No	No	Yes
Root River Canal											
Union Grove	West Branch Root River Canal	0.00	0.00	0.00	2.21	0.00	Yes	Yes	Yes	Yes	Yes
Des Plaines River											
Paddock Lake	Marsh Tributary to Brighton Creek	0.00	0.00	0.00	1.24	0.00	Yes	Yes	Yes	Yes	Yes
Hooker Lake	Brighton Creek-Salem Branch	0.012	0.00	0.012	0.42	0.03	Yes	No	Yes	Yes	Yes
Bristol-George Lake	Tributary to Des Plaines River	0.00	0.00	0.00	0.50	0.00	Yes	No	Yes	Yes	Yes
Bristol-IH 94	Des Plaines River	0.45	2.12	2.57	0.51	5.04	Yes	No	No	Yes	Yes
Pleasant Prairie-North	Des Plaines River	0.60	2.63	3.23	0.14	23.07	Yes	No	No	No	Yes
Pleasant Prairie-South	Des Plaines River	0.80	2.80	3.60	0.93	3.87	Yes	Yes	No	Yes	Yes
Upper Fox River											
Brookfield	Fox River	2.13	--	2.13	29.57	0.13	Yes	Yes	Yes	No	Yes
Waukesha	Fox River	4.70	29.57	34.27	27.09	1.23	Yes	Yes	Yes	No	Yes
Lower Fox River											
Mukwonago	Mukwonago River	7.00	0.00	7.00	2.15	3.25	Yes	Yes	Yes	Yes	Yes
East Troy	Honey Creek	2.40	0.00	2.40	1.08	2.22	Yes	Yes	Yes	Yes	Yes
Lake Geneva	White River	0.10	0.00	0.10	4.18	0.02	Yes	Yes	Yes	Yes	Yes
Lyons	White River	4.71	4.18	8.89	0.23	38.65	Yes	No	No	No	Yes
Genoa City	Nippersink Creek	2.80	0.00	2.80	0.46	6.09	Yes	No	No	No	Yes
Wind Lake	Waubeesee Lake Canal	0.00	0.00	0.00	2.24	0.00	Yes	Yes	Yes	Yes	Yes
Eagle Lake	Eagle Creek	0.00	0.00	0.00	0.39	0.00	Yes	No	Yes	Yes	Yes
Rochester	Fox River	19.00	58.51	77.51	1.55	50.01	Yes	Yes	No	No	Yes
Burlington	Fox River	37.40	67.80	105.20	3.87	27.18	Yes	Yes	No	No	Yes
Silver Lake	Fox River	50.60	72.60	123.20	1.10	112.00	Yes	Yes	No	No	Yes
Twin Lakes	Bassett Creek	0.00	0.00	0.00	1.16	0.00	Yes	Yes	Yes	Yes	Yes
Camp Lake	Fox River	51.00	73.70	124.70	1.64	76.04	Yes	Yes	No	No	Yes
Upper Rock River											
Allenton	Rock River	0.29	--	0.29	0.56	0.52	Yes	No	Yes	Yes	Yes
Hartford	East Branch Rubicon River	0.28	--	0.28	4.58	0.08	Yes	Yes	Yes	Yes	Yes
Slinger	Marsh Tributary to the Rubicon River	0.05	--	0.05	1.04	0.05	Yes	No	Yes	Yes	Yes
Middle Rock River											
Oconomowoc	Oconomowoc River	0.84	--	0.84	9.54	0.09	Yes	Yes	Yes	Yes	Yes
Delafield	Bark River	0.41	0.96	1.37	5.88	0.23	Yes	Yes	Yes	Yes	Yes
Merton	Bark River	0.19	--	0.19	0.59	0.32	Yes	Yes	Yes	Yes	Yes
Dousman	Bark River	0.54	6.47	7.01	0.71	9.87	Yes	No	No	Yes	Yes
Wales	Scuppernong Creek	0.04	--	0.04	0.36	0.11	Yes	No	Yes	Yes	Yes
Lower Rock River											
Whitewater	Whitewater Creek	4.90	0.62	5.52	5.67	0.97	Yes	Yes	Yes	Yes	Yes
Delavan	Turtle Creek	8.90	--	8.90	6.46	1.38	Yes	Yes	Yes	Yes	Yes
Darien	Seepage Lagoon	N/A	N/A	N/A	0.91	N/A	Yes	No	No	No	Yes
Williams Bay	Seepage Lagoon	N/A	N/A	N/A	2.17	N/A	Yes	No	No	No	Yes
Fontana	Seepage Lagoon	N/A	N/A	N/A	1.27	N/A	Yes	No	No	No	Yes
Walworth	Piscasaw Creek	4.73	--	4.73	1.47	3.22	Yes	Yes	Yes	Yes	Yes
Sharon	Sharon Creek	0.57	--	0.57	0.85	0.67	Yes	Yes	Yes	Yes	Yes
Out of Region Upper Milwaukee River											
Campbellsport	Milwaukee River	1.80	0.07	1.87	0.62	3.02	Yes	Yes	Yes	No	Yes
Cascade	Nichols Creek	0.90	0.0	0.90	0.40	2.25	Yes	No	Yes	No	Yes
Adell	Tributary to Milwaukee River Seepage Lagoon	N/A	0.0	N/A	0.11	N/A	Yes	No	No	No	Yes
Random Lake	North Branch Milwaukee River Silver Creek	0.35	0.0	0.35	0.47	0.74	Yes	No	Yes	No	Yes

Table E-1 (continued)

		U.S. Geological Survey-Wisconsin Department of Natural Resources: Stream Low Flow and Dilution Ratio Data							Level of Treatment Required					
										Advanced		Auxiliary		
Sewage Treatment Plant Site (By Subregional Area)	Receiving Stream	Natural 7-Day, 10-Year Low Flow[1] (cfs)	Upstream Sewage Treatment Plant[7] Flow-1970 (cfs)	Natural 7-Day, 10-Year Low Flow (cfs)	Upstream Sewage Treatment Plant Flow-1990 (cfs)	Total Design Low Flow-1990 (cfs)	Total Design Sewage Flow-1990[3] (cfs)	Dilution Ratio-1990[2] (cfs)	Secondary	Phosphorus Removal	Nitrification	Effluent Aeration	Disinfection	Treatment Level Affected By Differences Between Low Flow Estimates
Upper Milwaukee River														
Kewaskum	Milwaukee River	2.40	0.39	2.01	0.69	2.70	1.42	1.90	Yes	Yes	Yes	Yes	Yes	Yes
West Bend	Milwaukee River	4.20	1.15	3.05	2.16	5.21	9.45	0.55	Yes	Yes	Yes	No	Yes	No
Jackson	Cedar Creek	0.70	0.0	0.70	0.0	0.70	0.77	0.91	Yes	Yes	Yes	Yes	Yes	No
Newburg	Milwaukee River	4.90	4.67	0.23	11.60	11.83	0.19	62.26	Yes	No	No	No	Yes	No
Fredonia	Milwaukee River	9.50	4.85	4.65	12.65	17.30	0.36	48.06	Yes	No	No	No	Yes	No
Grafton	Milwaukee River	10.00	5.40	4.60	13.63	18.23	2.94	6.20	Yes	Yes	No	No	Yes	No
Cedarburg	Milwaukee River	11.60	6.20	5.40	16.57	21.97	3.84	5.72	Yes	Yes	Yes	No	Yes	No
Saukville	Milwaukee River	10.00	5.01	4.99	13.01	18.00	0.62	29.03	Yes	Yes	No	No	Yes	No
Sauk Creek														
Belgium-Lake Church	Onion River	--[6]	--	--	--	--	1.21	--	Yes	No	--	Yes	Yes	--
Port Washington	Lake Michigan	--[6]	--	--	--	--	4.02	--	Yes	Yes	--	No	Yes	--
Racine-Kenosha														
Racine	Lake Michigan	--[6]	--	--	--	--	75.08	--	Yes	Yes	--	No	Yes	--
Kenosha	Lake Michigan	--[6]	--	--	--	--	56.04	--	Yes	Yes	--	No	Yes	--
Root River Canal														
Union Grove	West Branch Root River Canal	< 0.01	0.0	0.0	0.0	0.0	2.21	<0.005	Yes	Yes	Yes	Yes	Yes	No
Des Plaines River														
Paddock Lake	Marsh Tributary to Brighton Creek	--[6]	--	--	--	--	1.24	--	Yes	Yes	--	Yes	Yes	No
Hooker Lake	Brighton Creek-Salem Branch	--[6]	--	--	--	--	0.42	--	Yes	No	--	Yes	Yes	--
Bristol-George Lake	Tributary to Des Plaines River	--[6]	--	--	--	--	0.50	--	Yes	No	--	Yes	Yes	--
Bristol-IH 94	Des Plaines River	--[6]	--	--	--	--	0.51	--	Yes	No	--	Yes	Yes	--
Pleasant Prairie-North	Des Plaines River	--[6]	--	--	--	--	0.14	--	Yes	No	--	No	Yes	--
Pleasant Prairie-South	Des Plaines River	--[6]	--	--	--	--	0.93	--	Yes	Yes	--	Yes	Yes	--
Upper Fox River														
Brookfield	Fox River	1.70	0.46	1.24	9.13	10.37	29.57	0.35	Yes	Yes	Yes	No	Yes	No
Waukesha	Fox River	3.30	2.66	0.64	29.56	30.20	27.09	1.11	Yes	Yes	Yes	No	Yes	No
Lower Fox River														
Mukwonago	Mukwonago River	5.60	0.0	5.60	0.0	5.60	2.15	2.60	Yes	Yes	Yes	Yes	Yes	No
East Troy	Honey Creek	1.60	0.0	1.60	0.0	1.60	1.08	1.48	Yes	Yes	Yes	Yes	Yes	No
Lake Geneva	White River	0.94	0.0	0.94	0.0	0.94	4.18	0.22	Yes	Yes	Yes	Yes	Yes	No
Lyons	White River	3.60	0.99	2.61	4.41	7.02	0.23	30.52	Yes	No	No	No	Yes	No
Genoa City	Nippersink Creek	1.60	0.0	1.60	0.0	1.60	0.46	3.48	Yes	No	No	No	Yes	No
Wind Lake	Waubeesee Lake Canal	--[6]	--	--	--	--	2.24	--	Yes	Yes	--	Yes	Yes	--
Eagle Lake	Eagle Creek	--[6]	--	--	--	--	0.39	--	Yes	No	--	Yes	Yes	--
Rochester	Fox River	--[6]	--	--	--	--	1.55	--	Yes	Yes	--	No	Yes	--
Burlington	Fox River	42.00	17.61	24.39	67.23	91.62	3.87	23.67	Yes	Yes	No	No	Yes	No
Silver Lake	Fox River	50.00	19.81	30.19	72.04	102.23	1.10	92.94	Yes	Yes	No	No	Yes	No
Twin Lakes	Bassett Creek	0.01	0.0	< 0.01	0.0	< 0.01	1.16	< 0.009	Yes	Yes	Yes	Yes	Yes	No
Camp Lake	Fox River	--[6]	--	--	--	--	1.64	--	Yes	Yes	--	No	Yes	--
Upper Rock River														
Allenton	Rock River	0.09	0.0	0.09	0.0	0.09	0.56	0.16	Yes	No	Yes	Yes	Yes	No
Hartford	East Branch Rubicon River	0.09	0.14	0.0	1.30	1.30	4.58	0.28	Yes	Yes	Yes	Yes	Yes	No
Slinger	Marsh Tributary to the Rubicon River	0.04	0.0	0.04	0.0	0.04	1.04	0.04	Yes	No	Yes	Yes	Yes	No
Middle Rock River														
Oconomowoc	Oconomowoc River	0.09	0.0	0.09	0.0	0.09	9.52	0.01	Yes	Yes	Yes	Yes	Yes	No
Delafield	Bark River	3.80	0.42	3.38	0.96	4.34	5.88	0.74	Yes	Yes	Yes	Yes	Yes	No
Merton	Bark River	--[6]	--	--	--	--	0.59	--	Yes	Yes	--	Yes	Yes	--
Dousman	Bark River	4.60	0.42	4.18	7.00	11.18	0.71	15.75	Yes	No	No	Yes	Yes	No
Wales	Scuppernong Creek	0.14	0.0	0.14	0.0	0.14	0.36	0.39	Yes	No	Yes	Yes	Yes	No
Lower Rock River														
Whitewater	Whitewater Creek	--	--	--	--	--	5.67	--	Yes	Yes	--	Yes	Yes	--
Delavan	Turtle Creek	5.80	1.09	4.71	2.10	6.81	6.46	1.05	Yes	Yes	Yes	Yes	Yes	No
Darien	Seepage Lagoon	--[6]	--	--	--	--	0.91	--	Yes	No	--	No	Yes	--
Williams Bay	Seepage Lagoon	--[6]	--	--	--	--	2.17	--	Yes	No	--	No	Yes	--
Fontana	Seepage Lagoon	--[6]	--	--	--	--	1.27	--	Yes	No	--	No	Yes	--
Walworth	Piscasaw Creek	1.30	0.0	1.30	0.0	1.30	1.47	0.88	Yes	Yes	Yes	Yes	Yes	No
Sharon	Sharon Creek	0.00	0.0	0.0	0.0	0.0	0.85	0.00	Yes	Yes	Yes	Yes	Yes	No
Out of Region Upper Milwaukee River														
Campbellsport	Milwaukee River	0.10	0.0	0.10	0.07	0.17	0.62	0.27	Yes	Yes	Yes	No	Yes	No
Cascade	Nichols Creek	--[6]	--	--	--	--	--	--	Yes	No	--	No	Yes	--
Adell	Tributary to Milwaukee River Seepage Lagoon	0.03	0.0	0.03	0.0	0.03	0.11	0.27	Yes	No	No	No	Yes	--
Random Lake	North Branch Milwaukee River Silver Creek	0.10	0.0	0.10	0.0	0.10	0.47	0.21	Yes	No	Yes	No	Yes	No

[1]Provisional estimates as of March 1973. Not corrected for upstream sewage treatment plant flow(s).
[2]The ratio of the design low flow to the design sewage flow-1990.
[3]See SEWRPC Planning Report No. 13, Volume 1, Page 349.
[4]See SEWRPC Planning Report No. 13, Volume II, Chapter V.
[5]See SEWRPC Planning Report No. 13, Volume II, Chapter V. The design sewage flow was adjusted upward for the Village of Kewaskum so as to accommodate the observed additional industrial sewage flows since 1967, the base year of the Milwaukee River watershed study.
[6]Low flow estimates not available.
[7]See SEWRPC Planning Report No. 16, Chapter V, and SEWRPC Planning Report No. 13, Volume I, Chapter IX.

Source: SEWRPC.

(This page intentionally left blank)

APPENDIX F

MODEL RESOLUTION FOR ADOPTION OF THE REGIONAL SANITARY SEWERAGE SYSTEM PLAN FOR SOUTHEASTERN WISCONSIN

WHEREAS, the Southeastern Wisconsin Regional Planning Commission, which was duly created by the Governor of the State of Wisconsin in accordance with Section 66.945(2) of the Wisconsin Statutes on the eighth day of August 1960 upon petition of the Counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha, has the function and duty of making and adopting a master plan for the physical development of the Region; and

WHEREAS, the Southeastern Wisconsin Regional Planning Commission has completed and adopted a regional land use plan at its meeting held on the 1st day of December 1966; and

WHEREAS, the Southeastern Wisconsin Regional Planning Commission has:

1. Collected, compiled, processed, and analyzed various types of demographic, economic, land use, natural resource base, and sanitary sewerage data and materials pertaining to the development of the Region.

2. Prepared objectives, principles, and standards for regional land and water use and sewerage system development.

3. Forecast regional growth and change as related to population, land use, and sanitary sewerage demand.

4. Developed, compared, and evaluated alternative sanitary sewerage system plans for the Region.

5. Selected and adopted on the day of________, 1974, a regional sanitary sewerage system plan to the year 1990; and

WHEREAS, the aforementioned inventories, analyses, objectives, principles, standards, forecasts, alternative plans, and adopted plan are set forth in a report entitled, SEWRPC Planning Report No. 16, <u>A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin</u>, published in February 1974; and

WHEREAS, the Commission has transmitted certified copies of its resolution adopting such regional sanitary sewerage system plan, together with the aforementioned SEWRPC Planning Report No. 16, to the local units of government; and

WHEREAS, the (Name of Local Governing Body) has supported, participated in the financing of, and generally concurred in the regional planning programs undertaken by the Southeastern Wisconsin Regional Planning Commission and believes that the regional sanitary sewerage system plan prepared by the Commission is a sound and valuable guide, not only to the development of the Region, but also of the community, and the adoption of such plan by the (Name of Local Governing Body) will assure a common understanding by the several governmental levels and agencies concerned and enable these levels and agencies of government to program the necessary areawide and local plan implementation work; and

WHEREAS, the (Name of Local Governing Body) did on the____day of________19__, approve a resolution adopting the regional land use plan.

NOW, THEREFORE, BE IT HEREBY RESOLVED that, pursuant to Section 66.945(12) of the Wisconsin Statutes, the (Name of Local Governing Body) on the____day of________19__, hereby adopts the regional sanitary sewerage system plan previously adopted by the Southeastern Wisconsin Regional Planning Commission as set forth in SEWRPC Planning Report No. 16 as a guide for regional and community development.

BE IT FURTHER HEREBY RESOLVED that the________clerk transmit a certified copy of this resolution to the Southeastern Wisconsin Regional Planning Commission.

____
(President, Mayor, or Chairman of the Local Governing Body)

ATTESTATION

____
(Clerk of Local Governing Body)