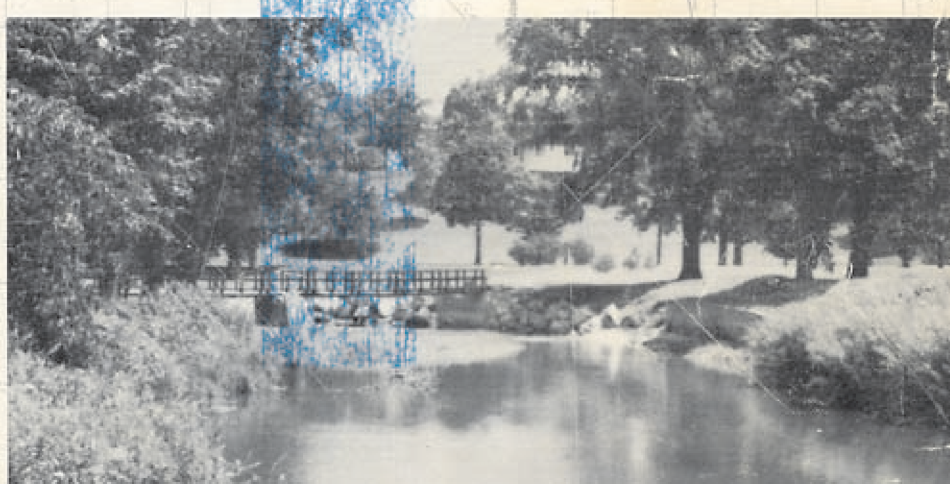
PLANNING REPORT NO. 9

A COMPREHENSIVE PLAN FOR THE ROOT RIVER WATERSHED



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

HARZA ENGINEERING COMPANY

Special acknowledgment is hereby given to Edgar A. Imhoff, former Chief of the SEWRPC Natural Resources Division, for his contribution to this report which was prepared during his tenure with the Commission.

Southeastern Wisconsin Regional Planning Commission

Root River Watershed Study

Old Courthouse
Waukesha, Wisconsin
53187

Planning Report No. 9

A COMPREHENSIVE PLAN FOR THE ROOT RIVER WATERSHED

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July, 1966

Inside Region — $ 5.00
Outside Region — $10.00

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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July, 1966

STATEMENT OF THE CHAIRMAN

The final Root River watershed planning report is herewith presented to the constituent local units of government for consideration. It contains a comprehensive plan for the physical development of the watershed designed not only to solve the pressing problems of flooding, pollution, and changing land use which exist within the watershed but to most advantageously develop the land and water resources of the watershed and provide an environment for human life which is attractive, as well as safe and healthful.

On December 7, 1965, the Commission published a preliminary watershed planning report which presented alternative watershed development plans. Subsequent to the publication of this preliminary report, five open meetings were held with public officials, citizen leaders, and technical advisors throughout the watershed for the express purpose of reviewing and assessing the alternative plans and selecting from among the alternatives the elements of the final plan recommended herein.

In its advisory role, the Commission has been much heartened by the favorable response to, and acceptance of, the recommended plan elements to date by the local units of government concerned. In partial discharge of its statutory responsibility, the Commission will soon give consideration to the formal adoption of the watershed plan recommended herein as an integral part of a comprehensive plan for the physical development of the Southeastern Wisconsin Region.

Immediately upon formal adoption of the final watershed plan by the Commission, an official copy thereof will be transmitted to all affected local, state, and federal units and agencies of government concerned. Plan implementation must necessarily be through the cooperative action of all such governmental units and agencies, with heavy emphasis, however, upon the role of the county level of government.

The Commission stands ready to provide such assistance as may be requested of it to assist in plan implementation.

Respectfully submitted,

George C. Berteau
Chairman

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HARZA ENGINEERING COMPANY
CONSULTING ENGINEERS
RIVER PROJECTS
400 WEST MADISON STREET
CABLE ADDRESS HARZENG CHICAGO' CHICAGO, ILLINOIS 60606 TELEPHONE RANDOLPH 6-3451

June 30, 1966

Kurt W. Bauer, Executive Director
Southeastern Wisconsin Regional
Planning Commission
916 North East Avenue
Waukesha, Wisconsin 53187

Dear Sir:

This report presents the results of planning investigations and studies of the Root River watershed, carried out jointly by the staff of the Southeastern Wisconsin Regional Planning Commission and Harza Engineering Company. Descriptions of procedures, results of investigations and studies, and interim conclusions were presented to the Root River Watershed Committee and to the Commission at frequent meetings during the study period. Our studies were authorized by contract with the Commission dated May 18, 1964.

A preliminary version of this report was published in December 1965 and distributed to concerned public officials and technical agencies. Procedures, results, and conclusions were discussed in a series of public hearings and technical conferences. This final report incorporates information and conclusions gained through these discussions, particularly in the selection of elements which make up the recommended plan.

We wish to acknowledge the participation of the Commission staff in the investigations, studies, and preparation of the report. Economic and demographic forecasts and preparation of land-use plans for the watershed outside the flood plains were largely based on studies carried out by the Commission. The format and large portions of the text material were also contributed by the Commission staff. The Harza Engineering Company and the Commission staff mutually participated in all phases of the watershed studies with emphasis by Harza on hydrologic, hydraulic, and economic aspects.

We have enjoyed this opportunity to contribute to the southeastern Wisconsin planning program, and we wish to congratulate the Commission on its successful development of public participation in its regional and watershed planning activities. Plans, such as this, which reflect the desires of the public, particularly in weighing of intangible considerations, are far more realistic and meaningful than plans prepared without active public participation.

For an overview of the report, we call the reader's attention to the final plan and summary chapters and to the various chapter summaries.

Respectfully submitted,
Harza Engineering Company

E. Montford Fucik

E. Montford Fucik
President

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Chapter I
INTRODUCTION

The Root River watershed planning study represents the first comprehensive watershed planning program to be carried out by the Southeastern Wisconsin Regional Planning Commission. Since this watershed study is an integral part of the Commission work 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 to a proper appreciation of the Root River watershed planning program and its findings and 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, or common areawide development problems. The need for such planning has been brought about by certain important social and economic changes which, while national phenomena, have far-reaching impacts on the problems facing local government. These changes include: unprecedented population growth and urbanization; increasing agricultural and industrial productivity, income levels, and leisure time; generation of mass recreational needs and pursuits; increasingly intensive use and consumption of natural resources; development of private water supply and sewage disposal systems; development of far-flung electric power and communications networks; and development of limited access highway systems and mass automotive transportation.

Under the impact of these changes, entire regions, such as southeastern Wisconsin, are becoming mixed rural-urban areas. This, in turn, is creating new and intensified areawide development problems of an unprecedented scale and complexity. Rural as well as urban people must increasingly concern themselves with these problems or face irreparable damage to their land and water resources.

The areawide problems which necessitate a regional planning effort in southeastern Wisconsin all have their source in the unprecedented population growth and urbanization occurring within the Region. These areawide problems include among others: inadequate drainage and mounting flood damages, impairment of water supply and increasing pollution, underdeveloped sewerage and inadequate sewage disposal facilities, rapidly increasing demand for outdoor recreation and for park and open-space reservation, rapidly changing and unplanned land use, and inadequate transportation facilities. These problems are 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 such areawide planning services for one of the large urbanizing regions of the nation. The Commission was created in August 1960, under the provisions of Section 66.945 of the Wisconsin Statutes, to serve and assist the local, state, and federal units of government in planning for the orderly and economic development of southeastern Wisconsin. The role of the Commission is entirely advisory; and participation by local units of government in the work of the Commission is on a voluntary, cooperative basis. The Commission itself is composed of 21 citizen members, who serve without pay, three from each county within the Region.

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 for the execution of its responsibilities. Basic funds necessary to support Commission operations are provided by the member counties, the budget being proportioned among the several counties on the basis of relative equalized valuation. The Commission is authorized to request and accept aid in any form from all levels and agencies of government for the purpose of accomplishing its objectives and is authorized to deal directly with the state and federal governments for this purpose.

The Commission, its committee structure, and its staff organization, together with its 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 planning. Its objective is to aid the local units of government in the solution of areawide development problems which cannot be properly resolved within the framework of a single municipality or a single county. As such, regional planning has three principal functions:

1. Areawide research; that is, 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 within the Region can better make decisions concerning community development.

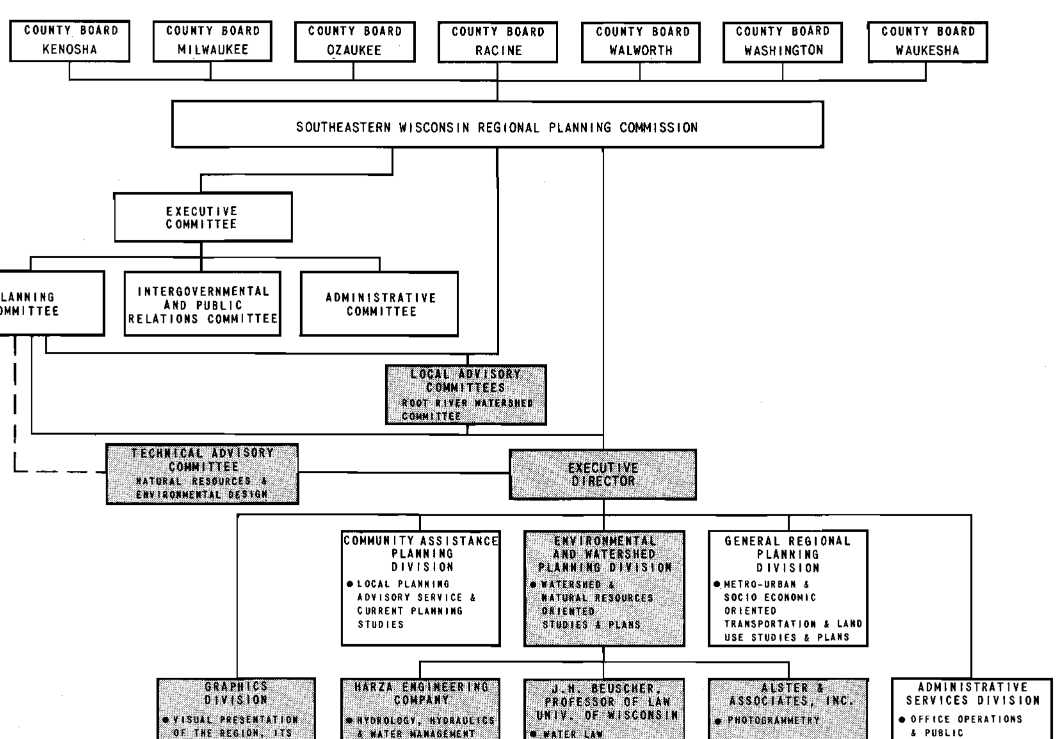
2. Preparation of a framework of long-range plans for the physical development of the Region, these plans being limited to those functional elements having areawide significance. To this end the Commission is charged by law with the function and duty of "making and adopting a master plan for the physical 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, however, the preparation of alternative spatial designs for the use of land and for the supporting transportation and utility facilities.

3. Provision of a center for the coordination of the many planning and plan implementation activities carried on by the various levels and agencies of government operating within the Region.

The work of the Commission is, therefore, visualized as a continuing planning process providing

Figure 1

ORGANIZATIONAL STRUCTURE OF THE SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION AND STAFF



outputs of great 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 of government. The work of the Commission emphasizes close cooperation between the governmental agencies and private enterprise responsible for the development and maintenance of land uses within the Region and for the design, construction, operation, and maintenance of their supporting public works facilities. All of the Commission work programs are intended to be carried out within the context of a continuing planning program which provides for the periodic reevaluation of the plans produced, as well as for the extension of planning information and advice necessary to convert the plans into action programs at the local, regional, state, and federal level.

THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha counties in southeastern Wisconsin. Exclusive of Lake Michigan, these seven counties have a total area of 2,689 square miles and together comprise 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 contain three of the five and one-half standard metropolitan statistical areas in the state. The Region contains approximately one-half of all the tangible wealth in the State of Wisconsin as measured by equalized valuation and represents the greatest wealth producing area of the state, about 42 percent of the state labor force being employed within the Region. It contributes about twice as much in state taxes as it receives in state aids. The seven-county 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 Region has been subject to rapid population growth and urbanization and from 1950 to 1960 accounted for 64 percent of the population increase of the entire 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 within 250 miles of the Region; and over 31 million people reside within this radius.

Initial Work Program

The initial work program of the Commission 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.

All of these initial studies were directed toward providing a basic foundation of planning and engineering data for regional planning and were documented in six published planning reports. None of these studies involved the preparation of plans. Their findings, however, provided a valuable point of departure for all subsequent Commission work, including the Root River watershed planning program.

Also as a part of its initial work program, the Commission adopted a policy of community planning assistance wherein functional guidance and advice on planning problems are extended to local units of government and through which regional planning studies are interpreted locally and regional plans may be integrated with local plans. Four local planning guides have been prepared to date under this community assistance program to provide municipalities throughout the Region with information helpful in the preparation of sound local planning and plan implementation codes and ordinances. These guides will aid in implementing regional as well as local plans and will further assist local public officials in carrying out their day-to-day planning functions. The subjects of these guides are: subdivision control, official mapping, zoning, and organization of local planning agencies. All include model ordinances, and all provide a framework for plan implementation through local land use control measures.

Land Use-Transportation Study

The first major work program of the Commission, which was actually directed toward the preparation of long-range development plans, was a regional land use-transportation study. This program was initiated in January of 1963 and has as its objective the preparation of two of the key elements of a comprehensive plan for the physical development of the Region: a land use plan and a transportation plan. The results of the inventory phase of this study, which has provided many important inputs to the comprehensive watershed planning programs of the Commission, have been published under the title SEWRPC Planning Report No. 7, Volume 1, Land Use-Transportation Study Inventory Findings 1963. Planning operation phases of the land use-transportation study are presently underway and will culminate in the publication of a final land use and supporting transportation plan for the Region in mid-1966.

THE ROOT RIVER WATERSHED PLANNING PROGRAM

The second major work program actually directed toward the preparation of long-range development plans to be undertaken by the Commission is the Root River watershed planning program. This program was initiated upon the specific request of the local units of government concerned, and several distinct phases are discernible in the origin and development of this important planning program. The first such phase became apparent from a review of historic newspaper articles and from personal interviews with long-time residents of the watershed. It consisted of a growing concern on the part of local public officials and citizen leaders over increasing problems encountered in the use of local areas of the Root River itself and of its floodways and flood plains. Concern over what seemed at first to be "local" problems was followed by a growing awareness among public officials that the causes and effects of such problems as flooding and deteriorating water quality transcend local municipal boundaries and are related to the entire stream network and tributary drainage areas. Finally, local public officials and citizens were aroused to the areawide nature of the problems and the urgency of the need for unified action as the result of the unusually severe flood which occurred within the watershed in the spring of 1960. This flood caused especially heavy damage to residences built on the Root River flood plain in and near the City of Racine.

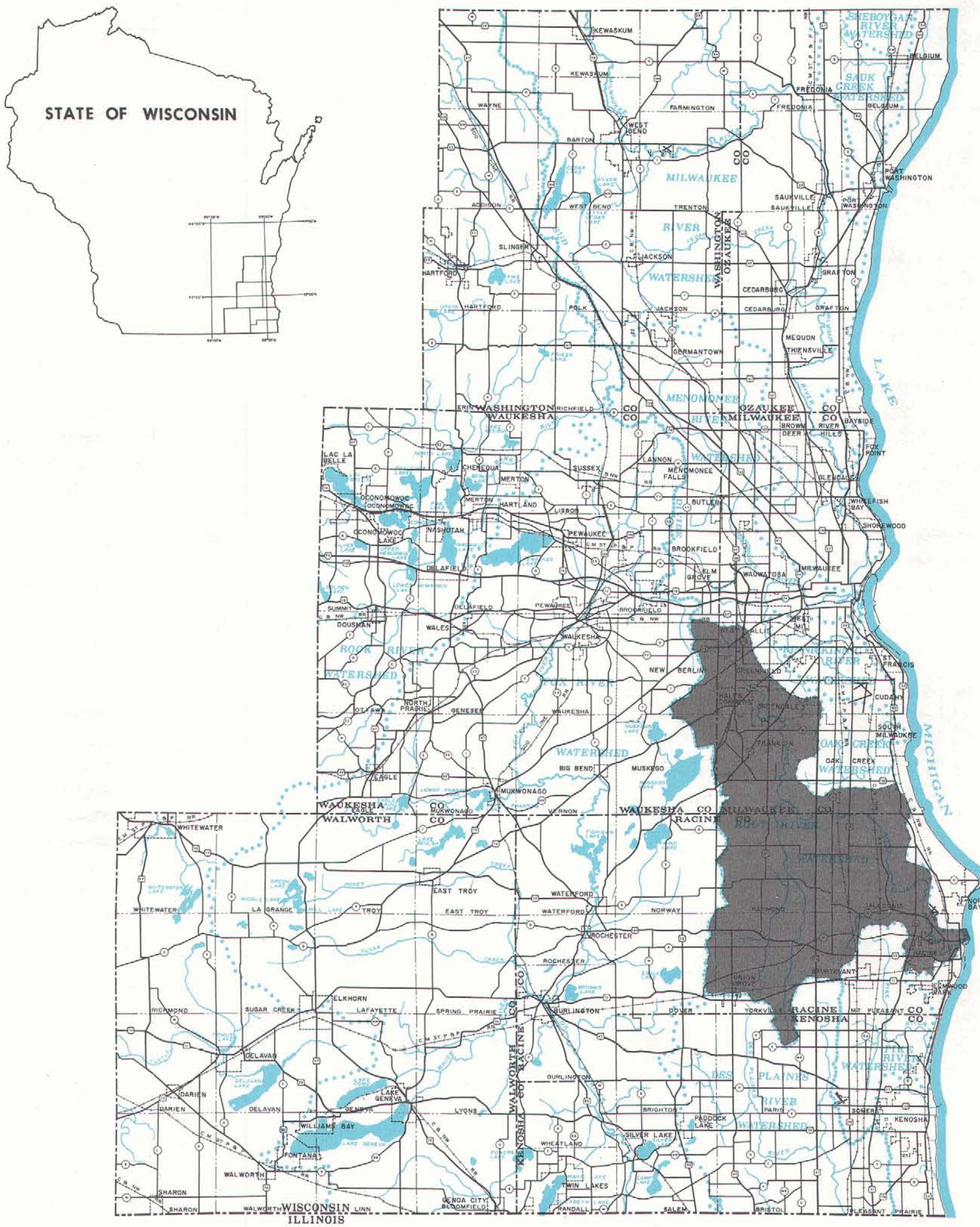
The severe flooding of 1960 predated the creation and functioning of the Regional Planning Commission by about one year. Late in 1961 Commission officials and technical staff were invited by local public officials to meet in Racine for the purpose of exploring ways to solve the water-related problems of the Root River watershed. Subsequently, on March 20, 1962, the City of Racine formally requested the assistance of the Commission in seeking practical and permanent solutions to these problems. Other communities and organizations followed suit.

In accordance with statutory authority and adopted procedure, the Commission appointed a watershed committee of 19 public officials and technicians to assist in the design, execution, and implementation of a planning program for the Root River watershed. This committee, in 12 separate meetings held over the seven-month period, extending from August 1962 through February 1963, prepared a prospectus for a comprehensive watershed planning study. This prospectus was endorsed by the Commission on May 6, 1963, published, and, in accordance with the advisory role of the Commission, transmitted to the governmental agencies concerned for their consideration and action. All four county boards concerned—Kenosha, Milwaukee, Racine, and Waukesha—formally endorsed the prospectus and agreed to provide the local funds necessary for execution of the indicated planning program. The U. S. Housing and Home Finance Agency also endorsed the prospectus and agreed to provide the necessary federal planning funds.

In order to accomplish the study as outlined in the prospectus, it was necessary for the Commission to effect separate contractual agreements with one federal agency, four county governments, and two private engineering firms. Under the contract between the U. S. Housing and Home Finance Agency and the Commission, the latter agreed to complete the necessary planning work in accordance with the prospectus, while the federal agency agreed to provide a Section 701 planning grant in partial support of the study. Under the contract between the four counties concerned and the Commission, the latter agreed to complete the necessary planning work, while the counties agreed to provide the local funds necessary to support the study. The local study costs, amounting to one-third of the total study costs, were allocated to the respective counties on the basis of each county's proportionate share of the 1962 state equalized assessed valuation in the watershed. The percentage share of the total study costs agreed upon in the contracts were: HHFA, 66.67 percent; Kenosha County, 0.03 percent; Milwaukee County, 16.45 percent;

Map 1

LOCATION OF THE ROOT RIVER WATERSHED IN THE REGION



The Root River watershed comprises 197 square miles of land and water area located in the urbanizing portion of southeastern Wisconsin adjacent to Lake Michigan.

Racine County, 15.62 percent; and Waukesha County, 1.23 percent. The contractual agreements executed between the Commission and private consultants provided for special services to the study.

The prospectus, as prepared by the watershed committee and published by the Commission, was not a finished study design. It was a preliminary design prepared to obtain support and financing for the necessary study, an objective it fully attained. The prospectus, however, outlined the necessary major work elements, specified a staff organization, established a time schedule, and provided cost estimates. Work on the study began on July 1, 1964.

Study Objectives

The primary objective of the Root River watershed planning program as set forth in the prospectus is to assist in abating the water-related problems of the Root River basin by developing a workable plan to guide the staged development of multi-purpose water-related facilities and related resource conservation and management programs for the Root River basin. This plan, to be effective, must be amenable to cooperative adoption and joint implementation by all levels and agencies of government concerned and must be capable of functioning as a practical guide for the making of development decisions concerning both land use and water control facility development within the watershed, so that through such implementation the major water-related problems within the watershed may be abated and the full potential of the water resources of the watershed realized.

Additional more specific objectives of the study, consistent with the primary, general objective, are to:

1. Prepare a plan for improved drainage and effective flood damage abatement in and along the major waterways and adjacent flood plains of the Root River basin.

2. Prepare a plan for water quality control and pollution abatement.

3. Prepare a plan for public open-space reservation and recreational development.

4. Refine and adjust the regional land use plans to the conveyance and storage capabilities of the perennial waterways and flood plains of the watershed and to the feasible water control facilities, thereby promoting the adjustment of changing land use in the basin to the surface water resources.

Staff, Consultant, and Committee Structure

The basic organizational structure for the study was outlined in the study prospectus and, as shown in Figure 1, consists of Commission staff and consultants reporting to the Executive Director, who, in turn, reports to the Southeastern Wisconsin Regional Planning Commission.

A comprehensive watershed planning program necessarily covers a broad spectrum of related governmental and private development programs; and no agency, whatever its function or authority, can "go it alone" in the conduct of such a study. The basic Commission organization provides for the attainment of the necessary interagency coordination through the establishment of advisory committees, and two types of such committees are provided as integral parts of the organization for the watershed planning work.

The first type of advisory committee, which functions as a part of the organization created by the Commission for watershed planning, is the Technical Advisory Committee on Natural Resources and Environmental Design. This committee was established in January 1962 and includes representatives from governmental agencies with active resource planning, development, or management programs in southeastern Wisconsin. The full committee membership is listed in Appendix A. The basic purpose of this committee, with respect to watershed planning, is to place the experience, knowledge, and resources of the represented federal, state, and local agencies at the disposal of the study and to ensure that the planning objectives and design criteria of these agencies are recognized and incorporated to the fullest extent possible into the work.

The second type of advisory committee which functions as a part of the organization created by the Commission for watershed planning is the Root River Watershed Committee. This important committee was established in August 1962, and the full membership is listed in Appendix B. The basic purpose of this committee is to actively involve the various governmental bodies, technical agencies, and private interest groups within the watershed in the planning process. The committee assists the Commission in determining and coordinating basic policies involved in the conduct of the study and in the resultant plans and plan implementation programs. Active involvement of local public officials in the watershed planning program through this committee is particularly important to any ultimate implementation of the watershed plans in light of the advisory role of the Commission in shaping regional and subregional development. The watershed committee performs an important function in familiarizing local leadership within the watershed with the study and its findings and in generating an understanding of basic watershed development objectives and implementation procedures. The watershed committee has proven to be a very active and valuable advisory body to the Commission and its staff throughout the conduct of the Root River watershed planning program. Through this committee certain federal and state as well as local planning and engineering data requirements, needs, and objectives have been effectively recognized and incorporated into the study.

The Executive Director of the Commission serves on the Root River Watershed Committee, administers the study, and as a professional engineer sponsors the study. The staff of the SEWRPC Natural Resources Planning Division assists the Executive Director in the coordination of the study and performs those work elements of the study which might logically be categorized as of a natural resources planning nature, including the necessary ground water, water quality, flood damage, water use, land use, economic analyses, and water law studies. The small resident Commission planning staff is heavily supplemented by contractual services to provide the complete spectrum of professional skills needed to successfully complete the study, particularly the hydrologic, hydraulic, and photogrammetric engineering skills required.

The consultants employed specifically for the study consist of the Harza Engineering Company of Chicago, Illinois, hydrologic and hydraulic engineers, and Alster and Associates, Inc., Madison, Wisconsin, photogrammetric engineers. By contract the Harza Engineering Company is responsible to the Commission for the accomplishment of all of the technical work program set forth in the prospectus not accomplished by the Natural Resources Planning Division, with the exception of the detailed flood hazard and land reservation mapping. Alster and Associates are responsible for the preparation of the large-scale topographic maps and control surveys necessary for the detailed flood hazard and land reservation mapping.

This report is a joint effort of the Commission staff and the Harza Engineering Company. Because of the close integration of the work, a precise delineation of responsibilities for various work elements is difficult, if not impossible, to achieve.

SCHEME OF PRESENTATION

The major findings and recommendations of the Root River watershed study are documented and presented in this report, which was first issued in preliminary form on December 10, 1965. The preliminary report set forth the basic concepts underlying the study; the factual findings of the study; forecasts of future economic activity, population growth, and of corresponding land use and natural resource demands. The preliminary report scaled the various demands against the existing supply of land and water resources and presented generalized alternative plans for future development of the watershed, based upon regional and watershed development objectives adopted by the watershed committee and Commission. The preliminary report was intended to allow careful, critical review by public officials, agency staff personnel, and citizen leaders within the watershed and to provide a basis for selection of a final plan from among the alternatives. This, the final report consists of a revision of the preliminary report, incorporating the changes dictated by official public review. In addition, it contains a detailed description of the final plan elements, together with a financial analysis and precise recommendations for implementation.

The plan report can only summarize in brief fashion the large volume of information assembled in the extensive data collection, analysis, and forecasting phases of the Root River watershed study. Although 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. Some of the hydrologic and hydraulic data developed during the study has already been utilized by certain planning and public works agencies within the Region for the planning and design of specific public works improvement projects. This report, therefore, serves the additional purpose of indicating the type of data on the Root River watershed which is available from the Commission and which may be of value in assisting federal, state, and local units of government and private investors in better making decisions about community development within the watershed.

Chapter II

BASIC PRINCIPLES AND CONCEPTS

Watershed planning is not new. Plans have been developed in the past for many river basin watersheds, both large and small, throughout the United States. Most of these plans, however, have been developed either to meet the needs of one or more specific revenue-producing functions, such as irrigation, power, or municipal water supply, or to fulfill a single-purpose requirement for which specific benefits are assignable to existing properties, such as flood control or soil and water conservation.

The application of comprehensive planning principles and practices to watersheds, as defined herein, however, is a relatively new concept. Consequently, little practical experience has been accumulated in such comprehensive watershed planning to date; and widely accepted principles governing such planning have not been established. Moreover, the need to carry out the comprehensive watershed planning as an integral part of a broader regional planning effort required the adaptation and modification of even the very limited body of comprehensive watershed planning experience to the specific needs of the Root River watershed planning program.

These factors occasioned the development of a unique approach to watershed planning, an approach which can only be explained in terms of the conceptual relationships existing between watershed planning and regional planning and of the basic principles applicable to watershed planning set within the framework of regional planning. Only after this foundation of conceptual relationships and applicable principles has been established can the specific problems of the Root River watershed and the recommended solutions to these problems be properly analyzed and understood.

THE WATERSHED AS A PLANNING UNIT

Resources planning could conceivably be carried out on the basis of various geographic units, including areas defined by governmental jurisdictions, economic linkages, or watershed boundaries. None of these are perfect as a resources planning unit. There are many advantages to selection of the watershed as a resources planning unit, however, since many resource problems and solutions are water-oriented.

Storm water drainage and flood control facilities should form a single integrated system over an entire watershed. This system must be capable of carrying both 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 and facilities can best be considered on a watershed basis. Moreover, drainage and flood control problems are closely related to other land and water use problems. Consequently, flood plain reservation, park and open-space reservation, and recreational facilities that are related to surface water resources also can best be studied on a watershed basis.

Water supply and sewerage frequently involve problems that cross watershed boundaries, but strong watershed implications are involved if the source of supply comes from the surface water resources of the watershed or if the sewerage systems discharge pollutants into the surface water system. Changes in land use and transportation requirements are ordinarily not controlled primarily by watershed factors but can have a great effect on watershed problems.

The land use and transportation pattern affects the amount and spatial distribution of the hydraulic and pollution loadings to be accommodated by water control facilities. In turn, the water control facilities and their effect upon the historic floodways and flood plains determine to a considerable extent the use to which such land areas may be put. Finally, the related physical problems of a watershed tend to create a strong community of interest among the residents of the watershed; and citizen action groups can readily be formed to assist in solving water-related problems.

It may be concluded, therefore, that the watershed is a logical areal unit to be selected for resources planning purposes, provided that the relationships existing between the watershed and the surrounding region are recognized. Accordingly, the SEWRPC regional planning program embodies a recognition of the need to consider watersheds as rational planning units in rapidly urbanizing areas if workable solutions are to be found to intensifying interrelated land and water use problems.

The foregoing discussion implies that the term watershed may have two meanings. Defined in a strictly physical sense, a watershed is simply a geographic area of overland drainage contributing surface runoff to the flow of a particular stream or watercourse at a given point. Under this definition the terms watershed and drainage basin are synonymous. The meaning of the term watershed may be expanded, however, to include planning concepts by adding to the above definition the phrase: whose natural and man-made features are so interrelated and mutually interdependent as to create a significant community of interest among its residents. This expanded definition of the term watershed contains within it the characteristics which a drainage basin, such as that of the Root River, must exhibit if it is to form a rational unit for comprehensive water resources planning.

Thus, it is recognized that a watershed is far more than a system of interconnected waterways and flood plains, which, in fact, comprise only a small proportion of the total watershed area. Land treatment measures, soil and water management practices, and land use over the entire watershed, as well as all related water resource problems, are of major importance in the proper development of watershed resources.

RELATIONSHIP OF WATERSHED TO REGION

Although recognizing the importance of the watershed as a rational planning unit within the Region, the SEWRPC planning program also recognizes the necessity to conduct individual watershed planning programs within the broader framework of areawide, comprehensive regional 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 natural watershed boundaries rarely, if ever, coincides with the artificial, generally rectangular boundaries of minor civil divisions and special purpose districts. Important elements of the necessary areawide planning program are being provided by the regional land use-transportation study presently underway and by other ongoing areawide planning programs of the Commission.

Conversely, within the context of the regional planning program, the comprehensive watershed planning programs 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 facilities. While the proposed watershed plans may be centered about drainage and flood control facilities, it must be recognized that these facility plans must be prepared in consideration of the related problems of land and water use, park and public open-space reservation, and water quality and stream pollution. Recognition of the need to prepare such facility plans on a watershed basis, as well as of the need to relate these facility plans to areawide regional development plans, is the primary factor which determines the unique nature of the SEWRPC watershed planning efforts. Ultimate completion of planning studies covering all of the watersheds within the Region will provide the Commission with a framework of community facility plans encompassing drainage, flood control, and pollution abatement facilities properly related to areawide development plans, and will make significant contributions to the preparation of a framework of regional community facility plans for parks and related open spaces and for water supply and sewerage facilities.

THE WATERSHED PLANNING PROBLEM

Although the water-related resource planning efforts of the Commission are focused on the watershed as a rational planning unit, the watershed planning problem is closely linked to the broader problem of resource conservation. Society has always had need to be concerned with resource conservation; but the need for such concern is greater today than ever before and grows, as does the need for regional planning, out of the unprecedented population growth and urbanization of the nation, the state, and the Region. Increasing urbanization has, moreover, changed the nature of the resource conservation problem.

In the past conservation was largely concerned with the protection of wilderness areas and possible future shortages of some resources through chronic mismanagement. The new problem which conservation now faces has to do mainly with the kind of environment being created by the ever increasing areawide diffusion of urban development over large regions and the relentless pursuit of an ever higher material standard of living. Regional settlement patterns so far have not been determined by design but by economic expedience and have failed to recognize the existence of a limited resource base to which urban development must be carefully adjusted if severe environmental problems are to be avoided. If increasing area-wide urbanization is to work for the benefit of man and not to his detriment, adjustment of such urban development to the ability of the resource base to sustain and support it, thereby maintaining the quality of the environment, must become a major physical development objective for urbanizing regions.

Enlightened public officials and citizen leaders are becoming increasingly aware of this new and pressing need for conservation. This growing awareness is often accelerated as the result of a major disaster or of the imminent threat of such a major disaster. Even in such cases, however, the magnitude and degree of the interrelationship of resource problems may not always be fully realized. In many cases, such as in the Root River watershed, the initial concern with the growing resource problems is centered in such highly visible problems as flooding and water pollution.

Growing urbanization is causing increasing concern on the part of public officials, citizen leaders, and technicians with these and other water-related problems; and the manner in which these problems are ultimately resolved will involve many important public policy determinations. These determinations must be made in view of an urbanizing Region which is constantly changing and, therefore, should be based upon a comprehensive planning process able to objectively scale the changing resource demands against the ability of the limited natural resource base to meet these demands. Only within such a planning process can the effect of different land and water use and water control facility construction proposals be evaluated, the best course of action intelligently selected, and the available funds most effectively invested.

The ultimate purposes of such a planning process are twofold: 1) to permit public evaluation and choice of alternative resource development policies and plans; and 2) to provide—through the medium of a long-range plan for water-related community facilities—for the coordination of local, state, and federal resource development programs within the Region and within the various watersheds of the Region. Important among goals to be achieved by this process are the protection of floodways and flood plains; the protection of water quality and supply; the preservation of land for park and open space; and in general, promotion of the wise and judicious use of the limited land and water resources of the Region and its watersheds.

BASIC PRINCIPLES

The foregoing discussion leads to the development of eight basic principles which form the basis for the specific watershed planning process applied in the SEWRPC Root River watershed planning program:

1. Watersheds must be considered as rational planning units if workable solutions are to be found to water-related resource problems.

2. A comprehensive, multi-purpose approach to water resource development and to the abatement of the water-related problems is preferable to a single purpose approach.

3. Watershed planning must be conducted within the framework of a broader area-wide regional planning effort; and watershed development objectives must be compatible with, and dependent upon, regional development plans and objectives.

4. Water control facility planning must be conducted concurrently with, and cannot be separated from, land use planning.

5. Both land use and water control facility planning must recognize the existence of a limited natural resource base to which urban and rural development must be properly adjusted to ensure a pleasant and habitable environment.

6. The capacity of each water control facility in the integrated watershed system must be carefully fitted to the present and probable future hydraulic loads, and the hydraulic performance and hydrologic feasibility of the proposed facilities must be determined and evaluated.

7. Primary emphasis should be placed on in-watershed solutions to water resource problems, and the export of water resource problems to downstream areas is unwise on a long-range and regional basis.

8. Plans for the solution of watershed problems and development of resources should offer as flexible an approach as possible in order to avoid "dead-end" solutions and provide latitude for continued adaptation to changing conditions.

THE WATERSHED PLANNING PROCESS

Based upon the foregoing principles, the Commission employs a seven-step planning process by which the principal functional relationships existing within a watershed can be accurately described both graphically and numerically, the hydrologic and hydraulic characteristics of the basin simulated, and the effect of different courses of action with respect to land use and water control facility development evaluated. The seven steps involved in this planning process are: 1) study design, 2) formulation of objectives and standards, 3) inventory, 4) analysis and forecast, 5) plan design, 6) plan test and evaluation, and 7) plan selection and adoption. Plan implementation, although necessarily beyond the foregoing planning process, must be considered throughout the process if the plans are to be realized.

The principal end results of the above process are land use and water control facility plans scaled to future land use and resource demands and consistent with regional development objectives. In addition, the process represents the beginning of a continuing planning effort that permits modification and adaptation of the plans and the means of implementation to changing conditions. Each step in this planning process includes many individual operations which must be carefully designed, scheduled, and controlled to fit into the overall process; and an understanding of this planning process is essential to an appreciation and understanding of the results. Each step in the process, together with its major component operations, is diagrammed in Figure 2 as described briefly below.

Study Design

Every planning program must embrace a formal structure or study design so that the program can be carried out in a logical and consistent manner. This 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 the data collected are to be processed and analyzed, specify requirements for forecast and for forecast accuracy, and define the nature of the plans to be prepared and the criteria to be used in their evaluation and adoption.

In the Root River watershed program, the study design was prepared jointly by the SEWRPC staff and Harza Engineering Company and presented to the Root River Watershed Committee for review and adoption.

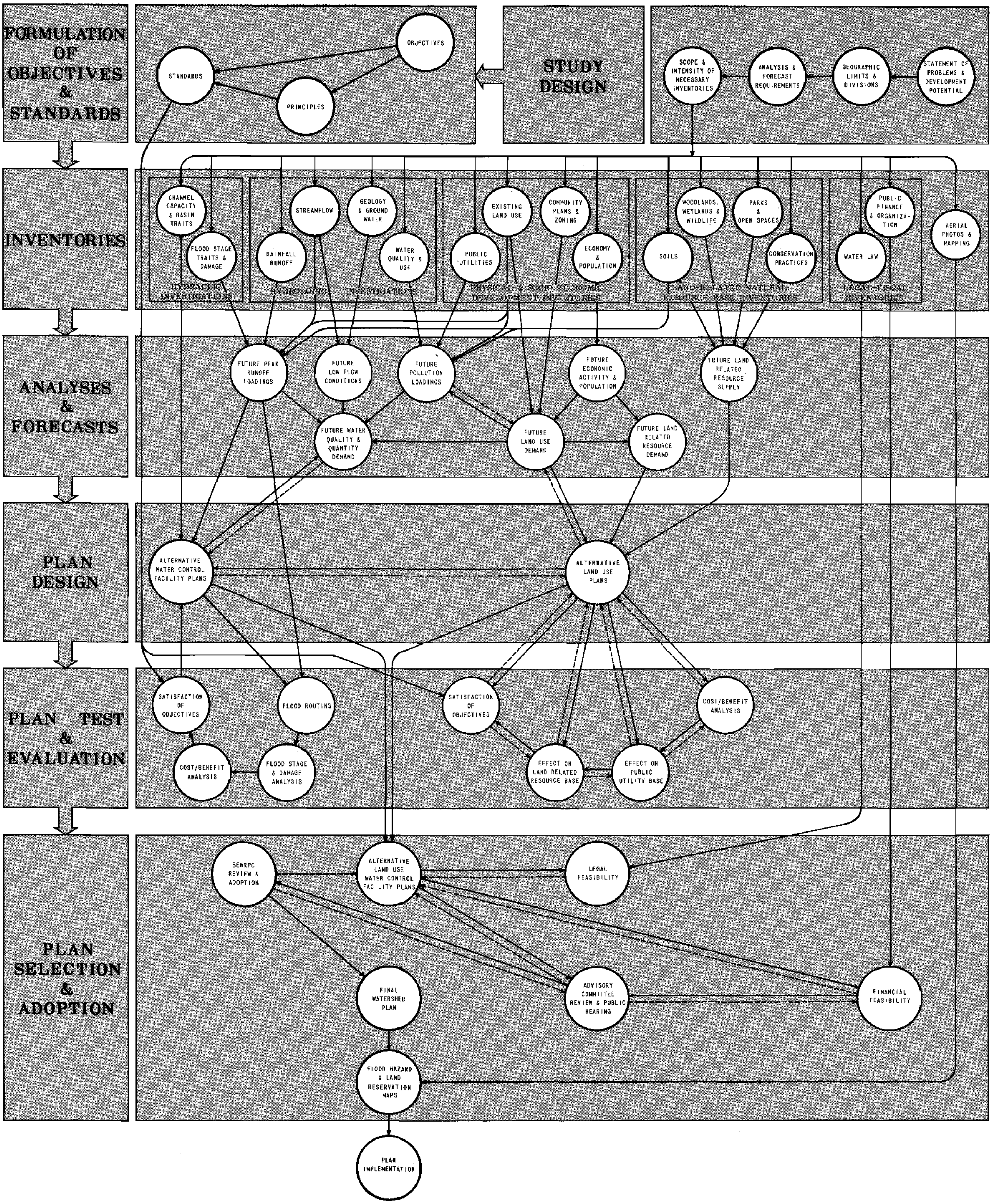
Formulation of Objectives and Standards

In its most basic sense, planning is a rational process for establishing and meeting objectives. The formulation of objectives is, therefore, an essential task to be undertaken before plans can be prepared. In order to be useful in the regional and watershed planning process, the objectives to be defined must not only be stated clearly and be sound logically but must also be related in a demonstrable way to alternative physical development proposals. This is necessary because it is the duty and function of the Commission to prepare a comprehensive plan for the physical development of the Region and its component parts and, more particularly, because it is the objective of the Root River watershed planning study to prepare one of the key elements of such a physical development plan—a long-range plan for water-related community facilities. Only if the objectives are clearly relatable to physical development and subject to objective test can a choice be made from among alternative plans in order to select that plan which best meets the needs of agreed-upon objectives. Finally, logically conceived and well-expressed objectives must be translated into detailed design standards to provide the basis for plan preparation, test, and evaluation.

Because the formulation of objectives and standards involves many nontechnical as well as technical policy determinations, all objectives and standards were carefully reviewed and adopted by the Root River Watershed Committee and the Commission. The objectives and standards ranged from general development goals for the watershed as a whole to detailed planning and engineering criteria covering rainfall intensity-duration-frequency relationships, rainfall runoff relationships,

Figure 2

GENERAL STEPS IN A COMPREHENSIVE WATERSHED PLANNING STUDY



channel capacity formulae, backwater computations, urban storm water drainage design methodology, and water quality parameters.

Inventory

Reliable basic planning and engineering data collected on a uniform, areawide basis is absolutely essential to the formulation of workable development plans. Consequently, inventory becomes the first operational step in any planning process growing out of the study design. The crucial nature of factual information in the planning process should be evident since no intelligent forecasts can be made or alternative courses of action selected without knowledge of the current state of the system being planned.

The sound formulation of comprehensive watershed development plans requires that factual data must be developed on the quantity of surface and ground water, precipitation, hydraulic characteristics of the stream channels, historic flooding, flood damages, water quality, water use, soil capabilities, land use, economic activity, population, recreation facilities, fish and wildlife, public utilities, and water law.

The degree of detail required in the various data collection operations must be varied with the intended use of the information. For example, in the Root River watershed study, it was determined that needed photogrammetric information would have to be very detailed in certain channel reaches because of its use in effectuating floodway and flood plain land use controls but that ground water information could be quite general because of the physical availability of a bountiful supply of good surface water to the majority of watershed residents and industries.

In the Root River study, the most expedient methods of obtaining adequate information of the necessary quality were followed; and the means of data collection included review of prior publications, perusal of agency files, personal interviews with private citizens and public officials, committee meetings of staff and technical advisors, and postal questionnaire surveys, as well as original field investigations.

Analysis and Forecast

Inventories provide factual information about historic and present situations; but analyses and forecasts are necessary to provide estimates of future needs for land, water, and water control facilities. These future needs must be determined from a sequence of interlocking forecasts. Economic activity and population forecasts enable determination of future growth within the watershed, which, in turn, can be translated into future demands for land use, resources, and water control facilities. These future demands can then be scaled against the existing supply and plans formulated to meet deficiencies.

To illustrate the complexity of this task in comprehensive watershed planning, consider that to prepare a forecast of future drainage and flood control needs it was necessary to analyze and to interrelate the following factors: precipitation characteristics, relationship between precipitation and runoff, relationship between basin morphology and runoff, effect of urbanization and soils on runoff, effect of the hydraulic characteristics of the stream network on streamflow, relationships of peak volumes of streamflow to stage heights and frequency of occurrence, relationship of differences between winter and summer runoff and streamflow characteristics, extent and depth of inundation on flood plains, and the horizontal and vertical location of possible future development in flood plains.

Two important considerations involved in the preparation of the necessary forecasts are the forecast target date and the forecast accuracy requirements. Both the land use pattern and the water control facilities must be planned for anticipated demand at some future point in time. In the planning of water control facilities, this "design year" is usually established by the expected life of the first facilities to be constructed in implementation of the plan. Although it may be argued that the design year for land use development should be extended further into the future than that for facilities because of the basic irreversibility of many land development decisions, practical considerations dictate that the land use planning design year be scaled to the facility design year requirement. In the Root River watershed study, the necessary forecast period was set as 25 years, both as a very conservative approximation of facility life and as a means for locking the watershed forecast periods into the previously determined regional land use and transportation study forecast periods.

Forecast accuracy requirements depend on the use to be made of the forecasts; and as applied to land use and water control facility planning, the critical question relates to the effect of any forecast inaccuracies on the basic structure of the plans to be produced. It is important to keep the forecast tolerances within that range wherein only the timing and not the basic structure of the plans will be affected.

Plan Design

Plan synthesis or design forms the heart of the planning process. The most well-conceived objective; the most sophisticated data collection, processing, and analysis operations; and the most accurate forecasts are of little value if they do not ultimately result in sound plans. The outputs of each of the three previously described planning operations—formulation of objectives and standards, inventory, and forecast—become inputs to the design problem of plan synthesis.

The land use plan design problem consists essentially of determining the allocation of a scarce resource—land—between competing and often conflicting demands. This allocation must be accomplished so as to satisfy the aggregate needs for each land use and comply with all of the design standards derived from the plan objectives, all at a feasible cost.

The water control facility plan design problem requires a similar reconciliation between hydrologic and hydraulic loading derived from the land use plan adopted, facility design standards, existing facilities, and new facility costs.

Plan Test and Evaluation

If the plans developed in the design stage of the planning process are to be realized in terms of actual land use and water control facility development, some measures must be applied to quantitatively test alternative plans in advance of their adoption and implementation. The alternative plans must be subjected vigorously to all the necessary levels of review and inspection including: 1) engineering performance, 2) technical feasibility, 3) economic feasibility, 4) legality, and 5) political reaction. Devices used to test and evaluate the plans range from the assignment of hydraulic loadings to the existing and proposed system of water control facilities through interagency meetings and public hearings. Plan test and evaluation should demonstrate clearly which alternative plan or portions of plans are technically sound, financially feasible, legally possible, and politically realistic.

Plan Selection and Adoption

In the Root River watershed study, it is proposed to develop not one but a number of alternative land use plans, each with its supporting water control facility system plan. The general approach contemplated for the selection of one plan from among these alternatives is to proceed through the use of the Root River Watershed Committee structure, interagency meetings, and hearings to a final decision and plan adoption by the Commission in accordance with the provisions of the state enabling legislation. The role of the Commission is to recommend to federal, state, and local units of government and private investors the final plan for their consideration and action. The final decisive step to be taken in the process is the acceptance or rejection of the plan by the local governmental units concerned and subsequent plan implementation by public and private action. Therefore, plan selection and adoption must be founded in the active involvement of the various governmental bodies, technical agencies, and private interest groups concerned with development in the watershed. The use of advisory committees and both formal and informal hearings appears to be the most practical and effective procedure for achieving such involvement in the planning process and of openly arriving at agreement among the affected governmental bodies and agencies on objectives and on a final watershed plan which can be cooperatively adopted and jointly implemented.

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Chapter III

DESCRIPTION OF THE WATERSHED

INTRODUCTION

A comprehensive description of the existing natural and man-made features of the Root River watershed is essential to the preparation of sound land use and water control facility plans for this basin. Such a description must identify the basic physical structure of the watershed and relate this structure to a changing pattern of development. For convenience, the necessary description is herein presented in five sections. The first places the watershed into proper perspective as a planning unit by describing its regional setting and delineating its boundaries. The second describes the natural resource base of the watershed as an interrelated complex of climate, geologic formations, topography, soils, vegetation, and wildlife. The third describes the demographic and economic base of the watershed, while the fourth describes the existing pattern of land use and the fifth section describes the public facilities provided to support human activity in the watershed. Finally, in the chapter summary, the subjects previously presented as separate parts are discussed as an interrelated whole. It is upon this basis that any meaningful watershed planning must proceed, even though isolation of watershed resources into separate compartments may facilitate description and analysis.

LOCATION AND IDENTIFICATION OF THE WATERSHED

Regional Setting

The Root River watershed is a surface water drainage unit, 197.43 square miles in areal extent, located in the east-central portion of the Southeastern Wisconsin Region. The boundaries of the basin, together with the locations of the main channels of the Root River and its principal tributaries, are shown on Map 1. The watershed lies south of the City of Milwaukee and directly in the path of the major Milwaukee-to-Chicago transportation routes. The northern headwater portion of the watershed lies in the rapidly expanding Milwaukee urbanized area, while the Racine urbanized area occupies the southeastern portion of the watershed, which discharges to Lake Michigan through the City of Racine. The southwestern portion of the watershed is occupied by a singular expanse of rich agricultural land, one of the few remaining large concentrations of such land within the Region. The westerly watershed boundary marks the subcontinental divide which separates surface waters flowing westerly and southerly through the Mississippi River to the Gulf of Mexico from surface waters flowing northerly and easterly through Lake Michigan and the St. Lawrence River to the Atlantic Ocean.

Political Boundaries

Superimposed upon the natural, meandering watershed boundaries is a rectangular pattern of local political boundaries, as shown on Map 1. The watershed lies in four counties—Kenosha, Milwaukee, Racine, and Waukesha—and in 18 cities, villages, and towns. The area and proportion of the watershed lying within the jurisdiction of each of these general purpose local units of government as of January 1, 1966, are shown in Table 1.

Since, in Wisconsin, the boundaries of the Soil and Water Conservation Districts are coterminous with county boundaries, the watershed also lies within four such districts, which have important responsibilities for the promotion of good soil and water conservation practices and for resource management. In addition, all that part of the watershed lying in Milwaukee County is within the district boundaries of the Metropolitan Sewerage Commission of the County of Milwaukee, a governmental agency which has important areawide responsibilities for flood control and pollution abatement. This portion of the watershed is also within the jurisdictional limits of the Milwaukee County Park Commission, a truly metropolitan park agency which operates a county-wide park system that includes regional, county, and local park facilities.

Superimposed upon these local units of government are the state and federal governments, certain agencies of which also have important responsibilities in resource conservation and management. These include the State Committee on Water Pollution, the State Board of Health, the Wisconsin Conservation Commission, the Wisconsin Public Service Commission, the U. S. Geological Sur-

Table I

AREAL EXTENT OF CIVIL DIVISIONS IN THE ROOT RIVER WATERSHED
JANUARY 1, 1966

Civil Division	Area Within Watershed Square Miles	Percent of Civil Division Area Within Watershed	Percent of Watershed Area Within Civil Division
Kenosha, County of			
Paris, Town of	2.61	7.24	1.32
County Subtotal	*2.61*	0.94	*1.32*
Milwaukee, County of			
Franklin, City of.	31.76	91.19	16.09
Greendale, Village of.	5.42	96.79	2.75
Greenfield, City of.	6.14	50.83	3.11
Hales Corners, Village of. . .	3.20	100.00	1.62
Milwaukee, City of	1.07	1.17	0.54
Oak Creek, City of	7.58	26.68	3.84
West Allis, City of.	2.97	26.28	1.50
County Subtotal	*58.14*	24.00	*29.45*
Racine, County of			
Caledonia, Town of	36.59	77.23	18.53
Dover, Town of	2.63	7.27	1.33
Mount Pleasant, Town of. . . .	14.35	37.06	7.27
Norway, Town of.	0.10	0.28	0.05
Racine, City of.	5.88	48.60	2.98
Raymond, Town of	33.65	94.63	17.04
Union Grove, Village of. . . .	0.28	51.85	0.14
Yorkville, Town of	30.18	84.49	15.29
County Subtotal	*123.66*	36.38	*62.63*
Waukesha, County of			
Muskego, City of	3.90	10.80	1.98
New Berlin, City of.	9.12	25.20	4.62
County Subtotal	*13.02*	*2.24*	*6.60*
Total	197.43		100.00

Source: SEWRPC.

vey, the U. S. Soil Conservation Service, the U. S. Public Health Service, and the U. S. Army Corps of Engineers.

THE NATURAL RESOURCE BASE

The natural resource base is the primary determinant of the development potential of a watershed area. The principal elements of the natural environment are climate, geology, topography, soils, vegetation, and wildlife. Without a proper understanding and recognition of these elements and their interrelationships, human use and alteration of the natural environment proceed at the risk of excessive costs, in terms of both dollars and destruction of nonrenewable or slowly renewable resources. In this age of high resource demand and accelerating technology, it is especially vital that the resource base be the primary consideration in any areawide planning effort, since these aspects of contemporary civilization make the underlying and sustaining resource base ever more vulnerable to misuse and destruction.

Climate

The watershed has a continental climate characterized by four distinct seasons. Winters begin in November, last through March, and tend to be cloudy, cold, and snowy. Freeze-up of streams and lakes usually occurs in early December and does not end until early April; however, there is often a short-lived mid-winter thaw due to unseasonably warm temperatures. Spring is slow in arriving, partially due to the cooling effects of the waters of Lake Michigan, and is a mixture of both summer and winter. Summers are fully developed and generally warm but marked by occasional hot and humid periods and unseasonably cool periods. Frequent breezes from Lake Michigan offer relief from high summer temperatures to those areas of the watershed lying within a few miles of Lake Michigan. Fall may extend from September to November and is characterized by mild, sunny days and cool nights. By fall Lake Michigan waters have become warm to the extent that the lake tends to prolong fall in the watershed a week or so longer than in areas farther inland. The climate of the watershed can be understood more fully by examining phenomena of temperature, precipitation, wind movement, sunshine, and evaporation recorded at the Milwaukee First Order Weather Station, which is located within three miles of the watershed and is considered generally representative of watershed climatic conditions.[1]

Temperature: The mean daily temperature during the hottest month, July, is 71.35°F with an official record high temperature of 101°F. The mean daily temperature during the coldest month, January, is 21.94°F with an official record low of -24°F. Temperature conditions within the watershed allow a growing season[2] of from 155 to 175 days. Average dates of the last killing frost in spring and the first killing frost in fall are May 1 and October 13, respectively, with upland areas tending to have the most frost-free days.

Precipitation: Annual precipitation on the watershed, including snowfall, averages about 30 inches (30.27 inches at Milwaukee), but annual amounts have ranged from a low of 18.69 to a high of 50.36 inches. Most precipitation occurs as rain falling during the growing season (see Table 2). Most summer rainfall occurs in localized thunderstorms which usually move over the watershed in a few hours. However, 24-hour rainfall amounts of up to 7 1/2 inches (July 17-18, 1964) have fallen on the watershed as a result of a thunderstorm which became stationary over the watershed and was kept active by convergent winds.

Rainfall is often unevenly distributed during the growing season. Considering agricultural needs of about one inch of rainfall during each week of the growing season, the time distribution of rainfall within the watershed is relatively poor. The probability of one inch of rainfall occurring during each summer week ranges from a high of 4 in 10 years in early June and early August to 2 in 10 years in late July and late August.

Rainfall depth-area-duration-frequency data, important in engineering design consideration, are presented in Chapter VI and Appendix I.

Table 2

MEAN MONTHLY PRECIPITATION AT MILWAUKEE, WISCONSIN (1854 - 1964)

Month	Mean Precipitation in Inches	Percent of Total
January. . . .	1.87	6.18
February . . .	1.65	5.45
March.	2.41	7.96
April.	2.72	8.98
May.	3.25	10.74
June	3.49	11.53
July	3.00	9.91
August	2.74	9.05
September. . .	3.10	10.24
October. . . .	2.29	7.57
November . . .	2.03	6.71
December . . .	1.72	5.68
Total	30.27	100.00

Source: U.S. Geological Survey, Surface Water Branch; Harza Engineering Co.

Snow is the primary form of precipitation from late November through March. Although seasonal snowfall on the watershed averages about 40 inches, individual seasons have ranged from 11 inches to 110 inches. The probability of having snow on the ground reaches a high in mid-February and then decreases sharply. The average percentage of the time snow has covered the ground in selected depths is given in Table 3. The actual water content of snowfall on the watershed varies with the individual storm but averages about 10 percent; that is, 10 inches of snowfall is equivalent to one inch of precipitation.

Wind Movement: Prevailing winds are westerly in winter and southerly in the summer over most of the watershed; but within three miles of Lake Michigan, northeasterly winds prevail during the period April through June. Wind speeds, neglecting gusts, can be expected to reach 55 miles per hour at the 30-foot level and 45 miles per hour at the 10-foot level in at least one out of two years.

[1] *Detailed summaries of climatological data collected at weather stations in the vicinity of the watershed have been published in SEWRPC Planning Report No. 5, The Natural Resources of Southeastern Wisconsin, June 1963.*

[2] *"Growing season" is defined as the number of days between the last 32°F freeze in spring and the first 32°F freeze in fall.*

Table 3

AVERAGE PERCENTAGE OF TIME THE ROOT RIVER WATERSHED IS COVERED BY SELECTED DEPTHS OF SNOW

Depth of Snow on Ground	Snowfall Season					
	November	December	January	February	March	April
1 inch or more . . .	10%	50%	70%	75%	40%	1%
5 inches or more . .	1%	10%	35%	40%	20%	-
10 inches or more . .	-	5%	10%	15%	5%	-

Source: Personal communication, 1964, Marvin Burley, Wisconsin State Climatologist, U.S. Weather Bureau, Madison, Wisconsin.

Speeds can be expected to reach 100 miles per hour at the 30-foot level and 85 miles per hour at the 10-foot level once in 50 years.[3]

Sunshine: Sunshine in the watershed occurs 55 percent of the maximum possible time during the year: 40 percent from November through February, 55 percent March through May and during October, 60 percent June through September, and about 70 percent of the maximum possible during July.

Evaporation: Annual evaporation from water surfaces, such as lakes and streams, is about equal to the mean annual precipitation of 30 inches; but 80 percent of this demand on water supply occurs during the period May through October. Evapotranspiration from soils and plants is normally less than free water surface evaporation, averaging about 21 inches, most of which is demanded during the growing season. Depending upon such factors as land use, temperature, available water, and soil conditions, evapotranspiration will vary from 15 to 28 inches, as shown in Table 4. From these values it can be seen that, although precipitation is adequate to supply evapotranspiration needs on an annual basis, it may fall short of the need in a given growing season or portion of such a season.

[3] *Personal communication, 1964, Marvin Burley, Wisconsin State Climatologist, U.S. Weather Bureau, Madison, Wisconsin.*

Geology

The landscape of the watershed and the underlying subsurface materials can be best described in terms of structure, composition, and spatial distribution. As shown on Map 2, the subsurface structure consists of a sequence of layered bedrock units, which are tilted uniformly toward Lake Michigan at slopes of up to 30 feet per mile.

On the basis of their water-carrying ability, the rock units can be divided into the non-water bearing and the water-bearing (aquifer) units. Except for their function in prohibiting or retarding the movement of water, the non-water-bearing rock units are of no significance in this report.

There are two major ground water-bearing units in the watershed. The first is a deep aquifer, composed primarily of Cambrian sandstones and

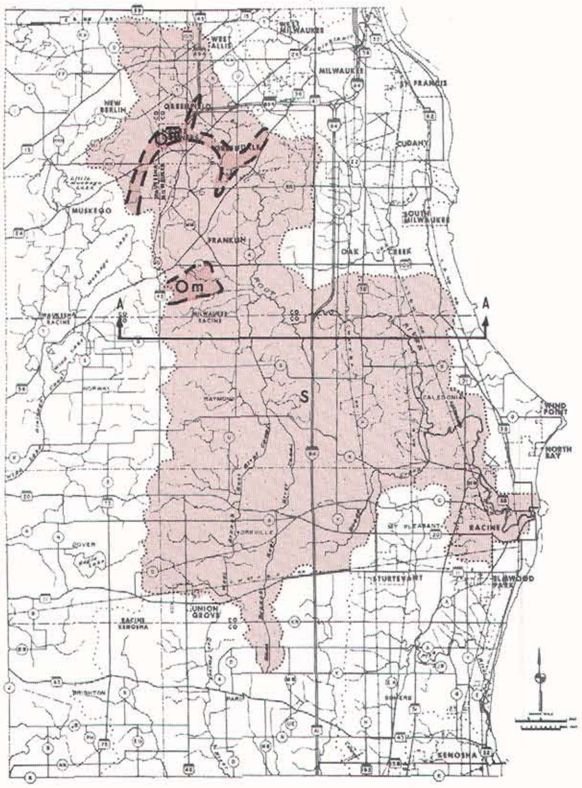
Table 4

POTENTIAL EVAPOTRANSPIRATION BY LAND USE AND GROWING PERIOD

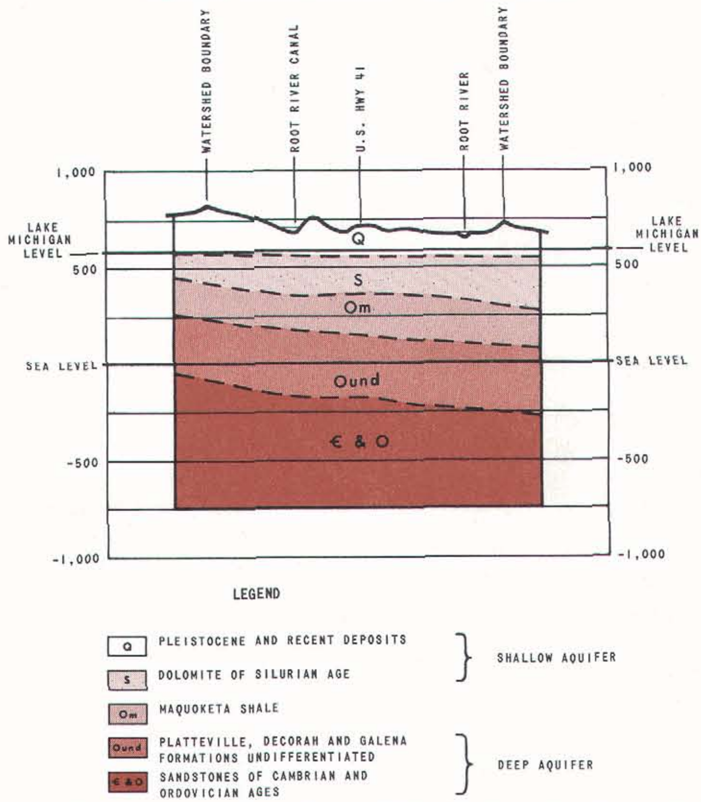
Type of Land Use	Annual Evapotranspiration In Inches	Seasonal Evaporation In Inches
Water Surface	29-32	23-26 (May-October)
Forest.	27-28	22 (May-October)
Alfalfa-brome	22-26	19-23 (April-September)
Corn.	18-22	11-15 (Mid-May through September)
Grain	18-22	9-13 (April-June)
Bare Soil (average)	15-20	11-15 (May-September)
Bare Soil (wet)	20-24	16-20 (May-September)

Source: Tanner, C.B., Wisconsin's Water Budget, Department of Soils, University of Wisconsin, 1963.

Map 2
BEDROCK GEOLOGIC MAP AND CROSS SECTION
OF THE ROOT RIVER WATERSHED



SECTION AA
Generalized Geologic Section Through Root River Watershed



The surficial deposits of the watershed are underlain by sedimentary rock formations which slope gently toward and extend beneath Lake Michigan.

contiguous Ordovician[4] dolomites and sandstones. The second is a shallow aquifer, composed of a consolidated rock unit of Silurian[5] age dolomitic rocks which are generally covered by a mantle of unconsolidated glacial drift and stream deposits. The top of the deep aquifer is found at depths of from 400 to 800 feet beneath the ground surface of the watershed. The Silurian dolomites are exposed in quarries in the Root River stream bed at Horlick Dam and in shallow excavations within the Hales Corners area. Generally, however, the dolomitic bedrock is buried by about 50 to 300 feet of glacial drift deposited during prehistoric times by glacial ice and meltwaters and partially reworked in subsequent time in streams and lakes.

[4] *"Cambrian" and "Ordovician" refer to successive geological time periods of some hundreds of millions of years ago, during which much of the area now included in southeastern Wisconsin was covered by a shallow sea and in which approximately horizontal beds of sandstone and limestone were deposited.*

[5] *"Silurian" refers to a geological time period immediately following the Ordovician, during which much of the area now included in southeastern Wisconsin was covered by a shallow sea and in which vast accumulations of limestone were deposited.*

Topography

The bedrock structure and composition exert a profound influence on ground water conditions, but it is the surficial deposits left by the glaciers which have determined the topography of the Root River watershed. The watershed is a rolling plain marked by broad asymmetrical ridges and small shallow waterways. Lakes are conspicuously absent. As shown on Map 3, and section AA, these broad asymmetrical ridges are glacial moraines[6] which control the slopes and patterns of the drainage network. Streams generally occupy northerly trending valleys between morainal ridges having relatively steep westward-facing slopes and gentle east-facing slopes. This pattern is particularly well developed in Racine County where runoff, in order to reach the main stem of the Root River, must follow a long and circuitous route of easterly flow down the gentle side of moraines and northerly up the inter-morainal valleys to the main stem of the Root River.

[6] *A moraine is defined as an accumulation of generally poorly sorted rock materials built within a glaciated region chiefly by deposition from glacial ice.*

Overall, the watershed has a flat to rolling topography with land slopes generally ranging from 0 to 5 percent. Main stream channel slopes are much flatter, however, the average slope of all perennial waterways being about six feet per mile (1.14 percent). The highest elevation in the watershed is about 960 feet above mean sea level on a glacial ridge top in Section 35, Town 6 North, Range 20 East, in the City of New Berlin; the lowest elevation in the watershed is about 580 feet above mean sea level on the Lake Michigan shoreline within the City of Racine. Thus, the maximum difference of elevation in the Root River watershed is about 380 feet, with a distance of about 24 miles separating the high and low points. Stream profiles and additional data on topography are presented in Chapter V, "Hydraulics of the Watershed."

Soils

The soils of the Root River watershed are a product of parent material, climate, living organisms, relief, and time. An especially complex pattern of soil types has been developed in the Root River watershed in which glacial action has left many different kinds of parent material deposits and a landscape with moderate local relief. In order to assess the significance of the diverse soil types to sound regional development, the SEWRPC in 1963 negotiated a cooperative agreement with the Soil Conservation Service, U. S. Department of Agriculture, for the completion of a modern standard soil survey of the entire Region. This soil survey not only maps the soils of the Region in great detail, and provides data on the physical, chemical, and biological properties of the soils, but is accompanied by interpretation of those properties for planning and engineering applications.[7] Results of these surveys have become available during the conduct of the Root River watershed study program and are being made available to local governmental units for use in solution of land use problems in the Root River and in other watersheds of the Region.

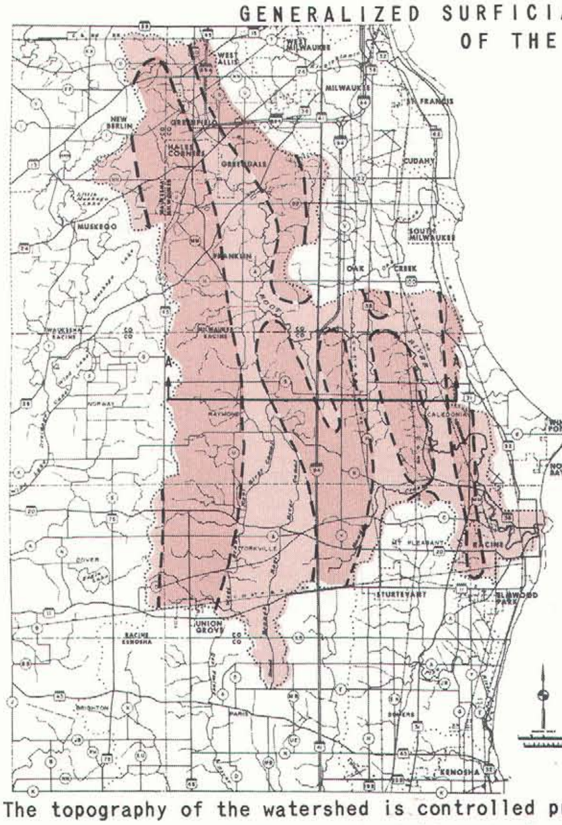
Analyses of the results of these surveys show that more than 80 soil types[8] are represented within the Root River watershed. Although many types

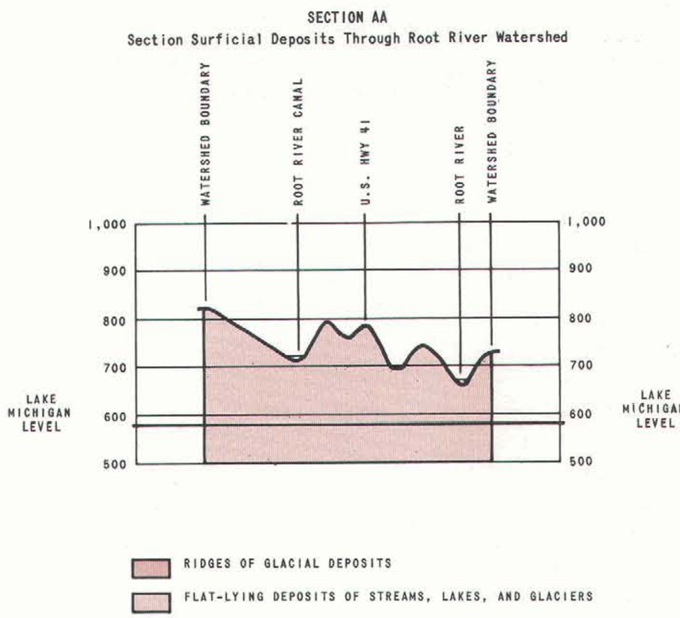
[7] *See "The Application of Soil Studies to Regional Planning," SEWRPC Technical Record, Vol. 1 - No. 4.*

[8] *A soil "type" is defined as a group of soils having genetic horizons (layers) similar as to important characteristics, including texture and arrangement in the soil profile and developed from a particular kind of parent material.*

Map 3

GENERALIZED SURFICIAL GEOLOGIC MAP AND CROSS SECTION OF THE ROOT RIVER WATERSHED





The topography of the watershed is controlled primarily by ridges of unconsolidated rocks deposited by glaciers which occupied the present Lake Michigan Basin some 6,000 years ago.

are present, the general characteristics of the soils of the watershed are exemplified by only a few soil types. The common types of soils occurring on the hilly glacial ridges of the watershed are Morley, Markham, and Varna loams and silt loams. Common types occurring in the flat areas of the watershed stream valleys are generally Houghton mucky peat, Will silt loam, Bono silty clay loam, and Ashkum silty clay loam. The topography intermediate between the hill land and the valley floor is occupied by many soil types, the most common of which are Beecher silt loam. Elliott silt loam, Blount silt loam, and the Casco-Fox loam complex. Detailed descriptions of the physical characteristics of these soil types, together with detailed soils maps, are available from the SEWRPC.

Results of the detailed soil survey reveal that large areas of the watershed are covered by soils poorly suited for urban development. Based upon soils characteristics, about 40 percent of the watershed area exhibits severe limitations for one or more of three types of residential development: residential development with public sewer service; residential development without public sewer service on lots more than one acre in size; residential development without public sewer service on lots of one acre or less in size. The spatial distribution of these soils within the watershed are summarized, respectively, on Maps 4 through 6. It should be noted that the use suitability rating is entirely objective and is based upon physically observed conditions, such as high water table, slow permeability, high shrink-swell potential, and high volume change under loading.

There are also hazards attendant to agricultural use of the soils of the Root River watershed. Roughly 50 percent of the agricultural lands are covered by Morley, Elliott, and Casco-Fox soil types, having a thin topsoil and a relatively "tight" subsoil. The potential for severe erosion on such soil types, particularly on steep slopes, is high and is being increased greatly by agricultural land use changes now in process within the watershed. Pasturage and hay land is being converted into row cropland with little ground cover, with the result that severe erosion problems are very apt to occur unless proper soil and water conservation practices are adopted and followed. The spatial distribution of the best agricultural soils within the watershed is shown on Map 7. Not only is the large areal extent of this valuable resource impressive, but it is also significant to note that many of the best agricultural soils are those types particularly susceptible to erosion.

Vegetation

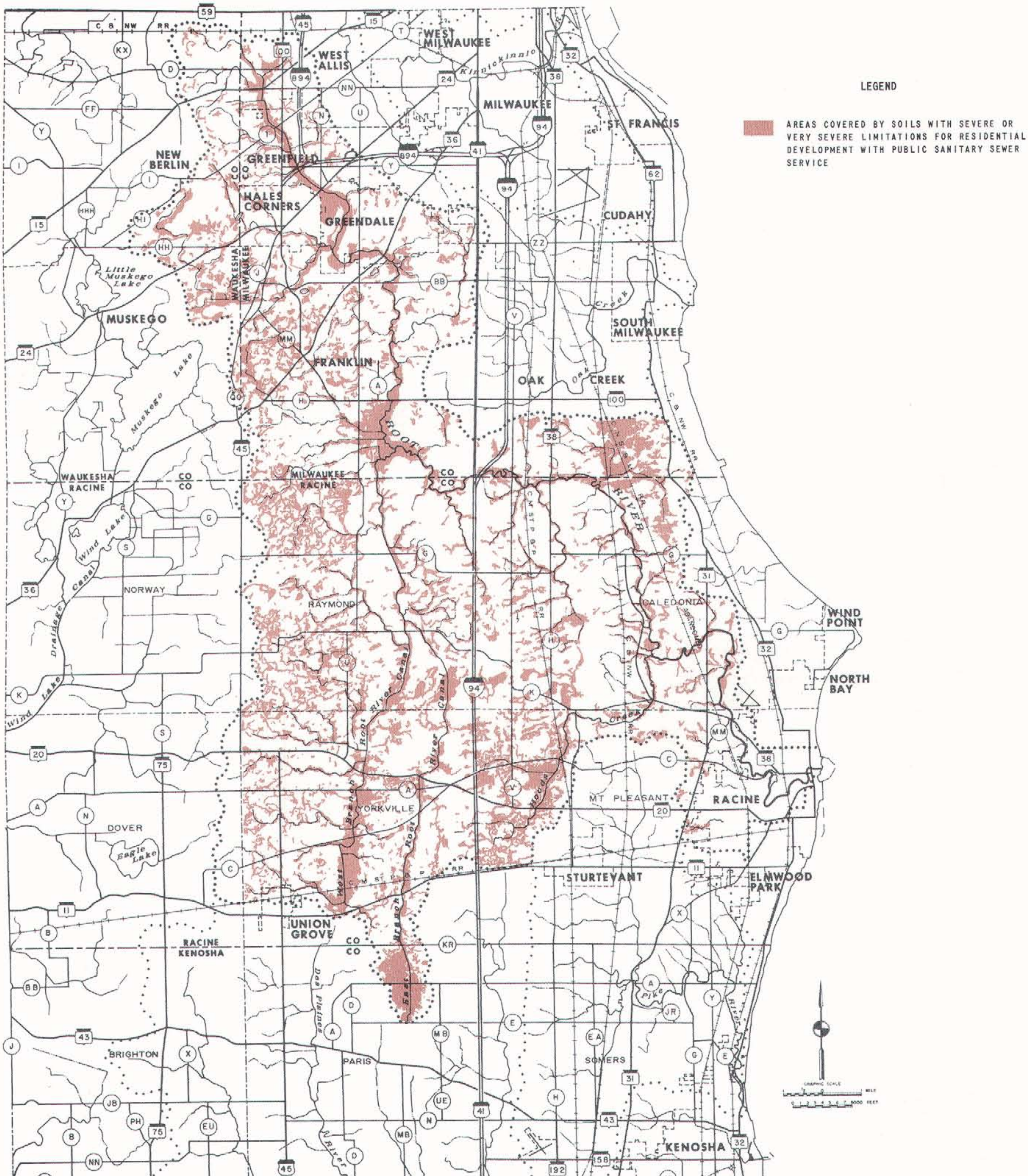
Historical records[9] indicate that the area now recognized as the Root River watershed was at the time of settlement characterized by three distinct native vegetational associations: prairie grasses, hardwood forests, and marsh plants. Prairie grasses, of the tall blue stem varieties, covered much of the Racine County portion of the watershed, especially occupying the broad, gently sloping morainal ridges. Hardwoods, primarily oak with some maple, apparently occupied much of the remainder of the watershed and were especially well developed in the Milwaukee County portion of the watershed and along the main channel of the Root River. Water-loving plants, such as cattails, were the primary occupants of wetlands and shallow water bodies. Under virgin conditions the area covered by wetland plant types was considerably larger than at present, and included a large marsh area in the Root River canal area. The native vegetational pattern of the watershed has been almost totally obliterated by settlement with its attendant introduction and cultivation of new plant species and earth moving and drainage activities. The virgin prairie plants have given way to field crops, such as corn, wheat, and barley; and the original forests have been utilized for building materials and destroyed to make way for cropland and pasturage. The so-called "Root River Woods" in Section 1, Town 4 North, Range 21 East, Town of Raymond, is apparently the last vestige of "original" forest. Drainage improvements have substantially reduced much of the quantity and quality of native wetland vegetation.

Whereas once there were nearly continuous belt-like patterns of wetland plant species along the tributary stream courses, these have been reduced to isolated areas, such as the large marsh near the Rainbow Airport within the City of Franklin. The remaining woodlands in the watershed are scant in quantity, occupying a total area of 8.66 square miles, or only 4.4 percent of the total watershed area, and are of low-to-medium value, being composed primarily of cut-over oak and smaller shrubs. As shown on Map 8, the remaining woodlands are distributed primarily in scattered areas along the major stream system.

[9] *Whitbeck, Ray H., "The Geography and Economic Development of Southeastern Wisconsin," Bulletin No. 58, Wisconsin Geological and Natural History Survey, 1921; and Gleason, H.A., "The Vegetational History of the Middle West," Ann. Assoc. Am. Geog., 12: 39-85, 1922.*

Map 4

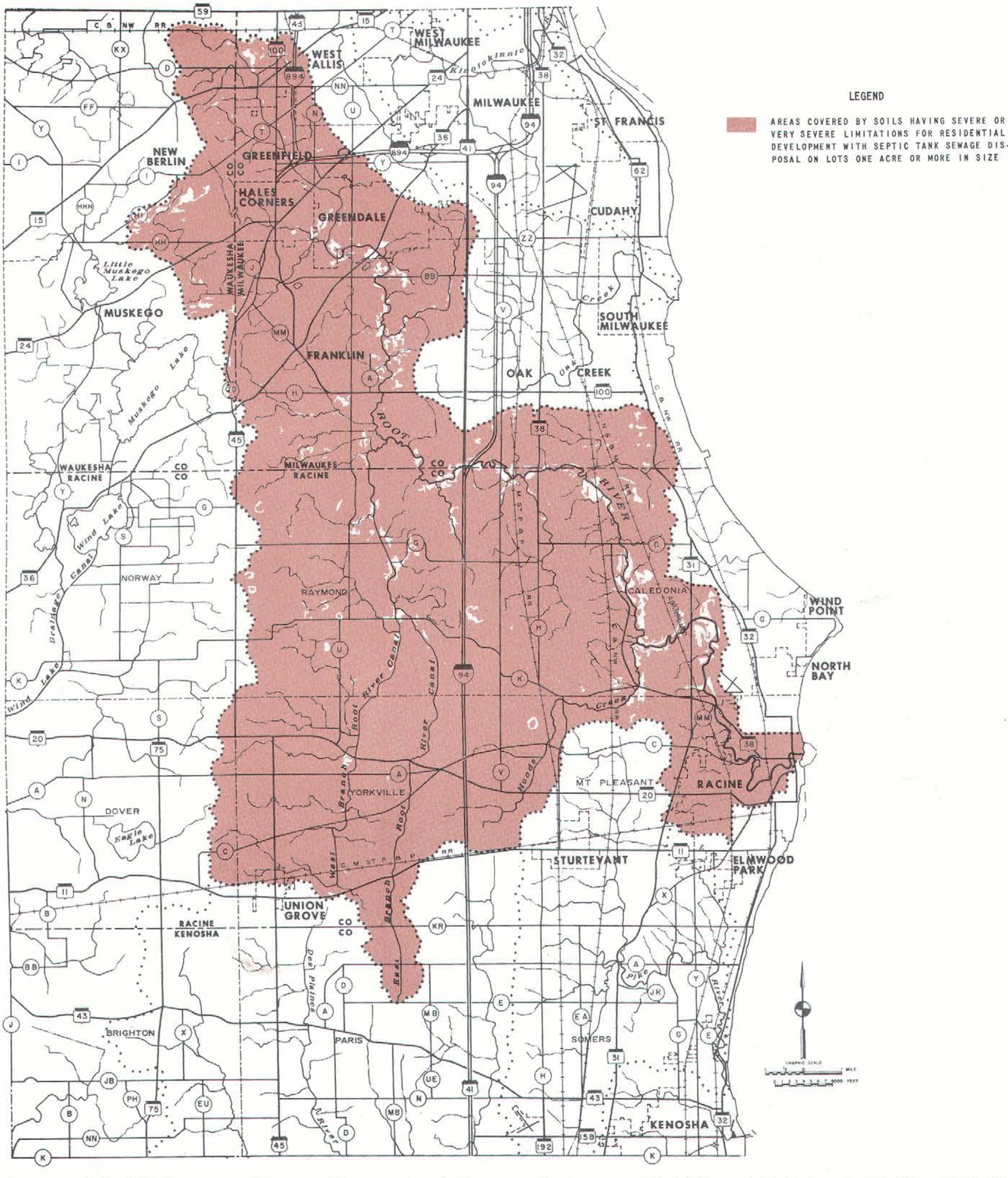
SOIL SUITABILITY INTERPRETATION MAP FOR THE ROOT RIVER WATERSHED
RESIDENTIAL DEVELOPMENT WITH PUBLIC SANITARY SEWER SERVICE



Approximately 42.7 square miles, or 26 percent, of the watershed are covered by soils which are poorly suited for residential development of any kind. These soils are especially prevalent in the riverine and wetland areas of the watershed.

Map 5

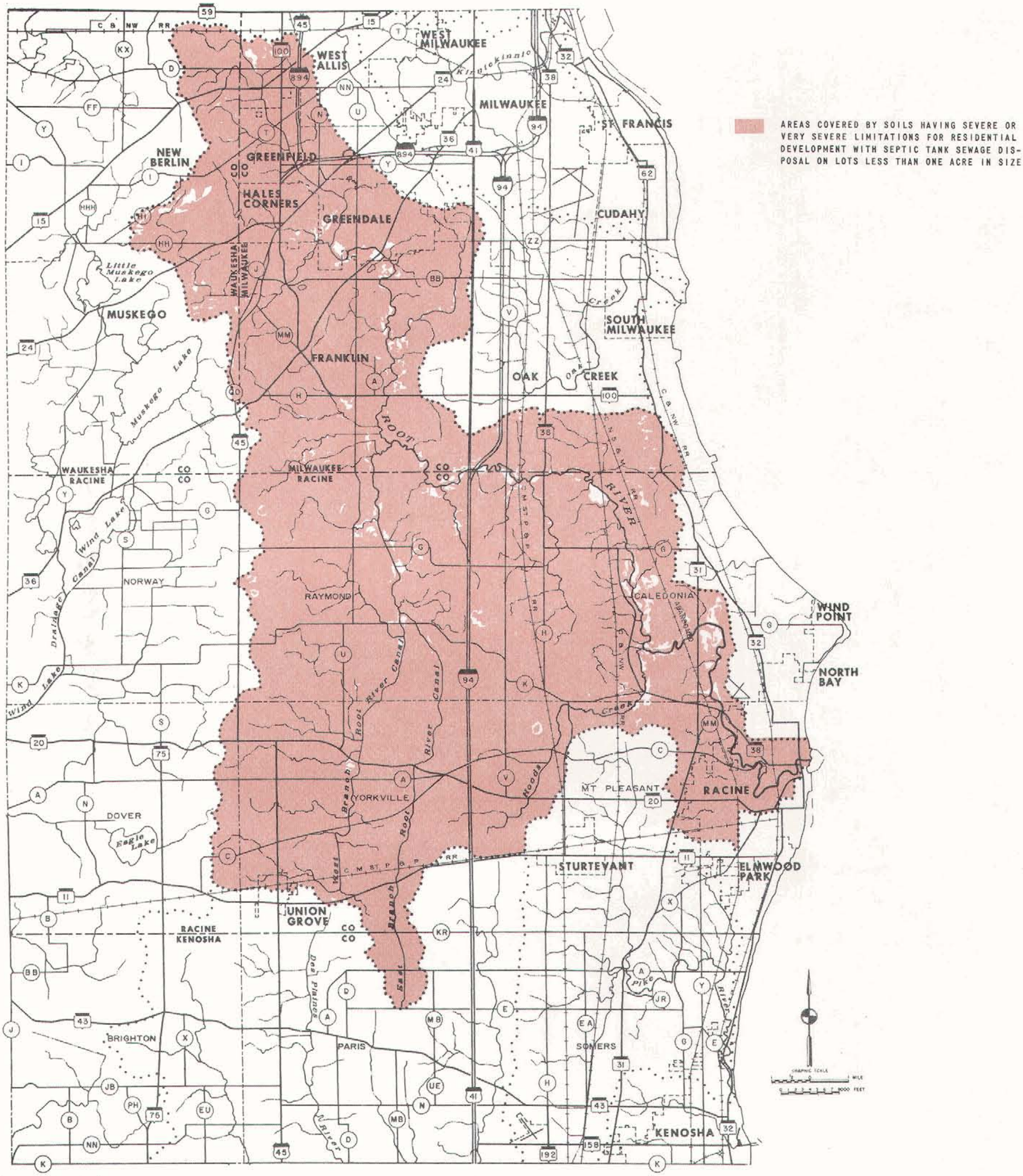
SOIL SUITABILITY INTERPRETATION MAP FOR THE ROOT RIVER WATERSHED
SMALL LOT RESIDENTIAL DEVELOPMENT WITHOUT PUBLIC SANITARY SEWER SERVICE



Approximately 191.5 square miles, or 97 percent, of the watershed are covered by soils which are poorly suited for residential development on lots having an area smaller than one acre and not served by public sanitary sewerage facilities. Such areas are particularly concentrated in the riverine areas of the watershed.

Map 6

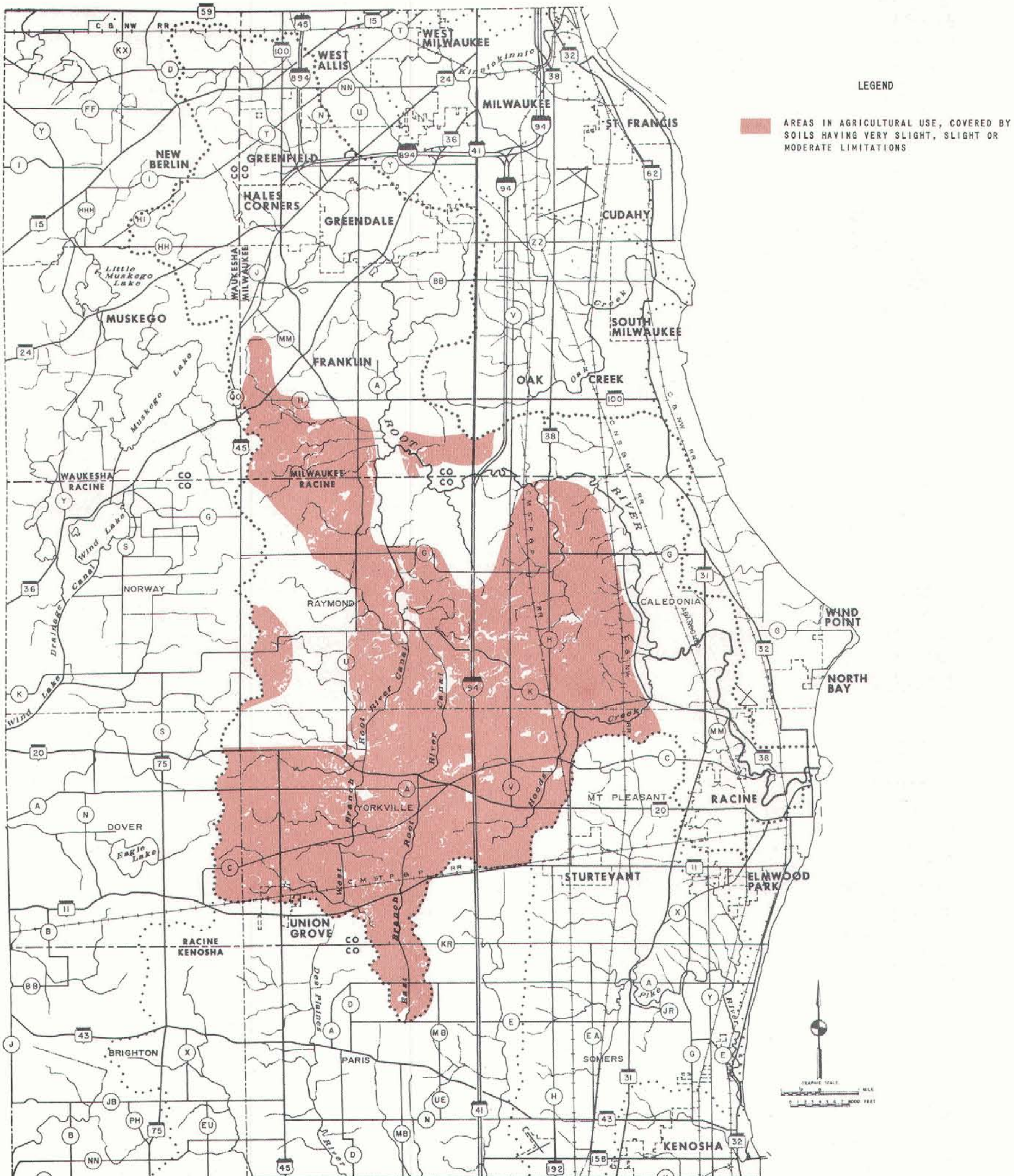
SOIL SUITABILITY INTERPRETATION MAP FOR THE ROOT RIVER WATERSHED
LARGE LOT RESIDENTIAL DEVELOPMENT WITHOUT PUBLIC SANITARY SEWER SERVICE



Approximately 191.5 square miles, or 97 percent, of the watershed are covered by soils which are poorly suited for residential development on lots having an area of one acre or more and not served by public sanitary sewerage facilities. These soils are located principally in the riverine areas of the watershed.

Map 7

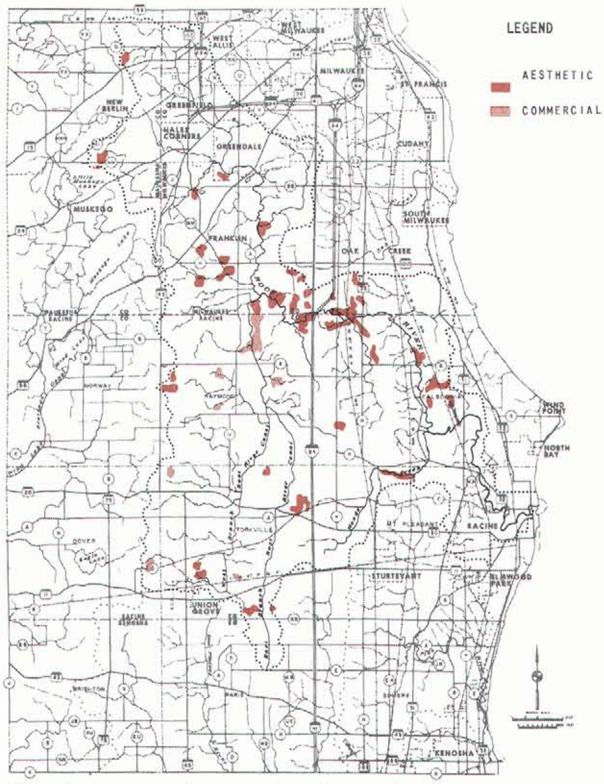
AGRICULTURAL AREAS OF THE ROOT RIVER WATERSHED
(1964)



Prime agricultural areas, consisting of the best agricultural soils occurring in large and efficiently worked tracts and not yet encroached upon by scattered urban development, comprise about 30 percent of the total watershed area. They comprise one of the few remaining resources of such lands in southeastern Wisconsin.

Map 8

FOREST AREAS IN THE ROOT RIVER WATERSHED (1963)



Remaining woodlands in the watershed occupy only 4.4 percent of the total watershed area and comprise an extremely valuable resource, not only for aesthetic enjoyment and enhancement of residential development, but also for the protection of the water resources.

Wildlife

In comparison to the exceptional wildlife resources available in many parts of Wisconsin, the wildlife resources of the Root River watershed seem small and relatively limited in variety. Because of the proximity of the watershed to several large population centers, however, these "limited" wildlife resources assume a considerable importance. The demand for park land adjacent to urban areas is rising, and the presence of wildlife enhances a park environment greatly. Opportunities for sighting wild mammals and birds—together with the demand for open space—are also significant factors contributing to the location of residential developments in rural areas.

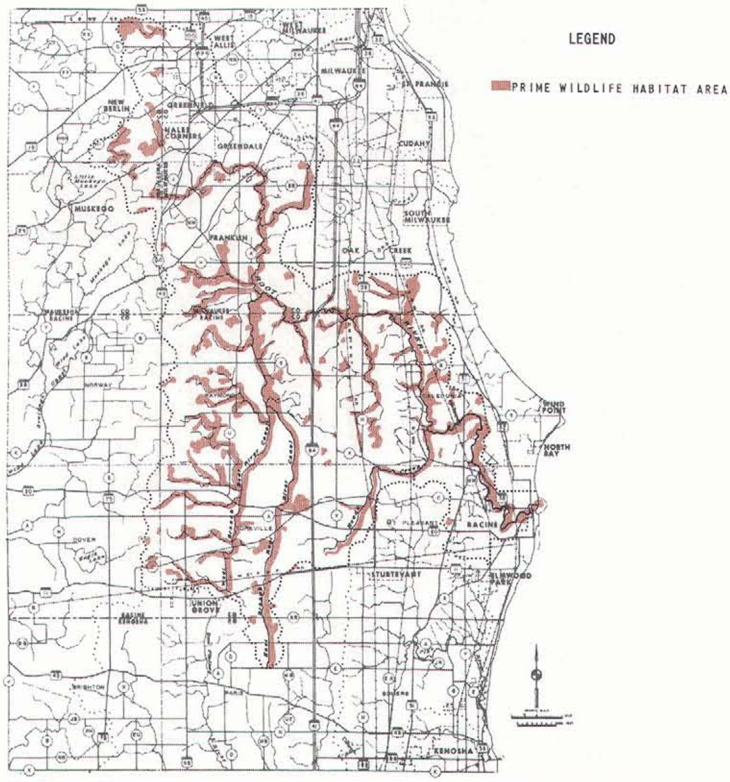
A joint SEWRPC-Wisconsin Conservation Commission regional wildlife inventory indicates that a number of kinds of game animals, presenting a recreational or economic opportunity, are present within the watershed. These include teal, scaup, and mallard ducks, pheasant, Hungarian partridge, cottontail rabbit, squirrel, red fox, muskrat, raccoon, and white-tail deer. In addition, the watershed has considerable value as a habitat for many species of birds; and at least two well-established heron (great blue) rookeries are located within the watershed. Bird-watchers, such as those representing the Hoy Bird Club of Racine, attach considerable importance to the Root River flood plain areas as a habitat area. The spatial distribution of the prime wildlife habitat areas remaining within the watershed are indicated on Map 9.

Hunting within the watershed is permitted only after receiving permission of owner and/or payment of fee, for there are no public hunting grounds. Several licensed shooting preserves, largely for pheasant harvesting, are located in the Root River Canal area of Racine County.

The fishery resources of the watershed are quite limited because of unfavorable habitat conditions imposed by stream pollution and exceptionally

Map 9

PRIME WILDLIFE HABITAT AREAS IN THE ROOT RIVER WATERSHED (1963)



Only a limited number of high value wildlife habitat areas remain in close proximity to present urban development within the watershed, because such development has not proceeded with an awareness of the values and needs of habitat areas.

poor low-flow conditions. "Rough" fish, such as carp, drum, and suckers, are caught—at times—in nearly all parts of the perennial stream network. Panfish, such as bullheads, pumpkinseed, and bluegill, are caught during occasional periods of more favorable water quality conditions in a reach of the river extending from Horlick mill pond downstream to the mouth of the river. According to many reports of local residents, and corroborated by the Wisconsin Conservation Commission, there once was a game fishery in the Root River; but it declined within recent years and disappeared entirely with the rise in stream pollution.

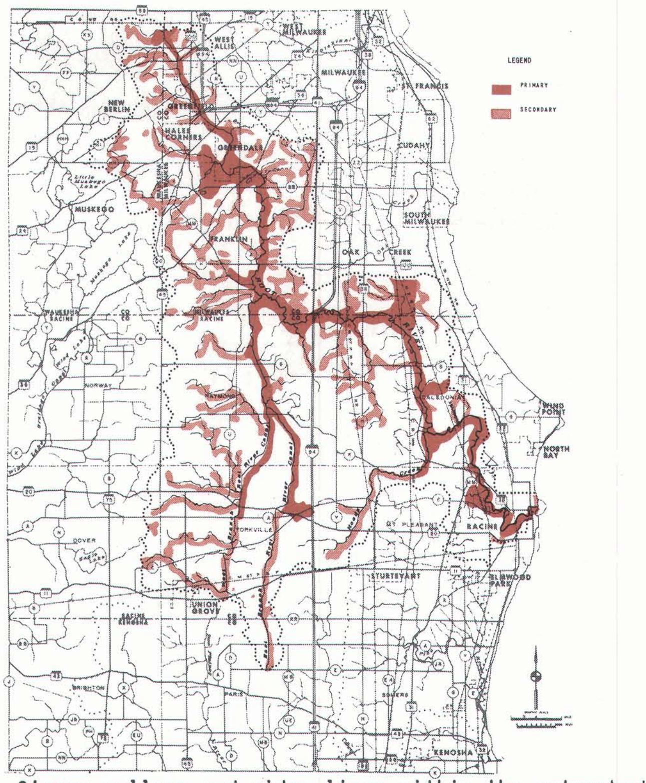
Environmental Corridors and Park and Recreation Lands

It is significant that many of the remaining natural resources of the Root River watershed, such as surface water, forests, and wildlife, are located in a highly interdependent relationship on the flood plains and associated wetlands and waterways, a combined area comprising only 11 percent of the watershed. These natural environments along the flood plains and wetlands have been termed "environmental corridors" by the SEWRPC. The distribution of the areas of these corridors within the watershed are shown on Map 10. It is important to note, and Maps 9 and 10 show, that prime wildlife areas are almost totally contained within these environmental corridors. The results of a detailed study of potential park sites by the SEWRPC, Wisconsin Conservation Commission, and the State Department of Resource Development also have revealed that most of the existing and the remaining good potential park sites within the watershed are located in the environmental corridors (see Map 11).

The Root River flood plain and adjacent lands are one of 14 broad areas within the Region which have been identified by the Wisconsin Conservation Commission and the SEWRPC as possessing recreational resource values of regional significance that warrant careful consideration for conservation and enhancement. Similar to such well-known resources as the Kettle Moraine and the Fox River,

Map 10

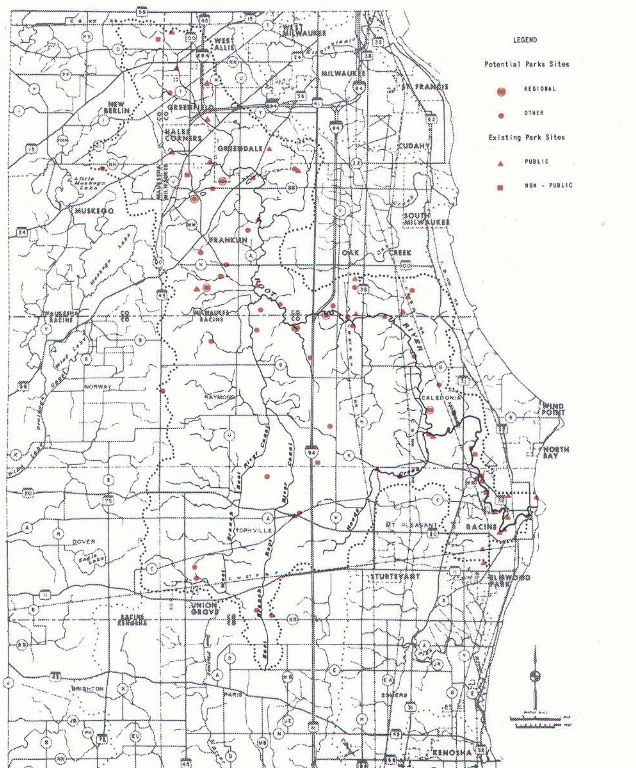
EXISTING ENVIRONMENTAL CORRIDORS IN THE ROOT RIVER WATERSHED (1964)



Stream valleys and ridge lines within the watershed form linear patterns of concentrated high value natural resources. Together, these environmental corridors comprise only 11 percent of the total watershed area but contain most of the remaining woodlands and wildlife habitat.

Map 11

EXISTING AND POTENTIAL PARK SITES IN THE ROOT RIVER WATERSHED (1964)



The riverine areas of the watershed comprise a primary recreational resource of great and, as yet, not fully developed potential for enhancement of the entire watersned environment.

it possesses multi-use potential for park, parkway, and related open space; wildlife habitat preserve; water impoundment; forest preserve; and nature study.

POPULATION AND ECONOMIC ACTIVITY

Since physical planning is intended to improve the environment in which people live and since the ultimate purpose of all facilities and services in any community is to meet the needs of the resident population, an understanding of the size, composition, and spatial distribution of the population is basic to any planning for future development. Population must also be studied because of the direct relationship existing between population levels and demand for soil, water, open space, and other elements of the resource base. The size and characteristics of the population of an area are greatly influenced by growth and change in economic activity; and, thus, population and economic activity must be considered together. It is important to note, however, that, because the Root River watershed is an integral part of a larger urbanizing Region, the economic forces which influence population growth within the watershed are largely centered outside of the watershed proper; and, thus, any economic analysis for the watershed must be regional in scope.

Population

Population Size: The 1963 population of the watershed is estimated at 134,000 persons, or about 8 percent of the total regional population of 1,674,000.[10] The population of the watershed has increased steadily since 1900; and since 1940 the rate of population increase has exceeded the regional growth rate which, in turn, has exceeded both the state and national growth rates. These trends are set forth in Table 5. Watershed population growth rates since 1940 exceed those which can be reasonably attributed to natural increase, that is, to an excess of births over deaths, and indicate that in-migration from other parts of the nation, state, and Region has been a significant factor in the recent, rapid population increase.

Population Distribution: Presently, about 90 percent of the residents of the watershed live in incorporated cities and villages, the combined areas of which comprise about 40 percent of the watershed (see Tables 1 and 6). These figures emphasize the peculiar fact that the Root River watershed is highly urbanized in the headwater and outlet areas but predominantly rural elsewhere.

The present spatial distribution of the population of the watershed is indicated by the population density pattern shown on Map 12. Four distinct population concentrations within the watershed are apparent: 1) an intense concentration in the northern headwater reaches of the watershed; 2) an intense concentration in the outlet reaches of the watershed; 3) less intense but significant concentrations along the major highway transportation routes; and 4) a large low-intensity, rural land area relatively unaffected to date by urban concentrations of population.

Population Characteristics: The geographic distribution of the resident population by age characteristics within the watershed is shown on Map 13. This map indicates a concentration of children and younger people in the rural and suburban areas of the watershed and of older people in the cities of Racine, Greenfield, and West Allis and in the Village of Hales Corners. The median age of the watershed population has decreased from 32 years in 1950 to 28 years in 1963.

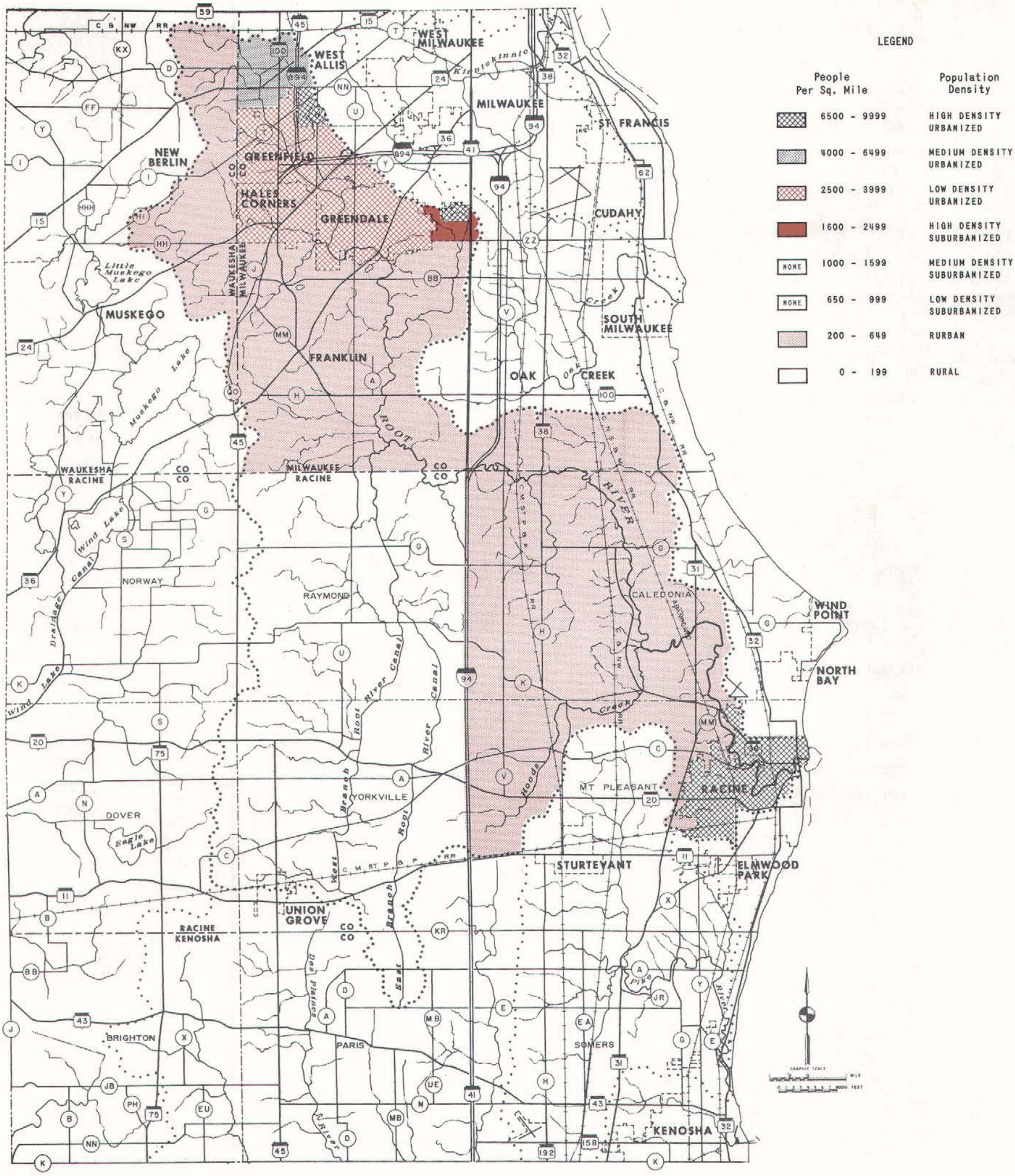
Because of a large increase in the proportion of married persons, the number of households in the Southeastern Wisconsin Region and in the Root River watershed has been increasing at a higher rate than has the size of the respective populations. Regional trends show a 38 percent increase in number of households versus a 26 percent increase in population during the period from 1950 to 1963, and it is believed that watershed trends parallel these. Under these conditions, resource demands are even greater than population size alone would indicate. The geographic distribution of median household sizes in the watershed is shown on Map 14.

Consistent with regional trends, the educational attainment level of the watershed population over 25 years of age has shown a substantial increase since 1950. Approximately one-half of the persons 25 years old or older in 1960 had completed 11 years or more of formal education compared to about 9 years in 1950. As shown on Map 15, educational attainment is especially high in the northern

[10] *Present and historic population estimates for the watershed have been prepared on the basis of the proportional areal extent of each minor civil division within the watershed. This method was necessary because historic population data have been reported only on a census tract or civil division basis but is believed to be within necessary limits of accuracy because of supplementary information compiled by the SEWRPC and presented in SEWRPC Planning Reports, Nos. 3, 4, and 7.*

Map 12

DISTRIBUTION OF URBAN, SUBURBAN, AND RURAL POPULATION IN THE ROOT RIVER WATERSHED (1963)



Although 47 percent of the watershed's residents are located in population density zones which can be classified as urban, attention focuses upon the large area of "rurban" watershed which, through recent population growth, is transcending from rural to urban and accelerating the water-related problems of the watershed.

Table 5

POPULATION SIZE TRENDS IN THE UNITED STATES, WISCONSIN, THE REGION, AND THE WATERSHED (1940 - 1963)

Year	Watershed	Percent Increase Per Preceding Decade	Region	Percent Increase Per Preceding Decade	Wisconsin	Percent Increase Per Preceding Decade	United States	Percent Increase Per Preceding Decade	Watershed Population as a Percent of the Regional Population
1900	24,100	--	501,808	--	2,069,042	--	75,994,575	--	4.8
1910	29,400	22	631,161	26	2,333,860	13	91,972,266	21	4.7
1920	40,700	38	783,681	24	2,632,067	13	105,710,620	15	5.2
1930	48,400	19	1,006,118	28	2,939,006	12	122,775,046	16	4.8
1940	70,700	46	1,067,699	6	3,137,587	7	131,669,270	7	6.6
1950	86,000	22	1,240,618	16	3,434,575	9	151,325,798	15	6.9
1960	125,000	45	1,573,620	27	3,952,771	15	179,323,175	18	7.9
1963	134,232	--	1,674,000	--	4,061,000	--	188,616,000	--	8.0

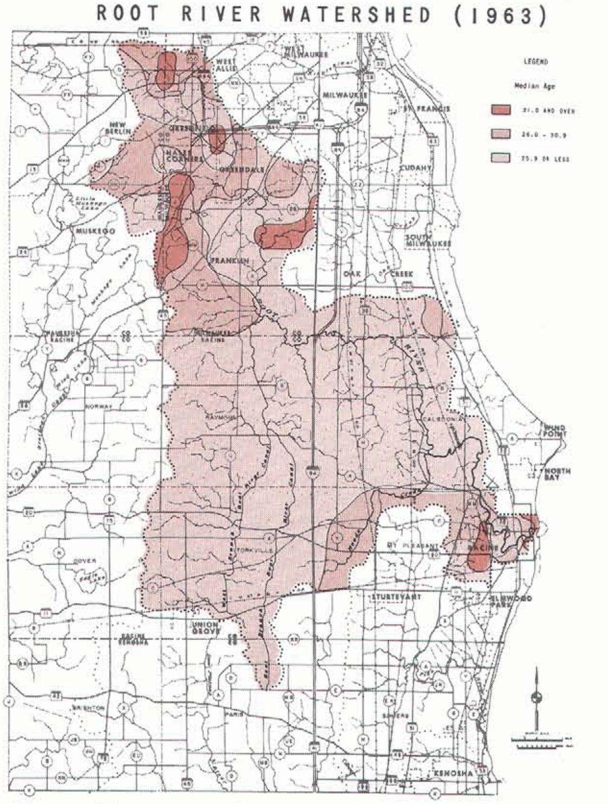
Source: U.S. Bureau of the Census; SEWRPC.

headwater portions of the watershed. Comparison of Map 16, showing the spatial distribution of median household income, with Map 15 reveals a high degree of correlation between education and income. Personal income is also increasing within the Region and within the watershed. The median household income within the watershed was about $7,200 in 1963, an increase of 18 percent over 1950.[11]

[11] *Comparison made on basis of constant dollars—1963 base with adjustment for price changes.*

Map 13

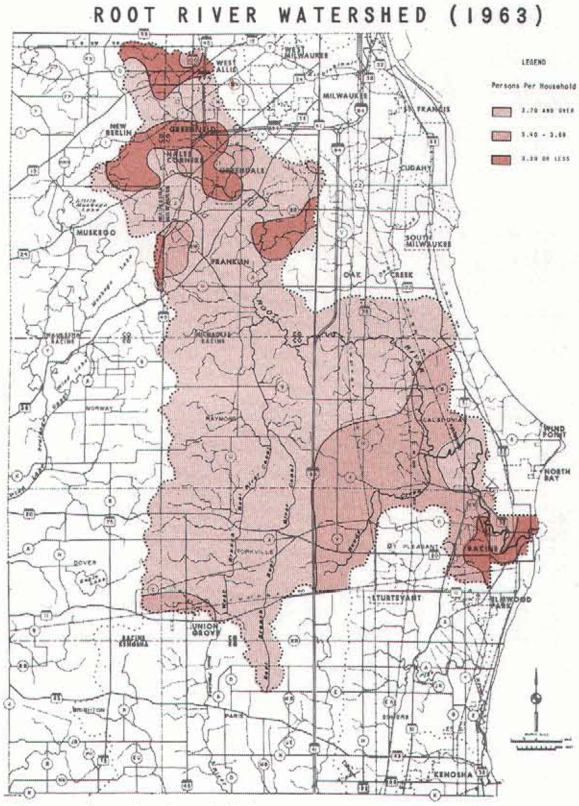
MEDIAN AGE DISTRIBUTIION IN THE ROOT RIVER WATERSHED (1963)



The median age of the watershed population has decreased from 32 years in 1950 to 28 years in 1963, as young families have moved out from the older central cities into the newer communities of the watershed.

Map 14

MEDIAN HOUSEHOLD SIZE IN THE ROOT RIVER WATERSHED (1963)



The watershed exhibits, in common with the Region, trends toward more but smaller households. Consequently, future resource demands will be even higher than population trends alone might indicate.

Table 6

ESTIMATED 1963 POPULATION AND POPULATION DENSITY IN THE ROOT RIVER WATERSHED BY COMPOSITE MINOR CIVIL DIVISIONS

Civil Division	Population Within Watershed	Percent of Watershed Population	Gross Population Density per Square Mile	Square Miles
Cities				
Franklin	10,454	7.79	329.1	31.76
Greenfield	13,626	10.15	2,219.2	6.14
Milwaukee	2,819	2.10	2,634.6	1.07
Muskego	3,524	2.63	903.6	3.90
New Berlin	6,343	4.73	695.5	9.12
Oak Creek	4,229	3.15	557.9	7.58
Racine	43,814	32.64	7,451.3	5.88
West Allis	13,274	9.88	4,469.3	2.97
Subtotal, Cities	*98,083*	*73.07*	Av. 1,433.5	*68.42*
Villages				
Greendale	9,450	7.04	1,743.5	5.42
Hales Corners	6,285	4.68	1,964.1	3.20
Union Grove	1,000	0.75	3,571.4	0.28
Subtotal, Villages	*16,735*	*12.47*	Av. 1,880.3	*8.90*
Townships				
Caledonia	7,048	5.26	192.6	36.59
Dover	117	0.09	44.5	2.63
Mount Pleasant	7,400	5.52	515.6	14.35
Norway	10	0.01	100.0	0.10
Paris	23	0.02	8.8	2.61
Raymond	2,819	2.10	83.8	33.65
Yorkville	1,997	1.46	66.2	30.18
Subtotal, Townships	*19,414*	*14.46*	Av. 161.6	*120.11*
Total, Watershed	134,232	100.00	Av. 679.9	197.43

Source: Population data presented in SEWRPC Planning Reports Nos. 3, 4, and 7 and adjusted to watershed basis by proportional area method.

The Economy

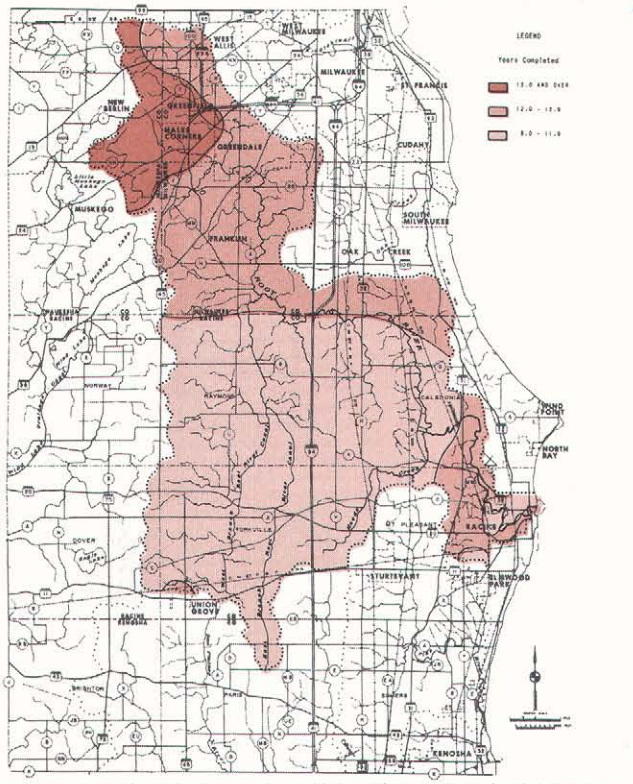
The relative importance of elements of economic activity to employment within the Region is shown in Figure 3. Economic activity within the Region and within commuting distance of the Root River watershed is heavily concentrated in the manufacturing of durable goods—primarily in machinery, electrical equipment, and transportation equipment—and in printing and publishing and food and beverage products manufacturing.

As shown on Map 17, most of the jobs that provide primary support to the population of the northern headwater portions of the watershed are located outside the watershed. Such firms as Allis-Chalmers Manufacturing Co. of West Allis, AC Spark Plug Division (General Motors Corp.) of Oak Creek, Allen Bradley Co. of Milwaukee, and Bucyrus-Erie Co. of South Milwaukee provide many employment opportunities within only a few miles of the watershed. The Racine area with such internationally known firms as J. I. Case Co., Twin Disc Clutch Co., and S. C. Johnson & Sons, Inc., also provides an important employment concentration.

Within the Root River watershed proper, expansion in economic activity has been largely of the type which would support the needs of a "bedroom" community; that is, a community whose population resides within the watershed but works elsewhere. In recent years there has been an expansion in

Map 15

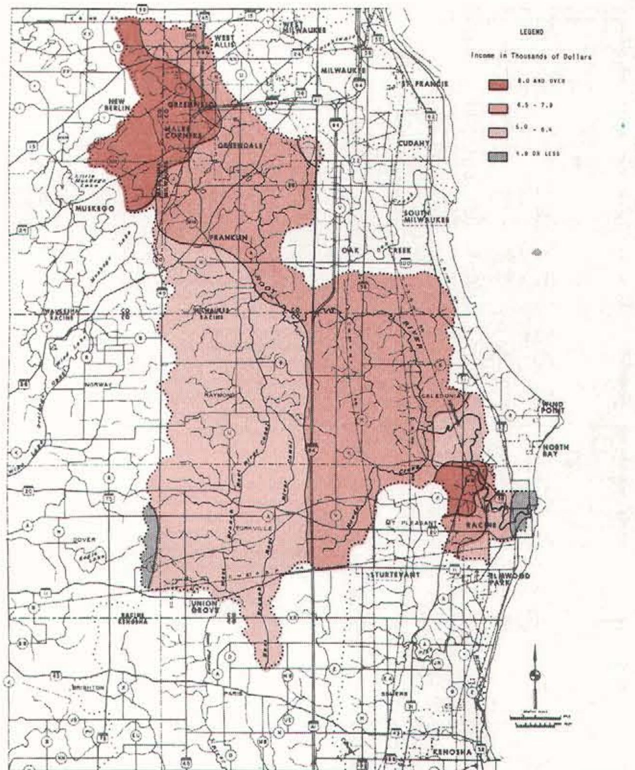
MEDIAN YEARS OF EDUCATION COMPLETED IN THE ROOT RIVER WATERSHED (1963)



Educational attainment within the watershed per person 25 years of age or over is now about 11 years and is rising. Since 1950 particularly rapid increases have occurred in the suburban headwater portions of the watershed.

Map 16

MEDIAN HOUSEHOLD INCOME IN THE ROOT RIVER WATERSHED (1963)



Median household income within the watershed was about $7,200 in 1963 but was increasing rapidly with urbanization.

jobs associated with such service activities as supermarkets, chain stores, local construction, and light manufacturing. Within the large central rural area, several food-processing centers provide a generally stable local employment base and serve as focal points for the development of clusters of population in otherwise rural areas. For example, kraut processing and canning is important to the community of Franksville; and meat processing and packaging provides small but locally important employment within the towns of Raymond and Yorkville. In all measures of economic activity, the importance of agriculture within the watershed is decreasing consistent with state and national trends; but the needs of the farmer are still very important to the local trade centers. Listed in order of importance by type of farm, the primary agricultural activities in the watershed are dairy, field crop, other livestock (beef), and vegetable (truck) farming.

In summary, the economy of the watershed is founded principally upon outside employment in the durable goods manufacturing industries. Out-of-watershed employment in non-durable goods is significant and increasing. In-watershed activities of services and sales, farming, food-processing, and light manufacturing are important; and all but farming are growing.

LAND USE

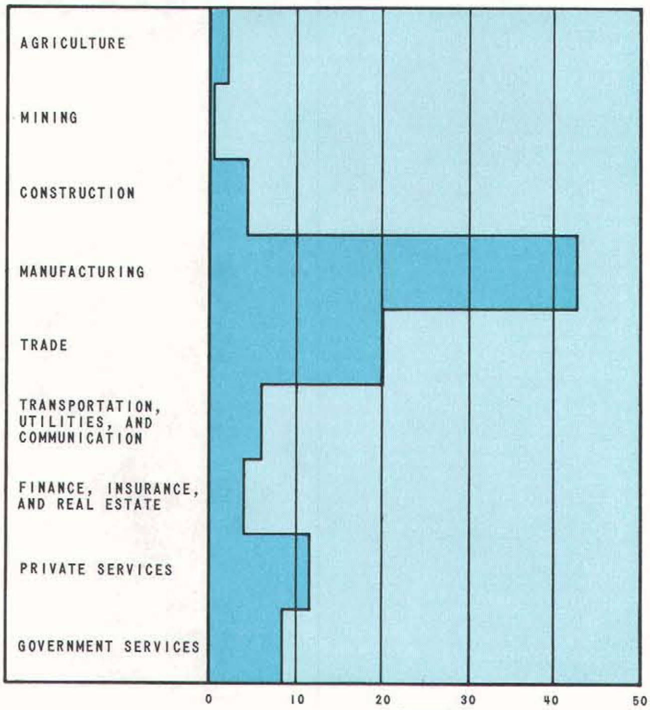
The type, intensity, and spatial distribution of land use determine, to a large extent, the soil and water uses and needs of a watershed. Water resource demand can be correlated directly with the quantity and type of land use. Similarly, water resource deterioration parallels directly the quality of land use. The existing land use distribution pattern can only be understood within the context of its historical development. Thus, attention is herein focused upon historical as well as existing land use development.

Historical Development

The stimulus for the original settlement of the Root River watershed by the white man was provided in 1833 with the signing of a treaty extinguishing Indian rights to a large land area in

Figure 3

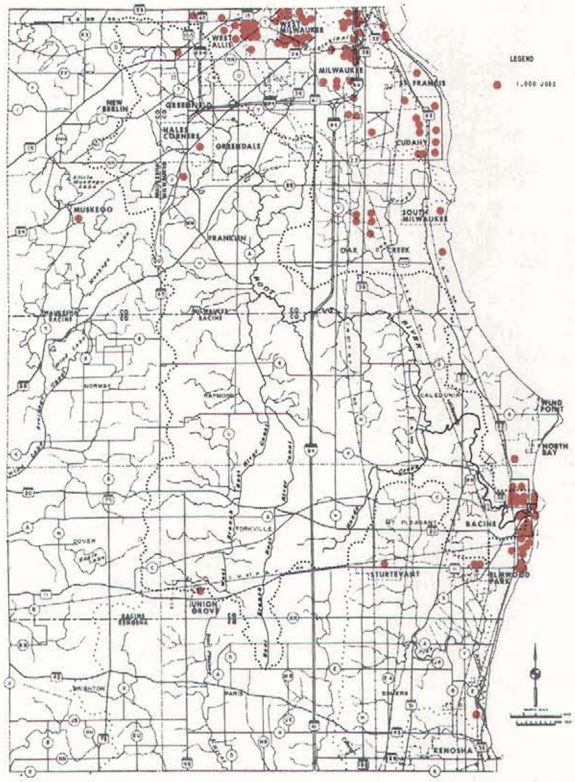
PERCENTAGE DISTRIBUTION OF TOTAL JOBS IN THE REGION BY MAJOR INDUSTRIAL GROUP (1963)



Source: SEWRPC.

Map 17

JOB DISTRIBUTION IN THE ROOT RIVER WATERSHED (1963)



Most of the jobs supporting urban development within the watershed are located outside the watershed boundaries in the Milwaukee and Racine manufacturing complexes.

southern Wisconsin, which included the Root River watershed. Following the treaty, the U. S. Public Land Surveys were completed in southeastern Wisconsin by 1836; and this further opened the way for settlement of the watershed by immigration through the Erie Canal-Great Lakes route to the port of Milwaukee—open since 1795—and to the port of Racine, opened at the mouth of the Root River in 1834.

From its founding the port city of Racine served as a trade and service center for inland agricultural settlement. Large tracts of open prairie lands in the Root River watershed provided an ideal wheat-growing environment and attracted immigrants to the watershed. During the period from 1834 to about 1870, wheat-growing was a substantial industry in the Root River watershed, although later supplemented by sheep-raising. In about 1835 a gristmill was constructed at the present site of Horlick Dam on the Root River where a bedrock ridge in the stream bed once created an ideal water power development site. Small agricultural service or trade centers developed at such places as Yorkville, Union Grove, and Hales Corners; but largely the hinterland away from the port of Racine remained a rural area of scattered homesteads.

In 1844 Jerome I. Case built his first threshing machine in the City of Racine; and during the period 1844 to 1870, additional small manufacturing firms were founded to serve the immediate local agricultural market. During the period from 1870 to 1910, a base was created for the modern export-oriented manufacturing industry of the Racine area. Farm machinery, foodstuffs, bricks, and leather goods were exported increasingly through the improved port facilities at Racine and Milwaukee. Toward the turn of the century, Racine and Milwaukee had grown to full-fledged urban units of dense population concentration in an otherwise almost entirely rural land use complex. These cities exerted a considerable demand for foodstuffs for local consumption and for processing and exportation. Consequently, this demand led to an expansion of agricultural land use onto the wetlands and flood plains of the watershed. It was during this period that the first extensive "reclamation" or drainage projects were carried out in the Root River watershed. Shallow meandering streams connecting several wetland areas were deepened and straightened to form the Root River Canal system.

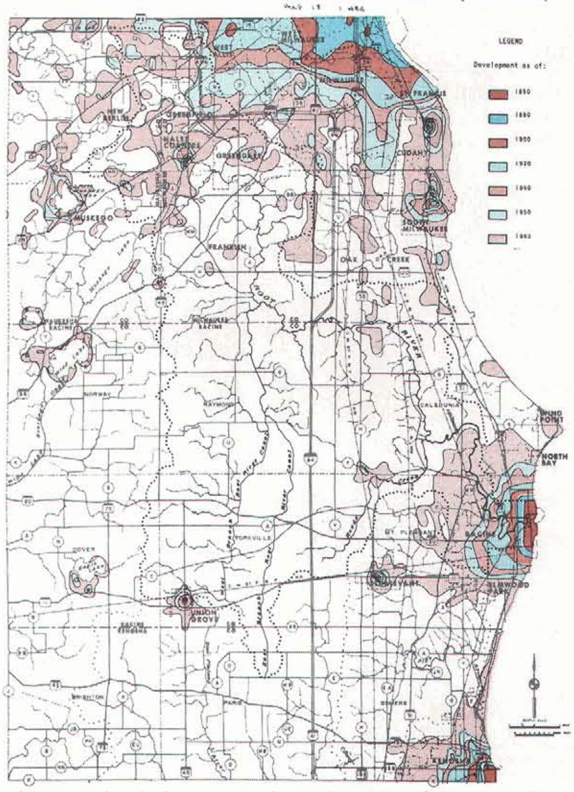
During the period from 1910 to the end of World War II in 1945, the trend toward more diversified and more intensified land use continued, marked particularly by the increasing mechanization of farming and the introduction of high-speed, all-weather highway transportation. During the twenty years since the end of World War II, land use within the watershed has changed more than in the entire previous 115 years. A burgeoning, affluent population is consuming land for residential, commercial, institutional, and transportation uses at an unprecedented rate. In the thirteen years from 1950-1963, a 61 percent increase in population within the watershed was accompanied by a 260 percent increase in land devoted to urban use. As shown on Map 18, this urbanization is occurring in a diffused pattern outward from the Racine and Milwaukee urbanized areas into the woodlands, fertile farmlands, and wetlands of the Root River watershed. Concomitant with the trend of movement outward from the central cities into the suburbs and rural areas, a multitude of problems connected with providing services to a diffused population have become apparent within the watershed.

Present Land Use

The spatial distribution of present land use (1963) within the Root River watershed is shown graphi-

Map 18

HISTORIC URBAN GROWTH MAP OF THE ROOT RIVER WATERSHED (1963)



The greatest increase in urban development within the watershed occurred in the 13-year period from 1950 to 1963, when the population of the watershed increased by 61 percent, but land devoted to urban use increased by 260 percent.

Table 7

SUMMARY OF EXISTING LAND USE IN THE ROOT RIVER WATERSHED - 1963[a]

Use Category	Acres	Square Miles	Percent of Watershed Area
Residential Density			
Low	9,170		
Medium	1,808		
High	1,937		
Subtotal	12,915	20.18	10.22
Commercial	584	0.91	0.46
Industrial	321	0.47	0.24
Mining	748	1.17	0.59
Transportation & Utilities	9,459	14.81	7.50
Governmental & Institutional	1,164	1.82	0.92
Recreational	3,258	5.09	2.58
Agricultural	83,725	130.82	66.27
Water, Woodland, & Wetland	14,181	22.16	11.22
Total	126,355	197.43	100.00

[a] *To summarize existing land use as tabulated in the SEWRPC land use inventory, the watershed boundary was approximated by U.S. Public Land Survey quarter-section boundaries, giving a total area for the watershed of 126,641 acres. The difference of 286 acres between this approximation and the actual area of the watershed was distributed by reducing the tabulated area in each land use category on the basis of the proportionate share which each such land use category formed of the total watershed.*

Source: SEWRPC.

cally on Map 19, and is summarized in tabular form in Table 7. Detailed tabulations are presented in Appendix C for the entire watershed and for three hydrographic sub-watershed areas tributary to the USGS-SEWRPC water stage recorder stations.

The boundaries of the sub-watersheds, which are both hydrographic and land use study units, are shown on Map 31, in Chapter VI. Several significant facts about the existing land use in the watershed become apparent from inspection of Map 19 and the statistical summary tables in Appendix C.

1. Urban land uses within the watershed occupy about one-fourth of the total watershed area and are concentrated primarily within Milwaukee County on the upper tributaries of the Root River and within the City of Racine at the mouth of the Root River.

2. The largest single urban land use category is residential, occupying 10.22 percent of the total watershed area. Over 80 percent of the residential land is devoted to single-family dwellings.

3. Industrial land use occupies only 0.24 percent of the total watershed area.

4. Non-urban land uses occupy 77.49 percent of the total watershed area and are concentrated primarily within Racine County, outside the City of Racine.

5. The largest single land use within the watershed is still agriculture, with nearly two-thirds of the total watershed area devoted to this use. The agricultural land uses are almost totally concentrated on the best agricultural soils within the watershed in the towns of Caledonia, Raymond, and Yorkville.

6. Developed recreational lands, in aggregate, comprise approximately 3 [12] percent of the total watershed area; and two-thirds of these are located in Milwaukee County primarily along the Root River flood plain.

7. Only 11 percent of the total watershed area is occupied by water, woodlands, and wetlands. Woodlands occupy only 4.4 percent of the total watershed area. In comparison to other watersheds within the Region, these respective values represent low percentages of the total watershed area. It must be recognized that these resources are vitally important to the watershed in the sense that they aid in the reduction of the storm water runoff; aid in the reduction of soil erosion and stream sedimentation; assist in maintaining natural relationships between plant and animal life; and provide unique opportunities for educational and recreational pursuits, as well as a desirable aesthetic setting for residential development.

Examination of the land use statistics on the hydrographic sub-watersheds in Appendix C reaffirms the above observations. The sub-watersheds served by stream gaging stations are summarized separately, however, for the express purpose of facilitating at a later date an interpretation of the effect of land use change upon streamflow behavior.

PUBLIC UTILITY BASE

The construction of public water supply and sewerage facilities within the watershed has not kept pace with urban expansion, with the result that in the suburban areas urban development is currently dependent upon individual, community, and industrial wells and individual septic tank sewage disposal systems. Presently only 15 percent of the total urban area within the watershed, and only 6 percent of the total watershed area, is served by public sanitary sewer facilities. Public water is provided to even a smaller percentage of those areas, 12 percent of the urban area and 5 percent of the total watershed area. It would seem, however, that at least in Milwaukee County this trend is changing; and all of the Milwaukee County portions of the watershed will be serviced by public sanitary sewerage facilities by the year 1975.

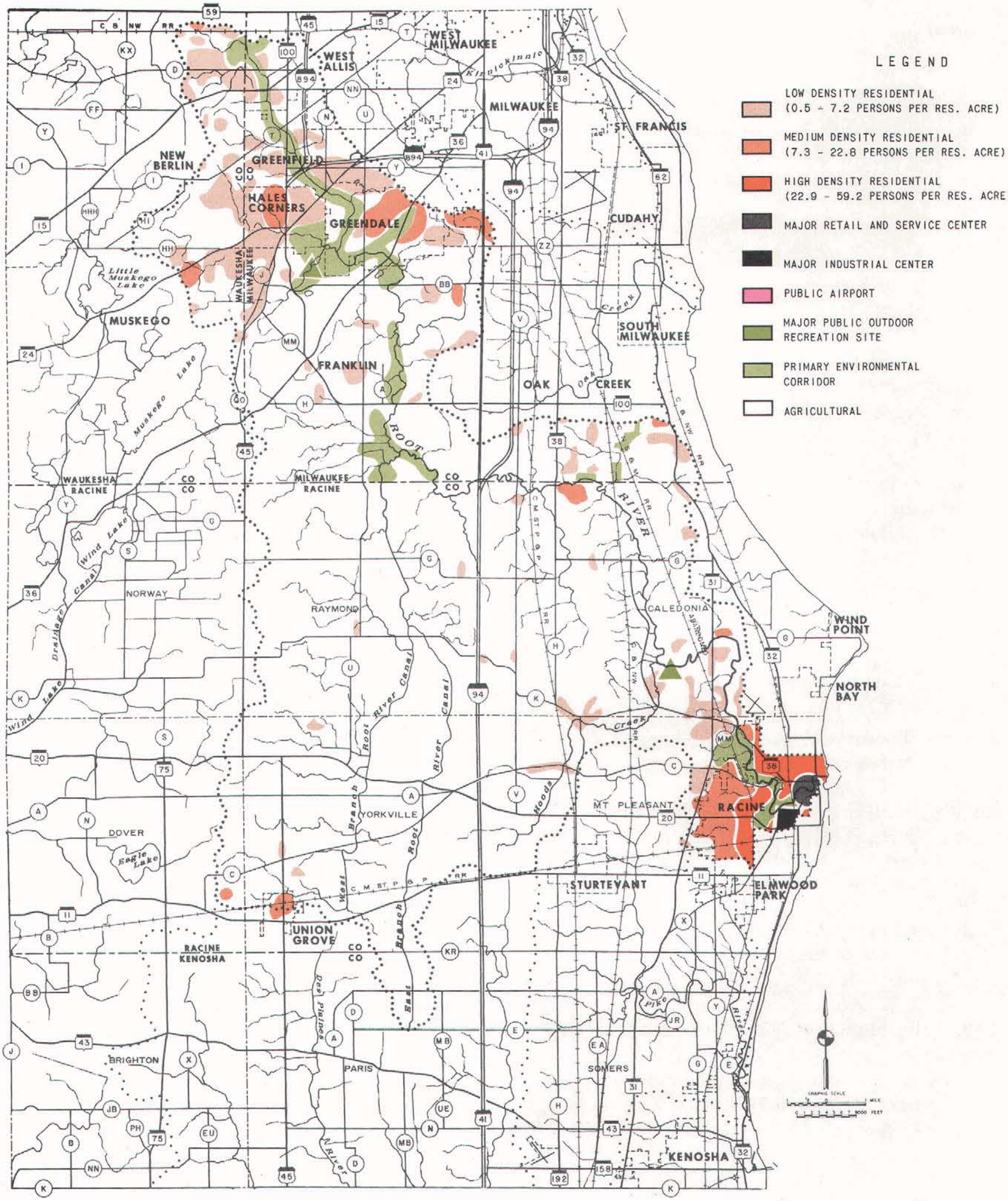
Existing public sanitary sewerage service areas are shown on Map 20. Detailed information on treatment, loadings, and efficiencies of sewage disposal plants is presented in Chapter IV.

In the near future, the four public and institutional sewage disposal plants presently located within the watershed in Milwaukee County will cease contributing effluent to the Root River; and the municipal sewage will be routed to a large new sewage treatment plant located on Lake Michigan in the City of Oak Creek. Within the urbanizing

[12] *Based upon acquisitions to September 1965.*

Map 19

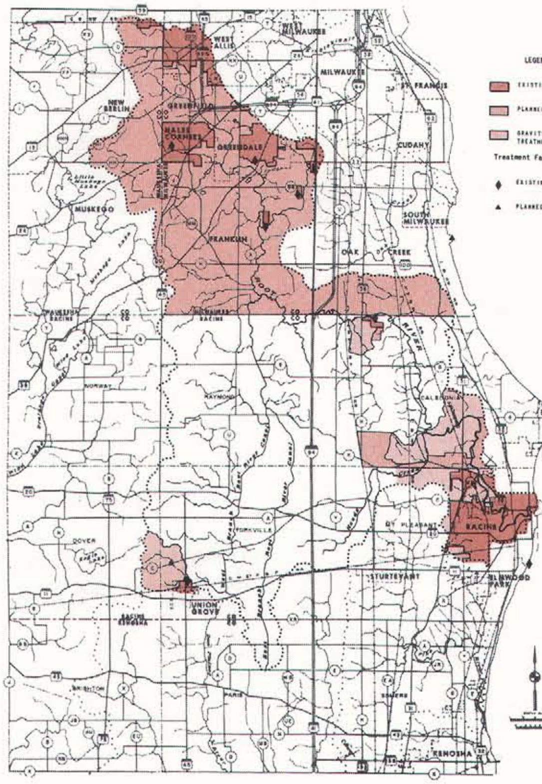
GENERALIZED EXISTING LAND USE (1963)



This generalized existing land use map depicts the extent of concentrated urban development within the watershed in 1963. Most of the medium-density and high-density residential areas were developed prior to 1950, while much of the low-density residential areas were developed during the period from 1950 to 1963.

Map 20

PUBLIC SANITARY SEWERAGE SERVICE AREAS IN THE ROOT RIVER WATERSHED (1964)



Within recent years, public sanitary sewerage service has been extended rapidly within the watershed but still has not been able to keep pace with the rapid rate of urban development. Consequently, much residential development still relies upon septic tank sewage disposal systems.

portion of Racine County, a similar trend toward centralized collection of sewage for efficient treatment is occurring as the community of Franksville has been provided service by the City of Racine. The location of the gravity drainage areas, however, indicates that a large portion of the still rural land in the towns of Yorkville and Raymond is likely to remain unserviced by public sanitary sewerage for many years to come.

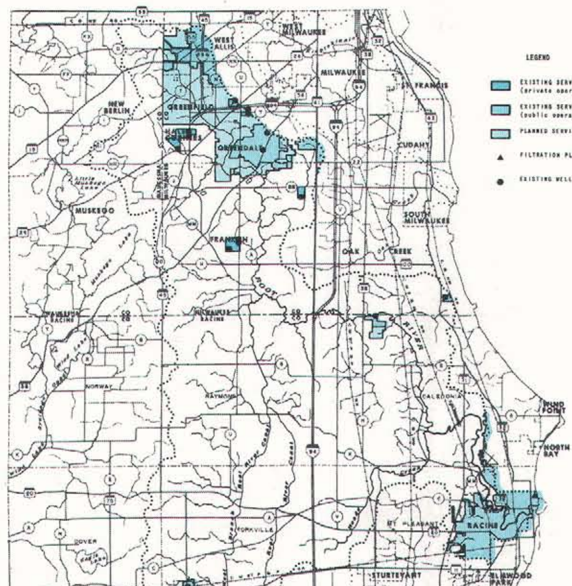
The Region is well endowed with natural water sources which are physically capable of meeting virtually all needs with minimal treatment requirements. Ultimately, Lake Michigan water could be made readily available to all parts of the watershed. Shallow and deep aquifers underlie the watershed and provide two additional sources of water supply. Detailed information on ground water supply and use is presented in Chapter IV.

The service areas of present public water supply are shown on Map 21. Because of lowering ground water tables and the treatment requirements of "hard" ground water, there is a tendency toward metropolitan water service, both in the Milwaukee and Racine areas, to follow urbanization into the Root River watershed, providing Lake Michigan water at competitive costs. In the upper portion of the watershed, the Village of Greendale recently placed the existing village-owned deep wells on a standby basis and began receiving Lake Michigan water from the City of Milwaukee water system. In the southern portion of the watershed, the Sturtevant area similarly recently contracted with the City of Racine for supply of Lake Michigan water.

As in the case of sewerage service, the central and western rural area of the watershed is placed disadvantageously for importation of Lake Michigan water—either alone or through the auspices of one of the metropolitan water systems. Thus, in these

Map 21

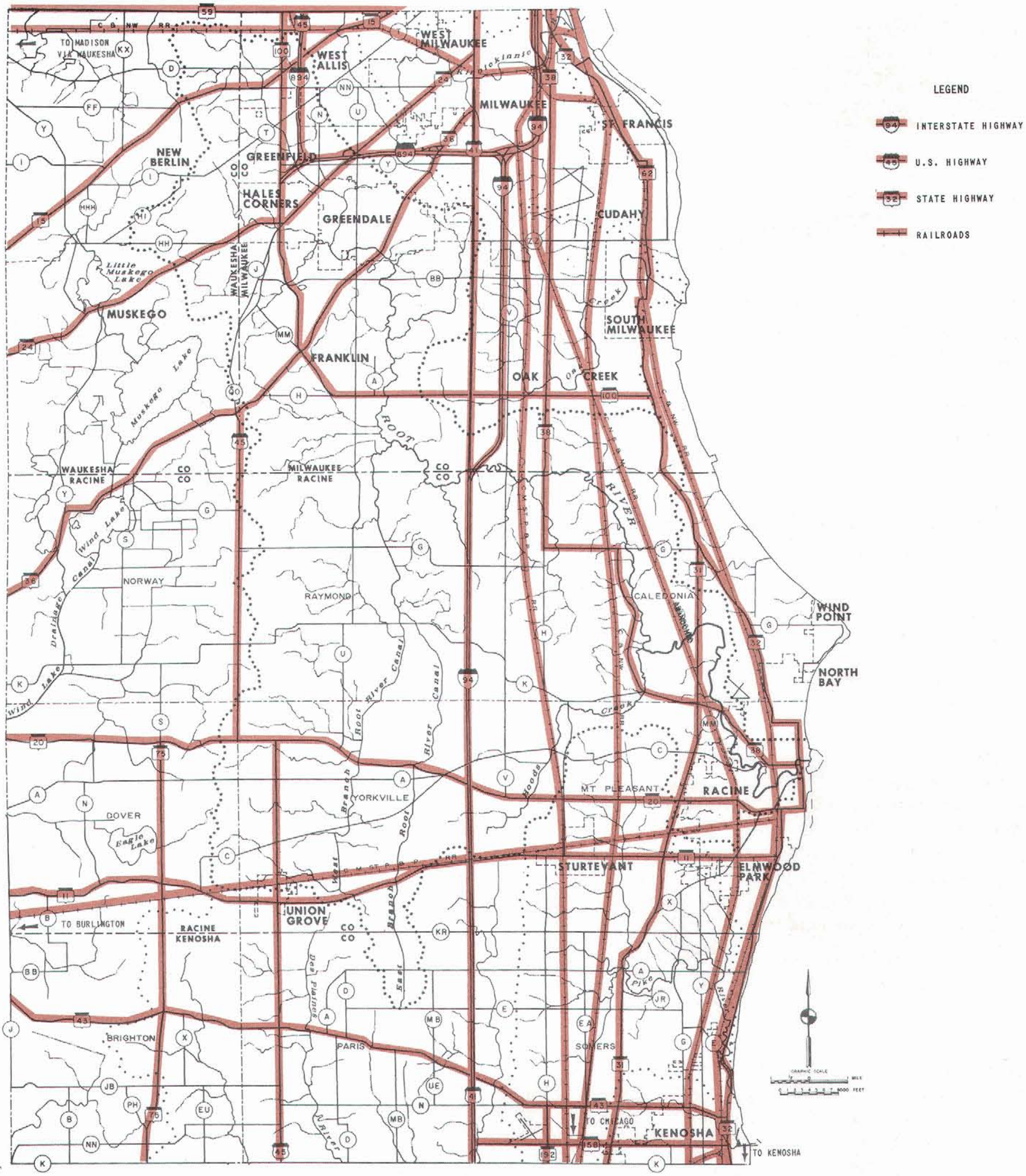
PUBLIC WATER SUPPLY SERVICE AREAS IN THE ROOT RIVER WATERSHED (1964)



Although high quality Lake Michigan water may ultimately be available to all urban development in the watershed, only the headwater portions and the Racine area are presently so serviced. Ground water remains an important source of supply in other areas of the watershed.

Map 22

ARTERIAL HIGHWAY AND TRUNK LINE RAILROAD FACILITIES IN THE ROOT RIVER WATERSHED (1966)



The watershed lies directly in the path of the major Chicago-to-Milwaukee transportation routes.

areas the ground water reservoirs assume considerable importance.

Electric power service to the entire watershed is provided by the Wisconsin Electric Power Company. Residential power service is available anywhere within the watershed, low voltage lines being in place on virtually every rural highway. Electric power to meet any commercial or industrial need could and would, as a matter of utility corporation policy, be extended to any customer requesting service anywhere within the watershed with the sole limitation that the anticipated earnings from a particular customer must over a four-year period be equal to, or greater than, the cost of the necessary service extension.

Gas service to the watershed is provided by three utilities: Wisconsin Southern Gas Company, Wisconsin Natural Gas Company, and Milwaukee Gas Light Company. No gas utility franchise exists in the Town of Raymond. As a matter of utility corporation policy, any major customer can obtain gas service anywhere within the franchised portions of the watershed; but extensions to serve small potential customers in areas remote from existing mains must be deferred until the number of such consumers economically justifies the necessary extension.

The Major Transportation System

The major transportation network within the watershed, consisting of arterial highway and trunk line railroad facilities, is shown on Map 22. The major transportation routes and dominant movements within the watershed are all in a north-south direction. The heaviest movements of motor vehicle traffic within the watershed occur along IH 94-USH 41 and connecting STH 100 and on STH 32. These major north-south highway routes are paralleled by three trunk line railroad routes: the Chicago, Milwaukee, St. Paul, and Pacific Railroad, Milwaukee-to-Chicago main line; the Chicago and Northwestern Railroad, Milwaukee-to-Chicago freight line; and the Chicago and Northwestern Railroad, Milwaukee—Racine—Kenosha—Chicago passenger line.

SUMMARY

This chapter has described the natural and man-made resources which—as an interrelated whole—comprise the complex and changing environment which is the Root River watershed. Certain findings having particular significance to any comprehensive planning effort for the Root River watershed are evident. They are summarized in the following paragraphs.

The Root River watershed is one of 11 natural surface water drainage units located within the rapidly urbanizing Southeastern Wisconsin Region. A complex pattern of general and special purpose units of government is superimposed upon this natural drainage unit complicating comprehensive watershed planning and plan implementation activities.

The watershed is experiencing a rapid population growth and urbanization, and the economic forces promoting these changes are largely centered outside of the watershed in the Milwaukee and Racine urbanized areas. Land within the watershed is undergoing a rapid change from rural to urban use. The new urban development is occurring primarily in the form of low-density residential use in the Milwaukee County headwater upper reaches of the basin and in the lower reaches of the basin near the City of Racine. Considerable sprawl in the form of isolated residential enclaves is also occurring in the still rural areas of the watershed away from established communities.

Large areas of the watershed are covered by soils having severe limitations for urban development and particularly for residential development without public sanitary sewer service. These problem areas for urban development are, however, largely the opportunity areas for development of additional woodland, wildlife habitat, and outdoor recreational areas.

The approximately 11 percent of the total area of the watershed remaining in water, woodland, and wetland use, together with the areas of soils poorly suited to urban development, form natural environmental corridors along the stream valleys. In their present undeveloped state, they support most of the remaining wildlife within the watershed. Only 3 percent of the total watershed area has been developed for outdoor recreational uses, and most of this area is in parkway lands within Milwaukee County.

Public sewer and water facility extension has not kept pace with urban development. The location of the watershed near Lake Michigan makes available to it—legally and practically—a dependable supply of high quality surface water.

The ability of the watershed to sustain a wildlife population has declined rapidly, and the remaining wildlife population is small and of a limited variety. A historic game fishery has declined in recent years and disappeared entirely due to adverse changes in water quality.

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Chapter IV

HYDROLOGY OF THE WATERSHED

INTRODUCTION

The hydrologic regimen of the Root River watershed is conditioned by a combination of influences—some natural and some caused by man's occupation and use of the land. As a result of its glacial origin, the land surface is made up of a large number of different soil types with varying influence upon the relation of rainfall to runoff. The natural channels also reflect the glacial origin of the topography with variable slopes and poorly developed drainage patterns. Many of the natural drainage courses in the river system have been modified, in the agricultural areas by tiles and ditches to drain former wetlands and in the urban areas by conversion into storm sewer receptors and wasteways. Urbanization has reduced the rate of ground water recharge with attendant lowering of shallow ground water aquifer levels and reduction in the ground water contribution to streamflow. The low-flow regimen of the river system and the chemical and biological quality of the streamflow has been greatly influenced by contributions of sewage disposal plant effluent. The Root River watershed thus is much changed from its natural condition, generally unfavorably with respect to its water resources. The watershed, however, still retains a potential for beneficial land use and water resource development.

Comprehensive planning for the wise use and development of the land and water resources of the watershed requires knowledge and understanding of the relationships existing between the many natural and artificial factors that together comprise the hydrologic system of the watershed. Because of the interdependence of streamflow, ground water, and land use, any planned modification or development of one facet of the hydrologic system must consider the resultant effects on all others. Only by considering the hydrologic system as a whole can a sound comprehensive watershed plan be prepared and the water-related problems of the basin ultimately abated.

QUANTITY OF SURFACE WATER

Surface water in the Root River watershed is made up almost entirely of streamflow. A few minor ponds, wetlands, and flooded gravel pits comprise the balance but are negligible in terms of the total water quantity. The quantity of streamflow varies widely from season to season and from year to year responding to variations in precipitation, temperature, soil moisture conditions, agricultural operations, the growth cycle of vegetation, and ground water levels. Since the quantity of streamflow is the product of many interrelated hydrologic factors, the only practical way to determine streamflow characteristics is to measure the streamflow itself.

Ideally, a long record of flow measurement is required before a representative picture of flow characteristics can be obtained. Unfortunately, systematic streamflow measurements in the watershed were initiated a comparatively short time ago, making estimates of streamflow characteristics highly dependent upon engineering judgment. Three stream gaging stations were installed in October 1963, less than one year before the Root River study began: one on the North Branch at W. Ryan Road (STH 100), one on the Canal at CTH G, and another on the main stem at STH 38 near the City of Racine. Two full annual streamflow cycles have now been recorded at these gaging stations, and the flow characteristics obtained are believed to be reasonably indicative of long-term conditions, particularly in the low-flow ranges.

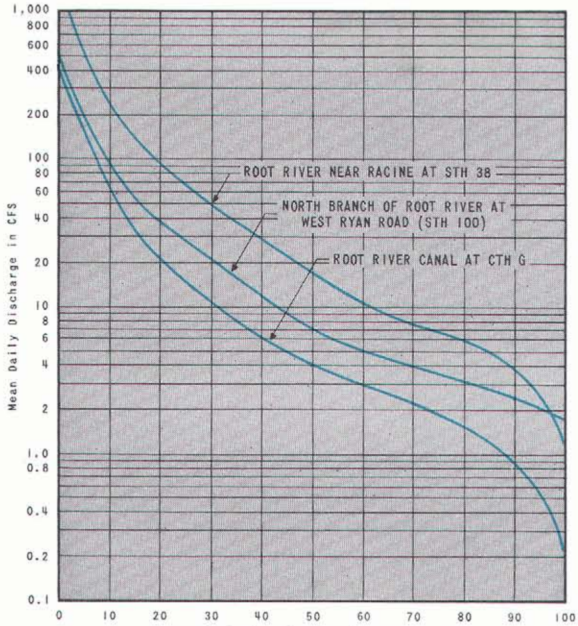
Streamflow characteristics for the published period of record, together with long-term estimates based on experienced engineering judgment, are summarized in Table 8. Flow duration curves for the period of published record are shown in Figure 4.

It should be noted that effluent from several sewage treatment plants contributes to the flow of the Root River. Approximate contributions of effluent to the flows at each station during the 1964 and 1965 water years[1] are summarized in Table 9. Since some of these contributions enter the stream system well above the stream gaging stations, differences between Table 8 and 9 are due to losses or gains incurred in channel seepage and routing.

[1] *"Water Year" is the 12-month period October 1 through September 30, designated by the calendar year in which it ends. Thus, the water year 1965 extends from October 1, 1964, through September 30, 1965.*

Figure 4

FLOW DURATION IN THE ROOT RIVER
1964-1965 WATER YEARS



Source: U.S. Geological Survey, Surface Water Branch; SEWRPC.

High streamflows occur principally in the late winter and early spring, usually associated with melting snow. Low flows persist for most of the remainder of the year with occasional rises caused by rainfall. Under present ground water conditions, the lowest flows of the river appear to consist almost entirely of sewage disposal plant effluent, without which, flows would probably drop to zero for considerable periods of time.

Surface runoff, the portion of precipitation which flows overland contributing directly to streamflow, is variable both in season and in location within the watershed. The ratio of runoff from winter rains and melting snow, usually occurring when the soil is frozen or saturated, can be very high. However, runoff during the later spring, summer, and fall season is generally a very small fraction of the causative rainfall. Figures 5, 6, and 7, show the hydrographs of river discharges recorded at the three gaging stations, during the 1964 water year, plotted together with precipitation as recorded at the U. S. Weather Bureau Milwaukee Station at General Mitchell Field. Precipitation recorded at the Milwaukee Station, however, is not always representative of precipitation over the entire watershed as indicated by isohyetal maps of unusual rainfall events, such as that of July 17-18, 1964. In summary, river discharge generally responds much more to winter and spring rainfall than to summer and fall rainfall.

Under present conditions of land use in the watershed, the amount of precipitation which becomes runoff and appears as streamflow in the Root River system is, when considered for the watershed as a whole, still fairly representative of stream systems in the Lake Michigan basin. Table 8 indicates that the long-term average annual flow of the Root River at Racine is equivalent to an annual runoff of about 6.3 inches depth of water over the entire watershed, or about 21 percent of the average annual precipitation of 30 inches. Considering

Figure 5

RELATIONSHIP OF STREAMFLOW, SEWAGE EFFLUENT, AND PRECIPITATION
IN THE ROOT RIVER AT HIGHWAY 100, CITY OF FRANKLIN, (1963-1964)

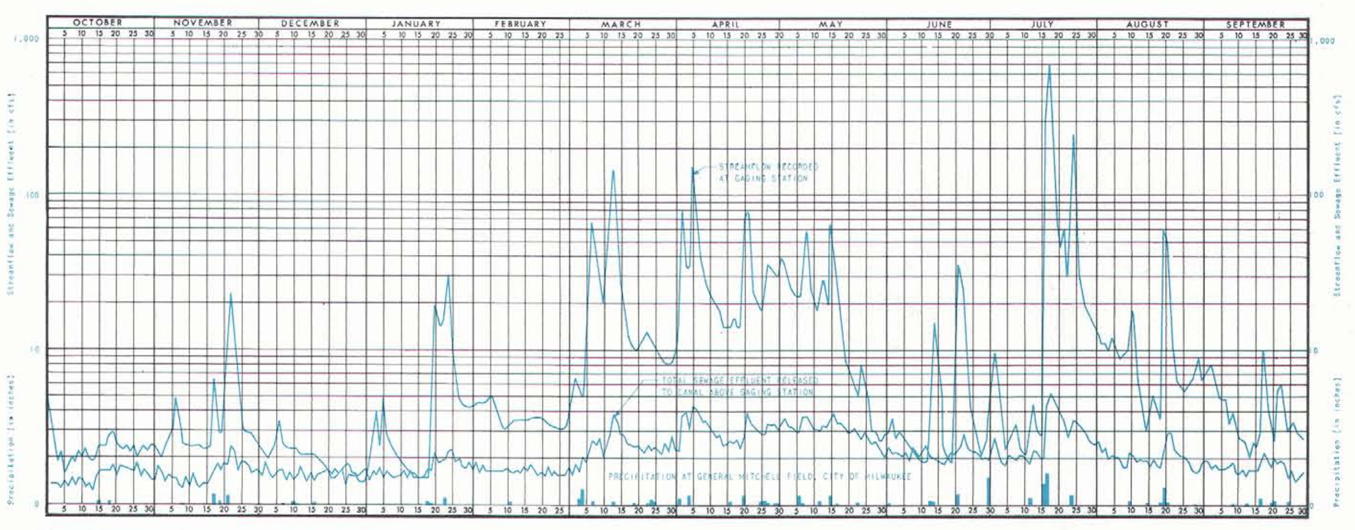


Table 8

STREAMFLOW DATA SUMMARY FOR THE ROOT RIVER WATERSHED

Station and Tributary Drainage Area	Mean Daily Flow (CFS)	Equivalent Runoff Depth (in.)	Instantaneous Peak Flow (CFS)	Min. Daily Flow (CFS)	Flow Equalled or Exceeded 90 Percent of Time (CFS)
Root River Canal at CTH G, 57.2 sq. mi.					
Oct. 1963 to Sept. 1964	7.7	1.83	309	0.3	0.7
Oct. 1964 to Sept. 1965	39.6	9.37	500	1.2	1.0[a]
Long-term Estimate (present conditions)	25.0[b]	6.05[b]	3,200[c]	--	--
North Branch at W. Ryan Rd. (STH 100), 49.3 sq. mi.					
Oct. 1963 to Sept. 1964	15.9	4.38	792	1.4	2.0
Oct. 1964 to Sept. 1965	51.3	14.12	1,600	2.1	2.3[a]
Long-term Estimate (present conditions)	36.8[b]	10.10[b]	5,000	--	--
Root River Near Racine (STH 38), 187 sq. mi.					
Oct. 1963 to Sept. 1964	34.4	2.51	997	1.3	2.0
Oct. 1964 to Sept. 1965	121.0	8.76	1,610	3.5	3.6[a]
Long-term Estimate (present conditions)	86.7[b]	6.26[b]	8,200[c]	--	--

[a] *Based on both 1964 and 1965 water years.*

[b] *Estimated by multiplying 1963-1965 runoff, adjusted for sewage plant effluent by ratio of long-term (20-year) average flow of Des Plaines River at Des Plaines to 1963-1965 Des Plaines runoff.*

[c] *Corresponds to March 1960 flood peak obtained from synthetic flood computations.*

Source: U.S. Geological Survey, Surface Water Branch; Harza Engineering Co.

the short period of runoff record, upon which these long-term estimates are necessarily based, this is not significantly different from the long-term average annual runoffs of other rivers in the Region, such as the Des Plaines, Fox, and Milwaukee, which range from 7.0 to 7.7 inches per year. Although runoff for the watershed as a whole is representative of streams in the Region, any such representative similarity disappears when sub-watersheds of the Root River basin are considered. For example, Table 8 indicates that the runoff from the drainage area tributary to the Root River Canal, a relatively flat agricultural area covered by retentive soils, is only 6.0 inches per year. The runoff from the drainage area tributary to the North Branch is 10.1 inches per year, or 1.7 times the runoff from the Root River Canal area and 1.6 times the runoff of the watershed as a whole. Although the soils of the area tributary to the North Branch are somewhat less retentive than those in the Root River Canal area and the topography somewhat steeper, the most striking difference between the two tributary drainage areas is in the degree of urbanization. About one-half of the drainage area tributary to the North Branch is presently occupied by urban land uses, while almost all of the drainage area tributary to the Root River Canal is in rural land use. The proportionate relations existing between these runoff values are basically unchanged when the contribution from sewage plant effluent is subtracted from the total flows. These differences in runoff characteristics may become even more pronounced as urbanization proceeds within vari-

Figure 6

RELATIONSHIP OF STREAMFLOW, SEWAGE EFFLUENT, AND PRECIPITATION IN THE ROOT RIVER CANAL NEAR CITY OF FRANKLIN (1963 - 1964)

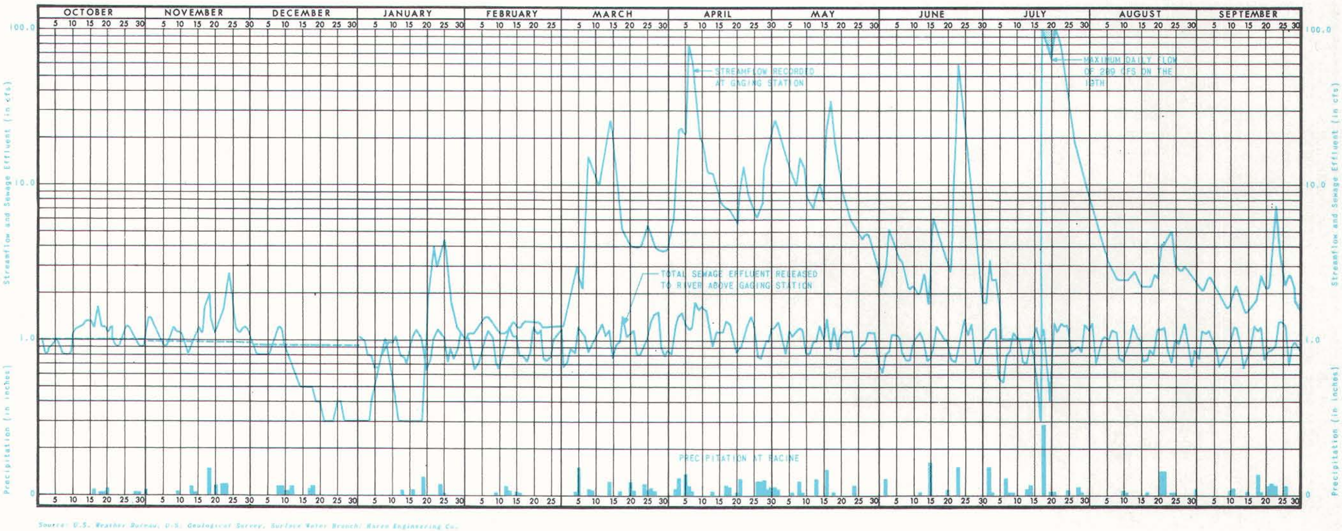
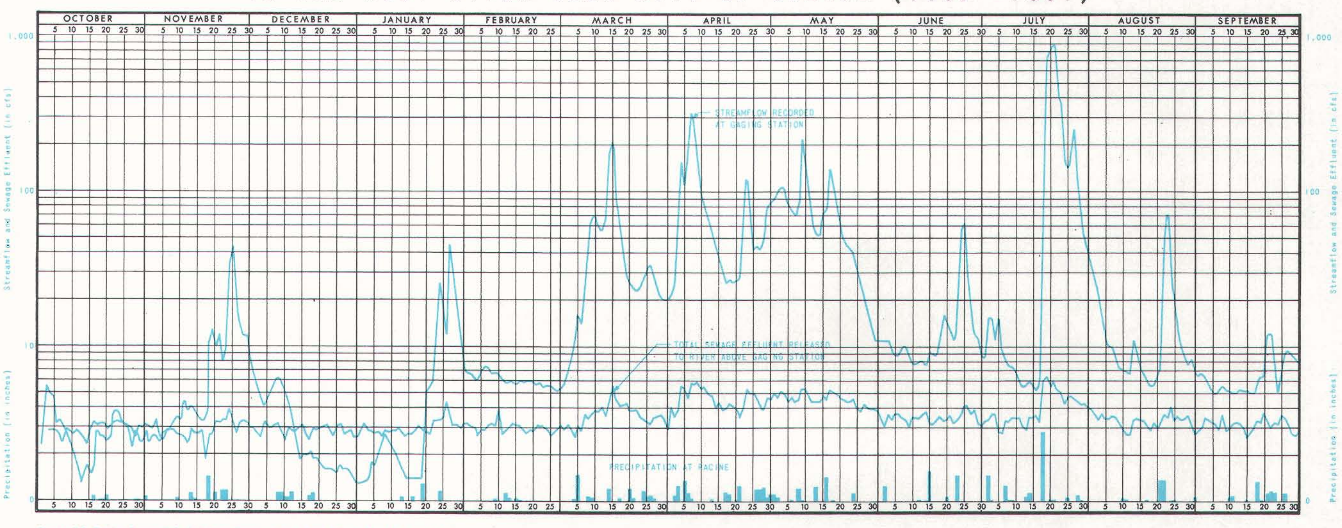


Figure 7

RELATIONSHIP OF STREAMFLOW, SEWAGE EFFLUENT, AND PRECIPITATION IN THE ROOT RIVER NEAR CITY OF RACINE (1963 -1964)



ous sub-watersheds. Equivalent depth of surface runoff resulting from individual storms was analyzed for two storms, with the results summarized in Table 10.

It is not possible to draw precise quantitative conclusions, as to the relationship between storm runoff from the urban and rural areas, from the small amount of hydrologic data presently available for the Root River watershed. The data indicate, however, that surface runoff ratios are definitely higher for the urban portion of the watershed. Therefore, as urban development continues within the watershed, the total quantity of annual runoff will probably increase. This increase, however, may be concentrated in periods of flood flow. Streamflow during dry periods may actually decrease. Low flows may also be strongly influenced by increases in sewage disposal plant effluent or by the export of sanitary sewage from the watershed. The trend of runoff changes resulting from urban development can, to some degree, however, be controlled through proper water management practices based upon a comprehensive watershed plan.

Table 9

SEWAGE PLANT FLOW CONTRIBUTION SUMMARY FOR THE ROOT RIVER WATERSHED
OCTOBER 1963 - SEPTEMBER 1965

Station	Average Effluent Flow Contribution (CFS)	Equivalent Runoff Depth (in.)	Maximum Daily Effluent Flow Contribution (CFS)	Minimum Daily Effluent Flow Contribution (CFS)
Root River Canal at CTH G	1.0	0.24	1.9	0.4
North Branch at W. Ryan Rd. (STH 100)	2.2	0.61	5.7	1.4
Root River Near Racine (STH 38)	3.7	0.26	6.4	1.9

Source: Metropolitan Sewerage Commission of the County of Milwaukee; Village of Union Grove; Caddy Vista Sanitary District; Wisconsin Committee on Water Pollution.

Table 10

RAINFALL-RUNOFF RELATIONSHIP FOR TWO MAJOR STORMS
ROOT RIVER WATERSHED

Major Storms	Rainfall (in.)	Retention (in.)	Runoff (in.)	Runoff Ratio
July 17-18, 1964				
Root River Canal at CTH G	4.61	4.02	0.59[a]	0.13
North Branch at W. Ryan Rd. (STH 100). . .	6.01	5.10	0.91	0.15
January 1, 1965				
Root River Canal at CTH G	1.00	0.87	0.13	0.13
North Branch at W. Ryan Rd. (STH 100). . .	0.60	0.41	0.19	0.32

[a] *Includes outflow from agricultural tile drains.*
Source: U.S. Weather Bureau; Harza Engineering Co.

FLOOD CHARACTERISTICS

Historical Floods

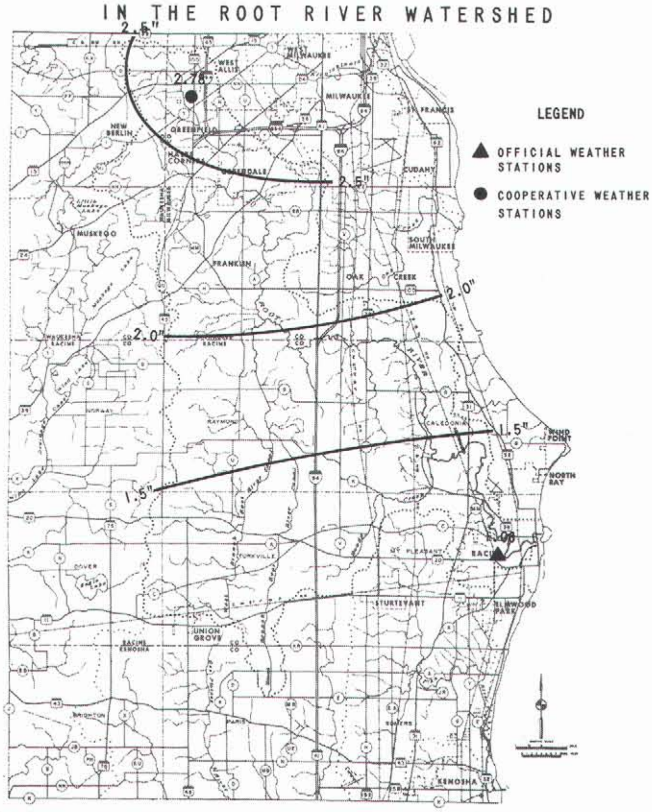
The Root River system, while having a history of relatively frequent minor local flooding, has experienced only one major flood in recent times. The flood which occurred in March-April of 1960 was by far the most damaging experienced on the Root River. Living memory and historical records show no evidence of overall damage and inundation from any other flood even approaching that experienced in this flood.

The combination of climatological events which caused the 1960 flood was unusual and undoubtedly rare. Based on the U. S. Weather Bureau Milwaukee Station record of 111 years, the 20 inches of snow on the ground on March 1, 1960, was the third highest recorded for that date. Fourteen inches of new snow fell between the 1st and the 25th of March. The average temperature during the month was the lowest ever recorded for March, with the temperature rising above freezing for only a portion of one day between the 1st and the 26th. After this sequence of steadily below freezing temperature, which minimized the loss of snow water content, the temperature rose to 46°F on the 27th, 41°F on the 28th, and 62°F on the 29th. Starting in the evening of the 29th, 2.57 inches of rain fell in a period of 24 hours, the highest ever recorded in 24 hours in March. This rainstorm appears to have been centered over the drainage area of the North Branch. An isohyetal map of this storm is shown on Map 23.

This heavy rain falling immediately after a sudden thaw resulted in a peak flow of 5,000 cubic feet per second (CFS) at W. Ryan Road (STH 100) as later

Map 23

ISOHYETAL MAP
STORM OF MARCH 29-30, 1960
IN THE ROOT RIVER WATERSHED



The severe flood event of 1960 was triggered by a 24-hour rainfall of about 2 inches, as shown, occuring on frozen ground and causing the runoff of an additional 3.5 inches of water from snowmelt.

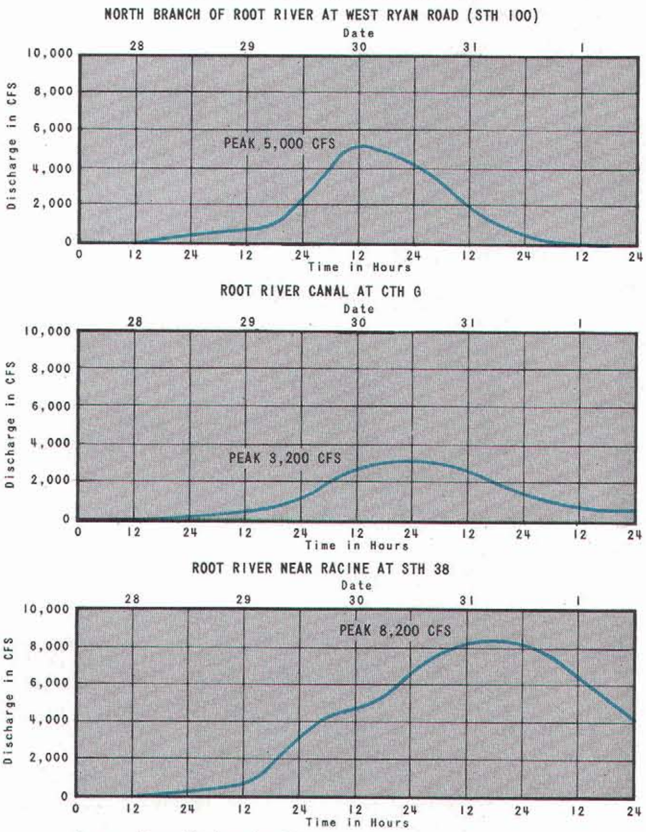
determined by an indirect measurement[2] made by the U. S. Geological Survey. Discharges were not measured elsewhere in the river system, but high water marks indicate that the flow was out-of-banks along most of the river length with several areas of widespread inundation. The peak stage at Spring Street in Racine was 15.2 feet, 3.7 feet higher than the next highest recorded peak in the 25 years of record. Synthetic reconstruction of the 1960 flood indicates a peak discharge near Racine at STH 38 of 8,200 CFS. The method of flood synthesis is described in Chapter VI. Synthesized hydrographs of 1960 flood flow at several points in the river system are shown in Figure 8. Specific location, extent of damages, and areas of inundation caused by the 1960 flood are described in Chapter VII.

The synthesis of the 1960 flood indicates that flood flow probably consisted of about 3.5 inches depth of snowmelt runoff over the entire watershed combined with about 2.4 inches depth of rainfall runoff from the drainage area of the North Branch and about 1.4 inches depth of rainfall runoff from the balance of the watershed.

A frequent contributing factor to local high water levels during late winter and early spring floods is jamming of ice at bridges and other channel

Figure 8

HYDROGRAPHS OF SYNTHESIZED FLOOD FLOWS MARCH - APRIL 1960 FOR THE ROOT RIVER WATERSHED



Source: Harza Engineering Co.

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[2] *Streamflow determinations are ordinarily based on the velocity-area method of measuring discharge in which the cross-sectional area of flow and the velocity of flow past the section are determined. The product attained by multiplying the area of the cross section by the velocity of flow constitutes the discharge measurement for that cross section of the stream system. The velocity may be measured either directly by current meter or determined indirectly by measurement of the head loss through a contracted opening, such as a bridge waterway, from which the velocity and discharge may be computed by standard engineering formulae. The head loss is usually determined by an instrumental survey of high water marks made as soon after a flood as practicable.*

By the indirect, contracted opening method of measurement, the calculated peak flow of the Root River at Ryan Road on March 30, 1960, was determined to be 5,130 CFS. This indirect measurement was rated as "fair" in accuracy (plus or minus 8 percent) when reviewed by the Washington Office of the USGS. For purposes of the planning studies, the value was rounded to 5,000 CFS.

constrictions. Although conflicting reports were obtained during the flood damage surveys, it is probable that ice jams were not a significant factor in the 1960 flood. Ice effects are most prevalent in the case of a river rise followed by freezing temperatures causing large ice sheets, in turn, followed by a flood. Such conditions did not occur in 1960.

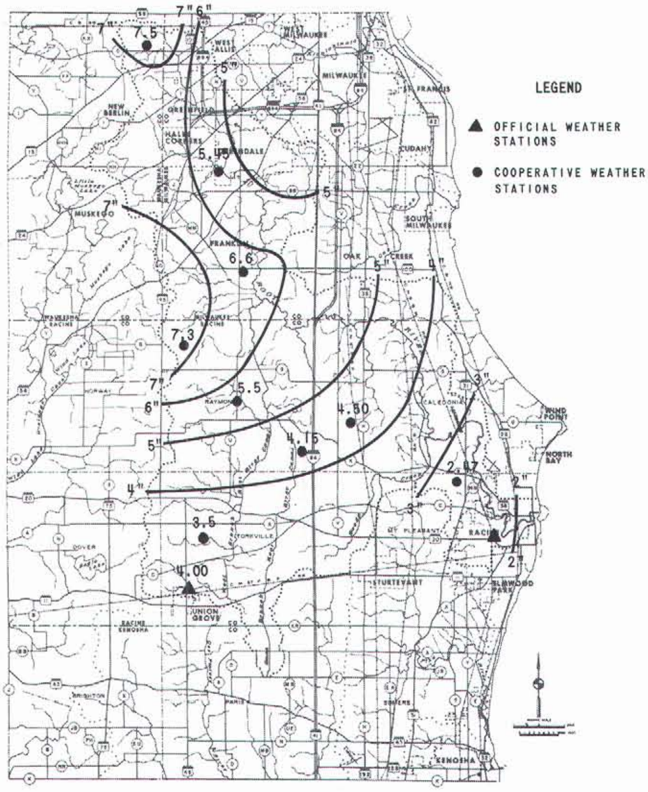
A recent minor flood, that of July 1964, while causing only relatively slight damage, was of great importance to the study of the flood hydrology of the Root River watershed. Widespread thunderstorm rain began in the evening of July 17 and continued until midnight. A second rainfall started around 4:00 a.m. on the 18th and continued intermittently until noon. A total of 4.04 inches of rain fell at the U. S. Weather Bureau Milwaukee Station in a period of 19 hours. Rainfall on the drainage area of the Root River was, at many points, even higher. The highest recorded rainfall in the drainage area was 7.51 inches (unofficial) in the northeast corner of the City of New Berlin. An isohyetal map of the July 17-18, 1964, storm is shown on Map 24. Rainfall depth-duration-frequency curves prepared by the U. S. Weather Bureau for Milwaukee Station indicate a recurrence interval in the order of 100 years for rainfalls of this magnitude.

The total volume of flood flow resulting from this unusually heavy rainfall was, however, relatively small. The peak flow at W. Ryan Road (STH 100) gaging station was 792 CFS; at CTH G, 309 CFS; and near Racine at STH 38, 997 CFS. Comparisons of rainfall volume and corresponding runoff volume for this storm are shown in Table 10. Hydrographs of these flood flows are shown in Figure 9.

The river response to the storm of July 1964, as compared to March 1960, illustrates the tremendous effect of seasonal variation in the water retention capability of the watershed soils. Watershed soil conditions were dryer than normal at the

Map 24

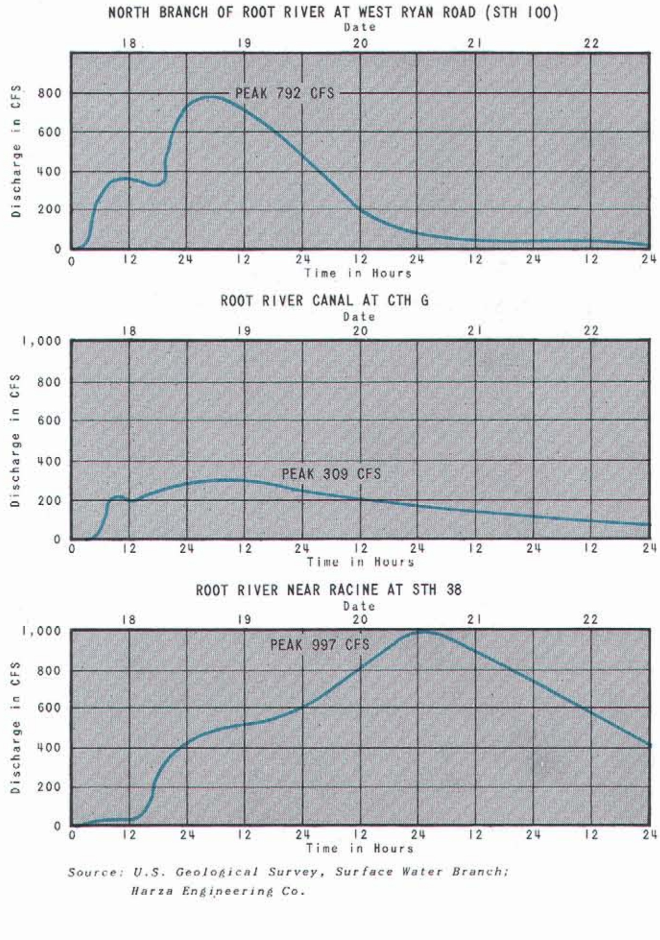
ISOHYETAL MAP
STORM OF JULY 17-18, 1964
IN THE ROOT RIVER WATERSHED



With the cooperation of local observers, the SEWRPC was able to construct this map showing the distribution of rainfall produced by an intense storm occurring during the conduct of the comprehensive planning study. Because of favorable antecedent moisture conditions, unfrozen soils, and vegetative cover, runoff from this rainfall was relatively small and resultant flooding was minor.

Figure 9

HYDROGRAPHS OF HISTORICAL FLOOD FLOWS
JULY 1964 FOR THE ROOT RIVER WATERSHED



Source: U.S. Geological Survey, Surface Water Branch; Harza Engineering Co.

beginning of the July storm. Using U. S. Soil Conservation Service (SCS) rainfall retention criteria, it is estimated that the flood peaks might have been up to three times as high with normal antecedent rainfall conditions, "normal" being defined as 1.4 to 2.1 inches of rainfall in the previous five days. Although the soils in the drainage area of the North Branch are less retentive than those of the Root River Canal area, the total depth of water retained in the North Branch area, as indicated by the flood of July 1964, is greater than the depth of retention in the Canal area. This is contrary to the expected effects of urbanization on rainfall retention and flood runoff and is probably due to the greater volume of rain on the North Branch falling on very dry soils. As indicated by the higher runoff ratio for the North Branch (0.15 versus 0.13), the Canal area would probably have retained more water had it received rainfall in an amount equal to the North Branch. Another possible compensating factor is that urban lawn areas have a higher retentive effect upon summer rainfall than agricultural cropland. The flood peak discharge from the North Branch was, however, higher than that of the Canal, as would be expected from an urban drainage area where more efficient drainage concentrates the runoff volume into a shorter time period.

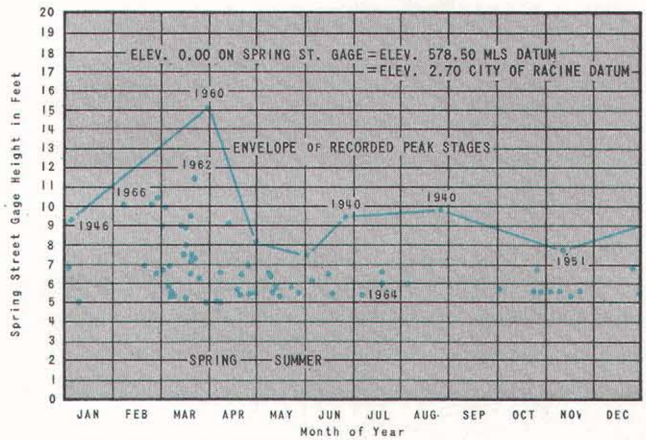
Seasonal Nature of Floods

A record of river stage (water level) obtained since 1940 at Spring Street Bridge by the City Engineer of the City of Racine shows that most flood flows in the last 25 years occurred during late winter or early spring. All stage peaks of 5.0 feet and over are shown plotted on their date of occurrence in Figure 10. Only the highest peak for each storm or snowmelt event was selected for plotting. Of the 64 peaks of 5.0 feet and over, 35 peaks, including the four highest of record, occurred during the months of February, March, and April. Of the 22 peaks of 7.0 feet and over, 17 peaks occurred during the months of February, March, and April.

The probability of heavy rainfall within the Region is much greater in the summer months than at any other time of the year. In spite of this greater rainfall potential, however, summer floods have been much less frequent and not as severe as spring floods. This is undoubtedly due to the greater capacity of the soil to retain rainwater during summer conditions and the absence of snowmelt contribution. Table 10 indicates a total retention as high as 5.1 inches depth over the drainage area of the North Branch in a period of about 24 hours. This amount of retention is twice the total rainfall associated with the flood of March-April 1960.

Figure 10

PEAK STAGE[a] OCCURRENCES
ROOT RIVER AT SPRING STREET, RACINE
(1940 - 1965)



[a] Represents all peak stages over 5.0 feet.

Source: City Engineer, City of Racine.

Flood Frequency

A most important characteristic of floods and of flood damages is the probability, or risk, of their occurrence. Probability, or risk, is defined as the chance of occurrence in any year of a flood equaling or exceeding a specified magnitude. Probability may be expressed as a decimal fraction or a percentage. "Recurrence interval" is defined as the average time interval between floods of a given magnitude and is equal to the reciprocal of the probability. For example, a flood of such magnitude that it occurred on the average of once in 100 years would have a recurrence interval of 100 years and a probability, or risk, of happening in any year of 1 percent. It may also be said that such a flood has one chance in one hundred of happening in any year.

A long and continuous record of river discharge is the best basis for determination of flood frequency. Unfortunately, the discharge records for the Root River are much too short for meaningful flood frequency analysis. It was necessary, therefore, to make statistical inferences as to flood frequency from other sources. These were made from the periodic measurements of river water levels recorded at the Spring Street Bridge in Racine since 1940, climatological records collected at Milwaukee over a period of 111 years, and long-term discharge records of other Wisconsin rivers with hydrologic regimens similar to that of the Root River.

Data from these sources were analyzed with particular emphasis on determining the probable frequency of the 1960 flood. The Spring Street gage record, being an actual measure of river performance over a period of 25 years, was given the heaviest weight in the analysis. The actual series of peak stages was analyzed using a statistical method (Hazen formula) of probability assignment to individual recorded stages. A similar analysis was also carried out for both spring and summer peak stages. The series of annual, spring, and summer peak stages as recorded at Spring Street is shown in Table 11. The frequency curves resulting from the statistical analysis are shown in Figure 11.

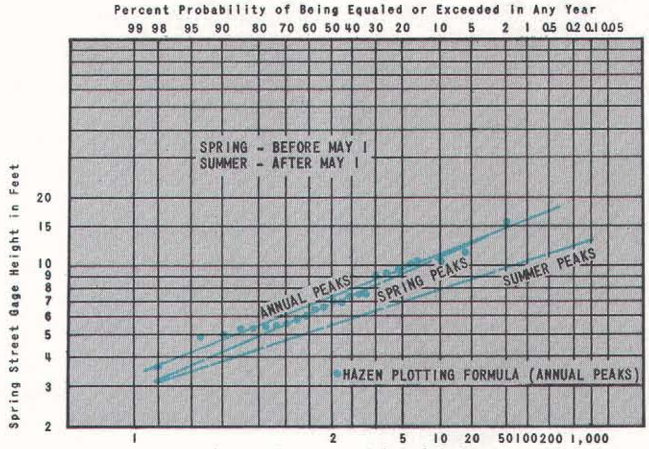
Statistical analysis of the Spring Street gage record indicates that the probability of occurrence in any year of a peak stage equal to, or greater than, the 15.2 feet recorded in 1960 is 0.014. This corresponds to an average recurrence interval of once in about 70 years. There is reason to believe, however, that the probability of occurrence of a flood comparable to the 1960 flood is smaller than 0.014. Analysis of Root River flood frequency in terms of the flood frequencies of similar rivers in a comparable geographical and climatological environment, using criteria prepared by the U. S. Geological Survey,[3] indicates a probability of occurrence in the range of 0.005 to 0.001, corresponding to recurrence intervals of 200 to 1,000 years. The combined probabilities of the climatological events which produced the 1960 flood also indicate a probability of occurrence for the flood less than that resulting from statistical analysis of the Spring Street record alone.

In consideration of the above factors, with most weight being given to the Spring Street gage record, it was concluded that the probability of occurrence of a flood comparable to that of 1960 is 0.01, or an average of once in 100 years. Frequencies of lesser floods were established by using the USGS regional frequency relationship together with the 100-year frequency assigned to the 1960 flood. Derived frequency curves for the three river gaging stations are shown in Figure 12. It is important to note that these frequency curves apply to present conditions of urban development in the watershed. Frequency-stage data for future land use conditions are contained in Chapter VI.

[3] *See: Ericson, D.W., Floods in Wisconsin, Magnitude and Frequency, U.S. Geological Survey open-file report. 1961.*

Figure 11

ROOT RIVER STAGE FREQUENCY AT SPRING STREET GAGE, CITY OF RACINE (1940 - 1965)



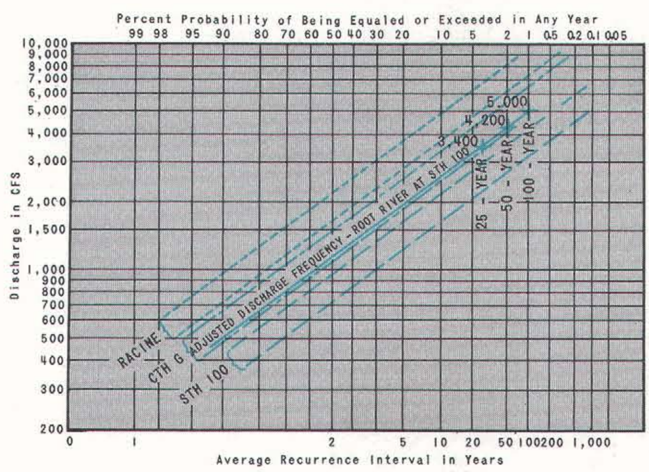
Source: Harza Engineering Co.; City Engineer, City of Racine.

Effects of Urbanization

As urban development in the watershed increases in the future, changes in flood characteristics are certain to occur. Urbanization generally modifies the hydrologic system of the watershed by decreasing the storm-water retention capability on much of the area of the watershed and by increasing the rate at which storm water is transported over the surface of the land. The potential changes in the peaks, duration, and frequency of floods are, however, extremely difficult to forecast on a quantitative basis. Moreover, the changes resulting from urbanization vary widely from watershed to watershed, depending upon such factors as soils, topography, and land use.

Figure 12

ROOT RIVER DISCHARGE FREQUENCY



Source: U.S. Geological Survey regional criteria

Table 11

SELECTED PEAK STAGES AT SPRING STREET, CITY OF RACINE, RACINE COUNTY, WISCONSIN

Year	Winter-Spring Peak		Summer Peak	
	Stage[a] (feet)	Date	Stage (feet)	Date
1940	4.9	Mar. 30	10.0	Aug. 26
1941	7.0	Jan. 3	5.5	Nov. 3
1942	4.2	Mar. 24	4.8	May 25
1943	10.2	Feb. 23	4.3	May 21
1944	6.6	Mar. 15	4.2	June 19
1945	5.4	Mar. 6	5.6	May 28
1946	9.3	Jan. 7	3.5	July 1
1947	7.5	Mar. 14	7.5	June 2
1948	9.0	Mar. 1	6.3	May 10
1949	5.4	Mar. 7	3.3	June 20
1950	7.0	Mar. 6 & Apr. 25	6.6	July 20
1951	10.4	Feb. 27	7.8	Nov. 13
1952	9.5	Mar. 20	6.0	Aug. 4
1953[b]	5.3	Mar. 16	4.9	May 6
1954[b]	5.3	Mar. 16	4.9	May 4
1955	5.5	Apr. 25	6.5	June 15
1956	5.5	Apr. 30	5.8	May 14
1957	5.0	Apr. 8	5.5	June 17
1958	5.0	Apr. 7	3.8	June 2
1959	7.5	Mar. 20	6.8	Oct. 21
1960	15.2	Mar. 31	6.5	May 9
1961	7.3	Mar. 22	5.7	Oct. 2
1962	11.4	Mar. 20	4.0	May 14
1963	3.6	Mar. 25	3.4	May 13
1964	3.7	Mar. 16	6.0	July 20
1965	10.1	Mar. 4	5.8	Oct. 25
1966	10.2	Feb. 11		

Annual peak underlined.

[a] *0.0 on Spring Street gage = 578.5 feet above Mean Sea Level datum, 1929 Adjustment; = -2.21 feet City of Racine datum.*

[b] *May be the same year.*

Source: City Engineer, City of Racine.

It has been demonstrated that, under present conditions of urban development, major floods are generally associated with snowmelt. The effect of urbanization on snowmelt floods appears, however, to be minimal. As the soil is either frozen or saturated under snowmelt conditions, the retention potential for concurrent rainfall is practically nil. Effectively then, the entire area of the watershed is impervious regardless of urban development. In fact, it is likely that the volume of snowmelt runoff in a flood situation will be somewhat smaller under urban conditions than it would be for agricultural conditions. Snow deposits disappear more rapidly in an urban situation, allowing comparatively less accumulation prior to a sudden thaw, such as occurred in 1960. Snow is removed or melted from streets, melts from roofs of buildings, and is more effectively melted off by solar radiation because of darkening from soot and dust.

The rate of runoff of snowmelt water from urban areas is increased, however, because of paved drains and sewers and hydraulically improved stream channels. As a result, flood peaks may be higher even though the total volume of runoff may be less. This only appears to be true of local areas, however.

As the area of consideration becomes larger, the effect of improved local drainage becomes less significant. Flood peaks may even be reduced because tributary flood peaks, being of shorter duration, may become out of phase with main channel peaks and have less additive effect. In the flood synthesis studies carried out for the Root

River watershed, the runoff volume of snowmelt floods was, therefore, assumed to be unaffected by urbanization, while the rate of runoff was increased by decreasing the time of concentration of sub-basin unit hydrographs. The resultant increase in peak flood discharges proved to be about 30 percent at W. Ryan Road (STH 100) and 22 percent at STH 38.

Urban development in the watershed may have a greater influence, however, upon floods caused by summer rainfall because of reduction by urban development of the high summer retention capacity of the land surface. As urbanization proceeds, a considerable portion of the land surface will become practically impervious due to cover by pavement and roofs. Even for summer conditions, however, counterbalancing factors exist. Since the bulk of the new urban land uses in the Root River watershed will probably consist of low- and medium-density residential development, the proportionate increase in impervious area will not be as great as would be associated with industrial, commercial, and high-density residential use. The average ratio of impervious to total area in urban portions of the watershed is estimated to be about 27 percent. The unpaved areas in an urban situation generally have grass cover and often are leveled or terraced. Roof drains of residential buildings are, under present practices, discharged onto lawns rather than directly into storm sewers. Rainfall retention criteria of the Soil Conservation Service assign a higher retention to grass cover than to agricultural cropland use for the same soil. As a result, the ratio of runoff to rainfall in an urban area will be reduced over that for the same area in agricultural use for the open-space portions and increased for the paved and roofed-over portions.

An estimate of summer flood potential under future conditions of urbanization was made using the hydrologic simulation methods described in Chapter VI. Synthetic floods resulting from 100-year recurrence interval rainfall were prepared using hydrologic factors corresponding to present conditions and to projected future conditions (1990). The resultant increase in peak flood discharges proved to be about 70 percent at W. Ryan Road (STH 100), with a decrease of 30 percent at STH 38. The counterbalancing effect indicated is due to the complex effect of urbanization on times of concentration of flood waters, as well as on coefficients of runoff. The methods and assumptions used in deriving summer rainfall floods, together with calculated flows for various channel locations, are presented in Chapter VI under the heading "Hydrologic Effects of Urbanization."

QUALITY OF SURFACE WATER

"Quality" refers to the physical, chemical, and biological characteristics of the water resources. Quality characteristics are influenced, as is the quantity of water, both by the natural environment of the river system and by man's activities. Quality considerations rank comparably in importance with quantity in assessing the suitability of a water supply for a specific use. A comprehensive watershed planning effort must, therefore, include an evaluation of surface and ground water quality, and, insofar as possible, relate this quality to existing and planned land and water uses.

The quality of water as conditioned by the natural environment of the watershed would present no problem for any reasonably possible uses of Root River system waters. Most of the potential water uses are, however, incompatible with present water-quality factors resulting from human activity—principally disposal of wastes and, to a lesser degree, agricultural and urban drainage. Therefore, primary emphasis in this report is focused on the condition of the stream resulting from waste disposal and on the identification and evaluation of probable sources of pollution.

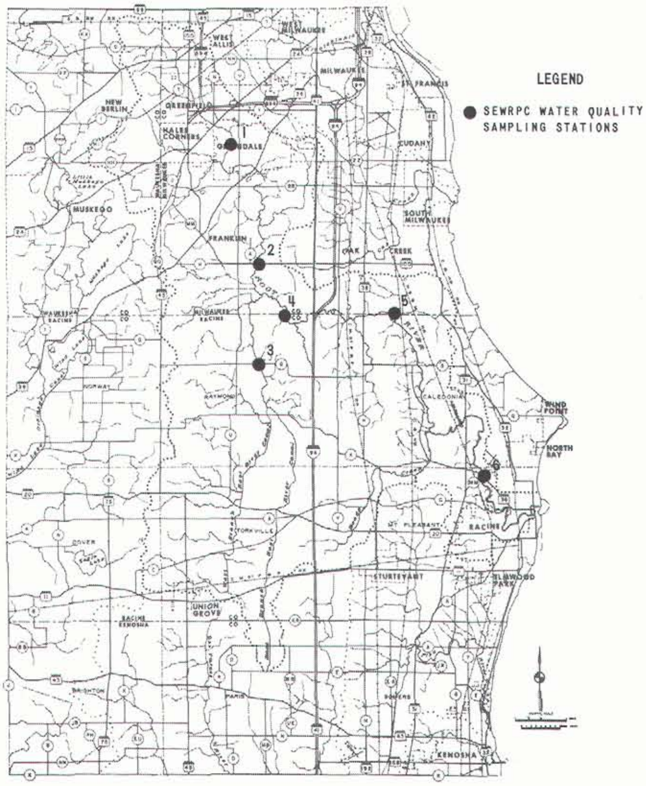
Present Water Quality

A water quality sampling and testing program carried out as part of the SEWRPC Regional Land Use-Transportation Study provided the primary source of basic data on the present quality of streamflow in the watershed. The locations of the SEWRPC sampling stations are shown on Map 25. During the period January 1964-February 1965, 77 samples were collected in the watershed, with laboratory determination of up to 29 quality constituents for some samples. Results of the field and laboratory examination are tabulated in Appendix D. The results of the stream water quality inventory and analyses for the Region as a whole are presented in SEWRPC Technical Report No. 4, Water Quality and Flow of Streams in Southeastern Wisconsin, 1966.

Water quality investigations of varying scope and duration have also been carried out within the watershed by other governmental agencies, including the Metropolitan Sewerage Commission of the County of Milwaukee, the Wisconsin State Board

Map 25

SEWRPC WATER QUALITY SAMPLING STATIONS IN THE ROOT RIVER WATERSHED (1964 - 1965)



Because of the paucity of water quality data for the Root River, the SEWRPC established six stations at which stream water samples were obtained periodically and analyzed for a full range of bio-chemical, physical, and bacteriological water quality indicators.

of Health, and the U. S. Geological Survey. The scope, duration, and results of these investigations are also summarized in Appendix D and in SEWRPC Technical Report No. 4. The findings of all these investigations indicate that serious pollution problems exist in the Root River stream system and are intensifying.

Although a large number of water quality constituents were analyzed in the SEWRPC investigation, it was determined necessary to consider in detail only three parameters in evaluation of stream water quality for the overall watershed planning purposes. These parameters—coliform bacteria, dissolved oxygen, and temperature—most profoundly influence the possible planned uses of the stream water.

Number of coliform bacteria is the most widely used index of possible fecal contamination (human excrement). Coliform bacteria may originate from other sources, however, so that a high coliform count is not always due to fecal contamination. The correlation of high coliform count in drinking water and epidemics of diseases, such as typhoid, is well established. The relationship of high coliform counts in water used for body-contact recreation to communicable diseases is, however, not as well established. As a result, adopted standards for maximum permissible upper limit of coliform bacteria in recreational use of waters involving whole body contact vary from 50 to 3000 MFCC/100 ml (membrane filter coliform count). Coliform bacteria are present in the effluent of sewage disposal plants, the number varying with the degree of treatment, and can be eliminated only by chlorination of the effluent.

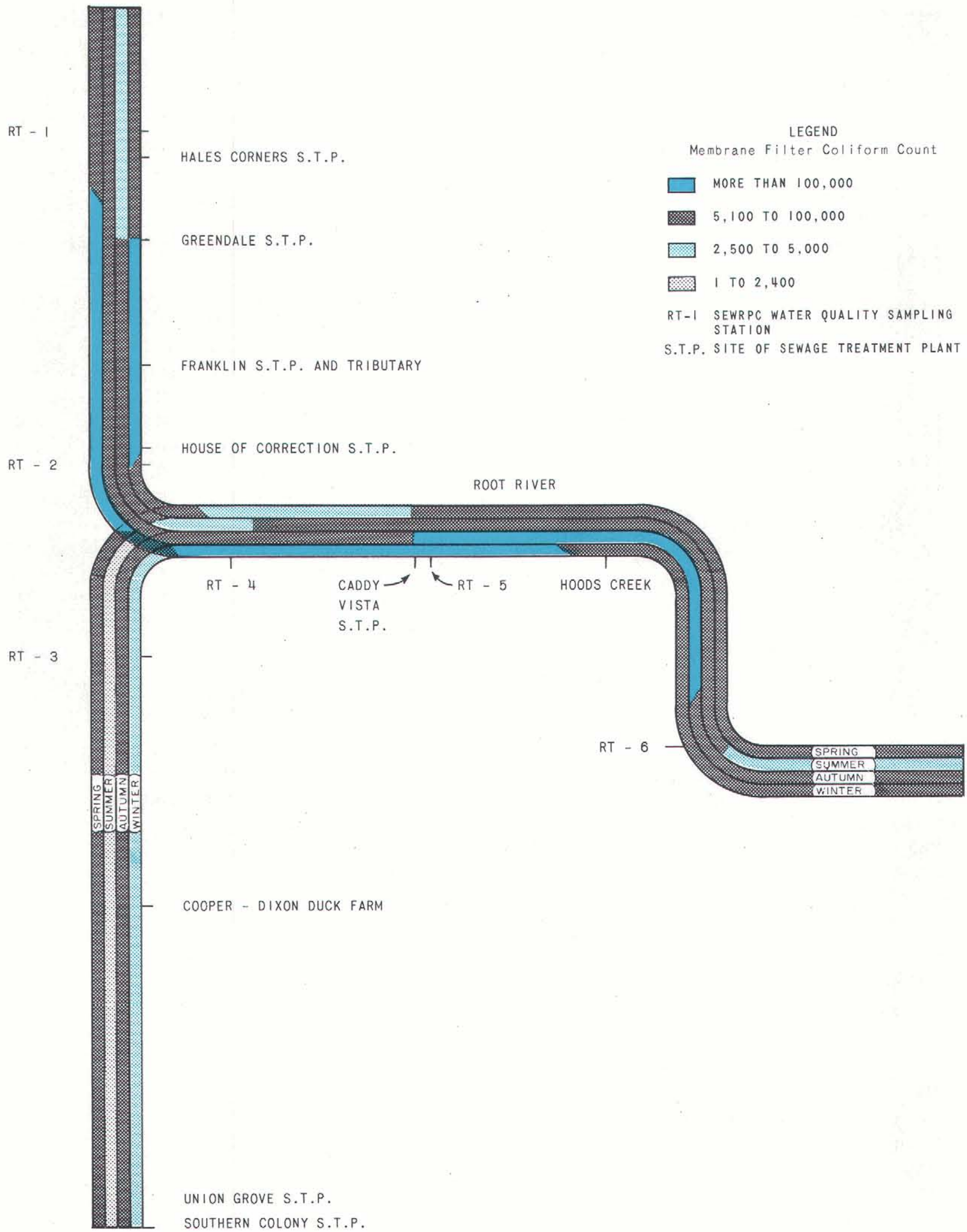
The maximum possible concentration of dissolved oxygen in water varies inversely with temperature ranging from a maximum of 14 mg/1 (ppm) at 32^{o}F to 8.5 mg/1 at 77^{o}F for saturation conditions. A minimum permissible limit of 4 mg/1 of dissolved oxygen is necessary to sustain facultative[4] fish life. Dissolved oxygen is consumed in the process of natural oxidation of sewage wastes in receiving waters. Septic conditions usually do not develop in streams if dissolved oxygen concentrations do not fall below 1.0 mg/1. Sources of dissolved oxygen include the atmosphere and aquatic plant life.

As determined from the one-year SEWRPC water quality study, the variation of stream water quality with respect to location and season, throughout the Root River system, is illustrated graphically in terms of coliform bacteria count in Figure 13; in terms of dissolved oxygen in Figure 14; and in terms of temperature in Figure 15. In addition, a graph depicting the monthly variation of these parameters over the period 1961 to 1964 at the City of Racine is shown in Figure 16. River discharge at the time of sampling has a strong influence upon the concentration of pollution factors. Since most pollutants are introduced into the river system at a relatively fixed flow rate, high streamflows result in greater dilution than do low flows. Coliform counts are, therefore, highest during the autumn and winter seasons when streamflow consists mostly of sewage plant effluent. Figure 13 shows the increase in coliform counts downstream from sewage treatment plants. The farthest down-

[4] *"Facultative" species of fish include: walleye, northern pike, bass, bluegill, muskie, perch, and shiner.*

Figure 13

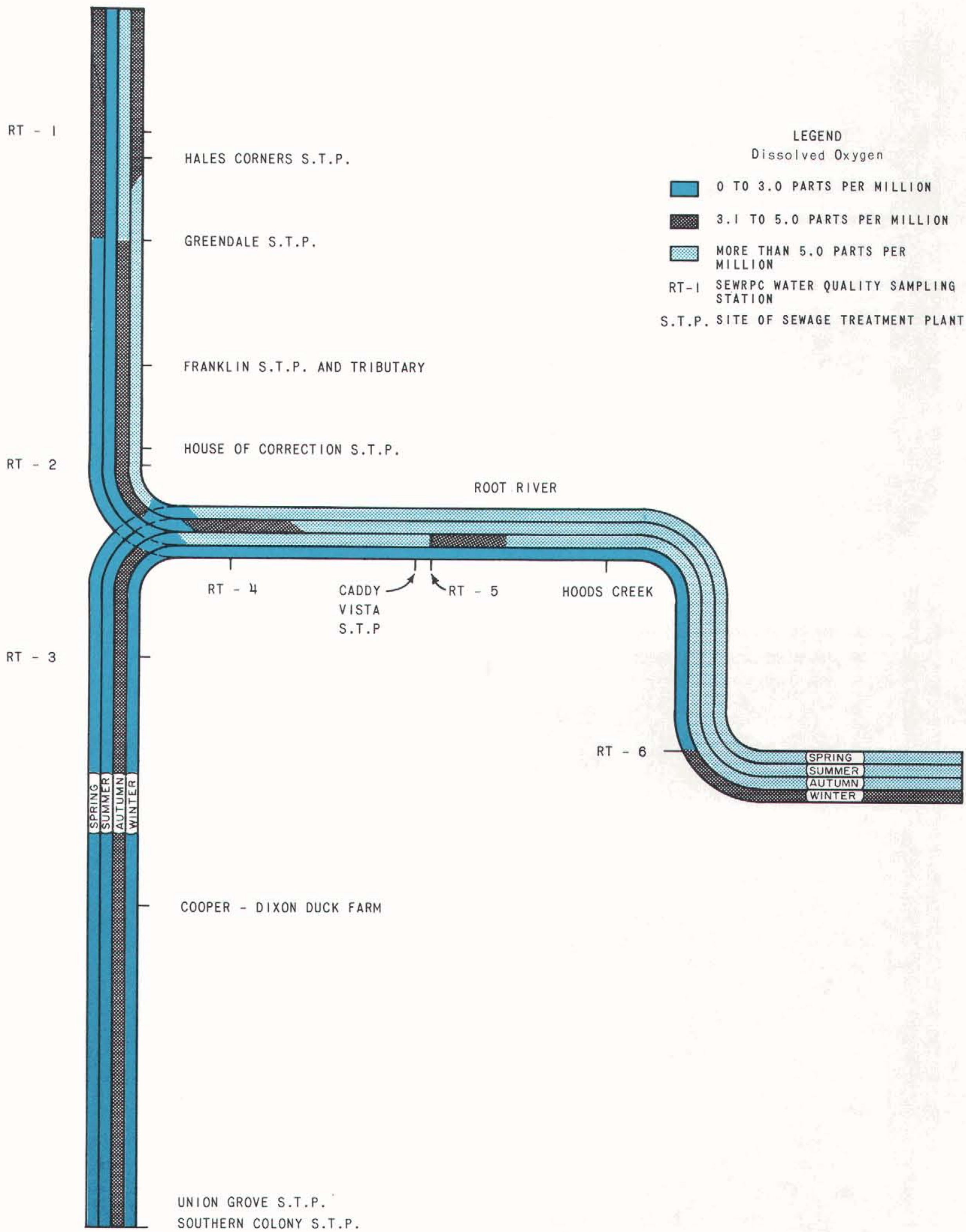
SEASONAL VARIATION OF COLIFORM BACTERIA IN THE ROOT RIVER SYSTEM (1964 - 1965)



Source: SEWRPC.

Figure 14

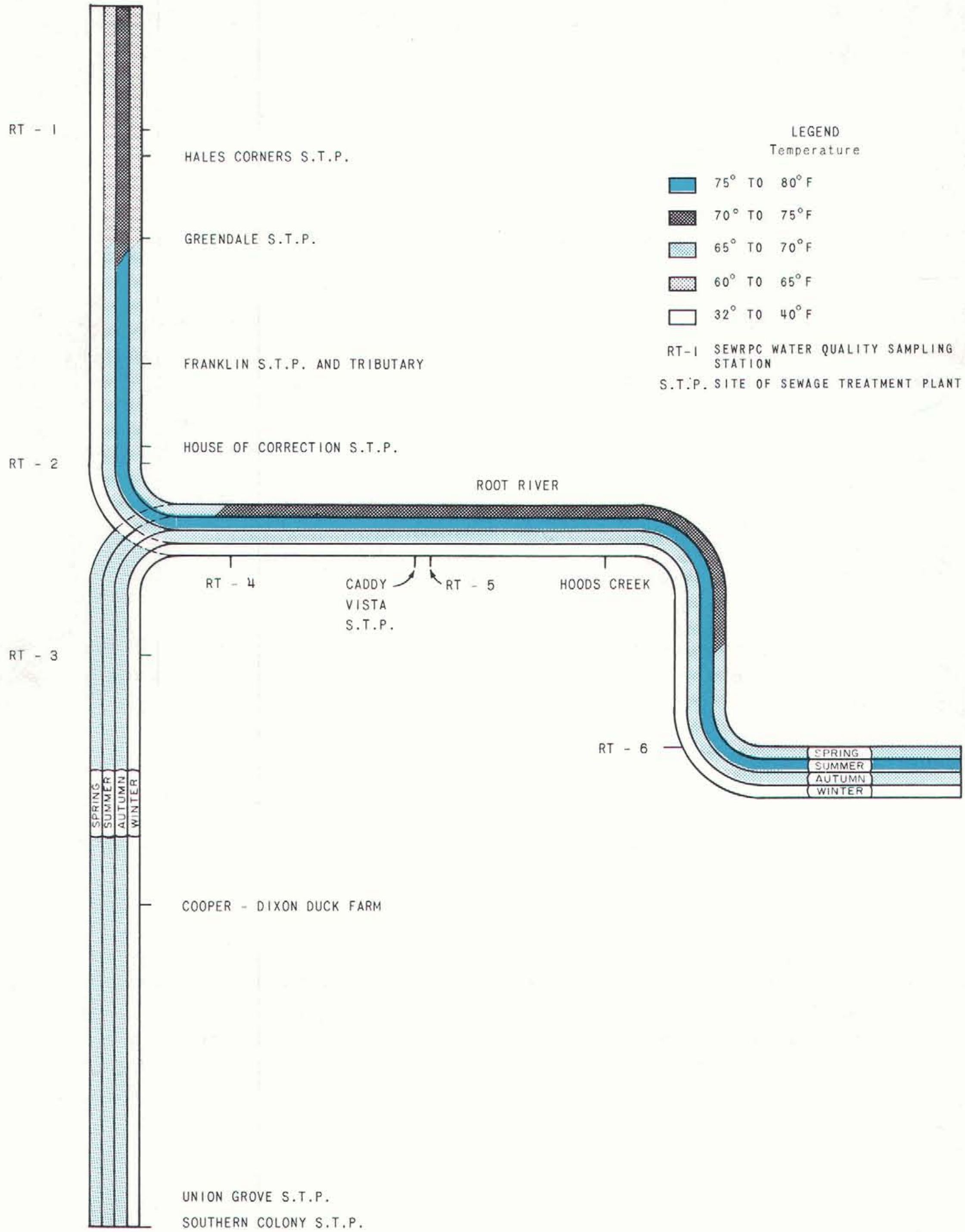
SEASONAL VARIATION OF DISSOLVED OXYGEN IN THE ROOT RIVER SYSTEM (1964 - 1965)



Source: SEWRPC.

Figure 15

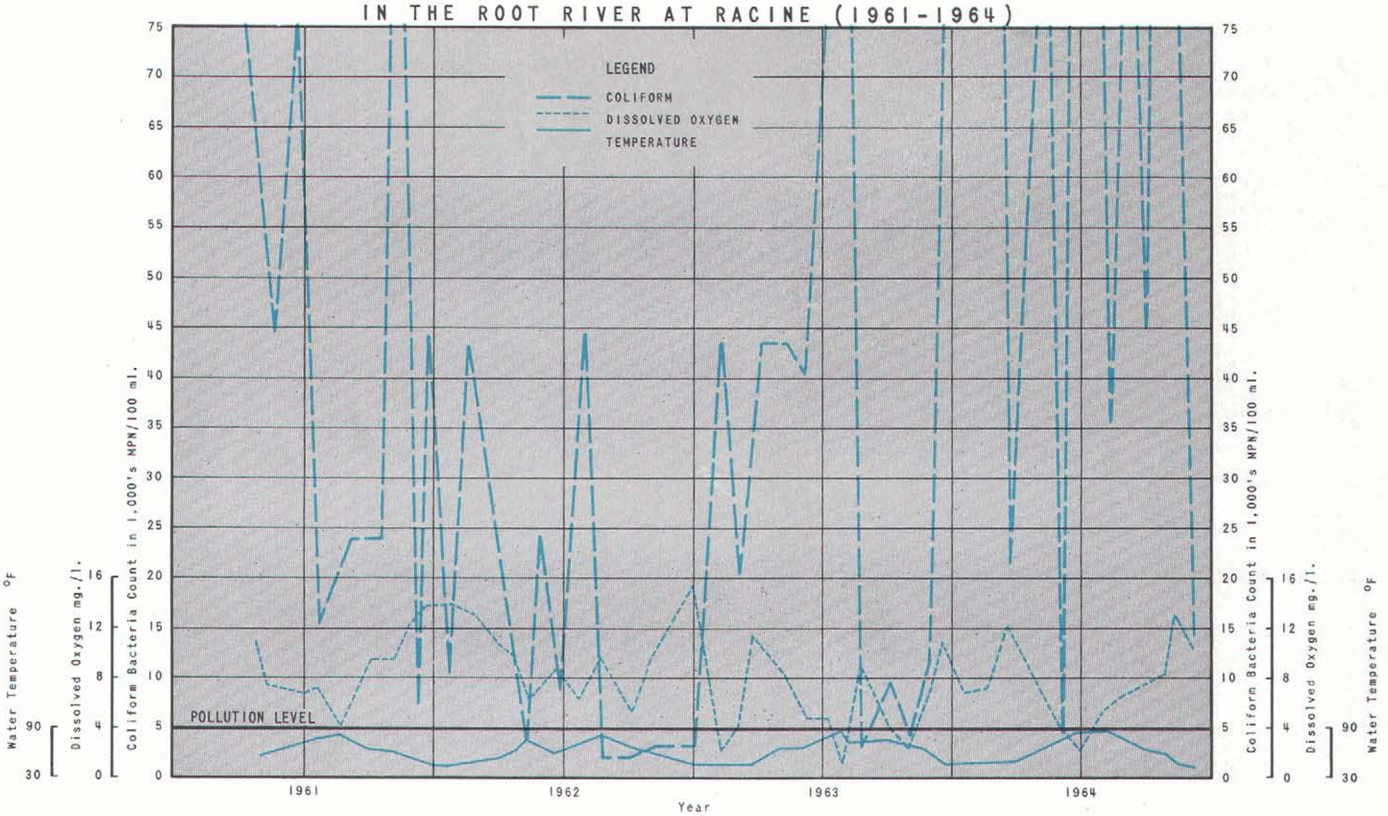
SEASONAL VARIATION OF WATER TEMPERATURE IN THE ROOT RIVER SYSTEM (1964 - 1965)



Source: SEWRPC.

Figure 16

WATER QUALITY CONDITIONS IN THE ROOT RIVER AT RACINE (1961-1964)



Source: State Committee on Water Pollution; State Board of Health.

stream disposal plant on the main stem is located at Caddy Vista in the Town of Caledonia. An improvement in coliform count generally occurs from Caddy Vista downstream as the natural process of stream purification takes place. At present it is evident, however, that the natural stream purification potential is overwhelmed by the pollution load.

The seasonal pattern of dissolved oxygen deficiency is similar to that of coliform count. Differences in geographic location may, however, be noted in Figure 14. Most noticeable is the low oxygen content of the water contributed by the Root River Canal. Lowest oxygen levels are found in the upstream reaches with a general improvement in the downstream direction. This is probably due to longer exposure to atmospheric oxygen and larger natural flows in proportion to sewage treatment plant effluent in the downstream reaches.

The temperature of a water affects the potential use of that water directly and indirectly. Higher temperatures indirectly affect fish life by diminishing the solubility of oxygen in the water while increasing respiration requirements. Higher temperatures directly affect fish life in that, even with adequate dissolved oxygen present, there is a maximum temperature that each species of fish can tolerate. Generally, facultative species of fish life are affected at temperatures above 90°F, while intolerant[5] species are affected at temperatures above 68°F. High temperatures indirectly affect the aesthetic value of waste-carrying streams through diminished oxygen availability. High temperatures also directly lower the aesthetic value of waste-carrying streams by stimulating putrefactive processes. Temperature, of course, also affects potential water use for industrial cooling. In the Root River stream system, as shown in Figure 15, high water temperatures are not currently a problem. As a result of urban activity, however, trends in stream water temperature conditions are generally upward; and it is possible that under increased urbanization seasonal problems of heat pollution could develop.

Sources of Pollution

The locations of major sources of wastes which discharge directly into the Root River system are

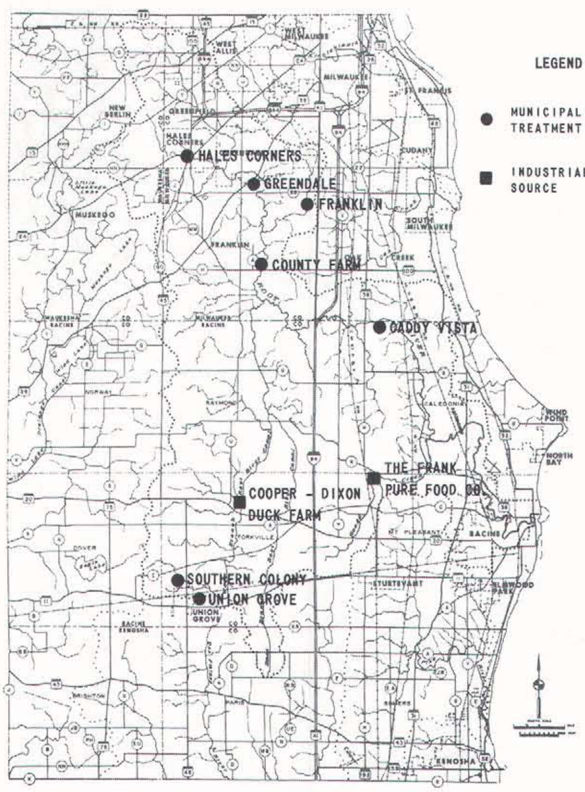
[5] *"Intolerant" species of fish include primarily trout.*

shown on Map 26. Information on origin, treatment, and probable pollution load of these waste sources is summarized in Table 12. Seven of the nine major waste sources are municipal sewage treatment plants providing secondary treatment. Two of the major waste sources are food processing plants, which generally provide lagooning of wastes for treatment.

The total equivalent population served by these plants is about 47,000. The daily biochemical oxygen demand remaining after treatment and the percent removal of BOD, as presented in Table 12, best indicate the relative effect of each waste source on the river system. The estimated present average daily five-day BOD stream loading from known major waste sources is 910 pounds in the entire watershed, 540 pounds of which are attributable to sources contributing to the North Branch of the Root River in Milwaukee County. In considering probable future conditions, however, it is important to note that the pollution load on the North Branch from municipal disposal plants will be eliminated upon completion by the Metropolitan Sewerage Commission of the County of Milwaukee of trunk sewers, presently under construction, which will convey all sanitary sewage from communities in the North Branch area to the new Puetz Road sewage treatment plant in the City of Oak Creek. A corollary effect of exportation of sanitary wastes out of the watershed will be the virtual elimination of low flows in the North Branch.

Map 26

MAJOR WASTE SOURCES IN THE ROOT RIVER WATERSHED (1965)



Field investigations and information made public by pollution control agencies revealed nine known major sources of surface water pollution in the Root River watershed: seven municipal sewage treatment plants and two food processing industries.

Exportation of sanitary wastes out of the watershed will not, however, entirely eliminate stream pollution in and below urban areas. Recent investigations by the U. S. Public Health Service[6] of the quality of storm water runoff from a medium-density residential area in Cincinnati indicate BOD levels as high as found in secondary sewage treatment plant effluent, together with coliform counts varying from 3,000 to 460,000 MFCC/100 ml. Concentrations of suspended solids and of nutrients were also found to be high. Other studies made in Detroit, England, Russia, Sweden, and South Africa support these findings. Although specific relationships between urban land use and the quality of urban-area storm runoff have not as yet been developed, it is certain that stream water quality problems will persist in and below urban areas of the watershed even after elimination of all sewage disposal plant effluent from the stream system.

Although knowledge about the effects of storm water upon water quality is meager, it would appear that pollution from storm water drainage is usually concentrated into short periods of time and its deleterious effects are balanced by the dilution effects of high volumes of streamflow during floods. Therefore, for present water quality planning purposes, the effect of urban storm water was not considered to be significant.

Pollution originating from decaying channel vegetation, farmland runoff, highway drainage, and overloaded septic tanks is small in comparison to that attributable to the major waste sources. It may become necessary to investigate these sources in the future if it becomes apparent that their effect is significant after elimination of the

[6] *Weibel, Anderson, Woodward, "Urban Land Runoff as a Factor in Stream Pollution," Journal of the Water Pollution Control Federation, Vol. 36 - No. 7, July 1964.*

Table 12

MAJOR SOURCES OF WASTE DISCHARGES TO THE ROOT RIVER AND TRIBUTARIES (1964)

Source of Wastes	Type of Treatment	Average Daily Discharge (CFS)	Total Equivalent Population Served, BOD Basis	Treatment Facility Loading, Av. Daily, 5-Day BOD (lbs.)[a]	Percent Removal of BOD by Treatment[b]	Stream Loading, Av. Daily 5-Day BOD After Treatment (lbs.)
1. Village of Greendale Sewage Treatment Plant	Activated Sludge & Oxidation Pond	1.10[c]	9,700[d]	1,649	75	410
2. Village of Hales Corners Sewage Treatment Plant	Trickling Filter	0.80[c]	5,000[d]	850	90	80
3. City of Franklin S.D. #1 Sewage Treatment Plant	Trickling Filter	0.05[d]	400[d]	68	80	10
4. Milwaukee County House of Correction Sewage Treatment Plant	Trickling Filter	0.15[e]	1,150[e]	196	80	40
Subtotal, Sources 1-4		*2.10*	*16,250*	*2,763*	--	*540*
5. State of Wisconsin Southern Colony & Training School Sewage Treatment Plant	Activated Sludge	0.50[f]	1,900[e]	323	90	30
6. Village of Union Grove[i] Sewage Treatment Plant	Activated Sludge	0.52[f]	2,100[d]	357	90	40
7. Cooper-Dixon Duck Farm & Food Processing Company	Lagooning	0.30[g]	14,000[h]	2,300[h]	90	230
Subtotal, Sources 5-7		*1.32*	*18,000*	*2,980*	--	*300*
8. Caddy Vista Sanitary District Sewage Treatment Plant	Trickling Filter	0.10[f]	1,100[d]	187	80	40
9. The Frank Pure Food Company	Lagooning	0.20[h]	12,000[h]	2,000[h]	99	30
Subtotal, Sources 8-9		*0.30*	*13,100*	*2,187*	--	*70*
Total, All Sources		3.72	47,350	7,930	--	910

[a] *Based on 0.17 pounds 5-day BOD per capita.*

[b] *Eighty percent for trickling filter, 90 percent for activated sludge, and 99 percent for the Frank Pure Food Company; Greendale Plant assumed estimated to be 75 percent, Hales Corners 90 percent.*

[c] *Based upon records obtained from the Metropolitan Sewerage Commission of the County of Milwaukee.*

[d] *Information published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin, 1963.*

[e] *Based upon data gathered by Gene Willeke, Chief of Engineering Section, Great Lakes-Illinois River Basin Project, U.S. Public Health Service, Chicago, 1964.*

[f] *Based upon the records of metered discharge as obtained from treatment plant operators.*

[g] *Information obtained from owner.*

[h] *Estimate based upon seasonal peak load and volume of water handled.*

[i] *On October 25, 1965, during the preparation of this report the Village of Union Grove reportedly separated industrial waste water from sanitary sewage and redirected the industrial water into the Des Plaines River watershed. This change would apparently remove about 200,000 gallons per day from the low flow of the Root River Canal. It is not known at this time whether such transfer is permanent or, for that matter, what legal and technical considerations might be involved.*

Sources: Given in footnotes c, d, e, f, and g.

major waste sources. If future development of the watershed is wisely planned, however, these minor waste sources should not magnify to cause, in aggregate, a major pollution problem.

Influence Upon Water Use

Two principal uses are presently being made of the stream waters of the Root River system. In areas in Milwaukee County and in the City of Racine, the river is an aesthetic component of existing outdoor recreation areas. The most general use for the river at present, however, is for the disposal of treated sewage. These uses are not completely compatible. Minor amounts of river water are also used for irrigation in the Root River Canal area.

In the course of the flood-damage survey, it was reported that, within the memory span of living older residents of the watershed, the river had been used for fishing, swimming, and stock watering. At present, however, only rough fish are known to exist in the river; and its waters are no longer used for swimming. Some stock watering may occur, but reports have been received of dairy cattle becoming ill from drinking river water and of bacterial counts in milk rising after allowing cattle access to Root River water.

The use of the river system for transportation of wastes has, therefore, effectively made the river unsuitable for all other uses except for a low standard of visual appreciation.

GROUND WATER

The underground waters underlying the Root River watershed are an important resource; and their use, and the effects of their use on the occurrence of surface waters, must be considered in any comprehensive watershed planning effort. Plan synthesis must be based in part upon investigations of the location, availability, and quality of the ground water body and of its interrelationship with the flows of surface streams.

The ground water resources in the Root River watershed have been developed primarily in areas of the watershed not served by Lake Michigan water. As a result of intensive use in many areas, the water table has been lowered significantly.

Characteristics of the ground water resource in the Southeastern Wisconsin Region have, historically, been subjected to investigation in greater detail than have the streamflow characteristics. A comprehensive study of ground water in Racine County has recently been carried out by the U. S. Geological Survey. Because of the apparent availability of data from these investigations, no additional field work was done in the course of the watershed study.

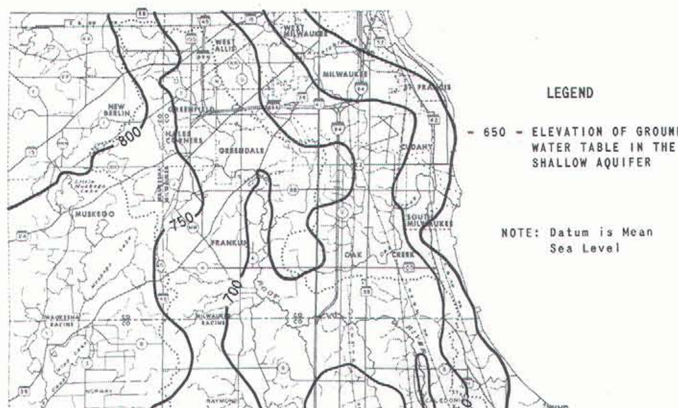
Geohydrology

As noted in Chapter III, the Root River watershed is underlain by alternating layers of dolomite, shale, and sandstone, which slope downward at 10 to 30 feet per mile toward Lake Michigan. These consolidated rocks are generally covered by a variable thickness of glacial drift and valley alluvium. The ground water reservoir materials can be categorized as comprising two aquifers: a shallow aquifer, made up of alluvium, glacial drift, and Niagara dolomite; and a deep aquifer, which includes Cambrian and Ordovician sandstones and dolomites. The deep aquifer is separated from the shallow by relatively impermeable strata, such as the Maquoketa shales. This condition causes significant differences in water quality and pressure between the two aquifers.

The approximate elevations of the ground water table in the shallow aquifer and the piezometric surface of the deep aquifer are shown on Maps 27 and 28, respectively. Approximate depths to the ground water table, or to the piezometric surface, from the ground surface may be estimated by subtracting the water elevation from the ground surface elevation. The water table of the shallow aquifer lies from within a few feet to many tens of feet below the ground surface. The water table, or piezometric surface, of the deep aquifer lies approximately 200 feet below that of the shallow aquifer. (Technically, the term "water table" cannot be properly applied to the confined waters of

Map 27

GROUND WATER TABLE OF THE SHALLOW AQUIFER IN THE ROOT RIVER WATERSHED (1962)



Source: U.S. Geological Survey, Ground Water Branch.

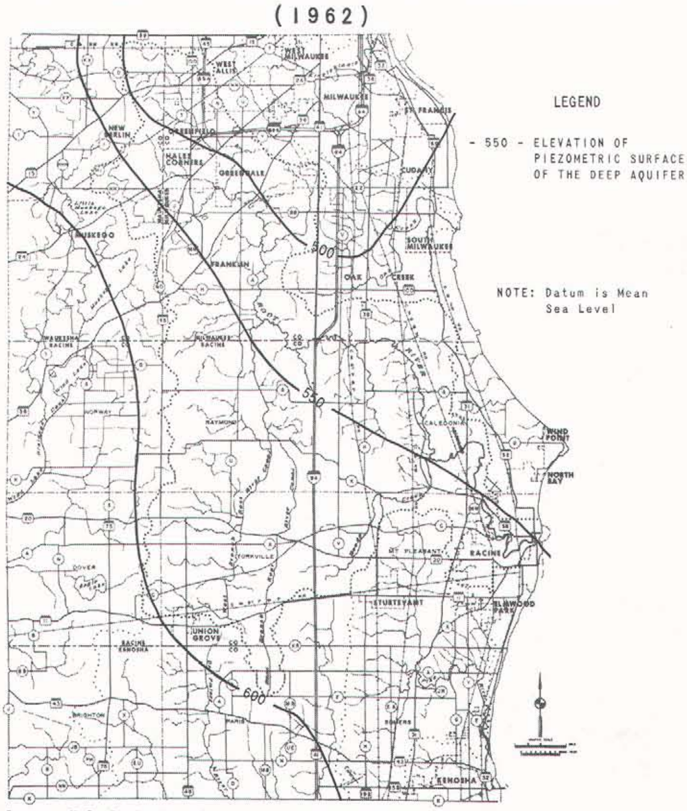
Water levels in the shallow aquifer underlying much of the watershed stand relatively close to the ground surface and provide the primary source of supply for both rural and urban residences not connected to a centralized public water supply system.

the deep aquifer. The piezometric surface in the deep aquifer is represented by the level to which the water will rise in a non-pumping well.)

The water table elevations shown on Map 28, indicate the cumulative effect of long-term withdrawals in populous areas, such as Milwaukee, Racine, and Waukesha. Water levels in the deep aquifer have been declining since the introduction of high capacity wells about the year 1900. In localized sites of exceptionally high withdrawal, such as downtown Milwaukee, deep aquifer water levels have dropped 300 to 400 feet since 1900. Within the Root River watershed, the maximum decline of the deep aquifer water levels has reached about 200 feet in both the West Allis-Greendale area and the Racine area. Water levels in the shallow aquifer in the west-central portion of the watershed have declined as a result of irrigation pumping in the Wind Lake sod farming area two to six miles west of the watershed boundary. Water levels in the shallow aquifer have, otherwise, generally remained high.

Map 28

PIEZOMETRIC SURFACE OF THE DEEP AQUIFER IN THE ROOT RIVER WATERSHED (1962)



Source: U.S. Geological Survey, Ground Water Branch.

The primary source of water supply for industries and for municipal systems not connected to the Racine and Milwaukee metropolitan water supply systems is a series of deep sandstone aquifers underlying the watershed.

According to the U. S. Geological Survey, all significant quantities of recharge to aquifers underlying the Root River watershed stem from precipitation on land surfaces within 30 to 40 miles of the watershed. The deep aquifer is recharged primarily by precipitation and percolation in the Kettle Moraine area of eastern Jefferson, western Waukesha, and western Walworth counties. This recharge area lies west of the subsurface occurrence of the relatively impermeable Maquoketa shale. Vertical percolation through overlying rock units from the shallow aquifer, sometimes through wells, also forms a component of the deep aquifer recharge.

Ground water in the shallow aquifer is recharged primarily by precipitation and percolation within the watershed. Some recharge contribution probably comes as lateral inflow from areas outside, but adjacent to, the western boundary of the watershed.

Availability of ground water supply is controlled by the hydraulic characteristics of the aquifer, as well as by recharge. Local lowering of the ground water table, particularly near high capacity wells, is often a result of low transmissibility of the aquifer so that ground water cannot move toward the well fast enough to meet the demand. Aquifer performance tests of the deep aquifer in Milwaukee County[7] have shown that the average coefficient of transmissibility[8] in the sandstones of the deep aquifer is about 24,000 gpd per foot. The pumping yield of the deep aquifer to wells as measured in gallons per minute per foot of drawdown (specific capacity) varies from 0.5 to 20 gpm/ft. Specific capacities in the shallow aquifer range from about 0.5 to 5 gpm/ft drawdown.

Ground Water Quality

The ground water in the Root River watershed area is chemically classified as hard, because of relatively high concentrations of calcium, magnesium, and sulfate. Physically, the ground water is clear, cool, tasteless, and odorless. In general, temperature increases slightly with depth; and the temperature of water in the shallow aquifer

[7] *Drescher, William J., and others, 1953 Water Resources of the Milwaukee Area, Wisconsin, U.S. Geological Survey Circular 247.*

[8] *Coefficient of transmissibility is defined as the rate of flow through a vertical strip of aquifer one foot wide and extending the full saturated thickness of the aquifer under a gradient of one foot per foot.*

averages about 50°F, while that in the deep aquifer averages about 55°F.

Waters of the deep aquifer have excellent quality in terms of bacterial and waste pollution. The shallow aquifer is generally of good quality in this respect but is much more vulnerable to local contamination. Therefore, ground water pollution in the shallow aquifer cannot be evaluated on an overall basis but must be tested for each individual well.

The constancy of quality and quantity makes ground water an especially useful commodity to industry. In the Milwaukee metropolitan area, ground water from the deep aquifer is used by industry for both processing and cooling water. In many smaller municipalities and on farms and rural residences, the shallow aquifer is the source of domestic water supply. Ground water is also used for supplemental irrigation on many truck farms.

Ground Water Quantity

Quantity of ground water is usually discussed in terms of the quantity or rate of present use. Public and private withdrawals of ground water in the Root River watershed area are estimated to average 7 million gallons daily (about 11 CFS), with about 4 million gallons per day being pumped from the deep aquifer and 3 million from the shallow aquifer. The general locations and estimated average daily pumpages of high capacity wells in the deep and shallow aquifers are shown on Map 29. It is not possible to show the location of the many small domestic and farm wells, which are scattered widely throughout the rural areas of Racine and Milwaukee counties. It is estimated, however, that these wells produce about 15 percent (1 million gpd) of the total pumpage.

The pattern of pumpage shown on Map 29 and the information previously published in SEWRPC Planning Report No. 6, The Public Utilities of Southeastern Wisconsin, July 1963, indicate the current degree of importance of ground water to the communities within the Root River watershed. It is significant that in 1965 more than half of the watershed area was served by ground water in areas lying outside the Lake Michigan water distribution service area. About 25 percent of the watershed residents live in areas where ground water is the only present supply. In general, dependence upon ground water as the sole source of supply increases in direct proportion to distances from either the City of Milwaukee or the City of Racine water utilities, which distribute Lake Michigan water. Although these service areas are expanding (recent examples are City of Milwaukee service to Greendale and City of Racine service to Sturtevant), a number of communities in the watershed still depend solely on ground water. These include the cities of New Berlin, Oak Creek, and Franklin; the villages of Hales Corners and Union Grove; and such unincorporated communities as North Cape, Raymond Center, Franksville, and Caddy Vista. In the Union Grove area, the volume of ground water withdrawals has increased threefold in the past 20 years. This illustrates the general trend toward increasing production of ground water in areas presently dependent on this source of supply. Perhaps the greatest dependence upon ground water, however, occurs in rural areas or in urbanizing areas where isolated homes, subdivisions, and industries rely upon ground water supplies as the only economic means of providing water supply to areas of such low population density.

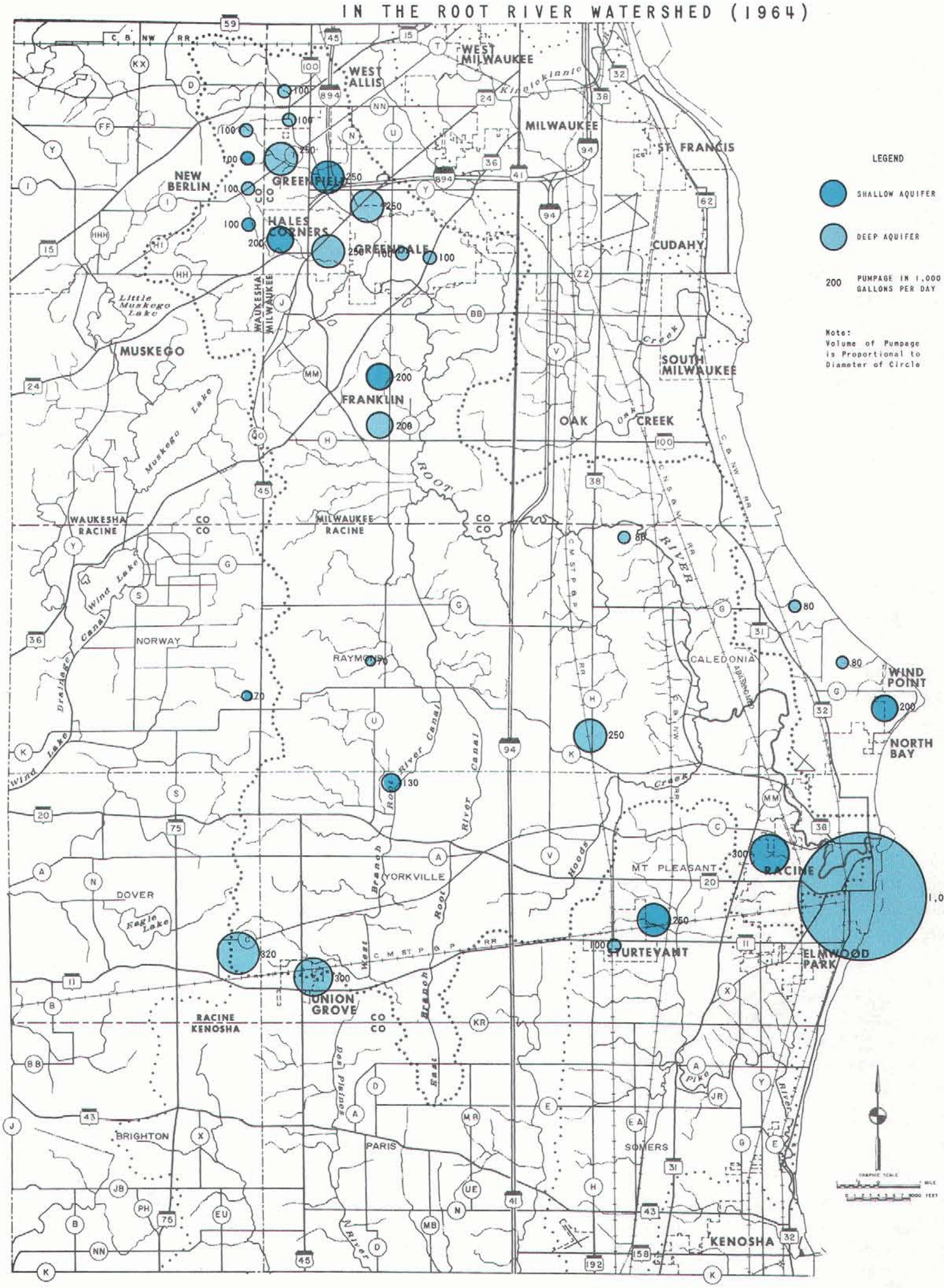
Relationship of Ground Water and Surface Water

In a natural hydrologic situation, the low flows of surface streams are usually related to the underlying ground water conditions. In the glaciated and drift-covered areas of southeastern Wisconsin, ground water levels are usually high enough to intersect land surfaces and stream channels, forming lakes and wetlands and contributing to streamflow. That this was the case in much of the Root River watershed prior to significant ground water extraction is indicated by the large number of former marsh and wetlands shown on historic maps. Most of these wetlands in the Root River Canal and Hoods Creek drainage areas have now been drained by subsurface tiles and channel improvements. Many other former wetlands have probably been dried up as ground water extractions have lowered the water table.

The quantitative contribution of ground water to streamflow can ordinarily be determined from the characteristic shape of the streamflow hydrograph during rainless periods. In the case of the Root River, however, the natural low flows of the river are obscured by substantial contributions of sewage disposal plant effluent. Comparisons of streamflow and the sewage component at the three gaging stations are indicated in Table 9. It is apparent that, under ground water conditions prevalent during 1963-1964, the low flows of the river

Map 29

ESTIMATED DAILY GROUND WATER PUMPAGE IN THE ROOT RIVER WATERSHED (1964)



Source: Wisconsin Geological and Natural History Survey; SEWRPC.

Even in areas of the watershed served by public water supply systems distributing Lake Michigan water, many industries prefer to supply their own water needs, especially for cooling purposes, with deep aquifer water of a favorable and generally constant temperature and quality.

system are made up almost entirely of sewage treatment plant effluent with only small to negligible ground water contributions.

Current meter discharge measurements made at several locations in the system during the fall of 1964 showed, in some cases, a net loss of streamflow in the downstream direction. Such losses may be attributed, in part, to influent seepage from the river to the ground water body and, in part, to high consumptive use of stream water by channel vegetation.

It can be concluded, then, that ground water contribution to the low flows of the Root River system is negligible under present conditions. It is very likely that removal of sewage treatment plant effluent from the river system would result in some reaches being dry during rainless periods. This condition may be expected in the North Branch of the Root River when the Metropolitan Sewerage Commission of the County of Milwaukee trunk sewers to the new Puetz Road plant begin to collect sanitary sewage from the communities in the drainage area. The possibility exists, however, that, as water supplies from Lake Michigan extend farther over this area and use of ground water diminishes, ground water levels will recover and once again contribute to streamflow.

WATER USES

Use of the water resources of the watershed has been discussed earlier in this chapter in the sections dealing with water quality and ground water. The major water uses were seen to be ground water for domestic, industrial, and agricultural use and stream waters for the transportation and assimilation of treated and untreated wastes.

A third major water use in the Milwaukee County portion of the watershed is the use of the river as a component of a recreation and public open-space parkway system. The parkway is a multi-purpose land use in that the parkway is intended to occupy the entire flood plain, thereby effectively excluding flood-vulnerable developments. Recreation activities in the parkway include scenic drives, picnicking, golf practice, and archery. No facilities for water sports other than rowboating are developed at present.

A substantial amount of recreational development is located along the river through the City of Racine. Recreation activities include scenic drives, picnicking, baseball, and tennis. The recreational areas in Racine do not, however, occupy the entire flood plain, with the result that the balance of the flood plain is occupied by residential development. Johnson Park, with an 18-hole golf course, is owned by the City of Racine and is located on the Root River about four miles upstream from the city limits. Racine Country Club, a private golf course, is located on the Root River just upstream from the Racine city limits; and Armstrong Park, a private facility for employees of the Johnson Wax Company, adjoins the river above Horlick Dam. Water sport facilities are not included in any of the Racine area park developments.

One minor irrigation use of river water was noted on a sod farm in Racine County.

SUMMARY

This chapter has described those elements of the hydrologic environment of the Root River which must be considered in planning for future land and water use within the watershed. Findings having particular significance to watershed planning are summarized in the following paragraphs.

The natural hydrologic regimen of the Root River watershed has been greatly changed by the activities of man. Pumpage of ground water has reduced streamflow during low-flow periods, while urban drainage has probably caused an increase in flood peaks. The quality of streamflow has seriously deteriorated as a result of drainage of treated and untreated sewage to the river, making the river water unsuitable for fish life and for water-oriented recreational use.

Streamflow varies widely from season to season and from year to year. Low flows generally persist through summer, fall, and winter with usually only minor rises after heavy rainfall. High flows and floods are generally associated with melting snow, and most critical flood flows result from rainfall during a snowmelt period. The low flows of the upper reaches of the river system consist almost entirely of sewage disposal plant effluent.

Only one major flood, that of March 1960, is known to have occurred in modern times. This flood resulted from rapid melting of an unusually great snow accumulation accompanied by unusually heavy spring rains. A flood peak flow of 5,000 CFS was measured on the North Branch at Ryan Road, and peaks from the Root River Canal at CTH G and near Racine at STH 38 were projected to be 3,200 CFS and 8,200 CFS, respectively. This flood is judged to have an average recurrence interval of 100 years. Future urbanization is expected to increase both the volume and peaks of summer rainfall floods but is expected to have only minor effects on floods associated with snowmelt.

Dissolved oxygen, coliform bacteria count, and temperature were selected as the three most significant factors for evaluation of Root River water quality. Coliform counts are highest and dissolved oxygen is lowest in the autumn and winter low-flow season. Quality is poorest in the mid-reaches of the river system, where most disposal plants are located, and gradually improves downstream from the lowest plant. The estimated present average five-day BOD stream loading from known major waste sources is 910 pounds, 540 pounds of which are attributable to municipal sewage treatment plants located on the North Branch of the Root River in Milwaukee County. The pollution load from these sources will, however, be eliminated by the year 1970 upon completion of trunk sewers which will carry all waste in the Milwaukee County portion of the watershed to the new Puetz Road plant in Oak Creek.

In terms of geographic distribution, ground water is the major source of water supply in more than half of the watershed area, but 75 percent of the watershed residents are now served by Lake Michigan water, and this percentage is increasing steadily. Most large-scale ground water development is dependent on the deep aquifer, while most individual residential and agricultural developments are dependent on the shallow aquifer. Total ground water withdrawal in the watershed is about seven mgd and increasing. Heavy pumping has caused the deep aquifer piezometric level to fall as much as 200 feet. Water levels in the shallow aquifer have remained generally high but appear to have declined enough to affect ground water contribution to low flows in the river system.

Only two principal uses are presently made of the river system. The first is a wasteway and the second as an inactive component in a multiple-purpose recreation and flood plain reservation development.

Chapter V

HYDRAULICS OF THE WATERSHED

INTRODUCTION

The major components of the hydrology of the Root River watershed are, as inflow: precipitation, ground water inflow, and importation of Lake Michigan water which appears as sewage treatment plant effluent; and as outflow: consumptive use, ground water outflow, and surface runoff.[1] The previous chapters describe the phenomena associated with all of these components of the hydrology of the watershed except the phenomena associated with the conveyance of surface water; that is, the overland and channel hydraulic characteristics. Because of their particular importance to the flood control and recreation elements of the watershed plans, these hydraulic characteristics are described separately.

Of special significance in watershed planning is the possibility of adjusting overland and channel hydraulic characteristics to meet plan objectives. Velocity of overland flow and resulting soil erosion may be reduced by land treatment. Flood levels may be lowered by increasing channel slope or cross-sectional area or by reducing hydraulic friction. Flood control and recreational lakes may be created by damming or excavation. Knowledge of the present hydraulic characteristics of the watershed drainage system is essential for the design and evaluation of such water control facilities as a part of a comprehensive watershed development plan.

WATERSHED DRAINAGE SYSTEM

Surface water draining from the watershed ordinarily moves over the surface of the land until it enters the channel system. The land surface is, then, the first element of the hydraulic system of the watershed. As a result of its glacial origin, the surface of the watershed consists primarily of gently rolling hills interspersed with relatively flat plains and marshy areas, many of which are outside the flood plain of the main channel system. Land slopes are generally less than 5 percent. The flat slopes, generally under full vegetative cover, and the long overland distances between channels result, under natural conditions, in low-peak, long-duration runoff contribution to the river channel system. Overland flow velocities, however, are significantly increased by urbanization. Paved areas are hydraulically fairly smooth, and the distance required for overland flow is reduced by extensive systems of gutters and storm sewers. Urban development thus causes an increase in runoff peaks and shortens runoff duration.

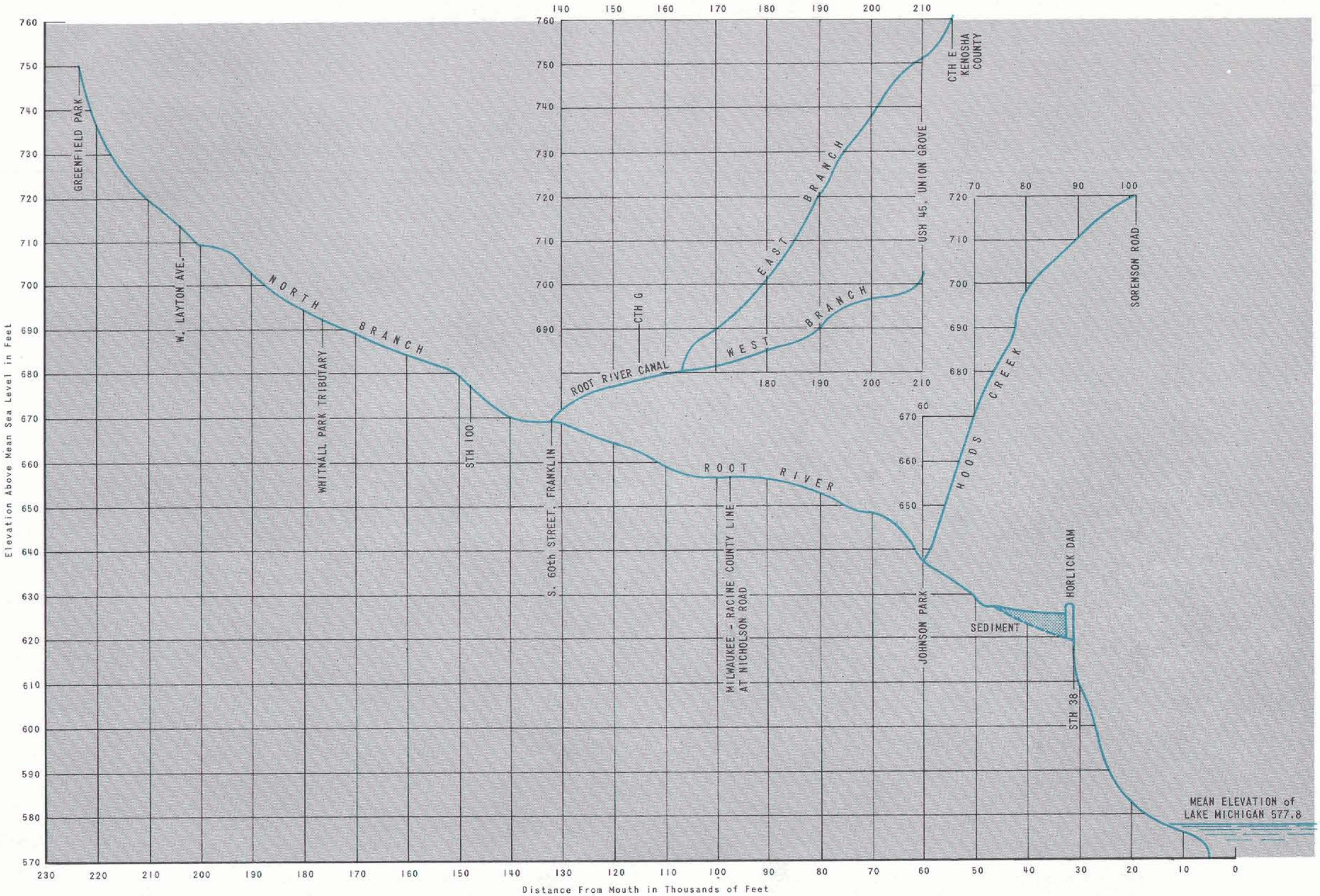
The trellis drainage pattern of channels and watercourses also reflects the glacial origin of the watershed topography. The physical arrangement of channels is circuitous, with several tributaries flowing in directions almost opposite from that of the main channel. The bed slope profiles of the main channel system are shown in Figure 17; and mean bed slopes of individual river reaches are summarized in Table 13. The channel system profile is irregular with relatively steeper slopes near the channel heads, relatively flatter slopes in the mid-reaches, and relatively steeper slopes near the mouth. The overall slopes of the Root River channels may, however, be classified as generally flat and result in low streamflow velocities and long flood peak travel times.

No major lakes exist in the Root River watershed, and even small lakes and ponds are relatively rare in comparison to the rest of the Region and the state. Only 0.1 percent of the total surface area of the watershed, or about 0.2 square miles, is composed of lakes and ponds which provide storage space for floodwaters; and none of the existing lakes and ponds have significant storage reduction effects on main channel flood peak flows. Wetlands, however, provide significant amounts of storage space for floodwaters; and the flood peaks of several tributary streams are reduced thereby. Wetlands occupy a total of about 3.1 square miles in the drainage area of the North Branch, 1.6 square miles in the Canal drainage area, and about 7.1 square miles in the total watershed.

[1] *The equation of hydrologic equilibrium usually used to present a detailed accounting of elements of the hydrologic cycle for a river basin may be expressed as: Surface inflow + subsurface inflow + imported water + decrease in surface storage + decrease in ground water storage = surface outflow + subsurface outflow + consumptive use + exported water + increase in surface storage + increase in ground water storage. As a practical matter, this equation was simplified as described above.*

Figure 17

STREAM CHANNEL PROFILES—ROOT RIVER AND MAJOR TRIBUTARIES (1965)



Source: Harza Engineering Co.

Table 13

WEIGHTED MEAN CHANNEL SLOPES ROOT RIVER AND MAJOR TRIBUTARIES - 1965

	Length River Miles	Slope Feet per Mile	Slope Feet per Foot
North Branch, Root River	16.6	4.82	0.000913
West Branch, Canal.	10.4	5.68	0.00108
East Branch, Canal.	11.6	7.54	0.00143
Root River Canal, All Channels.	27.8	5.71	0.00108
Root River, Confluence to Hoods Creek	14.0	2.22	0.000420
Root River, Hoods Creek to Horlick Dam. . . .	5.6	3.32	0.000629
Root River, Horlick Dam to Lake Michigan. . .	6.0	10.39	0.00197
Hoods Creek	9.2	11.03	0.00209
Root River, All Channels.	79.2	5.71	0.00108

Source: Harza Engineering Co.

Large portions of the drainage areas of the Root River Canal and of Hoods Creek were so poorly drained under natural conditions that farm operators found it necessary to deepen and straighten the main stream channels and to install tile underdrains to provide for more efficient agricultural operations. Because of the individual manner and the long period of time over which such drains were installed, it was not possible in the study to precisely determine the total tile-drained area. The area within legally established farm drainage district boundaries, however, totals 32.7 square miles for the entire watershed and 23.5 square miles for the area tributary to the Root River Canal. Of the total area within such districts, 1.8 square miles lie in Milwaukee County tributary to the North Branch; and 7.4 square miles lie in Racine County tributary to the main stem of the Root River and to Hoods Creek (see Map 30). The main channels in the Canal area were originally deepened and straightened by a floating dredge about the year 1905, with occasional trimming and clearing thereafter. However, portions of the Canal area are still poorly drained, especially during the spring, when small surface drainage courses are blocked by snow and ice and exhibit a significant retarding effect on flow. As a result, outflow hydrographs from these artificially drained areas have very long time bases, both in summer when farm tiles are operating and in spring when surface drainage is impeded.

CHANNEL AND FLOOD PLAIN HYDRAULIC CHARACTERISTICS

The main channels of the Root River system are generally small with relatively low banks. A nearly flat flood plain exists along most of the river length with widths varying from a few tens of feet to as much as one mile. The flood plain is defined, in this report, as the area which would be inundated by a 100-year recurrence interval flood.

During flood periods both the channel and the flood plain function to carry water. As already noted, channel slopes are irregular and relatively flat, resulting in low-flow velocities. Channel and flood plain hydraulic friction is strongly influenced by the seasonal variation in vegetation, which reaches a maximum growth in summer. Winter and spring flows, however, are often obstructed by ice and snow. The river channels and flood plains are crossed by 111 bridges and culverts, many of which because of inadequate waterway openings significantly affect flood levels.

Hydraulic Analysis

Determination of Velocity and Discharge: The Manning formula was selected to express the hydraulic relationship of flow velocity and discharge to channel size, shape, slope, and friction. The Manning formula may be stated as:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2} \quad \text{or, since } Q = AV \text{ as}$$

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

where: V = mean velocity in feet per second

Q = discharge in cubic feet per second

n = friction factor

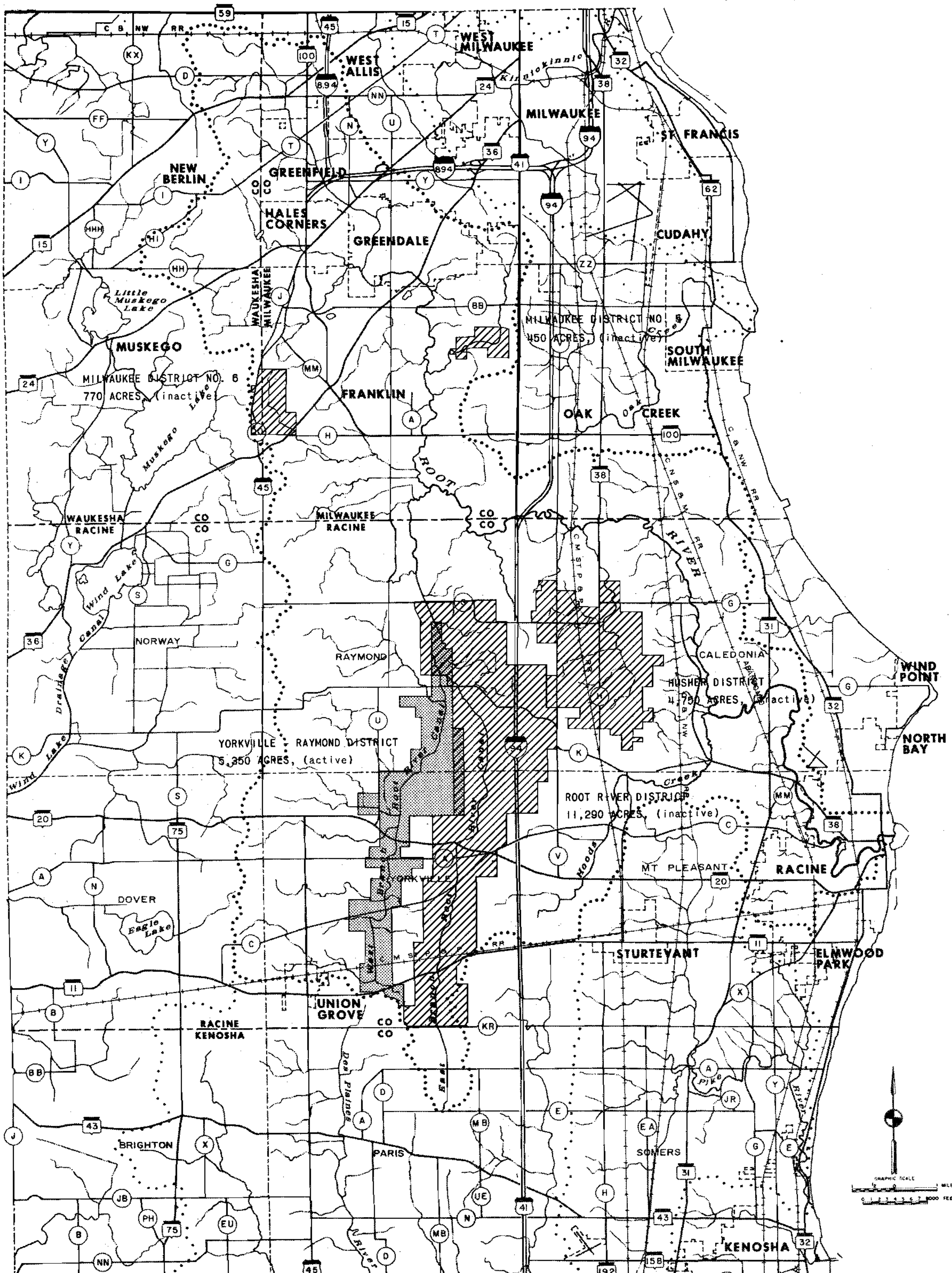
R = hydraulic radius

S = slope of the energy grade line in feet per foot (assumed equal to bed slope for the low velocities found in the Root River system)

A = cross-sectional area of channel flow in square feet.

Map 30

LEGALLY ORGANIZED FARM DRAINAGE DISTRICTS
IN THE ROOT RIVER WATERSHED (1965)



About 33 square miles, or about 17 percent, of the total area of the watershed are drained by an elaborate system of subsurface field tiles which represents a large capital investment in agriculture. These farm drainage systems, unlike urban storm sewerage systems, appear to exert a significant retarding effect upon runoff.

The Manning formula is by far the most widely used formula for determining open channel flow in present engineering practice. Values of hydraulic radius were obtained from field measurements of channel cross sections at 193 points along the channel system. Channel bed slopes were established by referencing bed elevations to local points of known elevation, such as bridge bench marks, survey bench marks, and ground survey control elevations used by the U. S. Geological Survey in preparation of topographic maps from aerial photographs. All elevations were adjusted to mean sea level datum (North American Datum-1929 Adjustment) as established by the U. S. Coast and Geodetic Survey by the following equations:

Elevation above mean sea level =

Milwaukee City Datum + 580.560 feet

Racine City Datum + 580.710 feet [2]

Channel and flood plain hydraulic friction, represented by the "n" value in the Manning formula was estimated on the basis of visual observation of channel conditions in each reach. Photographs were taken of channel and flood plain conditions upstream and downstream from each cross section and of every waterway opening and apparent obstruction, including all bridges and culverts. Values of n were estimated systematically as the sum of the friction components attributable to various contributing factors as summarized in Table 14. Separate estimates of n were made for the main channel and for overbank flow on the flood plain. Even with a systematic procedure, selection of the n value for a given reach is a matter highly dependent upon experienced engineering judgment. Selected n values for friction components were, therefore, reviewed by several experienced engineers; and special care was taken that values throughout the system were selected on a consistent basis.

The values of n change radically with the growth cycle of vegetation and with obstructions in the flow area. Values of n used in this study were based on summer or foliage season conditions. Although severe floods within the watershed are more likely to occur during the dormant season, it is likely that these floods will be accompanied by unpredictable obstructions in the flow area consisting of snow, ice, and debris. The use of higher summer n values compensates, to some degree, for these unpredictable obstructions and, in general, gives higher, more conservative floodwater heights for equivalent discharges.

In addition to the hydraulic characteristics of the channel and flood plain, flow depths and velocities are affected by roadway and railway crossing embankments, bridges, and culverts. All of the 111 bridges and culverts on the perennial stream system of the watershed were located, and field measurements of waterway openings and hydraulic characteristics were made for each. Several of the culverts and smaller bridges consist of farm lane crossings and are not accessible by public roads. These private crossings were located by inspection of 1" = 400' aerial photographs and, in some cases, by walking the channel between public roads.

Bridges and culverts affect river flow by raising upstream water levels above the downstream water levels by an amount equal to the head loss (loss of hydraulic energy) through the structure. Head losses through bridges were calculated following a procedure developed by the U. S. Bureau of Public Roads.[3] Briefly, this procedure expresses the head loss components resulting from flow contraction, abutments, piers, and skewness of the bridge in terms of the velocity head of the water flowing through the bridge. Head losses through culverts were calculated by standard procedures of hydraulic analysis. Flow over embankments was analyzed by standard broad-crested weir procedures.

Determination of Water Surface Elevations: Since the establishment of a design high water level (stage) along the perennial channels is an important and necessary work element of a comprehensive watershed planning study, it was necessary to calculate the relationship between flood discharge and corresponding water surface elevation. Water levels are a function of discharge, channel and flood plain shape, slope, friction, and structures, all of which vary along the length of the channel. Therefore, it was necessary to calculate stage-discharge relationships for local conditions at many points along the channel.

[2] *These equations were determined by second order vertical control surveys carried out in 1965 by Alster and Associates, Inc., photogrammetric engineers, under contract to the SEWRPC.*

[3] *"Hydraulics of Bridge Waterways," Hydraulic Design Series No. 1, by J.N. Bradley, U.S. Department of Commerce, Bureau of Public Roads, 1960.*

Table 14

CHANNEL FRICTION FACTOR COMPONENTS[a]

Component	Partial n Value
Character of Channel	
Channels in earth	0.020
Channels cut in rock	0.025
Channels in fine gravel	0.024
Channels in coarse gravel	0.028
Degree of Surface Irregularity	
Smooth	0.000
Minor	0.005
Moderate	0.010
Severe	0.020
Variation of Cross Section Size and Shape	
Gradual	0.000
Occasional	0.005
Frequent	0.010-0.015
Obstructions (boulders, logs, roots, debris)	
Negligible	0.000
Minor	0.010-0.015
Appreciable	0.020-0.030
Severe	0.040-0.060
Vegetation	
Grass and weeds - height 1/2-1/3 flow depth Supple seedling trees - 1/3-1/4 flow depth	0.005-0.010
Grass - height 1-1/2 flow depth Stemmy weeds, seedlings - 1/2-1/3 flow depth Brush growth along banks - dormant season	0.010-0.025
Grass - height equal to flow depth Trees, weeds, brush - dormant season Small willows, weeds along banks - foliage season	0.025-0.050
Grass - height twice flow depth Willows, weeds, cattails - foliage season Trees with weeds and brush - foliage season	0.050-0.100

Adjustment in Friction Factor for Channel Meandering:

Degree of Meandering	Ratio of Meander Length[b] to Straight Length	Factor[c] To Be Applied to Total n
Minor	1.0-1.2	1.00
Appreciable	1.2-1.5	1.15
Severe	Over 1.5	1.30

a *Summarized from Supplement B, U.S. Soil Conservation Service Engineering Handbook, Section 5, "Hydraulics."*

b *Equivalent straight line length measured along thread of channel.*

c *This factor is used to multiply total n value derived by adding partial values.*

Source: Summarized from Supplement B, U.S. Soil Conservation Service Engineering Handbook, Section 5, "Hydraulics."

Stage-discharge relationship curves were prepared for the upstream and downstream sides of 104 bridge and culvert crossings of the perennial channels which were judged to have a significant effect on water levels during high flow.[4] At each location, downstream water levels corresponding to a range of discharges were calculated on the basis of the hydraulic characteristics of the downstream channel reach using the Manning formula as described above. Curves showing the relationship of water level (stage) to discharge and the relationship of channel and flood plain flow cross-sectional area to stage were plotted.

Head losses through the bridge or culvert were calculated for the same range of discharges. These head losses were added to the downstream stages calculated for the corresponding discharges to obtain an adjusted stage-discharge curve for the upstream side. For very high discharges during which the roadway embankment would be overtopped, head losses were calculated for the combined flow situation. The calculated stage-discharge curves comprise a specific evaluation of channel hydraulic capacities and are used to establish water surface elevations generated by floods of given frequencies, as shown in the profiles of water surface elevations presented in Appendix E. Sample channel cross section computation of n value and stage-area-discharge curves are shown in Figures 18 and 19. Similar cross sections and curves were prepared for 104 crossings of the perennial channels and are on file in the SEWRPC offices. An explanation of the procedure for preparation of stage-area-discharge curves is presented in Appendix F.

Channel Backwater Computation: Water surface profiles in an open channel are raised above normal levels for some distance upstream from a flow obstruction; and because of lower velocities resulting from greater flow depths, the slope of the water surface and the energy grade line become flatter. The water surface profile resulting from an obstruction in a channel is called a backwater curve. Since the backwater curve has a flatter profile than would the water surface of the unobstructed channel, the two profiles intersect at an upstream point. This intersection locates the upstream extent of backwater caused by the obstruction.

Computations of backwater were performed using Leach's[5] method, which is based upon the Manning formula for flow in open channels. Essentially, this method involves calculation of water surface slopes upstream from a point at which the water surface elevation is known, taking into account the fixed hydraulic characteristics of the channel cross section and friction.

Backwater caused by bridges and culverts was generally so small that it was possible to estimate the backwater profile well within the range of accuracy of the overall hydraulic studies. Detailed backwater computations using Leach's method were made, however, for the channel reaches upstream from Horlick Dam and upstream from the river mouth at Lake Michigan.

THE HYDRAULICS OF SUB-WATERSHEDS

North Branch of the Root River

The perennial channel of the North Branch originates at W. Lincoln Avenue near the western boundary of Milwaukee County in the City of West Allis. It flows southeasterly through the City of Greenfield and the Village of Greendale to W. Loomis Road. From W. Loomis Road the river flows almost due south through the City of Franklin to its confluence with the Root River Canal about one mile north of the Milwaukee-Racine County line. The total length of the perennial channel of the North Branch is 16.6 miles. The total fall is 80 feet, resulting in an average slope of 4.82 feet per mile or 0.000913 feet per foot.

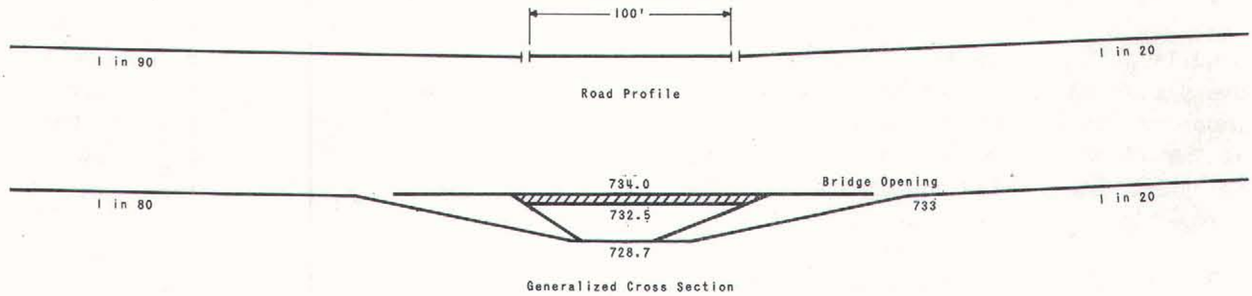
Hydraulic friction in the channel of the North Branch is moderately affected by vegetation while the flood plain, in comparison to the flood plain in the balance of the river system, is relatively free of vegetative obstruction. The hydraulic friction factors of the North Branch are relatively independent of seasonal changes in vegetative growth. The channel is relatively free of obstructions, is fairly straight through most of its length, and is reasonably uniform in section. The averages of the n values used in calculating discharge capacities are 0.048 for the channel and 0.057 for the flood plain.

[4] *Seven of the 111 total bridge and culvert crossings were found to have such structure and placement as to obviously not significantly affect flood profiles. These include: 1) two footbridges over the main stem in the Racine Country Club grounds; 2) park footbridge over the main stem in Lincoln Park, City of Racine; 3) one farm bridge over Hoods Creek 0.48 mile upstream from STH 38; 4) private footbridge over Hoods Creek 0.05 mile upstream from Airline Road; 5) private footbridge over Hoods Creek 0.36 mile upstream from STH 20; and 6) private footbridge over Hoods Creek 1.46 miles upstream from STH 20.*

[5] *Handbook of Hydraulics, King and Brater, McGraw-Hill, 1954.*

Figure 18

CHANNEL CROSS SECTION AND STAGE AREA DISCHARGE CURVES
ROOT RIVER AT PARK BRANCH UPSTREAM FROM STH 15
STA. 2172+00
1965

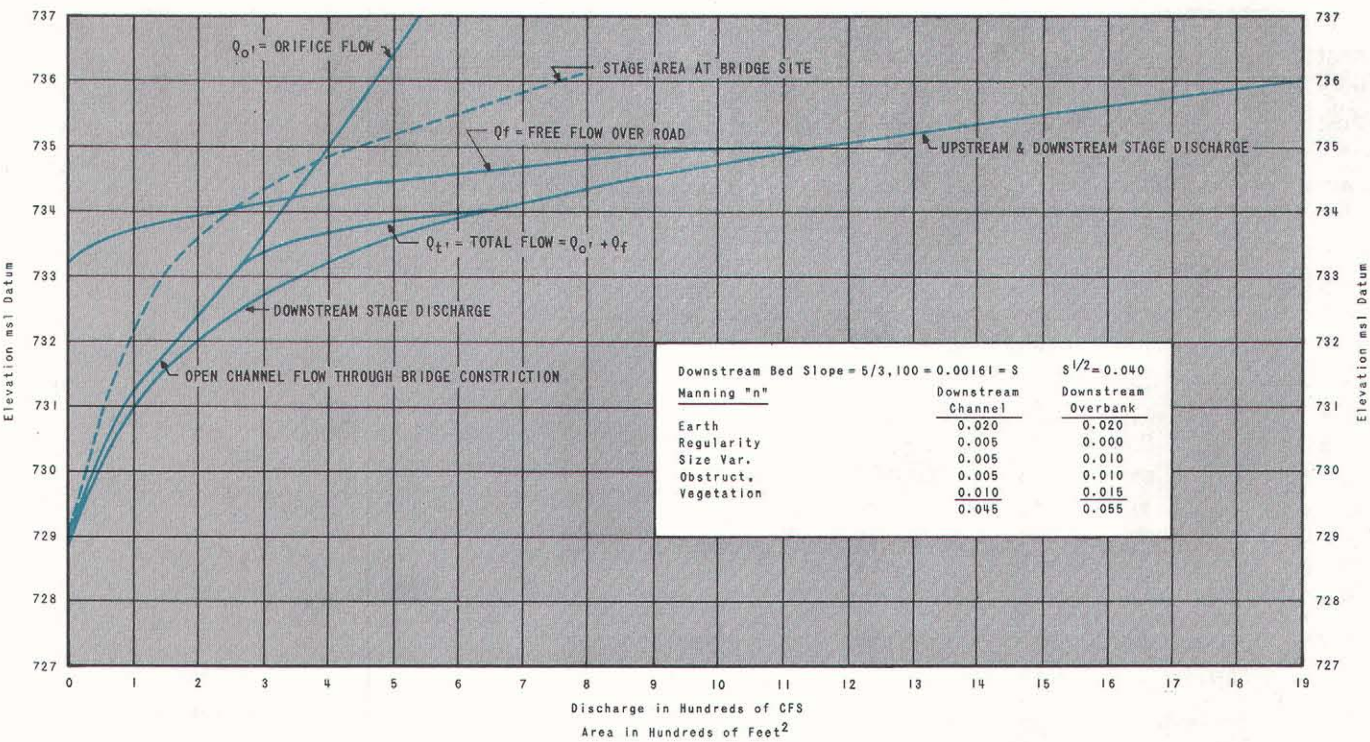


CALCULATION OF DOWNSTREAM FLOW

CHANNEL FLOW = $\frac{1.49}{n} AR^{2/3} S^{1/2} = \frac{1.49}{0.045} AR^{2/3}\ 0.040 = 1.324\ AR^{2/3}$

OVERBANK FLOW = $\frac{1.49}{n} AR^{2/3} S^{1/2} = \frac{1.49}{0.055} AR^{2/3}\ 0.040 = 1.083^{2/3}$

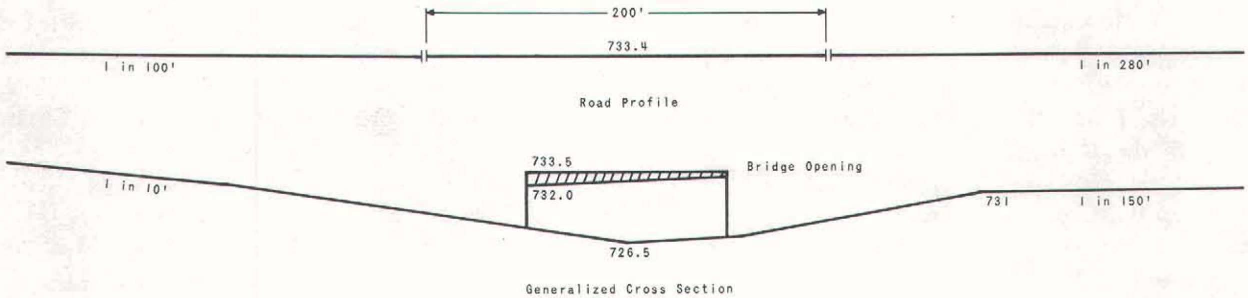
Elevation	Depth	Area	Wetted Perimeter	Hydraulic Radius	$R^{2/3}$	Q_c	Area	Wetted Perimeter	Hydraulic Radius	$R^{2/3}$	Q_o	$Q_t = Q_c + Q_o$
730	1.3	25	23	1.09	1.06	35						35
731	2.3	54	33	1.64	1.39	99						99
733	4.3	144	55	2.62	1.90	362						362
734	5.3	198	55	3.60	2.35	614	50	100	0.5	0.63	34	648
735	6.3	252	55	4.58	2.76	920	200	200	1.0	1.00	216	1,136
736	7.3	306	55	5.56	3.14	1,272	450	300	1.5	1.31	637	1,909



Source: See Appendix F for explanation of derivation of stage-area discharge curves.

Figure 19

CHANNEL CROSS SECTION AND STAGE AREA DISCHARGE CURVES
ROOT RIVER AT STH 15 AND W. OKLAHOMA AVENUE
STA. 2163+00
1965

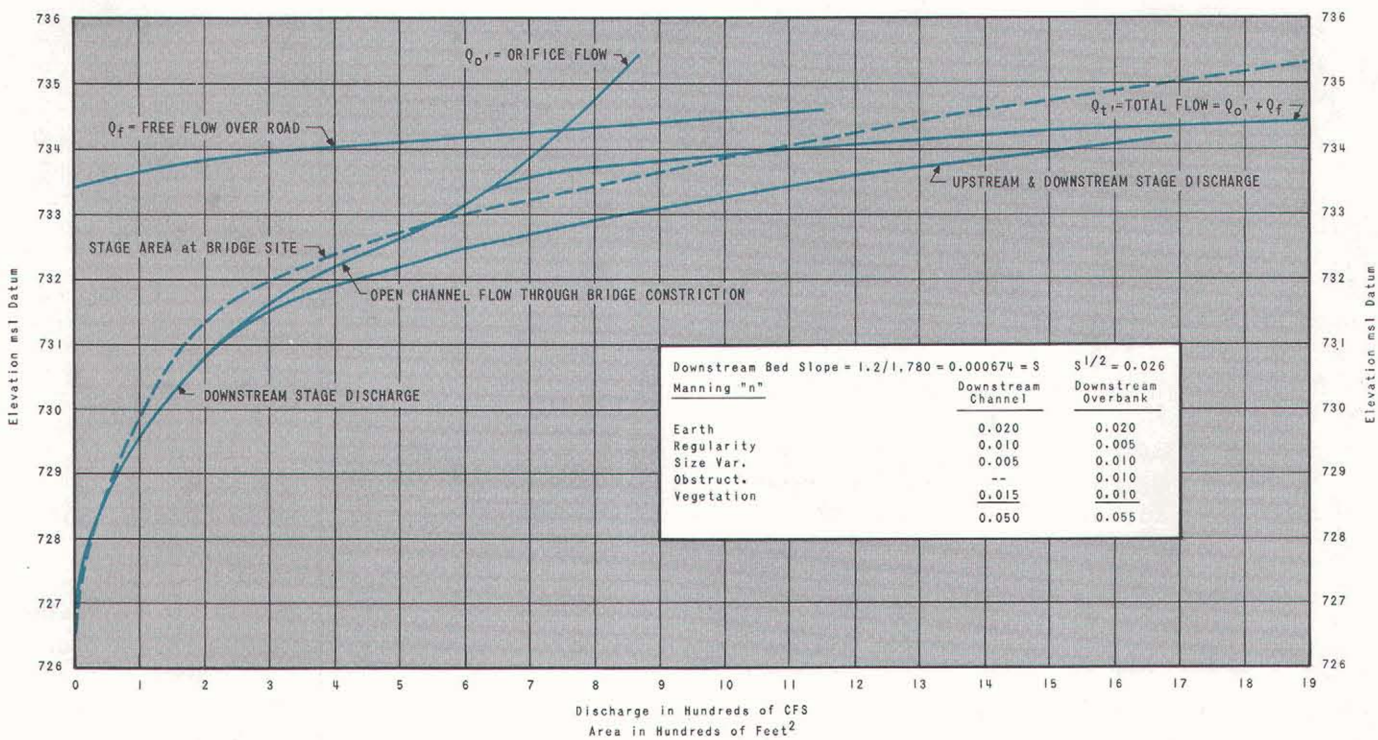


CALCULATION OF DOWNSTREAM FLOW

CHANNEL FLOW = $\frac{1.49}{n}$ $AR^{2/3}$ $S^{1/2}$ = $\frac{1.49}{.050}$ $AR^{2/3}$ 0.026 = 0.774 $AR^{2/3}$

OVERBANK FLOW = $\frac{1.49}{n}$ $AR^{2/3}$ $S^{1/2}$ = $\frac{1.49}{0.055}$ $AR^{2/3}$ 0.040 = 1.083 $AR^{2/3}$

Elevation	Depth	Area	Wetted Perimeter	Hydraulic Radius	$R^{2/3}$	Q_c	Area	Wetted Perimeter	Hydraulic Radius	$R^{2/3}$	Q_o	$Q_t = Q_c + Q_o$
728	1.5	28	26	1.08	1.05	23						23
729	2.5	62	38	1.63	1.38	66						66
730	3.5	105	50	1.88	1.52	124						124
731	4.5	160	60	2.68	1.93	239						239
732	5.5	220	60	3.68	2.38	406	80	160	0.5	0.63	35	441
733	6.5	280	60	4.67	2.79	605	320	320	1.0	1.00	225	830
734	7.5	340	60	5.66	3.18	840	720	480	1.5	1.31	665	1,505
735	8.5	400	60	6.66	3.54	1,100	1,280	640	2.0	1.59	1,430	2,530



Source: See Appendix F for explanation of derivation of stage-area discharge curves.

At present, 5.6 miles of main channel flood plain have been developed into parkway. Parkway reaches extend from W. Lincoln Avenue to W. Oklahoma Avenue and from W. Layton Avenue to W. Loomis Road. Landscaping of the flood plain has been carried out along the entire parkway length except for about 0.7 miles left in a wild state between S. 76th Street (CTH U) and W. Loomis Road. Landscaping, as practiced in the Root River Parkway, reduces hydraulic friction in the flood plain by removal of underbrush and maintenance of open areas under lawn cover. Modification of channel shape and vegetation, however, was carried out for only about two miles of the parkway.

The perennial channel of the North Branch is crossed by 22 public and 2 private bridges, which have a range of influence on the height of flood stages. The amount of backwater, or head loss, which may be expected to be caused by these bridges during a future 100-year flood varies from a negligible amount at 11 bridges to 3.8 feet at W. Loomis Road. (See Appendix G.) Of the 80 feet of potential energy head available to cause flow in the North Branch, as much as 27 feet may be lost at bridges in a 100-year flood occurring under 1990 land use conditions.

Bank-full channel capacities and the depths of overbank flow, bridge head losses, and depths of flow over roads expected for floods of 100-year, 50-year, and 10-year recurrence intervals under 1990 development projected in the alternative land use plans are shown in Appendix G. Bank-full channel capacities do not increase progressively in the downstream direction. In fact, on the North Branch, channel capacities appear to be generally higher in the upstream reaches than in the downstream reaches. This condition results from steeper slopes, deeper channels, and less hydraulic friction in the upstream reaches, partly due to the urban character of development in that area. Because of variations in channel section and in bank elevations throughout any reach, the overbank depths calculated for one point must be considered only as representative indications of conditions at that point.

As noted earlier, the area of lakes and ponds in the watershed is very small. Two small ponds were constructed on the main channel in the parkway near W. Forest Home Avenue. These ponds, with a combined surface area of about five acres, are so small as to have negligible effect upon streamflow. Four lagoons, with a combined surface area of about 20 acres, were formed by construction of low dams on a Root River tributary in Whitnall Park. Upper Kelly Lake, with about a 15-acre surface area, is also located on this tributary. The hydraulic effects of these ponds were included in the synthesis of the unit hydrograph for this sub-basin, as described in Chapter VI. Other ponds in the drainage area of the North Branch are located off the main channels of the tributary streams.

The City of West Allis and the Metropolitan Sewerage Commission of Milwaukee County have scheduled deepening and enlargement of the North Branch channel from S. 124th Street (Milwaukee-Waukesha County line) to some distance downstream from the City of West Allis. This deepening, of up to 6 feet, is required to accommodate urban storm sewer systems, presently under construction by the City of West Allis, which will drain that portion of the watershed lying upstream from W. Cleveland Avenue and east of the North Branch.

The scheduled channel deepening and enlargement were incorporated into the watershed study as a committed water control facility and represent a decision already made. The scheduled bottom elevations were followed in the City of West Allis, assuming a bottom width of four feet and one-on-four side slopes. The channel was assumed to be grass lined and to have an n value of 0.030. The channel deepening cannot be stopped abruptly; and, consequently, it was for the purposes of the study tailed-out to W. Layton Avenue in the City of Greenfield. Further deepening and enlargement of the channel through the City of Greenfield and into the Village of Greendale was studied as a possible structural plan element and is discussed in Chapter XII.

Root River Canal

The perennial channel of the West Branch of the Root River Canal originates near Union Grove in central Racine County. It flows easterly for about two miles and then northerly to its junction with the East Branch of the Root River Canal near Four Mile Road in Racine County. The perennial channel of the East Branch of the Root River Canal originates near CTH C in northern Kenosha County and flows almost due north to its junction with the West Branch. The Root River Canal then flows north into Milwaukee County to its confluence with the North Branch of the Root River. The length of the West Branch perennial channel is 10.4 miles; of the East Branch, 11.6 miles; and of the Canal, 5.8 miles for a total of 27.8 miles. The average bed slope of the channels comprising the Root River Canal system is 5.71 feet per mile or 0.00108 feet per foot.

All but about four miles of the perennial channels of the Root River Canal system have been deepened, straightened, and trimmed by dredging. The dredged portions of the channels have generally uniform cross sections with bed widths varying from about 10 feet to 20 feet and side slopes varying from one-on-one to one-on-two. Channel depths vary from 4 feet to 12 feet, being primarily a function of the amount of channel deepening which was required to achieve suitable bed slopes in the dredged sections. Spoil banks on the flood plain near the river banks still remain visible in some of the dredged reaches. These spoil banks often interfere with overland drainage into the river channel and may cause local ponding when the channel is flowing less than bank full.

Beds and banks of most of the dredged sections are in poor condition. In many places bank material has sloughed into the bed as a result of unstable slopes, seepage outflow, or, sometimes, cattle grazing. Near public road crossings, the channels are often used for refuse dumping, obstructing bridge and culvert waterway openings in some cases. Among materials noted in such refuse, in addition to household garbage, were timbers, boxes, broken concrete, bedsprings, and tires.

The most significant obstruction to flow in the Root River Canal channels is, however, the profuse growth of vegetation in, and adjacent to, most of the channel length. Some of the vegetation is supple enough so that it will bend down under high flows and, therefore, have less effect upon channel friction; but along most of the length, the channels are choked with cattails, reeds, bushes, willows, and other trees, some over three inches in diameter, which are not supple and which, therefore, seriously impede flow. The tangled growth of bushes and trees may in some locations obstruct flows almost as seriously in winter as in summer. During the growing season, it is often impossible to distinguish the channel shape or location because of the vegetation. According to local residents, the last known general channel maintenance was carried out over 15 years ago. The channel is well maintained in a few isolated locations by local individuals who own or farm adjacent lands. The averages of the n values used in calculating discharge capacities of channels in the Root River Canal system are 0.061 for the channel and 0.078 for the flood plain.

The perennial channels in the Root River Canal system are crossed by 26 public and 11 private bridges and culverts. Backwater from all of the bridges and culverts in the Canal area during a future 100-year flood will be generally less than that experienced in the North Branch because of lower discharges and lower velocities. (See Appendix G.) In addition, channel friction is so high and slopes are so flat, in some reaches of the West Branch particularly, that bridge and culvert crossings become completely submerged by the high water levels in the channel and contribute negligible additional head loss.

Bank-full channel capacities and the depth of overbank flow, bridge head losses, and depths of flow over roads expected for floods of 100-year, 50-year, and 10-year recurrence intervals under 1990 projected land use are shown in Appendix G. As in the North Branch, channel capacities appear to be higher near the upstream reaches than in the downstream reaches. In the Canal area, this situation is probably due to the steeper slopes, often deeper channels, and generally cleaner channel conditions prevailing in the upstream reaches.

Root River Main Stem

Downstream from the confluence of the North Branch and the Root River Canal near S. 60th Street and W. Oakwood Road in Milwaukee County, the Root River main stem meanders easterly along the Milwaukee-Racine County line. The river crosses the county line five times, finally leaving Milwaukee County near S. Nicholson Road. The main stem then flows southward to Johnson Park, where it is joined by Hoods Creek flowing from the southwest. The river turns east and then northeast before again turning south to enter the City of Racine, through which it meanders easterly to enter Lake Michigan in the harbor area.

The length of the Root River main stem from the confluence of the North Branch and the Canal to the mouth is 25.6 miles. The total fall from the confluence to mean lake level (msl elevation 577.8) is 91 feet, resulting in an average slope of 3.57 feet per mile. Bed depth at the mouth is about 20 feet so that the average bed slope of the river is 4.37 feet per mile. As indicated by the profile in Figure 17, however, there is a significant variation in bed slope along the main stem. The upstream portion, along the county line from the confluence to S. Nicholson Road, has a bed slope of only 1.62 feet per mile. Between S. Nicholson Road and the mouth of Hoods Creek, the slope steepens to 2.96 feet per mile. From Hoods Creek to Horlick Dam and from Horlick Dam to the mouth, bed slopes are 3.32 feet per mile and 10.39 feet per mile, respectively. In the reach of the Root River extending from the confluence of the North Branch and the Canal to about one mile beyond S. Nicholson Road, the channel slope is extremely flat. Thus, streamflow velocities are very low and channel capacities are quite limited, causing widespread inundation of adjacent lowlands during flooding.

For most of its length, the channel of the Root River main stem still remains in a relatively natural condition. Bed widths vary from 20 feet to over 100 feet, and channel depths vary from about 3 feet to 10 feet. The channel itself is relatively free of vegetation throughout the year, but the river banks and the portion of the flood plain adjacent to the river banks have profuse vegetation ranging from grass to bushes and trees. At the time of the field surveys in 1964, vegetation along the river banks in those portions of the channel in the county line area were being cleared and cleaned by the Metropolitan Sewerage Commission of Milwaukee County. The averages of the n values used in calculating discharge capacities along the main stem are 0.048 for the channel and 0.069 for the flood plain.

The low-lying land near the confluence of the North Branch and the Root River Canal forms a natural reservoir during periods of flood flow. Water levels in this area are not related to local channel conditions on the two main branches but appear to be controlled by the stage-discharge relationship of the constricted channel section of the main stem at its first crossing of County Line Road in Milwaukee County.

At the peak of the March 1960 flood, the water temporarily impounded in the confluence area spread over an area of about 1,000 acres or nearly 1 1/2 square miles. The corresponding volume of storage in this natural reservoir was about 6,400 acre-feet or the equivalent of one square mile covered with water to a depth of 10 feet. This volume would be filled by a stream of water flowing at the rate of 3,200 CFS for one day. This volume was, however, being filled during the entire period that the inflow was increasing so that the total volume was not available for reduction of the flood peak.

The flood peak reduction effect of the natural reservoir formed by the wetlands in the confluence area is most significant on floods of short duration with lesser effect on long duration floods, such as those resulting from snowmelt. In the flood synthesis studies, described in Chapter VI, the 1990, 100-year flood inflow based on combined snowmelt and rainfall was reduced by natural reservoir storage from 9,600 CFS to an outflow of 8,600 CFS. However, the flood peak inflow of 4,600 CFS based on a summer rainfall of 100-year recurrence interval was reduced to an outflow of 3,500 CFS. Possible adaptation of the confluence area as a structural measure for flood control is described in Chapter XII.

The channel of the Root River main stem is crossed by 23 public and 5 private bridges, which have a range of influence upon flood stages. (See Appendix G.) In general, the waterway openings of bridges along the main stem are large; and the flow velocities in most of the length of the channel are low so that head losses through bridges tend to be small. It appears that very flat slopes, particularly along the county line, are the principal cause of flood inundation rather than backwater caused by bridges.

Bank-full channel capacities and the depths of overbank flow, bridge head losses, and depths of flow over roads expected for floods of 100-year, 50-year, and 10-year recurrence intervals under 1990 projected land use are shown in Appendix G. Bank-full capacities vary along the channel depths. Again, it should be noted that because of variations in channel depths and in bank elevations throughout any reach, the calculated overbank depths must be considered as representative indications only.

Hoods Creek

The perennial channel of Hoods Creek originates at Sorenson Road one-half mile east of IH 94. It flows northerly to the community of Franksville, then easterly to Airline Road. From Airline Road the creek flows northerly to its confluence with the Root River at the western end of Johnson Park. The total length of Hoods Creek is 9.2 miles. The total fall is 101.2 feet, resulting in an average slope of 11.0 feet per mile or .002 feet per foot.

The upstream portion of Hoods Creek from Sorenson Road to CTH H has been deepened, straightened, and trimmed by dredging. The rest of the stream has been left in its natural condition.

Hydraulic friction in the channel and the flood plain is moderately affected by vegetation. The averages of the n values used in calculating discharge capacities are 0.058 for the channel and 0.073 for the flood plain.

The perennial channel of Hoods Creek is crossed by nine public bridges and six private bridges. Backwater from these bridges during a future 100-year flood will have an insignificant effect on stage. (See Appendix G.)

HORLICK DAM

Horlick Dam, located about 200 feet upstream from STH 38 near Racine, is the only major existing structural water control facility on the Root River. The dam is reported to have been first built around 1850 and then rebuilt or remodeled to substantially its present form in 1873. The dam was originally used to create a head of water of about 12 feet for the operation of a gristmill on the right bank of the river. Milling operations apparently ceased around 1920; and since then the only function of the dam has been to maintain a pond, which is used for aesthetic and recreational purposes. Several residences, some formerly used as summer homes, adjoin the pond; and Armstrong Park, a private recreational development, is located on the right bank.

The dam originally consisted of a masonry main overflow section, 124 feet long, slightly angled in plan with the apex upstream. A low-flow spillway (fishway) with a crest length of 18.5 feet discharged into a concrete flume about 100 feet long located on the left bank. A forebay at the right abutment carried water through a trash rack and a gate to the wheel pit of the gristmill. According to a rough sketch prepared by F. A. Potts, dated June 11, 1915, the main dam consists of two separate masonry structures with a gravel fill in between. The downstream masonry wall, originally about 12 feet maximum height, is the presently visible portion of the dam. The foundation and abutments of the dam are located on an outcrop of dolomitic rock, which appears to be sound and in good condition. A sketch of the plan and section of the dam and its features, based on the sketch prepared by Mr. Potts and on field investigations made for this study, is shown in Figure 20.

Local residents state that the crest of the main masonry wall was originally capped with timber planking for protection of the masonry. It appears that the sloping surface of the gravel fill was also covered with planking. The upstream portions of the structure, in the pond, are covered with silt and mud, making visual inspection difficult. A rectangular 5 foot long, 3 foot high opening in the masonry, closed with planking, is located about mid-channel near bed level. This may have been used as a sluiceway for diversion of water during construction of the dam. No gate-operating facilities for this sluiceway were noted in the field inspection.

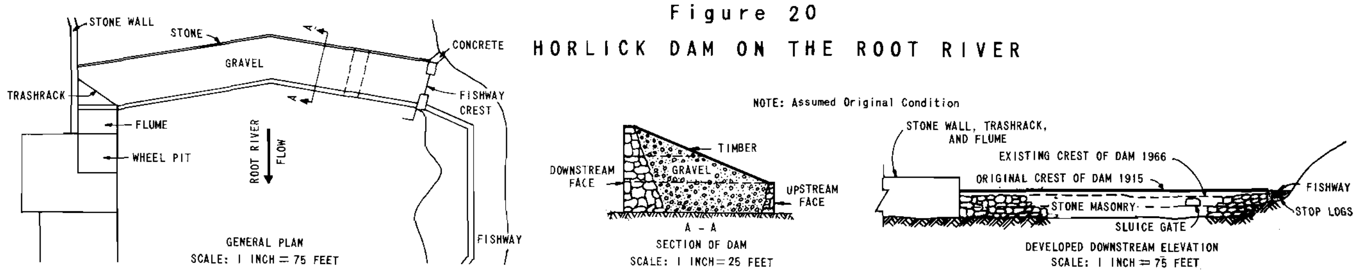
At present, the structure is in an advanced and apparently accelerating state of deterioration. The planking on the crest has disappeared, and portions of the masonry on the crest have broken off, irregularly lowering the dam crest by as much as three feet. The deterioration is most pronounced in the left-hand half of the main overflow section. Only remnants of the former left-bank spillway can be distinguished. The forebay intake is closed probably with the original gate or by planking or masonry. No leakage from the forebay and wheel pit area was noted, however. All of the masonry appears to be in poor condition.

Upstream riparian owners petitioned the Wisconsin Public Service Commission, both in 1940 and 1946, to require floodgates or sluiceways to be put into the dam to alleviate damages allegedly caused by backwater from the dam during floods. In both of the resulting hearings, engineers' expert testimony and investigation reports established the upstream limit of backwater to be located near the present STH 31 bridge, about 3 1/2 river miles upstream from the dam. Inadequate channel capacity rather than backwater from the dam was considered to be the cause of most of the claimed damages. It was also stated in expert testimony that the installation of floodgates or sluiceways or the passage of water through the wheel pit would have little effect on upstream flood levels.

Backwater computations were carried out in the watershed planning studies for the alternative conditions of the dam restored to its original crest level and for the dam removed. The indicated influence of backwater from the dam extends to a point about 500 feet downstream from the STH 31 bridge or three river miles upstream from the dam.

Figure 20

HORLICK DAM ON THE ROOT RIVER



Source: Based on sketch by F.A. Potts, dated June 11, 1915.

The reservoir formed by Horlick Dam has only a negligible reduction effect upon flood peaks of the Root River. In the synthesis of the 1990 condition 100-year flood, the peak was reduced by only 36 CFS in the reach immediately below the Horlick Dam pond.

SUMMARY

The natural hydraulic characteristics of the watershed are strongly influenced by the glacial origin of the watershed topography. The watershed is relatively slow draining because of a circuitous channel pattern and flat channel slopes, which cause local flooding but serve to moderate flood peak flows. Rapid overland runoff is retarded in many areas of poor natural drainage, vegetation, and soil conditions.

Hydraulic capacity of the stream channels varies throughout the system, often diminishing in the downstream direction. Hydraulic capacity is also strongly influenced by the seasonal growth of vegetation in the channels and flood plains. Channel cross sections and slopes and the selection of friction factors for channel capacity determinations were based on field observations. Head losses for various discharges were calculated for the 104 bridge and culvert crossings which were deemed to have an effect on flood stages, and stage-discharge and stage-area curves were prepared for these crossings.

For descriptive purposes, the hydraulic system of the watershed has been separated into three parts: the North Branch, the Canal, and the main stem. The perennial channel of the North Branch of the Root River originates near W. Lincoln Avenue, in western Milwaukee County, and flows southerly 16.6 miles at an average slope of 4.82 feet per mile (0.000913 feet per foot) to its confluence with the Root River Canal near S. 60th Street and W. Oakwood Road in the City of Franklin. Hydraulic friction in the channel and flood plain is moderate, but substantial head losses are caused by bridges with inadequate waterway openings. At present, 5.6 river miles of the flood plain are developed into a recreational parkway. Deepening of the channel within the City of West Allis and for some distance downstream is required to accommodate urban storm sewer systems presently under construction.

The perennial channels of the Root River Canal system drain central Racine County and join the North Branch to form the Root River main stem. The perennial channels comprising the Canal system have a total length of 27.8 miles and an average slope of 5.71 feet per mile (0.00108 feet per foot). The channels, in most of their length, have been deepened and straightened by dredging but have generally deteriorated from lack of maintenance. Much of the land in the Canal area is tile drained, which has the effect of prolonging the period of runoff contribution from summer rains.

The Root River main stem flows 25.6 miles to its mouth at Lake Michigan in the City of Racine. The slope averages 3.57 feet per mile (0.000676 feet per foot). However, in the reach where the river flows eastward along the Milwaukee-Racine County line, the slope is only 1.62 feet per mile (0.000307 feet per foot), resulting in very low velocities and low channel capacity.

The low-lying land around the confluence of the North Branch and the Canal functions as a natural flood-retarding reservoir inundating nearly 1 1/2 square miles and storing about 6,400 acre-feet of water during a 100-year recurrence interval flood. The flood-peak reduction effect of this natural reservoir is most pronounced in short duration floods caused by summer rainfall.

Horlick Dam, built prior to 1850, is the only existing major structural water control facility on the Root River. The dam is no longer used for mill operation and is rapidly deteriorating. Although damage from backwater was claimed by upstream riparians, it was concluded in hearings before the Wisconsin Public Service Commission, and confirmed in this study, that backwater effects were small. The dam has a negligible reduction effect on major flood peaks.

Chapter VI
HYDROLOGIC SIMULATION

INTRODUCTION

The watershed planning process requires knowledge of both the present and the projected future behavior of the river system, particularly with respect to floods, through a range of hydrologic conditions. In the Root River watershed, streamgaging station records of stage and discharge have not been obtained over a long enough period to represent more than a very small sample of the possible range of hydrologic conditions or to indicate any behavior trends resulting from changes in land use. Also, stream gaging records, regardless of their duration, do not provide direct information on river discharge and water levels in the reaches between or beyond the measuring points; but sound watershed planning requires knowledge of the river system behavior along the entire length of the principal channels. Such knowledge is best provided through hydrologic simulation studies.

"Hydrologic simulation," as used in this report, means the representation of the surface water hydrologic system of the watershed by mathematical means. In such simulation, a mathematical model is constructed from available information on the climate, topography, soils, land use, and hydraulics of the watershed combined by means of established hydrological relationships. The model is then calibrated to the specific watershed by use of those data on river performance, such as high-water marks, gage-height records, and discharge records, that may be available. Each item of pertinent information is thus combined to contribute toward a basic understanding of the specific hydrologic relationships of the watershed. It then becomes possible to vary hydrologic input factors and forecast resulting river system performance.

The hydrologic model constructed for the Root River watershed was used principally for evaluation of the future probable flood characteristics of the river system under alternative watershed development plans. The model was used to simulate floods corresponding to selected recurrence intervals of 10, 50, and 100 years for conditions of present and planned future land use in the watershed. It was used to evaluate the probable effects of urbanization on floods caused primarily by snowmelt and on floods caused by rainfall. The model also was used to evaluate the effect of various proposed water control facilities on flood levels and discharges in the river system.

REPRESENTATION OF THE WATERSHED

For the development of the hydrologic model of the Root River system, the watershed was divided into 52 hydrologic sub-basins; and stage-area-discharge curves were synthesized for 111 control points along the river channels. Channel-storage volume curves were prepared for 30 river reaches. The hydrological characteristics of each of the sub-basins were represented by soil type, land use, and by unit hydrographs based on drainage area, slope, and hydraulic friction. The stage-area-discharge curves were based on channel slope, cross-sectional area, hydraulic friction, and flow constrictions. The channel-storage volume curves were based on sub-reach end areas and reach lengths.

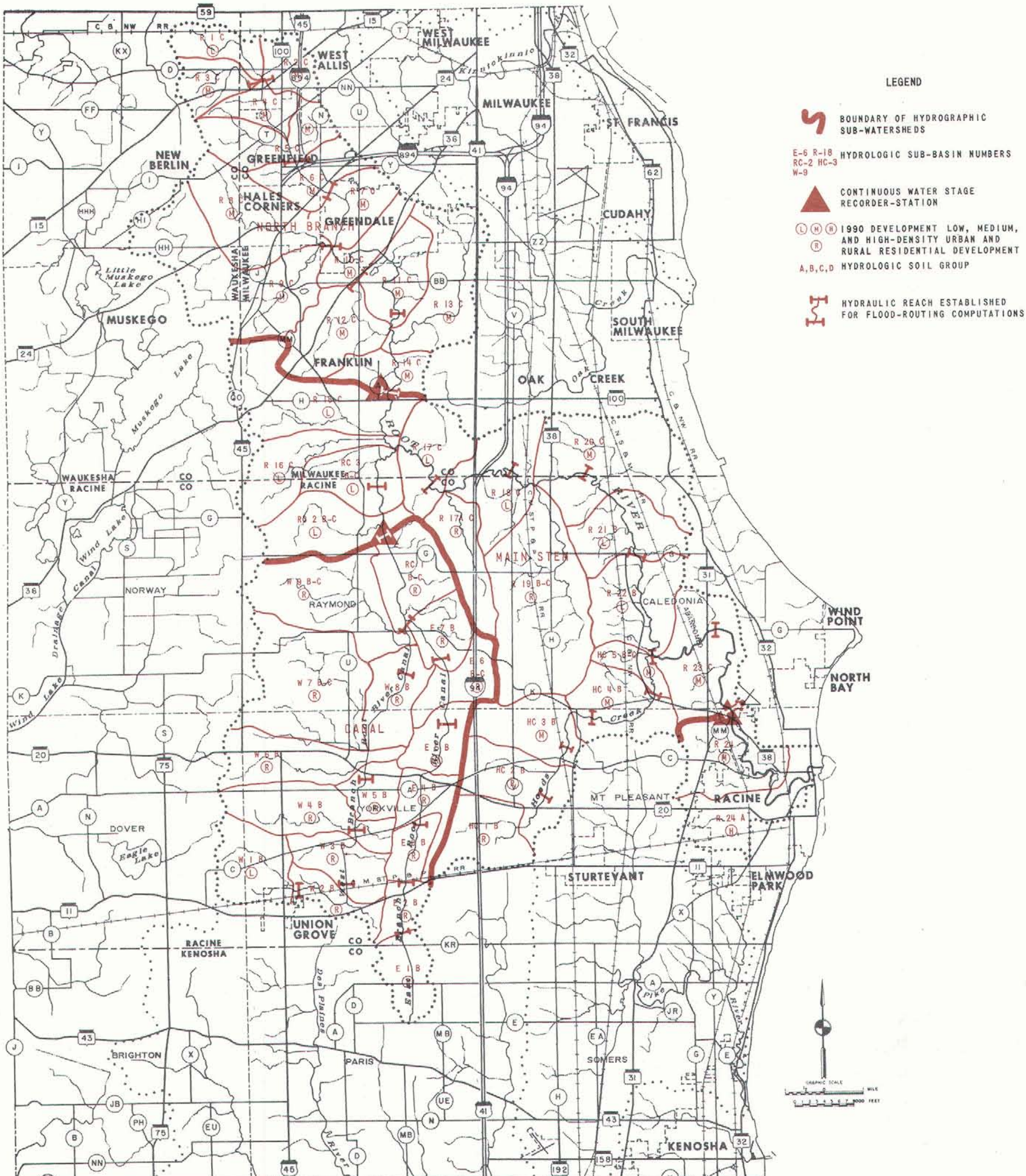
Delineation of Hydrologic Sub-Basins

In order to represent the progressive contribution of runoff water along the length of the main channels, the entire watershed was divided into 52 sub-basins ranging from 1.14 to 10.95 square miles in area. Relatively small sub-basins were delineated in the headwater areas, and sub-basin sizes were made progressively larger toward the river mouth so that roughly similar proportions between sub-basin runoff contribution and main channel streamflow would be maintained throughout the system. The locations of larger tributary watercourses were also considered in delineating sub-basins to ensure that tributary inflows would be represented at the proper points on the main channel. The selected sub-basins are shown on Map 31, together with the hydrologic soil group predominant in each sub-basin and the type of land use as proposed in the controlled existing trend land use plan element described in Chapter XII.

The ratio of runoff to rainfall was determined from the infiltration characteristics of the sub-basin soils and the existing and proposed future land use in each sub-basin. Detailed soils maps prepared by the U. S. Soil Conservation Service (SCS) in cooperation with the SEWRPC were used to determine the predominant hydrologic soils group,

Map 31

HYDROGRAPHIC SUB-WATERSHEDS AND HYDROLOGIC SUB-BASINS IN THE ROOT RIVER WATERSHED



In order to analyze the manner in which runoff causes flood stages, it was necessary to subdivide the watershed into 52 hydrologic sub-basins in which soil and land use conditions could be carefully evaluated, runoff generated, and flood flows routed with the aid of a simulation model. Key control points were provided by the records of three constant water stage recorder stations located in the watershed in preparation for the study.

A through D, in each sub-basin. Group A represents soils having the highest infiltration rate; and Group D, the lowest. All soil types occurring in the Root River watershed have been classified into one of these four hydrologic soils groups, as indicated in Appendix H.

In view of the availability of the detailed soils data, the SCS Runoff-Curve-Number system[1] was selected as the most suitable method for calculating runoff resulting from a given depth and duration of rainfall. This method assigns runoff numbers to a range of hydrologic soil-cover complexes made up of combinations of soil groups and agricultural land uses. The runoff number classifications used are shown in Table 15. The term "hydrologic condition," used as a column heading in Table 15, refers to the infiltration and retention characteristics accompanying the method of land use. In the case of row crops, small grain, and legumes or rotation meadow, hydrologic condition is based on the sequency of crop rotations ranging from good when rotation includes legumes or grasses to poor when a row crop is planted year after year. In the case of pasture or range, heavily grazed pasture would be classified as poor and lightly grazed as excellent. In the case of woodland, those that are heavily grazed and in which underbrush is burned would be classified as poor and those that are ungrazed as excellent.

Curves relating runoff to rainfall for various runoff numbers are shown in Figure 21. These curves were prepared by the SCS on the basis of field experience and infiltration tests. The curves are assumed to indicate the runoff resulting from rainfall in a 24-hour period.

Weighted average runoff curve numbers were prepared for sub-basins having mixed land use. A representative cropping pattern based on present agricultural land use, shown in Table 16, was used throughout the agricultural portion of the watershed. Urban areas were represented as consisting of lawns or open space and paved or roofed areas. Urban lawns and open space were considered comparable to good, contoured pasture or range. All paved and roofed (impervious) areas were assigned a coefficient of runoff of 92 percent of rainfall, comparable to the average rational formula C values recommended for such areas in Chapter XI and Appendix I. The proportions of impervious area used for different urban land use categories are summarized in Table 17. Runoff from urban sub-basins was calculated by adding the runoff from pervious areas and the runoff from impervious areas, each weighted by its proportion of the total sub-basin area.

[1] *Engineering Handbook*, Section 4, "Hydrology," U.S. Department of Agriculture, Soil Conservation Service, 1957.

Unit Hydrographs

The pattern of tributary inflow from the individual sub-basins was represented by unit hydrographs. The term unit hydrograph as used herein is defined as: the graph of direct runoff over time resulting from one inch of rainfall excess (that portion of rainfall which becomes direct surface runoff) generated uniformly over the drainage area at a constant rate during a specified duration.

Unit hydrograph characteristics vary with the size, shape, slope, and drainage efficiency of the tributary drainage basin. The most significant characteristics are the basin lag, which is the time from the center of mass of rainfall excess to the hydrograph peak, and the peak discharge of the unit hydrograph. Steep slope, compact basin shape, and efficient drainage tend to make lag times short and peaks high, while flat slope, elongated shape, and poor drainage tend to make lag time long and peaks low.

Unit hydrographs are ideally derived from streamflow and rainfall records. Practically, however, such records are, because of the costs involved, seldom if ever available for the individual sub-basins of a large watershed; and, therefore, synthetic unit hydrographs must be used. The most suitable means of synthesis is one which takes into account those basin characteristics that most influence the shape of the unit hydrograph and which can be measured, observed, or reliably estimated. A method developed by the Soil Conservation Service makes use of basin area, shape, slope, and overall hydraulic efficiency to determine the time of concentration from which lag time and unit hydrograph peak discharge can be derived. Time of concentration is defined as the time from beginning of runoff to arrival at the mouth of contribution from the hydraulically most distant portion of the basin.

An actual unit hydrograph would present a complex curvilinear relationship of discharge over time. When sub-basin flows, however, are to be added and routed to obtain total streamflow, little accuracy is lost by representing the unit hydrograph as a triangle. The triangle has an area equivalent

Table 15

RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL COVER COMPLEXES[a]
(For Watershed Moisture Condition II)[b]

Land Use or Cover	Treatment or Practice	Hydrologic Condition[c]	Runoff Curve Numbers by Hydrologic Soil Group			
			A	B	C	D
Fallow	Straight Row	--	77	86	91	94
Row Crops	Straight Row	Poor	72	81	88	91
	Straight Row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured & Terraced	Poor	66	74	80	82
	Contoured & Terraced	Good	62	71	78	81
Small Grain	Straight Row	Poor	65	76	84	88
	Straight Row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured & Terraced	Poor	61	72	79	82
	Contoured & Terraced	Good	59	70	78	81
Close-Seated	Straight Row	Poor	66	77	85	89
Legumes or	Straight Row	Good	58	72	81	85
Rotation Meadows[d]	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured & Terraced	Poor	63	73	80	83
	Contoured & Terraced	Good	51	67	76	80
Pasture or Range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow (permanent)		Good	30	58	71	78
Woods (farm woodlots)		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		--	59	74	82	86
Roads[e] (dirt)		--	72	82	87	89
(hard surface)		--	74	84	90	92

[a] *Engineering Handbook, Section 4, "Hydrology," U.S. Department of Agriculture, Soil Conservation Service, 1957.*

[b] *Moisture Condition II is defined as 1.4 to 2.1 inches of rainfall in the preceding five days.*

[c] *Hydrologic condition is defined as the rainfall retention characteristics of the land use or cover and the treatment or practice.*

[d] *Close-drilled or broadcast.*

[e] *Including right-of-way.*

Source: U.S. Department of Agriculture, Soil Conservation Service.

to the volume represented by one inch of runoff over the tributary basin and the same lag time as the actual curvilinear hydrograph.

Triangular unit hydrographs for each sub-basin were derived using the relationships shown in Figure 22. Time of concentration was derived from the Kirpich equation:

$$Tc = \frac{(11.9\ L^3)^{0.385}}{H}$$

where: Tc = time of concentration in hours
L = principal channel length in miles
H = rim to mouth elevation difference in feet

This equation represents an empirical relationship based on small agricultural watersheds. Urban watersheds exhibit shorter concentration times because of higher flow velocities over paved areas and in storm sewers. Adjustment for increased velocities in urban areas was made by reducing

Table 16

REPRESENTATIVE AGRICULTURAL LAND USE PATTERN

Land Use	Hydrologic Condition	Percent of Area in Agricultural Use
Row crops, contoured	Good	35
Small grain, straight row	Good	10
Legumes, straight row	Good	25
Pasture	Good	20
Woods	Fair	5
Farmsteads		2
Roads, hard surface		3

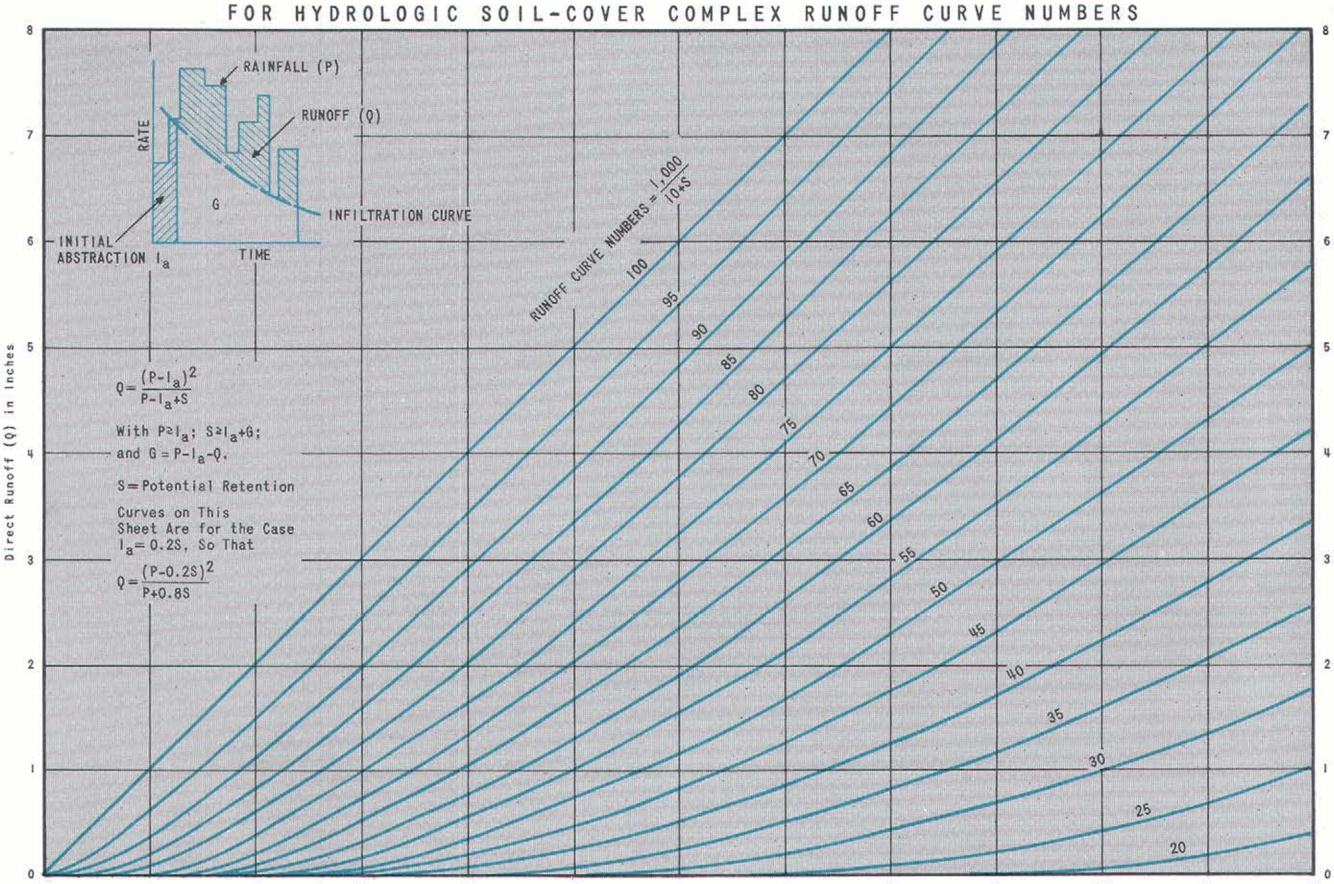
Source: Harza Engineering Company.

the calculated concentration time in direct proportion to the ratio of assumed hydraulic frictions of the drainage systems in urban and agricultural areas. Hydraulic friction was represented by Manning "n" values, using 0.075 for agricultural areas, 0.050 for partially storm-sewered urban areas, and 0.025 for fully storm-sewered urban areas.

In the calculation of concentration time for urban areas (T'c), it was recognized that runoff from the most remote portions of the basin will occur first as overland flow. A portion of the time of concentration in urban areas is, therefore, similar to that of agricultural areas. Fifteen minutes (0.25 hr.) was selected as a reasonable allowance for overland flow; and this portion of the calcu-

Figure 21

RAINFALL-RUNOFF RELATIONSHIPS FOR HYDROLOGIC SOIL-COVER COMPLEX RUNOFF CURVE NUMBERS



Source: U.S. Soil Conservation Service.

Table 17

URBAN LAND USE IMPERVIOUS AREA RATIOS

Land Use	Net Lot Area per Dwelling Unit	Dwelling Units per Net[a] Residential Acre	Persons per Net[a] Residential Acre	Persons per Gross[b] Square Mile	Ratio of Impervious Area to Total Area
Low-Density Residential.	20,000 sq.ft. & over	0.2- 1.6	0.6- 5.5	350- 3,499	15%
Medium-Density Residential	6,000-19,999 sq.ft.	1.6- 4.6	5.5-15.6	3,500- 9,999	30%
High-Density Residential	Under 6,000 sq.ft.	4.6-11.4	15.6-39.1	10,000-25,000	60%
Commercial-Industrial.					92%

[a] *Net residential area is defined as the area of land actually devoted to residential use within site boundaries and includes the building ground area coverage, together with the necessary on-site yards and open spaces.*

[b] *Gross residential area is defined as the net area devoted to a given use plus the area devoted to supporting land uses, such as streets, parks, schools, churches, and neighborhood shopping centers.*

Source: SEWRPC.

lated agricultural area time of concentration was kept unchanged in the calculation of T'c, as shown in Figure 22.

The adjustment of agricultural area concentration times to account for the effects of urbanization by the method described above is without precedent. An intensive search of the current literature on the effects of urbanization on runoff was made, and many papers were found which present conclusive evidence that urbanization of a formerly agricultural drainage basin will cause a decrease in hydrograph lag time and an increase in hydrograph peak discharges for similar rainfall. None of the papers reviewed, however, presented procedures for quantitatively representing the effects of urbanization in flood synthesis. The effects of urbanization on runoff from small drainage basins are also being studied in the Chicago area, and definite trends toward higher flood peaks with the growth of urbanization have been established. The results to date, however, are not adequate for the establishment of quantitative adjustment procedures.

Unit time, D, represents the duration of runoff-producing rainfall used in the construction of the unit hydrograph. The graphical relationships in Figure 22 indicate that the selected value of D should be smaller than Tc, since the triangular unit hydrograph relations are derived for situations wherein the peak runoff occurs after the end of the runoff-producing rainfall.

Small or topographically steep basins have short concentration times and require the selection of small values for unit time. In the flood routing process, however, it was impractical to use unit hydrographs with unit times shorter than one hour. Composite unit hydrographs for longer rainfall durations were prepared by adding the ordinates of several triangular unit hydrographs, each offset D hours and reduced in volume such that the resultant composite unit hydrograph will have a volume of one inch of runoff, as shown in Figure 22.

Flood Routing

Flood routing is the mathematical process of simulating the movement of floods through a channel system. As flood flows move through a channel, the peak flow is usually reduced and the duration of flow is prolonged because some of the water is put into temporary storage as flow depth increases in the channel and later released as flow depth decreases. The rate of flood travel, reduction of peak, and increase in duration are dependent upon the size, shape, slope, and hydraulic friction of the channel.

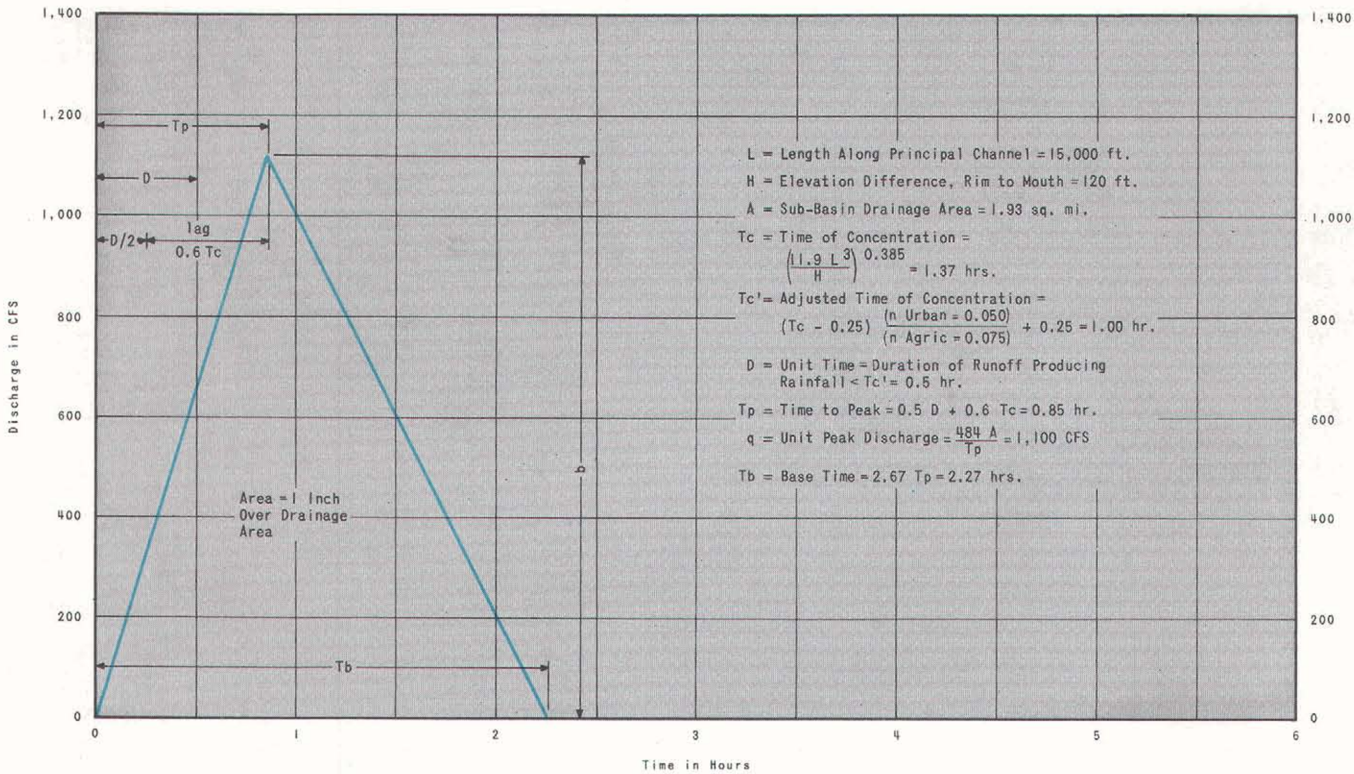
Runoff from snowmelt is delayed at the beginning of the snowmelt period because melt water is stored in the remaining snow pack and because many of the minor channels and culverts are blocked by snow and ice. It was assumed in the synthesis of snowmelt-rainfall floods that the tributary outflow from each sub-basin would follow the rainfall unit-hydrograph pattern except that the beginning of runoff would be delayed. It was further assumed that most of the snow that melted in the first melting periods did not start to run off until some time later, while snow that melted in later periods started to run off almost immediately.

Many methods of flood routing have been developed to suit a variety of purposes and types of data. The "storage-indication method" was selected as the most suitable for use in the Root River watershed planning study. This method is based upon the physical characteristics of the channel system, whereas most other methods are based upon streamflow records. Basically, in this method the variation in channel storage is calcu-

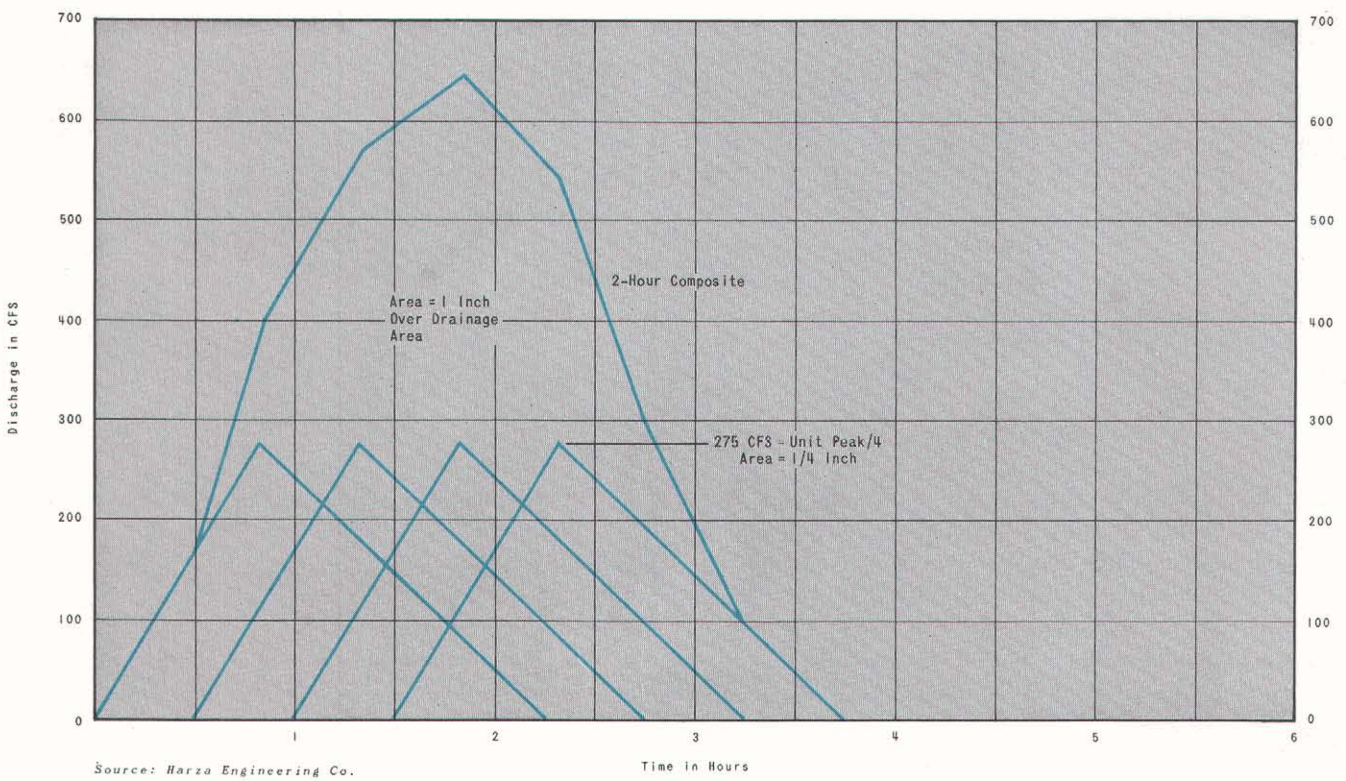
Figure 22

ROOT RIVER WATERSHED SYNTHETIC UNIT HYDROGRAPHS

UNIT HYDROGRAPH RELATIONSHIPS AND TYPICAL COMPUTATION



COMPOSITE UNIT HYDROGRAPH



Source: Harza Engineering Co.

lated for each river reach over a range of discharges using field observations of channel size, slope, and friction. Inflow at the head of the reach is adjusted for inflow to, or outflow from, channel storage and for time of travel to obtain outflow from the reach. The process is very similar to the movement of water through a series of reservoirs and for this reason is particularly appropriate in representation of the large number of culverts and bridges on the Root River. The head loss through culverts and bridges results in varying amounts of backwater creating temporary storage upstream from the structure. Another feature which makes application of the storage-indication method particularly appropriate is that stage-discharge curves are required at frequent sections along the channel for the additional purpose of establishing inundation levels corresponding to calculated flood discharges.

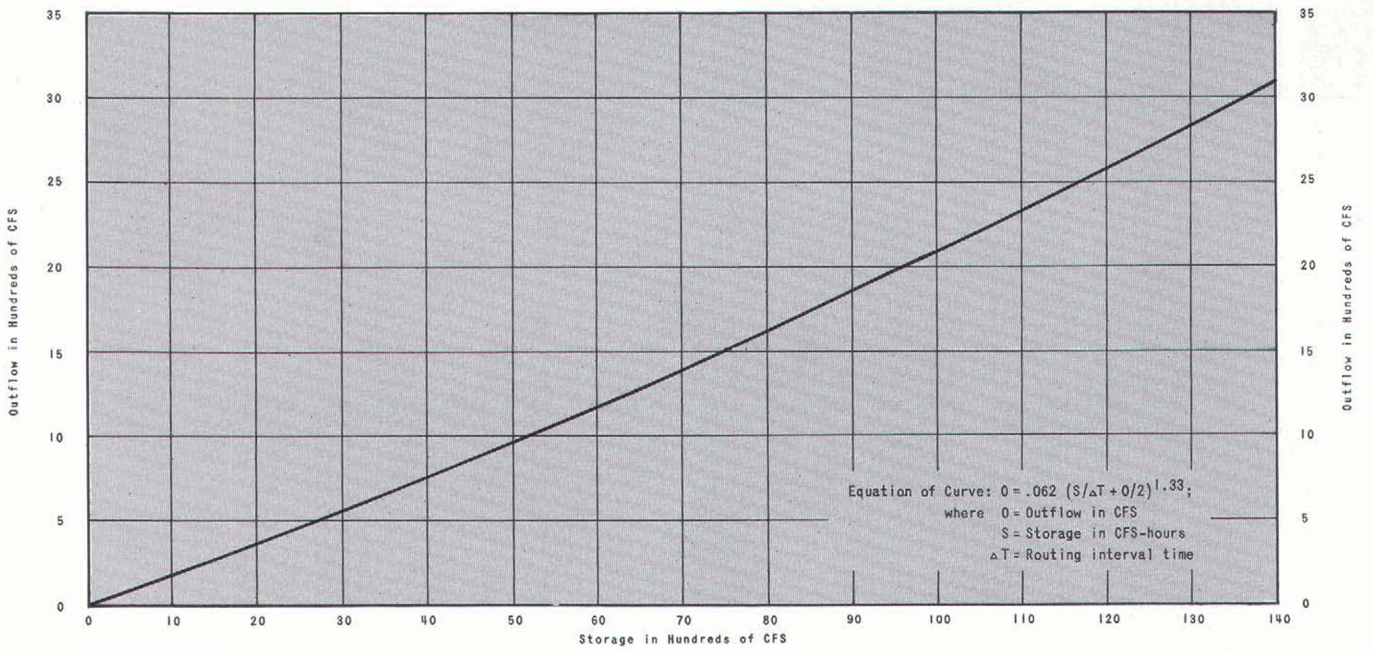
The flood routing process consists of two steps: 1) the representation of the hydraulic characteristics of the channel by graphical and numerical means, and 2) the movement of hydrographs of flood flow through the mathematical model of the channel. Channel characteristics are represented by a series of stage-area-discharge curves. These curves were prepared for the channel at the upstream and downstream sides of all of the bridges and culverts, as described under "Hydraulic Analysis" in Chapter V and shown in Figures 18 and 19, Chapter V.

After preparation of the stage-area-discharge curves, channel storage was calculated over a range of discharge for each reach. The perennial stream channels were divided into 30 reaches as shown on Map 31. Cross-sectional areas of flow were read from stage-area-discharge curves for a range of discharges in each channel reach. These areas were multiplied by appropriate channel distances to give a storage volume in the reach corresponding to a given discharge. Curves relating channel storage volume to discharge were prepared for each reach. A typical storage indication curve is shown in Figure 23. Similar curves for all of the channel reaches are on file with the Commission.

The flood routing procedure then consists of adjusting an inflow hydrograph for changes in channel storage to find outflow at the end of the reach. Computations are made for time intervals selected to be shorter than the travel time through the reach. The general routing equation may be stated as: average outflow during the time interval is equal to average inflow during the time interval plus or minus change in channel storage. Knowing inflow at the beginning and end of the time interval and outflow at the beginning of the time interval, the equation can be solved to find outflow at the end of the time interval. The outflow hydro-

Figure 23

STORAGE INDICATION CURVE USED IN COMPUTING OUTFLOW FROM REACH R-5 OF ROOT RIVER



Source: SEWRPC.

graph from a reach plus any local tributary inflow becomes the inflow hydrograph for the next downstream reach. Select hydrologic procedures are set forth in Appendix F.

Operation of the Hydrologic Model

The hydrologic model of the watershed was operated in a sequence of steps similar to that which occurs in nature. Rainfall excess was calculated for selected rainfall depths and durations and applied to sub-basin unit hydrographs to obtain tributary inflows to the main channel system. Snowmelt contributions were determined in a similar manner. Tributary inflows were added to main channel flows at appropriate locations, and the aggregate flow was routed through the channel system.

Most of the routine and repetitive computations were performed by an IBM-1620 electronic computer. However, the computer was programmed to carry out the computations in exactly the same manner as they would be done manually so that consistent additional computations can be made manually at any time without the necessity of using a computer.

SIMULATION OF HISTORIC FLOODS

Since general theoretical and empirical relationships were used to construct the hydrologic model, it was necessary to calibrate the model to the specific characteristics of the Root River watershed. Two suitable calibration standards were fortunately available. They were the discharge records of the July 1964 summer rain flood obtained at the three SEWRPC-USGS streamflow gaging stations established within the basin in September 1963 and a USGS indirect measurement of the 1960 flood peak discharge of the North Branch at W. Ryan Road (STH 100) in Milwaukee County, together with several high water marks at various locations.

Hydrograph Shape

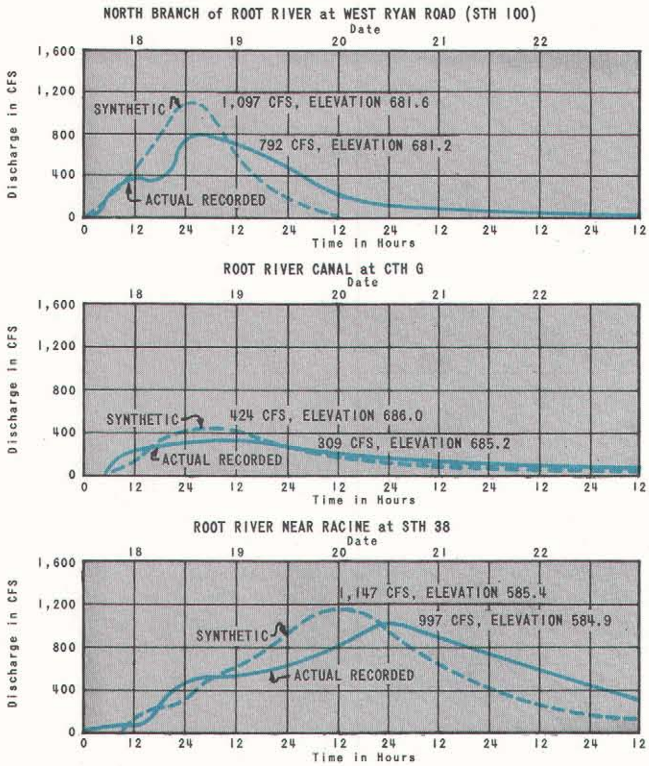
The shape of a streamflow hydrograph at any point in a river system is dependent primarily upon upstream rainfall distribution and timing, sub-basin outflow characteristics, and the hydraulic characteristics of the channel system. The July 1964 rain-flood streamflow records at W. Ryan Road (STH 100) and CTH G were used as a calibration standard for hydrograph shape. Rainfall records obtained at several locations within and near the drainage areas were used to establish rainfall distribution and timing. Total rainfall-runoff volume was determined from the gaging station records. A trial operation of the model was made using the areal, volume, and time distribution of runoff derived from the rainfall and streamflow records. The synthesized streamflow hydrographs were compared to the recorded hydrographs. The synthesized hydrographs were found generally to be too high in peak and too short in duration. The possibility of upward adjustment of channel storage volume was investigated, but it was concluded that physical limits on the range of possible adjustment of channel storage were not broad enough to account for the change in hydrograph shape required.

It was concluded, therefore, that the sub-basin unit hydrographs required adjustment. As a first step, an adjustment was made for the probable retarding effect of ponds and poorly drained lands in proportion to their surface area in each sub-basin. In addition, the time bases of all sub-basin unit hydrographs were extended and peaks correspondingly lowered through a trial-and-error adjustment process. Time bases of unit hydrographs for sub-basins in the Canal drainage area were substantially extended to portray the effects of agricultural tile drains. Although drain tile effluent is not strictly surface runoff, it follows surface runoff so closely and appears to be so substantial in quantity that it can be reasonably considered as a component of runoff from a rainfall event.

Comparisons of the final adjusted synthesized hydrographs to the recorded streamflow hydrographs at the USGS gaging stations are shown in Figure 24. The synthesized peaks are still substantially higher than the recorded peaks even after unit hydrograph adjustment. It was not, however, considered desirable to try to match the 1964 flood exactly because the 1964 flows were relatively low while the unit hydrographs are intended to be used primarily for calculation of high flood flows. Many engineers believe that the peaks of unit hydrographs derived from relatively low peak flows should be increased when used for synthesis of high flows to account for increased flow velocities in the drainage system. The U. S. Army Corps of Engineers customarily increases unit hydrograph peaks from 25 to 50 percent in calculation of design-flood flows. Furthermore, the excellent correlation with the high, measured 1960 flood peak at W. Ryan Road (STH 100), described in a following section, would not have been possible with the runoff available at that time if unit hydrograph peaks were any lower.

Figure 24

COMPARISON OF SYNTHETIC AND ACTUAL RECORDED FLOOD HYDROGRAPHS JULY 1964 FOR THE ROOT RIVER WATERSHED



Source: Harza Engineering Co.

Rainfall-Runoff Relationship

The SCS runoff curves for various hydrologic soil-cover complexes, described in a preceding section, are based on normal soil moisture conditions. However, runoff response from a given rainfall will vary widely with variations in soil moisture. To account for this variation, the SCS suggests adjustments to the curve numbers for conditions wetter or dryer than normal. "Normal," or Condition II, for the growing season is defined as having antecedent rainfall of 1.4 to 2.1 inches in the previous five days.

Rainfall at Milwaukee Station in the five days prior to July 17, 1964, totalled 0.46 inches, corresponding to less-than-normal soil moisture or Condition I. SCS adjustment relationships indicate an appropriate reduction of the runoff curve number for the pervious portion of the drainage area of 27 percent, from No. 70 to No. 51. However, comparison of measured runoff volume to measured rainfall volume for the July 1964 flood indicates a runoff number of 40, or a reduction of 43 percent from "normal."

In consideration of the derived runoff number being substantially less than would be obtained by the SCS generalized procedure, and the indication from inspection of rainfall records that the SCS "normal" antecedent rainfall has a somewhat greater than even chance probability of occurring on a summer day in the Root River watershed area, it was concluded that most probable conditions of soil moisture in the watershed would fall between the SCS normal and dry conditions. Accordingly, runoff numbers for most probable soil moisture conditions were assumed to be halfway between the SCS values for Condition I and Condition II. Synthesis of summer floods for selected rainfall frequencies was based on hydrologic soil-cover complex curve numbers reduced in the manner described above.

Flood Stage Elevations

The final step in calibration of the hydrologic model was reproduction of the March-April 1960 flood and adjustment of channel stage-discharge curves to reproduce recorded high water marks. The peak flow of the North Branch at W. Ryan Road (STH 100) was determined by the USGS by indirect measurement to be 5,000 CFS. This peak flow was reproduced by operation of the model on a trial-and-error basis using the previously calibrated sub-basin unit hydrographs and various combinations of snowmelt and rainfall runoff, based on recorded snow depths, temperatures, and rainfalls.

Climatological conditions leading up to the 1960 flood were described in Chapter IV. The flood was caused by unusually high snowmelt with concurrent heavy rainfall. Because of either frozen or saturated soil conditions during the time of rainfall, it was assumed that all rainfall in excess of 0.01 inch per hour would run off. Adjustments were made in the timing and volume of snowmelt runoff and in the snowmelt unit hydrographs to bring the synthesized, combined snowmelt-rainfall peak flow at W. Ryan Road (STH 100) to 5,000 CFS. Recorded temperature, precipitation, and snow depth and the finally selected snowmelt and rain runoff depths are summarized in Table 18.

In synthesis of the 1960 flood over the entire watershed, it was assumed that the snowmelt runoff component of the flood would be the same in all sub-basins. This assumption is based on the balancing effect of the long period of snow accumulation and the general areal uniformity of melting temperatures. The reconstructed isohyetal map

Table 18
MARCH-APRIL 1960 FLOOD—NORTH BRANCH ROOT RIVER
CLIMATE FACTORS AND RUNOFF

Date	Temperature °F		Precipitation Inches	Snow[a] on Ground Inches	Snowmelt[b] Runoff Inches	Rainfall[c] Runoff Inches
	Max.	Min.				
March 26.	29	1	0.00	7	0.0	0.00
March 27.	46	27	T	6	0.0	0.00
March 28.	41	34	T	1	0.5	0.00
March 29.	62	35	0.94	1	3.0	0.88
March 30.	52	30	1.63	T	0.0	1.47
March 31.	33	29	0.00	T	0.0	0.00

All recorded data for USWB Milwaukee Station.

[a] *Depth of snow at 6:00 a.m.*

[b] *Water equivalent depth.*

[c] *Based on average rainfall over the North Branch drainage area derived from an isohyetal map, Map 23, Chapter IV.*

Source: SEWRPC.

of rainfall over the watershed, shown on Map 23, Chapter IV, indicates an average rainfall depth of 2.5 inches over the drainage area of the North Branch and a fairly uniformly distributed average rainfall depth of 1.5 inches over the balance of the watershed. This distribution of rainfall was used in reproduction of the flood.

A high water profile for the synthesized 1960 flood, calculated by applying computed channel discharges to stage-discharge curves, was superimposed on a 1960 flood profile reconstructed from recorded high water marks. Calculated stage-discharge curves and the recorded high water marks were reviewed at locations indicating significant departures.

Appropriate adjustments were made in the stage-discharge curves by adjusting hydraulic friction, average slope, and channel cross section within limits judged to be reasonable for the particular location. In general, calibration was considered to be satisfactory if synthesized high water elevations were within one foot of recorded elevations. Most residual departures from the synthesized high water profile are on the high side.

Lesser Floods

The March-April 1960 flood was established, in Chapter IV, to be equivalent to a 100-year recurrence interval flood. Using the peak discharge of this flood at W. Ryan Road, together with the USGS regional flood-frequency criteria, a flood peak-frequency relationship was prepared for the North Branch representing present land use development in the drainage area. Synthesis of lesser floods of selected recurrence intervals was carried out by the same procedure as used in synthesizing the 1960 flood. The relationship and timing of snowmelt runoff and rainfall runoff was kept the same as for the 1960 flood synthesis, the runoff only being reduced in depth to correspond to the selected peak flow.

EFFECT OF HUMAN ACTIVITIES ON RUNOFF

The hydrologic model was constructed and calibrated on the basis of present-day hydrologic conditions in the watershed. Its principal function, however, is to permit portrayal of the changes in river system performance under conditions of future land use and water control facility development. For this purpose, components of the model were modified to reflect the land use development expected or proposed and the flood control alternatives considered.

Hydrologic Effects of Urbanization

A substantial increase in urban development in the watershed is expected by 1990, the plan target date. Existing trend and controlled trend alternative land use plan elements for that date are described in Chapter XII. After careful study, it was concluded that the difference between the hydrologic effects of the two alternative land use plans on river system performance would be negligible. Therefore, all analysis of the effect of urbanization on watershed hydrology was based on the "controlled existing trend" land use plan element.

Urban development of a formerly agricultural drainage area has two major effects on hydrologic relationships. The rainfall-runoff relationship is modified as a result of increased impervious area and changed land use in the remaining pervious area. The time of concentration of the drainage area is modified as a result of decreased hydraulic friction and improved drainage facilities.

The change in rainfall-runoff relationships accompanying urbanization was represented by changes in the hydrologic soil-cover complex numbers to reflect both the anticipated increase in impervious area and the greater retention capability of soils under lawn cover as compared to agricultural cropping. These two adjustments are, to some degree, compensating; but in each case the net effect was to increase the volume of runoff from a given rainfall.

The change in drainage hydraulics accompanying urbanization was represented by a reduction in the time of concentration of the affected sub-basins as described earlier. The time of concentration of a sub-basin expected to be fully storm sewered was reduced to one-third of the time under agricultural use. These reductions in concentration time have the effect of shortening the time of tributary outflow but increasing the peaks. Further increases in peak discharges are caused by enlargement of bridge waterway openings or replacement of bridges at locations where existing bridges cause backwater storage of floodwaters in the channel and on the flood plain. Channel improvements to lower floodwater elevations locally also cause increases in peak discharges due to reductions in channel and flood plain storage.

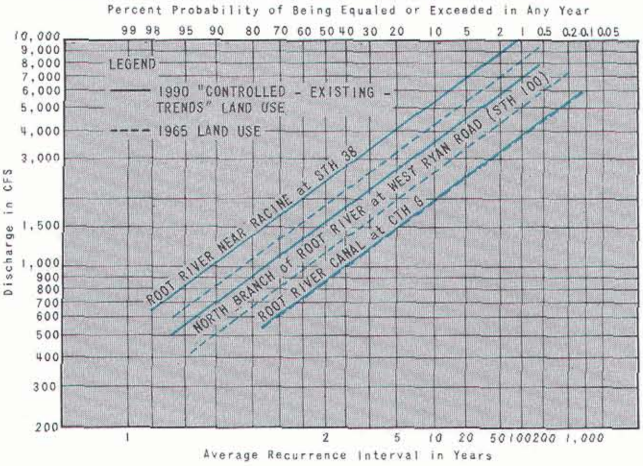
Future (1990) floods of various frequencies were synthesized using snowmelt- and rainfall-runoff depths calculated for corresponding frequency floods under present conditions. Based on the analyses set forth in Chapter IV, it was concluded that, even with increased urban development, most major floods would continue to be caused by the snowmelt-rainfall combination. Rainfall distribution was assumed to be proportional to the pattern recorded during the 1960 flood; that is, 2.5 inches average depth over the drainage area of the North Branch and 1.5 inches average depth over the balance of the watershed. Local floods for the Root River Canal drainage area, however, were generated under the assumption that the heavier rainfall was located in the Canal drainage area. Since the entire watershed is expected to be practically impervious during such a combination of events, only the hydraulic effects of increased urbanization need be considered. Results of model operation for different flood frequencies are summarized in Table 19; and revised (1990) flood-frequency relationships are shown in Figure 25. Calculated discharges for each bridge crossing point in the channel system for future floods of various frequencies are also shown in Appendix G. It was found that rainfall-snowmelt combination flood peaks would not be substantially increased by urban development.

The effect of urbanization on future summer rain floods was also investigated. A rainfall of 100-year recurrence interval (5.6 inches in 24 hours), uniformly distributed over the watershed, was applied to the model, both for present land use and for 1990 planned land use, assuming probable soil moisture conditions. It was found that summer flood peaks would be substantially increased by urban development. However, the 1990, 100-year summer rain flood peak has an indicated recurrence interval of only 10 to 12 years on the revised frequency curves. It may be interpreted that, of the ten 10-year floods expected to occur in a 100-year period, only one will be caused by summer rain. Since the frequency curves are so strongly influenced by snowmelt-rainfall floods, it was not considered necessary to further modify them even though urbanization causes proportionately greater increases in summer rain flood peaks.

Special study was made of the effects of urbanization on floods in the upper reaches of the North Branch channel. The headwater drainage area will eventually be completely drained by storm sewers all contributing to the main channel in

Figure 25

EFFECTS OF URBANIZATION ON ROOT RIVER DISCHARGE FREQUENCY



Source: Harza Engineering Co.

Table 19
RESULTS OF THE HYDROLOGIC SIMULATION OF PEAK FLOOD FLOWS
OF VARIOUS RECURRENCE INTERVALS
ROOT RIVER WATERSHED

Recurrence Interval	North Branch at W. Ryan Rd. (STH 100)	Canal at CTH G	Root River at S. 60th Street	Root River Near Racine at STH 38
Snowmelt-Rainfall Flood—1965 Land Use (in CFS)				
100-Year	5,000	3,800	7,900	8,200
50-Year	4,200	3,200	6,600	6,800
25-Year	3,400	2,600	5,300	5,500
10-Year	2,600	2,000	4,100	4,200
5-Year	2,000	1,500	3,100	3,200
Snowmelt-Rainfall Flood—1990 Land Use[a] (in CFS)				
100-Year	5,600	3,800	7,800	8,400
50-Year	4,700	3,200	6,400	6,900
25-Year	3,800	2,600	5,200	5,600
10-Year	2,900	2,000	4,000	4,300
5-Year	2,300	1,500	3,000	3,300
Summer Rainfall Flood[b]—1990 Land Use (in CFS)				
100-Year[c]	3,200[d]	1,600	3,000	3,100
5-Year	--	480	--	--

[a] *Based on "Controlled Existing Trend" land use plan.*

[b] *Based on six-hour unit hydrographs.*

[c] *Note that this recurrence interval is established in terms of rainfall events only.*

[d] *Under 1965 land use conditions, the 100-year rainfall peak discharge would be 1,880 cubic feet per second.*

Source: Harza Engineering Company.

a relatively short channel length. Since there is little channel storage available for moderation of peak flows in the upper channel, and will be even less after scheduled channel improvements in the City of West Allis, the high peak flows resulting from short-term intensive rainfall will be relatively undiminished for some distance down the main channel.

Future flood flows were synthesized for a 100-year recurrence interval 24-hour rainfall, which was assumed to include the 100-year six-hour and 100-year one-hour maximum intensities. Because of the small size and rapid concentration time of the local area, one-hour unit hydrographs were used instead of the six-hour unit hydrographs used for basin-wide studies. Studies were made assuming the channel to be in its present condition, deepened through the City of West Allis to W. Layton Avenue, and with deepening extended through the City of Greenfield to below W. College Avenue. The resulting flood flows exceed those calculated for the 100-year snowmelt-rainfall flood in the channel reach from W. Lincoln Avenue to W. College Avenue, and with deepening through the City of Greenfield, to W. Loomis Road. Discharges for the 100-year snowmelt-rainfall flood, the 100-year one-hour rainfall, and discharges calculated by the rational formula are shown in Table 20.

Peak flows calculated by the rational formula were based on 10-year recurrence rainfall intensity for individual sub-basin drainage areas and 100-year recurrence rainfall intensity for combined sub-basins, since storm sewers are often designed for 10-year recurrence intervals. The peak flows calculated by means of the rational formula are in substantial agreement with those calculated using one-hour unit hydrographs in the upper reaches but become higher and higher in the downstream direction. This is to be expected because the rational formula makes no provision for the effects of channel storage. The significance of the variation of channel storage can be noted by comparison of the one-hour rainfall flows of the present channel, which has substantial flood plain storage, with the improved channels, which will have little channel storage.

Flood Control Modifications

Structural flood control elements considered in the watershed planning studies included channel improvements in the North Branch, controlled storage at the confluence of the North Branch and the Canal, bypass channels to Lake Michigan, channel improvements in the City of Racine, and channel maintenance in the Root River Canal drainage area.

Based on experience gained through the operation of the hydrologic simulation model, it was concluded that the channel improvements considered for the North Branch would have negligible effect upon flows in the balance of the system.

The effectiveness of bypass channels to Lake Michigan was tested by operating the model modified for the assumption that all flow generated upstream from Nicholson Road, the farthest upstream location of the two alternative diversion points, would be diverted to Lake Michigan. Only runoff generated downstream from Nicholson Road would then contribute to the flood flow at Racine. The operation was carried out using snowmelt and rainfall runoff derived for the 100-year flood, assuming, however, an average rainfall depth of 2.5 inches being located in this portion of the watershed rather than in the drainage area of the North Branch. The resulting peak flow near Racine at STH 38 was 4,000 CFS, which would cause about $15,000 damage. The 1960 flood flow at STH 38, by way of comparison, was estimated at 8,200 CFS with $165,100 in resulting damage. By comparison of the drainage areas below the diversion points, it can be confidently stated that no damages would occur at Racine with a bypass channel at the alternative location closer to Racine.

Since a degree of flood control is now performed naturally by temporary storage of floodwaters in the marshland at the confluence of the North Branch and the Root River Canal, it was necessary to determine how much this function might be enhanced artificially and the resultant decrease in downstream peak flood discharges and stages. It was assumed that a dam would be constructed in the northwest one-quarter of Section 35, Town 5 North, Range 21 East, City of Franklin, with a fixed crest, ungated spillway. This dam would create a reservoir herein identified as the "Oakwood Reservoir." Maximum elevation of the reservoir pool during a 100-year recurrence interval snowmelt-rainfall flood was held to an elevation of 690.0 above msl, six feet higher than would occur naturally during a 100-year flood event. Pool elevations in excess of the selected reservoir pool elevation appeared to be impractical because

Table 20

EFFECTS OF URBANIZATION AND CHANNEL IMPROVEMENTS ON PEAK FLOOD FLOWS IN NORTH BRANCH OF ROOT RIVER

Location	Reconstructed March-April 1960 Flood CFS	1990[a] 100-Year Snow-Rain CFS	Reconstructed July 1964 Flood CFS	100-Year, 1-Hour Rain 1990			Rational Formula CFS
				Present Channel CFS	West Allis Improv.[b] CFS	Greenfield Improv.[c] CFS	
W. Lincoln Ave.	290	340	--[d]	800	800	800	810
W. Cleveland Ave.	320	390	--[d]	920	920	920	940
W. National Ave..	1,170	1,280	--[d]	3,040	2,975	3,040	3,420
W. Morgan Ave..	1,210	1,370	--[d]	2,670	3,010	3,050	3,320
S. 108th St.(STH 100) . . .	1,260	1,470	--[d]	2,300	3,040	3,060	3,220
W. Cold Spring Rd..	1,300	1,560	690	1,920	3,070	3,070	3,130
W. Layton Ave..	1,840	2,300	--[d]	2,790	3,540	3,540	4,180
W. Forest Home Ave.	2,160	2,400	910	2,690	3,650	4,480	4,200
W. Grange Ave..	2,260	2,460	870	2,470	3,300	4,230	4,030
W. College Ave., upstream .	2,370	2,520	830	2,250	2,930	3,990	3,860
W. College Ave., downstream	3,930	4,910	1,230	4,670	5,160	6,500	7,200
S. 76th St.	3,450	4,700	1,130	3,440	4,600	--	5,760
W. Loomis Rd.	3,620	4,670	1,090	3,640	4,510	--	6,070
W. Rawson Ave..	3,850	5,130	1,040	3,370	4,330	--	5,670
Drexel Ave.	3,970	5,370	1,010	3,240	4,230	--	5,470
W. Ryan Rd.(STH 100). . . .	5,000	6,500	1,100	3,600	4,530	--	6,330

[a] *Based on regional land use alternative plan "A," the 'Controlled Existing Trend" land use plan, with those enlargements in bridge waterway openings required to meet the design frequency standards set forth herein.*

[b] *Channel deepened as scheduled through City of West Allis; deepening tailed-out to zero depth of improvement at W. Layton Avenue in the City of Greenfield.*

[c] *Channel deepening extended to W. Forest Home Avenue in the City of Greenfield and tailed-out to W. College Avenue in the Village of Greendale.*

[d] *Data insufficient to allow reliable results from computations.*

Source: SEWRPC.

of the topography, since any further increase in the maximum reservoir pool elevation would result in a large increase in the area flooded by the proposed reservoir.

The hydrologic simulation model was then operated to show the effect on downstream flood discharges and stages. The model was first operated assuming zero reservoir outflow to determine the flow at Racine attributable to the drainage area downstream from the proposed dam site. The results of this initial flood routing are shown in Table 21. Inflows from the North Branch and the Root River Canal were then routed through the reservoir and to Racine, utilizing the available storage, in order to determine the flood abatement effects. Comparative results of flood routing with and without the hypothetical reservoir are shown in Table 22. It is significant that "Oakwood Reservoir" would cause a decrease in the 100-year flood stage at STH 38 near the City of Racine of only 0.4 of a foot. Pool elevations in excess of this elevation would because of the topography result in rapid increase of the area flooded by the reservoir. Flood control benefits of the proposed reservoir were found to be small, both because of the storage limitation and because of the distance from the principal present beneficiary, the City of Racine.

Table 21

FLOOD PEAK DISCHARGES AND STAGES[a] ORIGINATING ENTIRELY FROM RUNOFF OCCURRING DOWNSTREAM FROM "OAKWOOD RESERVOIR" - 1990 CONTROLLED EXISTING TREND LAND USE

Flood Recurrence Interval	Peak Discharge at STH 38 Near Racine CFS	Peak Flood Stage at STH 38 Near Racine MSL
100-Year	4,300	590.7
25-Year	2,900	589.2
10-Year	2,200	588.1
5-Year	1,700	586.9

[a] *Discharges and stages shown do not reflect the effects of probable enlargements in bridge waterway openings concomitant with urbanization.*

Source: Harza Engineering Company.

The lowering of flood high water elevations in the Root River Canal main channel system that would result from channel maintenance was also evaluated. Stage-discharge curves were recalculated using hydraulic friction (n) values that would be achieved after channel clearing and trimming. The general lowering of the water surface would result in some reduction in channel storage and, therefore, some increase in peak outflow. This secondary effect is judged to have small effect on flood flows in the balance of the system because of time differences between the occurrence of the higher North Branch peak and the Canal peak. Profiles showing the reduction of the 10-year floodwater levels in the Canal system as a result of channel maintenance are shown in Appendix E.

Table 22

COMPARISON OF THE HYDROLOGIC EFFECTS[a] OF "OAKWOOD RESERVOIR" ON FLOODS OF VARIOUS RECURRENCE INTERVALS 1990 CONTROLLED EXISTING TREND LAND USE

Flood Recurrence Interval	Without Reservoir			With Reservoir		
	Peak Discharge Near S.60th St. CFS	Peak Discharge at STH 38 Near Racine CFS	Peak Flood Stage at STH 38 Near Racine MSL	Peak Discharge Near S.60th St. CFS	Peak Discharge at STH 38 Near Racine CFS	Peak Flood Stage at STH 38 Near Racine MSL
100-Year	7,800	8,400	592.9	4,700	6,800	592.5
25-Year	5,200	5,600	591.5	3,200	4,600	591.0
10-Year	4,000	4,300	590.3	2,300	3,400	589.8
5-Year	3,000	3,300	589.3	1,800	2,600	588.7

[a] *Discharges and stages shown do not reflect the effects of probable enlargements in bridge waterway openings concomitant with urbanization and of scheduled channel improvements.*

Source: Harza Engineering Company.

SUMMARY

The preparation of sound, long-range, comprehensive watershed development plans requires information on the range of river performance that may be expected over a period of time and under differing land use conditions. As suitable historical records of sufficient duration were not available, it was necessary to use other measurable information to construct a hydrologic model capable of simulating the performance of the watershed drainage system. A hydrologic model of the Root River watershed based upon rainfall-runoff relationships and unit hydrographs for 52 sub-basins, stage-area-discharge curves for 104 bridge and culvert crossings, and flood routing channel-storage volume curves for 30 channel reaches was developed. This model was calibrated to represent actual river performance by use of the recorded flow hydrographs at the existing gaging stations and recorded historic high water marks.

After satisfactory calibration was achieved, elements of the model were adjusted to incorporate the hydrologic changes expected to occur as a result of urbanization. The adjustments were based upon three assumptions, the validity of which were indicated by both analysis and experience: first, that the total volume of runoff from future snowmelt based floods will not be changed significantly by urbanization since the generally frozen or saturated soil conditions attendant to such floods approximates a highly impervious surface over the entire watershed; second, that the rate at which runoff is transported to the main stream channels will be substantially increased by urbanization, since attendant pavement and storm sewer improvements will result in higher peak, shorter time base flows; third, that the total volume of runoff from summer rainfall will increase with urbanization because of the attendant increase in impervious area within the watershed. This increase will be partially compensated for, however, by the greater retention capability of soils under urban lawn cover as compared to such soils under agricultural crop cover.

Model operations indicated that urbanization will cause a 30 percent increase in the peak flows of snowmelt-rainfall floods and a greater than 70 percent increase in the peak flows of summer rainfall floods. The summer rainfall flood peaks, however, even though greatly increased by urbanization, remain substantially less than those of snowmelt-rainfall floods of comparable recurrence intervals.

Intensive study was made of the effects of urbanization and stream-channel enlargement on summer rainfall flood flows in the upstream portion of the North Branch channel. It was found that channel deepening and enlargement can cause up to a 60 percent increase in flood peaks at downstream locations because of reduction of temporary storage of water on the river flood plain.

The hydrological model also was modified to represent the effects of structural flood control measures on the performance of the river system. Channel enlargements in the North Branch could reduce the flood hazard locally but would increase flood peak flows in reaches immediately downstream. A flood-storage reservoir at the confluence of the North Branch and the Root River Canal would decrease peak snowmelt-rainfall flood stages in the City of Racine by only 0.4 foot. Bypass channels to Lake Michigan would lower flood stages in Racine almost to or below the zero damage stage. Channel clearing in the Root River Canal system would substantially reduce but not completely eliminate summer flooding of cropland.

Chapter VII
FLOOD DAMAGES

INTRODUCTION

Flooding, as a problem, has developed in the Root River watershed as a consequence of the failure to recognize and understand the relationship between the use of land and the behavior of the river system. Flood damages stem from inappropriate use of land in the river flood plains, together with development-induced changes in the hydrologic regimen of the watershed. Watershed planning is the first step in achieving or restoring the most beneficial, balanced use of the land in the riverine areas of the watershed through public acquisition, land use control, and river engineering.

Flood-damage potential and flood risk have grown from a nuisance level during predominantly agricultural occupation of the watershed to substantial hazard proportions as urban land use has increased. Practically all of the present flood risk can be ascribed to unnecessary residential occupation of the river flood plain—unnecessary since adequate alternative locations are available for residential use. Nevertheless, such residential occupation of the flood plain is continuing to increase as urban development proceeds within the watershed. Most of the flood plain, however, is as yet unoccupied by flood-vulnerable uses; and the opportunity still exists for limiting flood risk by means of public acquisition and sound land use control.

FLOOD DAMAGE HISTORY

Flood damages caused by the Root River have varied widely in character, intensity, frequency, and duration along the perennial channels of the river system. Urban and public-sector damages have been caused principally by snowmelt-rainfall floods in the spring, while practically all agricultural damages have been caused by summer rainfall floods. A necessary first step in any sound analysis of present and future flood risks in a watershed is a flood damage survey. Such a survey was conducted jointly by SEWRPC and Harza Engineering Company in the Root River watershed in the autumn of 1964 using personal interview survey techniques.

Flood Damage Survey

Because of the extreme variation possible in flood damages within the watershed, it was decided to attempt generally to obtain complete coverage in the flood damage survey and to use sampling techniques only in concentrated areas wherein large numbers of individual properties could be expected to experience similar damages. Prior to the conduct of the survey, methods and questionnaire forms were discussed with Mr. Louis D'Alba, Chief, Flood Control Section, U. S. Army Corps of Engineers, Chicago District; and with Mr. Gale Ewald, Economist, U. S. Soil Conservation Service, Madison.

The questionnaire forms prepared for, and used in, the Root River flood damage survey are shown in Appendix J. The primary purpose of the questionnaires was to obtain sufficient information on flood damages to allow accurate reconstruction of monetary losses in terms of current dollar values. The forms were also designed to solicit hydrologic information, such as maximum height of water, time of crest, and duration of flooding, for use in the hydrologic studies. Questionnaires were filled out by experienced engineers during personal interviews with the owner or resident of the damaged property or with appropriate public officials.

The field survey operations were divided into three sectors: public property and utilities, agricultural, and residential-commercial. Public-sector damage data was obtained through personal interviews with public officials of each municipality and governmental agency affected by Root River floods. These officials also furnished information on the location, degree, and frequency of private-sector flood damages in their communities. Since very little damage was done to utilities, information from this sector and from relief agencies was obtained by letter and telephone interview. A 100 percent sample was thus obtained of the public property and utility damage.

Personal interviews were conducted with 102 farm owners and lessors representing an approximately 85 percent sample of the probable damagees and a 90 percent sample of the area of probably damaged farmland in the flood plain. Farmers were questioned as to direct damages to crops, livestock, equipment, buildings, and other property; damage resulting from erosion and sedimentation; and the decreased profitability of land use because of the flood hazard. Results of the interview discussions were entered on the questionnaire forms, and inundation lines were delineated on prints of 1" = 400' scale SEWRPC aerial photographs.

Private, nonagricultural flood damages in the Root River watershed have been almost exclusively confined to residential property; and the survey of this sector was planned accordingly. Three basic categories of residential flood damage were used as a basis for establishing three sampling rate objectives as follows:

1. Direct overflow and inundation of buildings above the ground level—100 percent sample rate.

2. Inundation limited to lawns and grounds—20 percent sample rate.

3. Sewer back-up or seepage through walls and floors resulting in basement flooding—20 percent sample rate.

In isolated drainage areas or areas containing relatively few damaged properties, a 100 percent sampling rate was set as an objective.

Residential damage interviews were preceded by news media releases advising residents of the time and purpose of the interviews. If prospective interviewees were absent, attempts were made to contact them through return calls or by telephone. Information was obtained from neighbors in cases where a damagee had moved away and could not be located or in cases of death. In all, 179 residential damage interviews were completed, distributed geographically as shown in Tables 23 and 24.

Evaluation of Flood Damage Survey Results

The field data entered on the interview forms and aerial photographs were reviewed immediately after completion of the interviews and converted into a consistent form suitable for economic analysis. Conversion was necessary since most of the interviews resulted in information on the extent and type of physical damage incurred by the damagees. Some of the interviews, however, resulted in information on the actual costs of the damages, while in a few instances the interviews resulted only in information on the flooding characteristics.

Table 23

RESIDENTIAL FLOOD DAMAGE INTERVIEW DISTRIBUTION BY MUNICIPALITIES

Municipality	Interviews
City of West Allis	19
City of Greenfield	23
Village of Greendale	2
Village of Hales Corners . . .	1
City of Franklin	8
City of Oak Creek.	10
Town of Raymond	5
Town of Caledonia.	12
Town of Mount Pleasant	1
City of Racine	98
Total	179

Source: Field surveys by Harza Engineering Company and SEWRPC.

Generally, public officials were able to provide accurate costs of damages to public facilities which could be accepted without adjustment. Private-sector cost quotations were reviewed and adjusted as necessary. Where data on the extent and type of physical damage were available, these were converted to monetary values with a cost schedule based on average regional prices. If neither cost quotations nor the exact nature of the physical damage were available, empirically derived cost tables obtained from the U. S. Soil Conservation Service were used to compute probable monetary loss from the depth of inundation. These tables are reproduced in Appendix K and, in several instances in which both flood inundation data and individual cost quotations were provided, were found to compare satisfactorily with the quoted damage costs for the various depths of inundation.

Many possible sources of error and inaccuracy necessarily exist in any flood damage survey and must be guarded against during the conduct of the interviews and in the interpretation and application of resulting data. The principal factors which may have adversely affected the accuracy of the Root River flood damage survey are:

1. A high rate of change in ownership between the time of the flood and the time of the damage survey, especially in high damage reaches. Present owners of damaged units were often found to be unaware of past flood damage. Former owners were difficult to find and were sometimes uncooperative as they retained little interest in the affected property.

2. Absentee ownership of about 10 percent of all private units damaged. Absentee own-

ers were generally unresponsive to mailed inquiries.

3. A relatively long period of elapsed time since the last major flood event and damages. With the passage of time, private damagees who had not documented damages sustained may have forgotten entirely or may inaccurately recall past events.

4. Under-reporting of damages because of fear of depreciation. This was particularly apparent among owners who were subdividing farmland or trying to sell urban dwellings.

5. Unestablished repair costs. Some damaged properties were not restored to preflood condition, so that repair costs were not representative of damage.

6. Unrecognized damages. It was apparent that some owners failed to recognize all damages sustained, particularly certain indirect damages.

7. Damagee unprepared. Although urban and rural newspapers and other means of communication were used to announce the conduct and purpose of the survey, many damagees were found to be unaware of, and unprepared for, the actual interviews.

It is important to note that all of the above factors will tend to cause under-reporting of actual damages, resulting, therefore, in conservatively low damage estimates.

Flood-Damage Characteristics in Municipalities of the Watershed

West Allis, Milwaukee County: The Root River

Table 24

RESIDENTIAL FLOOD DAMAGE SURVEY SAMPLING RATES

Damage Area and Type of Damage	Number of Probable Damaged Units	Number of Completed Interviews	Actual Sampling Rate (percent)
North Branch Area			
Surface Overflow	50[a]	19	38
	16[b]	16	100
	14[c]	7	50
Seepage and Back-Up	19	9	69
Miscellaneous	2[d]	2	100
Subtotal	*101*	*53*	--
Main Stem Area			
Surface Overflow and Sewer Back-Up	33[e]	27	82
City of Racine Area			
Surface Overflow	62[f]	40	64
Surface Overflow (special)	1[g]	1	100
Seepage and Back-Up	268	57	21
Subtotal	*331*	*98*	--
Canal Area			
Surface Overflow	1	1	100
Total	466	179	39

[a] *Primarily lawn damage in West Allis.*

[b] *Basement and first floor damage in Greenfield.*

[c] *Primarily lawn damage in Greenfield.*

[d] *Damage to airport and stone quarry.*

[e] *Includes six homes that have since been razed.*

[f] *Heavy move-outs prohibited 100 percent interview sample.*

[g] *Exceptionally high damages due to combined industrial and residential use.*

Source: Field surveys by Harza Engineering Company and SEWRPC.

flows through a parkway for most of its approximately 1.75 mile length within the City of West Allis. Flood damages to residential property occur frequently, however, in locations where the parkway is not wide enough or the channel not deep enough to contain flood flows. Historic flood damage has consisted primarily of basement flooding except for minor damage to several parkway bridges during the 1960 flood. Significant basement flooding occurred in July 1955, March-April 1960, August 1960, and July 1964. The field damage survey indicates that 50 residential units have periodically experienced flood damage.

The present city zoning ordinance requires that the lowest floor elevation of any building in the area designated "Root River Valley District" must be at least three feet above the controlling high water elevation, which is the maximum observed high water elevation during the period 1938-1948.[1] Many of those residences suffering flood damages were built either before this provision of the zoning ordinance was adopted or are located in an area recently annexed to the city. It was discovered by a comparison of flood stages that the official restricting elevation was in places slightly lower than the height attained by the March-April flood of 1960. However, the comparisons revealed that the restricting elevation adopted in the zoning ordinance was generally adequate. (See Table 25 and Figure 26)

[1] *Section 4.11 of the City of West Allis zoning ordinance (city ordinance number 2643) entitled, "Root River Valley," provides: "Within the area shown and designated on the Zoning Map as 'Root River Valley' no building or structure shall be erected, and no existing building or structure shall be moved unless the ground upon which said building or structure is to be erected and ten (10) feet beyond the limits of said building or structure shall, prior to or at the time of construction, be raised to such level that the main floor of said building or structure shall be not less than three (3) feet above the high water level as shown on the Zoning Map. No basement floor or other floor shall be constructed below or at lower elevation than the main floor."*

City of Greenfield, Milwaukee County: The entire Root River channel length of approximately 2.75 miles within the City of Greenfield is either developed as parkway, with an average width considerably greater than in West Allis, or reserved for eventual parkway development. The parkway width is relatively narrow between W. Layton Avenue and W. Forest Home Avenue, however; and severe residential flooding has been experienced in this reach. The damage survey indicates that 30 residential units have probably experienced flood damages during the maximum flood of record.

The City of Greenfield zoning ordinance contains similar provisions to that of the City of West Allis in which the lowest floor elevation of any building must be at least three feet above controlling high

Table 25

WATER SURFACE ELEVATIONS[a] SET BY ZONING AND REACHED UNDER FUTURE AND HISTORIC FLOODING

Location of Station	Flood Elevations Occurring Under 1990 Land Use					
	Control[b] Elevation of Local Zoning Ordinance	10-Year Flood With City of Greenfield Channel Improvements	10-Year Flood Without City of Greenfield Channel Improvements	100-Year Flood With City of Greenfield Channel Improvements	100-Year Flood Without City of Greenfield Channel Improvements	Maximum Elevation of 1960 Flood
City of West Allis						
W.Lincoln Ave.	750.6	749.0	749.0	750.6	750.6	755.2
W.Arthur Ave.	745.6	744.9	744.9	746.8	746.8	752.0
W.Cleveland Ave.	740.4	734.2	734.2	735.7	735.7	741.6
S.Wollmer Rd.	732.6	729.0	729.0	731.5	731.5	735.1
W.Oklahoma Ave.	730.6	726.8	726.8	729.5	729.5	734.4
S.116th St.	728.8	726.4	726.4	729.4	729.4	732.2
W.Morgan Ave.	726.4	726.1	726.1	729.3	729.3	730.0
City of Greenfield						
W.Beloit Rd.	724.7	724.0	724.0	727.1	727.1	728.2
S.108th St.(STH 100).	723.9	723.8	723.8	726.3	726.3	727.2
Cold Spring Rd.	721.9	723.0	723.0	723.7	725.1	724.5
W.Layton Ave.	719.2	719.4	720.7	720.7	723.6	721.7
W.Forest Home Ave.	719.1[c]	713.5	718.0	715.8	720.7	719.0

[a] *All elevations are for upstream side of bridge at stations shown and in feet above mean sea level.*

[b] *Floor of dwelling or basement required to be constructed at least three feet above this elevation.*

[c] *Unlike other control elevations which are set on basis of 1938-48 observed high water levels, this elevation is reportedly based on 1960 high water level at site.*

Source: Field surveys by Harza Engineering Company and SEWRPC.

water elevations.[2] Damage has been especially severe to residences antedating the ordinance. Again, as in the City of West Allis, the restricting elevations were found to be generally adequate. (See Table 25.)

The City of Greenfield has had no flood damage of significance in the public sector.

Village of Greendale, Milwaukee County: Along its entire length of approximately four miles within the Village of Greendale, the riverine area is developed as a parkway. Flood damage to public property has been negligible. In March 1960 the river backed water through the outfall sewer into the municipal sewage treatment plant temporarily interrupting plant operation but causing no physical damage. During this same flood, the S. 76th Street and W. Loomis Road bridges were overtopped for a few hours; but no significant damage resulted.

A small amount of residential damage, principally basement flooding, has been experienced near S. 92nd Street and near W. Loomis Road. The damage survey indicated that four residential units have probably experienced damage.

Village of Hales Corners, Milwaukee County: Although there are no perennial channels of the Root River in the Village of Hales Corners upstream from Whitnall Park, the village does have minor local flooding problems. The W. Parnell Avenue and S. Kurtz Road bridges, crossing non-perennial tributaries of the Root River, were overtopped in March 1960. According to village officials, no residential damage attributable to the Root River itself has been experienced.

City of Franklin, Milwaukee County: Although a developed parkway does not exist in the City of Franklin at this time, most of the land adjoining the approximately six miles of main channel has been acquired by the Milwaukee County Park Commission for future parkway development. A small group of residential units near the northern edge of the city has experienced flood damage. These properties will, however, be acquired by the Park Commission.

[2] *Section 5.304 of the City of Greenfield zoning ordinance (city ordinance number 271) entitled, "F-1 District," provides: "a) With the exception of structures used for boating, no building may be altered or erected whose lowest floor level is less than three feet above the highest anticipated seasonal surface water level, as shown on the zoning map. b) The foundations of all structures in an F-1 District shall be designed to withstand possible flood conditions on the area."*

Agricultural flood damage has occurred frequently at the junction of the North and South Branches near S. 60th Street and W. Oakwood Road. This area is also being acquired by the Milwaukee County Park Commission. The Rainbow Airport located west of the river between W. Ryan Road and W. Oakwood Road has experienced flooding of the runways almost annually and damage to facilities and airplanes during 1960 and 1962.

Public-sector flood damage has been limited to overtopping of bridges and roads at the following locations: W. Oakwood Road (almost annually), W. Drexel Avenue between S. 35th and S. 51st Streets (tributary), W. County Line Road near S. 46th Street extended, and S. 60th Street.

City of Oak Creek, Milwaukee County: Extensive inundation occurred in 1960 on low-lying land between Nicholson Road (S. Pennsylvania Avenue) and 15th Avenue. This inundation extended northward to join inundation caused by a simultaneous flood on Oak Creek. Since most of the inundated area is marshland, little physical damage resulted.

Some damage has occurred to roads and bridges, with S. 27th Street, S. 13th Street, and Nicholson Road being overtopped in March of 1960. Physical damage, however, was slight.

Substantial residential damage occurred during the March 1960 flood in the vicinity of S. 27th Street, S. Howell Avenue, Elm Road, and Nicholson Road. The damage survey indicated that ten residential units experienced flood damage.

Towns of Yorkville and Raymond, Racine County: Flood damage in this area has occurred mostly to agricultural crops and farming operations. Many low-lying areas are inundated each year in late winter or early spring at the time of snowmelt. This inundation usually occurs before plowing and planting and consequently causes little damage. Summer floods have occurred in seven of the last 29 years, and these floods have caused varying amounts of crop damage to farmland adjacent to the river. About 260 acres of cropland have been affected by floods in this area.

Very little damage has been done to buildings and equipment since farmhouses and buildings are almost always located on high ground away from the river. Some farm bridges across the river have been damaged, however. No instance of flood damage to farm drainage facilities was reported.

Towns of Caledonia and Mount Pleasant, Racine County: At the present time, most of the land adjacent to the river is under agricultural use; but both towns are beginning to receive an influx of residential development. Much of the land immediately adjacent to the river is forested.

Agricultural damages in this reach are presently small, with damages reported only for summer 1964 and spring 1960. Testimony presented in a hearing on the alleged effects of Horlick Dam on floodwater levels, held in 1946, indicates that floods occurred in 1921, 1924, 1938, 1940, and 1942. These floods inundated farmland between Horlick Dam and Johnson Park. It is interesting to note that farm residents in this area when interviewed during the 1964 flood damage survey indicated that they had no particular flood problems. Land in this particular area is being rapidly converted to residential use.

Substantial residential damage occurred in the reach between Horlick Dam and Johnson Park in spring of 1960. A number of additional residential units have been built in the 1960 flood-inundation zone since the 1960 flood.

Damage to public property in this reach of river has been minimal, although references were made to bridges and roads which had occasionally been overtopped. It was apparent, however, that some bridges have been replaced in recent years; and usually the new bridges have higher clearance and larger waterway openings.

Local reports indicate that Horlick Dam has been gradually deteriorating, but it is not possible to determine specific damages caused by any particular flood. Two footbridges in the Racine Country Club golf course were destroyed by the spring 1960 flood.

City of Racine, Racine County: The greatest historic concentration of flood damage caused by the Root River occurred in the City of Racine in March-April 1960. The river often develops ice jams within the City of Racine at the time of the spring thaw, but these have not historically caused physical damage. In spring 1960, however, very high discharge, unaffected by ice, caused flooding from the Racine city limits to Lafayette Street. Flooding of park areas caused no damage. At locations where residential development adjoins the river banks, however, severe overflow damages resulted.

The largest damage area was comprised of 12 contiguous city blocks bounded by Spring Street, Freres Avenue, Rupert Boulevard, and the Root River. Substantial damages also occurred to residences on Parkview and Liberty streets, and minor damage occurred on the right bank upstream from the Lafayette Street Bridge. In all, probably 62 residences were affected by direct overflow; and 268 residences experienced basement flooding due to seepage and flood-related sewer back-up. Since the 1960 flood, however, one of the factors contributing to basement flooding has been removed with the construction by the City of Racine of a new sanitary sewage pumping station at Spring Street and the Root River.

COST OF FLOOD DAMAGES

Selection of alternative watershed development plans must be based, in part, upon consideration of the economic benefits and costs of each alternative. Flood protection benefits are equivalent to the cost of flooding, or flood losses, that would be alleviated through implementation of a particular plan. The historical flood losses derived from the flood damage survey are used as a basis for calculation of present flood risk and for protection of future flood risk associated with each alternative watershed plan.

Definitions

Flood damage is the physical deterioration or destruction caused by floodwaters. The term flood loss refers to the net effect of the flood damage on the regional economy and is usually expressed in monetary terms.

All losses resulting from a flood or the risk of flood can be broadly classified as direct, indirect, depreciation, and intangible. Reduction of flood risk by flood-protection measures creates benefits equal to the damages protected against, and these benefits can be similarly classified as direct, indirect, depreciation, and intangible. To assure full compatibility with the practices of any federal agencies which may be asked to assist in the implementation of the selected watershed plan, the definitions used in the planning studies are consistent with those used by the U. S. Corps of Engineers and the U. S. Soil Conservation Service. The four major flood loss categories are accordingly defined as follows:

1. Direct losses are defined as monetary expenditures required or which would be required to restore flood-damaged property

to its preflood condition. Also included is the net potential value of farm crops destroyed by flooding.

2. Indirect losses are defined as the net monetary cost of flood fighting, floodproofing, and flood-caused loss of wages, sales, and production. Increased cost of carrying on normal operations during periods of flood disruption and increased cost of transportation because of flood-caused detours are also defined as indirect losses. Indirect losses, although often difficult to determine with accuracy, nevertheless constitute real monetary losses to the economy of the Region.

3. Depreciation losses are defined as the reduction in the value of real property when the risk of flooding becomes known. Property values after a flood are reduced by the probable amount of money which will have to be expended for future flood repairs. This being the case, depreciation losses should be equal to the probable direct losses from future floods. Depreciation losses are difficult to define in monetary terms, however, because the economic value of depreciation depends not only on actual direct flood losses but also on public attitudes, time elapsed since the last major flood, the vagaries of human memory, and the information available to prospective buyers. When damaging floods are infrequent, many residents or buyers of residential property in a potential damage area are unaware of flood risks; and, consequently, flood risk may not actually enter into the establishment of property values. This is indicated by the fact that depreciation effects are marked immediately after a damaging flood and then generally decrease with time. Experience in the residential area of Racine within the Root River flood plain bears out this diminishing depreciation effect.

   Because of the difficulty and uncertainty in assigning a monetary value to depreciation losses, these losses were not included in the economic analyses. The direct flood losses, which are another means of determining the depreciation, were instead evaluated and included in the economic analyses of the alternative watershed plans.

4. Intangible losses are defined as losses which cannot be measured in monetary terms. Intangible losses caused by floods range from loss of life to minor inconvenience and include health hazards, interruption of schooling, loss of fire protection, and severe mental aggravation. It is significant to note, however, that in the course of the flood damage surveys many damagees declared that the intangible damages, such as mental aggravation, were the most severe flood damage they experienced—monetary costs notwithstanding.

Flood damages may also be classified on the basis of ownership into public-sector and private-sector losses. Private-sector losses can be further subclassified into residential-commercial losses and agricultural losses. A summary of these losses in the Root River watershed is shown in Table 26.

Public-Sector Losses

The costs of flood damages to public property, utilities, and relief agencies were generally accepted as reported in the flood damage survey without adjustment. Direct losses included road and bridge repairs, basement pumping, and flood cleanup operations. Indirect losses include highway traffic rerouting and control, blasting of ice jams, relief and health services, and train rerouting. In evaluating flood costs resulting from public flood-connected labor charges, only the cost of overtime pay was included.

An important indirect loss accompanying flood closure of streets and highways is the road user detour cost. This cost was calculated on the basis of traffic volume, detour length, time of closure, and average per-mile vehicle operation cost over the normal route and over the detour. The incremental cost of using the detour was taken as the flood loss. The three-day closure of USH 41 (IH 94) in March-April 1960 created by far the greatest detour cost attributable to Root River floods. The estimated traffic volume on the route was 15,800[3] vehicles per day, of which 15 percent was truck traffic. The extra travel length imposed by the flood closure was five miles on poorer quality roads, resulting in an incremental road user cost of $58,400.[4] Detour costs resulting from closure of STH 38 were

[3] *Traffic volume data obtained from SEWRPC Regional Land Use-Transportation Study.*

[4] *Vehicle operating costs from AASHO "Road User Benefit Analysis for Highway Improvements."*

similarly estimated to be $3,000. Detour costs of other road closures were so much smaller that it was decided to lump them at $4,000, resulting in an overall total detour cost of $65,000 for the 1960 flood. The future flood risk attributable to detours will be greatly reduced, however, when IH 94 is carried over the Root River on new bridges not subject to flood closure and the present highway is used only for local traffic. Public-sector flood losses incurred during the 1960 flood are summarized in Table 26 and are reported in detail in Appendix K. Roads and bridges reported to be closed to traffic during the flood of March-April 1960 are listed in Table 27.

Private-Sector Losses

Residential and Commercial Flood Losses: Flood damage survey data on residential and commercial land uses were summarized in three general categories: reported costs, physical damages, and floodwater elevations. When detailed cost tabulations were obtained from a damagee in the flood damage survey, they were used directly or with minor adjustment. Although there were few reports with sufficient detail on costs for such direct use, these few reports nevertheless served well as checks on the methods used to compute costs when only data on physical damage were available.

Data on actual damage costs were not obtained in most of the field interviews; and, in many cases, the exact extent of the physical damage could not be recalled by the damagee. If the major items of physical damage could be recalled, however, a generally good reconstruction of the actual monetary damages was possible. In cases where neither cost nor physical damage data could be recalled by the damagee, empirically established tables, prepared by the U. S. Soil Conservation Service, relating property value, height of water, and flood damage were used to reconstruct flood costs. These tables were spot-checked against recorded damages in the Root River watershed and found to be in substantial agreement. The tables used are reproduced in Appendix K.

Indirect losses were calculated on the basis of $25 per day per household for lost wages and $6 per day per person for temporary accommodations if evacuation was necessary. As already noted, no monetary allowance was made for depreciation unless a complete change in land use re-

Table 26

MAXIMUM REPORTED FLOOD LOSS FOR A SINGLE YEAR[a] IN THE ROOT RIVER WATERSHED

Flood Zone	Public Sector	Private Sector: Residential & Commercial	Private Sector: Agricultural	Total
City of West Allis.	$ 4,000	$ 25,600	$ 0	$ 29,600
City of Greenfield.	400	28,900	0	29,300
Village of Greendale.	100	1,800	0	1,900
Village of Hales Corners. . .	0	100	0	100
City of Franklin.	200	21,200	1,700	23,100
City of Oak Creek	200	3,300	0	3,500
State and County Highways . .	6,700	---	---	6,700
Subtotal, Milwaukee County	*$11,600*	*$ 80,900*	*$ 1,700*	*$ 94,200*
Town of Yorkville	0	0	400	400
Town of Raymond	0	14,300	12,100	26,400
Town of Caledonia	2,500	17,100	800	20,400
Town of Mount Pleasant. . . .	0	7,000	0	7,000
City of Racine.	6,000	159,100	0	165,100
State Highways and Railroads.	8,200	---	---	8,200
Subtotal, Racine County	*$16,700*	*$197,500*	*$13,300*	*$227,500*
Detour Costs.	65,000	---	---	65,000
Total	$93,300	$278,400	$15,000	$386,700

[a] *March-April 1960 for Public Sector and Residential and Commercial; Summer 1964 for Agricultural.*

Source: Field surveys by Harza Engineering Company and SEWRPC.

Table 27

ROADS AND BRIDGES CLOSED TO TRAFFIC MARCH - APRIL 1960 FLOOD IN THE ROOT RIVER WATERSHED

Road	Location		Estimated Closure Time (days)
STH 15	In the City of:	West Allis, Root River	0.5
S.116th St.		West Allis, Root River	0.5
CTH V (S.13th St.)		Oak Creek, Root River	2.0
Nicholson Rd.		Oak Creek, Root River	2.0
S.60th St.		Franklin, Root River	3.0
W.Oakwood Rd.		Franklin, Root River	3.0
W.Drexel Ave.		Franklin, Root River	1.5
Five Mile Rd.	In the Town of:	Caledonia, Root River	1.0
Seven Mile Rd.		Caledonia, Root River	1.0
S.43rd St.		Raymond, Root River	3.0
Seven Mile Rd.		Raymond, Root River Canal	2.0
Five Mile Rd.		Raymond, Root River Canal	0.5
Three Mile Rd.		Raymond, East Branch	1.5
Three Mile Rd.		Raymond, West Branch	1.0
Two Mile Rd.		Raymond, West Branch	1.0
CTH G (Six Mile Rd.)		Raymond, Root River Canal	1.0
50th Rd.		Yorkville, East Branch	1.0
55th Dr.		Yorkville, East Branch	0.5
58th Rd.		Yorkville, East Branch	0.5
60th Rd.		Yorkville, East Branch	0.5
50th Rd.		Yorkville, West Branch	1.0
58th Rd.		Yorkville, West Branch	0.5
STH 20		Yorkville, West Branch	0.5
CTH A.		Yorkville, West Branch	0.5
STH 36	In the Village of:	Greendale, Root River	0.5
CTH V (S.76th St.)		Greendale, Root River	0.5
USH 41 (IH 94)	Near Racine-Milwaukee County Line, Root River		3.0
STH 38	Near Racine-Milwaukee County Line, Root River		2.0
W.County Line Rd.	West of USH 41 (IH 94), Root River		2.0

Source: Field surveys by Harza Engineering Company and SEWRPC.

sulted. Depreciation in the flood hazard area was investigated, however; and data and opinions were obtained from property owners, real estate agents, and tax assessors. Data collected on actual sale prices subsequent to the 1960 flood indicate a decrease in some property values and an increase in others. This inconsistent behavior is most probably due to a lack of awareness of the flood hazard by the buyer.

The analysis of commercial property flood loss was similar to the analysis of residential property flood losses. Damage to commercial property resulting from Root River flooding has been very slight. Principal damages have been to the airport operation in the City of Franklin, to a grocery store in the City of Racine, and to several gravel pits.

Residential and commercial flood damages incurred during the 1960 flood are also summarized in Table 26.

Agricultural Flood Losses: Agricultural flood damages were found to consist almost entirely of damage to crops, with negligible damage to buildings and equipment. Although the monetary value of crop losses was requested from the damagee during the interviews, all crop damage costs ultimately used in the economic analyses were adjusted or calculated.

The monetary loss from flooding of a crop varies with the date of flood occurrence, the duration of flooding, the depth of flooding, and the type of crop. Velocity of floodwaters was not found to be a significant damage-producing factor in the Root River watershed because of the low gradients. An early flood allows time for replanting of a crop the yield of which may be equal to that of the crop destroyed, with only the cost of replanting representing a flood loss. A mid-season flood may allow the production of a lesser value crop, such as hay. Late season floods shortly before harvest may cause a complete loss with no opportunity for recovery but "save" the expense of harvesting. Floods occurring prior to planting or after harvest cause practically no damage except for possible land damage from erosion or deposition.

Truck crops, such as cabbage and potatoes, can be severely damaged by only a few inches of standing water, especially if air temperatures are high during and immediately after flooding. Oats and soybeans can survive flood inundations which would destroy truck crops, but they are less flood tolerant than corn. Certain types of hay and pasture are very flood tolerant.

The general formula used to establish monetary crop loss in terms of present dollars is as follows:

Adjusted Monetary Loss =
full probable cash value of original crop -
costs not incurred in cultivation, harvest, and storage +
cost of all operations in producing, harvesting, and storing substitute crop -
market value of the substitute crop

Cost, yield, and market value tables used in the calculations are presented in Appendix K.

A frequent flood damage in the Root River agricultural areas is silt deposition on pasture crops, making them unpalatable to livestock. This situation is generally alleviated by the next rainfall, which cleans the crop. Where data were available, an attempt was made to assign a monetary value to this damage.

Agricultural flood damages sustained within the Root River watershed in several recent years are shown in Table 28. This tabulation represents unexpanded sample data, since it was not possible, from the data available, to determine the probable full extent of inundation or the specific agricultural land use in years prior to 1964 as a basis for sample expansion. The 1964 survey sample was expanded, however, as shown in Table 29; and the increase in damage cost to account for unsurveyed farms was found to be small. Agricultural flood losses in 1964 are also summarized in Table 26.

ANNUAL RISK OF FLOOD DAMAGE

Annual flood-damage risk is defined as the sum of the damage costs of floods of all probabilities, each weighted by its probability of occurrence. Thus, the 10-year flood damage is weighted 10 percent; the 50-year, 2 percent; and the 100-year, 1 percent. The annual flood-damage risk associated with each alternative watershed plan is useful as a basis for the comparison of the flood protection benefits of each alternative watershed plan and as a basis for the economic analysis of flood protection measures.

Table 28

ESTIMATED COSTS OF AGRICULTURAL FLOOD DAMAGES[a] IN THE ROOT RIVER WATERSHED
(Unexpanded Sample)

Stream and Reach	Estimated Damages								
	July 1964	Summer 1962	Spring 1960	Summer 1959	Summer 1956	July 1954	Summer 1950	Summer 1945	Summer 1936
Root River Canal, West Branch	$ 3,484	$--	$--	$ --	$--	$1,022	$--	$ --	$--
Root River Canal, East Branch	6,733	--	608	1,610	608	3,400	608	2,278	608
Root River Canal, Junction North to CTH G . .	501	--	--	--	--	--	--	--	--
Root River Canal to CTH G, Subtotal I	*10,718*	--	*608*	*1,610*	*608*	*4,422*	*608*	*2,278*	*608*
Root River Canal, CTH G to Junction Root River.	3,123	--	138	--	--	--	--	5,629	--
Root River Canal, Subtotal II	*13,841*	--	*746*	*1,610*	*608*	*4,422*	*608*	*7,907*	*608*
Upper Root River.	--	638	--	638	--	638	--	--	--
Middle Root River	875	--	50	--	--	--	--	--	--
Root River Subtotal	*875*	*638*	*50*	*638*	--	*638*	--	--	--
Total	$14,716	$638	$796	$2,248	$608	$5,060	$608	$7,907	$608

[a] *Costs shown are the result of direct physical damage to crops or livestock.*

Source: Field surveys by Harza Engineering Company and SEWRPC.

Stage-Damage Curves

Flood-damage costs generally increase with higher floodwater elevations, due both to greater depth of flooding and greater area of inundation. The relationship between flood-damage cost and floodwater elevation is defined by a stage-damage curve. Stage-damage curves, representing January 1, 1965, land use conditions within the watershed and projected 1990 land use conditions under uncontrolled development of the riverine areas, were prepared for each of nine river reaches in the urban portions of the watershed. Criteria governing the selection of the river reaches included a relatively uniform character of land use and relationship to the location of possible flood control structures.

Because of the sloping nature of the water surface through the fairly long damage reaches, it was decided to represent stage by increments above and below a known water-surface profile rather than by water-surface elevation at one point in the reach. The 1960 floodwater surface profile was selected as a convenient datum from which to measure damage stages. Thus, each damage stage is represented by a plane parallel to, and a specified distance above or below, the 1960 floodwater surface.

Table 29

ESTIMATED COSTS OF AGRICULTURAL FLOOD DAMAGES[a] RESULTING FROM FLOOD OF JULY 1964 IN THE ROOT RIVER WATERSHED (Expanded Sample)

Stream and Reach	Estimated Damages
Root River Canal, West Branch. .	$ 3,832
Root River Canal, East Branch. .	6,733
Root River Canal, Junction North to CTH G.	551
Root River Canal to CTH G, Subtotal I	*$11,116*
Root River Canal, CTH G to Junction Root River . .	3,435
Root River Canal, Subtotal II	*$14,551*
Upper Root River	--
Middle Root River.	998
Root River, Subtotal	$ *998*
Total	$15,539
Say	$15,000

[a] *Costs shown result from a sampling of the direct physical damage to crops or livestock, expanded to an estimated 100 percent.*

Source: *Field surveys by Harza Engineering Company and SEWRPC.*

Flood-damage costs for selected stages were calculated using the 1960 recorded flood damages as a basis. Cost calculations for the 1965 curves included consideration of the damage costs to individual properties for flooding depths greater or less than 1960 and prospective damage to structures built since 1960. Adjustments were made for reduction of damage potential in the period since 1960 by either the removal of structures or by floodproofing.

Forecasts of the prospective locations of individual structures which might be built in the flood plain by 1990 under uncontrolled conditions were made following the criteria for the preparation of the "uncontrolled existing trend" alternative land use plan element (see Chapter XII). Potential flood damage to these structures for various stages was calculated and added to the 1965 potential damage to obtain the 1990 stage-damage curves for uncontrolled land use development practices. The stage-damage curves used in the planning studies are shown in Figure 26.

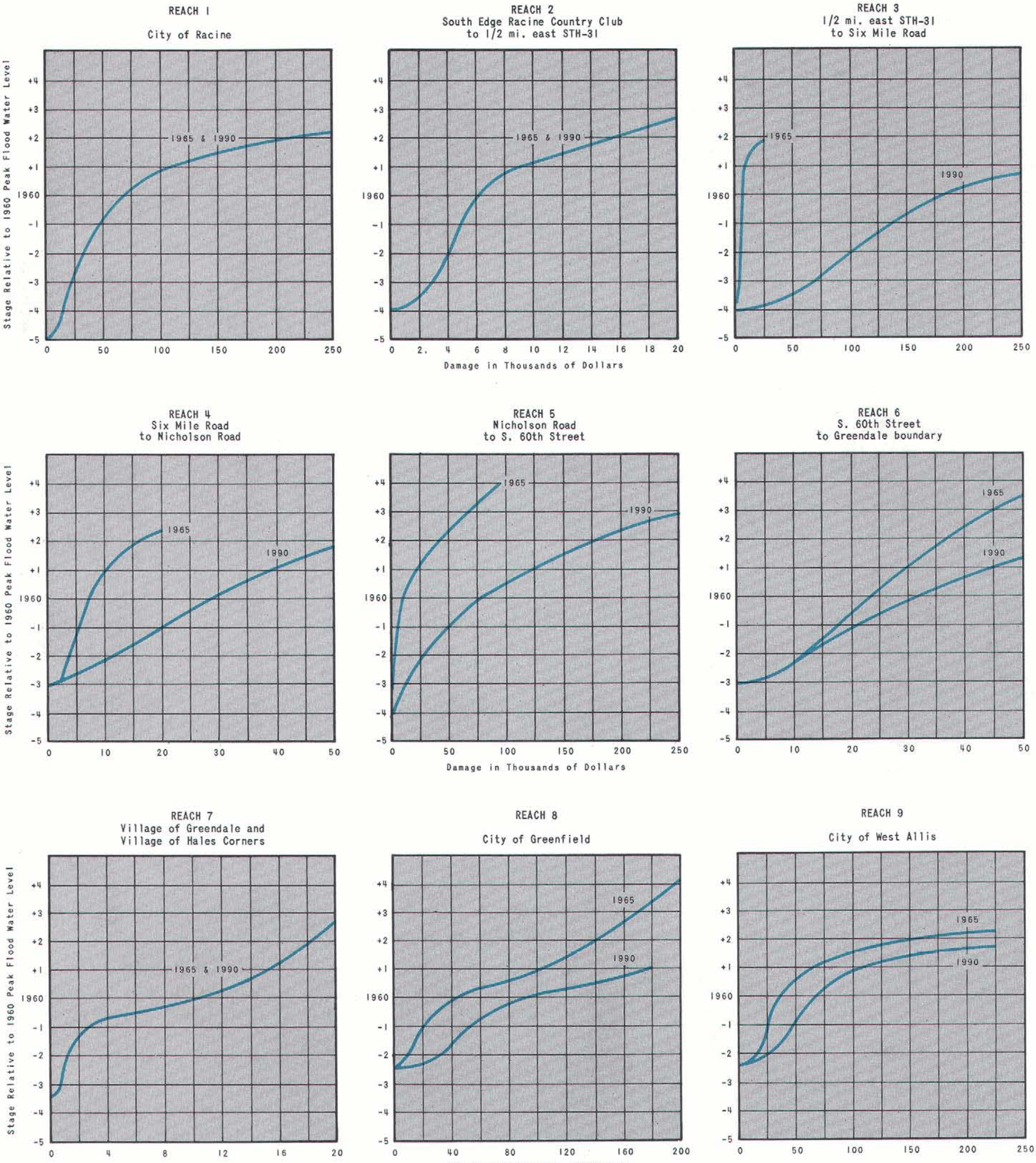
Damage-Frequency Curves

The frequency of a specific flood-damage total can be derived by combining stage-damage curves and stage-frequency curves. Flood-frequency relationships for 1965 and 1990 conditions were derived from the hydrologic model described in Chapter VI. These relationships were converted to stage-frequency by use of appropriate stage-discharge curves for each damage reach.

Damage-frequency curves were prepared by plotting the damage associated with a given stage against the frequency of that stage. Damage-frequency curves derived for each of the damage reaches for both 1965 land use conditions within the watershed and projected 1990 land use conditions under controlled development of the riverine areas are shown in Figure 27. The frequency of zero damage was established at 0.33, corresponding to a three-year recurrence interval flood, based on the absence of reported damages from recent floods of this approximate magnitude. The area under each damage-frequency curve is equal to the annual flood-damage risk in that reach. Total annual flood-damage risk in urban areas of

Figure 26

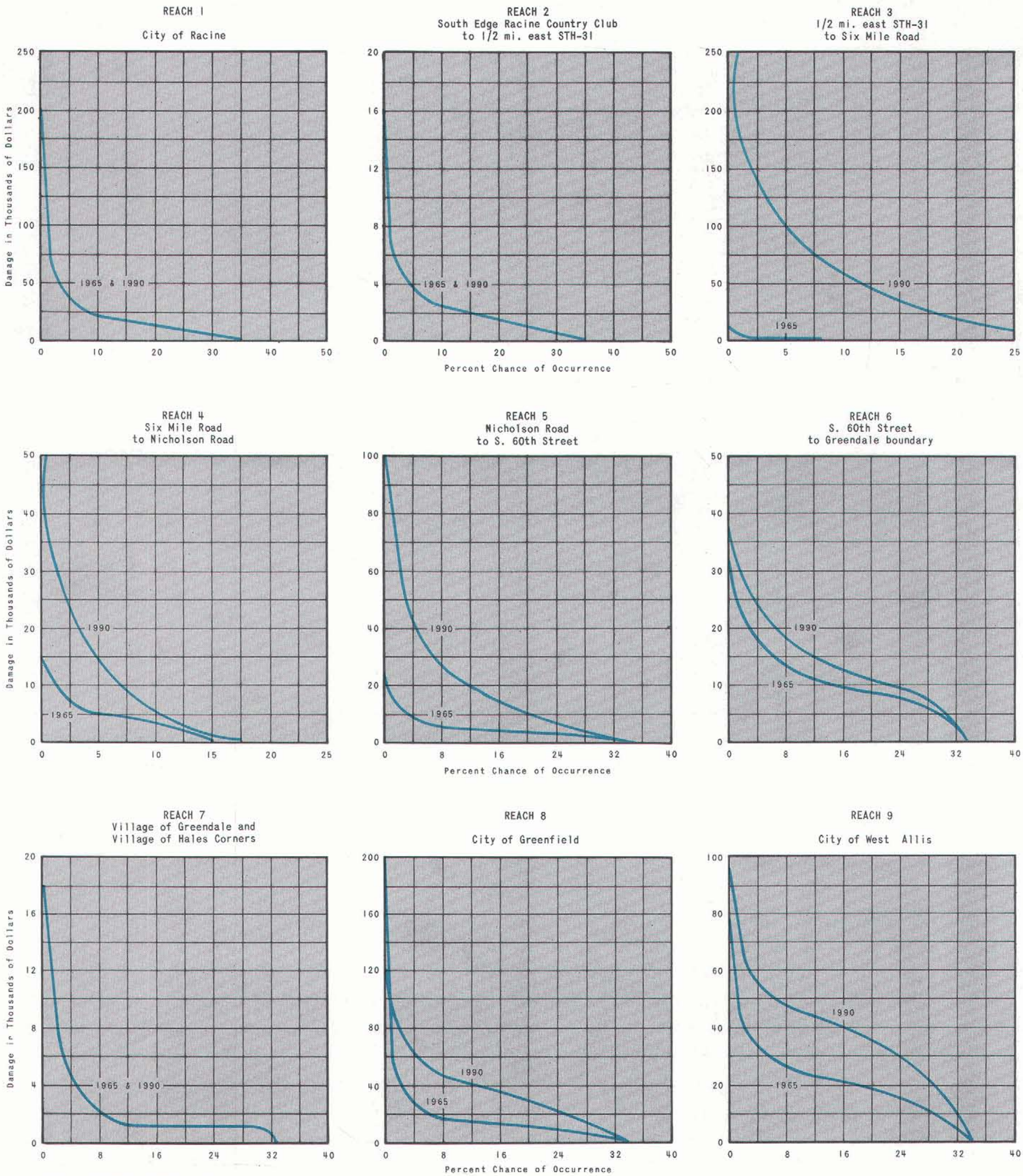
ROOT RIVER WATERSHED STAGE DAMAGE CURVES
EXISTING 1965 LAND USE AND PROJECTED 1990 LAND USE
UNDER UNCONTROLLED FLOOD PLAIN DEVELOPMENT



Source: Harza Engineering Co.

Figure 27

ROOT RIVER WATERSHED DAMAGE FREQUENCY CURVES
EXISTING 1965 LAND USE AND PROJECTED 1990 LAND USE
UNDER UNCONTROLLED FLOOD PLAIN DEVELOPMENT



Source: Harza Engineering Co.

Table 30

AVERAGE ANNUAL FLOOD DAMAGE RISK IN THE ROOT RIVER WATERSHED

Reach	Location	Annual Flood-Damage Risk	
		1965	1990[a]
1	City of Racine	$ 6,600	$ 6,600
2	South Edge Racine Country Club to 1/2 Mile East STH 31	710	770
3	1/2 Mile East STH 31 to Six Mile Road	250	15,900
4	Six Mile Road to Nicholson Road	650	1,830
5	Nicholson Road to S. 60th Street	760	6,630
6	S. 60th Street to Village of Greendale Southerly Limits	3,320	4,390
7	Villages of Greendale and Hales Corners	550	550
8	City of Greenfield	4,800	12,460
9	City of West Allis	6,200	11,900
Rounded Totals		$24,000	$61,000

[a] *Based upon projection of existing land use development trends.*

Source: Field surveys by Harza Engineering Company and SEWRPC.

the watershed is $24,000 for 1965 conditions and $61,000 for 1990 conditions under projected uncontrolled development trends. Values for individual reaches are shown in Table 30.

SUMMARY

An intensive survey of the historic flood damages which have occurred in the Root River watershed was conducted jointly by Harza Engineering Company and SEWRPC during the fall of 1964. Results of this survey reveal that within recent decades flood-damage potential and flood-damage risk have risen from a nuisance level to substantial proportions as urban land use has increased on the flood plains of the watershed. If existing land use development trends are allowed to continue unregulated in the riverine areas, the total annual flood-damage risk in urban areas of the watershed will increase from the current (1965) level of approximately $24,000 to $61,000 by the year 1990. About 95 percent of the potential damages are urban, and most of the urban damages occur to residences.

The flood of March-April 1960, the greatest flood of record within the watershed, caused total monetary damages of $371,700. Approximately 25 percent of the total monetary losses were inflicted upon public property and 75 percent upon private nonagricultural property. Private residential damages in excess of $20,000 in aggregate occurred in the upper urbanizing portions of the watershed—in the cities of Greenfield, West Allis, and Franklin—and at the urbanizing mouth of the river in the City of Racine, which alone suffered residential damages of $159,100. Monetary flood damage was caused about equally by direct overflow floodwater and by floodwater infiltrating through basement walls and backing into basements through drainage and sewer facilities.

The summer flood of July 18 and 19, 1964, occurring at the peak of the growing season, was the record flood in terms of agricultural damages, causing total damages of $15,000 to crops in the Root River Canal area and along the main stem of the Root River. The magnitude of agricultural flood-damage potential is related directly to the amount of truck-crop farming on the flood plains, for such crops have high cash value per acre and are extremely flood vulnerable.

Chapter VIII

OTHER PROBLEMS

INTRODUCTION

Although the flooding problem in the Root River watershed has had the greatest public impact, other problems of a less dramatic but no less important nature have developed or become apparent as urban development has continued to expand within the watershed. Of these problems, the most important are deteriorating water quality, inadequate water quantity during periods of low streamflow, and the misuse of soil and land. Any comprehensive watershed plan must consider these problems in addition to the flooding problem and must allow for the effects that alleviation of one problem may have on all other problems.

WATER QUALITY PROBLEMS

"Water Quality" refers to the physical, chemical, and biological characteristics of the water resources. Quality characteristics are influenced both by the natural environment of the watershed and by human activity within the watershed. The quality of stream water as conditioned by the natural environment of the watershed would present no problem for any reasonably possible uses of Root River system waters. Most potential beneficial water uses are, however, as a result of pollution, incompatible with present stream water quality conditions.

The quality of the ground water resource as a commodity for domestic and industrial water supply and for irrigation use does not, at this time or in the foreseeable future, present any significant problem other than hardness and iron. Experience, however, indicates that aquifers such as the dolomite aquifers underlying the watershed are particularly susceptible to pollution from septic tank effluent and refuse seepage and from improper use of abandoned pits and quarries for refuse dumps. The danger of polluting ground water, therefore, will probably increase with continued uncontrolled low-density residential development and with increasing volumes of domestic and industrial liquid and solid wastes.

The quality of the surface water resource, however, presents serious problems in the development of potentially desirable uses of streamflow waters. The river system is presently being used principally for the transportation and assimilation of treated and untreated domestic and industrial wastes. Possible alternative uses considered in the preparation of the watershed plans were all in the recreation-conservation sector. They include development of the riverine areas from the City of West Allis to the City of Racine for parkway purposes, boating and fishing from the City of Racine to the confluence of the North Branch and the Root River Canal, an artificial lake for recreational and low-flow augmentation use at the confluence, and livestock and wildlife watering throughout the perennial stream system.

Water quality standards recommended in Chapter XI for the potential uses of the Root River system are:

Proposed Water Use	Recommended Water Quality Standard
Sustenance of desirable fish and aquatic life	Minimum dissolved oxygen content of 4 ppm, maximum temperature of 90°F
Boating	Maximum coliform bacteria count of 5,000 MFCC
Aesthetic	Minimum dissolved oxygen content of 1 ppm
Livestock and wildlife watering	Maximum coliform bacteria count of 5,000 MFCC

At the present time, surface water quality in the Root River system falls short of all of these standards during most of the year, as illustrated in Figures 13, 14, and 15.

A substantial improvement in water quality is expected to occur upon completion, by the Metropolitan Sewerage Commission of the County of Milwaukee, of trunk sewers which will convey all sanitary sewage from communities in the North Branch drainage area to the new Puetz Road sewage treatment plant on Lake Michigan in the City of Oak Creek. This action will eliminate about 75 percent of the present daily average BOD loading contributed to the river system by sewage disposal plants. The remaining sources of municipal sewage disposal plant effluent will then be the State of Wisconsin Southern Colony and

Training School and the Village of Union Grove,[1] both contributing to the West Branch of the Root River Canal, and the Caddy Vista Sanitary District contributing to the main stem. In addition, the Cooper-Dixon Duck Farm and the Frank Pure Food Company will be contributing partially treated industrial wastes to the West Branch of the Root River Canal and to Hoods Creek, respectively.

Other sources of streamflow pollution include agricultural drainage, drainage from private septic tanks, and storm water runoff from urban areas. Agricultural drainage contains fertilizers, which promote growth of algae and other aquatic plants, and herbicides and pesticides which may be harmful to fish life. Drainage from private septic tanks does not constitute a serious pollution problem at this time but could in the future under continued unplanned and uncontrolled land use development since many watershed soils are unsuitable for septic tank operation. Urban storm water runoff is becoming recognized as a pollution source in terms of BOD, nutrients, and suspended solids; but its significance in terms of stream pollution is as yet largely unknown.

LOW FLOW PROBLEMS

River flows during most of the year are very low. As summarized in Table 8, the flows equaled or exceeded 90 percent of the time at the SEWRPC-USGS stream gaging stations during the 1964-1965 water years were 1.0 CFS in the Root River Canal at CTH G, 2.3 CFS in the North Branch at W. Ryan Road (STH 100), and 3.6 CFS at STH 38 near Racine.

A major proportion of the present low flows consists of sewage disposal plant effluent, as indicated by Table 9. The scheduled exportation of sewage from communities in the North Branch drainage area will consequently diminish the existing low flows and probably result in periods of no flow in the North Branch. It will also significantly reduce downstream low flows. Drying up of parts of the North Branch channel for prolonged periods may detract to some degree from the aesthetic quality of the parkway recreational area. Reduction of low flows in the downstream river reaches will detract from the potential boating, fishing, and other recreational uses of the river and will aggravate residual pollution problems. Extreme low flows and temporary dry-bed conditions will also foster weed growth in channel reaches where constant water presence now keeps the main channel reasonably clear of such growth.

LAND-RELATED RESOURCE PROBLEMS

The conversion of land from rural to urban use within the watershed proceeds in the absence of an areawide land use plan with the hazard that such "fixed" investments as industrial and commercial buildings, residences, and supporting facilities may be developed in a pattern which is inefficient, unhealthful, and aesthetically unpleasing. Often such conversion proceeds not only without regard for the effect upon water resources but also without regard for the effect upon other important related elements of the underlying and supporting natural resource base as well. Thus, the soils, woodlands, wetlands, and wildlife of the watershed may be injured or destroyed entirely in the process of urban development; and this, in turn, may have a deteriorating effect upon the quantity and quality of the water resources. Such injury or destruction occurs through the composite effect of many seemingly unrelated local development decisions by individual private investors and public agencies. Each individual decision, by itself, may have little impact upon the resource base; but, collectively, these land use decisions will shape the total environment of the watershed for generations to come.

Investigation of the pattern of urbanization to date in the Root River watershed reveals some serious misuse of the land resources. In the absence of a sound land use plan for the watershed, such misuse and the effects of such misuse on the resource base will be greatly magnified, not only by the rapidly increasing population level within the watershed, but also by increasing per capita consumption of resources. Future land-related resource problems could, therefore, rapidly reach serious proportions unless preventive action is taken.

The significant fact about the pattern of urban development within the watershed to date is not its extent, but its form. Less than one-quarter of the total area of the watershed is currently occupied by urban land uses which are largely residential; but the new urban development, as shown on Map 18, is occurring increasingly in a sprawling

[1] *On October 25, 1965, during the preparation of this report, the Village of Union Grove reportedly separated clear waters from sanitary sewage and redirected the clear waters into the Des Plaines River watershed. This change would apparently remove about 200,000 gallons per day from the low flow of the Root River Canal. It is not known at this time whether such transfer is permanent or, for that matter, what legal and technical considerations might be involved.*

pattern rather than as orderly annular growth outward from the older urban cores with their highly developed utility and community facilities and services. This form of development is costly to the homeowner, for public water supply, sewerage, and solid waste disposal services are not available except at a disproportionate public expense and must, therefore, be provided by the homeowner. This form of development is also costly for the public, for government must provide transportation facilities and fire, police, health, and educational services to a dispersed yet urban population.

Urban development has also shown strong tendencies to proceed within the watershed in disregard of the natural capabilities of the soils to support such development. Although the detailed soil surveys indicate that approximately two-thirds of the total area of the watershed is suitable for all types of residential development, relatively small areas of unsuitable soils occur throughout the watershed. One of the most permissive soil use or suitability rating categories established by the SEWRPC is the rating for residential development with public sanitary sewer service. (See Map 4.) Eventually, all of the Waukesha and Milwaukee County portions of the watershed will be so served. Yet, with all of the area available within the watershed for development, at least 400 acres of residential development, in the Waukesha and Milwaukee County portions of the watershed, have been developed on soils having severe limitations for development even with sewer service. Another soil related land use problem is appearing in Racine County, where scattered residential development is beginning to occur on some of the last remaining large "blocks" of the best agricultural soils within the Southeastern Wisconsin Region.

Throughout the watershed there are further signs of an unawareness or disregard of principles of wise resource development and conservation. Urban encroachment upon the natural flood plains of the Root River system continues; and during the conduct of the study alone, at least 10 homes have been constructed on the flood plains. Not only does this practice increase potential flood hazards and damages and the threat of water pollution, but it removes the riverine areas from proper allocation to resource conservation and recreational uses. The Root River watershed has very limited forest resources, essential to protection of the water resources and to maintenance of a balanced natural ecology in the basin; yet during the conduct of this study, 40 acres of prime woodland were cut away to make room for residential development.

Eleven large abandoned gravel pits exist within the watershed. These are not only aesthetically unattractive but constitute a hazard to children. The abandoned pits are being used primarily for rubbish and garbage disposal and if improperly managed can thereby constitute a pollution hazard to the shallow ground water aquifer and threaten the only economical water supply currently available in about one-half of the geographical extent of the watershed.

Although soil erosion and stream siltation are not at the present time severe problems within the watershed, these problems do occur on a small scale throughout much of the agricultural areas. The mechanism established by state and federal agencies to combat such problems, the individual farm conservation plan, has, to date, been utilized by only 15 percent of the farm owners. As shown on Map 30, first stage agreements are in effect on 90 farms covering 8,400 acres; and individual farm plans are being implemented on 32 farms covering 2,600 acres. With a few exceptions, row crops are not contour-planted, waterways are not grassed, and there is little terracing on the rolling lands which comprise much of the watershed within Racine County. Even though there are few concentrated locations within the watershed where land mismanagement is pronounced, the general lack of adoption of proper soil and water conservation practices and land treatment measures constitutes a significant problem.

The spatial distribution of the land-related resource problems of the Root River watershed, as indicated by Commission surveys, is shown schematically on Map 32.

SUMMARY

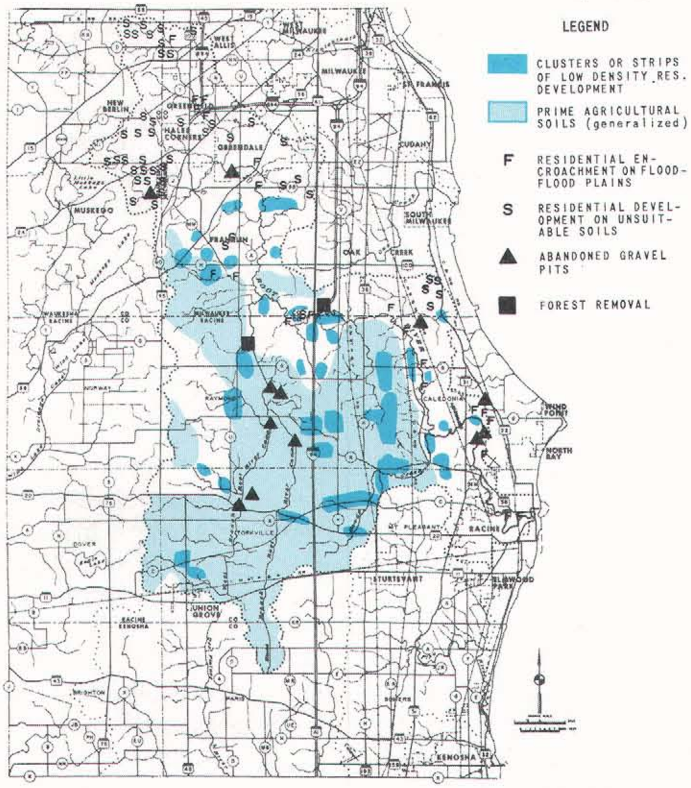
In addition to flooding, other problems directly related to urbanization are appearing in the watershed. These problems are interrelated and include:

1. Gross pollution of the Root River throughout much of its length by municipal sewage treatment plant effluent and food processing wastes.

2. Very low streamflows in the North Branch, which will be further depleted by exportation of sanitary sewage.

Map 32

LAND RELATED PROBLEM AREAS IN THE ROOT RIVER WATERSHED (1964)



Although flood drainage and water pollution are perhaps the most obvious problems of the Root River watershed, problems related to the misuse of land are widespread and often directly related to unplanned urban sprawl.

3. Continued residential development in the natural floodways and flood plains of the river system with creation of attendant health and flood hazards and destruction of wildlife habitat.

4. Intrusion of scattered low-density residential development into large areas of prime agricultural soils.

5. Continued residential development on soils that have severe limitations for such use.

6. Destruction of already scarce forest resources and related wildlife habitat.

7. Abandonment of gravel pits to leave an ugly landscape and a health and safety hazard.

These problems are primarily the result of urban sprawl, proceeding in the absence of sound areawide development objectives and plans. An economically inefficient, aesthetically unpleasing, and potentially unhealthful environment will be created within the watershed unless these land-related resource problems are abated along with the water-related resource problems.

Chapter IX
WATER LAW

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. The law can be as important as the hydrology of the basin or the costs and benefits of proposed water control facilities in determining the ultimate feasibility of a given watershed plan. If the legal constraints bearing on the planning problem are ignored during plan formulation, serious obstacles may be encountered during plan implementation. This is particularly true in the area of water resources.

Water constitutes one of the most important natural resources. It is not only essential to many of the most important economic activities of man but is essential to life itself. The available quantity and quality of this important resource are, therefore, among the most vital concerns of a host of interest groups representing agriculture, commerce, industry, conservation, and government. Not only are rights to the availability and use of water of vital concern to a broad spectrum of public and private interest groups, but the body of law regulating these rights is far from simple or static. Moreover, changes in this body of law will take place even more rapidly as pressure on regional, state, and national water resources becomes more acute. In such circumstances, generalizations and broad conclusions become hazardous; and careful analysis of the legal aspects of watershed planning becomes particularly important.

A survey of the present legal framework of public and private water rights affecting water resources management, planning, and engineering was, therefore, undertaken as one of the important work elements of the Root River watershed planning program. This survey was carried out under the direction of Professor J. H. Beuscher, of the 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 resources 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 addition, effort was concentrated upon certain specific legal problems which became apparent as work progressed on the preparation of the comprehensive plan for the Root River watershed. The findings of this legal study have been set forth in detail in SEWRPC Technical Report No. 2, <u>Water Law in Southeastern Wisconsin</u>, published in January 1966. This chapter consists of a summary presentation of this more detailed technical report and is intended to inform public officials and citizens within the watershed about the salient legal factors bearing on the water-related problems of the basin and on plans for their solution, thereby laying the basis for intelligent future action. It does not, however, dispense with the need for continuing legal study since this aspect of the overall watershed planning effort becomes increasingly important as plan proposals reach the implementation phase.

In the first part of the chapter, attention is focused upon the general aspects of water law applicable to the Root River or any watershed in southeastern Wisconsin. Then the important subjects of flood plain regulation and pollution control are discussed in greater detail. Finally, attention is devoted to an analysis of the specific legal problems encountered in the watershed study.

SUMMARY OF WATER LAW

<u>Classifications of Water and Divisions of Water Law</u>

The Wisconsin Supreme Court and the State Legislature, in dealing with water regulation, have recognized five distinct legal classifications of water:

1. Surface water in natural watercourses; defined as water occurring or flowing in natural rivers, streams, lakes, and ponds.

2. Diffused surface water; defined as water occurring or flowing diffused over the ground in places other than natural watercourses and resulting from falling rain or melting snow.

3. Ground water in underground streams; defined as water occurring or flowing in a well-defined underground channel, the course of which can be distinctly traced. It is extremely doubtful that such identifiable underground channels exist within the watershed or indeed within the Region.

4. Percolating ground water; defined as water which seeps, filters, or percolates through underground porous strata or earth or rock but without confinement to a definite channel.

5. Springs; defined as natural discharge points for ground water from either an underground stream or percolating water.

Based in part on these definitions, three principal divisions of water law can be identified. These are: riparian law, ground water law, and diffused surface water law. Riparian law applies to the use of surface water occurring in natural rivers, streams, lakes, and ponds. This law has been evolved largely by the courts, case by case, as a matter of "common law." Important here also are both court-made law and legislation defining public rights in those watercourses which are navigable. Ground water law applies to the use of water occurring in the saturated zone below the water table. Here again the law has evolved largely by court interpretation as "common law." Diffused surface water law applies to floodwater draining over the surface of the land. This law in Wisconsin relates not to water use but to conflicts which arise in trying to dispose of this surface water.

The Wisconsin Supreme Court has developed many of the legal rules covering all three of these divisions of water law, case by case, over a long period of time. In addition, the State Legislature has from time to time enacted statutes affecting some of these divisions. Reference must also be made to the important body of administrative law made by state agencies in the day-to-day administration of state water statutes. Examples are statutes governing the issuance of permits by the Public Service Commission for irrigation and mining purposes; for hydroelectric power and other dams; for the fixing of bulkhead lines; and for the construction of bridges, piers, docks, and other shoreline improvements along navigable watercourses. The Public Service Commission is also authorized to fix levels for navigable lakes and flow rates for navigable streams. In addition, there are statutes governing the control of pollution by the Committee on Water Pollution and the State Board of Health.

Rights to the Use of Water in Natural Watercourses

Rights in water may be designated as private and public. Industrial cooling, irrigation, and power generation are examples of private rights, while fishing, boating, and swimming are examples of public rights. It is essential, however, to recognize that private and public rights to use water are interrelated and that, while these labels may be convenient for classification purposes, they tend to encourage oversimplification. In certain circumstances, it may be more in the public interest to promote a private use even though the conventional public rights are consequently limited. The Wisconsin taconite law is a case in point. This legislation permits mining companies to divert water upon a finding that the resulting public benefits outweigh any impairment or elimination of traditional public rights. Conflicts may also arise among various segments of the public regarding which of the public rights is paramount, particularly where the exercise of one public right may seriously affect the possibility of exercising another.

Riparian Rights: The riparian doctrine, which in Wisconsin forms the primary basis of the law governing the use of surface water in natural watercourses, provides that owners of lands that adjoin a natural watercourse have rights to co-share in the use of the water so long as each riparian is "reasonable" in his use. Obviously, the definitions of "reasonableness" and "natural watercourse" are critical to the application of riparian law.

Natural Watercourse: The Wisconsin Supreme Court requires that in order to constitute a natural watercourse there must be "a stream usually flowing in a particular direction though it need not flow continually. It may sometimes be dry. It must flow in a definite channel having a bed, sides or banks and usually discharges itself into some other stream or body of water."[1] Although riparian rights are sometimes conceived to attach to artificial watercourses, usually they are restricted

[1] *Hoyt v. City of Hudson, 27 Wis. 656 (1871). A lengthy definition distinguishing watercourse from diffused surface water is contained in Fryer v. Warne, 29 Wis. 511 (1872). The Wisconsin Court has held that the existence of a watercourse is a question of fact for the jury. Eulrich v. Richter, 37 Wis. 226 (1875). In an injunction case, the question of fact would be for the court.*

to watercourses which are natural in origin. The term watercourse comprehends springs, lakes, or marshes in which the stream originates or through which it flows. Natural lakes or ponds which are not a part of a stream system are, nevertheless, waters to which riparian rights also attach. Clearly, the Root River and its major tributaries meet the definitional requirements of a watercourse; and riparian law applies. The same body of doctrine also applies to natural lakes and ponds within the Root River watershed.

Natural Flow and Reasonable Use: With respect to the relative rights of riparian landowners along a watercourse, there is language in Wisconsin cases, still relied on by sportsmen, to the effect that a riparian owner is entitled to have a watercourse flow through his land without material diminution or alteration—the so-called "natural flow" doctrine. Strict application of such a rule would preclude effective use of the water for other than domestic needs.

In those cases in which the Wisconsin Court used "natural flow" language, however, the court was merely indulging in preliminary observations, for in each such case the language is subsequently modified or limited and the "reasonable use" rule applied to the particular situation presented. It is, therefore, an abstract statement to say that in Wisconsin riparian owners are entitled to the continuous full and natural flow of a watercourse, for in the words of the Wisconsin Supreme Court:

> To say, therefore, that there can be no obstruction or impediment whatsoever by the riparian owner in the use of the stream or its banks would be in many cases to deny all valuable enjoyment of his property so situated. There may be, and there must be, allowed of that which is common to all a reasonable use.[2]

Thus, in Wisconsin the "reasonable use" doctrine qualifies the strict right to the natural flow of a stream or the natural level of a lake. This use right is not a right in the sense that a riparian proprietor owns the water running by or over his land. It is a right called usufructuary in that the riparian may make a reasonable use of the water as it moves past.

[2] *A. C. Conn Co. v. Little Suamico Lumber Mfg. Co.*, *74 Wis. 652, 43 N.W. 660 (1889).*

The term "reasonable use" implies that a question of fact must be resolved in each case, and the Wisconsin Court has recognized the concept as a flexible one in conceding that no rule can be stated to cover all possible eventualities. The court has said, in determining what is a reasonable use, that:

> Regard must be had to the subject matter of the use, the occasion and manner of its application, its object, extent, and the necessity for it, previous usage, the nature and condition of the improvement upon the stream, the size of the stream, the fall of the water, its volume and velocity.[3]

Thus, it may be concluded that a user's utilization of water must be reasonable under all the circumstances; and he may meet this test despite substantial interference with the natural flow of a watercourse, for it is recognized that any rule preventing all or almost all interference with the flow would needlessly deprive riparian proprietors of much of the value of the stream and prevent its utilization for any beneficial purpose. In this respect, it should be recognized that, wherever the Public Service Commission, at the request of one or more riparians, and after notice and hearing, fixes the level of a lake or grants a permit for the construction or enlargement of a dam or pier, other riparians will probably have a difficult time establishing that the permitted uses are unreasonable. A permit to irrigate imposes a similar burden of proof upon co-riparians who may later complain of unreasonable use. In addition, a water user may acquire a firm right to a specific quantity of water by adverse use (prescription) over a period of time, usually 20 years, or by contract with co-riparians.

Chapter 313 of the Laws of 1963 amends Section 30.03 and repeals and recreates Section 30.19 of the Wisconsin Statutes to prohibit the construction or enlargement of any artificial waterway without permission of the Wisconsin Public Service Commission, where the purpose of such enlargement is an ultimate connection with an existing navigable stream or lake, or where any part of such artificial waterway is located within 500 feet of the ordinary high water mark of an existing navigable stream or lake. By the act the law was further amended to require authorization not only for the construction of an artificial waterway within

[3] *Timm v. Bear, 29 Wis. 254 (1871).*

500 feet of navigable waters, but also for the connection of any waterways and for the removal of topsoil from the banks of navigable streams and lakes. Public highway construction, improvements related to agricultural uses of land, and improvements within counties having a population in excess of 500,000 were excepted from provisions of the Act.

Lands Affected by Riparian Law: The Wisconsin Supreme Court has never defined the term "riparian land" with precision. It is clear, however, that to be riparian land must adjoin the watercourse and probably it must lie within the watershed of that watercourse. It is also held in Wisconsin that riparian rights rest upon ownership of the bank or shore in lateral contact with the water, not upon title to the soil under the water.

The Wisconsin Public Service Commission, in administering the issuance of permits to irrigators, has limited riparian land to that land bordering a lake or stream which has been in the same ownership in an uninterrupted chain of title from the original government patent. This is similar to the so-called "source of title" test. Under it, the conveyance by "A" of a back parcel of his riparian land to "B" renders the transferred parcel non-riparian unless the deed provides otherwise; and it remains so even though "A" subsequently repurchases it. Presumably also, if "B" having first purchased the back parcel later also buys the tract touching the water, the back parcel continues non-riparian. Thus, a riparian cannot assemble non-riparian land and make it riparian. A non-riparian cannot convert his land to riparian status by buying a riparian tract. Under this rule there is a continual dwindling of riparian land.

Non-Riparian Use: Non-riparian use occurs when a riparian uses an excessive quantity of water beyond his reasonable co-share; when a riparian uses water on non-riparian land which he owns or controls; or when a non-riparian takes water from a watercourse, usually with permission or by grant from a riparian, for use on non-riparian land. The latter situation deserves particular attention since, as a practical matter, problems of this sort are apt to arise in the Root River watershed because of possible withdrawals for municipal, irrigation, or industrial use.

In this respect, it is not known whether the Wisconsin Court would treat municipal use from a natural watercourse as a special case. Surprisingly, most states that have spoken on the subject refuse to do so and treat a municipal water utility as just another water user and point with disapproval to the distribution of water to non-riparian customers of the utility. The courts insist that, if downstream riparians are hurt by the municipal diversion, the utility must acquire by eminent domain or otherwise the requisite downstream rights.

The irrigator who wants to use water from a stream must get a permit under the Wisconsin irrigation permit law, Section 30.18 of the Wisconsin Statutes. He must limit his irrigation to riparian land unless he was using water on contiguous non-riparian land in 1957. Permits are not required of commercial or industrial water users as a precondition to withdrawal from a watercourse. Whether such users can use water on non-riparian land is an unresolved question, although the court in Munninghoff v. Wisconsin Conservation Commission [4] has said: "It is not within the power of the state to deprive the owner of submerged land the right to make use of the water which passes over his land or to grant the use of it to a non-riparian." The Wisconsin Attorney General has stated that: "Previous decisions in other states have held that a riparian owner could make any reasonable use of the water even on non-riparian land providing there was no unreasonable diminishment of the current and no actual injury to the present or potential enjoyment of the property of the lower riparian owner." [5]

Public Rights in Navigable Water: When a riparian uses navigable water, his uses may impinge upon public rights in the water. Private water uses are often completely consistent with the exercise of public rights in navigable streams and lakes, but serious conflicts may arise between private riparians and those seeking to exercise public use of a given watercourse. In that event, in Wisconsin the public rights will likely prevail. This does not mean that private riparian rights may in every case be taken or substantially abridged without compensation, for it has long been recognized that such rights are property rights which cannot be "taken" for a public purpose without compensation.

The Wisconsin Court might, however, treat the riparian's private property right as "inherently

[4] *255 Wis. 252, 38 N.W. 2d 712 (1949).*

[5] *39 Op. Atty. Gen. 654 (1950).*

limited" by public rights in the water. The court might say that this limitation existed at the time the riparian acquired his private right and that he took subject to the limitation. This line of reasoning would permit a holding that compensation need not be paid even though public uses impair private uses substantially.

One of the important riparian rights attaching to lands bordering navigable lakes and streams is the right of access to water. It is recognized in Wisconsin that a riparian has a right of access from the front of his land to the navigable part of the stream or lake and the right to build a pier subject only to legislative control.

Test of Navigability: In order for public rights to attach, the water must be navigable. The Wisconsin Court's test of navigability has moved from one of commercial transport only to include suitability for recreational boating. Earlier the question was whether the stream or lake could be used to float products of the country to market for a significant period during the year. The principal product floated to market in those days was the sawlog, hence the so-called "sawlog" test of navigability. More recently, in 1952, the Wisconsin Court said: "Any stream is navigable in fact which is capable of floating any boat, skiff, or canoe of the shallowest draft for recreation purposes."[6] The stream, pond, or lake does not in order to qualify as navigable have to be capable of floating a product to market or of floating a boat, skiff, or canoe every day of the year or every rod of its length or surface area. By the recreational boating test, most natural ponds and lakes are navigable; and streams of even modest size may be navigable. Clearly the Root River and its principal tributaries are navigable by this test.

Ownership of the Land Underlying a Water Body: Determination of ownership of a stream or lake bed may have important consequences. If the bed is privately owned, removal of material from the bed may be authorized by the owner so long as there is no interference with the exercise of possible public rights to use the water. If the bed is publicly owned, removal can only be with permission of, and payment to, the state.

Wisconsin holds that the beds of streams, whether navigable or non-navigable, belong to the owners of the adjacent shorelands, always subject, however, to the overriding public servitude of navigation and other public rights that adhere to navigable water. Private proprietors whose lands make lateral contact with the waters of a stream own the bed to the middle or thread of that stream, regardless of whether the stream is navigable or not. The bed owner is in a position comparable to a landowner whose land is subject to a public highway easement.

Beds of natural navigable lakes are owned by the state in trust for all of the people. A private proprietor whose lands abut the waters of a natural lake has no claim to any portion of the bed. The ownership of beds underlying man-made lakes or reservoirs, caused by damming a stream or otherwise impounding a natural flow of water, remains in the hands of abutting landowners. Where the stream was navigable before it was dammed, the waters spread behind the dam are likewise navigable. Thus, the privately owned bed of the reservoir in such a case seems to be subject to the same public servitude that originally applied to the undammed stream.

Rights to the Use of Ground Water

Wisconsin ground water law is based upon the so-called English absolute rights doctrine. The landowner owns the ground water he captures in his well or otherwise. It is his to do with as he wishes, to use on the overlying land or elsewhere, and even to waste.

The Wisconsin Legislature has intervened in this rather primitive legal thicket in only one way. It has required that a State Board of Health permit be obtained by anyone who desires a new or reconstructed well or well field which yields more than 100,000 gallons a day.[7] However, the ground on which the State Board of Health can deny a permit is narrow; namely, that the proposed well or wells will "adversely affect or reduce the availability of water to any public utility in furnishing water to or for the public." Interference with a nonpublic utility well, thus, is not a ground for denial of a permit.

Diffused Surface Water Law

The Wisconsin Supreme Court has defined diffused surface waters, more commonly known as storm water, as "waters from rains, springs, or melting snow which lie or flow on the surface of the earth but which do not form part of a watercourse

[6] *Muench v. Public Service Comm.*, 261 Wis. 492, 53 N.W. 2d 514 (1952).

[7] *Wis. Stats. 144.03(8). See also Regulation of Well Drillers, Wis. Stats. 162.01.*

or a lake."[8] A ravine which was usually dry except in times of heavy rains or spring freshets was early held by the Wisconsin Court not to be a watercourse, and the water in it was held to be diffused surface water.[9]

Riparian law does not apply to diffused surface water. The law that does apply deals not with water use rights but with conflicts which arise in attempting to dispose of water. Where these conflicts arise between private landowners, the Wisconsin Court has evolved as case law the so-called "common enemy rule" regarding diffused surface waters. Basically, this rule permits a landowner who is seeking to improve his land to fight as a "common enemy" the diffused surface water in a particular drainage area. This he can do regardless of harm caused to others so long as he does it to improve his own land and so long as he does not tap a new drainage area. The improvements may include grading, diking, ditching, and damming, but not the drainage of a natural pond or artificial reservoir.

The prohibition against tapping water from a new drainage area drops away where a municipal project is involved. Here the rule of law has been stated as follows:

> By constructing streets and gutters within its limits, a city may change the natural watercourse so as to increase the flow of water upon private land.[10]

At least three general limitations upon this broad municipal power have been stated, two by the court and one by the Legislature:

1. The municipality may not collect water in a body and then cast it on land in a large volume.[11]

2. A municipality that has collected water in a sewer or drain is liable for damages if, because of negligent construction or maintenance, water is allowed to escape from the sewer or drain to adjacent land.[12]

3. Section 88.87 of the Wisconsin Statutes requires:

> Whenever any county, town, city, village ... or the state highway commission has heretofore constructed and now maintains or hereafter constructs and maintains any highway ... in or across any marsh, lowland, natural depression, natural watercourse, natural or man-made channel or drainage course, it shall not impede the general flow of surface water or stream water in an unreasonable manner so as to cause either unnecessary accumulation of waters flooding or waters soaking uplands or an unreasonable accumulation and discharge of surface waters flooding or waters soaking lowlands.

In spite of the above language, municipal construction projects are relatively immune from legal damages resulting from the interference with, or rerouting of, draining surface waters. The relative immunity enjoyed by municipalities presumably also applies to towns if the storm sewer system was built under appropriate statutory enabling authority. This authority exists where a town assumes village powers under Sections 60.18(12) and 60.29(13) of the Wisconsin Statutes or where a special sanitary district has been created pursuant to Section 60.30 of the Wisconsin Statutes. It also exists, under Section 60.29(19) of the Wisconsin Statutes, where the county in which the town is located has a population of 150,000 or more.

ENCROACHMENTS IN AND ALONG STREAMS—FLOOD PLAIN REGULATION

Effective abatement of flooding can be achieved only by a comprehensive approach to the problem. Certainly, physical protection from flood hazards through the construction of dams, flood control reservoirs, levees, channel improvements, and other water control facilities is not to be completely abandoned in favor of flood plain regulation. As urbanization proceeds within a watershed, however, it becomes increasingly necessary to develop an integrated program of land use regulation of the flood plain within the entire watershed to supplement required water control facilities if efforts to provide such facilities are not to be self-defeating.

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[8] *Thomson v. Public Service Comm.*, 241 Wis. 243, 5 N.W. 2d 769 (1964).

[9] *Hoyt. v. City of Hudson*, 27 Wis. 656 (1871).

[10] *Tiedeman v. Middleton*, 25 Wis. 2d 443 (1964).

[11] *Champion v. Crandon*, 84 Wis. 405, 54 N.W. 775 (1893).

[12] *Hart v. Neilsville*, 125 Wis. 546, 104 N.W. 699 (1905).

Principles of Flood Plain Regulation

Certain legal principles must be recognized in the development of land use regulations to implement a comprehensive watershed plan. With respect to the flood plain areas of the watershed, these are:

1. Contrary to the common assumption that flood plain regulations must seek to retain the entire flood plain in open-space uses, sound flood plain regulation may contemplate permitting certain buildings and structures at appropriate locations in the flood plain. Any such structure, however, should comply with special design, anchorage, and building material requirements.

2. Sound flood plain regulation must recognize that the flood hazard is not uniform over the entire flood plain. Restrictions and prohibitions with respect to buildings and structures in the flood plain should, in general, be more rigorous in the channel itself and in those areas of the flood plain subject either to more frequent flooding or to dangerously high flood stages and velocities and less restrictive in the rest of the flood plain.

3. Sound flood plain regulation must recognize, and be adjusted to, existing land uses in the flood plains. Structures may already exist in the "wrong places." Fills may be in place constricting flood flows or limiting the natural flood storage capacities of the river. The physical effects of such misplaced structures and materials on flood flows, stages, and velocities can be determined; and flood plain regulation based on such determinations must include legal measures to bring about the removal of at least the most troublesome offenders.

4. In addition to the physical effects of structures or materials, sound flood plain regulation must also be concerned with the social and economic effects, particularly the promotion of public health and safety. Beyond this, sound flood plain regulation must take into account such diverse and general welfare items as impact upon property values, the property tax base, human anguish, aesthetics, and the need for open space.

5. Sound flood plain regulation must coordinate all forms of land use controls, including zoning, subdivision control, and official mapping ordinances and housing, building, and sanitation codes.

Land Use Regulation in Flood Plains

Based upon these principles, a pattern of flood plain regulation is herein proposed which divides the total flood plain of a stream into three areas or districts: 1) the channel district, consisting of that part of the total flood plain occupied by the stream during periods of normal flow; 2) a primary flood plain district, consisting of that part of the total flood plain occupied by the stream during floods having a relatively short recurrence interval, such as 10 years; and 3) a secondary flood plain district, consisting of that part of the flood plain lying between the outer limits of the primary flood plain district and the outer limits of the entire flood plain, the latter being defined as that area occupied by the stream in floods having a relatively long recurrence interval, such as 100 years.

Channel District Regulation: Sections 30.11, 30.12, and 30.15 of the Wisconsin Statutes establish rules for the placement of material and structures on the bed of any navigable water and for the removal of material and structures illegally placed on such beds. With approval of the Public Service Commission, pursuant to Section 30.11 of the Wisconsin Statutes, any town, village, city, or county may establish bulkhead lines along any section of the shore of any navigable water within its boundaries. Where a bulkhead line has been properly established, material may be deposited and structures built out to the bulkhead line. A Public Service Commission permit is required for deposit of material or the erection of a structure beyond the bulkhead line. Where no bulkhead line has been established, it is unlawful to deposit any material or build any structure upon the bed of any navigable water unless a Public Service Commission permit has first been obtained.

The delineation of the outer boundary of the bed of a navigable lake or stream thus becomes a crucial legal issue, and the statutes provide no assistance in this problem. Where the lake or stream has sharp and pronounced banks, it will ordinarily be possible, using stage records, the testimony of knowledgeable persons, and evidence relating to types of vegetation and physical characteristics of the bank, to establish the outer limit of the stream or lake bed.[13] The task can, however, present a difficult practical problem, particularly where the stream is bordered by low-lying wetlands. Where bulkhead lines have been established, however, or where the outer limits of navigable waters can be defined, existing encroachments in the beds of these navigable waters can be removed and new encroachments prevented under existing Wisconsin legislation.

Primary and Secondary Flood Plain District Regulation: The Wisconsin Legislature has recognized, in the regulation of stream channel encroachments, that such regulation is an areawide problem transcending county and municipal boundaries and has, therefore, provided for state regulation. While it would appear to be a logical and relatively easy step to move from state regulation of channel encroachments by the Public Service Commission to state flood plain regulation by the same agency, no flood plain regulation authority presently exists at the state level or even at the county level without town board approval.

A bill presently pending before the Wisconsin Legislature[14] would authorize counties to zone flood plains without town board approval. This bill would also create Section 87.30 of the Wisconsin Statutes, which would empower the State Department of Resource Development to adopt flood plain zoning regulations where it was found that any county, city, or village had not adopted a reasonable or effective flood plain zoning ordinance by January 1, 1968.

The Wisconsin Industrial Commission has long held power to establish state level building safety codes.[15] These codes have never specifically focused on special anchorage, construction, safety, and material requirements of structures which are proposed to be or have been erected in a flood plain but could probably be amended to do so. The basic legal authority for such amendment already exists. The powers of the Wisconsin Industrial Commission, however, do not extend to all structures. It does not have power, for example, over single- or two-family housing units. It does have power with respect to buildings which are used in whole or in part as a place of resort, assemblage, lodging, trade, traffic, occupancy, or use by the public or by three or more families. It is also given power to assure safe places of employment.

The State Highway Commission and the State Board of Health presently possess state level subdivision plat review powers. These powers do not stretch out to encompass the full limits of the flood plain problem. Nevertheless, adaptations might be effected where these reviews concern land located within a flood plain to make a modest contribution to an integrated state-local program of flood plain regulation. For example, the State Highway Commission regulations might impose more stringent performance standards in those situations where flood damage to roadways, culverts, and bridge structures situated within, or close to, a subdivision seem likely. State Board of Health regulations applying to subdivisions not to be served by public sewers prohibit the development of subdivision lots which are less than two feet above the high water elevation of a lake or stream or less than three feet above the highest ground water level. This regulation could be supplemented by prohibitions against the development of any lot where floodwaters would be backed or constricted. Such regulation, however, under existing law would apply only to subdivisions not served by public sewer.

Another state level control available for land use regulation in flood plains is through public nuisance actions brought by the Attorney General to remove, by injunction, existing structures or fill in the flood plain that substantially retard and constrict the flow of navigable streams. Wisconsin cases directly in point are lacking, but a number of out-of-state cases could be used as precedents.[16] In addition, there is power granted by Wisconsin Statutes to abate old and dilapidated structures; and this power could be especially brought to bear on such structures situated in the flood plain. As a practical matter, however, an extensive program of "flood plain clearance," like

[13] *The normal high water mark is defined by the Wisconsin Conservation Commission and the Wisconsin Public Service Commission as that point at which the waters of the stream or lake remain long enough to cause an observable change in vegetative type and density of growth. In field practice these state agencies attempt to establish the channel limits by determination of those points where the terrestrial vegetation ends and the aquatic vegetation begins.*

[14] *Assembly Bill 328, which passed the Assembly in the Spring of 1965.*

[15] *Wis. Stats. 101.01(12), 101.10(5); Haberman and Hoefelt, "The Wisconsin State Building Code," 1947 Wis. L. Rev., 373.*

[16] *See: "State Regulation of Channel Encroachment," Beuchert, 5 Nat. Res. J., 486 (1965).*

a program of slum clearance, would require the expenditure of substantial public funds to buy out landowners whose structures are located in the wrong places.

A good potential for intelligent land use regulation in flood plains exists at the county and local level of government if these units can be persuaded to coordinate their zoning, subdivision control, and official mapping activities through the medium of a comprehensive watershed plan prepared by the Regional Planning Commission. In this respect, attention is directed to the following salient factors:

1. Local subdivision control ordinances have a substantial and as yet largely unused potential for effective flood plain regulation of new development. To encourage the full development of this potential, the Commission has prepared a model subdivision control ordinance for consideration and adaptation by local units of government within the Region.[17] The salient portions of this ordinance which are applicable to regulation of flood plain development are set forth in Appendix L. The Commission offers assistance to any local unit of government in the Region that desires to incorporate these provisions in its ordinances.

2. Local zoning ordinances also have a substantial and as yet largely unused potential for effective flood plain regulation. The aforementioned concept of dividing the flood plain into primary and secondary flood plain districts seems desirable. Grants of zoning enabling authority to cities, villages, and towns, under Section 62.23(7) of the Wisconsin Statutes, and to counties, under Section 59.97 of the Wisconsin Statutes, appear broad enough to permit this. To encourage the full development of this potential, the Commission has prepared a model zoning ordinance for consideration and adaptation by local units of government within the Region.[18] The salient portions of this ordinance which are applicable to regulation of flood plain development are set forth in Appendix L. The Commission also offers assistance to any local unit of government in the Region that desires to incorporate these provisions in its ordinances.

3. Local building and safety codes can also be used to impose special requirements for any buildings permitted in the primary and secondary flood plain districts.

4. Finally, the extraterritorial zoning powers available to cities and villages in Wisconsin under Section 62.23(7)(a) of the Wisconsin Statutes and extraterritorial subdivision control powers available under Section 236 of the Wisconsin Statutes should be noted. These powers might be especially useful in regulating through local action flood plains lying above and below municipal corporate limits.

To effectively regulate the use of land in the flood plain of the Root River, the subdivision control ordinances, zoning ordinances, official map ordinances, building codes, safety codes, and nuisance control ordinances of all of the local units of government within the watershed must be closely coordinated. The medium for such coordination exists in the Southeastern Wisconsin Regional Planning Commission, in the hydrologic and hydraulic data and land use and water control facility plans prepared as a part of the Root River study, and in the model zoning and subdivision control ordinances prepared by the Commission as a part of its continuing planning program. Final action, however, rests entirely with the local governing bodies. These bodies can, if they choose, not only request the Commission to assist them in preparing necessary plan implementation ordinances but can request the Commission to assist them in the review of all flood plain zoning and platting proposals affecting the Root River.

POLLUTION CONTROL

Inasmuch as the Root River watershed study was intended to deal with problems of water quality, as well as of water quantity, and recommends stream water quality goals for the Root River basin, it is necessary to examine the existing and potential legal machinery through which attainment of water quality goals may be sought at various levels of governmental and private action.

State Water Pollution Control Machinery

State level water pollution control in Wisconsin is centered primarily in the State Committee on

[17] *See SEWRPC Planning Guide No. 1, Land Development Guide, November 1963.*

[18] *See SEWRPC Planning Guide No. 3, Zoning Guide, April 1964.*

Water Pollution and the State Board of Health. Lesser roles are carried out by the Public Service Commission and the Wisconsin Conservation Commission.

The State Committee on Water Pollution deals primarily with pollution of surface water that does not directly endanger public health, principally pollution through discharge to surface waters of industrial wastes. The State Board of Health deals primarily with surface water pollution that may directly threaten public health, principally through the discharge to surface waters of sanitary wastes. In addition, the Board has general responsibilities for the control of ground water pollution. This practical division of responsibilities between the Committee and the Board could not ripen and, indeed, has not ripened, in the view of existing statutory language, into a legal division of responsibilities. This explains why the large majority of pollution control orders are issued jointly in the names of both of these regulative bodies, though the agency staff work underlying a particular order may have been performed primarily by one or the other of these two agencies.

The actual pollution control program, as administered by these two agencies, while competent and thorough, is time consuming. Rather than attack pollution solely on a case-by-case basis, it has been the sound practice of both of these two agencies to examine or survey entire river basins or major sectors thereof. These basin studies involve a water quality sampling program; physical, chemical, and biological analyses of the samples; and preliminary assessment of the results. All probable polluters—private, industrial, and municipal—who utilize a particular watercourse to carry away effluent are given notice that such a study is taking place and will be followed by public hearings, usually held within the river basin under study, at which time the preliminary findings are presented and at which the polluters can appear and submit statements in refutation, defense, or mitigation. Findings based upon the results of the study and subsequent hearing are summarized in a stream pollution report, wherein the extent of each stream user's contribution to the total pollutant load and his individual efforts to minimize or control the polluting qualities of his effluents are documented. The next step in the procedure, after all analyses have been completed, the hearing of testimony ended, and the basin pollution report prepared, is the preparation of orders addressed individually to each polluter on the stream directing him to take such action as the Committee and Board jointly feel is necessary to reduce or eliminate his contribution to the pollutant load of the stream. The unique circumstances 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.

The major difficulty with existing state water pollution control machinery is the long time lag between detection and remedy. The phase spanning initial investigation, sampling, analysis, and hearing to the issuance of an order for improvement requires from six to nine months. An additional six months to a year may be allowed for compliance, and time extensions for compliance are given if cause can be shown. Moreover, a basic policy of the Committee and Board has been to rely primarily on education and persuasion for pollution abatement action; and resort to court enforcement of pollution control orders, consequently, is seldom used and then only as a last resort.

If state pollution control, as administered by these two agencies, is to become more effective in rapidly urbanizing areas, some means of shortening the interval between discovery of a pollution problem and enforcement of abatement orders must be developed. A greater willingness to resort to legal action on the part of the Board or Committee may be a start. Quick fines for failure to comply with a single stage of a multiple stage order would also help. Finally, it may be helpful to concentrate all pollution cases in one Circuit Court to build judicial expertise in this complex field.

The Public Service Commission has an indirect role in surface water pollution control under Section 31.02(1) of the Wisconsin Statutes, which imposes a statutory mandate "... to regulate and control the level and flow of water in all navigable waters ...." The ability of any body of water to assimilate wastes depends in part upon the quantity of water available for dilution. Therefore, stage and streamflow are key considerations in determination of the total volume of pollutants which a body of water can naturally absorb with only minimal changes in water quality. There are instances of record where the Public Service Commission has refused to grant or has restricted irrigation permits on the grounds that the diversion would lower downstream water levels to the extent that the stream could not then assimilate existing municipal sewage treatment plant effluent loads and that a stream pollution problem would thus be created.

Among the state agencies, the Wisconsin Conservation Commission has water pollution control responsibilities that are second in importance only to those of the State Committee on Water Pollution and the State Board of Health. Under the provisions of Section 23.09(1) of the Wisconsin Statutes, the Commission is charged with establishing:

> ... an adequate and flexible system for the protection, development, and use of forests, fish and game, lakes, streams, plant life, flowers and other outdoor resources in the State of Wisconsin.

Water quality and pollution of lakes and streams are, therefore, of direct concern to the Commission. Though broad programs and the day-to-day routine of pollution control are left to the State Board of Health and the State Committee on Water Pollution, the Conservation Commission often becomes involved with the problems of pollution when an abnormally high surge of pollutants in a particular reach of the stream results in a fish kill. Under Section 23.095(1) of the Wisconsin Statutes, it is "unlawful for any person, firm, or corporation unreasonably to waste or maliciously injure, destroy or impair any natural resource." If the cause of the fish kill is not natural, and following investigation it is attributed to man-made pollution, the Commission is empowered to immediately bring a civil action to recover damages for the killed fish. Amounts range from \$2 to \$10 per fish depending on species. Thus, the aggregate penalty can be substantial when, as may be the case, many thousands of fish are killed as the result of a heavy discharge of pollutant. The severity of the penalty and the immediacy of the response thus serves to deter to some extent single acts of pollution which are so detrimental to water quality as to arouse the attention of the Conservation Commission. This approach is not, however, effective in correcting slow, long-term increases in pollution which may eventually so degrade water quality as to completely destroy a fishery.

Metropolitan Water Pollution Control Machinery

The Metropolitan Sewerage Commission of the County of Milwaukee, under Section 59.96 of the Wisconsin Statutes, has the power to establish and carry out a program of water pollution control. The broad mandate to the Commission states that they shall 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. To assist the Commission in carrying out these functions, the Statutes further state that any town, city, or village in the discharge of sewage effluent into any river or canal within the county or drainage area may be subject to such regulations as the Commission may determine; and the Commission may make and promulgate and enforce such reasonable rules for the supervision, protection, management, and use of the entire sewerage system as it deems expedient. The enabling legislation contemplates that the county-wide Metropolitan Sewerage Commission would work closely with the Sewerage Commission of the City of Milwaukee, organized pursuant to Chapter 608, Laws of 1913. The older Sewerage Commission of the City of Milwaukee has broad regulative powers similar to those cited above.[19] Thus, these two commissions have broad powers to regulate all aspects of private, industrial, and municipal effluent discharges which at any time enter into either the county-wide metropolitan sewerage system or the City of Milwaukee sewerage system and can use these powers to maintain reasonable water quality standards in receiving streams; as for example, that part of the Root River within the metropolitan district limits.

Local Water Pollution Control Machinery

All towns, villages, and cities in Wisconsin have, as part of the broad grant of authority by which they exist, sufficient police power to regulate by ordinance any condition or set of 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 would fall within this regulative sphere by virtue of its potential danger to health and welfare. In addition, towns, under the provisions of Section 60.30 of the Wisconsin Statutes, may establish sanitary districts; and cities and villages, under Section 66.20 of the Wisconsin Statutes, may establish sewerage

[19] *Chapter 608, Laws of Wisconsin 1913, particularly Section 5(c)(h).*

districts, both of which bodies, under Sections 60.306(2) and (2)(m) and 66.205(7) of the Wisconsin Statutes, respectively, have broad regulative powers not dissimilar to those of the Metropolitan Sewerage Commission of the County of Milwaukee, which seemingly would enable a program of water quality and pollution control to be carried out by these local units of government.

Private Steps for Water Pollution Control

Each of the previously discussed methods of pollution control depend upon an agency of government taking action within the framework of statutorily delegated powers. Any number of factors may intervene to negate the application of such controls. Attempts to control water pollution by the direct action of a private individual or organization in the courts may not only be the quickest but also in some cases the most effective pollution control device available. This avenue of relief is little used, however, probably because of the heavy costs involved in meeting the burden of proving "unreasonable pollution."

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 their 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, they 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 the Root River are not foreclosed by the existence of state or local pollution control efforts from attempting to assert their common law rights in court. The court may ask the State Board of Health or the State Committee on Water Pollution 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 to abate pollution.

Federal Water Pollution Control Machinery

The United States Congress in 1965 enacted a Water Quality Act. Under the provisions of this act, states are given until July 1, 1967, to establish satisfactory water quality criteria, or standards, to protect interstate waters. Lake Michigan is an "interstate water" under the act. If pollutants in the Root River as it flows into the lake adversely affect the quality of Lake Michigan water, federal action to abate the pollution might ultimately be undertaken in the event that the State of Wisconsin should fail to take acceptable action. In any event, federal pressure almost certainly would be brought to bear on the state to prescribe and enforce meaningful water quality standards.

CONSTRUCTION OF WATER CONTROL FACILITIES BY LOCAL UNITS OF GOVERNMENT

Sound physical planning principles dictate that a watershed be studied in its entirety, if practical solutions are to be found to water-related problems, and that plans and plan implementation programs, including the construction of water control facilities, be formulated dealing with the interrelated problems of the watershed as a whole. A watershed, however, typically is cut in a most haphazard fashion by a complex of man-made political boundaries—county, city, village, town, and special district. When public works projects covering and serving an entire watershed are contemplated, these artificial demarcations become important because they limit the jurisdiction—the physical area within which any one particular arm of local government may act. Several possibilities exist, with respect to the Root River, by which this limitation may be overcome. These include delegation of the task to the SEWRPC, creation of a special development district, and delegation of the task to the Metropolitan Sewerage Commission of the County of Milwaukee.

The Role of the Regional Planning Commission

The language of Section 66.945(8)(a) of the Wisconsin Statutes clearly limits the role of regional planning commissions to planning and advisory functions. Yet Section 66.30 of the Wisconsin Statutes would seem to permit the SEWRPC, pursuant to a valid contractual arrangement with the local units of government, to carry out comprehensive public works projects within an entire watershed for, and in behalf of, the contracting municipal units. The resolution of this apparent statutory conflict may simply lie in the argument that Section 66.945 of the Wisconsin Statutes, under which the SEWRPC was organized, does not expressly permit an implementing role to be played by the Commission and thus overrides what appears to be the enabling provisions of Section 66.30 of the Wisconsin Statutes.

The local units of government concerned, however, could in any case proceed without the SEWRPC, under the provisions of Section 66.30 of the Wisconsin Statutes, to implement specific water control facility plans under a mutual contractual relationship. If it is assumed that the benefits of comprehensive watershed public works accrue in some rough proportion to all of the municipal units involved and that the self-interest and sense of propriety of each would impel them all to be party to a contract, then the contractual provisions of Section 66.30 of the Wisconsin Statutes seem completely capable of dealing with the problem. A commission separate and distinct from the SEWRPC could be set up to administer the contract, or seemingly any other administrative device mutually agreed upon may be set up to carry out the joint public works projects deemed necessary. Recent legislation may make this approach all the more feasible inasmuch as it is now possible to finance "the acquisition, development, remodeling, construction, and equipment of land, buildings, and facilities for regional projects" by a joint bond issue backed in allocate shares by the contracting local units.[20]

[20] *Chapter 238, Laws of Wisconsin 1965.*

The Use of Special Districts

Another possibility for areawide water control facility plan implementation is through the creation of a special district embracing the entire watershed and capable of raising revenues through taxation and bonding, acquiring land, and constructing and operating the necessary facilities and otherwise dealing with the wide range of problems, alternatives, and projects inherent in comprehensive watershed planning. Such a district might be specifically charged in the enabling legislation by which it is created with carrying out the plans formulated by the SEWRPC. Though such enabling legislation has been proposed to the Wisconsin Legislature in the past, it has not, to date, received approval and thus is not presently available as a means of dealing with the problem. However, its broad approach and long-run desirability may dictate that the Legislature be reapproached with strengthened legislation towards these ends.

Present legislation, Section 92 of the Wisconsin Statutes, authorizes the creation of soil and water conservation districts, the boundaries of which are coterminous with county lines. There exists such a district in each county of the Root River basin. These districts to date have had a strong agricultural orientation. In southeastern Wisconsin their efforts have been focused primarily on inducing individual farmers to use good soil management and conservation techniques. Respective county board agricultural committee members are ex officio the board of supervisors of the soil and water conservation districts. Of major practical significance is the fact that these districts have no taxing, special assessment, or bonding power. They are completely dependent upon county funds and U. S. Department of Agriculture grants for their finances. Federal grants under Public Law 83-566 can be obtained by such districts for the construction of flood control projects only if the federal preconditions are met. If, however, any proposed water control facilities within the Root River watershed can meet these requirements, these districts may serve as an agent for federal financing of the project.

The Metropolitan Sewerage Commission of the County of Milwaukee

It is also possible that the Metropolitan Sewerage Commission of the County of Milwaukee could carry out public works improvements along the entire length of the Root River under the provisions of Section 59.96(6)(a) of the Wisconsin Statutes. A question arises as to how far outside the district limits the Commission may go in making stream improvements. Certainly no definite distance in miles can be given. Where the proposed improvement has no or only a very slight relationship to the carrying off or movement of potential floodwater arising within the district, the courts may not permit the district to reach out very far beyond its boundary. On the other hand, where a large volume of water to be controlled originates within the district or becomes an increased flood threat to downstream landowners by virtue of having been channeled, collected, or accelerated in flow within the district, the courts may allow the Commission to reach out many miles to construct improvements designed to alleviate the hazard. It appears that the Metropolitan Sewerage Commission of the County of Milwaukee may obtain financial support from any governmental unit outside the district which would be benefited by the improvement. This may be accomplished by contract with such governmental unit under Section 59.96(6)(a) of the Wisconsin Statutes. If the Commission encounters a reluctance on the part of any municipal unit to obligate itself to pay its fair share of the improvement cost, the provisions of Section 59.96(7)(a) of the Wisconsin Statutes seemingly give to the Commission the power to levy the amount required.

SPECIFIC LEGAL CONSIDERATIONS IN THE ROOT RIVER WATERSHED

Certain specific legal problems became apparent as work on the Root River watershed study proceeded. These dealt with the backing of floodwaters into established agricultural drains, the location of the watershed boundary itself, interbasin water diversion, and private dams. All received special study.

Legal Implications of Temporarily Backing Floodwaters Into Agricultural Drains

One type of water control facility being considered for incorporation in the Root River watershed plan is the retention reservoir. While retention reservoirs sometimes provide a practical engineering approach to water control problems, the construction of such reservoirs presents certain legal problems which must be recognized and considered before a final plan selection is made. One of these concerns the legal consequences of ponded water which may damage the improvements of drainage districts or nullify the effect of privately owned farm drains and tiles. A drainage district would have a cause for action if it could prove injury resulting from the backing of floodwaters into its drainage system. The legal remedy of damages can be employed even though the equitable remedy of injunction may not be available to prevent construction or use of retention reservoirs. From the standpoint of expediency and simplicity, the drainage district might negotiate the sale of a flowage right. If this is not feasible, an action can be brought by the drainage district each time that temporary flooding causing provable damage occurs. If the damage is permanent, that is, constitutes a "taking," the drainage district can initiate inverse condemnation proceedings.

The governmental unit considering construction of retention reservoirs seemingly has two approaches available to it. One of these might be called "active." Here the purchase of a flowage right is sought or condemnation proceedings commenced. An active approach has the advantage of doing today what might prove considerably more expensive if done at a later date. Furthermore, if any liability for damage appears imminent, it should be fixed and limited in advance, rather than left open and uncertain as to amount. The other general approach is just the opposite, an "inactive" or wait and see attitude. This approach seems especially attractive in the Root River watershed owing to the infrequency, short duration, and the usually early spring occurrence of major flooding on the Root River. No actual injury to drainage districts may ever occur. Thus, simply building the retention reservoirs without seeking to condemn land or acquire flowage rights and dealing with any damage claims if and when they do arise may be the least costly and simplest way of proceeding.

The legal alternatives open to private individuals are identical with those described above wherein the drainage district was portrayed opposite a governmental unit. Individual farmers are in no way prevented from suing or acting on their own behalf either in law or in equity to preserve their interests in whatever drainage improvements they may have created on their lands.

The Root River Watershed Boundary

One of the more important legal questions encountered early in the Root River watershed study involved delineation of the watershed boundary. Early investigation revealed that some question existed as to whether the true historical northwest boundary of the Root River watershed excluded the land drained by, and the waters of, Muskego Lake and Little Muskego Lake as shown on the Official Map of the watershed prepared by the SEWRPC, No. RT-1, dated January 1965 (see Map 1) or whether the true historical boundary included this land and these waters, thus enlarging in a westerly direction the total size of the watershed by approximately 21,000 acres (32.8 square miles). The question posed is of legal interest because it involves a possible diversion of international waters. The lands and waters in question presently drain into the Fox-Illinois River system and thence to the Gulf of Mexico. If the true historical boundary of the Root River watershed included these waters, they at one time drained into Lake Michigan.

The problem becomes more immediate and meaningful inasmuch as the Metropolitan Sewerage Commission of the County of Milwaukee is currently undertaking a program of expanding sanitary sewerage facilities, premised in part on a reassertion of what that agency believes to be the true and historic watershed boundary of the Root River and a reading of Sections 59.96(6)(a) and 59.96(9)(c) of the Wisconsin Statutes. Riparians who have relied for some time on the present boundary of the watershed are likely to resist any change.

As might be expected, there is some evidence to support either point of view. The weight of evidence to date, however, seems to indicate conclusively that Little Muskego Lake and Muskego Lake have naturally and historically drained into Wind Lake and thence into the Fox-Illinois River system, thus excluding these waters and the lands they drain from the Root River watershed. Subsequent man-made improvements of this natural drainage pattern would not at the time they were made or now provide any legal basis for altering the historic watershed boundary.

The most important single piece of evidence indicating that these lands and waters drained in a southerly direction and eventually into the Fox-Illinois River system is the original United States Public Land Survey conducted in the Region in 1836-1837. The field notes of the government surveyor and detailed accompanying plats, which are on file in the State Land Office, Madison, Wisconsin, clearly indicate that a major natural drainage existed in Section 33, Township 5 North, Range 20 East, moving in a southerly direction between Muskego and Wind lakes. Little Muskego Lake and the waters above it are shown to flow into Muskego Lake; and from an examination of these notes and plats, there can be no doubt that the waters of Wind Lake flowed into the Fox River. Furthermore, these notes and plats fail to show any natural drainage from the northeast portion of Muskego Lake to the Root River. On the contrary, the government surveyor indicated that much of the northern, northeastern, and eastern shore of the lake had a three- to four-foot bank, while most of the western, southwestern, and southern shore was low-lying marsh and swampland. In those few instances where small marsh or swamp areas abut the northeastern shore of the lake, the surveyor indicated that their course of drainage was into the lake and not away from it towards the Root River.

Laws passed by the Wisconsin Legislature in 1887 and 1890 permitted man-made improvements to be carried out in these natural drainage patterns between Muskego and Wind lakes. Man-made improvements of previously existing natural drainage patterns cannot be considered a diversion of waters.

Evidence that these waters at one time flowed into the Root River may be inferred from a number of early laws of Wisconsin authorizing private parties to drain the waters of Muskego Lake into the Root River.[21] The enabling legislation, however, does not state that these waters naturally flowed into the Root or that the improvement authorized was in conformity with any previously existing natural flow. As to some later maps showing a flowage to have existed from Muskego Lake into the Root,[22] it would be a curt, though not wholly unwarranted, answer to say simply that the maps were improperly drawn. This is not an entirely satisfactory explanation, however.

A plausible explanation has been advanced by Mr. George F. Hanson, Wisconsin State Geologist. He notes that the entire area was historically very poorly drained and that no sharp watershed divides existed. He theorizes that in such circumstances it would not be impossible, during periods of peak flow or exceptionally high runoff, for waters to drain temporarily in both directions; that is, south into the Fox River and northeast into the Root River. In other words, what was shown on some maps as marsh or small flowages moving into Muskego Lake from the northeast may, during periods of extremely wet weather and high runoff, have actually moved away from the lake,

[21] *Laws of Wisconsin 1854, Chapter 262; 1856, Chapter 498; and 1868, Chapter 198.*

[22] *Map of 1878 found in the Historical Atlas of Wisconsin, published by Snyder Van Vechten and Co. of Milwaukee, and an 1891 USGS map on file in the office of the Wisconsin Geological and Natural History Survey, Madison, Wisconsin.*

spilling over into the Root River system. As the waters receded to more normal levels, these flowages would once again move into Muskego Lake. After the man-made improvements in the natural drainage patterns between Muskego and Wind lakes, which lowered the level of Muskego Lake substantially, such a phenomenon, drainage into two major watersheds, would be almost impossible. Some evidence tending to support Mr. Hanson's theory may be found in the fact that during the period 1875 to 1878, shortly before one of the maps in question was prepared, the U. S. Weather Bureau Station at Milwaukee recorded a cumulative total of 51.64 inches of water in excess of the normal rainfall for this period. As a result, surveyors working at that time may very well have encountered the situation Mr. Hanson described and so recorded it on their maps.

Interbasin Water Diversion

Another one of the more important legal problems in water resources planning concerns interbasin diversion. The traditional common-law riparian doctrine which, for the most part is still in effect today, forebade the transfer of water between watersheds. This was regarded as a non-riparian use of water and often gave rise to a per se violation. It must be recognized, however, that states by legislative action can and have created exceptions to this general doctrine and that major interwatershed diversions have on occasion taken place. A prominent example is the diversion of water from the Lake Michigan-St. Lawrence River drainage basin to the Mississippi River drainage basin via the Chicago and Illinois rivers.

Such diversions are not made without great legal difficulty. Two major groups of individuals 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 private or public agencies carrying out the diversion. The first group are those riparians along the stream from which the diversion is made. If the diversion is total, that is, if the entire flow is permanently terminated, courts will have little difficulty finding that a "taking" of private property had occurred. A buying out of these property interests would then almost certainly be required, regardless of the public benefit which might accrue from such a diversion. If either less than the entire flow is diverted or if the entire flow is diverted, but for only limited and determinable periods of time, then the question of reasonableness enters in. If under the circumstances of a particular case the diversion is unreasonable, then compensation more than likely will have to be paid. If, too, the plaintiff can show damages as a direct result of either the less than total flow diversion or the total flow diversion which occurs only periodically, he may be able to recover these damages even though the diversion is otherwise termed reasonable.

The second group of individuals who may be in a position to assert legal rights are those whose lands abut the stream or lake shore into which the diversion is made. The diverter is liable to these riparians for lands taken or damages caused as a consequence of the unnatural increased flow. If the increased flow is permanent and overflows property beyond the normal lake or stream high water mark, a compensable "taking" of this newly overflowed property will have occurred. If the increased flow is minimal or occurs only occasionally, the question of reasonableness, to be determined in the context of all of the relevant facts in each particular case, is again present. If found unreasonable, compensation must be paid. Again, if the plaintiff can show damages, he will probably be compensated, though in other respects the increased flow may be deemed reasonable. Obviously, if an interbasin water diversion is of major proportions, the number of people in either or both of these two groups of riparians will be very large. Consequently, the amount of land involved and the total cost of compensation for land taken and/or for damages may be great. This can be and in fact is a major factor in preventing such interbasin diversions.

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.[23] 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 current and longstanding litigation between Wisconsin and Illinois in the Supreme Court of the United States concerning the Chicago diversion and developments arising therefrom. A central point in the Wisconsin argument before the court is 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 longheld 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 U. S. Supreme Court litigation.

Private Dams

One of the specific problems encountered in the Root River watershed planning program involves the disposition of an existing mill dam, Horlick Dam located near STH 38 in Racine County. Here a dam has created a flowage or impoundment, and landowners whose lands abut the flowage have relied over a period of time on the artificial condition created by the dam. This reliance is evidenced by home and recreation facilities constructed in close proximity to, and because of, the flowed water. The Supreme Court has recently stated the applicable law:[24]

> If an artificial body of water is created, landowners incidentally benefited are entitled to injunctive relief to prevent disturbance of the new state of the water. Wisconsin prescriptive rights cases involving proprietors of lands which border bodies of water, who in some way relied on the new water level which was maintained by another's dam hold that when the artificial level of the water is continued for a considerable period of time, usually 20 years, it becomes a natural condition.

So in cases where a dam created a flowage, which is now more than 20 years old, owners on the flowage seemingly are able to compel the owner of the dam to continue to maintain it.

A local unit of government or the state itself has only limited powers to compel the owners of private dams to maintain them. These powers are based on some combination of arguments involving the preservation of public rights in the flowage created, public safety, health, and welfare or, in some instances, the specific terms or inferences which may be found in dam permits issued pursuant to statute by the Railroad Commission or its successor, the Public Service Commission.

SUMMARY

This chapter has described in summary form the legal framework within which comprehensive watershed planning and plan implementation must take place in southeastern Wisconsin. The salient findings having particular importance for planning in the Root River watershed include the following.

Water law is not a simple or fixed body of law. It has historical roots which reach back beyond the common law. The traditional riparian doctrine was early modified to include principles of reasonable use and more recently state permit systems. Renewed recognition of public water rights, state and local regulative activities, and federal regulations have further altered relationships between individuals and between individuals and government as they relate to water. The field of water law has never been in a greater and more constant state of change and development than it is today.

For purposes of flood control, flood-damage prevention, and proper use of the riverine environment, a stream valley can be divided into three main sectors: the channel, defined as that area within which the average high annual streamflow is confined; the primary flood plain district, recommended to be defined as that area back from the

[23] *Wis. Stats. 30.18(2). Surplus water as used in this section means any water of a stream which is not being beneficially used. The Public Service Commission may determine how much of the flowing water at any point in a stream is surplus.*

[24] *Tiedeman v. Middleton, 25 Wis. 2d 443 (1964).*

channel which is inundated by floodwaters having a recurrence interval of 10 years; and the secondary flood plain district, recommended to be defined as that area back from the primary flood plain district which is inundated by floodwaters having a recurrence interval of 100 years.

It is completely reasonable to impose different land use restrictions on each of these land areas. Whereas all encroachments in the channel may be removed summarily without compensation under Section 30 of the Wisconsin Statutes or by local ordinance, many activities and some structures may be quite properly permitted in the secondary flood plain district, with due regard as to their placement in relation to the channel and to the primary flood plain district, their ability to withstand occasional flooding, the total cost of the damage they are likely to sustain, their conformance with flood-oriented safety and building codes, and their effect upon valley storage. The use of lands in the primary flood plain district should be carefully restricted in the public interest but not taken. Very few structures and only those of low value and capable of withstanding fairly frequent flooding should be permitted. Recreation, park, parkway, public parking, and agricultural uses seem best suited to this area.

Statewide building and safety codes are promulgated by the Wisconsin Industrial Commission. It seems entirely possible in view of the unique dangers inherent within the flood plain that more stringent regulatory measures designed to more adequately control development within the flood plain could be embodied in these codes. Such a course of action could be accomplished by an exercise of the presently existing rule-making powers of the Industrial Commission.

Pollution control and maintenance of water quality standards are problems of growing importance. Many more tools exist than are presently being used to control pollution. The State of Wisconsin, the Metropolitan Sewerage Commission of the County of Milwaukee, local units of government, and private individuals acting through the courts each have powers to exercise in an effort to control pollution, powers which heretofore have been used only sparingly and with caution. The Federal Government has indicated its intention to enter this field and more forcefully deal with the problem of pollution upon continued failure of the states, the local units of government, and private individuals to act. The SEWRPC itself can act as a research, liaison, and coordinating body to effect pollution control and desired water quality standards within the Region and its component watersheds, such as the Root River.

There is little likelihood that the erection of retention reservoirs as a means of controlling flooding along the stream by holding peak runoffs will present serious legal problems. Some drainage districts or individual farm lands may be affected (damaged), but they can be suitably dealt with either before the dams and reservoirs are built, by means of purchasing flowage rights or condemning the necessary land, or after the dams and reservoirs are operational by settling with each claimant as, if, and when he comes forward.

The best evidence in hand indicates that the historic and the present boundary of the Root River watershed is as shown on SEWRPC Map No. RT-1, dated January 1965 (see Map 1). There has always been a natural flowage between Muskego Lake and Wind Lake and thence to the Fox-Illinois River system; and thus these waters and the lands they drain never were, and are not now, a part of the Root River watershed. What dispute exists seems to stem from the fact that in comparatively recent years the natural drainage pattern has become more definite due to man-made improvements. These improvements may have been erroneously regarded by some as diversions.

There are a number of legal impediments to large scale inter-watershed diversions. Two major groups of riparians, those from whom and those to whom water is being diverted, have legal rights which may well be infringed upon in such an undertaking. In addition, the legal problems of state consent, public rights in the diverted water, and the seemingly restrictive language of Section 30.18 of the Wisconsin Statutes must be faced. Finally, the tactical legal position which Wisconsin has taken in opposition to Illinois in the Chicago River diversion case before the U. S. Supreme Court seems to make unlikely, if not actually impossible, any project involving the diversion of a major quantity of water from one river basin to another.

The maintenance and upkeep of private dams built along streams within Wisconsin is best attained by those riparians who have relied upon the existing flowage created by the dams, in that they have constructed housing or recreational facilities in close proximity to the waters edge. Local governmental units or the state have only limited powers to compel such upkeep; and these powers must be based on some aspect of public rights in the flowage or the preservation of health, safety, and welfare.

Chapter X

ANTICIPATED GROWTH AND CHANGE IN THE ROOT RIVER WATERSHED

INTRODUCTION

In any planning effort, forecasts are required of all future events and conditions which are outside the scope of the plan but which affect plan design or implementation. Normally, the future demand for land and water resources is determined primarily by the size and spatial distribution of future population and economic activity levels within a watershed or a planning area. Control of changes in population and economic activity levels, however, lies largely outside the scope of governmental activity at the regional and local level and entirely outside the scope of the watershed planning process. In the preparation of a comprehensive watershed plan, therefore, future population and economic activity levels within the watershed must be forecast. These forecasts can then be converted to the future demand for land and water resources within the watershed and a land and water use plan prepared to meet this demand.

It is important to note that in the Root River watershed planning program the spatial distribution of future land use, because of the basic concepts underlying the program, lies within the scope of the plan to be produced and is, therefore, a design rather than a forecast problem. Thus, while it is necessary to forecast the future gross requirements within the watershed for each of the major land use categories, the spatial allocation of land to meet these requirements within the watershed is an important element of the plan itself.

The geographic location of the Root River watershed within the rapidly urbanizing Southeastern Wisconsin Region and in close proximity to Lake Michigan is an important factor affecting forecast requirements and methods. Economic activity affecting development within the Root River watershed is located largely outside the watershed boundaries. Thus, the primary determinant of future land and water demand within the watershed is the future level of population; and forecasts of economic activity , per se, are not required.

Watershed planning must focus not only upon future requirements for land and water but also upon the effect of these requirements upon the natural resource base. Although such focus with respect to water resources must receive careful consideration in any watershed planning effort, the ready availability of Lake Michigan as a source of water supply for all of the Root River watershed limits long-range future water uses to a relatively narrow range and simplifies water demand forecast requirements.

The primary natural resource element affected by population growth within the watershed, therefore, is land, particularly land as open space with its attendant recreational and broad resource conservation values. The riverine areas, comprising approximately 6 percent of the total area of the watershed, are particularly important in this respect because it is here that the problems and opportunities arising out of a rapidly changing land use pattern will most affect the other elements of the natural resource base and the quality of the total environment within the watershed.

POPULATION

Several basic methods for preparing population projections for planning areas are in common use, and for each of these methods a variety of specific procedures and techniques have been developed. Because the Root River watershed is an integral part of the Southeastern Wisconsin Region, population growth within the watershed is closely related to economic and population changes in the Region; and historic relationships between population growth in the watershed and the Region can provide a valuable guide for the projection of watershed population. Moreover, population forecasts for a relatively large area, such as the Southeastern Wisconsin Region, can be prepared with a much higher degree of reliability than for a relatively small area, such as the Root River watershed. It was, therefore, decided to prepare population projections for the watershed by the ratio method.

Population Size

The SEWRPC has prepared population forecasts for the Region to the year 1990, based upon economic as well as demographic studies and analyses and using several independent methods.[1] These forecasts estimate the 1990 population level of the Region at 2,678,000 persons, an increase of about one million persons over the 1963 level of 1,674,000 persons. A projection of the historic ratio between the regional and the watershed population would place the 1990 population level of the watershed at 294,500 persons, or 11 percent of the total regional population (see Figure 28 and Table 31). This represents an increase of about 160,000 persons over the 1963 population of the watershed of 134,200 persons. This represents a very rapid rate of population growth for the watershed, resulting in a population increase of about 120 percent in only 27 years, which is only slightly lower than the highest recent historic rates of population increase within the watershed.

There are several factors influencing development within the Region and the watershed which indicate that this projected value is a reasonable estimate of the population level which might be expected within the watershed by 1990. Growth within the watershed will probably tend to be stimulated by what appears to be an increasing public demand within the Region for housing served by public sewer and water supply systems, with consequent restrictions of new urban development to areas of the Region relatively readily served by existing and proposed sanitary sewerage and water supply systems. The Root River watershed constitutes such an area within the Region; and, therefore, population growth and urbanization within the watershed can be expected to continue to occur at a rapid rate. There also appears to be an increasing tendency for governmental action directed at restricting residential development without public sewer service to soils well suited for such use and prohibiting such development on soils poorly suited for such development. This factor would tend to stimulate development in some areas of the watershed and restrict it in others. Finally, growth within the watershed will tend to be moderated by the fact that the communities which have historically accounted for the largest population increases within the watershed, the cities of Greenfield, Racine, and West Allis and the villages of Greendale and Hales Corners, will be nearing their limits of complete development by 1990. These factors tend to offset each other so that development within the watershed can reasonably be expected to occur at approximately recent historic rates.

[1] *See SEWRPC Planning Report No. 7, Volume 2.*

Population Characteristics

Changes in the characteristics of the watershed population are expected to closely parallel those of the regional population, as described in Chapter III of SEWRPC Planning Report No. 7, Volume 2. There will be proportionately more older and more younger persons in the watershed than there are now; personal incomes will rise considerably above the 1963 levels; and the average resident of the watershed will be better educated and have more leisure time.

THE ECONOMY

In 1990, as at present, the economic activity most vital to watershed development is expected to be located primarily in the Milwaukee and Racine industrial complexes, largely outside the boundaries of the watershed, and will be highly concentrated in the manufacturing of durable goods and food and kindred products and in printing and publishing. The watershed will continue to provide a residential "bedroom" community for these industrial complexes. Within the watershed an expansion in economic activity associated with the needs of a highly expanded residential community can be expected. This expansion will primarily take the form of neighborhood and community commercial activity and light manufacturing.

The pressure of urban land development, accompanied by rising real estate taxes, may be expected to force agricultural activities into production of high-value crops. The practice of natural pasturing of dairy and beef stock may largely disappear, and pen-feeding may be used to save land. Truck-farming is likely to become the dominant form of row-cropping. Additional detailed information on forecasted economic activity within the Region is provided in SEWRPC Planning Report No. 7, Volume 2.

LAND USE DEMAND

The requirements of approximately 294,000 residents for dwelling space and service facilities will largely determine the amount and variety of each of the various land uses within the Root River watershed in 1990. If present trends continue without regulation in the public interest, it appears likely that the approximately 160,000 new residents which the watershed will probably gain over the 27-year period from 1963 to 1990 will live primarily in residential areas developed at low and medium densities.

Table 31

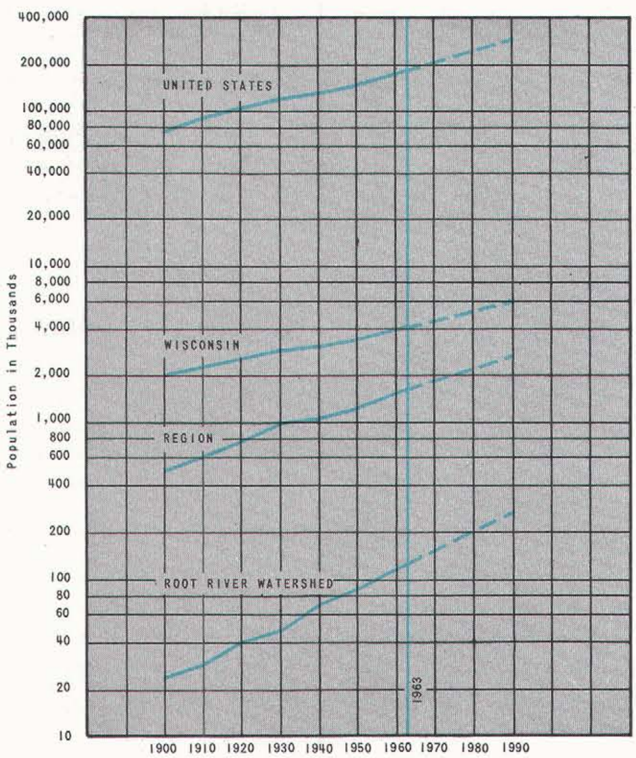
POPULATION TRENDS AND PROJECTIONS FOR THE UNITED STATES, WISCONSIN, THE REGION, AND THE ROOT RIVER WATERSHED (1900 - 1990)

Year	United States	Wisconsin	Region	Root River Watershed	Watershed Population as a Percent of the Regional Population
1900.	75,994,575	2,069,042	501,808	24,100	4.8
1910.	91,972,266	2,333,860	631,161	29,400	4.7
1920.	105,710,620	2,632,067	783,681	40,700	5.2
1930.	122,775,046	2,939,006	1,006,118	48,400	4.8
1940.	131,669,270	3,137,587	1,067,699	70,700	6.6
1950.	151,325,798	3,434,575	1,240,618	86,000	6.9
1960.	179,323,175	3,952,771	1,573,620	125,000	7.9
1963.	188,616,000	4,061,000	1,674,000	134,200	8.0
1970.	208,996,000	4,511,000	1,870,000	166,400	8.9
1980.	245,313,000	5,176,000	2,223,000	220,100	9.9
1990.	288,219,000	5,977,000	2,678,000	294,500	11.0
1963 - 1990 Percentage Increase	52.8	47.1	59.9	119.5	

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

Figure 28

POPULATION TRENDS AND PROJECTIONS FOR THE UNITED STATES, THE STATE OF WISCONSIN, THE REGION AND THE ROOT RIVER WATERSHED (1900-1990)



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

An analysis of urban development within the watershed from 1950 to 1963 indicates that 69 percent of the residential development during this period occurred in the form of low-density development, 30 percent in the form of medium-density development, and only 1 percent in the form of high-density development.[2] The analysis further indicates that, for the Region as a whole, 98 percent of the population resides in households and that the average household size in 1960 was 3.30 persons.

For land use demand forecast purposes, it was, therefore, assumed that 98 percent of the population increase in the watershed from 1963 to 1990 would reside in households with an average household size of 3.30 persons. It was further assumed that, if existing trends continue, at least 65 percent of the new households within the watershed would reside in low-density residential areas and 35 percent in medium-density residential areas and that there would be no appreciable demand for additional high-density residential development during the forecast period. Commercial and industrial land use demand was forecast using existing land use to population ratios of 5.2 acres per thousand persons and 2.8 acres per thousand persons, respectively. Transportation and utility land uses were forecast to increase in direct proportion to increases in residential, commercial, industrial, and governmental and institutional land uses, the increase in the former group being equal to 33 per-

[2] *Low-density residential development is defined as 0.2 to 1.7 dwelling units (households) per gross acre; medium-density, as 1.8 to 4.7 dwelling units per gross acre; and high-density, as over 4.8 dwelling units per gross acre. The midpoints of these ranges correspond to net lot areas of 35,700, 10,000, and 3,630 square feet per dwelling unit, respectively.*

cent of the increases in the latter group. Governmental and institutional and recreational land use demand was forecast using land use to population ratios of 11 acres per thousand persons and 14 acres per thousand persons, respectively. The comparable existing ratios for these uses in 1963 were 9.1 and 24.3 acres per thousand persons, respectively. Future agricultural and water, woodland, and wetland demand was not forecast since these uses within the watershed generally provide the area for expansion of the other land uses.

Based upon the foregoing assumptions and the population forecast for the watershed, the 1990 demand within the watershed was forecast for each of the major land use categories, as shown in Table 32. Comparison with existing land use data indicates that, if existing trends continue, residential land use within the watershed will increase from 20.18 square miles in 1963 to 65.78 square miles in 1990, an increase of 225.9 percent. All other urban land uses would increase from 24.27 square miles in 1963 to 49.33 square miles in 1990, or 103.2 percent. This total "demand" for urban land would be satisfied primarily by conversion of agricultural lands, woodlands, and wetlands, which would collectively decline by 70.66 square miles, or 46.2 percent.

WATER RESOURCES

Surface Water Resources

In the consideration of any forecast of future surface water conditions within the watershed, it must be recognized that such a forecast can only reflect general conditions that are likely to prevail throughout the watershed. Specific conditions may vary greatly from such general conditions because of the variable influence of the effect of several important factors, including: 1) weather; 2) ground water levels; 3) land use type, distribution, and intensity; 4) land management practices; 5) sewage treatment and disposal and storm water drainage facilities; and 6) the volume, kind, and place of waste discharge.

The topography and geology of the watershed is such that, in the absence of any artificial water control facilities, there is little long-term natural storage of rainfall and runoff within the watershed in a form available for streamflow supplementation. Floodwater discharge is unimpeded by any

Table 32

FORECAST LAND USE DEMAND IN THE ROOT RIVER WATERSHED (1990)

Major Land Use Category	Existing Land Use		Incremental Land Use Demand 1963 - 1990		Total Land Use 1990		
	Acres	Square Miles	Acres	Square Miles	Acres	Square Miles	Percent of Watershed
Residential							
Low-Density	9,170	14.33	25,360	39.62	34,530	53.95	27.3
Medium-Density	1,808	2.82	3,825	5.98	5,633	8.80	4.5
High-Density	1,937	3.03	--	--	1,937	3.03	1.5
Subtotal	*12,915*	*20.18*	*29,185*	*45.60*	*42,100*	*65.78*	*33.3*
Commercial	700[a]	1.09	802	1.25	1,502	2.35	1.2
Industrial	384[b]	0.60	481	0.75	865	1.35	0.7
Mining	748	1.17	--	--	748	1.17	0.6
Transportation	9,220[c]	14.41	10,744	16.79	19,964	31.19	15.8
Governmental	1,224[d]	1.91	1,763	2.75	2,987	4.67	2.4
Recreational	3,258	5.09	2,244	3.51	5,502	8.60	4.3
Agricultural	83,725	130.82	--	--	52,687	82.32	41.7
Water, Woodlands, Wetlands	14,181	22.16	--	--			
Total	126,355	197.43	--	--	126,355	197.43	100.0

[a] *Includes 116 acres of on-site parking.*

[b] *Includes 63 acres of on-site parking.*

[c] *Includes communications and utilities uses; excludes 239 acres of on-site parking.*

[d] *Includes institutional uses and 60 acres of on-site parking.*

Source: SEWRPC.

major artificial device; and continued urbanization of the watershed will tend to facilitate, not detain, surface water runoff. In the previous discussion of the probable effects of urbanization on surface water runoff in Chapters IV and VI, it was noted that the improved efficiency of urban drainage systems and the effect of increased impervious areas will probably cause a doubling of the frequency of summer rainfall flood events over the period from 1963 to 1990. A 10-year rainfall flood event in 1963, for example, will probably become a 5-year rainfall flood event by 1990. As explained previously, however, urbanization will probably not appreciably change the frequency of a snowmelt induced flood event. It is also probable that urbanization will not appreciably change significantly the total volume of runoff of either spring snowmelt or summer rainfall induced flood events but will tend to concentrate that runoff in a shorter time interval, thus increasing peak flood stages.

The effect of urbanization in the watershed will also be reflected in exceptionally low flows. The Root River, especially under prevailing ground water table conditions, receives little low-flow supplementation from the shallow ground water aquifer. It is likely that under future conditions it will receive even less ground water contribution. Low flows will be further reduced by exportation of sewage wastes, now contributing all of the 90 percent reliable flow of the North Branch, to a new sewage treatment plant on Lake Michigan in the City of Oak Creek.

The decline of low-flow volume in the North Branch fortunately will be accompanied by a removal of much of the pollution loading, measured in terms of BOD load, on the North Branch and the main stem. Some sources of pollution, such as that which occurs from storm water drainage, will continue to affect the North Branch, probably in increasing quantities as urbanization proceeds within the Region and the watershed. Significant sources of pollution will remain on other portions of the river system, and increasing surveillance will be required to monitor their effects on quality conditions of the Root River. In general, it is believed that a scattered type of urban development causing reliance on septic tank disposal of wastes and small largely inefficient treatment plants would be more deleterious than an integrated system of sewage treatment and disposal emphasizing a high degree of treatment.

Ground Water

Because of ground water withdrawals occurring in the large urbanizing area surrounding the watershed and extending from Chicago to Milwaukee and from Lake Michigan to Waukesha, pressure levels in the deep aquifer underlying the watershed are declining at the rate of about four feet per year. This decline is apt to continue and perhaps accelerate. This fact has significant implications for municipalities within the watershed, such as Union Grove, which presently depend solely upon ground water as the source of municipal supply; but it has particularly serious implications for the rural domestic or industrial user of the deep aquifer. It is anticipated that continued pressure declines in the deep aquifer will encourage a trend toward centralization of water supply into fewer and larger utilities better capable of dealing with rapidly declining deep well water levels and importation of Lake Michigan water.

Many ground water withdrawal facilities within the watershed, particularly rural domestic wells, take water from the shallow aquifer. The shallow aquifer is recharged primarily in the Fox River watershed to the west of the Root River watershed. It is discharged through ground water withdrawals occurring primarily in the rural and suburban areas in and surrounding the watershed. Especially heavy withdrawals and consumptive use of water from the shallow aquifer occur immediately to the west of the watershed in the Wind Lake irrigated farm area. This heavy demand will probably accelerate the rate of decline in shallow well water levels in localized areas of the watershed, affecting some private water supplies. Under other heavy local pumping or induced recharge, it is possible that many local cones of depression or ground water mounds could occur, irrespective of the general regional rises or declines of the shallow ground water table.

SUMMARY

It is estimated that the population of the Root River watershed will increase from 134,200 in 1963 to 294,500 by 1990, an increase of about 120 percent in the 27-year period. If the present trend toward a low-density, highly diffused pattern of urban development is projected to 1990, residential land use will increase threefold; and supporting land uses will expand significantly, requiring a conversion of 42 percent of the now limited wetlands, woodlands, and related open spaces and 41 percent of the present agricultural lands within the watershed to urban use.

Urbanization of the watershed will accentuate present surface water problems. Summer flood peaks will become significantly higher and will carry increasing amounts of polluting substances received from urban storm runoff. Low flows will be depressed further by exportation of sewage from the watershed, by less local recharge of the shallow aquifer with increases in impervious areas, and by the general region-wide decline of the shallow aquifer in response to increased ground water withdrawals. The potential for development of septic water conditions on the Root River will rise. In the deep aquifer, ground water levels will probably continue to fall at the rate of about four feet per year as a result of regional and interregional withdrawals. In the shallow aquifer, ground water levels will probably continue to be drawn down significantly by localized high-capacity pumping.

In summary, it is apparent that over the 27-year period from 1963 to 1990 land and water resource problems within the watershed will increase in direct proportion to the magnitude, extent, and rate of urbanization. Many of the undesirable effects of urbanization, however, can be avoided or ameliorated by sound land and water resource planning and plan implementation measures.

Chapter XI

WATERSHED DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

Since planning is a rational process for defining and meeting objectives, the formulation of objectives is an essential task to be undertaken before plans can be prepared. The objectives chosen guide the preparation of alternative plans and, when converted to standards, provide the criteria for evaluation of the alternatives and selection from among the alternatives of the final plan. Since objectives provide the logical basis for plan synthesis and evaluation, the formulation of sound objectives is a crucial step in the planning process.

It is important to recognize that, because the formulation of objectives involves a formal definition of a desirable physical system by listing in effect the broad needs which the system aims to satisfy, the objectives implicitly reflect an underlying value system. Thus, every physical development plan is accompanied by its own unique value system. The diverse nature of value systems in a complex urban society complicates the process of goal formulation and makes it one of the most difficult tasks in the planning process. This difficulty relates, in part, to the lack of a clear-cut basis for a choice between value systems and, in part, to the reluctance of public officials to make an explicit choice of ultimate goals. Yet, it is much more important to choose the "right" objectives than the "right" plan. To choose the wrong objectives is to solve the wrong problem; to choose the wrong plan is merely to choose a less efficient physical system. While there may be no single argument to support a given choice of objectives because of differing value systems, it is possible to state certain planning principles which provide at least some support for the choice.

It must also be recognized that objectives may change as a selection is attempted from among alternative plans. In the process of evaluating alternative plans, the various alternative proposals are ranked according to ability to meet objectives. If the best plan so identified, nevertheless, falls short of the chosen objectives, either a better plan must be synthesized or the objectives must be compromised. Plan evaluation provides the basis for deciding which objectives to compromise. The compromises may take three forms: certain objectives may be dropped because their satisfaction has been proven unrealistic; new objectives may be suggested; or conflicts between inconsistent objectives may be balanced out. Thus, formulation of objectives must proceed hand in hand with plan design and plan implementation as part of a continuing planning process.

Concern for objectives cannot end with a mere listing of desired goals. The goals must be related in a demonstrable and, wherever possible, quantifiable manner to physical development proposals. Only through such a relationship can alternative development proposals be properly evaluated. This relationship is accomplished through the formulation of a set of supporting standards for each chosen objective.

Because of the value judgments inherent in any set of development objectives and their supporting standards, soundly conceived watershed development objectives, like regional development objectives, should incorporate the combined knowledge of many people who are informed about the watershed and should be established by duly elected or appointed representatives legally assigned this responsibility rather than by planning and engineering technicians. Active participation by duly elected or appointed public officials and by citizen leaders in the regional planning program is implicit in the structure and organization of the Southeastern Wisconsin Regional Planning Commission itself. Moreover, the Commission has provided for the establishment of advisory committees to assist it in the conduct of the regional planning program, including the necessary watershed planning studies, and to broaden the opportunities for active participation in the regional planning effort.

The use of these advisory committees appears to be the most practical and effective procedure available for involving officials, technicians, and citizens in the regional planning process and of openly arriving at decisions and action programs which can shape the future physical development of the Region and its component watersheds. Only by combining the accumulated knowledge and experience which the various advisory committee members possess can a meaningful expression of desired direction, magnitude, and quality of future regional and watershed development be attained. One of the major tasks of these advisory committees, therefore, is to assist the Commission in the formulation of development objectives, supporting principles, and standards. This chapter sets forth the watershed planning objectives, principles, and standards which have been adopted by the Commission after careful review and recommendation by the advisory committees concerned.

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 by the Commission 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 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 only with the first three of these terms, an understanding of the interrelationship between the foregoing definitions and the basic concepts which they represent is essential to any consideration of watershed development objectives, principles, and standards.

WATERSHED DEVELOPMENT OBJECTIVES

Objectives, in order to be useful in the watershed planning process, must not only be sound logically and related in a demonstrable and measurable way to alternative physical development proposals but must also be consistent with, and grow out of, region-wide development objectives. This is essential if the watershed plans are to comprise integral elements of a comprehensive plan for the physical development of the Region and if sound coordination of regional and watershed development is to be achieved.

The Southeastern Wisconsin Regional Planning Commission has, in its planning efforts to date, adopted, after careful review and recommendation by various advisory and coordinating committees, nine general regional development objectives, eight specific regional land use development objectives, and seven specific regional transportation system development objectives. These, together with their supporting principles and standards, are set forth in SEWRPC Planning Report No. 7, Volume 2. Certain of these specific regional development objectives relating to land use are directly applicable to the watershed planning effort and are hereby recommended for adoption as development objectives for the Root River watershed. 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 the protection, wise use, and development of the natural resources of the Region—soils, inland lakes and streams, wetlands, woodlands, and wildlife.

3. A spatial distribution of the various land uses which is properly related to the supporting transportation, utility, and public facility systems in order to assure the economical provision of transportation, utility, and public facility services.

4. 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 recreational program providing a full range of facilities for all age groups.

5. 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 rural areas which provide wildlife habitat and are essential to shape and order urban development.

In addition to the foregoing specific regional land use development objectives, the following specific land use development objective is recommended for adoption as an additional development objective for the Root River watershed:

6. Good soil and water conservation practices to reduce storm water runoff, soil erosion, and stream sedimentation and pollution.

The following specific water control facility development objectives are also recommended:

1. An integrated system of drainage and flood control facilities which will effectively serve the existing land use pattern of the watershed and promote the implementation of the watershed land use plan, meeting the anticipated runoff loadings generated by the existing and proposed land uses.

2. An integrated system of water quality control facilities and pollution abatement devices adequate to ensure the quality of water necessary to permit the following water uses:

   a. Recreation involving partial body contact.

   b. Preservation of facultative fish life.

   c. Wildlife and livestock watering.

   d. Aesthetic setting for residential and recreational land use development.

Complementing each of the foregoing specific land use and water control facility development objectives is a planning principle and a set of planning standards. These, as they apply to watershed planning and development, are set forth in Tables 33 and 34 and serve to facilitate quantitative application of the objectives in plan design, test, and evaluation.

It should be noted that the planning standards herein adopted 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. The standards set forth herein should serve not only as aids in the development, test, and evaluation of watershed land use and water control facility plans but also in the development, test, and evaluation of local land use and community facility plans and in the development of plan implementation policies and programs as well.

The foregoing watershed development objectives and their supporting principles and standards necessarily reflect certain value judgments by experienced public officials and technicians within the Region and the watershed. In addition, certain engineering design criteria were utilized in the preparation of the watershed plans; and while these are firmly based in present engineering practice, it was, nevertheless, felt important to document these herein. It should be noted that, while these criteria were used in the preparation of the watershed plans, they do not comprise standards as defined herein, in that they relate to the methods used in inventory, analysis, and plan synthesis and test, rather than to specific development objectives.

ENGINEERING DESIGN CRITERIA FOR THE ROOT RIVER WATERSHED

Rainfall-Frequency Relationships

If local storm water drainage and main river flood-control measures are to be compatible and function in harmony, plans for both must be based on consistent engineering design criteria. A fundamental criterion for both local and watershed drainage planning is the rainfall intensity–duration–frequency relationship representative of the watershed area.

Intensity–duration–frequency curves based on a 48-year record at Milwaukee Weather Bureau Station are shown in Appendix I. The curves in Figure I-1 are directly applicable to urban storm water drainage system design using the rational formula, while the equivalent curves in Figure I-2 are expressed in a form more convenient for hydrologic simulation. These curves are applicable to the Southeastern Wisconsin Region and to the

Table 33

LAND USE DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE ROOT RIVER WATERSHED

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 watershed at each density, the following minimum amounts of land should be set aside:

Residential Land	Net Area[a]	Gross Area[b]
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[c]
Regional[d]	3 acres/1,000 persons
Local[e]	6 acres/1,000 persons

Park and Recreation Land[f]	Gross Area[g]
Regional[h]	4 acres/1,000 persons
Local[i]	10 acres/1,000 persons

2. For each additional 100 commercial and industrial employees to be accommodated within the watershed, the following minimum amounts of land should be set aside:

	Gross Area[j]
Commercial Land[k]	5 acres/100 employees
Industrial Land[l]	7 acres/100 employees

OBJECTIVE NO. 2

A spatial distribution of the various land uses which will result in the protection, wise use, and development of the natural resources.

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.

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.

A. Soils

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[m] to be developed for low-density residential use, no more than 2.5 percent of the gross area should be covered by 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 be covered by 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 be covered by soils rated in the regional soil survey as poor, questionable, or very poor for such development.

2. Rural development, principally agricultural land uses, shall be allocated primarily to those areas covered by soils rated in the regional soil survey as very good, good, or fair for such uses.

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. Not more than 50 percent of the length of the shoreline of inland lakes having a surface area in excess of 50 acres and of perennial streams should be allocated to urban development except park and outdoor recreational uses.

2. 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.

3. Flood plain lands[n] should not be allocated to any urban development[o] which would cause or be subject to flood damage.

4. No unauthorized structure or fill should be allowed to encroach upon and obstruct the flow of water in the perennial stream channels[p] and floodways.[q]

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.

STANDARD

All wetland areas[r] adjacent to streams or lakes, all 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[s]

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[t] 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[u]

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.

STANDARD

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. 3

A spatial distribution of the various land uses which is properly related to the supporting transportation and public utility systems 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 prime natural resource areas by through traffic.

2. The transportation system should be located and designed to provide access not only to all land presently devoted to urban development but also to all land well suited for urban development.

3. 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.

4. 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.

5. Urban development should be located so as to maximize the use of existing transportation and utility systems.

OBJECTIVE NO. 4

The preservation and provision of open space[V] to enhance the total quality of the regional environment, maximize essential natural resource availability, give form and structure to urban development, and provide the basis for 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 it is essential to outdoor recreational pursuits.

STANDARDS[W]

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. 5

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[x] 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. 6

Good soil and water conservation facilities and practices to reduce storm water runoff, soil erosion, and stream sedimentation and pollution.

PRINCIPLE

Good soil and water conservation practices, including contour strip cropping, crop rotation, and grass waterways 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 in urban areas can assist in reducing storm water runoff, soil erosion, and stream siltation and pollution.

STANDARDS

1. A minimum of 50 percent of the area of the watershed in agricultural use should be under district cooperative soil and water conservation agreements and planned conservation treatment.

2. A minimum of 25 percent of the area of the watershed in agricultural use should be under conservation treatment.

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[a] 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.

[b] 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.

[c] 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.

[d] Includes federal, state, and county governmental uses; hospitals; cemeteries; colleges and universities; and large region-serving, semipublic institutional uses, such as central YMCA facilities. Presently approximates 3 acres/1,000 persons.

[e] Includes schools and churches. Approximately one-half of this standard is met implicitly if the gross acreage standard for residential use is met. Presently approximates 6 acres/1,000 persons.

[f] This category does not include regional or local open spaces other than those actively used for public park or outdoor recreational purposes; that is, 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.

[g] Gross park and recreation area is defined as equal to net area.

[h] Presently includes only 14 existing parks within the Region classified as being of regional significance, which combined contain 4,432 acres or 2.6 acres per 1,000 persons. These are: the Fox River Park and Petrifying Springs Park in Kenosha County; six of the Milwaukee County Park Commission Metropolitan parks--Brown Deer Park, Grant Park, Greenfield Park, Lake-Juneau Park, Lincoln Park, and Whitnall Park; Hawthorne Hills Park in Ozaukee County; Johnson Park in Racine County; Big Foot Park in Walworth County; and Menomonee Park, Mukwonago Park, and Nagawaukee Park in Waukesha County.

[i] Presently includes 379 neighborhood and community parks, which combined contain 5,698 acres or 3.4 acres per 1,000 persons. A portion of this standard is met implicitly if the gross acreage standard for residential use is met. This implicit 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.

[j] 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.

[k] Includes all regional, local, and highway-oriented commercial activities plus adjacent streets and on-site parking. Presently approximates 3.4 acres per 100 employees.

[l] Includes all manufacturing and wholesaling activities plus adjacent streets and on-site parking. Presently approximates 4.1 acres per 100 employees.

[m] Areas, as used in this context, refer to any land unit, 160 acres or more in areal extent, which is subject to development.

[n] Flood plain 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.

[o] Urban development, as used herein, refers to all land uses except agriculture, water, woodlands, wetlands, and open lands.

[p] A stream channel is herein defined as that area of the flood plain 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.

[q] 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.

[r] 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.

[s] The term woodlands, as used herein, is defined as a dense, concentrated stand of trees and underbrush covering a minimum area of 20 acres.

[t] 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.

[u] Includes all fish and game.

[v] 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.

[w] 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 this 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.

[x] Prime agricultural areas are defined as those areas which a) contain soils rated in the regional detailed operational soil survey as very good or good for agriculture, and b) occur in concentrated areas over five square miles in extent which have been designated as exceptionally good for agricultural production by agricultural specialists.

Table 34

WATER CONTROL FACILITY DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE ROOT RIVER WATERSHED

OBJECTIVE NO. 1

An integrated system of drainage and flood control facilities which will effectively serve the existing land use pattern of the watershed and promote the implementation of the watershed land use plan, 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. The waterway opening on all existing bridges and culverts over major drainageways and perennial waterways shall be adequate to accommodate the following hydraulic loadings without causing overtopping of the directly related road surface and resultant disruption of traffic by floodwaters:

   a. Minor streets used or intended to be used primarily for access to abutting properties: a 10-year recurrence interval flood flow.

   b. Arterial streets and highways, other than freeways and expressways, used or intended to be used primarily for fast or heavy through traffic: a 50-year recurrence interval flood flow.

   c. Freeways and expressways: a 100-year recurrence interval flood flow.

2. The waterway openings on all new bridges and culverts over major drainageways and perennial waterways shall meet the applicable foregoing standards, providing, however, a minimum freeboard between the specified recurrence interval peak floodwater surface elevation and the high point of the waterway opening of the bridge or culvert.

3. The structural type of waterway opening for all bridges over major drainageways and perennial waterways shall be such as to maximize the passage of ice floes and other floating debris often associated with significant backwater effects and flood damage; and in selection of the structural bridge type, it should be recognized that clear spans and rectangular openings are more efficient than interrupted span and curvilinear openings in allowing passage of ice floes and debris.

4. Channel improvements should be restricted to the minimum number and extent absolutely necessary for implementation of the watershed land use plan, and channel improvements which may significantly increase 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.

5. All water control facilities on major drainageways and perennial waterways, other than bridges and culverts, such as dams and diversion channels, shall be adequate to accommodate the hydraulic loadings resulting from a 100-year recurrence interval flood.

6. All public land acquisitions intended to eliminate the need for water control facilities shall encompass at least all of the riverine areas lying within the 100-year recurrence interval flood inundation line.

OBJECTIVE NO. 2

An integrated system of water quality control facilities and pollution abatement devices adequate to ensure a quality of stream water permitting the following beneficial water uses:

a. Recreation involving partial body contact.

b. Preservation of facultative fish life.

c. Wildlife and livestock watering.

d. Aesthetic setting for residential and recreational land use development.

PRINCIPLE

Surface water is one of the most valuable resources of southeastern Wisconsin; and even under the effects of increasing population and economic activity levels, the potential of natural stream waters to serve a reasonable variety of beneficial uses in addition to the single-purpose function of waste transport and assimilation should be protected and preserved.

STANDARDS

1. All urban residential development except single-family residences on lots of five acres or more in area and located on soils rated in the regional soil survey as suitable for the soil absorption method of sewage disposal shall be served by public sanitary sewerage facilities conveying liquid wastes to a sewage treatment plant.

2. In those reaches of the stream system designated for the maintenance of a facultative fishery, minimum dissolved oxygen content of waters shall at all times equal or exceed 4.0 ppm and water temperatures shall not rise above 90°F.

3. In those areas of the stream system designated for boating and related partial body contact recreational uses, the bacteria count, expressed in membrane filter coliform count per 100 milliliters (MFCC/100ml), shall not exceed 5,000 during the primary use season of April 1 through October 31.

4. In those reaches of the perennial stream system not designated for the maintenance of a facultative fishery, minimum dissolved oxygen content of waters shall at all times equal or exceed 1.0 ppm.

Root River watershed. The variation of rainfall depth with area of consideration and the seasonal variation of rainfall probability are described in Figures I-3 and I-4 respectively.

Storm Sewer Design Criteria

Revised rainfall criteria and newly available soil survey data made possible more detailed consideration of rainfall-runoff relationships in design of storm sewers for urban areas in the Southeastern Wisconsin Region and in the watershed. Recommended values for the coefficient of runoff, C, which are based on land use, land slope, and soil type, are presented in Appendix I, Table I-1, Soils which occur in the watershed are categorized in hydrologic groups according to their infiltration capability in Appendix H, Table H-1.

Rainfall-Runoff Relationships

The rainfall-runoff criteria adopted for storm sewer design are not adequate for hydrologic simulation of basin-wide floods. For this purpose, Soil Conservation Service rainfall-runoff relationships were adopted. These relationships, and adjustments made to them for the specific conditions existing in the Root River watershed, are described in Chapter VI, "Hydrologic Simulation."

Channel Capacity, Flood Routing, and Backwater Computation

Channel capacities were calculated using the Manning formula for open-channel flow. This formula is used almost universally and has the advantage that values for the empirical coefficient used to represent the hydraulic friction are based on extensive field tests. The methods used in applying the Manning formula and the procedure for determining appropriate values for the friction factor, "n," are described in detail in Chapter V, "Hydraulics of the Watershed."

Flood routing is the mathematical process of simulating the effects of channel characteristics on the peak flow and duration of a flood as it moves through a channel system. The rate of flood travel, reduction of peak, and increase in duration are dependent upon size, shape, slope, and hydraulic friction of the channel. The storage-indication method of flood routing was selected as the most suitable for application in the Root River study since it is based upon the physical characteristics of the channel system, whereas most other methods are based upon streamflow records.

Backwater at bridges was calculated by the U. S. Bureau of Public Roads method, which is described and referenced in Chapter V, "Hydraulics of the Watershed." Backwater at culverts and other channel obstructions was calculated by standard hydraulic methods described in such books as King's Handbook of Hydraulics. Explanations of specific methods and appropriate references are given in Chapters V and VI.

Flood Frequency

An analysis of flood frequencies under present development conditions is presented in Chapter IV. Based on regional relationships, climatological data, and a gage height record in Racine, it was concluded that the flood peak flow recorded in March 1960 on the North Branch at W. Ryan Road (STH 100) is equivalent to a 100-year recurrence interval flood event. Furthermore, it was decided by the Watershed Committee that the design flood for watershed planning purposes should be at least as large as the 1960 flood, suitably adjusted for future land use conditions.

Flood frequency relationships for present and future land use conditions are all based on the assignment of 100-year recurrence interval to the 1960 flood. It should be recognized that this assignment of frequency, although representing the best engineering judgment in light of existing data, is still highly subjective. As streamflow data collection continues within the watershed, flood-frequency relationships should be reviewed and revised, if necessary.

OVERRIDING CONSIDERATIONS

In the application of the watershed development objectives, principles, and standards in the preparation, test, and evaluation of the watershed plans, several overriding considerations must be recognized. First, it must be recognized that each proposed water control facilities plan must constitute an integrated system. It is not possible from an application of the standards alone, however, to assure such a system since the standards cannot be used to determine the effect of individual facilities on each other or on the system as a whole. This requires the application of the hydrologic simulation models to quantitatively test the proposed system, thereby permitting adjustment of the spatial distribution and capacities of the system to the existing and future runoff loadings as derived from the land use plan. Second, it must be recognized that it is unlikely that any one plan proposal will meet all the standards completely; and the extent to which each standard is met, exceeded, or violated must serve as a measure of the ability of each alternative plan proposal to achieve the specific objectives which the given standard complements. Third, it must be recognized that certain objectives and standards may be in conflict and require resolution through compromise. Finally, it must be recognized that an overall evaluation of each combination of land use and water control facility plans must be made on the basis of cost. This concept is so important that it warrants special attention herein.

ECONOMIC CRITERIA

The concepts of economic analysis and economic selection are vital to the public planning process. Sound *economic* analysis of benefits and costs should be an important guide to planners and decision-makers in the selection of the most suitable plan from an array of alternatives. All decisions concerning monetary expenditures, either private or public, are based on an evaluation of benefits and costs. This is not to imply that a formal economic analysis is made before every expenditure. The process of decision itself, however, consists of a consideration of whether the benefit received would be worth the amount paid. Benefits are not necessarily accountable in monetary terms and may be purely intangible, but the very act of expending money (or resources) for an intangible benefit implies that the benefit is worth to the purchaser at least the amount spent.

In addition to the consideration involved in deciding that a potential benefit is worth its cost, consideration is also given to possible alternative benefits that could be received for alternative expenditures within the limits of available resources. Alternative benefits are compared, either objectively or subjectively; and the one which is considered to give the greatest value for its cost is selected. Again, the benefits may be purely intangible; but the decision-making process itself implies an evaluation of which alternative is considered to be worth the most. When consideration is made of investment for future benefits, one alternative that should always be considered is the benefit which could be received from investment in the money market. This benefit is expressed in the prevailing interest rate.

Personal and private decisions, while implying at least subjective consideration of benefits and costs, broadly defined, are not necessarily based upon either formal or objective evaluation of monetary benefits and costs. Public officials, however, have a responsibility to objectively and explicitly evaluate the monetary benefits and costs of alternative investments to assure that the public will receive the greatest possible benefits from limited monetary resources.

It is then a fundamental principle that every public expenditure should return to the public a value at least equal to the amount expended plus the interest income foregone from the ever-present alternative of private investment. This principle may also be stated that the public should receive a value return from its tax investment at least equal to what it could receive from private investment, since government exists, presumably, to serve the people.

Therefore, economic analysis is a fundamental requirement of responsible public planning; and all plans should promise a return to the public at least equal to the expenditure plus interest. It is emphasized that public expenditures should not be expected to "make money" but that they should be expected to return a value in goods and services which is worth to the public the amount expended plus interest.

Benefit-Cost Analysis

The benefit-cost analysis method of evaluating government investments in public works came into general use after the adoption of the Federal Flood Control Act of 1936. The act stated that waterways should be improved "if the benefits to whomsoever they may accrue are in excess of the estimated costs." Monetary value of benefits has since been defined as the amount of money which an individual would pay for that benefit if he were given the market choice of purchase. Monetary costs are taken as the total value of resources used in the construction of the project.

Benefits must exceed costs in order for a project to be justified, but this criterion alone is not sufficient to justify the investment. Although a project may have a benefit-cost ratio greater than 1.0, the ratio may be less than the benefit-cost ratio of an alternative project which would accomplish the same objectives. Therefore, in order to assure that public funds are invested most profitably, alternative plans or projects should be investigated and analyzed.

Implementation of comprehensive plans for the Root River watershed could include benefits of flood control, recreation, efficient community utilities and facilities, enhancement of property values, and an aesthetically pleasing community environment. Costs which could be incurred in implementation of watershed plans include construction, land acquisition, and income foregone as a result of regulation of land use.

Time Value of Money-Interest

The benefits and often the costs of construction projects accrue over long periods of time. Each project or alternative, public and private, is likely to have a different time flow of benefits and costs. Benefits of one project may be realized earlier than those of another, while the time flow of costs may vary from one large initial investment for one project to small but continuously recurrent expenditures for another. In order to place these projects with varying time flows of benefits and costs on a comparable basis, the concept of the time value of money must be introduced.

A dollar has a greater value to the consumer today than does the prospect of a dollar in the future. Because of this time preference for money, a consumer will agree to pay more than one dollar in the future for one dollar today. Conversely, to an investor one dollar in the future is worth less than one dollar today because he can obtain one dollar in the future from the investment of less than one dollar today. By the same reasoning, for public projects a one dollar cost or a one dollar benefit at some time in the future has a value of less than one dollar today. The variation of value of capital, benefits, and costs with respect to time is expressed through the mathematics of compound interest.

Use of an interest rate automatically incorporates consideration of the ever-present possibility of private investment as an alternative. A project, to be economical, should return to the public at least as great a benefit as it might obtain through private investment. Money invested privately is expected to return generally from 6 to 10 percent interest. Since implementation of the watershed plan should return benefits to the public equal to, or greater than could be attained through, private investment, an interest rate of 6 percent is recommended for use in the economic evaluation of plans. It should be noted that certain government agencies use a lower interest rate in such evaluation. Therefore, benefit-cost analyses of the watershed plans were also made using a 3 percent interest rate in order to allow evaluation by the criteria of other agencies.

The benefit-cost analysis for a project must be based on a specified number of years, usually equal to the physical or economic life of the project. Most of the improvements proposed in the Root River watershed plans, however, will continue to furnish benefits for an indefinite time, particularly the land use control and park reservation elements. In indefinite situations, such as this, government agencies have generally selected 50 years for the period of analysis; and this period is recommended for the Root River watershed plans. Using 6 percent interest, benefits accrued after 50 years, when discounted to the present, are very small. For example, given a uniform annual benefit of one dollar, the total present worth of the entire 50-year period from year 51 through year 100 would be only one dollar. The total present worth of the benefits for the 50-year period from year 1 through year 50 would, however, be almost $16. A final reason for using a 50-year period as a basis for benefit-cost analysis is the inability to anticipate the social, economic, and technological changes which may occur in the more distant future and which may influence project benefits and costs.

Project Benefits

The benefits from a project can be classified as direct, or measurable in monetary terms, and as intangible. Intangible benefits either are of such a nature that no monetary value can be assigned to them or are so obscure that calculation of the monetary value is impracticable. In the Root River watershed planning studies, direct benefits include flood-damage reduction, enhancement of property values, and that part of recreation to which a monetary value can be assigned. Intangible benefits include aesthetic factors deriving from natural beauty and a pleasant environment. Intangibles also include benefits, such as improved efficiencies in community utilities and facilities, that have monetary values but which are impracticable to calculate.

Direct benefits attributable to flood control were calculated by subtracting annual flood-damage risk for each plan alternative from annual flood-damage risk in an unplanned situation. Annual flood-damage risk was calculated for each alternative by means of the damage-frequency curves prepared for the study as described in Chapter VII, "Flood Damages."

The direct benefits from land use controls and from the provision of recreational opportunities are more difficult to establish. A partial account of the benefits resulting from the implementation of sound land use plans was made in terms of increased land values for housing sites adjacent to attractive natural environments. The remainder of the benefits of the land use plans were considered to be intangible. These intangibles include benefits from the provision of a more attractive and pleasant environment for living and working and benefits to communities and individuals because community facilities, such as drainage, water supply, roads, schools, and waste disposal, cost less per capita in a well-planned land use situation.

Direct benefits from the provision of recreation opportunities were calculated by multiplying estimated user benefits by estimated number of future users. The estimate of the number of future users was based on data on present use of similar facilities provided by the Milwaukee County Park Commission and the Wisconsin Conservation Commission and data on future parkway traffic provided by the State Highway Commission of Wisconsin. It was assumed that recreational demand would grow such that new facilities would have at least the same intensity of use as do existing facilities. Growth of demand appears assured by virtue of expanding population, higher income levels, shorter working hours, and increased travel.

The unit monetary benefits that were assigned to the individual users of the various recreational facilities were selected from those proposed in Supplement No. 1 to U. S. Senate Document No. 97. This publication sets forth the federal interagency standards for evaluation of outdoor recreation benefits. The unit values of zero to $1.50 per recreation day as set forth in the Supplement are intended to measure the amount that the users should be willing to pay, if such payment were required, to avail themselves of the recreation resources. Values assigned to individual recreation elements are presented in Chapter XII, "Alternative Plans."

The specific benefit of water quality improvement was considered to be intangible in the sense that it is difficult to measure, but very real since a high level of recreational use of the stream water is possible only if water quality is improved.

Project Costs

The direct costs of water resource development include the construction costs of physical elements of the plan and the cost of acquiring land.

Costs of structural facilities were calculated using unit prices which reflect the magnitude of work, the location in urban areas, and regional labor costs.

The cost of land acquisition was based on present market prices for urban improved, urban unimproved, and rural agricultural land in the Root River watershed. The cost of land use controls, such as would occur in a zoning-only plan, was taken as the difference in present market price between urban unimproved land and rural agricultural land. This is based upon the assumption that the present market price of land is equivalent to the present worth of the future income expected to be derived from that land. Under flood plain zoning, the principal profitable land use would remain agriculture.

Relationship of Economic and Financial Analysis

The distinction between economic feasibility and financial feasibility is of particular importance in the consideration of the costs of land already under public ownership. A financial analysis involves an examination of the liquidating characteristics of the project from the point of view of the particular government agency undertaking the project. The relevant matters are the monetary disbursements and monetary receipts of the project. The financial analysis determines whether or not the prospective available funds are adequate to cover all of the costs.

On the other hand, an economic analysis by a government body determines if the project benefits to whomsoever they accrue exceed the costs to whomsoever they accrue. Since one of the legitimate objectives of government is to promote the general welfare, it is necessary to consider the effect of a proposed project on all of the people who may be affected, not just the income and expenditures of a particular agency. The economic valuation of the benefits and costs may differ considerably from the actual income and expenditures of a government agency. The present market value of publicly owned but uncommitted land, such as the undeveloped holdings of the Milwaukee County Park Commission, is counted on the cost side of the economic analysis. Under the economic criterion of benefits and costs to whomsoever they accrue, this land must be considered to have an economic value for alternative uses which are foregone when the land is committed to another use, such as open space or recreation. The costs of public lands already developed with facilities for recreation are considered as sunk costs and not included in the economic analysis because alternative uses of the land can no longer be reasonably considered. The costs of land under public ownership, undeveloped or developed, are not considered in the financial analysis since no monetary outlay is required.

Staged Development

An attractive feature of many water resource developments is their divisibility into several individual projects which may be financed and built at different times. Staged construction requires lesser initial capital investments, reduces interest costs, and allows for flexibility of continued planning. Staging developments may also allow deferring an element until increased demands raise its benefit-cost ratio. However, in planning for staged development, consideration must be given to possibilities of higher costs in the future and the possible unavailability of land. In any development staging also serves to lower risks incurred through inavailability of data during preparation and partial implementation of initial plans.

SUMMARY

The process 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 and watershed development plans 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 watershed development and to quantify them insofar as possible through standards in order to provide the framework within which watershed plans can be prepared. Moreover, if the watershed plans are to form an integral part of the overall long-range plans for the physical development of the Region, then the watershed development objectives must be compatible with, and dependent upon, regional development objectives while meeting the primary watershed development objectives. Therefore, the watershed development objectives and supporting principles and standards set forth herein are based upon, and incorporated in, previously adopted regional development objectives, supplementing these only as required to meet the specific needs of the Root River watershed planning program.

Chapter XII

ALTERNATIVE PLANS

INTRODUCTION

Planning has been defined as a rational process for establishing and meeting objectives. Ideally, public planning should involve all levels of government concerned and offer an opportunity for citizen participation through duly elected and appointed public officials. If, in fact, the planning process is to achieve such active participation, the technical personnel largely responsible for the collection and analyses of data, preparation of forecasts, and plan synthesis must present to the responsible public officials alternative plans setting forth all reasonably feasible means of attaining previously agreed-upon development objectives. If alternative plans are not prepared, and only one plan is presented for evaluation, then a public right may have been usurped or ignored. The alternative plans presented by the technician must be physically attainable and should be generally beneficial to the public health, safety, and welfare. It is not essential that all of the plans be economically sound or aesthetically pleasing, but it is essential that the information necessary for public evaluation of these factors be included in the description of the plans.

BASIC CONCEPTS

The preparation of alternative comprehensive watershed plans is simplified by postulating individual plan elements which singularly represent partial solutions to the overall problems of the watershed. These elements then can be combined into alternative sets, or mosaics, each of which represents an alternative comprehensive plan. A large number of such possible combinations, representing alternative comprehensive plans, exist if there are many individual plan elements; but the possible combinations can usually be reduced through preliminary analysis to a few representing practical basic alternatives.

The individual plan elements for the Root River watershed may be separated into land use elements and water control facility elements. Three major individual land use elements and three major individual water control facility elements, which can be added singly or in combination to the land use plan elements, appear feasible (see Figure 29). In addition, certain accessory plan elements, which generally serve to complement the major water control facility alternatives, appear feasible. These include water pollution control measures which would be compatible and desirable adjuncts of the major components of an adopted plan (see Map 33). The land use plan elements, although emphasizing the riverine areas, apply to the watershed as a whole and represent the major basic approach to the comprehensive solution of the watershed problems. The water control facility plan elements are subordinate to the land use plan elements in that they do not affect the entire watershed and cannot alone offer a comprehensive solution to the watershed problems. Alternative watershed plans have, therefore, been herein identified by the name of the basic land use plan element, even though one or more of the water control elements are generally included as necessary adjuncts.

The alternative land use elements have been termed the "Uncontrolled Existing Trend Alternative," the "Controlled Existing Trend-Land Use Regulation Alternative," and the "Controlled Existing Trend-Parkway and Recreation Land Development Alternative." The major water control facility plan elements which serve as major adjuncts to the foregoing land use alternatives consist of channel improvements, diversion channels, and multi-purpose reservoirs. These, together with the pollution control alternatives and other accessory plan elements, are described and evaluated in the following sections. The results of a preliminary analysis of a privately proposed scheme to create a large lake in the Canal area, with water levels maintained by interbasin diversions of streamflow and pumped storage of Lake Michigan waters, are also reported.

Although the sharp distinction between alternative plans and their component elements must be recognized, for simplicity of presentation the alternative plans set forth in this and subsequent chapters take the name of the included land use element. Therefore, when the word "plan" is used instead of "element," it should be understood that certain water control facility and other adjunctive elements are included even though the plan is identified by a title referring solely to the land use element.

UNCONTROLLED EXISTING TREND ALTERNATIVE PLAN

Description

Land Use Element: The land use element of the Uncontrolled Existing Trend Alternative Plan is based upon a projection of existing land use development trends within the watershed. Land use development was assumed, in the absence of an areawide land use plan, to be guided only by private decision and the presently adopted local land use plans and zoning ordinances (see Map 34). It was further assumed that residential development of the flood plains would continue as in the past. This alternative is not so much a plan as it is a forecast of probable unplanned development and is intended to serve not as a recommendation but as a standard of comparison for the evaluation of true land use plans directed toward attaining watershed and regional development objectives, providing an indication of the probable ultimate character of the watershed environment if existing development trends are allowed to continue without limitation in the public interest. It serves the particularly important function of a reference for the calculation of the flood control benefits attendant to the other land use plans. Flood control benefits of the latter were determined by subtracting the residual flood-damage risk associated with each alternative from the flood-damage risk projected for the Uncontrolled Existing Trend Plan Alternative.

The probable spatial distribution of land uses within the watershed under uncontrolled conditions is shown on Map 35. This spatial distribution is based upon consideration of the following factors:

1. Satisfaction of the gross land use demands of the projected 1990 watershed population.

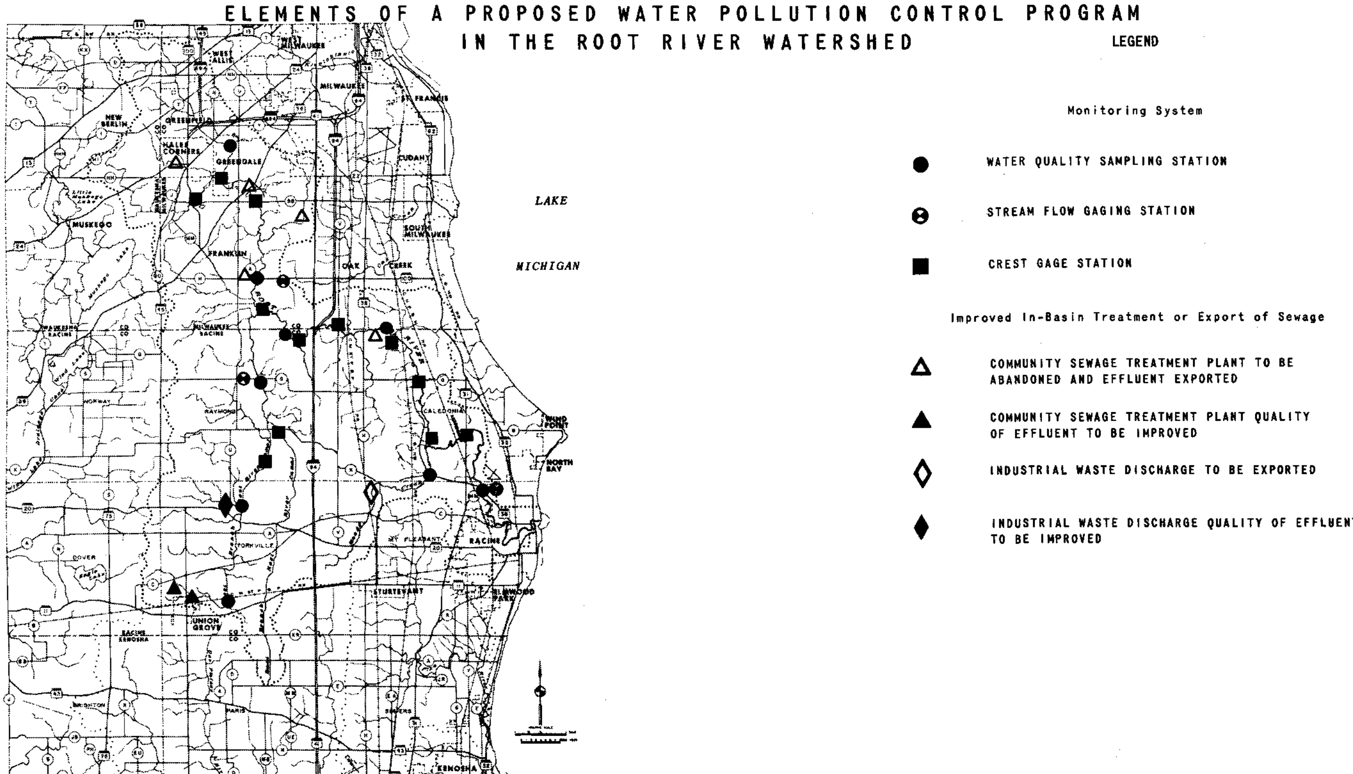
2. Execution of presently adopted local land use plans and zoning regulations by watershed communities.

3. Effect of committed decisions concerning drainage, sewerage, and highway facility development.

4. Existing land purchase and development trends.

Map 33

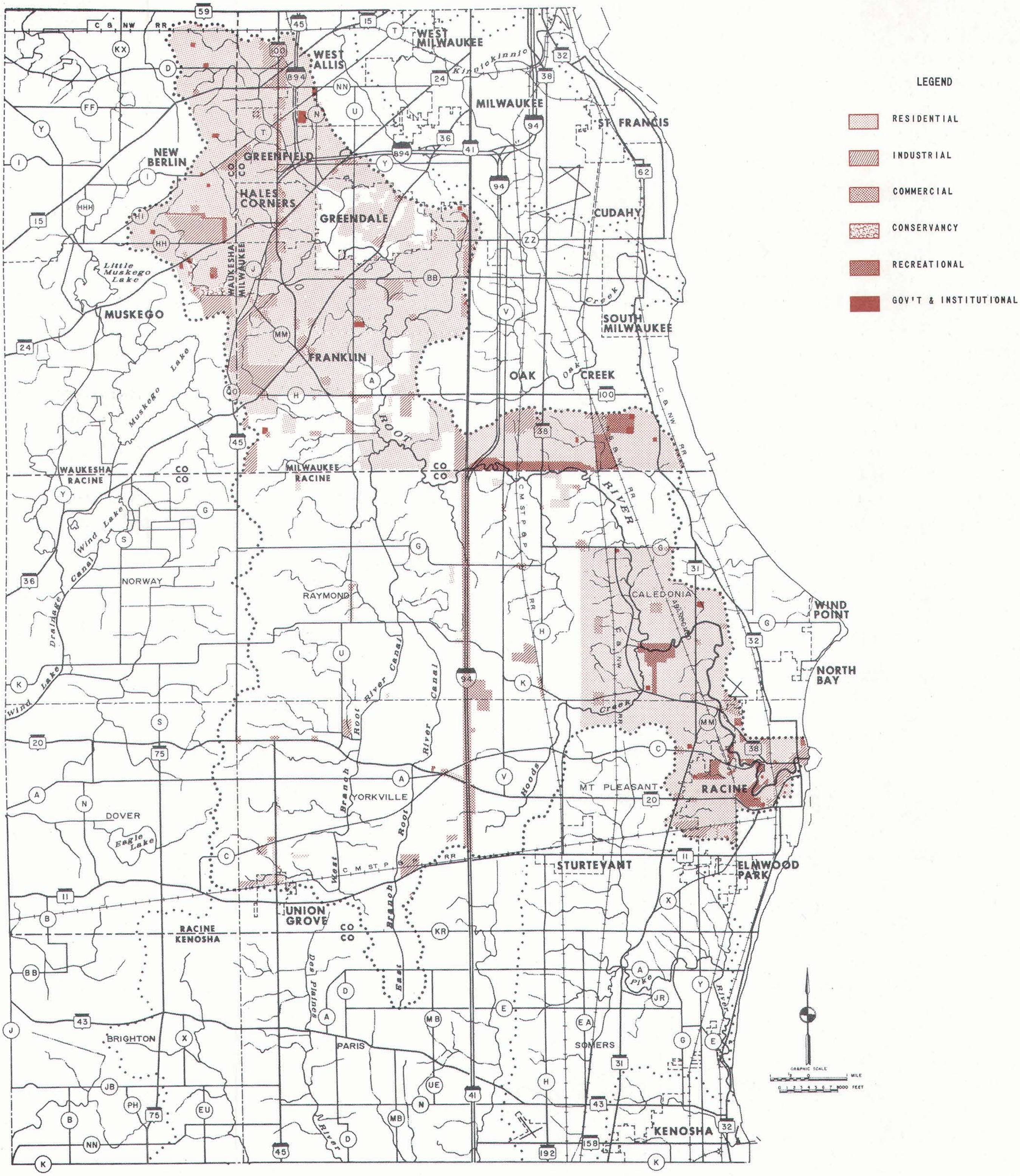
ELEMENTS OF A PROPOSED WATER POLLUTION CONTROL PROGRAM IN THE ROOT RIVER WATERSHED



Problems of water pollution are severe and extensive so that only a comprehensive control program having application throughout the watershed will ensure the kind of water quality environment necessary to support esthetic and limited recreational uses.

Map 34

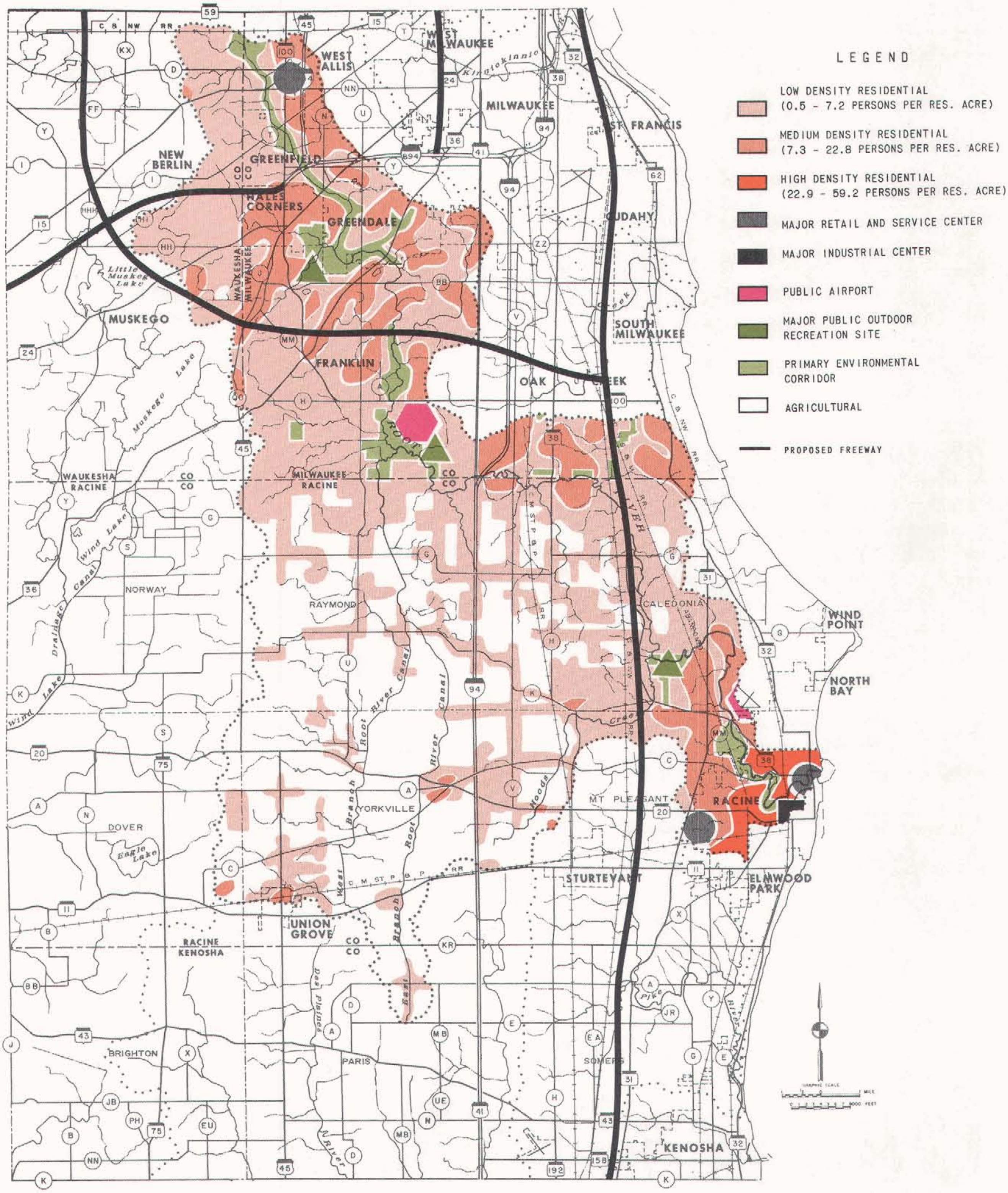
LOCALLY PROPOSED GENERALIZED LAND USES IN THE ROOT RIVER WATERSHED SEPTEMBER 1964



In the preparation of plans for the Root River watershed careful consideration was given to locally adopted land use plans and plan implementation devices.

Map 35

UNCONTROLLED EXISTING TREND LAND USE PROJECTION (1990)



Continued land use development within the watershed in the absence of any attempt to regulate such development in the public interest, will result in scattered basin-wide development of low densities without regard for soil capabilities, logical utility service areas, development opportunities, or protection of the floodways and flood plains.

5. Location of the major shopping, employment, and community service concentrations; bodies of water; and scenic areas which attract residential development.

6. Location of dumps, quarries, abandoned developments, and concentrations of heavy industry which serve to repel residential development.

Special attention was given to the probable location of future residential development on flood plain lands. Such development was projected on a house-by-house basis, with determination of the spatial distribution and estimated property values being guided by observed existing trends and by existing and committed utility and transportation system service areas. Stage-damage curves and damage-risk curves were prepared for the resulting future probable flood plain development, as described in Chapter VII, "Flood Damages."

Land located in the flood plain which is presently owned by the Milwaukee County Park Commission but which has not, as yet, been developed for recreational purposes posed a special problem in economic analysis. As explained in Chapter XI, "Watershed Development Objectives, Principles, and Standards," public investment in this undeveloped land does not represent a committed cost since it could be recovered by placing the land back on the private market. Since this opportunity is available, it was necessary to recognize and account for the cost of this undeveloped land in the economic analyses of any of the watershed plan alternatives that call for public ownership of flood plain land. For comparative purposes, therefore, it was also necessary to assume that, in the uncontrolled existing trend alternative land use element, this land would be returned to the private market and that residential development would take place on this land in accordance with the criteria applied to all other flood plain land. Although flood-damage relief benefits of the other plans were increased somewhat under this assumption, the inclusion of the far greater land values as costs in the other plan alternatives resulted in a conservative economic analysis.

Water Control Facility Elements: In the designing of alternative plans, three possible water control facility elements were considered as possible adjuncts to the uncontrolled existing trend alternative land use element. The committed decision to improve drainage within the City of West Allis required consideration of future channel improvements within the City of Greenfield, if the committed upstream channel improvements are to be effective and if flood plain use for residences is to be maximized. Construction of a floodwater diversion bypass channel to Lake Michigan was considered to allow extensive residential development of downstream flood plains. A multi-purpose reservoir at the junction of the North and Canal branches, however, was not considered to be generally compatible with a projection of existing land use development trends, for a minor portion of the reservoir site is already used for urban purposes and further encroachment would occur under extension of existing trends. The adoption of water pollution control measures would not be incompatible with the uncontrolled existing trend alternative land use element, but it is doubtful if such measures actually would be adopted if existing development trends were continued. The high cost of providing scattered urban development with centralized public sanitary sewer service would make effective pollution control under this alternative element particularly difficult to achieve.

Component Elements of the Uncontrolled Existing Trend Alternative Plan

In summary, the Uncontrolled Existing Trend Alternative Plan is composed of the following major component elements:

1. The uncontrolled existing trend alternative land use element;

2. Channel improvements of indeterminant extent as the primary alternative water control facility element; and

3. A diversion channel to Lake Michigan.

This alternative plan is evaluated in terms of its component elements in the following discussion. Additional, detailed evaluation of each separate water control facility element is provided in a later section of this chapter. A comparative evaluation of alternative plans is set forth in Chapter XIII of this report.

Evaluation of the Uncontrolled Existing Trend Alternative Plan

Satisfaction of Development Objectives: The land use plan element of the Uncontrolled Existing Trend Alternative Plan does not meet any of the regional or watershed development objectives (Chapter XI). In fact, it violates most of these. It is particularly destructive to the open space and prime agricultural soils of the uplands and almost totally destructive to the wildlife habitat and environmental corridors that comprise the river flood plains. The following statements are specifically related to the effect of the Uncontrolled Existing Trend Alternative Plan upon the watershed planning objectives.

Drainage and Flood Control: Problems of urban drainage and particularly of damage caused by river flooding would increase under the Uncontrolled Existing Trend Alternative Plan. Drainage problems would intensify in the low-density residential areas because the construction of comprehensive storm sewer systems would not be economically feasible. Solutions to drainage problems would have to be attempted on an ad hoc basis, often alleviating the problem in one area only to aggravate it in another. When urban development attained sufficient density to justify full storm sewerage, trunk lines would have to be built to carry magnified peak discharges of storm water directly to the main river channel. In the meantime, substantial residential development would have taken place in the river flood plain in downstream areas; and it would, therefore, become necessary to deepen and pave the river channels to protect lives and property.[1] The value of the flood plains as a storage place for floodwaters would be largely lost as structural measures would have to be taken to keep the river within the banks of its channel. At the present time, the amount of water temporarily stored on the flood plain at the peak of a 100-year recurrence interval snowmelt flood is about 24,000 acre-feet, equivalent to a flow of 12,000 CFS for one day. This storage causes a significant reduction of peak flows over those which would occur if the channels were deepened and improved.

Under the Uncontrolled Existing Trend Alternative Land Use Plan, it is anticipated that urban development would probably reach sufficient density by 1990 to justify the construction of extensive storm sewer systems in West Allis, Greenfield, and Greendale, which would require channel improvements to be carried into the City of Franklin. Storm sewer contributions to the river in the Racine metropolitan area would not create a significant problem because the capacity of the receiving channel would be proportionately much higher than in the headwater areas. Also, with improved drainage in the Racine area, the peaks caused by local inflow would recede prior to the arrival of upstream flood peaks.

[1] *This process has already been started on the North Branch, where channel deepening is required in West Allis and Greenfield because of residential development close to the river.*

Flood Plain Land Use--Open Space and Recreation: The Uncontrolled Existing Trend Alternative Plan does not distinguish between lands directly influenced by river flooding and other lands within the watershed. Residential development in the flood plain would continue; and, consequently, flood damages would increase.

Furthermore, this plan does not recognize the particular qualities of the flood plain lands for recreation and public open-space use. As discussed in Chapter III, "Description of the Watershed," the flood plains comprise a unique combination of soil, water, plant, and wildlife resources that together constitute environmental corridors along the perennial stream channels. These "corridors" present a unique opportunity for public open space and outdoor recreation use in close proximity to urban areas. This opportunity can never be practically recovered after urban development has taken place on the flood plain.

Stream Pollution and Water Quality: The problems of stream pollution and poor water quality would continue under the Uncontrolled Existing Trend Alternative Plan. No further action to abate the pollution problems of the watershed is presently scheduled after completion of the metropolitan trunk sewers which will carry wastes from communities in the North Branch drainage area to the Puetz Road sewage treatment plant.

Water quality in the river system, except in the Root River Canal, is expected to improve substantially after the trunk sewers are in full operation. Scattered residential developments in the Root River Canal drainage area, however, will cause pollution loads in that stream to increase, particularly if residential developments with septic tanks are continued to be allowed on soils poorly suited for such use and if small "package" treatment plants are installed to serve cluster developments. The Caddy Vista sewage treatment plant would continue to contribute wastes to the river, and additional disposal plants would probably have to be built to serve portions of the Town of Caledonia distant from the Racine municipal system.

At this time it is not practical to make quantitative forecasts of specific future water quality factors, such as BOD, coliform, dissolved oxygen, and temperature, under 1990 conditions; but it appears quite certain that the water quality objectives recommended for the watershed would not be met, except in the North Branch area, under the Uncontrolled Existing Trend Alternative Plan.

Benefits of the Uncontrolled Existing Trend Alternative Plan: One advantage that can be advanced for the Uncontrolled Existing Trend Alternative Plan is that decision-making as to land use would continue to be decentralized in individual landowners and developers. No monetary value, however, can be placed upon this single benefit, which is intangible. In a free enterprise economy, each landowner and developer should be subject to a minimum of constraints in selecting the utilization of his land that, to him, appears to offer the greatest profit; and each consumer should be free to choose the opportunity that, to him, appears to offer the greatest value. Theoretically, in a free enterprise economy, the individual is in the best position to evaluate his own particular set of circumstances and then to choose the opportunity that appears most profitable. For example, a land developer and home-builder would be free to choose whether or not to locate on the flood plain. If he decided to locate on the flood plain, in theory he would have carefully weighed the attendant benefits and costs and have concluded that the risk of flood damage was outweighed by other benefits of the flood plain location.

For this theory to apply in practice, however, it would be necessary for the individual decision-maker to have full knowledge of the existence and magnitude of the flood risk in making his decision and be willing to act responsibly upon that knowledge. This is seldom the case, particularly in the Root River watershed where major floods have been rare. It is also highly unlikely that an individual deciding whether or not to buy an existing residence or building in the flood plain would have all the facts as to the flood risk made available to him or be able, if the facts were known, to analyze them properly.

Costs of the Uncontrolled Existing Trend Alternative Plan: Both heavy direct and spillover[2] costs would be incurred under the Uncontrolled Existing Trend Alternative Plan.

Direct costs would result from recurring flood damages which would be incurred by residents of the flood plain and by the watershed communities. The procedures used for calculation of flood damages and annual flood-damage risk are described in Chapter VII, "Flood Damages." Annual flood-damage risk was calculated for 1965 land use and hydrologic conditions and for 1990 projected conditions. Prospective flood-damage risks in 1970, 1980, 2000, and 2010 were obtained by straight line interpolation and extrapolation; and it was assumed that each of the flood-damage risks applied over the five years preceding and following the selected decennial years. For example, the 1970 flood-damage risk was used to represent the period 1965 to 1975. Progressive growth of annual urban flood-damage risk under the Uncontrolled Existing Trend Alternative Plan is shown in Table 35. The total damages are estimated to increase by about 300 percent in 50 years.

[2] *Spillover costs are defined as costs which outside parties or the community as a whole must bear as a result of a private individual's decision.*

Table 35

PROJECTED GROWTH OF AVERAGE ANNUAL FLOOD-DAMAGE RISK
UNCONTROLLED EXISTING TREND ALTERNATIVE PLAN (1960 - 2010)

Damage Reach		Average Annual Flood-Damage Risk					
		1960	1970	1980	1990	2000	2010
1	City of Racine	$ 6,600	$ 6,600	$ 6,600	$ 6,600	$ 6,600	$ 6,600
2	South edge Racine Country Club to 1/2 mile east STH 31.	710	750	750	750	750	750
3	1/2 mile east STH 31 to Six Mile Road.	250	3,200	9,700	15,900	22,000	28,300
4	Six Mile Road to Nicholson Road.	650	880	1,370	1,830	2,300	2,770
5	Nicholson Road to S. 60th Street	760	1,900	4,300	6,630	9,000	11,400
6	S. 60th Street to Greendale boundary	3,000	4,100	5,600	7,170	8,800	10,300
7	Villages of Greendale and Hales Corners.	550	550	550	550	550	550
8	City of Greenfield	4,800	7,100	8,500	10,000	11,400	12,800
9	City of West Allis	6,200	--	--	--	--	--
	Total	$23,520	$25,080	$37,370	$49,430	$61,400	$73,470

Source: SEWRPC.

In addition to the direct costs resulting from flood damage, there would be costs to the community as a whole from spillover effects. Several areas in which spillover costs would be incurred are: the loss to the community of prime recreation and open-space land resources; the loss of value of the stream to downstream users as a result of upstream pollution; and the increased costs of providing community services, such as water, sewer, school, transportation, and police and fire protection, because of scattered residential development. These spillover costs have real monetary value but are virtually impossible to calculate and have, therefore, been classified as intangibles.

The Uncontrolled Existing Trend Alternative Plan not only fails to satisfy the objective of flood abatement but would, if carried out, inevitably cause peak flood discharges to become higher. The target date for projection of land use and hydrologic conditions is the year 1990, but it is apparent that flooding problems would continue to increase after that date. The primary factor contributing to the continued increase of peak flood discharges and stages would be the execution of channel improvement, deepening and smoothing projects, necessary to protect urban development already established in the flood plain. Flood peaks are increased by such projects as a result of increased velocities and reduced channel storage.

A benefit-cost analysis was not made for the Uncontrolled Existing Trend Alternative Plan because the only recognized benefit is maximization of individual decision-making, which cannot be assigned a monetary value. Presumably, this alternative would be accepted only if the benefit-cost ratios of all other alternative plans, including allowances for intangible considerations, were found to be less than 1.0.

The benefits and costs of individual water control facility elements which could be combined with the uncontrolled existing trend land use element are discussed on pages 172 through 181 of this report. It has been noted that channel improvements and a diversion channel are physically compatible with the uncontrolled trend plan. If either of these elements are added to the uncontrolled existing trend land use element, a revised benefit-cost evaluation can be obtained by the algebraic addition of the benefits and costs associated with each of these water control facility elements.

CONTROLLED EXISTING TREND-LAND USE REGULATION ALTERNATIVE PLAN

Description:

Land Use Element: The land use element basic to this alternative plan is set within the context of the regional "Controlled Existing Trend Land Use Plan," prepared under the SEWRPC Regional Land Use-Transportation Study; and regional land use planning objectives, principles, and standards [3] serve to establish its basic structure. These objectives, principles, and standards serve, in effect, to "control" the 1990 spatial distribution of land uses within the Region and the watershed in order to achieve a safer, more healthful, pleasant, and efficient land use pattern while meeting the gross land use demand requirements of the forecast population levels. The controlled existing trend-land use regulation element emphasizes efficient utility services, cohesive urban development on appropriately suitable soils, reservation of prime agricultural lands, preservation of unique resource areas, regulation of flood plain areas,[4] and the eventual removal of incompatible uses. The spatial distribution of land use in the Root River watershed under this land use element is shown on Map 36.

Under this element scattered residential development within the watershed would be channeled into low-, medium-, and high-density residential areas with included supporting facilities. Prime agricultural lands and unique resource areas are located and designated for preservation. Specific regulations would govern the use of water and lands located in flood plain areas, and structures permitted in these areas would have to be floodproof and noninjurious to the natural resource base. Regulations would be varied in severity in direct proportion to the degree of flood hazard.

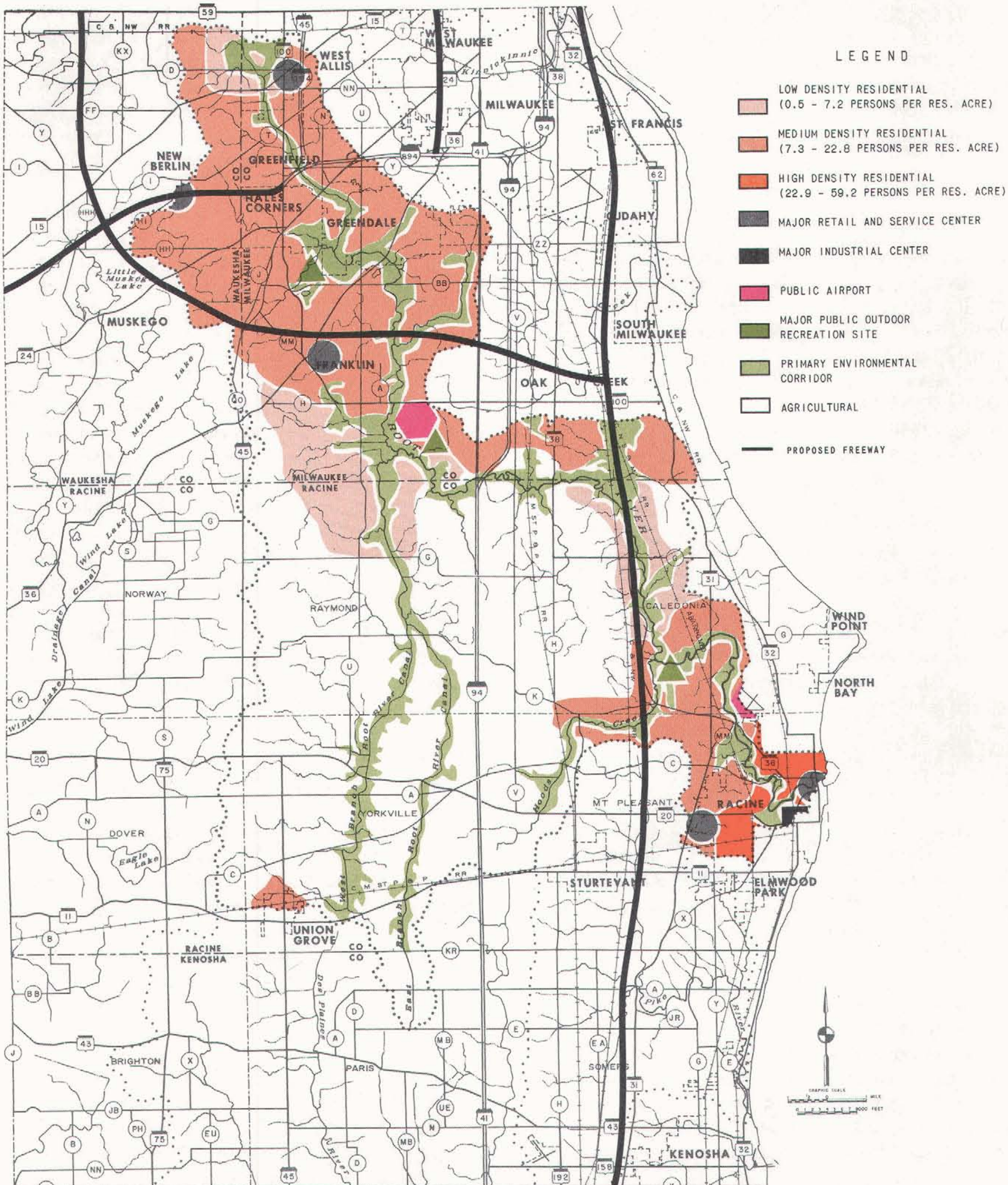
Existing land uses and structures not developed in conformance with these proposals would be considered nonconforming, and regulations would provide for their eventual discontinuance or removal. Sound land use throughout the watershed, and particularly within the flood plain areas, is thus the basic underlying element of this alternative land use element.

[3] *See Table 33, Chapter XI.*

[4] *Flood plain areas include the channel and the primary and secondary flood plains discussed in SEWRPC Planning Report No. 2, Water Law in Southeastern Wisconsin, 1966; and flood areas also include floodways and flood plains discussed in SEWRPC Planning Guide No. 2, Zoning Guide, 1964.*

Map 36

CONTROLLED EXISTING TREND PLAN (1990)



The Controlled Existing Trend Plan represents an effort to concentrate new urban development within the watershed in close proximity to existing, highly developed community facilities or their logical extensions and to protect the remaining high quality land and water resources of the watershed from further deterioration and destruction by the preservation of primary environmental corridors.

The salient provisions of the necessary land use regulations may be summarized as follows:

Residential District: At least three residential districts would be created to accommodate the proposed low-, medium-, and high-density residential areas. Supporting facilities, such as churches and schools, may be permitted in these districts as conditional uses. Excerpts from SEWRPC Planning Guide No. 3, illustrating sample residential districts, are presented in Appendices L-2 and L-3.

Agricultural District: A separate district permitting agricultural and related uses exclusively is necessary to preserve the prime agricultural lands in the watershed. This district would permit all agricultural uses and structures either as a principal or a conditional use and would permit accessory uses, such as farm dwellings for those resident owners and agriculturists actually engaged in farming. This district may also be used as a holding district until residential lands are ready for development or park lands are ready for acquisition. Excerpts from SEWRPC Planning Guide No. 3, relating to the uses and structures permitted in an agricultural district, are presented in Appendices L-2 and L-3.

Conservancy District: The conservancy district should include those areas naturally possessing mineral, plant, animal, or topographic features which should be preserved from destruction caused by commercial, industrial, and residential developments. The purposes of this district are to preserve the underlying and sustaining natural resource base, to complement existing and proposed parkways and recreation areas, and to give form and setting to adjacent rural and urban development. Excerpts from SEWRPC Planning Guide No. 3, relating to the uses and structures permitted in a conservancy district, are presented in Appendix L-2.

Park District: A separate district should be created to preserve those existing public and private parks and to provide a district for those parkways and recreational lands to be acquired in the near future. Excerpts from SEWRPC Planning Guide No. 3, relating to the uses and structures in this district, are included in Appendices L-2 and L-3.

Flood Plain Regulations: The hydraulic function of the flood plain portion of a river valley is to provide storage area for floodwaters. Major reductions in the storage potential of the flood plain caused by land filling or substantial structures will result in increased peak flood discharges downstream. Construction of nonresidential buildings may be allowed, provided that buildings meet special structural and safety requirements and do not substantially reduce floodwater storage capacity or raise upstream flood stages. Excerpts from SEWRPC Planning Guide No. 3, on the regulation of uses and structures in flood plains, are presented in Appendices L-3 and L-4.

Floodway Regulations: The hydraulic function of the floodway portion of the river valley is to provide a passage for floodwaters. Velocities and depths are greatest in this area, and obstructions and encroachments that restrict the discharge capacity of the floodway and serve to raise upstream water levels for a given discharge should be prohibited. Embankments for bridge approaches cannot always be reasonably excluded from the floodway; but in cases where they must be permitted, the bridge waterway opening should be adequate to compensate for the flow section obstructed by the embankment. Excerpts from SEWRPC Planning Guide No. 3, on the regulation of uses and structures in the floodways, are presented in Appendices L-3 and L-4.

Channel Regulations: The hydraulic function of the channel of the river valley is to provide a passage for the normal average annual high flows; and no structures, filling, or dumping which might obstruct such flow should be permitted in this area. The substructures of bridges may be permitted, but any embankments associated with bridge crossings should terminate outside the limits of the channel. The river channel for this purpose can be readily identified in most areas by distinct banks and by a change in the character of vegetation. However, the bank heights are usually too low to be distinguished on topographic maps alone; and field location of the banks should be made in every case. Excerpts from SEWRPC Planning Guide No. 3, on the regulation of structures in the channel area, are presented in Appendices L-3 and L-4.

Nonconforming Uses and Structures: At the time of establishment of any zoning ordinance restricting uses and structures, there will be many existing uses and structures which will not conform to the provisions of the zoning ordinance. Provisions for bringing these land uses and structures into eventual conformation with the zoning provisions should be included in the zoning ordinance. Effective provisions should also be made for the eventual removal of nonconforming uses, especially within the flood hazard areas. Excerpts from SEWRPC Planning Guide No. 3, which present nonconforming use and structure regulations, are reproduced in Appendix L-5.

As an interim measure before formal adoption of this alternative land use plan element or before adoption of these comprehensive amendments to the local zoning ordinance, the local units of government may desire to create flood districts (see Appendix L-6).

These districts are designed so as to provide for "immediate" regulation of development in the floodway and flood plains of the Root River watershed. Whereas the adoption of these districts will not implement the plan element, they will prevent incompatible development in the flooding areas and will not conflict with subsequent adoption of the proposed plan nor with subsequent implementation of such plan.

Water Control Facility Elements: If the Controlled Existing Trend-Land Use Regulation Alternative Plan were adopted without modification, there would be no vital need for certain of the water control facility plan elements. Channel improvements within the City of Greenfield would still be needed, however, if the decision were made to protect residences in the reach of the river extending from W. Layton Avenue to W. Forest Home Avenue in the City of Greenfield. This improvement is not required, however, to accommodate the committed decision for channel improvements in the City of West Allis.[5] A diversion channel would not be a logical adjunct of a plan built around land use regulation. A multi-purpose reservoir, if utilized primarily for recreation and low-flow augmentation, would be a logical adjunct.

It would be essential to the execution of the Controlled Existing Trend-Land Use Regulation Plan to carry out water pollution control measures. Even though much of the land adjoining the river would continue in private ownership under this plan, the public has the right to use the river waters since the Root River is, throughout much of its length, a navigable stream. Both in consideration of these public rights to recreational use of the river in privately owned reaches and in consideration of the substantial existing public recreational development along the river, action would be required to abate and control pollution of the stream waters.

[5] *Receiving elevations required of the Root River within the City of West Allis had been set previous to the initiation of the Root River watershed study by the City of West Allis and the Metropolitan Sewerage Commission of the County of Milwaukee; and local storm water facilities have been constructed to these design elevations.*

Component Elements of the Controlled Existing Trend-Land Use Regulation Alternative Plan

In summary, the Controlled Existing Trend-Land Use Regulation Plan is composed of the following major component elements:

1. A basin-wide land use element emphasizing regulation of land in riverine areas;

2. A multi-purpose reservoir serving the primary purposes of recreation and low-flow augmentation; and

3. Effectuation of a water pollution control program.

This alternative plan is evaluated in terms of its component elements in the following discussion. Additional, detailed evaluation of each separate water control facility element is provided in a later section of this chapter. A complete evaluation of alternative plans is set forth in Chapter XIII of this report.

Evaluation of Controlled Existing Trend-Land Use Regulation Alternative Plan

Satisfaction of Development Objectives: As this alternative development plan for the watershed is set within the context of a regional land use plan, it theoretically meets all regional development objectives. If carried out, maximum opportunity would be provided for: the protection of natural resources, the efficient development of urban areas, the reservation of open space and recreational areas, and the preservation of prime agricultural land areas. Because private rights to manage the land are involved, however, this plan does not guarantee the protection of the natural resource base in the zoned areas. Woodlands and wetlands in particular may be destroyed as much by mismanagement as by urbanization under this alternative plan.

Drainage and Flood Control: Under the Controlled Existing Trend-Land Use Regulation Alternative Plan, with its water and pollution control facility adjuncts, the flood plains and floodways would continue to perform their natural functions of transport and storage of floodwaters. Flood damage would be prevented; and an integrated, unobstructed system of major drainageways would be preserved, facilitating local drainage system design on the tributaries and urbanizing uplands.

Flood Plain Land Use—Open Space and Recreation: Problems of changing land use in relation to the stream and its floodways and flood plains would be eliminated by the very nature of the principal plan element, which is land use regulation; but under this alternative plan, the major objective of recreation and public open-space reservation would be only partially achieved. Land presently under public ownership in Milwaukee County but undeveloped for recreational uses would presumably be available for public open-space use. Land already developed for recreation would, of course, be available. Some of the lands in the flood plain would probably be developed privately for recreational purposes, such as golf courses and riding academies. On the balance of the flood plain, however, the Controlled Existing Trend-Land Use Regulation Alternative Plan would fall short of achieving the full recreation and public open-space potential of the flood plain lands.

Even though the land use base of this alternative plan may, in itself, fall short of the recreation and public open-space potential of the flood plain lands, it would function to preserve these lands in relatively low-value development and thereby guarantee their eventual availability for public use. The unique resources of woodlands and wetlands in general might be preserved, but not as reliably or effectively as they would be under public ownership.

Stream Pollution and Water Quality: The Controlled Existing Trend-Land Use Regulation Alternative Plan, complemented by pollution control, channel improvements, and possibly a multi-purpose reservoir, would lead to accomplishment of the water quality objectives. This plan, being strongly influenced by the existing and future availability of public sanitary sewerage facilities, would result in minimum contributions of wastes to the streams. The water quality monitoring aspects of the pollution control plan element would help not only to locate pollution sources and determine compliance with quality standards but would also furnish data for substantiating court actions.

<u>Benefits of Controlled Existing Trend-Land Use Regulation Alternative Plan:</u> Application of this land use plan to the river flood plains has a direct, tangible benefit in reduction of potential flood damages and intangible benefits in the preservation of the flood plain resources, provision of open space, and control of stream water quality.

The benefits from reduction of flood damages are measured by comparison with flood damages projected under the Uncontrolled Existing Trend Alternative Plan. Following procedures described in Chapter VII, "Flood Damages," the expected annual damages under the Controlled Existing Trend-Land Use Regulation Alternative Plan were computed for each damage reach, assuming that only existing (January 1965) development would be located in the flood plain and floodway areas.

Gradual removal of nonconforming flood plain land uses was not considered in the economic analysis because of the problematical nature of such removal. The effects of scheduled channel deepening through the City of West Allis and consequent raising of flood stages in the City of Greenfield were, however, taken into account. In other reaches, 1990 flood-damage potential was found to be almost equal to 1965 flood-damage potential since flood stages were concluded to be only slightly changed by urbanization.

Flood benefits for each reach were computed by 10-year intervals over a period of 50 years, as summarized in Table 36; and the benefits were discounted to the present time. At a 6 percent interest rate, the total present worth would be $278,500. The total benefit calculated at 3 percent interest would be $589,000.

It is not possible to calculate a monetary value for the intangible benefits derived from the Controlled Existing Trend-Land Use Regulation Alternative Plan. These benefits, however, have real value to the community and should be considered in terms of the public interests and desired expressed by official representatives of public agencies and local governmental units.

<u>Costs of Controlled Existing Trend-Land Use Regulation Alternative Plan:</u> The bulk of the cost of this alternative plan falls upon the private owners of land whose uses will be regulated by the zoning ordinance. The two major alternative uses of the floodway and flood plain lands in the Root River watershed are for agriculture and for residential development. Each of these uses returns an income to the owner, whether a private individual or a public agency; and this income eventually contributes to the total economic income of the community and the Region.

Table 36

FLOOD-DAMAGE ALLEVIATION BENEFITS

LAND USE REGULATION AND PARKWAY RECREATION LAND DEVELOPMENT PLAN ALTERNATIVES

Description	Annual Damage Risk or Benefit					Present Worth	
	1966 1975	1976 1985	1986 1995	1996 2005	2006 2015	6 Percent Interest	3 Percent Interest
Reach 1 (City of Racine)							
Existing Trends	$6,600	$6,600	$ 6,600	$ 6,600	$ 6,600	$	$
Controlled Trends[a]	6,600	6,600	6,600	6,600	6,600		
Benefits	--	--	--	--	--	--	--
Reach 2 (South edge Racine Country Club to 1/2 mile east STH 31)							
Existing Trends	750	750	750	750	750		
Controlled Trends	750	750	750	750	750		
Benefits	--	--	--	--	--	--	--
Reach 3 (1/2 mile east STH 31 to Six Mile Road)							
Existing Trends	3,200	9,700	15,900	22,000	28,300		
Controlled Trends	250	250	250	250	250		
Benefits	2,950	9,450	15,650	21,750	28,050	144,500	309,300
Reach 4 (Six Mile Road to Nicholson Road)							
Existing Trends	850	1,370	1,830	2,300	2,770		
Controlled Trends	650	650	650	650	650		
Benefits	230	720	1,180	1,650	2,120	11,000	23,500
Reach 5 (Nicholson Road to S.60th Street)							
Existing Trends	1,900	4,300	6,630	9,000	11,400		
Controlled Trends	760	760	760	760	760		
Benefits	1,140	3,540	5,870	8,240	10,640	54,500	116,800
Reach 6 (S. 60th Street to Greendale boundary)							
Existing Trends	4,100	5,600	7,170	8,800	10,300		
Controlled Trends	3,320	3,320	3,320	3,320	3,320		
Benefits	780	2,280	3,850	5,480	6,980	37,000	71,300
Reach 7 (Village of Greendale and Village of Hales Corners)							
Existing Trends	550	550	550	550	550		
Controlled Trends	550	550	550	550	550		
Benefits	--	--	--	--	--	--	--
Reach 8 (City of Greenfield)							
Existing Trends	7,100	8,500	10,000	11,400	12,800		
Controlled Trends	6,500	6,500	6,500	6,500	6,500		
Benefits	600	2,000	3,500	4,900	6,300	31,500	67,900
Reach 9 (City of West Allis)							
No Damages						--	--
Total Benefits						$278,500	$588,800

[a] *Controlled trends are defined as those land use conditions occurring under either the Controlled Existing Trend-Land Use Regulation Alternative Plan or the Controlled Existing Trend-Parkway and Recreation Land Development Alternative Plan.*

Source: SEWRPC.

The present worth of the income expected from a parcel of land is equal to the free market value of that land. In the Root River watershed, a representative average free market value for agricultural land is approximately $500 per acre, while the average value of unimproved potential residential land is approximately $1,000 per acre. It is apparent, then, that the income potential anticipated from residential land use is greater than that anticipated from agricultural land use. It is also apparent that restriction of use of potential residential land to agricultural use results in a real monetary loss to the owner and to the economy. It must be kept in mind, however, that in this analysis benefits and costs are considered separately and that the land use restriction also has monetary benefits to the economy.

The major cost of the land use regulation element of this plan is, therefore, the cost of income foregone as a result of land use restrictions. As indicated above, this cost has been estimated to be about $500 per acre for those floodway and flood plain lands which would be expected to be under residential development by 1990 under an uncontrolled land use situation. This area was projected to be 4,430 acres, which at $500 per acre would result in a total present worth of income foregone of approximately $2,220,000.

Under the provisions of the zoning ordinance, other open-space land uses besides agriculture would be permissible, some of which would return higher incomes and some lower. It was assumed that, at least until 1990, agriculture would remain the primary land use if land use controls were effected and that the average of incomes from other allowed uses would approach that of agriculture.

A further cost of the land use regulation element of this plan, considered intangible in this analysis, is the cost of administering and enforcing the zoning ordinance. This cost would be borne by the operating budgets of local governmental bodies and would be difficult to separate from the costs of other routine zoning operations.

On the above bases, the total monetary cost of the Controlled Existing Trend-Land Use Regulation Alternative Plan with the water quality monitoring program would be $2,330,000.

Benefit-Cost Ratio: The economic analysis of the land use regulation element of this plan can be expressed by the ratio of monetary benefits to monetary costs. At 6 percent interest rate, the benefit-cost analysis is summarized:

Benefit (present worth)
Flood-damage alleviation $ 278,500

Costs (present worth)
Land use income foregone $2,220,000

$$\text{Benefit-Cost Ratio} = \frac{278,500}{2,220,000} = 0.12$$

$$\text{At 3 percent interest} = \frac{589,000}{2,220,000} = 0.26$$

The monetary benefit-cost ratio of the land use regulation element of this plan alternative is quite unfavorable whether calculated on the basis of a 6 percent or even a 3 percent interest rate. In deciding whether to accept or reject this plan, other considerations of a basically intangible nature, however, must also be evaluated.

The benefits and costs of water control facilities which could be added to the land use element base are discussed on pages 172 through 181 of this report. It has been noted that a water pollution control program is a necessary adjunct of this plan. A multi-purpose reservoir should also be included as a desirable water control facility element. As these elements are added to the land use element, a revised benefit-cost evaluation can be obtained by algebraic addition of benefits and costs associated with each of these water control facility elements.

CONTROLLED EXISTING TREND-PARKWAY AND RECREATION LAND DEVELOPMENT ALTERNATIVE PLAN

Description

Land Use Element: Like the preceding alternative, the land use plan element of the Controlled Existing Trend-Parkway and Recreation Development Alternative Plan is set within the context of the regional "Controlled Existing Trend Land Use Plan," prepared under the SEWRPC Regional Land Use-Transportation Study. The two alternative plans have an identical structure for the upland areas of the watershed but differ significantly in the riverine areas. The Controlled Existing Trend-Parkway and Recreation Development Alternative Plan, as it relates to the riverine areas, includes the following major elements:

1. Public ownership of flood plain area lands along the North Branch and the main stem of the Root River from Greenfield Park in Milwaukee County to the City of Racine and along Hoods Creek from CTH H near the community of Franksville to its junction with the Root River.

2. Utilization of these lands for recreation and for wildlife conservation.

3. Development of a continuous parkway drive along the entire length of the main stem of the Root River from Greenfield Park in Milwaukee County to the City of Racine.

4. Flood plain-floodway regulations along the perennial stream channels in the Root River Canal area.

5. Conservancy districts, adjacent to portions of the parkway recreation lands, encompassing secondary environmental corridors.

A portion of the Root River flood plain area in Milwaukee County has already been developed as parkway with recreational facilities and a conservancy area.

The parkway-recreation land use element envisions a similar development along the entire river length. Existing parkway extends from W. Lincoln Avenue to W. Oklahoma Avenue and from W. Layton Avenue to W. Loomis Road in Milwaukee County and totals 1,490 acres, including Whitnall Park. Johnson Park in Racine County, totaling 330 acres, also would be incorporated into the parkway. The costs of these already developed park lands are not included in the economic analysis of this plan.

Land areas proposed for public acquisition and related land use regulation are shown on Map 36, together with flood area lands already under public ownership and existing parks and parkway sections. Proposed acquisition limits are based upon existing land ownership lines, topography, areas of woodlands and wetlands, and areas with soils having severe limitations for residential or other urban development.

The total parkway-recreation land area required in Milwaukee County for this plan is 4,490 acres, including undeveloped land already under public ownership. Of this total, 730 acres are now in private ownership and would have to be acquired.

The total area of the proposed parkway in Racine County is 2,460 acres, of which 37 acres are owned by Racine County and 39 acres are now owned by the Milwaukee County Park Commission. The costs of the already developed Johnson Park, owned by the City of Racine, has not been included in the economic analysis. It is assumed that Armstrong Park, located between STH 31 and STH 38, would remain in private ownership but in a use compatible with the plan proposals.

The parkway in Racine County should extend downstream from the county line to at least STH 38. A portion of the Root River flood plain between STH 38 and the private Racine Country Club is presently under private ownership. This land contains a flooded, abandoned quarry, which is presently used by a private skin-diving club. Use of this quarry and of other quarries near the river channels for flood control purposes was investigated but found to have no significant benefit. No definite recommendation is made in the plan for this area except that it remain in open space or recreational use, public or private.

In ultimate development the proposed parkway land should resemble the existing parkway along the North Branch of the Root River between W. Grange Avenue and W. Loomis Road in Milwaukee County. The proposed parkway would have an average width of about 1,500 feet, with widths of over one-half mile at several locations and a minimum width of about 700 feet. About half of the proposed parkway area would be landscaped and developed for recreational activities and half left in a natural state. The developed recreation areas would include facilities for various organized sports, such as tennis, baseball, volleyball, and archery; areas reserved for golf practice and open field sports; and picnic facilities. The wilderness portion of the parkway also would have picnic facilities, together with bridle and hiking trails and nature study areas. Maintenance of the proposed water quality objectives and standards would encourage fish life in the river from S. 60th Street to Lake Michigan.

A continuous parkway road would extend the entire length of the parkway, approximately 30 miles, of which 23 miles would consist of new construction. In contrast to the existing parkway along the Root River in West Allis and Greenfield, which is developed with dual drives located on opposite sides of the river, only a single roadway to be located on one side of the river is proposed herein. Adequate space for a second roadway, however, would be available throughout most of the parkway length. The roadway could generally be located well within the limits of the parkway area, rather than skirting the edges; and no private property frontage on, or access to, the parkway drive would be permitted. A public park would be developed along Hoods Creek from its confluence with the Root River to County Trunk H in the community of Franksville. The remainder of the riverine area lands along Hoods Creek would be left in a conservancy district. No parkway drive is contemplated along Hoods Creek.

The zoning districts and regulations proposed in the Root River Canal area are identical to those proposed in the land use base element of the Controlled Existing Trend-Land Use Regulation Alternative Plan and differ only in the inclusion of less area. Although this area is expected to remain in agricultural use, zoning will guarantee preservation of these flood plain area lands for possible future conversion to park and recreation use.

Water Control Facility Elements: The water control facility elements which are logically compatible with the Controlled Existing Trend-Land Use Regulation Alternative Plan are also compatible with the alternative plan proposing public acquisition of park and recreation lands in the riverine areas. A multi-purpose reservoir is a possible attractive adjunct, especially if utilized primarily for recreation and low-flow augmentation. A water pollution control program would be absolutely essential in order to provide the proper water setting for the proposed parkway development. The water control facilities and accessory plan elements are presented on pages 172 through 188.

Component Elements of the Controlled Existing Trend-Parkway and Recreation Land Development Alternative Plan

In summary, the Controlled Existing Trend-Parkway and Recreation Land Development Alternative Plan is composed of the following major elements:

1. A basin-wide land use element emphasizing public purchase and development of riverine area lands for public park and recreation purposes;

2. A multi-purpose reservoir serving the primary purposes of recreation and low-flow augmentation; and

3. A water pollution control program.

This alternative plan is evaluated in terms of its component elements in the following discussion. Additional, detailed evaluation of each separate water control facility element is provided in later sections of this chapter. A complete evaluation of alternative plans is set forth in Chapter XIII of this report.

Evaluation of Controlled Existing Trend-Parkway and Recreation Land Development Alternative Plan

Satisfaction of Development Objectives: Implementation of the Controlled Existing Trend-Parkway Recreation Land Development Alternative Plan, with supporting water control facilities, would achieve all of the watershed development objectives, as set forth in Table 33.

Drainage and Flood Control: Regulation of flood plain land use would halt the growth of flood-damage risk both through exclusion of flood-vulnerable development and by keeping the flood plain available for storage of floodwaters. Flood hazard to existing development would continue, however, and could only be eliminated by channel improvements and/or flood plain zoning, including eventual removal of nonconforming uses.

Flood Plain Land Use—Open Space and Recreation: If implemented, the Controlled Existing Trend-Parkway and Recreation Land Development Alternative Plan would provide optimum protection of the resource base and maximum opportunities for public utilization of the open-space and recreation resources of the riverine area.

Stream Pollution and Water Quality: The Controlled Existing Trend-Parkway and Recreation Land Development Alternative Plan, complemented by channel improvements, a water pollution control program, and possibly a multi-purpose reservoir, would lead to accomplishment of the water quality objectives and standards.

Benefits of Controlled Existing Trend-Parkway and Recreation Land Development Alternative Plan: The parkway-recreation land use plan for the river flood plains offers several direct, tangible benefits, as well as intangible benefits. Direct benefits of the parkway-recreation land use base element evaluated in the planning studies are: 1) reduction of flood damages, 2) enhancement of outdoor recreational activities, and 3) enhancement of land values adjacent to the parkway. The intangible benefits include protection and preservation of the natural resource base, reduction of stream pollution, and contribution to an aesthetically attractive environment. Much of the total recreation benefit cannot be given a monetary value and, therefore, will contribute to the total intangible benefit.

Benefits from reduction of flood damages are measured by comparison with flood damages projected under the Uncontrolled Existing Trend Alternative Plan. The monetary value of flood-damage relief benefits of the parkway and recreation land development version of the controlled existing trend plan alternative element is identical to that of the land use regulation alternative. At 6 percent interest, the total present worth would be $278,500. The total benefit calculated at 3 percent interest would be $589,000.

The monetary benefits attributable to recreation were calculated by projecting the number of users of the various facilities and assigning to each user a dollar valuation of the experience. Only two basic activities were evaluated in the calculation of recreation benefits: pleasure driving and picnicking. The details of this evaluation are presented in Appendix M.

Average annual benefits of pleasure driving were calculated by 10-year intervals from 1965 to 2015 and discounted at 6 percent interest to a present worth of $7,475,000. The equivalent benefit at 3 percent interest is $15,705,000. Average annual benefits of picnicking were calculated by 10-year intervals from 1965 to 2015 and discounted at 6 percent interest to a present worth of $2,896,000. The equivalent benefit at 3 percent interest is $5,736,000.

Experience has shown that parkway development of the type proposed in this plan causes an increase in the market value of adjacent residential land and attracts higher value development. Data obtained from property appraisers and realtors having knowledge of property values in the area of the Root River Parkway reveal a significant value differential between physically equivalent lots or developed properties on the parkway versus off the parkway. Lots immediately adjacent to the parkway often have market values $1,000 to $3,000 higher than otherwise physically equivalent lots located a short distance from the parkway. Generally, the value differential increases directly from zero, at a distance of about 800 feet, to a maximum value immediately adjacent to the parkway. It was estimated that by the year 2000 approximately 1,200 residential lots would benefit from such enhancement. At 6 percent interest, the present worth of the increased land values, assuming completion of one mile of parkway per year for 23 years, would be $1,039,000. The equivalent benefit at 3 percent interest is $1,516,000.

The total present worth of monetary benefits attributable to the parkway-recreation land use plan element would be $11,688,500 at 6 percent interest and $23,546,000 at 3 percent interest. No monetary value can be ascribed to the intangible benefits of this plan, but it is noteworthy that this plan undoubtedly has the highest level of intangible benefits of the plans studied.

Costs of Controlled Existing Trend-Parkway and Recreation Alternative Plan: The monetary costs of the parkway-recreation land use plan element are attributable to: 1) purchase of land, 2) construction of roadway, 3) landscaping, and 4) maintenance of park land and facilities and roadway.

The total acreage required for the parkway-recreation land use plan element is 6,950 acres, of which some 3,835 acres are already in public ownership. It was assumed that the private land would be purchased in equal increments over the next 12 years at an average price of $1,000 per acre, plus 15 percent for administrative costs. The cost of publicly owned land must also be included in the economic analysis. This cost was assumed to be $1,000 per acre, plus 10 percent administrative costs for a total cost of $4,218,500.

The gross land acquisition cost present worth at 6 percent, for public and private land, would be $6,723,500 and at 3 percent, $7,191,300. An allowance was made for leasing part of the public land for agricultural purposes during the parkway development period. If 30 percent of the remaining undeveloped public land were leased with an annual return of $50 per acre over 23 years, the present worth at 6 percent interest would be $560,400 and at 3 percent, $707,300. Corresponding net land acquisition costs would be $6,163,100 and $6,484,000.

The construction cost per mile of park roadway, according to the State Highway Commission of Wisconsin Scenic Roads and Parkways Study is about $240,000. This amount includes engineering, construction, and landscaping costs for a 300-foot wide strip of parkway centered on the drive. Assuming a construction schedule of one mile per year for 23 years, the present worth of the roadway cost at 6 percent interest would be $2,960,000 and at 3 percent, $3,950,000.

Landscaping costs were estimated to be $700 per acre. On the basis of half of the area outside the roadway right-of-way and assuming completion of one mile of parkway per year for 23 years, the present worth of landscaping cost at 6 percent interest would be $1,158,000 and at 3 percent, $1,551,000.

Based on the State Highway Commission of Wisconsin Scenic Roads and Parkways Study, it was estimated that annual maintenance cost of the parkway and road would be $5,000 per mile. Assuming completion of one mile per year for 23 years, the present worth of maintenance cost at 6 percent interest would be $1,084,000 and at 3 percent, $2,173,000.

The total present worth of monetary costs of the parkway-recreation land use plan element at 6 percent interest would be $11,365,000 and at 3 percent, $14,158,000.

The costs of the proposed Hoods Creek park acquisition and development are included in the total costs cited above.

Benefit-Cost Ratio: The economic analysis of the parkway-recreation land use plan element can be expressed as the ratio of monetary benefits to monetary costs. At 6 percent interest, the benefit-cost analysis is summarized:

Benefits (present worth)	
Flood-damage alleviation	$ 278,500
Pleasure driving	7,475,000
Picnicking	2,896,000
Increased land values	1,039,000
Total	$11,688,500
Costs (present worth)	
Purchase of land	$ 6,163,100
Roadway construction	2,960,000
Landscaping	1,158,000
Maintenance	1,084,000
Total	$11,365,100

$$\text{Benefit-Cost Ratio} = \frac{11,688,500}{11,365,100} = 1.03$$

$$\text{At 3 percent interest} = \frac{23,546,000}{14,158,000} = 1.66$$

The benefit-cost ratio of the parkway-recreation land use plan element is favorable when tested at both 6 percent and 3 percent interest rates.

ALTERNATIVE WATER CONTROL FACILITY ELEMENTS

In addition to the alternative land use plan elements described in the preceding sections, several major water control facility plan elements were analyzed as possible adjuncts required to facilitate the attainment of regional and watershed development objectives. These elements are considered to be subordinate to the basic land use plan elements, and their incremental benefits and costs can be separated from those of the land use plan elements. Some of these water control facility plan elements can be incorporated into any of the land use plan elements, while others are incompatible with particular land use plan alternatives. The major water control facilities are shown diagrammatically in Figure 29.

Channel Improvements

Channel Improvements Within the City of Greenfield and the Village of Greendale: The risk of flood damages within the City of Greenfield below W. Layton Avenue will be increased as a result of channel deepening in the City of West Allis. A general plan map and a typical cross section of the proposed channel improvements within the City of West Allis and the City of Greenfield are shown in Figure 30. These channel improvements represent a committed decision in the sense that significant local construction funds for urban storm sewers, necessitating the channel deepening, have already been expended on drainage facilities within the City of West Allis. Consequently, any alternative plan must be adjusted to this committed decision. An alternative plan element was, therefore, prepared for additional channel enlargement and deepening which would be required below W. Layton Avenue to eliminate flood-damage risk within the City of Greenfield from a 100-year recurrence interval flood.

The proposed channel improvement would begin at W. Layton Avenue and tail out at W. College Avenue within the Village of Greendale. The improved channel would be grass lined with side slopes of one-on-four and one-on-five and with a bottom width of 20 feet. Maximum depth below normal ground level would be 12 feet, and the maximum top width would be 140 feet. The volume of excavation required is estimated to be 265,000 cubic yards.

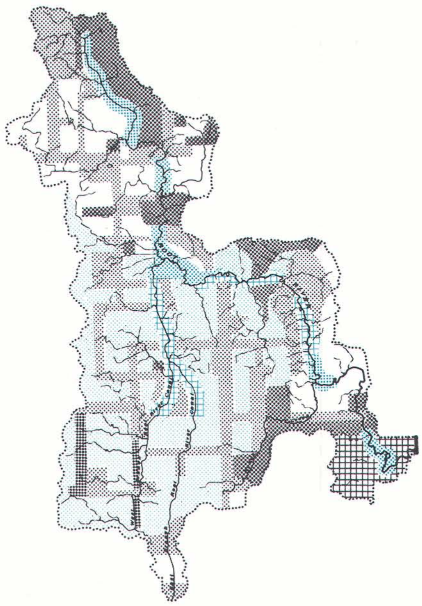
Benefits: Average annual flood-damage risk in the reach between W. Layton Avenue and W. Forest Home Avenue is $6,500, of which $1,700 is estimated to be attributable to scheduled channel deepening from the City of West Allis to W. Layton Avenue. Present worth at 6 percent interest of removal of the total damage is $102,000 and at 3 percent, $167,000.

Costs: The direct capital cost of channel improvements and attendant replacement and alteration of bridges in the City of Greenfield and the Village of Greendale is estimated to be $516,000. To this must be added the intangible cost to the community of damage to the aesthetic appearance of the existing parkway. Channel improvement also has the effect of increasing the magnitude of flood peaks through increase in flow velocity and reduction of channel storage. In this case, however, flood risk would not thereby be increased appreciably downstream because the existing parkway width in the Village of Greendale is adequate to accept the resulting increased discharges. Maintenance costs were assumed to be unchanged from those of the existing parkway.

Figure 29

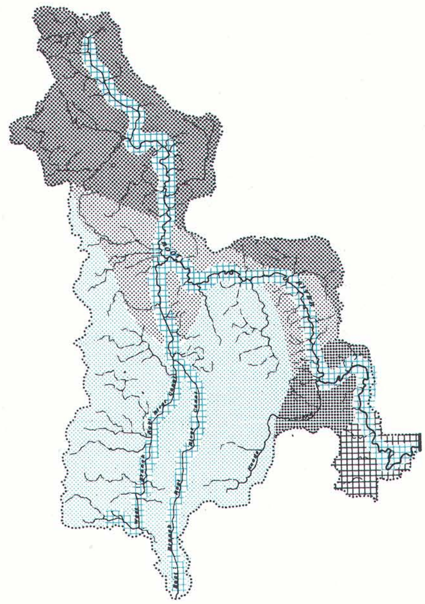
PRINCIPAL PLAN ELEMENTS IN THE ROOT RIVER WATERSHED

ALTERNATIVE LAND USE ELEMENTS



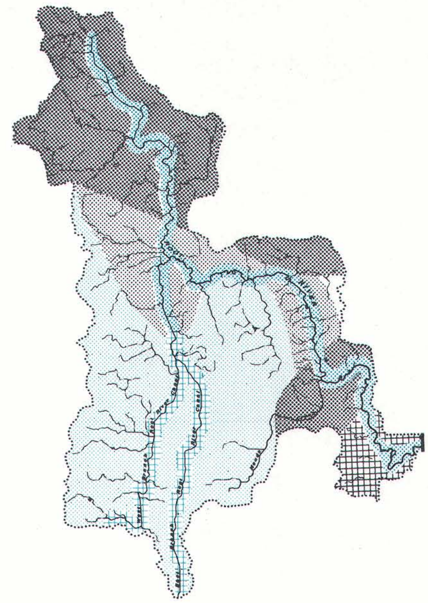
A. UNCONTROLLED EXISTING TREND ALTERNATIVE

SCATTERED BASIN-WIDE LOW-DENSITY URBAN DEVELOPMENT OCCURRING WITHOUT REGARD FOR SOIL CAPABILITIES, LOGICAL UTILITY SERVICE AREAS, DEVELOPMENT OPPORTUNITIES, OR PROBLEMS ATTENDANT TO THE RIVERINE AREA



B. CONTROLLED EXISTING TREND—LAND USE CONTROL ALTERNATIVE

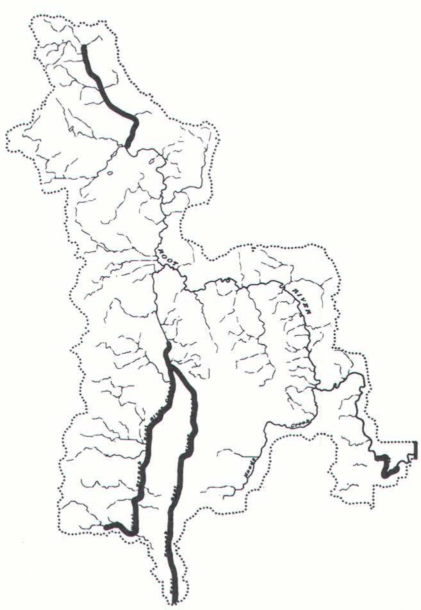
LOGICAL EXPANSION OF EXISTING URBAN DEVELOPMENT INTO AREAS WHICH CAN BE READILY SERVED BY GRAVITY-FLOW SANITARY SEWERS, RESERVATION OF AGRICULTURAL LANDS, PROTECTION OF FLOOD PLAINS AND THE RESOURCE BASE, AND FLOOD DAMAGE PREVENTION



C. CONTROLLED EXISTING TREND—PARKWAY & RECREATIONAL DEVELOPMENT ALTERNATIVE

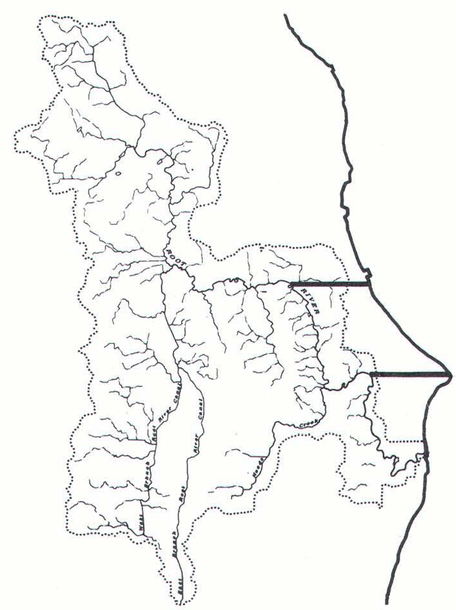
LOGICAL EXPANSION OF EXISTING URBAN DEVELOPMENT INTO AREAS WHICH CAN BE READILY SERVED BY GRAVITY-FLOW SANITARY SEWERS, RESERVATION OF AGRICULTURAL LANDS, PUBLIC ACQUISITION OF FLOOD PLAINS FOR RECREATION, OPEN-SPACE USES, AND FLOOD DAMAGE PREVENTION

ALTERNATIVE WATER CONTROL FACILITY ELEMENTS



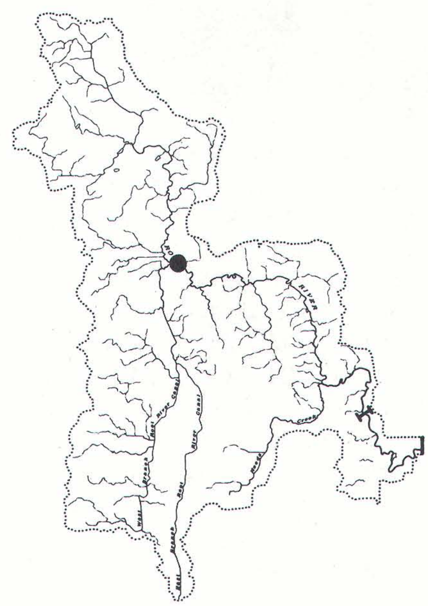
A-1. CHANNEL IMPROVEMENT ALTERNATIVES

DEEPENING AND WIDENING OF STREAM CHANNELS WITHIN THE CITIES OF WEST ALLIS, GREENFIELD, AND RACINE; CHANNEL MAINTENANCE WITHIN THE ROOT RIVER CANAL AREA AS FLOOD CONTROL MEASURES



B-1. DIVERSION CHANNEL ALTERNATIVES

CONSTRUCTION OF A DIVERSION CHANNEL IN ONE OF TWO POSSIBLE ALTERNATIVE LOCATIONS TO BYPASS FLOOD FLOWS TO LAKE MICHIGAN AS FLOOD CONTROL MEASURES TO PROTECT PARTS OF THE TOWN OF CALEDONIA AND THE CITY OF RACINE



C-1. MULTI-PURPOSE RESERVOIR ALTERNATIVES

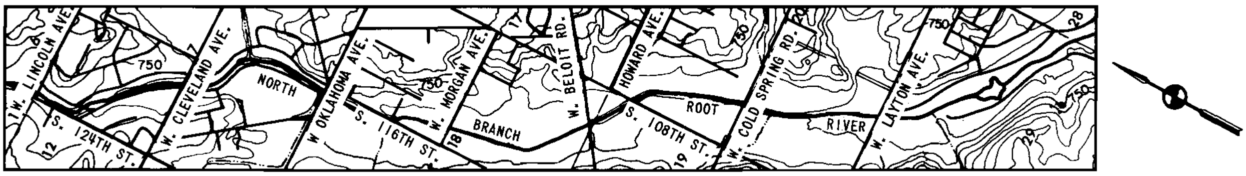
CREATION OF OAKWOOD RESERVOIR FOR FLOOD CONTROL, LOW FLOW AUGMENTATION, RECREATION, AND RESIDENTIAL LAND ENHANCEMENT PURPOSES.

LEGEND

LOW-DENSITY RESIDENTIAL
MEDIUM-DENSITY RESIDENTIAL
HIGH-DENSITY RESIDENTIAL
LAND USE ZONING
PARKWAY DEVELOPMENT
PRIME AGRICULTURAL RESERVE
RESERVOIR
DAM RESTORATION
CHANNEL IMPROVEMENT

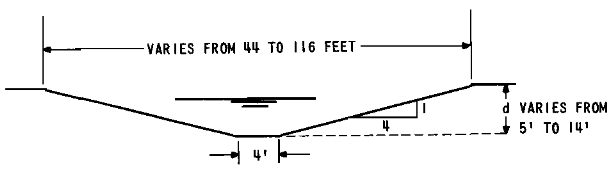
Figure 30

PROPOSED CHANNEL IMPROVEMENTS, CITIES OF WEST ALLIS AND GREENFIELD



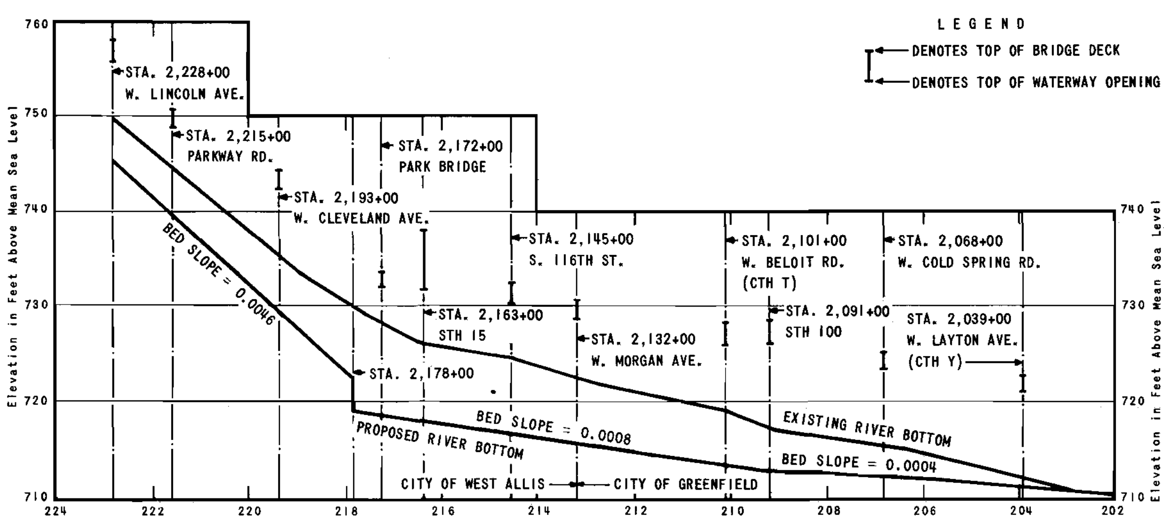
PLAN

Scale: 1 Inch = 4000 Feet



TYPICAL CHANNEL CROSS SECTION

Scale: 1 Inch = 20 Feet



PROFILE

Scale: Horizontal, 1 Inch = 4000 Feet

Vertical, 1 Inch = 20 Feet

NOTE: Station 0+00 is located at the mouth of the Root River in the City of Racine.
International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) - 1.3 feet.
Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum (1929 Adjustment) - 580.560.

Source: *Harza Engineering Company; SEWRPC.*

Benefit-Cost Ratio: The monetary benefit-cost ratio calculated on the basis of present worth at 6 percent interest is:

Benefit
Flood-damage alleviation $102,000

Cost
Channel improvement $516,000

$$\text{Benefit-Cost Ratio} = \frac{102,000}{516,000} = 0.20$$

$$\text{At 3 percent interest} = \frac{167,000}{516,000} = 0.32$$

Channel Improvements Within the City of Racine: If channel deepening were used to alleviate the flooding problem within the City of Racine, it would have to extend from a point about one mile south of Horlick Dam to Fourth Street, a distance of about three miles. The improved channel would include bank protection devices and would have side slopes varying from one-on-one to one-on-three with a maximum bottom width of 150 feet and a maximum top width of 175 feet. The average deepening would be about five feet, and about 500,000 cubic yards would be excavated. The abandoned quarry adjacent to the Root River downstream from STH 38 could serve as a possible disposal site for the spoil.

Benefits: The maximum monetary benefit which could be ascribed to elimination of the flood hazard in the City of Racine, expressed as present worth, would be $104,000 and $170,000 at 6 percent and 3 percent discount interest rates, respectively.

Costs: The cost of channel deepening to eliminate flood damages is estimated to be $1,100,000. This cost includes excavation by dredge and dragline, trucking of spoil, and allowance for replacement and alteration of six bridges and for bank protection.

Benefit-Cost Ratio: The monetary benefit-cost ratio of channel deepening in the City of Racine, calculated on the basis of present worth at 6 percent, would be:

Benefit
Flood-damage alleviation $ 104,000

Cost
Construction $1,100,000

$$\text{Benefit-Cost Ratio} = \frac{104,000}{1,100,000} = 0.09$$

$$\text{At 3 percent interest} = \frac{170,000}{1,100,000} = 0.15$$

Channel Clearing and Maintenance in the Root River Canal: Reduction in flood stages and consequent reduction in agricultural damages could be obtained by improving the hydraulic capacity of channels in the Root River Canal system through clearing of vegetative growth.

The West Branch and the East Branch of the Root River Canal were considered individually for such improvement. The portion of the West Branch channel considered extends from one-half mile downstream from the Chicago, Milwaukee, St. Paul, and Pacific Railroad Company bridge to the confluence with the East Branch. This reach would require 1.9 miles of heavy clearing, 5.9 miles of light clearing, and 8.3 miles of maintenance work.

The East Branch channel considered in the analysis extends from CTH E in Kenosha County to one-half mile north of Five Mile Road in Racine County. This reach would require 2.2 miles of heavy clearing, 8.1 miles of light clearing, and 11.1 miles of maintenance work.

Benefits: The annual benefits attributable to channel clearing and maintenance are equal to the reduction in annual flood risk. Along the West Branch, annual risk would be reduced from $2,640 to $790. The present worth of this benefit is $29,000 at 6 percent interest and $47,500 at 3 percent interest. Along the East Branch, annual risk would be reduced from $860 to $260. The present worth of this benefit is $9,450 at 6 percent interest and $15,500 at 3 percent interest.

Costs: It is estimated that heavy clearing would cost $2,500 per mile, and the cost of light clearing is estimated at $1,500 per mile. Using these unit prices, initial clearing on the West Branch would cost $13,600 and on the East Branch, $17,600. It was assumed that maintenance would be required every three years and would cost approximately $300 per mile.

Including maintenance, the present worth of channel clearing on the West Branch would be $25,400 at 6 percent interest and $33,700 at 3 percent interest. Present worth of channel clearing on the

East Branch would be $34,100 at 6 percent interest and $45,500 at 3 percent interest.

An intangible cost consideration is that channel clearing would destroy a portion of the wildlife habitat in the watershed.

Benefit-Cost Ratio: The monetary benefit-cost ratio of West Branch channel clearing, calculated on the basis of present worth at 6 percent interest, is:

Benefit	
Flood-damage alleviation	$29,000
Cost	
Channel clearing and maintenance	$25,400

$$\text{Benefit-Cost Ratio} = \frac{29,000}{25,400} = 1.14$$

$$\text{At 3 percent interest} = \frac{47,500}{33,700} = 1.41$$

The monetary benefit-cost ratio of East Branch channel clearing, calculated on the basis of present worth at 6 percent interest, is:

Benefit	
Flood-damage alleviation	$ 9,450
Cost	
Channel clearing and maintenance	$34,100

$$\text{Benefit-Cost Ratio} = \frac{9,450}{34,100} = 0.28$$

$$\text{At 3 percent interest} = \frac{15,500}{45,500} = 0.34$$

Diversion Channels to Lake Michigan

Flood damages in the lower reaches of the Root River, including the City of Racine, could be substantially reduced by diverting excess floodwaters directly to Lake Michigan at upstream points. This alternative is physically possible because of the proximity of the Root River to the Lake Michigan shore. Two diversion routes were selected for analysis; and factors of distance, topography, and present land use were considered in route location. General route plans and profiles are shown in Figure 31 and 32.

The upper diversion route would originate near Nicholson Road in Section 3, Town 4 North, Range 22 East, and run parallel to the Milwaukee-Racine County line, entering Lake Michigan just south of the Wisconsin Electric Power Company Oak Creek power plant in Section 6, Town 4 North, Range 23 East. This diversion channel would be 3.4 miles long and require excavation of approximately 3.5 million cubic yards.

The lower diversion route would originate about one-half mile downstream from STH 31 in Section 30, Town 4 North, Range 23 East, and run in a northeasterly direction, entering Lake Michigan just south of the Dominican College in Section 21, Town 4 North, Range 23 East. This diversion channel would be 2.5 miles long and require excavation of approximately 1.7 million cubic yards.

The channels would be capable of diverting the entire 100-year recurrence interval flood flow. During non-flood conditions, the channels would be dry.

Benefits: In calculation of the benefits of the diversion alternatives, it was assumed that full urban occupation of the downstream flood plain would be permitted since downstream flows could be held to channel capacity.

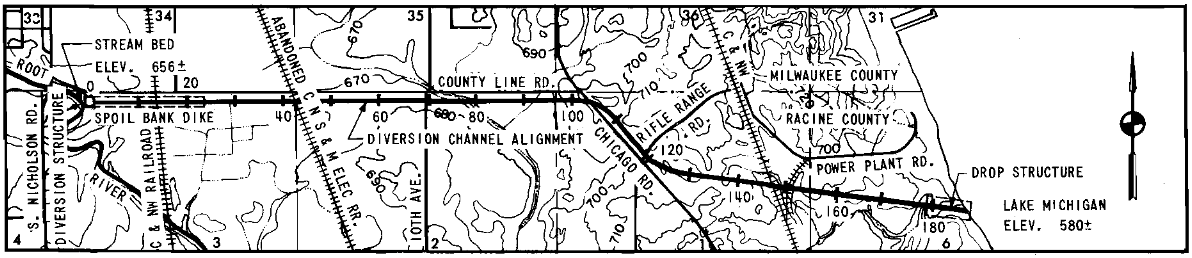
The upper diversion channel would eliminate flood damages in the flood plain of the Root River downstream to the City of Racine. A small residual flood-damage annual risk of $900 would remain in the City of Racine because of flood flows generated in the Root River drainage area downstream from the diversion point. The present worth of flood-damage alleviation attributable to the upper diversion channel is $270,000 at 6 percent interest and $519,000 at 3 percent interest.

The lower diversion channel alternative would virtually eliminate all flood-damage risk downstream. The City of Racine, however, would be the only beneficiary in this alternative. The present worth of flood-damage alleviation attributable to the lower diversion channel is $115,000 at 6 percent interest and $187,000 at 3 percent interest.

Costs: The construction cost of the upper diversion channel is estimated to be $2,800,000 and of the lower diversion channel, $1,800,000. These costs include land acquisition, excavation, necessary drop structures, and bridges. Annual costs of maintenance and operation were not included in the analysis.

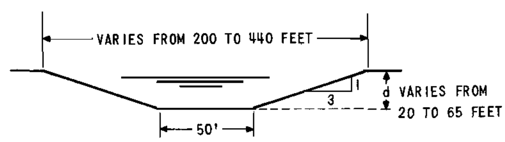
Figure 31

DIVERSION CHANNEL UPSTREAM ALIGNMENT



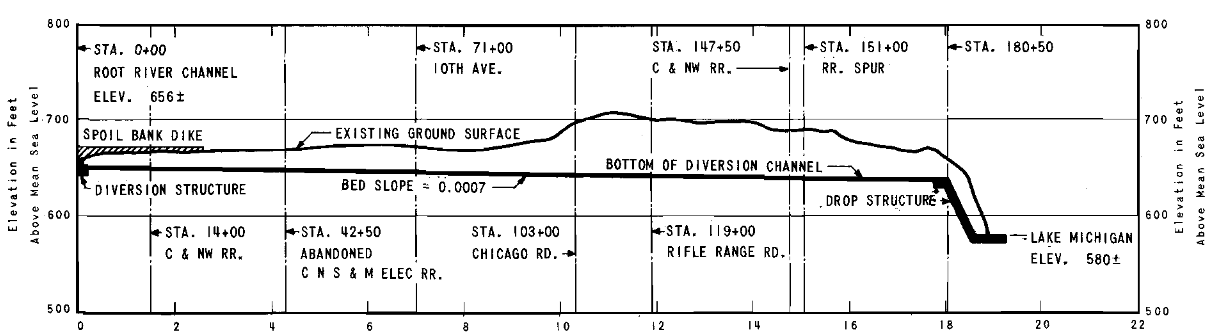
PLAN

Scale: 1 Inch = 4000 Feet



TYPICAL CHANNEL CROSS SECTION

Scale: 1 Inch = 100 Feet



PROFILE

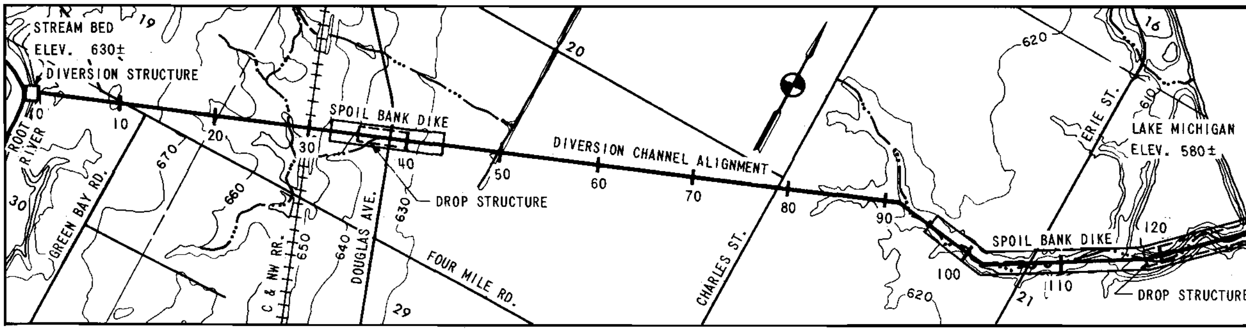
Scale: Horizontal, 1 Inch = 4000 Feet
Vertical, 1 Inch = 200 Feet

NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) - 1.3 feet.
Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum (1929 Adjustment) - 580.560.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) - 580.710.

Source: Harza Engineering Company; SEWRPC.

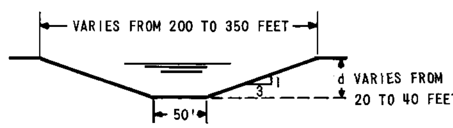
Figure 32

DIVERSION CHANNEL DOWNSTREAM ALIGNMENT



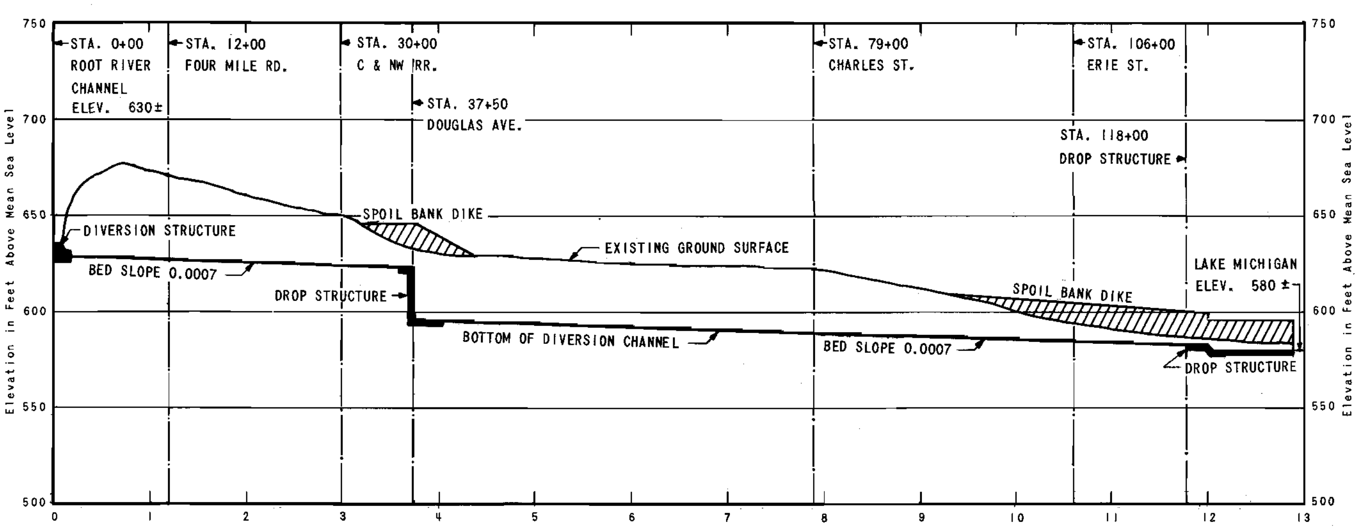
PLAN

Scale: 1 Inch = 2000 Feet



TYPICAL CHANNEL CROSS SECTION

Scale: 1 Inch = 160 Feet



PROFILE

Scale: Horizontal, 1 Inch = 2000 Feet

Vertical, 1 Inch = 100 Feet

NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) - 1.3 feet.
Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum (1929 Adjustment) - 580.560.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) - 580.710.

Source: Harza Engineering Company; SEWRPC.

Benefit-Cost Ratio: The monetary benefit-cost ratio of the upper diversion channel, calculated on the basis of present worth at 6 percent interest, is:

Benefit	
Flood-damage alleviation	\$ 270,000
Cost	
Land and construction	\$2,800,000

$$\text{Benefit-Cost Ratio} = \frac{270,000}{2,800,000} = 0.10$$

$$\text{At 3 percent interest} = \frac{519,000}{2,800,000} = 0.19$$

The monetary benefit-cost ratio of the lower diversion channel, calculated on the basis of present worth at 6 percent interest, is:

Benefit	
Flood-damage alleviation	\$ 115,000
Cost	
Land and construction	\$1,800,000

$$\text{Benefit-Cost Ratio} = \frac{115,000}{1,800,000} = 0.06$$

$$\text{At 3 percent interest} = \frac{187,000}{1,800,000} = 0.10$$

Multi-Purpose Reservoir

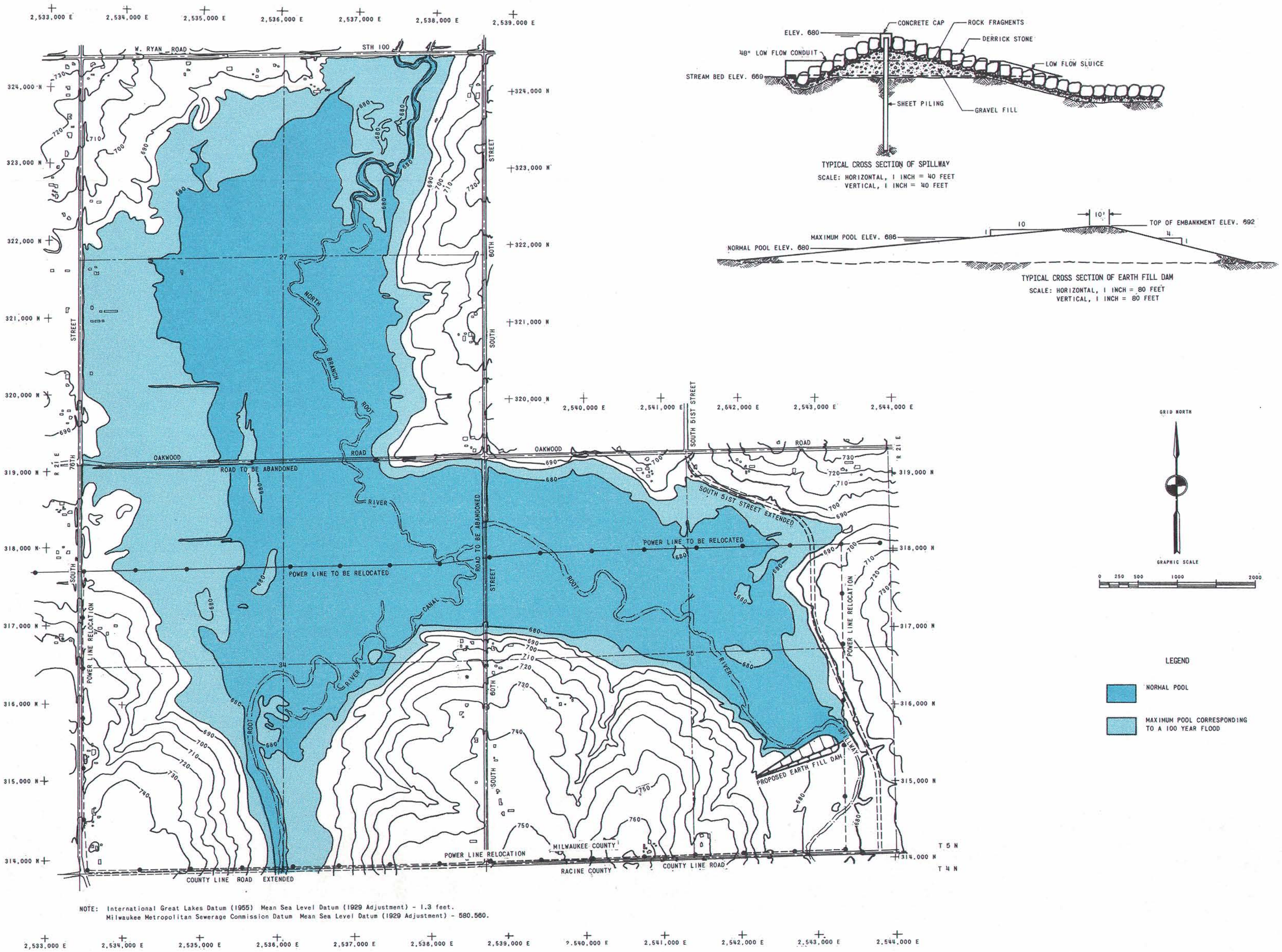
As discussed in Chapters IV, "Hydrology of the Watershed," and VI, "Hydrologic Simulation," lowlands around the confluence of the North Branch and the Root River Canal form a natural reservoir during flood periods, the outflow of which is regulated by a narrow section in the Root River channel near W. County Line Road. The possibility of artificially increasing the flood regulation effect of this natural reservoir and of constructing a permanent lake for recreation, conservation, and low-flow augmentation was investigated; and preliminary specifications were devised.

The normal water surface area of the lake would be about 660 acres. About 400 acres of land underlying this lake would be excavated to provide for such recreational pursuits as boating and fishing. The remaining 260 acres of lake area would provide shallow water for fish and wildlife habitat. The water surface of the lake would be held between elevations 679 and 680 by means of a low rock dam. Water stored between these elevations would be released for streamflow augmentation, which would vary from 3 to 5 cubic feet per second depending upon lake level. A flow of 3 CFS would result in a stream 24 feet wide and 6 inches deep flowing at a velocity of 0.25 feet per second. In the recreation portion of the lake, a mean bottom elevation of 675 would be established to provide a minimum water depth of 5 feet. Five miles of shoreline would be partially developed for recreation and partially left in a natural state. Schematic diagrams of the proposed facility are shown in Figure 33.

In the preliminary examination of all physically possible alternatives, other versions of a reservoir in the vicinity of W. Oakwood Road and S. 60th Street were considered. These consisted of: 1) a single-purpose flood control reservoir with dam crest elevation at 680 msl and 2) several incrementally larger reservoirs with dam crest elevations above 680 msl in order to provide significant flood control benefits in addition to low-flow supplementation and recreation benefits. All of these additional flood control alternatives appeared to be unsound because of requirements for multi-purpose uses, topography, relative location in the channel system, and economic considerations. Flood control reservoirs function most effectively if provision is made for maximum possible floodwater storage through rapid drawdown after a flooding event in order to make room for another flooding event. If Oakwood Reservoir were operated in this manner, recreation and low-flow augmentation benefits would be virtually eliminated; and a wide mud flat would be exposed between flooding events to depreciate rather than to enhance adjacent residential development. These probable effects would apply to either a single-purpose flood control reservoir or a multiple-purpose reservoir with a flood storage increment provided on top of a permanent pool. The feasibility of a high dam flood control reservoir was also reduced by the general level topography of the site. Floodwater storage above elevation 685 msl would cause extensive inundation of W. Ryan Road (STH 100) and of the lands lying west of S. 76th Street (CTH U), defeating the purpose of flood-damage prevention. Geographic factors are such that more than one-half of the drainage area causing flooding to the City of Racine lies below the Lake Oakwood reservoir site. This causes the flood-damage alleviation benefits at site to be very small in comparison to costs. Also, as dam crest elevations are heightened incrementally above the proposed 680 foot level, additional costs

Figure 33

GENERAL LAYOUT OF PROPOSED OAKWOOD LAKE



Source: Harza Engineering Company; SEWRPC.

arise because of the necessity of strengthening the structure and adding appurtenances. Because of these factors, a flood control reservoir, especially one large enough to reduce flooding significantly, appeared to be economically unsound.

Benefits: In the recreation-flow augmentation alternative, all benefits would be related to recreation and conservation. Monetary evaluation of these benefits would be extremely difficult and of little significance in terms of the required capital investment. Experience with artificial lakes developed elsewhere for recreation purposes indicates that those direct benefits which can be evaluated in monetary terms have a value in approximately the same order of magnitude as the annual cost of operation and maintenance. Such small measurable monetary benefits require that the capital cost of the lake be evaluated against intangible benefits.

The intangible benefits of the lake would be extensive and of a high order. The area surrounding the proposed lake includes woodlands and wetlands and attractive topographic features, all of which would be enhanced by the lake. The lake and its surroundings would constitute a major wildlife habitat within what will eventually be an urbanized area. Recreational activities on and near the lake could include rowing, sailing, canoeing, fishing, and picnicking. The lake would be four times the size of all the combined area of all of the existing lakes (165 acres) in Milwaukee County and would provide more publicly accessible shoreline than do such large natural inland lakes as Pewaukee or Oconomowoc.

The present worth of flood-damage reduction attributable to the flood control features of the multipurpose reservoir is $66,000 at 6 percent interest and $108,000 at 3 percent interest. Flood storage at Oakwood Reservoir would reduce the 100-year flood peak stage in the City of Racine 0.4 feet with a corresponding reduction of damages from $65,000 to $55,000.

Costs: The direct cost of the artificial lake is estimated to be $2,416,000. This cost includes a construction cost of $1,943,000 plus the present worth at 6 percent interest of estimated annual operation and maintenance costs of $30,000. At 3 percent interest, the total cost is $2,715,000. Land acquisition costs are not included in the total reservoir costs because land required for the reservoir would be required for parkway development, and the cost of this land has been included in the cost of the parkway-recreation plan element. These costs are based on a rock overflow dam 205 feet long with a maximum height of 11 feet, excavation of 670,000 cubic yards in the lake area, construction of two miles of roadway, landscaping, and power line relocation, as shown in Figure 33.

Benefit-Cost Ratio: The principal benefits of the recreation-only alternative for Oakwood Reservoir are intangible, and the desirability of constructing the lake must be evaluated on that basis.

ALTERNATIVE ACCESSORY PLAN ELEMENTS

Adequate Waterway Openings of Bridges

The water control facility standards set forth herein (see Chapter XI) for achieving an integrated and effective drainage system within the Root River watershed require that any necessary improvements in bridge waterway openings be considered as an integral part of any comprehensive watershed plan. Application of the hydrologic and hydraulic information set forth in Appendices E and G, together with an analysis of data on the hydraulic performance of bridge openings collected by field survey during a snowmelt flooding event when ice effects were present, provided the basis for a listing of existing bridges requiring removal and replacement with structures having adequate waterway openings by the year 1990. Because of substandard waterway openings under 1990 land use conditions, 26 existing bridges will require replacement. These bridges are listed in Table 37. Not included in the listing are the S. 60th Street and W. Oakwood Road bridges (both in the City of Franklin), which lie in the proposed Oakwood Reservoir site, and park and farm bridges having little effect on streamflow. Additional related information, including hydraulic data, is presented in Appendix G.

The recommended bridge replacements are in keeping with current practice by local, state, and federal highway agencies in which existing bridges are replaced with new structures having adequate waterway openings as new highways are built or old highways reconstructed. Benefit and cost analyses were not considered as a valid factor in evaluation of the bridge replacement plan element because the structures requiring replacement have, with few exceptions, served their useful life and require replacement for transportation system construction, operation, and maintenance purposes because of either traffic capacity or safety considerations.

Table 37

PUBLIC HIGHWAY BRIDGES HAVING SUBSTANDARD HYDRAULIC CAPACITIES

Location	Stream	Date of Construction
W. Layton Avenue	Root River, North Branch	1939
S. 84th Street	Root River, North Branch	1930
W. Grange Avenue	Root River, North Branch	1928
S. 76th Street (CTH U)	Root River, North Branch	1934
W. Loomis Road	Root River, North Branch	1933
W. Drexel Avenue	Root River, North Branch	1960
CTH A	Root River Canal, East Branch	1930[a]
50th Road	Root River Canal, East Branch	1960[a]
W. Three Mile Road	Root River Canal, East Branch	1935[a]
CTH A	Root River Canal, West Branch	1940[a]
50th Road	Root River Canal, West Branch	1920[a]
W. Two Mile Road	Root River Canal, West Branch	1920[a]
W. Three Mile Road	Root River Canal, West Branch	1935[a]
W. Four Mile Road	Root River Canal, West Branch	1940[a]
CTH G	Root River Canal	1949
W. Seven Mile Road	Root River Canal	1965
W. County Line Road	Root River, Main Stem	1910[a]
S. 43rd Street	Root River, Main Stem	1910[a]
W. County Line Road	Root River, Main Stem	1910[a]
USH 41	Root River, Main Stem	1931
CTH V	Root River, Main Stem	1927
Howell Avenue (STH 38)	Root River, Main Stem	1929
S. Nicholson Road	Root River, Main Stem	1918
E. Five Mile Road	Root River, Main Stem	1950[a]
Spring Street	Root River, Main Stem	1920
Kyle Road	Hoods Creek	1930[a]

[a] *Estimated age, actual date of construction unestablished.*

Source: SEWRPC

In addition, it is to be especially noted that nine existing highway bridges over the North Branch in the reach extending from W. Lincoln Avenue to W. Cold Spring Road will have to be replaced in order to accommodate a committed decision to widen and deepen this portion of the stream system (see Appendix G). This is not considered as an alternative plan element but, rather, as a committed decision upon which detailed plans must be built.

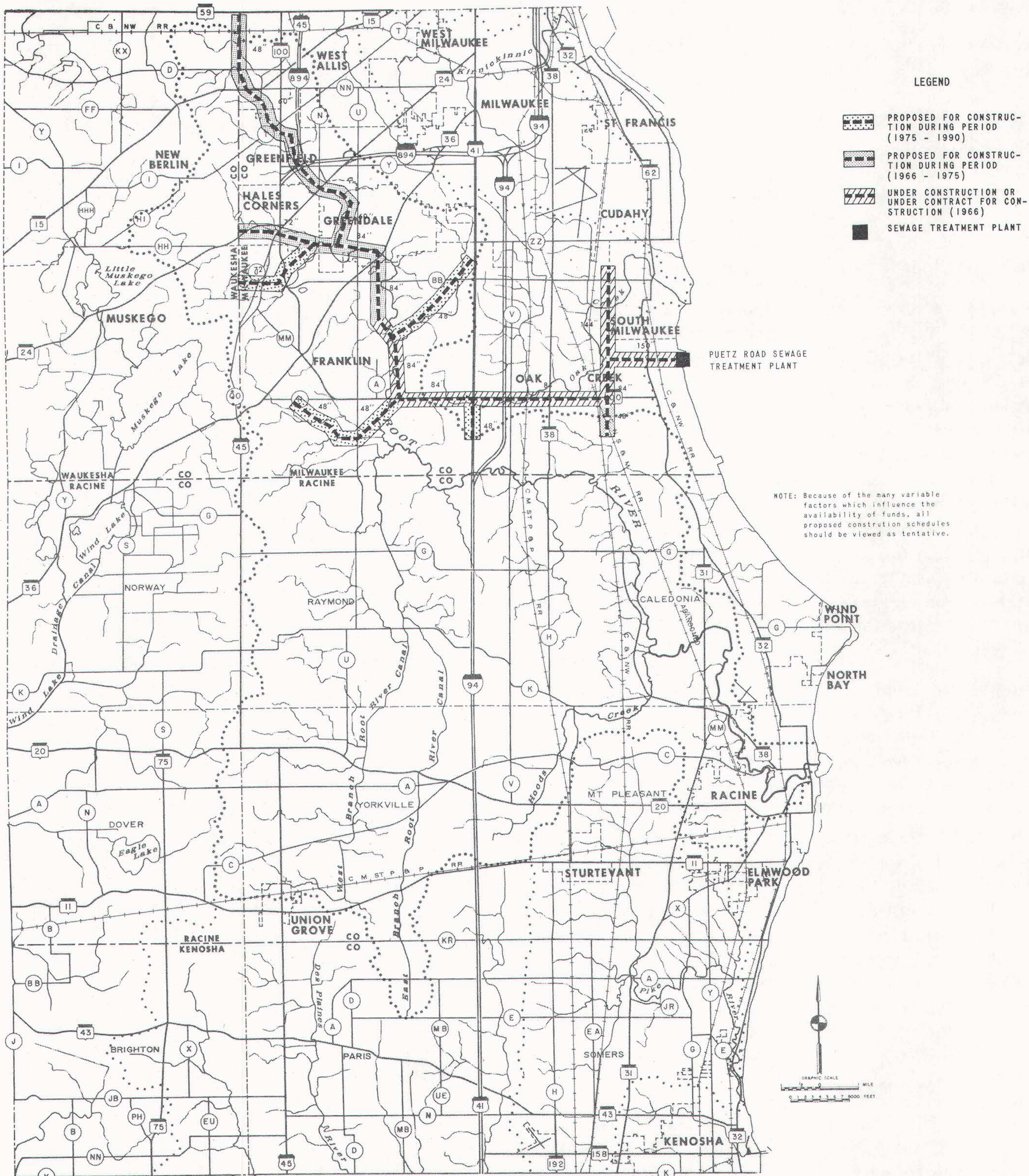
Water Pollution Control Measures

Additional water pollution control measures are necessary to reduce present contributions of wastes to the Root River system, to avoid increased future contributions, and to meet the watershed development objectives with respect to surface water quality and use. Trunk sewers, presently under construction by the Metropolitan Sewerage Commission of the County of Milwaukee, will export wastes from the drainage area of the North Branch to the Puetz Road sewage treatment plant in the City of Oak Creek. This step will relieve the Root River system of about 75 percent of its present known BOD loading. But at several locations on the river (see Map 37), there will remain sources of pollution with potential for greatly increased waste-loading contributions. Undoubtedly, other sources of pollution will also appear in the future. One possible course of action would be to extend sanitary sewer service by the Metropolitan Sewerage Commission to the Caddy Vista area in Racine County and to that portion of Racine County in the Town of Raymond near the mouth of the Root River Canal which is expected to urbanize in the controlled trend land use plans. Since drainage from both of these locations enters Milwaukee County, such action appears to be within the present legal powers of the Commission. Wastes from the Frank Pure Food Company should be transported, after partial treatment, to the City of Racine sewage disposal plant.

Transportation of wastes from Union Grove, the Southern Colony, and the Cooper-Dixon Duck Farm to disposal points outside the watershed does not

Map 37

PROPOSED INTERCEPTING SEWERS AND TREATMENT PLANT LOCATIONS IN THE ROOT RIVER WATERSHED



The proposed water pollution control program includes continued monitoring of water quality and quantity within the watershed, the improvement of certain in-basin waste treatment, and exportation of other wastes where improved treatment can be obtained more economically outside the watershed.

appear feasible at this time or within the plan period. Improvements in the degree of treatment should, therefore, be sought, especially of the wastes from the Southern Colony and the duck farm.

Neither treatment nor exportation of urban storm drainage appear to be practicable, at least within the near future. The high flows associated with urban storm runoff should, however, transport pollution from that source out of the system quickly. Agricultural drainage is not expected to be a major problem because of the small quantity of runoff involved during the summer season. Only a portion of the snowmelt runoff will leach through the soil to collect fertilizers and pesticides.

State government administrative machinery for pollution abatement and control is discussed in detail in Chapter IX, "Water Law." It is also noted in Chapter IX that court action may be a more expeditious approach to pollution problems. No matter what type of action is selected, factual information on the location of waste sources and the type and degree of pollution attributable to such sources will be required. To obtain such data and data useful for eventual plan refinement or reevaluation, a program of water quality and quantity monitoring is recommended for inclusion in any combination of plan elements that may finally be agreed upon.

Water quality samples should be obtained at about monthly intervals and analyzed at least for coliform, dissolved oxygen, chlorides, and temperature. Stations at which quality samples should be obtained are shown on Map 33. This program would continue monitoring at five of the six stations used for the planning studies and would add two stations on the West Branch of the Root River Canal and one station on Hoods Creek. The monitoring station on the North Branch of the Root River at W. Grange Avenue in the City of Greenfield would be discontinued since the extension of trunk sewers to this area by the Metropolitan Sewerage Commission of Milwaukee County will eliminate sanitary waste contributions to the North Branch. The planned locations of water quality monitoring stations and their function are:

1.[6] North Branch, Root River at W. Grange Avenue. Monitor "base" water quality before introduction of municipal sewage treatment plant effluent.
2. North Branch, Root River at W. Ryan Road (STH 100). USGS stream gaging station. Monitor overall water quality of North Branch, particularly with respect to questionable quality of urban storm runoff.
3. Root River Canal at Six Mile Road (CTH G). USGS stream gaging station. Monitor overall quality of Root River Canal contributions and contributions from East Branch.
4. Root River at County Line Road. Monitor outflows from natural reservoir or proposed Oakwood Reservoir, also monitor quality upstream from Caddy Vista area.
5. Root River at Nicholson Road. Monitor water quality below Caddy Vista Sanitary District outfall.
6. Root River at STH 38 near Racine. USGS stream gaging station. Monitor overall river system water quality.
7. Hoods Creek at STH 38. Monitor water quality of Hoods Creek, particularly with respect to effluent from food processing plant.
8. West Branch, Root River Canal downstream from duck farm outfall. Monitor contributions from duck farm treatment facilities.
9. West Branch, Root River Canal downstream from Village of Union Grove. Monitor contributions from treatment plants operated by Village of Union Grove and State of Wisconsin Southern Colony and Training School.

In conjunction with the water quality monitoring program, the continuous recording stream gaging stations operated by the U. S. Geological Survey under cooperative agreements with the SEWRPC, Metropolitan Sewerage Commission of the County of Milwaukee, and Racine County on the North Branch at Ryan Road, the Root River Canal at CTH G, and the Root River at STH 38 near Racine should be continued. The following crest-gage stations installed and operated by the USGS should also be continued:

1. Root River at W. College Avenue.
2. Root River tributary at W. Rawson Avenue and STH 100.

[6] *Numbers correspond to station numbers on Map 25.*

3. Root River at W. Rawson Avenue (CTH BB).

4. East Branch, Root River Canal at CTH K.

5. West Branch, Root River Canal at Three Mile Road.

6. Root River at S. 60th Street.

7. Root River at S. 43rd Street.

8. Root River at CTH V.

9. Root River at Nicholson Road.

10. Root River at Six Mile Road.

11. Root River at Four Mile Road.

12. Root River at STH 31.

Continuance of the stream gaging program will make possible future refinement of the hydraulic studies made in the present planning program. It must be recognized that the present studies are based on very short-term streamflow data and are, therefore, inherently of a lower level of accuracy than might be attained with definitive streamflow data extending over a longer time period. In addition, water quantity information is needed for interpretation of water quality observations and data.

The water quality and quantity monitoring program would cost approximately $7,000 per year. This cost estimate is based upon the maintenance of 8 quality stations, 3 continuous recording stream gaging stations, and 12 crest-gage stations. At 6 percent interest, the present worth of this program over 50 years is $110,000, at 3 percent interest, $180,000.

Removal of Residences From Flood Plain in the City of Greenfield

The removal of certain residences in the flood plain reach lying between W. Layton Avenue and W. Forest Home Avenue in the City of Greenfield would accomplish flood-damage abatement and would provide additional land for park and recreation use. Hence, this alternative must be considered as a possible adjunct to any watershed plan. Criteria indicating the practicality of removal of houses are largely economic. As shown in Appendix J, flood damages mount rapidly per unit depth of flooding as first floors of dwellings are inundated. Also, it is generally difficult to floodproof residences when floodwaters rise above first floor levels. Within the W. Layton to W. Forest Home reach, 23 residences, having a present (1965) estimated property value of about $575,000, will be subjected to various depths of inundation at above first floor levels by a 100-year recurrence interval flood under 1990 land use conditions and with the proposed West Allis channel improvements (see Map 38).

It is assumed that salvage value of the house at the time of purchase would be sufficient to cover demolition or removal costs and landscaping of the site. The benefit-cost ratio of removal of the 23 houses lying within the City of Greenfield, calculated on the basis of present worth at 6 percent, would be:

Benefit

Flood-damage alleviation	$150,000

Cost

Market value of property	$575,000

$$\text{Benefit-Cost Ratio} = \frac{150,000}{575,000} = 0.26$$

$$\text{At 3 percent interest} = \frac{250,000}{575,000} = 0.43$$

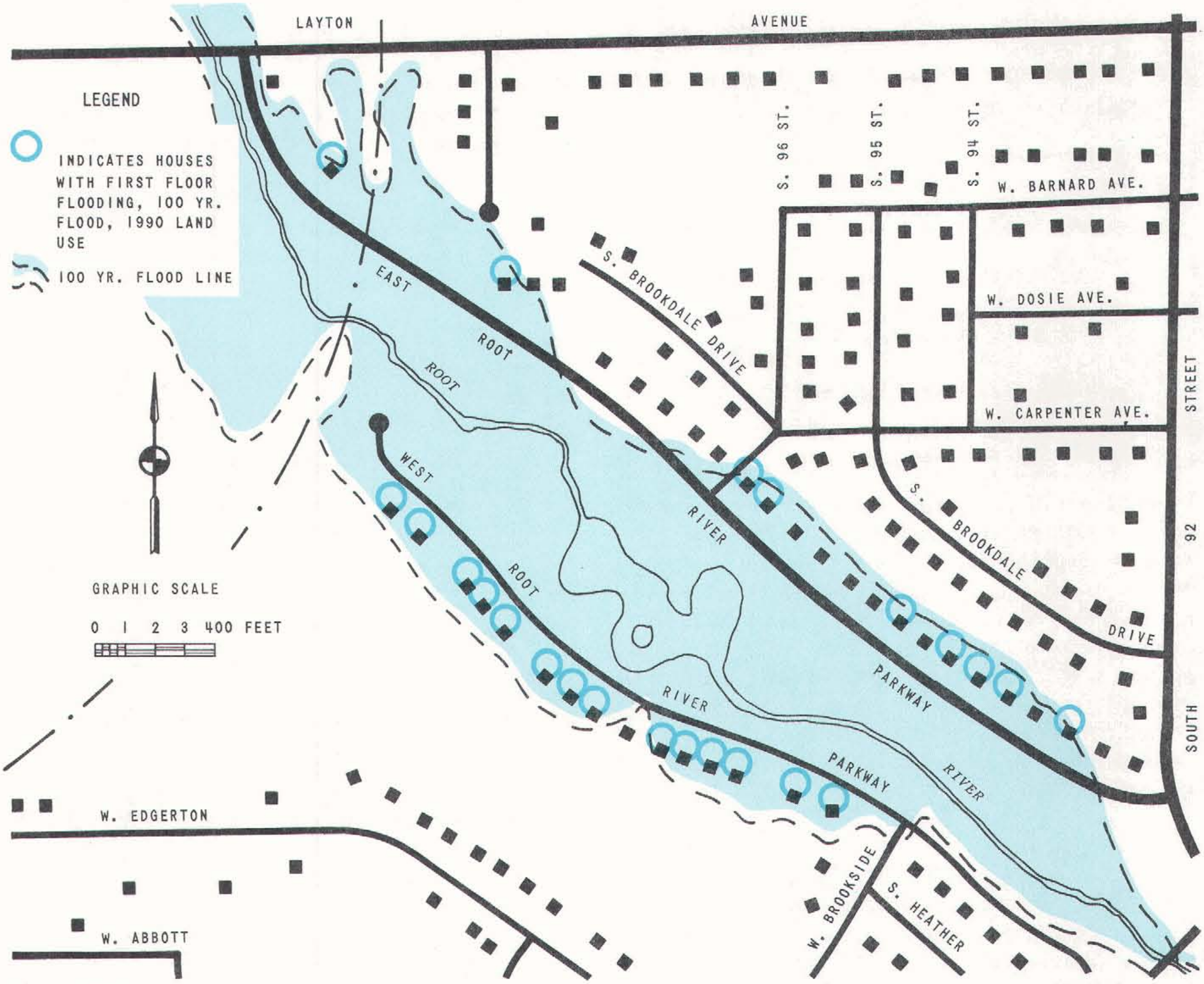
It should be noted that these benefit-cost ratios, while less than 1.0, are greater than the corresponding ratios for the channel improvement alternative element set forth previously for this channel reach.

Removal of Residences From Flood Plain in the City of Racine

Removal of certain residences in the Island Park area of the City of Racine would accomplish flood-damage abatement and would provide additional land for park and recreation use. Hence, this measure must be considered as a possible adjunct to any watershed plan. Criteria for removal of houses in the City of Racine are identical to that for removal of houses in the City of Greenfield, inundation above the first floor level of a residence being assumed to constitute grounds for investigating the feasibility of removal. Some 35 residences, having a present (1965) estimated property value of about $385,000, will be subjected to various depths of inundation at above first floor levels by a 100-year recurrence interval flood under 1990 land use and water control facility con-

Map 38

AN ALTERNATIVE PLAN ELEMENT: REMOVAL OF RESIDENCES FROM THE FLOOD PLAIN IN THE CITY OF GREENFIELD



Source: SEWRPC.

ditions (see Map 39). It is assumed that salvage value of the house at the time of purchase would be sufficient to cover demolition or removal costs and landscaping of the site.

The benefit-cost ratio of removal of damage-susceptible residences from the flood plain within the City of Racine, calculated on the basis of present worth at 6 percent, would be:

Benefit
- Flood-damage alleviation $ 85,000

Cost
- Market value of property $385,000

$$\text{Benefit-Cost Ratio} = \frac{85,000}{385,000} = 0.22$$

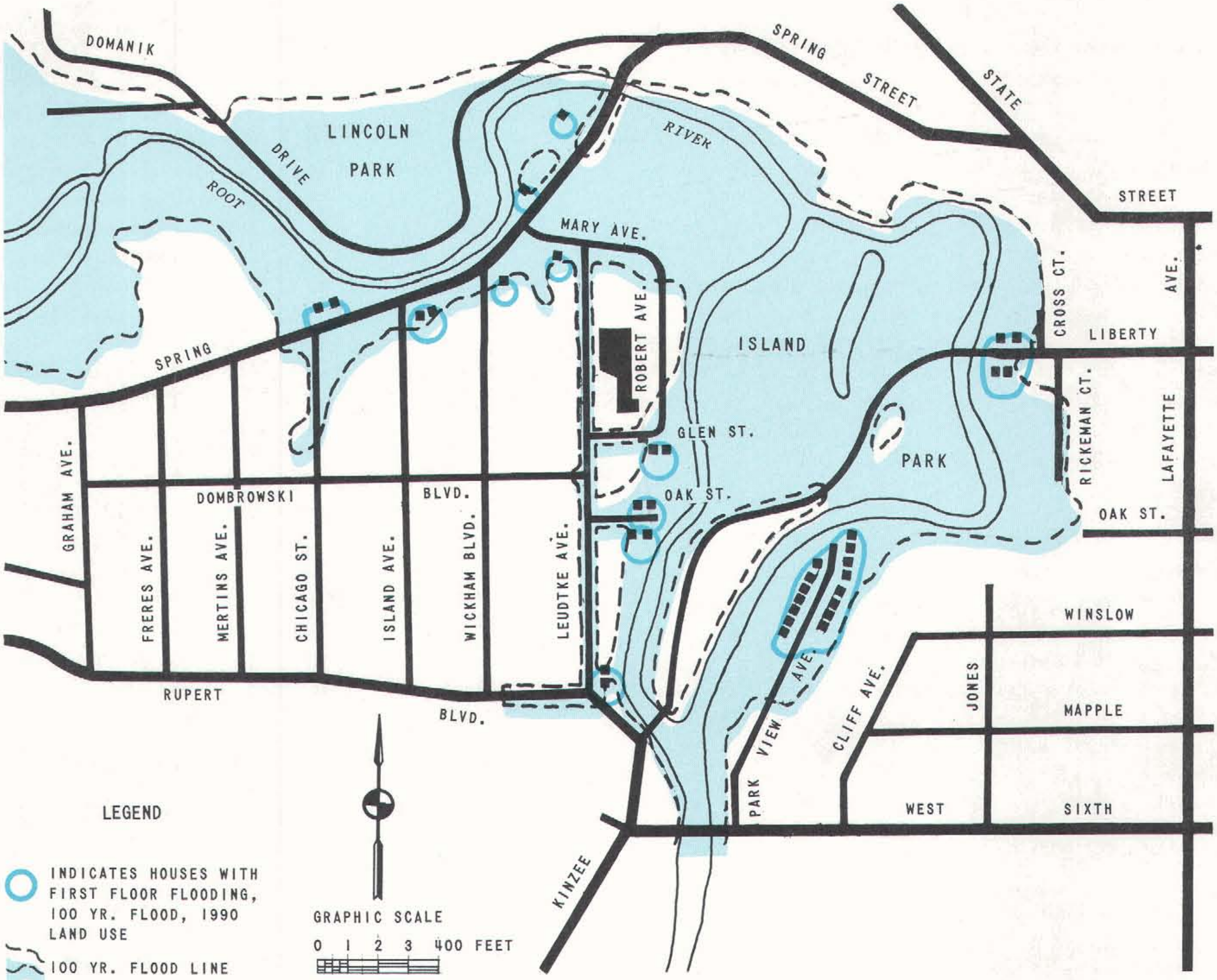
$$\text{At 3 percent interest} = \frac{142,000}{385,000} = 0.37$$

Restoration of Horlick Dam

A decision must be made soon with respect to the ultimate disposition of Horlick Dam because of the rapidly accelerating deterioration of the dam. As discussed in Chapter V, "Hydraulics of the Watershed," the dam does not contribute to flood control nor is it responsible for any significant flood damages. Restoration of the dam and pond in the context of the parkway-recreation land use

Map 39

AN ALTERNATIVE PLAN ELEMENT: REMOVAL OF RESIDENCES FROM THE FLOOD PLAIN IN THE CITY OF RACINE



Source: SEWRPC.

plan element would create an attractive and desirable water-oriented recreation facility. Removal of the dam would expose unsightly mud banks which would be difficult to incorporate into an aesthetic parkway or open-space development. In the controlled existing trend land use alternative elements, removal of the dam would detract from the value of property along the present banks of the pond. It is likely that a great deal of the silt and mud deposited in the pond would be washed downstream to deposit in the channel in the City of Racine if the dam were removed.

Monetary benefits for restoration of Horlick Dam and pond were not calculated. As in the case of "Oakwood Reservoir," benefits are primarily of an intangible nature and must be evaluated subjectively. Benefits of restoration would include scenic beauty, boating, fishing, and the preservation of a historic site.

Horlick Dam could be restored either by repairing the existing structure or by replacing it with a new dam. Repair might be desirable for historic considerations, but replacement would probably be more economical. An estimate was made of the cost of constructing a concrete gravity dam, stable in itself, in contact with the downstream face of the existing dam. The estimated cost of such a dam would be $24,000. A lump-sum allowance of $10,000 was estimated for snagging and cleaning the pond, making the total estimated cost $34,000.

Augmentation of Low Flow in North Branch

As noted in Chapter VIII, "Other Problems," the scheduled export of sewage from communities in the North Branch drainage area will probably result in periods of very low or no flow in the North Branch and will significantly reduce downstream low flows.

Drying up of parts of the North Branch channel for prolonged periods may detract to some degree from the aesthetic quality of the parkway recreational area. Reduction of low flows in the downstream river reaches will detract from the potential boating, fishing, and other recreational uses of the river and will aggravate residual pollution problems. Extreme low flows and temporary dry-bed conditions will also foster weed growth in channel reaches where constant water presence now keeps the main channel reasonably clear of such growth.

The relaxation of demand on ground water for municipal water supply in the North Branch drainage area as the facilities for supply of Lake Michigan water are extended may result in water table recovery and increased ground water contribution to the channel. As ground water may be developed for other uses, there is no assurance of water table rise; and quantitative forecasts of future ground water contribution are not possible.

Possible measures that may be considered for alleviation of low-flow problems include ground water pumpage, use of Lake Michigan water, and reservoir storage. The minimum flow requirement in the North Branch for aesthetic purposes is suggested as 0.5 CFS. This is equivalent to a stream 3 feet wide and 4 inches deep flowing at a velocity of 0.5 feet per second. A minimum of 3 CFS, equivalent to a stream 24 feet wide and 6 inches deep flowing at a velocity of 0.25 feet per second, is suggested as desirable for the main channel downstream from the North Branch.

Augmentation of low flows of the North Branch could be accomplished by ground water pumping or by Lake Michigan water supplied through the municipal water supply system. The latter source is probably impracticable both because of cost and because the demand for low-flow augmentation would occur during the peak-load season of the water supply system. Ground water pumping would appear to be a more reasonable alternative, although the volume of flow desired, approximately 300,000 gpd, is very large in terms of ground water supply. Development of an augmentation supply from the shallow aquifer would be difficult because several wells would be required. Moreover, pumping from the shallow aquifer in the vicinity of the river might lower the water table near the river and induce seepage losses from the river. Use of the deep aquifer, even if an already constructed well could be used, would be very expensive as pump lifts would be around 400 feet. Also, pumping for streamflow augmentation would further lower the already depressed piezometric level in the deep aquifer and increase pumping costs for present users. The possibility of drainage into the river of Lake Michigan water and ground water used for cooling purposes was also investigated, and it was concluded that no significant flow contribution from this source can be expected.

The extent and consequences of the low-flow problem in the North Branch are unpredictable. Costs of supplying water for augmentation will be high, and administrative problems will be substantial. There is also the possibility that the problem may be alleviated by water table recovery or by drainage from unrelated activities. In consideration of these factors, specific action should be deferred, at least until the existence of a problem becomes apparent.

FLOODPROOFING OF RESIDENCES

It is possible and generally practicable for homeowners, as individuals, to make certain structural adjustments or to impose use restrictions on private properties in order to reduce flood damage. These structural measures and use restrictions applied to buildings and contents are known as "floodproofing." The flood damage survey revealed that many private individuals have practiced and will apparently continue to practice various kinds of floodproofing. The floodproofing which has been practiced has undoubtedly contributed substantially to reduction of the potential flood damages. The calculation of future flood damages (see Chapter VII) is based partially upon the implied assumption that floodproofing will reduce future damages by a percentage equivalent to its reduction of historic damages. A review of the technical literature and of the reports of the flood damage survey of the Root River watershed supports a presentation of floodproofing elements which can be applied by private individuals.

It should be noted that selection of the specific floodproofing elements to be applied to a particular structure depend upon the features of the individual house, such as kind of structural material, age of structure, substructure conditions, nature of the exposure to floodwaters, height of water table, sewerage facilities, and uses demanded of the structure. Extensive floodproofing should be applied only under the guidance of a registered professional engineer who has carefully inspected the building and its contents.

Categorized according to function, floodproofing elements are of four types: 1) general floodproofing independent of type of flooding, 2) seepage control, 3) relief from sewer back-up, and 4) protection from overland flow.

General Measures: A number of floodproofing measures apply to flood-damage prevention regardless of the manner of flooding. These include the following: 1) keeping valuable items away from areas which could conceivably be flooded; 2) using waterproof cement in laying tile or linoleum; 3) having adequate fuse protection in all homes; 4) unplugging, disconnecting, or removing from vulnerable areas all electrical appliances; and 5) anchoring all fuel tanks securely so that the force of buoyancy of floodwater will not cause floating and spillage.

A review of the events of the 1960 flood reveals that many persons avoided flood damages by removing electric motors from furnaces and appliances and by removing perishable items from basements. The most severe instances of flood damages were caused by fuel oil storage tanks which floated loose from anchorage, ruptured, and spilled oil over the contents and interior of homes. Other instances of exorbitantly high flood damages were caused by unsuitable uses of basements or by impractical designs of flood plain homes. In a number of high damage cases, flood plain basements were used as bedrooms or kitchens. Also, several individuals suffering severe damages had home designs featuring a flat located in a basement with an exposed wall and used as a living floor with large picture windows facing the river.

Seepage Control: During periods of flooding and accompanying high water tables, basements situated in the permeable sands and silts of flood plains are particularly susceptible to seepage through walls. Experience has shown that basements can be severely flooded by seepage within a few hours. Where structures are sound and hydrostatic pressure from ground water is low, basements may be waterproofed from seepage by sealing walls with either asphalt or quick set hydraulic compounds. In many instances, however, because it is not practical to exclude seepage water, it becomes necessary to operate a sump pump. The flood damage survey revealed that most of the 300 homes located on the Root River flood plains have basement sump pits equipped with pumps for discharging seepage or sewer back-up water onto a lawn or driveway. As a safeguard against power failure, some homeowners have an auxiliary pump which is gasoline-fueled; and one homeowner has installed a gasoline-fueled, electric power generation plant.

As a general principle, all homes constructed in flood plains—in which water tables are high—should have basement walls sealed for maximum waterproofing and should be equipped with a sump pit and with a pump which is actuated automatically as waters rise.

Relief From Sewer Back-Up: Because of flat topography, high water tables, and surface overflow into manholes, most flood plain homes have experienced flood-damage problems from the backing up of sewer water through a basement or wall floor drain. During the flood of 1960, this problem was particularly severe in the Island Park residential area of the City of Racine because floodwaters rendered a municipal sewage pumping station inoperative. An efficient and effective general remedy to this problem has now been provided by the City of Racine with the construction of a new sewage pumping station which has an increased capacity and is located above the expected elevation of the 100-year recurrence interval flood. It would be advisable, however, as a precautionary measure, for flood plain homeowners in the Island Park area to continue to floodproof against sewer back-up. Elsewhere along the flood plain, as a standard construction procedure, protection should be provided against sewer back-up.

A number of relatively inexpensive standard devices can be installed in sewer lines to prevent reverse flow of water. These include standard backwater valves, horizontal swing check valves, and a closed end pipe threaded into a floor drain. It is important to note that in order for these devices to accomplish flood-damage relief the floor drain must be securely anchored in the basement floor; or hydrostatic pressure may cause the sewer line to break loose, rupture, and thus introduce floodwaters.

Under certain conditions of rapidly rising floodwaters, flood-damage prevention may be accomplished more by letting a basement flood than by trying to exclude the inflow of floodwater through sewer lines or in other ways. During the record flood of 1960, several instances of severe damage were caused by the differential pressure between floodwaters and empty basements. In one home equipped with a back-water value and a high capacity sump pump, the basement floor was uplifted by hydrostatic pressure and ruptured extensively. In another instance, a basement wall collapsed apparently because of the differential pressure. Basement floors, walls, and floor drains should not be floodproofed without consideration of the probable forces which the structure must withstand.

Protection From Overland Flow: Generally, it is not practicable to floodproof residences when floodwaters rise above first floor levels. Exceptions are offered by particularly sturdy structures, such as well-constructed brick buildings; but most frame structures are difficult to floodproof at first floor levels. Below first floor levels, overland flow can sometimes be excluded from homes by the installation of seal-tight, wire-reinforced glass on all basement windows. An alternative measure is to seal all exterior openings to basements and depend entirely on artificial light and air conditioning.

THE "LAKE MORAINE" PROPOSAL

An independent proposal for the development of the water resources of the Root and Des Plaines watersheds has been suggested by a Milwaukee area consulting engineer. The primary element of this proposal would be an artifical lake of about 30 square miles in area occupying a portion of the Root River Canal drainage area and extending into the headwater drainage area of the Des Plaines River. The artificial lake would receive floodwaters from parts of the Root, Fox, and Des Plaines watersheds and would provide recreation and pumped-storage hydroelectric power. This proposal was evaluated, and it was concluded that it would not justify consideration as an alternative plan for the Root River watershed.

From a physical standpoint, the maintenance of "Lake Moraine" water levels at a design elevation resulting in the necessary recreation and power benefits appears of questionable feasibility. Evaporation losses would approximately balance rainfall-runoff inflows, while the probable magnitude of seepage losses might be quite large. Application of the pumped-storage concept for maintaining the water levels with supplementary water from Lake Michigan would be uneconomical at the low heads available, while interbasin diversion would raise serious legal problems.

Preliminary economic analyses of all facets of the proposal indicate that the flood control and power benefits of this plan would leave approximately $38,000,000 of the total project cost of $46,000,000 to be ascribed to recreation benefits derivable from the artificial lake. While such an expenditure might conceivably be justified, it is considered to be far beyond the scope of the Root River watershed requirements. It should be pointed out, however, that none of the alternative plan elements proposed for the Root River watershed in these studies would preclude eventual implementation of the "Lake Moraine" proposal if it should ever be concluded to be desirable on a state or interstate basis.

Chapter XIII
RECOMMENDED COMPREHENSIVE PLAN FOR THE ROOT RIVER WATERSHED

INTRODUCTION

The preparation of a recommended plan for the Root River watershed required that a selection be made from among the alternatives of those plan elements which together should comprise the recommended plan, including a land use base and necessary supporting water control and pollution abatement facilities. Such a selection must be based upon consideration of many tangible and intangible factors but should focus primarily upon the degree to which the agreed-upon watershed development objectives are satisfied and upon the accompanying costs. The selection of the plan elements to be included in the final plan must ultimately be made by the responsible elected and appointed public officials concerned and not by the planning technicians, although the latter may properly make recommendations based upon evaluation of technical considerations.

In order to facilitate the necessary selection by responsible officials, the degree to which the individual plan elements described in the previous chapter meet the development objectives, together with the associated costs, was presented in a preliminary report and recommendations made therein as to the most effective combination. A financial analysis of the recommended plan was also included, together with a recommended implementation schedule. A summary of the findings and recommendations of the preliminary report was mailed to each elected member of every local governing body within the watershed. A series of five public meetings was then held within the watershed before the governing bodies and interested elected and appointed governmental officials and citizen groups for the specific purpose of obtaining the reaction of the governing bodies concerned to the preliminary plan recommendations. The meetings were held as set forth below:

Units of Government Attending	Place of Meeting	Date of Meeting
City of Racine, Towns of Caledonia and Mount Pleasant	Racine, Wisconsin	February 3, 1966 7:30 p. m. - 9:30 p. m.
Towns of Raymond and Yorkville, Village of Union Grove, and the Racine County Board	Ives Grove, Wisconsin	February 10, 1966 7:30 p. m. - 9:00 p. m.
Cities of Greenfield, New Berlin and West Allis and the Villages of Greendale and Hales Corners	West Allis, Wisconsin	February 17, 1966 7:30 p. m. - 8:45 p. m.
Cities of Franklin, Muskego, and Oak Creek	Oak Creek, Wisconsin	February 21, 1966 7:30 p. m. - 9:15 p. m.
City of Milwaukee Milwaukee County: County Board of Supervisors Metropolitan Sewerage Commission Milwaukee County Park Commission	Milwaukee, Wisconsin	February 23, 1966 1:30 p. m. - 3:30 p. m.

Complete minutes of the meetings are on file in the Commission Offices. It is important to note here, however, that the reaction to the recommended plan as herein set forth was completely favorable, with the expressed interest of the elected officials being directed only at the means by which the recommended plan could best be implemented. Indeed, although not requested to do so, the Milwaukee County Board, upon the recommendation of the Milwaukee County Park Commission and the City of Racine Plan Commission, adopted formal resolutions approving the recommended preliminary watershed plan. The preliminary plan was also submitted to the SEWRPC Technical Advisory Committee on Natural Resources and Environmental Design on February 4, 1966, and was approved unanimously by this committee on that date. The Root River Watershed Committee unanimously approved the preliminary plan at a meeting on June 22, 1966.

The final plan recommended herein, therefore, does not depart in any significant way from the preliminary plan presented at the meetings and approved by the advisory committees after careful public review over a period of over six months. Although based upon experienced professional judgment and a very careful technical evaluation, the final plan is not to be regarded as a rigid mold to which all watershed development is to be shaped; but, rather, it should be regarded as a recommendation which, for valid reason, is subject to modification by the governmental units and agencies concerned. Any modifications, however, should be made only after the same careful consideration is given to all of the factors involved as was given in the initial plan preparation effort.

BASIS OF RECOMMENDATION: A COMPARATIVE EVALUATION OF ALTERNATIVE PLAN ELEMENTS

Satisfaction of Development Objectives

The development objectives to be met by the final watershed plan, together with the standards which relate these objectives to physical development proposals and facilitate evaluation of the ability of the plan proposals to meet the chosen objectives, have been set forth in Chapter XI. In order to facilitate plan evaluation and selection, these objectives and their supporting standards have been summarized in Table 38. Careful inspection of this table will show that no one land use plan element or water control facility plan element fully satisifies all of the eight major development objectives set for the Root River watershed. Therefore, the recommended plan must consist of a combination of individual plan elements.

Among the land use plan elements, the controlled existing trend alternatives are superior to the uncontrolled existing trend alternative with respect to every objective. Indeed, the uncontrolled existing trend alternative would defeat every watershed development objective and result in an inefficient spatial distribution of urban development, which would be highly susceptible to future flood damages. Continued uncontrolled urban sprawl would be particularly destructive to the natural resource base through further intrusion of urban development into the riverine areas, which comprise integral parts of the natural environmental corridors of the Region, and into the remaining prime agricultural areas of the watershed. The opportunity for establishment of high-value homesites in the attractive setting of adjacent resource conservation areas would be lost. With a continuation of uncontrolled land use development within the watershed, the future demand for residential land would have to be provided primarily by reducing present scarce woodlands, wetlands, wildlife habitat, and prime agricultural areas. On the basis of satisfaction of watershed development objectives, the uncontrolled trend alternative must be rejected.

The two controlled trend land use plan alternatives differ largely in land ownership aspects. The land use regulation alternative would attempt to attain objectives through land use control exercised over private land holdings through the police power of local government. The parkway-recreation alternative would secure the same and certain additional objectives through public acquisition of riverine area lands for public use and administration. Of the two alternatives, the parkway and recreation land development alternative warrants adoption in the urbanizing areas of the watershed both on the basis of its multi-use potential and its sounder economic basis.

Because of both man-made and natural features, the land use plan elements alone will not allow attainment of all development objectives. They must, therefore, be complemented by other plan elements largely of a water control and pollution abatement facility nature. Inspection of Table 38 will show that each of the water control facility accessory elements shown adds to accomplishment of at least one additional objective for any given land use base element. A multi-purpose artificial reservoir at the junction of the North Branch and Root River Canal appears particularly attractive as an adjunct to the parkway and recreation land use plan base, for it would enhance several of the development objectives. The floodwater diversion channels are particularly unattractive, not only

Table 38

COMPARISON OF RELATIVE ABILITY OF ALTERNATIVE PLAN ELEMENTS TO MEET WATERSHED DEVELOPMENT OBJECTIVES

PLAN ELEMENT	LAND USE OBJECTIVES						WATER CONTROL OBJECTIVES	
	Meet Future Land Needs[a]	Protection, Wise Use, and Development of Resource Base.	Efficient Adjustment to Supporting Services and Facilities	Preservation and Provision of Open Space and Recreation Lands	Preservation of Prime Agricultural Areas	Good Soil and Water Conservation Practice	Integrated and Efficient Systems for: Drainage and Flood Control	Integrated and Efficient Systems for: Water Quality Control
SUPPORTING STANDARDS								
	Low dens. res. 312 ac./1000 pers. Med. dens. res. 98 ac./1000 pers. Regional recreation areas 4 ac./1000 pers.	A. Soils[b] B. Stream[b] C. Wetland[b] D. Woodland[b]	Medium-density residential shall be in gravity drainage area tributary to public sewerage facilities and shall be accessible to public water supply; maximize utilization of existing transportation and utility systems.	Local park and open spaces should be within 1/2 mile of every residence. Unique scientific, cultural, and scenic areas not to be allocated to any urban or agricultural use.	Preserve remaining agricultural soil rates as very good, good, or fair, which comprise 5 square mile units and have open-space potential.	A minimum of 50 percent of the agricultural area under cooperative soil and water agreements and 25 percent under actual treatment by owner.	Waterway openings in bridges should accommodate floods on basis of traffic: minor streets - 10-year event; arterials - 50-year event; expressways - 100-year event.	Stream water should allow selected water uses of boating, facultative fishing, wildlife and livestock, and aesthetics: public sewerage to all residences except single-family 5-acre developments.
Land Use Base: Uncontrolled Existing Trend	Demands not met except for regional recreation: Low dens. res. 500 ac./1000 pers. Med. dens. res. 150 ac./1000 pers. Regional recreation areas 3.3 ac./1000 pers.	Residential developed on unsuitable soils; Annual flood damages of $61,000; 60 percent river banks developed; Continued loss of wetland; 4.0 percent of area in woodlands.	Standards not met.	Standards not met.	Standards not met; urban encroachment would continue.	Standard not met.	Standards not met.	Standards not met.
Controlled Existing Trend - Land Use Regulation	Demand met except for regional recreation: Low dens. res. 500 ac./1000 pers. Med. dens. res. 150 ac./1000 pers. Regional recreation areas 3.3 ac./1000 pers.	All resource standards met except woodlands: flood damage nil; wetlands preserved; 5 percent of river banks developed. Over 5 percent of watershed in woodlands.	Standards met.	Standards met.	Standards met.	Standards could be met.	Standards met.	Standards could be met.
Controlled Existing Trend - Parkway and Recreation Development	Demand met: Low dens. res. 500 ac./1000 pers. Med. dens. res. 150 ac./1000 pers. Regional recreation areas 4 ac./1000 pers.	All resource standards met except woodlands: flood damage nil; wetlands preserved; 5 percent of river banks developed. Over 5 percent of watershed in woodlands.	Standards met.	Standards met.	Standards met.	Standards could be met.	Standards met.	Standards could be met
Major Water Control Facilities: Channel Improvements Greenfield, City of, and Greendale, Village of	--	On site reduction in flood damages, but stream bank standards not met.	--	--	--	--	Supports.	--
Racine, City of	--		--	--	--	--	Supports.	--
Canal, West Branch of	--	--	--	--	--	--	Supports.	--
Canal, East Branch of	--	--	--	--	--	--	Supports.	--
Diversion Bypass Channels North Route	--	Downstream reduction in flood damages.	--	--	--	--	Standards met for downstream areas.	--
South Route	--					--		
Oakwood Reservoir	--	Supports.	--	Supports.	--	--	Supports.	Supports.
Replacement of Bridges	--	Supports.	--	Supports.	--	--	Supports	Supports
Accessory Facilities: Water Pollution Control Measures Caddy Vista Waste Export to Milwaukee	--	Supports.	Supports	Supports	--	--	--	Supports
Frank Pure Food Waste Export to Racine	--	Supports	Supports	Supports	--	--	--	Supports
Monitoring Program	--	Supports	--	Supports	--	--	--	Supports
Residence Removal Greenfield, City of	--	Supports	--	Restoral of open space	--	--	Supports	Supports
Racine, City of	--	Supports	--	Restoral of open space	--	--	Supports	Supports
Restoration of Horlick Dam	--	Supports	--	Supports	--	--	--	Supports
Low-Flow Augmentation, North Branch	--	Supports	--	Supports	--	--	--	Supports
Flood Proofing of Residences	--	Supports	--		--	--	--	Supports

[a] *Gross residential land area defined as the net area devoted to said area plus supporting facilities (see Footnote b to Table 32).*

[b] *Standard consists of the following: no more than 2.5 and 3.5 percent, respectively, of areas proposed for low- and medium-density residential development should be covered by soils rated as poor, questionable, or very poor for such development. Only soils rated as very good, good, or fair for septic tank waste disposal should be developed in absence of public sewer service. Also, it is required that there be no flood-vulnerable development on flood plains, no obstruction of floodways, the preservation of all wetlands 50 acres and larger, preservation of 50 percent of river banks in natural state, and preservation of a minimum of 10 percent of total watershed in woodlands.*

Source: SEWRPC.

because of their single-purpose nature, but also because of their poor economic basis. Channel deepening and widening represents a costly inflexible measure satisfying few objectives. Unfortunately, existing and committed urban storm water drainage system improvements in the headwater portions of the North Branch of the Root River require the application of such deepening and widening. Channel clearing and maintenance is a more flexible undertaking offering satisfaction of the flood control objective in the Canal area.

The water pollution control measures are far more valuable than can be indicated in the tabular analysis alone. By encouraging the proper water quality environment in the riverine area, water pollution control measures support all watershed development objectives, at least in the riverine area. Recreation objectives and water quality standards would be partially met by restoration of Horlick Dam and reservoir.

Benefit-Cost Factors

Because of the extreme difficulty of expressing all benefits and costs in monetary terms, the ability of any given plan element to satisfy watershed development objectives should be considered of equal importance to an economic analysis. A comparison of the results of economic analyses of the applicable plan elements is presented in Table 39. A careful inspection of this table reveals that a favorable benefit to cost ratio exists for only the parkway-recreation land use element (1.03) and for channel improvements on the West Branch of the Root River Canal (1.14). None of the other plan elements show a benefit-cost ratio approaching 1.0. Nevertheless, the intangible benefits accruing from several of these elements are of sufficient importance to justify their recommendation. It is particularly significant that the single-purpose floodwater diversion channels have particularly low benefit-cost ratios (0.10 and 0.06).

PLAN RECOMMENDATIONS

Based upon the foregoing analysis of the ability of the various plan elements to satisfy watershed development objectives and the related benefit-cost analyses, the following plan elements are recommended for inclusion in the final Root River watershed plan:

1. Recommended land use plan elements:

   a. Controlled Existing Trend-Parkway and Recreation Land Development Alternative:

      This plan element consists of a mixed program of public acquisition and regulation of private holdings of land in order to meet future needs for residential, agricultural, conservancy, and park land uses efficiently and easily with a minimum of destruction to the supporting natural resource base. This element is centered in the acquisition of land for, and eventual development of, a parkway along the main channel of the Root River from its source in Greenfield Park in the City of West Allis to STH 38 in the City of Racine, as shown on Map 40 (inside back cover). This would place all flood plain lands within the limits of the proposed parkway in public ownership and utilize these lands for active recreation and wildlife conservation purposes and provide for the development of a continuous parkway drive along the entire length of the main stream channel. This plan element would also include the regulation of land use in the riverine areas of the entire Root River Canal, including the East and West branches, and the riverine areas of other perennial tributaries, as indicated on Map 40 (inside back cover), through the use of floodway district, flood plain district, and conservation district zoning; subdivision control; and official mapping, all carried out under the local police power.

2. Water control facility plan elements. Although the basic water control plan elements are nonstructural and based upon sound land use development in the watershed and particularly the riverine areas, the following structural water control facilities are recommended as supporting the watershed development objectives:

   a. Channel clearing and maintenance on the Root River Canal:

      This plan element includes channel debrushing and cleaning on the West Branch of the Root River Canal from a point one-half mile downstream from the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge near the Village of Union Grove to the confluence with the East Branch and does not contemplate any major channel deepening, widening, or

Table 39

COMPARISON OF RESULTS OF ECONOMIC ANALYSES OF ALTERNATIVE PLAN ELEMENTS

Plan Element	Benefits[a]			Costs[a]			Ratio of Tangible Benefit to Cost		Intangible Benefits (B) and Costs (C)
	Items	Value at 6% Interest	Value at 3% Interest	Items	Cost at 6% Interest	Cost at 3% Interest	6% Interest	3% Interest	
Land Use Base:									
Uncontrolled Existing Trend	---	$ ---	$ ---	Flood Damage	$ 278,500	$ ---	$ ---	$ ---	(B) Individual decision-making; (C) destruction of natural resources, high costs of public facilities and services, and unattractive environment for residences.
Land Use Regulation Alternative	Flood damage alleviation.	278,500	589,000	Income foregone on zoned land.	2,220,000	2,220,000	0.12	0.26	(B) Partial satisfaction of watershed development objectives. (C) Demarcation of flood plain and administration of zoning.
Parkway and Recreation Development Objectives	Flood damage alleviation. Pleasure driving. Picnicking. Increased land value.	278,500 7,475,000 2,896,000 1,039,000	589,000 15,705,000 5,736,000 1,516,000	Purchase of land. Roadway Construction. Landscaping. Maintenance.	6,163,000 2,960,000 1,158,000 1,084,000	6,484,000 3,950,000 1,551,000 2,173,000			(B) General satisfaction of watershed development objectives.
Total		$11,688,500	$23,546,000		$11,365,000	$14,158,000	1.03	1.66	
Water Control Facilities and Accessory Plan Elements:									
Channel Improvements:									
Root River in City of Greenfield	Flood damage alleviation.	102,000	167,000	Channel enlargement.	516,000	550,000	0.20	0.32	(C) Defacement of parkway.
Root River in City of Racine	Flood damage alleviation.	104,000	170,000	Excavation and structures.	1,100,000	1,100,000	0.09	0.15	
Root River Canal in Towns of Raymond and Yorkville									
West Branch	Flood damage alleviation.	29,000	47,500	Clearing and maintenance.	25,400	33,700	1.14	1.41	(C) Destruction of wildlife habitat.
East Branch	Flood damage alleviation.	9,450	15,500	Clearing and maintenance.	34,100	45,500	0.28	0.34	(C) Destruction of wildlife habitat.
Diversion Channel to Lake Michigan:									
Upper Route	Flood damage alleviation.	270,000	519,000	Channel construction.	2,800,000	2,800,000	0.10	0.19	(C) Pollution of lakeshore.
Lower Route	Flood damage alleviation.	115,000	187,000	Channel construction.	1,800,000	1,800,000	0.06	0.10	(B (C) Pollution of lakeshore.
Multi-purpose Artificial Lake (Oakwood Reservoir)	Flood damage alleviation.	66,000	108,000	Dam construction, excavation of reservoir, related facilities.	2,416,000	2,715,000	---	---	(B) Significant recreation, wildlife, and low-flow augmentation benefits.
Water Pollution Control Measures									
Caddy Vista Connection to Milwaukee	---	---	---	---	44,000[c]	---	---	---	(B) Health, recreation, and aesthetics.
Frank Pure Food Connection to Racine	---	---	---	---	16,000[c]	---	---	---	(B) Health, recreation, and aesthetics.
Water Quality and Quantity Monitoring	---	---	---	Operation of gaging and sampling stations.	110,000	180,000	---	---	(B) Basis of all the benefits dependent upon water quality.
Removal of Residences									
City of Greenfield	Flood damage alleviation.	150,000	250,000	Total market value.	575,000	575,000	0.26	0.43	(B) Open space and recreation.
City of Racine	Flood damage alleviation.	85,000	142,000	Total market value.	385,000	385,000	0.22	0.37	(B) Open space and recreation.
Restoration of Horlick Dam	---	---	---	Structural improvement and cleaning.	34,000[c]	---	---	---	(B) Recreation and aesthetics.

[a] *Calculated in terms of present worth, using a 50-year time base and the indicated rates of interest.*

[b] *Excluding the cost of a highway bridge on relocated Oakwood Road over the Root River Canal.*

[c] *Initial construction costs; interest not included.*

Source: SEWRPC.

NOTE: A benefit-cost ratio consists of the sum of total tangible benefits, such as flood damage reduction, divided by the total tangible costs, such as costs of land to be purchased for parkway. A ratio in excess of 1.0 indicates that the proposed project will produce more tangible benefits than it will cost in terms of dollars.

reconstruction. Based upon the results of the plan review by local public officials, it is further recommended upon the specific request of the Racine County Board that similar channel debrushing and cleaning be carried out for the East Branch of the Root River Canal from CTH E in Kenosha County to one-half mile north of Five Mile Road in Racine County.

b. Oakwood Lake artificial reservoir:

This plan element includes the construction of a multi-purpose reservoir in the area around the confluence of the North Branch and the Root River Canal. The recommended reservoir would have a normal water surface area of 660 acres and would be maintained between the elevations of 679 and 680 feet above msl by means of a dam constructed in Section 35, Town 5 North, Range 21 East, in the City of Franklin (see Figure 33).

The lake would serve recreation, conservation, and low-flow augmentation purposes; would serve to enhance the development of the recommended parkway; and would provide a focal point for the attraction of high-value residential development to the City of Franklin.

c. Replacement of Highway Bridges:

Twenty-six highway bridges on the perennial stream system of the Root River require replacement because of inadequate hydraulic capacity, as well as for traffic and safety considerations (see Table 37).

d. Restoration of Horlick Dam:

This plan element includes the reconstruction of Horlick Dam and the cleaning of its headwater pool to protect a unique historic site and to enhance the Racine portion of the recommended parkway development (see Figure 20).

e. Removal of Existing Residences in Flood Plain:

This plan element includes the public acquisition and removal of 23 homes in the City of Greenfield and 35 homes in the City of Racine in which the first floor levels are inundated by a 100-year recurrence interval flood. The lands so vacated are recommended to be converted to park and parkway use. Gradual acquisition is anticipated as existing homes should be zoned as "nonconforming uses" and purchased as they come on the market.

f. Floodproofing:

This plan element is designed to allow owners of homes located in the flood plain, in which a 100-year recurrence interval flood will not inundate the first floor level, a means of continued occupance of flood plains through individually assuming the structural adjustments and use restrictions necessary to hold the flood-damage potential to an absolute minimum.

The foregoing water control facility recommendations are predicated on the completion of channel improvements on the North Branch in the cities of West Allis and Greenfield, extending from a point immediately south of W. Lincoln Avenue to a point just north of W. Layton Avenue, regarded for the purposes of this report as a committed facility. The improved channel would have side slopes of one-on-four with a maximum bottom width of 10 feet and a maximum top width of 80 feet. The average deepening would be about 5 feet, and about 300,000 cubic yards would have to be excavated. The improved channel could accommodate a peak discharge of 3,500 CFS at W. Layton Avenue.

3. Pollution abatement facilities and action programs:

a. Abandonment of the Caddy Vista Sanitary District secondary treatment plant and connection of the tributary public sanitary sewers to the Milwaukee metropolitan system.

This plan element includes the construction: 1) of approximately one-half mile of 12-inch diameter gravity flow sanitary sewer laid in open trench, 2) of a 100 gpm lift station at or near the Nicholson Road bridge, and 3) of about 3,000 feet of 6-inch diameter force main.

b. Conveyance of food processing wastes from the Frank Pure Food Company plant at Franksville in Racine County to the Racine sanitary sewerage system.

   This plan element includes the construction of approximately 3,000 feet of 10-inch diameter gravity flow sanitary sewer in open trench from the processing plant to the existing sewerage system in the unincorparated community of Franksville. The latter system is already connected to the City of Racine sewage treatment plant.

c. Improvement of the degree of treatment provided by the existing sewage treatment plants at Union Grove, Southern Colony, and the Cooper-Dixon Duck Farm.

d. Continuation of the water quality and streamflow monitoring program on the perennial stream system of the watershed in both Milwaukee and Racine counties.

The foregoing recommended plan elements have all been described separately and in considerable detail in Chapter XII. In the recommended watershed plan, each serves to complement and strengthen the other.

Future urban development would be guided through locally exercised land use controls into a more efficient and attractive pattern. Continued encroachment of the natural flood plains would be arrested and future intensification of flood problems avoided. Residential development would be concentrated within logical sanitary sewerage service areas tributary to existing systems and on soils suited for such use, thus avoiding future sanitation problems. The remaining prime agricultural areas within the watershed would be protected from urban encroachment.

The environmental corridors of riverine woodlands, wetlands, and water would be preserved, first, by immediate zoning to prohibit inadvisable urban development and, gradually, by public acquisition. Eventually, the Root River stream valley would be transformed into an attractive greenbelt of parkway and recreation land serving to attract high-value residences along its entire length. The parkway and recreation plan would be enhanced by a large artificial lake created at the confluence of the Canal and North Branch in Milwaukee County. This lake would be partly developed, by deepening, for small-craft boating and related activities and partly retained as shallow water and associated wetland for wildlife habitat and conservation preserve. The lake would also serve to augment low flows of the Root River, effecting an improvement in water quality and, thus, allowing downstream fishing, boating, and aesthetic use.

The parkway belt would be further enhanced by structurally restoring historic Horlick Dam and cleaning the lagoon upstream from the dam site.

The large private investment in homes and in public recreation and conservation lands, which is considerably dependent upon suitable water quality, would be protected by a water pollution control program. Existing waste loadings would be reduced by elimination of all existing sewage treatment plants on the North Branch and main stem of the Root River through connection of the tributary sewerage systems to the Milwaukee metropolitan system. Water quality and quantity would be monitored at regular intervals, and improved treatment of wastes would be sought wherever needed. An active pollution control program, when coupled with low-flow augmentation from Oakwood Reservoir, would produce a water quality environment capable of supporting fishing, boating, wildlife and livestock watering, and aesthetic use of the riverine areas.

The flood damage hazard, which is rising rapidly under urbanization of the watershed, would be gradually eliminated as new flood-vulnerable development would be prohibited and existing development would be phased out through purchase and zoning or under special conditions by floodproofing. Existing residential development located in the flood plain and subject to first floor inundation would be purchased, razed, and replaced by park and parkway use, while such development subject only to basement flooding would be floodproofed.

FINANCIAL ANALYSIS

In order to assist the responsible public officials concerned in evaluating the recommended watershed plan, a preliminary capital improvements program has been prepared which, if followed, would result in total plan implementation by the year 1990, with the costs distributed over a 23-year period. This program is summarized in Tables 40 and 41, which set forth the estimated

Table 40

SCHEDULE OF CAPITAL COSTS OF THE 1990 RECOMMENDED PLAN ELEMENTS WITHIN MILWAUKEE COUNTY: 1967 - 1989

Calendar Year	Project Year	Parkway and Recreation Land Use Plan Element					Oakwood Reservoir			Water Pollution Control Program	
		(1) Parkway Land Acquisition[a]	(2) Parkway[c] Road and Recreation Facility Construction	(3) Parkway Maintenance[d]	(4) Revenue[b] From Lease of Acquired Land	(5) Subtotal Columns (1), (2), and (3) Minus Column (4)	(6) Con-struction[e]	(7) Annual Maintenance	(8) Removal of Residences[f] From Flood Plains in City of Greenfield	(9) Operation of 4 Quality Monitoring Stations, 2 Gaging Stations, and 5 Crest Gages	(10) Total Cost
1967	1	$ 83,950	$ 185,000	$ 2,600	$ 3,000	$ 268,550	$ 971,500	$ --	$ 25,000	$ 5,000	$1,270,050
1968	2	83,950	185,000	5,200	2,900	271,250	971,500	30,000	25,000	5,000	1,302,750
1969	3	83,950	185,000	7,800	2,800	273,950	--	30,000	25,000	5,000	333,950
1970	4	83,950	185,000	10,400	2,700	276,650	--	30,000	25,000	5,000	336,650
1971	5	83,950	185,000	13,000	2,600	279,350	--	30,000	25,000	5,000	339,350
1972	6	83,950	185,000	15,600	2,500	282,050	--	30,000	25,000	5,000	342,050
1973	7	83,950	185,000	18,200	2,400	284,750	--	30,000	25,000	5,000	344,750
1974	8	83,950	185,000	20,800	2,300	287,450	--	30,000	25,000	5,000	347,450
1975	9	83,950	185,000	23,400	2,200	290,150	--	30,000	25,000	5,000	350,150
1976	10	83,950	185,000	26,000	2,100	292,850	--	30,000	25,000	5,000	352,850
1977	11	--	185,000	28,600	2,000	211,600	--	30,000	25,000	5,000	271,600
1978	12	--	185,000	31,200	1,800	214,400	--	30,000	25,000	5,000	274,400
1979	13	--	185,000	33,800	1,600	217,200	--	30,000	25,000	5,000	277,200
1980	14	--	185,000	36,400	1,400	220,000	--	30,000	25,000	5,000	280,000
1981	15	--	185,000	39,000	1,200	222,800	--	30,000	25,000	5,000	282,800
1982	16	--	185,000	41,600	1,000	225,600	--	30,000	25,000	5,000	285,600
1983	17	--	185,000	44,200	800	228,400	--	30,000	25,000	5,000	288,400
1984	18	--	185,000	46,800	700	231,100	--	30,000	25,000	5,000	291,100
1985	19	--	185,000	49,400	500	233,900	--	30,000	25,000	5,000	293,900
1986	20	--	185,000	52,000	400	236,600	--	30,000	25,000	5,000	296,600
1987	21	--	185,000	54,600	300	239,300	--	30,000	25,000	5,000	299,300
1988	22	--	185,000	57,200	200	242,000	--	30,000	25,000	5,000	302,000
1989	23	--	185,000	59,800	100	244,700	--	30,000	25,000	5,000	304,700
Total		$839,500	$4,255,000	$717,600	$37,500	$5,774,600	$1,943,000	$660,000	$575,000	$115,000	$9,067,600
Annual Average		$ 36,500	$ 185,000	$ 31,200	$ 1,630	$ 251,070	$ 84,478	$ 28,695	$ 25,000	$ 5,000	$ 394,243

[a] *Estimated average cost of $1,150 per acre for 730 acres.*

[b] *Rental fees of $3 per acre from purchased land awaiting development.*

[c] *One-half mile of parkway completed yearly at unit costs of $240,000 per mile of roadway and $700 per acre for landscaping and picnicking facilities.*

[d] *Maintenance costs of $5,200 per mile of completed parkway.*

[e] *Costs include: dam structures, relocation of S. 60th Street and W. Oakwood Road (new bridge not included), relocation of power line, purchase of private structure on reservoir site (land not included), clearing and landscaping, excavation of reservoir area, 20 percent contingencies, and 10 percent engineering fees.*

[f] *One residence acquired annually over 23-year period.*

Source: SEWRPC.

Table 41

SCHEDULE OF CAPITAL COSTS OF THE 1990 RECOMMENDED PLAN ELEMENTS LYING WITHIN RACINE COUNTY: 1967 - 1989

Calendar Year	Project Year	Parkway and Recreation Land Use Plan Element					Channel Improvement W. Branch Root River Canal		Water Pollution Control Program				Restoration of Horlick Dam	Total Cost
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)		
		Parkway Land Acquisition[a]	Parkway Road[c] and Recreation Facility Construction	Parkway[d] Maintenance	Revenue[b] From Lease of Acquired Land	Subtotal of Columns (1), (2), and (3) Minus Column (4)	Initial Clearance	Triennial Maintenance	Removal of Residences[e] From Flood Plain in City of Racine	Construction of Connecting Sewer From Caddy Vista to Metropolitan System	Construction of Connecting Sewer From Frank Pure Food Co. to Franksville	Operation of 5 Quality Monitoring Stations, 1 Gaging Station, and 7 Crest Gages	Repair of Dam and Cleaning of Reservoir	
1967	1	$ 215,510	$ 140,000	$ 2,400	$ 100	$ 357,810	$13,600	$ --	$ 22,000	$ --	$16,000	$ 2,000	$34,000	$ 445,410
1968	2	215,510	140,000	4,800	200	360,110	--	--	22,000	--	--	2,000	--	384,110
1969	3	215,510	140,000	7,200	300	362,410	--	--	22,000	--	--	2,000	--	386,410
1970	4	215,510	140,000	9,600	400	364,710	--	2,500	22,000	--	--	2,000	--	391,210
1971	5	215,510	140,000	12,000	500	367,010	--	--	22,000	--	--	2,000	--	391,010
1972	6	215,510	140,000	14,400	600	369,310	--	--	22,000	44,000	--	2,000	--	437,310
1973	7	215,510	140,000	16,800	700	371,610	--	2,500	22,000	--	--	2,000	--	398,110
1974	8	215,510	140,000	19,200	800	373,910	--	--	22,000	--	--	2,000	--	397,910
1975	9	215,510	140,000	21,600	900	376,210	--	--	22,000	--	--	2,000	--	400,210
1976	10	215,510	140,000	24,000	1,000	378,510	--	2,500	22,000	--	--	2,000	--	405,010
1977	11	293,250[f]	210,000	31,400	1,000	533,650	--	--	22,000	--	--	2,000	--	557,650
1978	12	293,250[f]	210,000	38,800	900	541,150	--	--	22,000	--	--	2,000	--	565,150
1979	13	--	210,000	46,200	800	255,400	--	2,500	11,000	--	--	2,000	--	270,900
1980	14	--	140,000	48,600	800	187,800	--	--	11,000	--	--	2,000	--	200,800
1981	15	--	140,000	51,000	700	190,300	--	--	11,000	--	--	2,000	--	203,300
1982	16	--	140,000	53,400	600	192,800	--	2,500	11,000	--	--	2,000	--	208,300
1983	17	--	140,000	55,800	600	195,200	--	--	11,000	--	--	2,000	--	208,200
1984	18	--	140,000	58,200	500	197,700	--	--	11,000	--	--	2,000	--	210,700
1985	19	--	140,000	60,600	400	200,200	--	2,500	11,000	--	--	2,000	--	215,700
1986	20	--	140,000	63,000	400	202,600	--	--	11,000	--	--	2,000	--	215,600
1987	21	--	140,000	65,400	300	205,100	--	--	11,000	--	--	2,000	--	218,100
1988	22	--	140,000	67,800	200	207,600	--	2,500	11,000	--	--	2,000	--	223,100
1989	23	--	140,000	70,200	100	210,100	--	--	11,000	--	--	2,000	--	223,100
Total		$2,741,600	$3,430,000	$842,400	$12,800	$7,001,200	$13,600	$17,500	$385,000	$44,000	$16,000	$46,000	$34,000	$7,557,300
Annual Average		$ 119,200	$ 149,130	$ 36,626	$ 556	$ 304,400	$ 591	$ 761	$ 16,739	$ 1,913	$ 696	$ 2,000	$ 1,478	$ 328,578

[a] *Estimated average cost of $1,150 per acre for 1,880 acres of parkway and 510 acres of park.*

[b] *Rental fees of $3 per acre from purchased land awaiting development.*

[c] *0.45 mile of parkway completed yearly at unit costs of $240,000 per mile of roadway and $700 per acre for landscaping and picnicking facilities.*

[d] *Maintenance costs of $4,800 per mile of completed parkway.*

[e] *Thirty-five residences acquired over a 23-year period at unit price of $11,000.*

[f] *Two hundred fifty-five acres of park lands purchased in Hoods Creek riverine area during project years 11 and 12.*

Source: SEWRPC.

Table 42

GRANTS-IN-AID AVAILABLE FOR PARTIAL FINANCIAL SUPPORT OF LOCAL AND REGIONAL PUBLIC WORKS PROJECTS

Purpose	Federal or State Aid Program	Percent Cost Sharing	Administering Agencies	Remarks
1. Drainage, Flood Control, and Recreation	Watershed Protection and Flood Prevention; P. L. 566	50	State Soil and Water Conservation Committee and the U.S. Department of Agriculture	50 percent of the tributary watershed area must be rural; 50 percent of the agricultural area involved must be under conservation plans.
2. Hydrologic Data Collection	Cooperative Data Collection Program	50	U.S. Geological Survey	Existing stream gages already under this program.
3. Construction of Pollution Control Facilities	Federal Water Pollution Control Act; P. L. 660	30	Wisconsin Committee on Water Pollution and U.S. Department of Health, Education, and Welfare	Available funds limited.
4. Recreation and Open Space				
a. Land and Facilities	Land and Water Conservation Fund P. L. 88-578	50	Wisconsin Conservation Commission and U.S. Bureau of Outdoor Recreation	Available funds limited.
b. Land	Sec. 66.36 of the Wisconsin Statutes	50	Wisconsin Department of Resource Development	Available funds limited.
c. Park and Open Space	Federal Open Space Land Program (Title VII of 1961 Housing Act as amended)	50	U.S. Department of Housing and Urban Development	---
d. Urban Beautification	Housing and Urban Development Act of 1965	50	U.S. Department of Housing and Urban Development	---
e. Greenspan	Food and Agricultural Act of 1965 (Title VI)	50	U.S. Department of Agriculture, Agricultural Stabalization and Conservation Service	Grant computed on value of crops withdrawn; grants made to municipalities and to individuals.
5. Soil and Water Conservation Programs	Agricultural Conservation Program	50 percent; $2,500 maximum to one individual	U.S. Department of Agriculture	---
6. Urban Renewal	Blight Clearance	66 2/3	U.S. Department of Housing and Urban Development	---
7. Neighborhood Facilities Program	Housing and Urban Development Act of 1965	66 2/3	U.S. Department of Housing and Urban Development	---
8. Water and Sewer System Program	Housing and Urban Development Act of 1965	50	U.S. Department of Housing and Urban Development	---

Source: SEWRPC.

annual and total costs for each of the recommended plan elements.

The ultimate adoption of a capital improvements program for the watershed will require determination by public officials of not only those elements which are to be included in the plan itself and their costs but also the principal beneficiaries of the plan elements and the possible means of financing.

Beneficiaries

All of the recommended major plan components lie entirely within Milwaukee and Racine counties. Consequently, it would appear that financing of the necessary plan implementation programs could best be accomplished at the county level and, if the work is to be expedited, be limited to participation by Milwaukee and Racine counties as project sponsors. For this reason, the capital improvement cost schedule presented herein has been tabulated separately for the recommended plan elements for Milwaukee and Racine counties. Although the recommended plan elements will have certain regional benefits, the primary beneficiaries will remain the local residents of the watershed. The regional nature of a portion of the plan benefits, however, should make certain of the plan elements eligible for supporting financial assistance from the state and federal levels of government. Such possible sources of financing assistance have been indicated in outline form in Table 42, and utilization of these sources could reduce the local costs by as much as 50 percent.

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Chapter XIV

PLAN IMPLEMENTATION

INTRODUCTION

The Root River watershed plan provides a design for attaining the watershed development objectives set forth by the Southeastern Wisconsin Regional Planning Commission and the Root River Watershed Committee acting with the consent and on the advice of all of the local units of government concerned. The design of the final plan emphasizes three main elements: the regulation, in the public interest, not only of the use of land lying in areas subject to periodic flooding but also the use of land and water throughout the entire watershed; the acquisition of riverine area lands for public recreational uses; and the construction of water control and pollution abatement facilities. In a practical sense, this plan is not complete until the steps required to implement it are specified.

This chapter is, therefore, presented as a guide for use in the implementation of the recommended watershed plan. Basically, it outlines the actions which must be taken by existing levels and agencies of government if the recommended plan is to be implemented. These actions include: 1) the formal adoption of various recommended plan elements, 2) the adaptation and adoption of specific plan implementation devices, and 3) the provision of financing. It should be particularly noted that all plan implementation recommendations made herein are based upon, and related to, existing enabling legislation. It should also be noted that, because of the ever-present possibility of unforeseen economic changes, new state legislation, case law decisions, governmental reorganization, and shifts in tax structure and fiscal policy, it is not possible to declare once and for all time exactly how plan implementation should be administered and financed. In the continuing planning process, it will be necessary to update, periodically, not only the actual watershed plan elements but also the recommendations for implementation.

ORGANIZATION FOR PLAN IMPLEMENTATION

Examination of the various agencies that are available under existing enabling legislation to implement the recommended watershed plan reveals an array of commissions, committees, and boards at all levels of government that can be utilized. These agencies range from relatively autonomous special purpose units of government, as for example, farm drainage districts having a single purpose, such as construction of ditches, pipelines, and pumps for the drainage or protection of agricultural land, to cooperative contracts between multiple general-purpose units of government having all the powers of the composite units, such as police, taxing, eminent domain, and appropriation powers. Many of the agencies needed for plan implementation are already in existence at the state or local levels of government within the watershed. It becomes exceedingly important, therefore, to recommend only the use and the creation, if necessary, of those agencies which are best able to carry out the recommended plan and which would most effectively complement and supplement agencies already in existence.

Watershed 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 watershed plan and to undertake plan updating or renovation as necessitated by changing events. Although the SEWRPC is charged with and will perform this continuing areawide planning function, it cannot do so properly without the active participation and support of local governmental officials through an appropriate advisory committee structure. It is, therefore, recommended that the Root River Watershed Committee be established as a continuing intergovernmental advisory committee to provide a focus for the coordination of all levels of government in the execution of the Root River watershed plan. Since the major plan elements significantly affect only the Milwaukee and Racine County portions of the watershed, the committee membership should be readjusted so that each municipality which is affected or is likely to be affected by the final plan is represented on the standing committee. This would include at least the following units of government: County of Milwaukee, including the Milwaukee County Park Commission and the Metropolitan Sewerage Commission of the County of Milwaukee; the cities of Franklin, Greenfield, Oak Creek, and West Allis; the villages of Greendale and Hales Corners;

County of Racine; City of Racine; Village of Union Grove; the towns of Caledonia, Mount Pleasant, Raymond, and Yorkville; and the SEWRPC.

Local Planning Agencies

Proper implementation of the major land use plan elements, including reports to, and formal adoption by, the County Boards; drafting and administration of the necessary zoning ordinance provisions; and the acquisition, development, operation, and maintenance of the recommended park and parkway system, is probably best achieved through a county park and planning commission. Not only is such a commission highly desirable for proper implementation of the recommended watershed plan, but Section 27.015(4) of the Wisconsin Statutes requires that every County Board create either a rural planning committee, a park board, or such a park and planning commission. Milwaukee County created a park commission in 1907, which possesses a highly competent professional staff and which has to date acquired and developed almost 13,000 acres of land for park and parkway purposes, including almost 5,000 acres to date in the Root River watershed.

It is, therefore, recommended that the Racine County Board consider the creation of a county park and planning commission pursuant to Section 27.02 of the Wisconsin Statutes and assign to that commission all county zoning and land division duties and functions, as well as responsibility for park and parkway acquisition and development. The commission, if created, should be assigned primary responsibility for the implementation of the land use elements of the Root River watershed plan as they apply to Racine County. A model ordinance creating such a commission may be found in SEWRPC Planning Guide No. 4, Organization of Local Planning Agencies, Appendix E. Sections 27.03(2), 27.06, 59.75(2)(d), 59.97(7)(b) and (8) provide for the staffing and financing of such commissions. In lieu of the creation of such a park and planning commission, responsibility for park and parkway acquisition may remain with the Racine County Highway Committee; but additional staff having sole and full-time responsibility for park and parkway acquisition, development, operation, and maintenance should then be provided within this agency.

City, village, and town park boards or plan commissions created pursuant to Sections 27.08, 27.13, 62.23(1), 61.35, and 60.18(12) may be used to supplement the county park and planning commissions in implementation of the various elements of the proposed plan. It is, therefore, recommended that the Town of Raymond consider the creation of a town plan commission and that all other cities, villages, and towns within the watershed consider amending their ordinances creating a local plan commission to incorporate the suggestions contained in the model ordinance and resolution creating such commissions found in SEWRPC Planning Guide No. 4, Appendices D and F.

Water Control Agencies

While the water control facility elements recommended in the watershed plan should all be accomplished by existing agencies, such as soil and water conservation districts, metropolitan sewerage districts or commissions, farm drainage districts, or county park commissions, such works might also be accomplished through the creation of a "flood control board" in accordance with Chapter 87 of the Wisconsin Statutes.[1] The creation of such a board, however, should only be considered if the existing agencies fail to act to implement the water control facility elements of the watershed plan in a timely manner.

Metropolitan Sewerage Commissions

Those water control facility and pollution abatement elements recommended by the watershed plan can be most effectively implemented through metropolitan sewerage commissions that have areawide authority to plan, construct, maintain, and operate facilities for storm water drainage and for the collection transmission, treatment, and disposal of sewage. The Milwaukee County Metropolitan Sewerage Commission serves Milwaukee County and could carry out public works improvements to provide both drainage and sewerage facilities and services in parts of Racine County in the Root River watershed. Service by the Milwaukee County Metropolitan Sewerage Commission would be the most effective way to serve those portions of the Town of Raymond which may be expected to urbanize by 1990 and the area tributary to the Caddy Vista sewage treatment plant. Such services outside Milwaukee County, however, would have to be provided by contract pursuant to Section 59.96(9)(c) of the Wisconsin Statutes when authorized by a three-fourths vote of the local governing body. As an alternative a metropolitan sewerage district containing two or more municipalities, such as cities or villages in their entirety and one or more towns wholly or in part, might

[1] *Recently amended by Chapter 481, Laws of Wisconsin, 1965.*

be created in Racine County pursuant to Sections 66.20 through 66.203 of the Wisconsin Statutes; or the City of Racine may continue to extend municipal sewerage facilities into urbanizing areas of the lower watershed.

Soil and Water Conservation Districts

The importance of proper soil and water conservation and management practices not only to specific land use and pollution control elements of the plan but to the successful functioning of the other elements of the watershed plan can not be overemphasized. Lack of such practices will have a critical adverse effect upon land use, flood control works, pollution abatement, and recreational facilities. For example, through improper soil and water conservation and management practices, agricultural land capabilities would be lowered by erosion; the rate of runoff from agricultural areas would be increased, with resultant increases in downstream flood stages; sedimentation would occur in stream beds and reservoirs; and all riverine areas would be adversely affected by sedimentation and agricultural water pollutants, such as herbicides, pesticides, and fertilizers.

Fortunately, both Milwaukee and Racine counties have created Soil and Water Conservation Districts under Section 92.05 of the Wisconsin Statutes which have basic and supplemental Memoranda of Understanding with the U. S. Department of Agriculture, Soil Conservation Service. Thus, there exist locally the duly constituted bodies required to represent rural areas of the watershed in those agricultural, conservation, and management programs which are sponsored by state and federal agencies.

Cooperative Contract Commissions

Section 66.30[2] of the Wisconsin Statutes provides that counties, towns, cities, villages, school districts, and regional planning commissions may all contract with one another for the receipt or furnishing of services or the joint exercise of any power or duty required or authorized by statute, including the financing of regional projects. A contract commission may be created under this enabling statute for the purpose of plan implementation and may be utilized in lieu of any of the aforementioned organizations.

ADOPTION OF PLAN ELEMENTS

After recommendation by the Regional Planning Commission and endorsement by the Milwaukee and Racine County Boards, adoption of the watershed plan by the several agencies and governing bodies involved is desirable, and in some cases necessary, to assure a common understanding between the several governmental units and to enable their staffs to program the necessary implementation work. In some cases, formal adoption is required by the state statutes, as in the case of city, village, and town plan commissions created pursuant to Section 62.23 of the Wisconsin Statutes, and also may be required for state and federal aid eligibility. To fully achieve the development objectives satisfied by the proposed plan, it becomes necessary not only for the county boards to adopt the plan but also other affected governmental bodies, thereby providing for the full integration of the watershed plan into local community plans and plan implementation efforts.

It is recommended that the Milwaukee County Board formally adopt the comprehensive park and parkway elements of the proposed plan, including the Oakwood Reservoir, by ordinance pursuant to Section 27.04(2) of the Wisconsin Statutes after a report and recommendation by the Milwaukee County Park Commission. It is recommended that the Racine County Board also adopt the comprehensive park and parkway elements of the proposed plan, including the land use elements, streamflow recordation, and Horlick Dam restoration by ordinance pursuant to Section 27.04(2) of the Wisconsin Statutes after a report and recommendation by the County Park and Planning Commission, the County Planning Committee, or the County Highway Committee.

It is recommended that the Plan Commissions of the cities of Franklin, Greenfield, Oak Creek, Racine, and West Allis; the villages of Greendale, Hales Corners, and Union Grove; and the towns of Caledonia, Mount Pleasant, Raymond, and Yorkville adopt the recommended plan as it affects them by resolution pursuant to Section 62.23(3)(b) and certify such adoption to their respective governing body.

It is recommended that the Metropolitan Sewerage Commission of the County of Milwaukee adopt the recommended plan as it affects the work of that body, including the recommended Oakwood Reservoir, Caddy Vista sewer connection, and streamflow recordation elements, and formally delineate those areas outside the District limits that the Commission would be willing to provide with sew-

[2] *Chapter 238, Laws of Wisconsin, 1965.*

erage service pursuant to the plan under contracts authorized under Section 59.96(9)(c) of the Wisconsin Statutes.

It is recommended that the Milwaukee and Racine County Soil and Water Conservation District supervisors adopt those portions of the recommended plan affecting them, including the agricultural and conservancy land use elements, so as to establish a broad, well-defined basis for the development of comprehensive conservation plans under Section 92.08(4) of the Wisconsin Statutes and to assure eligibility for tax relief and technical and financial assistance.

LAND USE PLAN ELEMENTS

The implementation of the land use elements of the comprehensive watershed plan is perhaps the singularly most important item to the realization of the overall plan and requires the most intricate implementation devices and the utmost cooperation among the local units of government.

Zoning

The single most important and versatile planning tool for implementing the land use elements of the proposed plan is the application of the police power through the adoption of appropriate local zoning ordinance regulations. Such ordinances or appropriate amendments to existing ordinances should be adopted immediately so as to present a clear indication of the willingness of the local governments to implement the watershed plan and also to provide a framework for all other plan elements.

It is recommended that the Racine County Park and Planning Commission or the County Planning Committee and County Highway Committee and the plan commissions of the cities of Franklin, Greenfield, and Oak Creek and the villages of Greendale and Union Grove formulate and petition or recommend to their respective governing bodies amendments to the text of their existing zoning ordinances. These amendments should provide for exclusive residential, agricultural, conservancy, and park district zoning recommended in Appendix L-2 and 3 and recommend changes to their zoning maps to reflect these exclusive districts as related to the recommended land use elements delineated on the watershed plan. It is recommended that the Racine County Board and the governing bodies of the aforesaid cities and villages adopt such revised text and changed boundaries by amendatory ordinances pursuant to Sections 59.97(3) and 62.23(7)(d) of the Wisconsin Statutes. It is recommended that all Town Boards in Racine County file certified resolutions approving the amendatory ordinances pursuant to Section 59.97(3)(g) of the Wisconsin Statutes. It should be noted that Section 59.971 of the Wisconsin Statutes [3] provides that counties may by separate zoning ordinances regulate shorelands in unincorporated areas within 1,000 feet of a lake or stream and within 300 feet upland of a flood plain without town board approval.

The zoning of lands in the towns of Caledonia, Mount Pleasant, Raymond, and Yorkville may be supplemented by the exercise of the extraterritorial zoning power of the cities of Franklin, Oak Creek, and Racine and the Village of Union Grove jointly with the towns pursuant to Section 62.23(7a).

The delineation of the zoning district boundaries to directly reflect the land use plan proposed for 1990 would result in over-zoning and probably in mixed and uneconomical land use patterns. The desirable relationship of an initial composite zoning map to the land use plan for a portion of the watershed may be seen in Figure 34. The following suggestions are made to assist the local planning agencies in the preparation of the necessary zoning district maps and map changes:

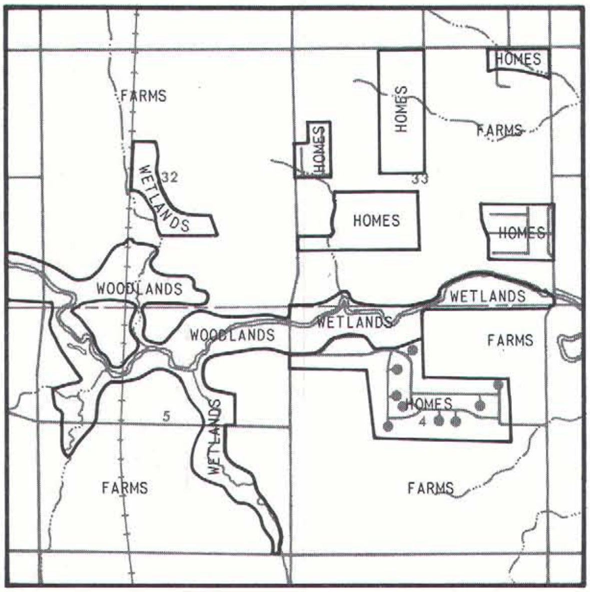
1. Existing residential areas, as well as those areas that have immediate residential development potential and can be economically served by municipal utilities and facilities, such as sanitary sewer and schools, should be placed in one of three exclusive residential districts (Appendix L-2). It should be noted that under the zoning approach being recommended these residential districts must lie outside the flood plain areas. The balance of the residential land use elements should be placed in an exclusive agricultural district as a holding zone so as to regulate community growth in an orderly and economical manner. The use of such a holding district is thoroughly discussed on pages 64 and 65 of SEWRPC Planning Guide No. 1, Zoning Guide, 1964. Such holding district should be rezoned into the appropriate residential district or supporting land use district only when the community can economically and efficiently accommodate such additional development.

[3] *Recently created under the State Water Pollution Control Act, Chapter 614, Laws of Wisconsin, 1965.*

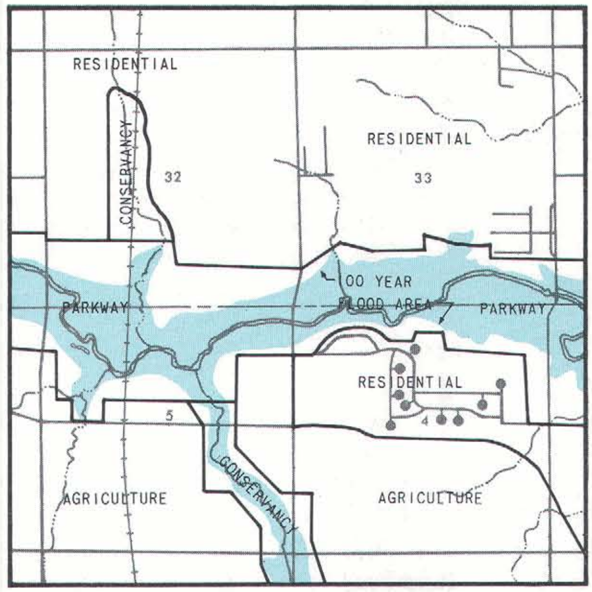
Figure 34

RELATION OF THE ZONING MAP TO THE LAND USE PLAN

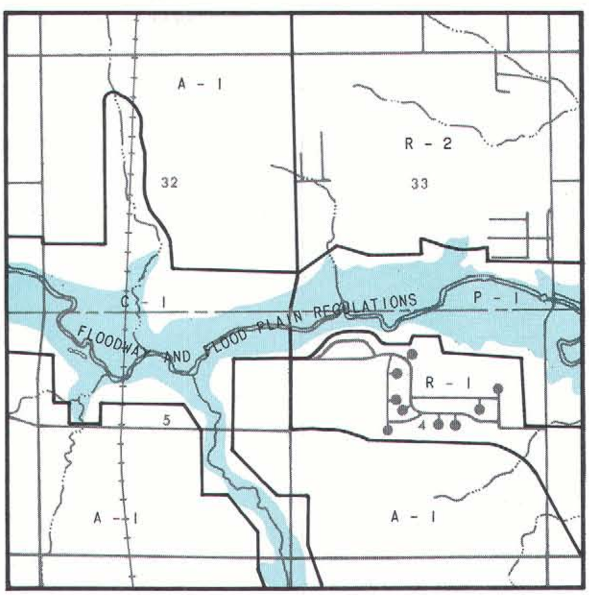
EXISTING LAND USE



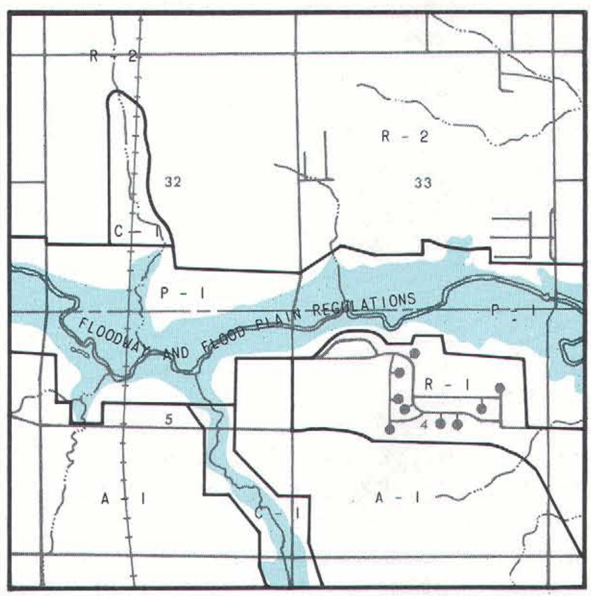
LAND USE PLAN



INTERIM ZONING MAP



FUTURE ZONING MAP



SOURCE: SEWRPC.

2. All conservancy areas shown on the plan should be placed in an exclusive conservancy district (Appendix L-2), which may include floodway and flood plain areas. Subsequently, selected portions of this district may be rezoned into a park district when urbanization takes place.

3. The existing public and private park lands, as well as those park lands to be acquired within the next ten years and all of the flood plains in urban and urbanizing areas of the watershed, should be placed in an exclusive park district (Appendix L-2). The remaining park lands shown on the plan should be placed in agricultural or conservancy districts as holding zones until acquisition or dedication takes place or is imminent and then appropriately rezoned into a park district.

4. Those agricultural lands shown on the plan should be placed in an exclusive agricultural district (Appendix L-2).

Special land use regulations supplementing the foregoing zoning district regulations are required in the floodway and flood plain areas of the conservancy, agricultural, and park districts. Such additional regulations are discussed under the implementation of the water control facility plan elements. The county soil and water conservation district supervisors may supplement the agricultural and conservancy district regulations by formulating additional land use regulations for adoption by the county boards pursuant to Section 92.09 of the Wisconsin Statutes.

Tax Relief

One of the valid criticisms concerning exclusive agricultural and conservancy zoning is that Section 70.32 of the Wisconsin Statutes directs assessors to value all real estate at the price which would ordinarily be obtained at a private sale. This implies that the potential development value must be included in the appraisal and assessment of open lands. Where such open lands are adjacent to a large rapidly growing community or lying within an urbanizing area where poor land use regulations have permitted leapfrog, or sprawling development, the assessment often reflects an exaggerated development potential.

Under Wisconsin's present constitutional and statutory laws, the most satisfactory way to relieve the owner of lands zoned conservancy and agricultural from unrealistic property taxes is to remove the development potential. This may be accomplished in the following ways:

1. Through voluntary grant of an easement by the owner to a local unit of government that prohibits development upon the open lands, for a period of at least 20 years.

2. Through voluntary placement by the owner of restrictive covenants upon the open lands enforceable by a local unit of government in perpetuity or for some other substantial period of time.

3. Through purchase of development rights in the open lands by a local unit of government.

All of these private or governmental actions will result in the local assessor appraising and assessing the open lands based upon their market value for agricultural and conservancy uses and not upon the potential value for other uses. This lowering or freezing of the land value and a corresponding lowering or freezing of the real property taxes would continue either in perpetuity or the assessment and taxes would increase in steps as the remaining effective time period of the covenants or easements decrease.

It is recommended that the cities of Franklin, Oak Creek, and Racine and the towns of Caledonia, Mount Pleasant, Raymond, and Yorkville instruct their assessors that such tax relief exists for individual property owners upon their voluntary sale or relinquishment of potential development rights.

Park Land Preservation

In order to effectively implement the watershed plan, the ultimate acquisition and development for parkway purposes of an additional 730 acres of riverine area lying in Milwaukee County and 2,384 acres lying in Racine County will be necessary over a 22-year period. Since it is not economically possible to acquire all of these park lands immediately, certain police powers that are available to the local units of government should be used to protect the riverine areas from development while awaiting outright acquisition through fee or less-than-fee public purchase. In addition to preservation of existing public and private parks and park lands to be acquired in the next 10 years by the use of exclusive conservancy, agricultural, and park districts under zoning ordinances, the official mapping powers possessed by local units of government should also be utilized for this purpose. Such powers, as well as recommended surveying and mapping procedures, are throughly discussed in SEWRPC Planning Guide No. 2, Official Mapping Guide, 1964. The single most important prerequisite of such official mapping is the availability of accurate base maps at an adequate scale which are properly related to the U. S. Public Land Survey system. Such base maps at a scale of 1" = 200' are available from the SEWRPC for portions of the riverine areas of the Root River watershed (see Appendix N). Additional mapping at this scale and to the recommended standards should be accomplished in those areas of the watershed proposed for urbanization.

It is recommended that the cities of Franklin, Oak Creek, and Racine and the towns of Caledonia and Mount Pleasant adopt or prepare official maps pursuant to Section 62.23(6). Such official maps should show those parks and parkways shown on the plan, both within their corporate limits and within their extraterritorial subdivision plat approval, and adopt an ordinance similar to that set forth in the SEWRPC Official Mapping Guide, Appendix A.

Park Land Acquisition and Development

Acquisition of park lands shown on the plan may be accomplished in various ways, including outright gifts by owners, dedication by land dividers and developers at the time of platting, and outright purchase of the entire fee or of lesser interests by a state or local unit of government. The justification for requiring land dividers or developers to dedicate those portions of park lands lying within, or adjacent to, their subdivision or development or to pay a fee in lieu of dedication toward the purchase of neighboring park land is based upon the local governing body permitting such divider or developer to create building sites or dwelling units. The creation of such sites or units results in the entire community thereafter being responsible for the community services that must be provided to such development and its residents, including park facilities; and the owner, divider, or developer or future resident should, in justice, bear all or a portion of such cost directly attributed to his land.

It is recommended that Racine County and the cities of Franklin and Oak Creek adopt a land division ordinance or amend their existing subdivision control ordinances in a manner similar to that recommended in Appendix A of SEWRPC Planning Guide No. 1, Land Development Guide, 1963, so as to assure dedication of park lands or payment of fees in lieu of dedication, as urbanization proceeds within the watershed. Such an ordinance requiring dedication of an amount of land equal in value to $200.00 per residential lot created by the subdivision or a fee of $200.00 per residential lot in lieu of such dedication has been recently upheld by the Wisconsin Supreme Court.[4]

Where park lands shown on the plan cannot be acquired by gift or dedication, acquisition of the entire fee interest is the most desirable method of acquiring such lands. It is recommended that Milwaukee and Racine counties adopt the "Schedules of Capital Costs" set forth in Tables 40 and 41; allocate annually those monies required by the schedule for park land acquisition, development, and maintenance; and continue or commence an active park and parkway acquisition and development program pursuant to Section 27.065 of the Wisconsin Statutes.

It is recommended that the City of Racine and the towns of Caledonia and Mount Pleasant supplement such county action by acquisition, whenever possible, of those parkway lands that are most appropriate for city and town parks, pursuant to Section 27.08 of the Wisconsin Statutes, for municipal use or future transfer to a county park and recreation agency.

Purchase by the counties, towns, or cities of less-than-fee interests in park lands shown on the plan may be considerably cheaper and would result in more rapid preservation, acquisition, and proper use of the riverine areas. Such acquisition of less-than-fee interests may be in the form of scenic easements for vista protection, conveyances of development rights to assure continuance of private parks or open spaces, and grants of various public access and development rights for construction and use of park facilities. These devices should be used only when acquisition of the entire fee interest is too costly or for other reasons is not available.

Floodway and Flood Plain Land Use Controls

Floodway and flood plain land use controls consist of both corrective and preventive measures and regulations. Corrective measures vary from condemnation of obstructions in the channels and

[4] *Jordan v. Menomonee Falls, 28 Wis. 2d 608, 137 N.W. 2d 442 (1965).*

floodways, through acquisition of park land in the flood plain and relocation of structures located thereon, through floodproofing of existing structures, to ultimate removal of private structures through application of the nonconforming use provisions of zoning ordinances, coupled with public acquisition.

It is recommended that Milwaukee and Racine counties formally request the Public Service Commission to periodically survey the bed of the Root River and institute appropriate legal action to cause the removal of any materials or structures not placed or erected in accordance with Sections 30.11, 30.12, and 30.13 of the Wisconsin Statutes. It is further recommended that any local units of government lying along the Root River report to the Public Service Commission in writing every violation, which has or may occur, relative to structures and deposits in navigable waters and extensions beyond duly established pierhead lines pursuant to Section 30.14(1) of the Wisconsin Statutes.

It is recommended that the cities of Franklin, Oak Creek, and Racine and the towns of Caledonia, Mount Pleasant, Raymond, and Yorkville direct their local municipal engineers and building or housing inspectors to periodically inspect and determine whether any structure lying in the floodway or flood plain is so old or has become so out of repair as to be dangerous, unsafe, unsanitary, or otherwise so unfit for human habitation as to make it unreasonable to make necessary repairs. Whereupon the municipalities would cause the razing of such structure pursuant to Section 66.05 of the Wisconsin Statutes or institute an action pursuant to Chapter 280 of the Wisconsin Statutes.

It is recommended that Milwaukee and Racine counties give first consideration to the acquisition for parkway purposes of floodways and flood plains containing dwellings which are subject to first floor inundation. It is recommended that Racine County and the cities of Franklin, Greenfield, and Oak Creek create or amend the nonconforming use sections of their zoning ordinances so as to result in regulations similar to those recommended in Appendix L-5.

Substantially cheaper than removal and floodproofing, and more effective than nonconforming use provisions, are restrictions that prevent construction of homes within the areas subject to flooding and restrictions that regulate other structures within the floodways and flood plains. Because of the detailed flood hazard maps available (see Appendix N for sample map) and the extensive bank of sound hydrologic and hydraulic engineering data supporting such maps collected in the watershed study, the adoption of ordinances restricting and regulating development in the floodways and flood plains is the most efficient and most economical method of preventing future flood losses and heartaches.

It is recommended that Racine County; the cities of of Franklin, Greenfield, Oak Creek, and Racine, the villages of Greendale and Hales Corners; and the towns of Caledonia, Mount Pleasant, Raymond, and Yorkville adopt or amend their zoning, building, housing, subdivision, or sanitary ordinances, whichever is more appropriate and capable of proper enforcement, so as to result in appropriate regulation of land use in the floodways and flood plains as recommended in Appendices L-1 and 4. It should be noted that these floodway and flood plain regulations are in addition to and supplement the exclusive residential, agricultural, conservancy, and park zoning districts previously recommended under implementation of the land use plan elements.

Recently, the Wisconsin Legislature adopted a <u>Water Pollution Control Act</u>[5] which provided for the creation of a Water Resources Division, under a reconstituted State Department of Resource Development, having the power to zone flood plains, including floodways, if the local units of government have not acted to do so. It should be noted that, in the event any local unit of government within the watershed fails to adopt or amend their ordinances so as to provide for proper protection of the floodways and flood plains, any interested state agency or any other local unit of government or 12 or more freeholders may petition the State Department of Resource Development to exercise its flood plain zoning powers under Section 87.30 of the Wisconsin Statutes.

Other supplemental preventative measures may include the erection of flood warning signs at appropriate locations and spacing along the 100-year recurrence interval flood boundary and the design and installation of municipal utilities and facilities, such as sanitary sewerage and streets, so that the development of such flood lands are thereby discouraged.

[5] *Chapter 614, <u>Laws of Wisconsin, 1965.</u>*

WATER CONTROL FACILITY PLAN ELEMENTS

The recommended water control facility plan elements include channel clearing, construction of a multi-purpose reservoir, restoration of Horlick Dam, construction of new or replacement of existing bridges, and streamflow recordation.

Root River Canal Clearing and Maintenance

It is recommended that the Yorkville-Raymond Farm Drainage Board undertake the proposed debrushing and clearing of the channel under the maintenance powers granted them under Section 88.19 of the Wisconsin Statutes. In lieu of such activity by the Drainage Board, a metropolitan sewerage district, a cooperative contract commission, or a flood control board would have to be created to accomplish the necessary work under the powers granted under Section 59.96(6)(a), 66.204, 66.30, and 87.15 [6] of the Wisconsin Statutes.

Channel Improvements

It is recommended that the Metropolitan Sewerage Commission of the County of Milwaukee undertake those channel improvements scheduled from W. Layton Avenue north to W. Lincoln Avenue in the headwater reaches of the North Branch of the Root River in Milwaukee County.

Oakwood Reservoir

It is recommended that the Milwaukee County Park Commission sponsor cooperatively with the Metropolitan Sewerage Commission of the County of Milwaukee the construction, operation, and maintenance of all lands, waters, and facilities associated with the proposed reservoir. Alternate sponsoring agencies could include a flood control board or a cooperative contract commission under the powers granted in Sections 87.12 or 66.30 of the Wisconsin Statutes.

Horlick Dam Restoration

It is recommended that Racine County acquire, restore, and maintain Horlick Dam, including the upstream reservoir area, as part of the county's parkway acquisition, development, and maintenance programs. Although existing laws permit the Wisconsin Public Service Commission to require a private owner of the mill dam to effect restoration, such action may be inequitable in view of the plan proposals to convert the riverine areas to public parkway uses. This facility is presently used by the public; and, hence, the public could properly pay for its restoration and maintenance. In lieu of such action by Racine County, acquisition, restoration, and maintenance could be carried out jointly by the Town of Mount Pleasant and the City of Racine or by an association of affected property owners for eventual transfer to the county.

Bridge Construction

It is recommended that any public or private body constructing new bridges or replacing existing bridges over the perennial stream channel system of the Root River watershed design and construct such bridges in accordance with the water control facility standards set forth in Chapter XI of this report and with the accompanying design methodology and criteria.

Streamflow Recordation

It is recommended that Racine County and the Metropolitan Sewerage Commission of the County of Milwaukee continue to finance the operation and maintenance of the three existing stream gages within the watershed under the interagency cooperative agreements executed between these agencies, the SEWRPC, and the U. S. Geological Survey.

POLLUTION ABATEMENT FACILITY PLAN ELEMENTS

The recommended water pollution abatement facility plan elements include connections to metropolitan and municipal sewerage systems of certain existing residential and industrial land uses, improvement of existing sewage treatment facilities, regulation of private septic tank sewage disposal systems, improved soil and water conservation practices, periodic stream basin surveys, and a continuing water quality monitoring program.

Caddy Vista Sanitary District Connection

It is recommended that the governing body of the Caddy Vista Sanitary District, by a three-fourths vote of its membership, authorize the negotiation of a contract with the Milwaukee County Metropolitan Sewerage District for the transmission and treatment of wastes from the present sanitary district via the proposed W. Ryan Road trunk sewer, scheduled for completion by 1970.

Frank Pure Food Company Connection

It is recommended that the towns of Caledonia and Mount Pleasant and the City of Racine provide for the connection of the Frank Pure Food Company industrial waste disposals system to the existing City of Racine sewerage system after appropriate pretreatment of said wastes.

[6] *Chapter 481, Laws of Wisconsin, 1965.*

Sewage Treatment Improvement

It is recommended that the Cooper-Dixon Duck Farm, the Southern Wisconsin Colony Institution, and the Village of Union Grove provide for improvement in the degree of treatment afforded their industrial, institutional, and municipal sewage.[7] Consideration should be given to combining the Southern Wisconsin Colony and Village of Union Grove plants in order to effect economies in operation and achieve a better level of operation in both plants.

Private and Public Sewage Disposal Systems

It is recommended that Racine County and the cities of Franklin and Oak Creek adopt sanitary, plumbing, or building codes, pursuant to Sections 59.07(51) and 62.11(5) of the Wisconsin Statutes, that would prohibit soil absorption septic tank sewage disposal systems on soils which have been rated in the regional soil survey as having severe and very severe limitations for such systems. These units of government should further carefully regulate the installation of such systems on soils not having such limitations, so as to prevent any further installation of systems that are periodically inoperative or which drain directly into surface waters of the watershed.

It should be noted that the State Department of Resource Development has been recently given power under Section 144.025[8] of the Wisconsin Statutes to prohibit the installation or use of septic systems in any area of the state where ground or surface water quality may be impaired by such installation. Enforcement of this power is to be facilitated by issuance and recordation of septic tank permits by the county clerk or other person designated by the State Board of Health under Section 144.03 of the Wisconsin Statutes.[9]

It is recommended that the towns of Caledonia, Mount Pleasant, and Raymond and the City of Racine arrange to serve those areas within the watershed proposed for residential development in the watershed plan with public sanitary sewer facilities either by contract with the Metropolitan Sewerage Commission of the County of Milwaukee or by creation of a metropolitan sewerage district pursuant to Sections 59.96(9)(c) or 66.20, respectively, of the Wisconsin Statutes. In lieu of such metropolitan sewerage district service, the City of Racine may continue to extend its public sewerage system outside the Racine corporate limits or the towns may create town sanitary districts pursuant to 60.30 through 60.31 of the Wisconsin Statutes. However, any sewerage systems installed under the latter alternative should be connected to the Milwaukee or Racine centralized sewerage systems; and no new sewage treatment plants discharging effluent to the Root River system should be constructed within the watershed.

Soil and Water Conservation Practices

It is recommended that the Racine County Soil and Water Conservation District Supervisors, pursuant to Section 92.09(1) of the Wisconsin Statutes, formulate proposed land use regulations for the purpose of conserving soil resources and controlling erosion,[10] thereby reducing pollution of the Root River and promoting good soil and water conservation practices. The latter may include the construction of upland water control structures, such as terraces, terrace outlets, erosion control dams, dikes, ponds, and diversion channels, and the practice of methods, such as contour cultivating, grassed waterway, reforestation, contour strip cropping, and the seeding and planting of lands to special plants, trees, and grasses.

It is recommended that the Racine County Board adopt such proposed regulations pursuant to Section 92.09 of the Wisconsin Statutes; that such regulations be enforced; and, if necessary, that the work be performed by the district supervisors pursuant to Sections 92.10 and 92.11 of the Wisconsin Statutes.

Stream Basin Survey

It is recommended that the State Department of Resource Development, pursuant to their pollution control powers under Section 144.023 of the Wisconsin Statutes, conduct periodic surveys of the Root River basin, including the collection and analyses of water samples, the identification of major sources of pollution, and the preparation of pollution control orders addressed to each stream polluter. Such surveys should be made within the watershed at regular intervals of no more than three and one-half years.

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[7] *It should be noted that the State Department of Public Welfare recently made application for a 33 percent federal grant under the federal Water Pollution Control Act in partial support of the cost of improving the Southern Wisconsin Colony treatment facilities.*

[8] *Chapter 614, Laws of Wisconsin, 1965.*

[9] *Ibid.*

[10] *The enactment of such regulations requires a recommendation by the County Soil and Water Conservation District Supervisors after public hearings and approval by the County Board and requires a referendum in which two-thirds of the land occupiers affected approve the regulation.*

It is further recommended that the State Department of Resource Development reevaluate any pollution control orders outstanding in the Root River basin and resort to legal enforcement of such orders pursuant to Sections 144.09, 144.11, and 144.536 of the Wisconsin Statutes.[11]

Water Quality Monitoring Program

It is recommended that the Southeastern Wisconsin Regional Planning Commission continue the water quality monitoring program previously inaugurated on the Root River system in cooperation with the Metropolitan Sewerage Commission of the County of Milwaukee and the State Department of Resource Development.

FINANCING THE PLAN

Upon adoption of the various land use, water control facility, and pollution abatement facility plan elements and the schedule of capital costs, it becomes necessary for the local units of government to look to the sources of revenue available to them for the execution of these elements. In addition to current revenue sources, such as property taxes, fees, fines, public utility earnings, highway aids, educational aids, welfare aids, and state collected taxes, the local units of government can also make use of other revenue sources, such as borrowing, special taxes and assessments, state and federal grants, and gifts.

Borrowing

Local units of government and their agencies are usually authorized to borrow so as to effectuate their powers and discharge their duties. The following is a partial listing of such borrowing powers as they affect the implementation of the watershed plan. Section 67.04 of the Wisconsin Statutes specifically authorizes local units of government to borrow money and issue bonds for the purpose of acquiring and improving parks.

Farm drainage boards may be authorized under Section 88.12 of the Wisconsin Statutes to issue notes or bonds for any or all of their obligations. Town sanitary districts are empowered by Section 60.307 of the Wisconsin Statutes to issue bonds for the construction or extension of sanitary sewers. Villages and cities are authorized under Section 67.04 to borrow money and issue bonds for sewage disposal plants.

[11] *As amended by Chapter 614, Laws of Wisconsin, 1965.*

Milwaukee County is authorized by Section 59.96(7) to issue corporate bonds in the name of the Milwaukee County Metropolitan Sewerage District for the projection, planning, and construction of sewage disposal works and drainage improvements. Section 66.202 of the Wisconsin Statutes authorizes metropolitan sewerage districts to borrow money and issue bonds for sanitary sewerage facilities.

Special Taxes and Assessments

Counties are empowered under Section 27.06 of the Wisconsin Statutes to levy a mill tax to be collected into a separate fund and to be paid out only upon the order of the county park commission for the purchase of land and other commission expenses. Counties and cities have special assessment powers under Sections 27.065 and 27.10(4) of the Wisconsin Statutes. Farm drainage boards, town sanitary districts, metropolitan sewerage districts, cities, and villages also have taxing and special assessment powers under Sections 88.06, 60.306, 60.309, 59.96(9), and 62.18(16) of the Wisconsin Statutes.

Although soil and water conservation districts have no taxing, bonding, or assessment powers, such districts may recover the costs and expenses with interest of performing work or operations when authorized by a court under Section 92.11 of the Wisconsin Statutes.

Park Acquisition Grants

Many state and federal grant programs are available for the financing of park land acquisition and development. In general, the local units of government and agencies in the Region are eligible for these grants. Eligibility of specific projects is based upon certain planning and other requirements and must be determined for each specific project. The following is a brief description of some of these programs:

1. The Federal Open-Space Program provides federal grants to local units of government in amounts up to 50 percent of the cost of acquisition and development of parks and open lands.

2. The Federal Land and Water Conservation Fund (LAWCON) provides federal grants to local units of government in amounts up to 50 percent of the cost of acquisition and improvement of outdoor recreation areas.

3. The Federal Cropland Adjustment Program (Greenspan) provides federal grants to local units of government in amounts up to 50 percent of the cost of acquisition and conversion of cropland to park and recreation purposes.

4. The Federal Urban Beautification Program provides federal grants to local units of government up to 50 percent of the cost of improving and beautifying publicly owned or controlled land.

5. The State Recreation Aid Program (ORAP) provides state grants to metropolitan counties and cities in amounts up to 50 percent of the cost of acquiring recreational land and rights in land to be used for urban-area park systems.

Water and Sewer System Grants

Two federal grant programs are available for the financing of water systems, sewer facilities, storm water systems, and sewage treatment facilities:

1. The Housing and Urban Development Act of 1965 provides federal grants to local units of government, including sewer and water districts, in amounts up to 50 percent of the cost of providing facilities for storing, supplying, treating, and transmitting water; sanitary sewer collection and transmission; and storm water collection and transmission.

2. The Water Pollution Control Act provides federal grants to local units of government in amounts up to 33 percent of the cost of construction of sewage treatment works, including intercepting sewers that prevent the discharge of untreated or inadequately treated sewage into any waters.

Streamflow Data Collection Program—Grants-In-Aid

The U. S. Department of the Interior, Geological Survey, administers a cooperative data collection program that provides federal matching funds in amounts up to 50 percent of the cost of installation, calibration, operation, and maintenance of stream gage recording stations.

Shoreland Zoning—Grants-In-Aid

Section 144.26[12] of the Wisconsin Statutes provides state grants to counties up to $1,000.00 annually toward the cost of administration and enforcement of regulations relating to shorelands.

Gifts

Donations of lands or monies from public spirited private individuals and corporations should not be overlooked as a possible source of funds for watershed plan implementation, particularly for park and parkway acquisition; and the potential contributions both in leadership and funds from private groups, such as the Johnson Foundation, should not be underestimated. Such gifts, either in lands or monies, may be used as part or all of the local contribution in obtaining various state and federal grants.

SUMMARY

This chapter has described means of implementing the various elements of the recommended Root River watershed plan. These means are summarized in the following paragraphs by the responsible unit of government or agency concerned.

Milwaukee and Racine County Boards

1. Support the establishment of the Root River Watershed Committee by the SEWRPC as a continuing intergovernmental advisory body concerned with watershed plan adjustment and implementation.

2. Since a land use as well as a park and parkway plan implementation agency is needed in the Racine County portion of the watershed, and since these multiple plan implementation functions can best be performed under existing enabling legislation by a County Park and Planning Commission, Racine County should consider the early creation of such a commission (Racine).[13]

3. Adopt the recommended Root River watershed plan as it applies to each county.

4. Officially adopt the comprehensive park and parkway elements of the Root River watershed plan upon recommendation of the county park and planning commission.

[12] *Chapter 614, Laws of Wisconsin, 1965.*

[13] *Parentheses indicate that recommended action is applicable only to one unit of government.*

5. Adopt the recommended "Schedules of Capital Costs" recommended herein for plan implementation and allocate annually the monies so scheduled.

6. Report to the Public Service Commission any alleged encroachments on the navigable channels of the Root River system.

7. Amend the county zoning ordinance as it applies to riverine areas to provide for the eventual elimination of existing flood-vulnerable structures located in the floodways and flood plains of the Root River watershed through nonconforming use provisions and to provide for floodway and flood plain land use regulations (Racine).

8. Amend the county subdivision control ordinance to prohibit further land division and development in the floodways and flood plains of the Root River watershed and to provide park land dedication or fees in lieu of dedication (Racine).

9. Acquire, restore, and maintain Horlick Dam (Racine).

10. Continue operation and maintenance of streamflow gages (Racine).

11. Adopt a county sanitary code to provide for regulation of the design and installation of septic tank sewage disposal systems (Racine).

12. Amend the county zoning ordinance as it applies to the entire watershed to provide for the recommended exclusive residential, agricultural, conservancy, and park districts (Racine).

13. Adopt soil conservation land use regulations as formulated by the Soil and Water Conservation District Supervisors (Racine).

Milwaukee and Racine County Park and Planning Commissions

1. Recommend adoption of the recommended park and parkway plan elements to the county board.

2. Formulate and petition the county board to amend the existing zoning ordinance to effectuate the land use plan elements (Racine).

3. Give first consideration to acquisition, for parkway purposes, of lands within the floodways or flood plains containing dwellings experiencing first floor inundation.

4. Co-sponsor the Oakwood Reservoir (Milwaukee).

Metropolitan Sewerage Commission of the County of Milwaukee

1. Formally adopt the Root River watershed plan elements affecting the service areas and functions of the Commission.

2. Indicate those areas outside of the district to which the Commission could and would provide contract services as recommended in the plan.

3. Receive and treat sewage from Caddy Vista Sanitary District.

4. Co-sponsor the Oakwood Reservoir.

5. Continue the operation and maintenance of the streamflow gages.

6. Carry out channel improvements from W. Layton Avenue north to W. Lincoln Avenue as provided in the watershed plan.

Milwaukee and Racine County Soil and Water Conservation District Supervisor

1. Adopt those portions of the Root River watershed plan affecting the functions of the District.

2. Formulate and enforce soil conservation land use regulations (Racine).

Governing Bodies of the Cities, Villages, and Towns Within the Watershed

1. Support the establishment of the Root River Watershed Committee as a continuing intergovernmental coordinating body concerned with the Root River watershed plan adjustments and implementation.

2. Adopt or revise the ordinances creating local plan commissions.

3. For cities and villages, adopt, and for towns file, resolutions approving the recommended zoning text and map changes necessary to regulate land use in the riverine areas and throughout the watershed, including regulation of uses in, and provisions for the discontinuance of nonconforming uses in, the floodways and flood plains.

4. Instruct local assessors that tax relief is available to owners of lands zoned for conservancy and agriculture in accordance with the recommended watershed plan (Caledonia, Mount Pleasant, Raymond, and Yorkville).

5. Prepare and adopt or amend official maps showing parkway land use plan elements (Caledonia, Franklin, Mount Pleasant, Oak Creek, and Racine).

6. Amend or adopt land division ordinances prohibiting further land division and development in the floodways and flood plains of the perennial channel system of the Root River watershed and assuring dedication of park land or fees in lieu of dedication (Franklin, Oak Creek, and Racine).

7. Include floodway and flood plain regulations in the local building, housing, subdivision, and sanitary ordinances.

8. Provide for the connection of the Frank Pure Food Company plant to the existing sewerage system (Caledonia, Mount Pleasant, and Racine).

9. Provide for improved sewage treatment (Union Grove).

10. Adopt sanitary ordinances regulating use and installation of septic tank sewage disposal systems (Franklin and Oak Creek).

11. Arrange to serve all new residential development with public sanitary sewer systems (Caledonia, Mount Pleasant, and Racine).

Plan Commissions of the Cities, Villages, and Towns Within the Watershed

1. Adopt the watershed plan elements and certify such adoption to their governing body.

2. Formulate and recommend to their governing body amendments to their existing zoning ordinances to effectuate the land use plan elements (Franklin, Greendale, Greenfield, Oak Creek, and Union Grove).

Caddy Vista Sanitary District

1. Abandon existing treatment plant and connect tributary sanitary sewers to the Milwaukee metropolitan sewerage system.

Cooper-Dixon Duck Farm and Southern Wisconsin Colony

1. Provide for improved sewage treatment.

Yorkville-Raymond Farm Drainage Board

1. Undertake channel debrushing and clearing.

State Department of Resource Development

1. Conduct periodic pollution control surveys of the Root River basin.

2. Reevaluate and enforce outstanding pollution control orders.

Financing

In addition to current revenue sources, such as property taxes; fees; fines; public utility earnings; highway, welfare and educational aids; and state collected taxes, the local units of government can also make use of other revenue sources, such as borrowing, special taxes and assessments, gifts, and state and federal grants for plan implementation.

Chapter XV

SUMMARY AND CONCLUSIONS

ORGANIZATION AND PURPOSE

The Root River watershed study, which resulted in the preparation of this document, has been undertaken within the statutory authority of the SEWRPC and upon the request and approval of the local units of government. The study has from its inception been guided by the Root River Watershed Committee, an advisory committee to the SEWRPC composed of elected and appointed public officials. The technical work was carried out jointly by the SEWRPC staff; the Harza Engineering Company of Chicago, Illinois; and Alster and Associates, Inc., photogrammetric engineers, Madison, Wisconsin, with the assistance of certain state and federal agencies.

The study was founded upon the recognition by public officials, technicians, and citizen leaders within the watershed that problems, such as flood damage and water pollution, transcend local governmental boundaries and that solution to such areawide problems must be sought on a regional basis. Furthermore, it was recognized by those who initiated the study that the water and water-related resource problems of the Root River basin are directly related not only to each other but also to urbanization and its associated, increasing, and often misdirected resource demands. The aim of the study has been to design a comprehensive watershed plan to guide the solution of water and water-related resource problems and develop the full potential of the resources of the watershed.

Accordingly, the study has been broad in scope and detailed in content, with application of a full range of scientific disciplines to the tasks of inventory, analysis, and plan design. The facts and conclusions presented in this summary represent a condensation of data presented in Chapters I through XIV of this report, which data, in turn, necessarily represent only a small portion of the large volume of useful information which has been collected and analyzed in the study and which is on file in the Commission offices.

FINDINGS OF FACT

Geography

The Root River watershed is one of 11 surface water drainage basins within the Southeastern Wisconsin Region and comprises a total land and water area of 197.43 square miles. The naturally meandering watershed boundary includes part or all of 18 cities, villages, and towns in four counties and significant portions of the Milwaukee and Racine urbanizing areas. Those portions of the watershed lying outside of the urbanizing areas consist of rich agricultural areas. The total resident population of the watershed in 1963 was 134,200. Land within the watershed is undergoing a rapid transition from rural to urban use in response to increasing economic activity in nearby, but out-of-watershed, industrial centers. Urban land use in the watershed is predominantly residential; and much of the new urban development is being expressed as scattered, low-density residential land uses located in the Milwaukee County headwater reaches of the watershed and in eastern Racine County near the mouth of the watershed. Much of this development is not related sensibly to soil capabilities, to the floodways and flood plains of the Root River system, or to long-established public utility systems. Detailed soil surveys completed by the SEWRPC indicate that large areas of the watershed are covered by soils having severe limitations for urban development and particularly for residential development dependent upon on-site sewage disposal systems.

Moreover, the very areas of the watershed which would present severe environmental problems if converted to urban development, such as the floodways and flood plains, are the best areas remaining within the watershed for use as public outdoor recreation and related open space, wildlife conservation, recharge of ground water, and development of a desirable aesthetic setting for high-value residential development.

Approximately 11 percent of the total area of the watershed is presently in water, woodland, and wetland use; and these areas, together with the areas of the watershed covered by soils poorly suited to urban development, form natural environmental corridors along the stream valleys. In their present undeveloped state, these corridors support most of the remaining wildlife within the watershed. The ability of the watershed to sustain a wildlife population, however, is declining rapidly with urbanization; and the remaining wildlife population is small and of a limited variety. A historic game fishery has declined in recent years and finally disappeared entirely due to adverse changes in water quality, with only a small number of rough fish presently surviving in the grossly polluted perennial streams of the watershed. Only 3 percent of the total watershed area has been developed for outdoor recreational uses, and most of this area is in parkway lands within Milwaukee County.

Public sewer and water facility extension has not kept pace with urban development within the watershed. The location of the watershed near Lake Michigan, however, makes available to it, legally and practically, a dependable supply of high-quality surface water. Proximity to existing highly developed, centralized sewerage systems of the Milwaukee and Racine metropolitan areas makes public sewer service available to much of the urbanizing area of the watershed, if the spatial location of new development is properly planned.

Hydrology

The average annual precipitation in the watershed is about 30 inches. During December through March, a considerable accumulation of snow may occur on the ground, which, when coupled with spring rains, constitutes the principal flood hazard in the watershed. The natural hydrologic regimen of the Root River watershed has been greatly changed by the recent activities of man. Urban development and increased pumpage of ground water has reduced streamflow during low-flow periods, while installation of more efficient urban drainage systems has increased flood peaks. The quality of streamflow has seriously deteriorated as a result of drainage of treated and untreated sewage into the river, making the stream water unsuitable for the preservation of game fish and for water-oriented recreational use.

Streamflow varies widely from season to season and from year to year. Low flows of only a few tens of cubic feet per second (CFS) generally persist during much of the summer, fall, and winter months, with only minor rises after heavy rainfall. High flows and floods are generally associated with snowmelt, and most critical flood flows result from rainfall during a snowmelt period. The low flows of the upper reaches of the river system consist almost entirely of sewage disposal plant effluent.

The maximum known flood of record occurred in March-April of 1960. This flood resulted from rapid melting of an unusually great snow accumulation accompanied by unusually heavy spring rains. A flood peak flow of 5,000 CFS was measured on the North Branch of the Root River at W. Ryan Road (STH 100). Flood peak flows of 3,200 CFS were estimated on the Root River Canal at CTH G, of 8,200 CFS on the main stem at STH 38, and of 9,000 CFS at Spring Street in the City of Racine. This flood is judged to have an average recurrence interval of 100 years, or a probability of occurrence on an annual basis of 1 percent. Future urbanization is expected to increase both the volume and peaks of summer rainfall floods but is expected to have only minor effects on snowmelt floods.

Dissolved oxygen content, coliform bacteria count, and temperature were selected as the three most significant indicators of the quality of the surface water of the watershed. Coliform counts were found to be highest and dissolved oxygen content lowest in the perennial stream channels during autumn and winter. Stream water quality conditions are unfavorable for beneficial types of aquatic life in the mid-reaches of the river system. The estimated present average five-day BOD stream loading from known major waste sources is 910 pounds, 540 pounds of which are attributable to municipal sewage treatment plants located on the North Branch of the Root River in Milwaukee County. The pollution load from these sources will be eliminated by 1970 upon completion of trunk sewers which will carry municipal wastes from the Milwaukee County portion of the watershed to the new metropolitan sewage treatment plant located on Puetz Road in the City of Oak Creek.

Gross pollution presently permits only two principal uses of the river system. The first is as a wasteway and the second as a relatively inactive component of a multiple-purpose recreation and flood plain reservation development which has heretofore achieved success only in the Milwaukee County portion of the watershed.

The Hydraulic System

The hydraulic characteristics of the Root River watershed are strongly influenced by the glacial origin of the topography, which exhibits a generally immature development of drainage with much ponding and slow runoff. Watercourses are circuitous and stream beds slope gently, factors which tend to cause local flooding but serve to moderate peak flood flows. The ability of the stream system to convey water is strongly influenced by the seasonal growth of vegetation in the channels and flood plains and by ice conditions in the spring. The significance of these factors and the specific effects of all channel constrictions, such as bridge and culvert waterway openings, upon a range of streamflow have been fully described in this report.

For analytical purposes, the main system of perennial waterways, 79.1 miles in aggregate length, was separated into four major components: the North Branch of the Root River, 16.5 miles in length; the Root River Canal, 27.8 miles in length; the Root River main stem, 25.6 miles in length; and Hoods Creek, 9.2 miles in length. Average slopes of the channel beds in feet per mile are respectively: 4.82, 3.57, 5.71, and 11.0. Hydraulic friction in the channels and flood plains is moderate, but substantial head losses and resultant backwater effects are caused throughout the channel system by bridges having undersized waterway openings. Man-made modifications in channel hydraulics include the canalization, by straightening and deepening, of most of the Canal and Hoods Creek system and Horlick Dam at STH 38, a deteriorating, historic mill dam, which raises upstream water stages for a distance upstream of about 2.5 miles at peak flood flow. Within the City of West Allis, the installation of a local urban storm water drainage system having outlet elevations below the present creek bed necessitates deepening and widening of the receiving North Branch channel from W. Lincoln Avenue in the City of West Allis to W. Layton Avenue in the City of Greenfield.

The preparation of sound, long-range, comprehensive watershed development plans requires information on the full range of river performance that may be expected over a period of time and under various land use conditions. As a part of the watershed study, therefore, a hydrologic model was developed, which could be used to mathematically simulate the hydrologic and hydraulic operation of the Root River watershed drainage system with its 52 sub-basins, 104 bridge and culvert crossings, and 30 channel reaches. This model was carefully calibrated to accurately simulate actual river performance by use of recorded flow hydrographs from three stream gaging stations and historic high water marks obtained during the inventory portion of the watershed study.

Elements of the model were adjusted to incorporate the hydrologic changes expected to occur as a result of urbanization. Operation of the model indicated that continued urbanization within the watershed will cause a 10 to 15 percent increase in the peak flows of snowmelt-rainfall floods and up to a 70 percent increase in the peak flows of summer rainfall floods. The summer rainfall flood peaks, however, even though greatly increased by urbanization, will remain substantially less than those of snowmelt-rainfall floods.

The hydrological model also was adjusted to represent the effects of structural flood control measures on the hydraulic performance of the river system. Channel deepening and widening in the North Branch would reduce the flood hazard locally but would increase flood peak flows in reaches immediately downstream up to 60 percent. A flood-storage reservoir at the confluence of the North Branch and the Root River Canal would decrease peak snowmelt-rainfall flood stages in the City of Racine by only 0.4 foot. Bypass channels to Lake Michigan would lower flood stages in Racine almost to or below the zero damage stage. Channel clearing in the Root River Canal system would substantially reduce but not completely eliminate inundation of cropland during summer flooding.

Flood Damages

Extensive field surveys revealed that within recent decades flood-damage potential and flood-damage risk had risen from a nuisance level to substantial proportions as urban land use increased in the floodways and flood plains of the watershed. These floodways and flood plains together comprise less than 6 percent of the total area of the watershed. If existing land use development trends are allowed to continue unregulated in the riverine areas, the total average annual flood-damage risk in urban areas of the watershed will increase from the current (1965) level of approximately $24,000.00 per year to $61,000.00 per year by 1990. About 95 percent of the potential flood damages are urban, and most of the urban damages occur to residences located on the flood plains.

The flood of March-April 1960, the greatest flood of record within the watershed, caused total monetary damages of $371,700.00. Approximately

25 percent of the total monetary losses were inflicted upon public property and 75 percent upon private nonagricultural property. Private residential damages in excess of $20,000.00 in aggregate occurred in the upper urbanizing portions of the watershed in the cities of Franklin, Greenfield, and West Allis. Damages in excess of $159,000.00 occurred in the lower reaches of the watershed, primarily in the City of Racine. Monetary flood damage was caused about equally by direct overflow and by floodwaters infiltrating through basement walls and backing into basements through sewerage facilities.

The summer flood of July 18 and 19, 1964, occurring at the peak of the growing season, was the record flood in terms of agricultural damages, causing total damages of $15,000.00 to crops in the Root River Canal area and along the main stem of the Root River.

Pollution and Other Problems

In addition to flooding, other problems directly related to urbanization are appearing in the watershed. These problems include: gross pollution of the Root River by municipal sewage treatment plant effluent and food processing wastes; low-base streamflows, which will be further depleted by future exportation of sanitary sewage; loss of prime agricultural soils to urban development; continued development of residences on soils having severe limitations for such use; destruction of already scarce forest and wetland resources and related wildlife habitat areas; and abandonment of gravel pits leaving an ugly scar upon the landscape and causing health and safety hazards. These problems are primarily the result of urban sprawl, proceeding in the absence of sound areawide development objectives and plans. An economically inefficient, aesthetically unpleasing, and potentially unhealthful environment will be created within the watershed unless these land-related resource problems are abated along with the water-related resource problems.

Legal Considerations

In order to reveal the framework of law within which the watershed plan would have to be designed and implemented, a legal study was carried out, focused upon the interrelated problems of the watershed in relation to the rights of the private individuals and governmental bodies affected. The study indicated that the existing legal and administrative framework, if fully and properly utilized, was adequate to accomplish the anticipated planning and plan implementation tasks and that legal and administrative solutions to most of the watershed problems can be accomplished by more than one agency or level of government. Key facts revealed by the law study were: 1) the inadvisability of inter-basin diversion as a solution to water-resource related problems, such as the diversion of floodwaters between the Oak Creek and the Root River watersheds for flood abatement purposes; 2) the legal soundness of stream impoundments even when significant backwater effects might result; and 3) the great expense of legal machinery available for effecting water pollution control and flood-damage abatement.

More specifically, the legal study indicated that for purposes of flood control, flood-damage prevention, and proper use of the riverine environment, a stream valley can be divided into three main sections: the channel, defined as that area within which the average high annual streamflow is confined; the primary flood plain district, defined as that area back from the channel which is inundated by floodwaters having an average recurrence interval of 10 years; and the secondary flood plain district, defined as that area back from the primary flood plain district which is inundated by floodwaters having an average recurrence interval of 100 years.

It is completely reasonable to impose different land use restrictions on each of these land areas. Whereas encroachments in the channel may be removed summarily without compensation under Chapter 30 of the Wisconsin Statutes, many activities and some structures may be quite properly permitted in the secondary flood plain district, with due regard as to their placement in relation to the channel and to the primary flood plain district, their ability to withstand even occasional flooding, the total cost of the damage they are likely to sustain, their conformance with flood-oriented safety and building codes, and their effect upon valley storage. Although land use in the primary flood plain district should be carefully restricted in the public interest, the right to all use should not be taken without fair compensation. Very few structures and only those of low value and capable of withstanding fairly frequent flooding should be permitted. Recreation, park, parkway, public parking, conservancy, and agricultural uses seem best suited to this area.

Pollution control and maintenance of water quality standards are problems of growing importance.

Many more tools exist than are presently being used to control pollution. The State of Wisconsin, the Metropolitan Sewerage Commission of the County of Milwaukee, local units of government, and private individuals acting through the courts each have powers to exercise in an effort to control pollution, powers which heretofore have been used only sparingly and with caution.

There is little likelihood that the erection of retention reservoirs as a means of controlling flooding along the stream by holding peak runoffs will present serious legal problems. Some drainage districts or individual farmlands may be affected (damaged); but they can be suitably dealt with either before the dams and reservoirs are built, by means of purchasing flowage rights or condemning the necessary land, or after the dams and reservoirs are operational, by settling with each claimant as, if, and when he comes forward. There are, however, a number of legal impediments to large-scale inter-watershed diversions. Two major groups of riparians, those from whom and those to whom water is being diverted, have legal rights which may well be infringed in such an undertaking. In addition, the legal problems of state consent, public rights in the diverted water, and the seemingly restrictive language of Section 30.18 of the Wisconsin Statutes must be faced. Finally, the tactical legal position which Wisconsin has taken in opposition to Illinois in the Chicago River diversion case before the U. S. Supreme Court seems to make unlikely, if not actually impossible, any project involving the diversion of significant quantities of water from one river basin to another.

Projection of Resource Demand Factors and Related Problems

Forecasts of future (1990) watershed population and related land use demand were made as a basis for determining the nature and scaling the probable magnitude of future resource problems within the watershed. It is estimated that the population of the Root River watershed will increase from 134,200 in 1963 to 294,500 by 1990, an increase of about 120 percent over the 27-year period. If present trends toward a low-density, highly diffused pattern of urban development are projected to 1990, residential land use within the watershed will increase threefold; and supporting land uses will expand significantly, requiring the conversion of 42 percent of the now limited wetlands, woodlands, and related open spaces and 41 percent of the agricultural lands remaining within the watershed to urban use.

Urbanization of the watershed will intensify present surface water problems. Summer flood peaks will become significantly higher and will carry increasing amounts of polluting substances received from urban storm runoff. Low flows will be depressed further by exportation of sewage from the watershed, by decreased local recharge of the shallow aquifer through increases in impervious areas, and by the general region-wide decline of the shallow aquifer in response to increased ground water withdrawals. The potential for development of septic water conditions on the Root River will rise. In the deep aquifer, ground water levels will probably continue to fall at the rate of about four feet per year as a result of regional and extra-regional withdrawals. In the shallow aquifer, ground water levels will probably continue to fall at the rate of about one foot per year as a result of in-watershed and regional withdrawals.

ALTERNATIVE PLANS

The Design Framework

Following ascertainment of present and probable future conditions within the watershed, a framework of watershed development objectives with supporting principles and standards was established to guide the design of alternative plans and to provide a basis for the evaluation of the relative merits of the alternative plans. The objectives and standards set forth relate to land use, water control and conservation, engineering design, and economic feasibility and were formulated within the context of broader regional development objectives. Briefly, this framework of development objectives, principles, and standards envisions a future watershed environment which is varied, safe, healthful, efficient, and aesthetically pleasing.

Alternative Plan Elements

In the design of alternative plans, a concerted effort was made to offer for public evaluation all physically feasible alternative plan elements which might satisfy one or more of the watershed development objectives. Each alternative plan element was evaluated in terms of engineering, economic, and legal feasibility and satisfaction of watershed development objectives. The alternative plan elements can best be visualized in terms of various combinations of land use patterns and water control facilities.

With respect to land use, three alternatives available to the watershed were explored:

1. An uncontrolled existing trend land use alternative, which would permit continued scatteration of low-density residential development throughout the watershed, imposes no regulations on land use in the floodways and flood plains, and requires no adjustment of development to soil capabilities or sanitary sewer service areas.

2. A controlled existing trend-land use regulation alternative, which would exercise some regulation, preferably at the local level of government, of land use in the floodways and flood plains of the perennial stream channels through land use controls and which would seek to guide new urban development into those areas of the watershed which can be readily served by extensions of existing centralized public sewerage systems, thus encouraging a more orderly and efficient land use pattern. This land use plan element would be implemented solely by public regulation of private landholdings.

3. A controlled existing trend-parkway and recreation land development alternative, which would seek to encourage a watershed land use pattern similar to that of the land use regulation alternative but with the significant difference that lands lying in the floodways and flood plains in urbanizing portions of the watershed along the North Branch, the main stem of the Root River, and a portion of Hoods Creek would be acquired and developed for public park and parkway use. The riverine areas in the rural portions of the watershed would be protected through public land use controls.

Coupled with these three land use plan alternatives, a number of water control facility proposals were explored. These included:

1. Channel improvements within the City of Greenfield and the Village of Greendale, which would seek to reduce local, urban flood damages by deepening and widening a reach of existing channel now in a natural state.

2. Channel improvements within the City of Racine, which would seek to reduce local, urban flood damages by deepening, widening, and lining a reach of existing channel now in a semi-natural state.

3. Channel clearing and maintenance in the Root River Canal area, which would seek to increase the hydraulic capacity of an extensive rural canal system and reduce significant crop damages from summer flooding. This water control facility plan element consists of initial clearing and triennial maintenance of vegetative growth and bank sloughings.

4. Diversion channels to Lake Michigan, which would seek to reduce downstream flood damages by diversion of floodwaters to Lake Michigan by means of a diversion channel to be excavated either along the Milwaukee-Racine County line or along an alternative route from the environs of the Racine-Horlick Airport to a point on Lake Michigan above the Village of Wind Point.

5. A multi-purpose artificial reservoir at the junction of the North Branch and the Canal, with an impoundment area of 660 acres, which would provide recreation, wildlife conservation, and low-flow augmentation benefits, as well as a focal point and setting for high-value residential development.

6. Adequate waterway openings for bridges over the perennial stream channels. This water control facility plan element designates 12 existing highway bridges for replacement because of undersized waterway openings, recommends the design of all new bridges in accordance with governing watershed development objectives and standards, and thereby seeks to reduce significant backwater effects and attendant upstream flood damages.

7. Water pollution control measures, which seek to improve water quality conditions through a) abandonment of all existing sewage treatment plants discharging wastes to the North Branch and export of all Milwaukee County sewage via the Milwaukee metropolitan sewerage system to a new treatment plant on Lake Michigan; b) abandonment of the Caddy Vista sewage treatment plant and connection of the tributary sewers to the Milwaukee metropolitan sewerage system; c) connection of the Frank Pure Food Company industrial waste outlet to the City of Racine sanitary sewerage

system; d) improvement in the degree of sewage treatment provided at the Southern Wisconsin Colony, the Cooper-Dixon Duck Farm, and the Village of Union Grove; and e) the continuation of the SEWRPC administered water quality and quantity monitoring program.

8. Removal of residences from the flood plains in the City of Greenfield. This accessory plan element proposes to remove 23 residences now subject to first floor inundation during a 100-year recurrence interval flood through purchase at the rate of one per year, structural removal, and conversion of the land to parkway use.

9. Removal of residences from the flood plain in the City of Racine. This accessory plan element proposes to remove 35 residences now subject to first floor inundation during a 100-year recurrence interval flood through purchase at the rate of about two per year, structural removal, and conversion of the land to parkway use.

10. Restoration of Horlick Dam. This accessory plan element provides for the restoration of an existing mill dam having great potential for recreational and aesthetic use.

11. Augmentation of low flow in the North Branch. This accessory plan element seeks to improve the quality of stream water above a proposed reservoir site by flushing with Lake Michigan water or pumped ground water during periods of low flow.

12. Floodproofing of residences. This accessory plan element seeks to achieve flood-damage protection through private action by a variety of structural measures and use restrictions on individual existing residences located in the flood plains but not subject to first floor inundation.

13. The "Lake Moraine" proposal. This independent proposal by a Milwaukee area consulting engineer would seek to create a 30 square mile lake, which would occupy about 15 percent of the total area of the watershed and would provide recreation, power, flood-damage reduction, and low-flow supplementation benefits at a total project cost estimated at $46,000,000.00.

Recommended Alternative Plan

Each of the plan elements were evaluated individually and in various compatible combinations during watershed plan synthesis. The resultant watershed plan, which is being recommended on the basis of the plan test and evaluation procedure, contains the following salient proposals:

1. Regulation of land use development over the entire watershed through local zoning to assure the logical expansion of urban development into those areas of the watershed that can be readily served by existing centralized gravity flow sanitary sewerage systems. The land use plan element being recommended is graphically summarized on Map 36.

2. Protection of the floodway and flood plain areas along the perennial stream channels. In areas of the watershed which are expected to urbanize by 1990, this protection should be achieved through public acquisition of floodway and flood plain lands for park and parkway purposes. In the areas which are anticipated to remain largely in agricultural use, at least to the design year of the plan, 1990, this protection should be achieved through local conservancy zoning and local floodway and flood plain regulation.

3. Channel clearance and maintenance, but not widening or deepening, operations in the Root River Canal area, where channels are badly in need of clearance to reduce impedance of streamflow. These relatively inexpensive operations would significantly reduce agricultural flood damages and improve agricultural drainage, a fact of particular importance to farm drainage districts operating in the area.

4. Construction of a multi-purpose recreation and low-flow augmentation reservoir at the junction of the North Branch and the Root River Canal in the City of Franklin.

5. Replacement by 1990 of those existing highway bridges (see Appendix G) which have undersized waterway openings causing backwater and overtopping of roadways with resultant flood damages.

6. Restoration of Horlick Dam.

7. The public acquisition and removal of those existing flood plain residences in which the first floors are inundated by a flood having a recurrence interval of 100 years. These residences can be acquired both through purchases as they come on the market and through application of the nonconforming use provisions of local zoning ordinances.

8. Floodproofing by the individual homeowner of any residence which is situated on the flood plain and is not scheduled to be removed by public acquisition.

9. Abandonment of the Caddy Vista sewage treatment plant and connection of the tributary sewers to the Milwaukee metropolitan sewerage system.

10. Connection of the Frank Pure Food Company plant to the City of Racine sewerage system.

11. Improvement in the degree of sewage treatment provided at the Southern Wisconsin Colony, Union Grove, and Cooper-Dixon Duck Farm, as no practical way exists at this time to connect these waste sources to centralized sewerage systems for exportation of pollutants.

12. Continuation of the SEWRPC water quality and quantity monitoring program for the perennial channel system.

The recommended water pollution control actions, when coupled with plans now being implemented by the Metropolitan Sewerage Commission of the County of Milwaukee for the abandonment of the existing Hales Corners, Greendale, House of Correction, and Franklin sewage treatment plants and connection of the tributary sewers to the metropolitan system, would eliminate six of the nine major sources of stream pollution in the watershed and all of the major sources of pollution on the North Branch and main stem. The plan, by recommending removal of the remaining major sources of pollution and construction of the Oakwood Reservoir, seeks to substantially restore the quality of water in the main stem of the Root River. It is thereby hoped to restore a game fishery, consisting of facultative species, and to make possible the safe use of the stream water for partial body-contact recreation. Even if all sanitary sewage contribution is removed from the stream, storm water runoff would still continue to contribute pollutants. These pollutants, however, are contributed at a time when the flow in the stream is high and should not, therefore, adversely affect fish life in the water. The plan also recommends improved soil and water conservation practices on the farmlands in the agricultural areas of the basin in order to minimize the effects upon the stream water quality and fish life of runoff from agricultural areas containing fertilizers, herbicides, and pesticides.

The recommended plan reflects the conviction of the Commission staff and consulting engineers that the flood plains of the perennial streams should be used primarily for the dual purposes of storage and conveyance of floodwaters and park and open-space reservation and not for flood-vulnerable types of urban development. The study recommends, as one of the first steps toward plan implementation, the protection of the riverine areas by a rezoning into park and conservancy districts and the regulation of the channels, floodways, and flood plains by special restrictions so as to relate them to their special respective function; namely, navigation, floodwater passage, and floodwater storage.

Public Evaluation of Alternatives and Resultant Addition of Elements

The findings of fact, results of analyses, alternative plan elements, and the recommended plan were presented to technical advisory committees and local officials in a series of public meetings held throughout the watershed in order to draw forth constructive criticism to be used in preparation of this—the final plan report.

Costs

The full cost of implementation of the plan, based on a preliminary capital improvement program included in the report, and resulting in total plan implementation by 1990 with the cost distributed over a 23-year period, is estimated at $16.5 million, $7.5 million of which would be for improvements located in Racine County and $9.0 million for improvements in Milwaukee County. This would amount to an average annual cost of about $394,000.00 in Milwaukee County and $329,000.00 in Racine County or about 40 cents and $2.00 per person per year, respectively, based on present population levels in the two counties. It should be possible to reduce these costs to the local units of government concerned by about half through utilization of available state and federal aids.

Implementation

The existing legal and administrative framework applicable to the Root River watershed is such that local agencies—counties, cities, villages, and towns—can readily implement the recommended plan. In Chapter XIV a comprehensive, cooperative plan implementation program is set forth which indicates the action which will be required of each unit of government concerned if the recommended plan is to be implemented. These units of government include: the State of Wisconsin; the counties of Milwaukee and Racine; the cities of Franklin, Greenfield, Oak Creek, Racine, and West Allis; the villages of Greendale and Union Grove; and the towns of Caledonia, Mount Pleasant, Raymond, and Yorkville. Agencies for which specific implementation roles are demarcated include: the U. S. Geological Survey; the Wisconsin Department of Resource Development;[1] the Milwaukee and Racine County Park and Planning Commissions; the Milwaukee and Racine County Soil and Water Conservation Districts; the Metropolitan Sewerage Commission of Milwaukee County; the Caddy Vista Sanitary District; and the Yorkville-Raymond Farm Drainage Board. Considerable emphasis is placed upon action by the Milwaukee and Racine County Boards and related county level agencies. This does not mean, however, that the other implementation roles are less important. In the final analysis, the implementation of the recommended plan must proceed with the assistance and cooperation of all affected levels and units of government within the watershed.

Conclusion

Although the cost of adopting and implementing the recommended watershed plan may appear high, the cost of not doing so is even higher, not only in monetary terms, but in terms of an irreversible deterioration of the resource base and decline in the quality of the watershed environment. Failure to act upon the plan recommendations in a timely manner will inevitably commit local units of government within the watershed to the construction of channel improvements and eventually a diversion channel at a monetary cost of many millions of dollars. If the floodways and flood plains of the perennial stream system are not protected from incompatible development as recommended in the plan, urban flood damages will continue to mount; and the construction of such extensive artificial floodways will be demanded. Experience elsewhere has shown that wherever extensive channel improvements are undertaken, downstream flood peaks are increased and, in turn, channel improvements are required in the downstream areas as a self-protective measurement. Such progressive artificial channel widening, deepening, and lining in the Root River watershed would eventually require the diversion of floodwaters to Lake Michigan by a costly diversion channel in order to protect the Racine area.

Channel improvements of this kind would destroy for all time the aesthetic and resource conservation values of the riverine areas. The planning studies have clearly indicated that the primary value of the riverine areas of the watershed be in their use as an attractive aesthetic setting for high-value residential development and for recreational and conservancy purposes. Thus, implementation of the land use and water control facility elements of the recommended plan is essential to development of the full potential of the resources of the watershed. Equally important to the development of the full potential of the resources of the watershed is implementation of the pollution abatement elements of the plan. Grossly polluted stream waters are not compatible with the proper use of the riverine areas of the watershed as a setting for high-value residential development and for recreation. Consequently, if the pollution abatement elements of the plan are not implemented, then the full residential development potential of the watershed will never be realized.

Time is of the essence; for if the recommended plan is not implemented, urban development within the watershed will overwhelm the limited resource base and create severe developmental and environmental problems which will be extremely expensive to solve if, indeed, solutions will be at all possible.

[1] *As expanded by Chapter 614, Laws of Wisconsin, 1965, to include water resources functions formerly held by the Wisconsin Public Service Commission, the State Committee on Water Pollution, and the State Board of Health.*

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APPENDICES

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Appendix A

TECHNICAL ADVISORY COMMITTEE ON NATURAL RESOURCES AND ENVIRONMENTAL DESIGN

Benjamin F. Richason, Chairman	Professor of Geography, Carroll College, Waukesha
Ed Imhoff, Secretary	Chief Natural Resources Planner, SEWRPC
Kurt W. Bauer	Executive Director, SEWRPC
George F. Hanson	State Geologist, Wisconsin Geological and Natural History Survey
Charles L. R. Holt, Jr.	District Geologist, U. S. Geological Survey, Ground Water Branch
Walter K. Johnson	Director, Planning Division, Wisconsin Department of Resource Development
Cyril Kabat	Assistant Superintendent, Research and Planning Division, Wisconsin Conservation Department
Harry M. Major	Assistant State Soil Conservationist, Soil Conservation Service
Harold A. McMiller	Executive Director, Waukesha County Park and Planning Commission
Robert J. Mikula	County Landscape Architect, Milwaukee County Park Commission
Donald W. Niendorf	Field Representative, State Soil and Water Conservation Committee
James R. Price	Division Engineer, Sewer Construction and Maintenance, Sewerage Commission of the City of Milwaukee
William Sayles	Water Engineer, Wisconsin Public Service Commission
William F. Steuber	Assistant Chief Highway Engineer, State Highway Commission of Wisconsin
George B. Wesler	Chief, Planning and Reports Branch, U. S. Army Corps of Engineers
Donald G. Wieland	Division Engineer, Sewer Design, Sewerage Commission of the City of Milwaukee
Harvey E. Wirth	Assistant State Sanitary Engineer, State Board of Health
Theodore F. Wisniewski	Director, State Committee on Water Pollution
K. B. Young	District Engineer, U. S. Geological Survey, Surface Water Branch

Appendix B

ROOT RIVER WATERSHED COMMITTEE

Howard W. Gregg, Chairman	General Manager, Milwaukee County Park Commission
Kurt W. Bauer, Secretary	Executive Director, SEWRPC
Arthur Abendschein	Mayor, City of Oak Creek
Ralph A. Becker	City Engineer, City of New Berlin
William H. Beyer	Mayor, City of Racine
Floyd G. Carlson	Planning Director, City of Racine
William J. Chadwick	City Engineer, City of Racine
Francis W. Conner	Work Unit Conservationist, Soil Conservation Service
Theodore Fadrow	Mayor, City of Franklin
Walter J. Fehr	President, Village of Hales Corners
Jerome J. Gottfried	Mayor, City of Muskego
Maurice L. Kimbrough	City Engineer, City of West Allis
John M. Kuglitsch	Village Manager, Village of Greendale
Milton F. LaPour	Commissioner, SEWRPC
Ray D. Leary	Chief Engineer and General Manager, Milwaukee-Metropolitan Sewerage Commissions
Elwin G. Leet	Racine County Agent, Cooperative Extension Service of the University of Wisconsin
John Margis, Jr.	Chairman, Town of Caledonia
John P. Murphy	Commissioner, SEWRPC

The following public officials also participated actively in the work of the Watershed Committee: Richard N. Hay, Robert J. Mikula, Nick T. Paulos, Norbert Theine, Frank Wellstein, Donald G. Wieland, and Thomas N. Wright.

Appendix C

LAND USE IN THE HYDROGRAPHIC SUB-WATERSHEDS -- 1963

Table C-1

SUMMARY OF EXISTING LAND USE
IN THE NORTH BRANCH SUB-WATERSHED[a]
OF THE ROOT RIVER WATERSHED (1963)

Use Category	Acres	Square Miles	Percent of Sub-Watershed Area
Residential Density			
Low.	6,246	9.76	19.85
Medium	1,163	1.82	3.70
High	0	0.00	0.00
Subtotal	*7,409*	*11.58*	*23.55*
Commercial.	359	0.56	1.14
Industrial.	85	0.13	0.26
Mining.	301	0.47	0.96
Transportation and Utilities.	3,506	5.48	11.15
Governmental and Institutional. . . .	544	0.85	1.73
Recreational.	2,108	3.29	6.69
Agricultural.	11,940	18.66	37.96
Water, Woodland, and Wetland.	5,208	8.14	16.56
Total	31,460	49.16	100.00

[a] This sub-watershed comprises the drainage area above the USGS water stage recorder station, "Root River near Franklin," located at W. Ryan Road (STH 100) in the City of Franklin.

Source: SEWRPC.

Table C-2

SUMMARY OF EXISTING LAND USE
IN THE MAIN STEM SUB-WATERSHED[a]
OF THE ROOT RIVER WATERSHED (1963)

Use Category	Acres	Square Miles	Percent of Sub-Watershed Area
Residential Density			
Low.	2,230	3.48	4.29
Medium	417	0.65	0.80
High	0	0.00	0.00
Subtotal	*2,647*	*4.13*	*5.09*
Commercial.	48	0.08	0.10
Industrial.	58	0.09	0.11
Mining.	178	0.28	0.34
Transportation and Utilities.	3,273	5.11	6.29
Governmental and Institutional. . . .	142	0.22	0.27
Recreational.	431	0.67	0.82
Agricultural.	39,034	61.00	75.13
Water, Woodland, and Wetland.	6,157	9.62	11.85
Total	51,968	81.20	100.00

[a] This sub-watershed comprises the net drainage area obtained by subtracting the areas of the North Branch and Root River Canal sub-watersheds from the total drainage area above the USGS water stage recorder station, "Root River at Racine," located at STH 38 in the Town of Mount Pleasant.

Source: SEWRPC.

Table C-3

SUMMARY OF EXISTING LAND USE
IN THE ROOT RIVER CANAL SUB-WATERSHED[a]
OF THE ROOT RIVER WATERSHED (1963)

Use Category	Acres	Square Miles	Percent of Sub-Watershed Area
Residential Density			
Low	694	1.08	1.84
Medium	100	0.16	0.27
High	0	0.00	0.00
Subtotal	*794*	*1.24*	*2.11*
Commercial	17	0.03	0.05
Industrial	19	0.03	0.05
Mining	269	0.42	0.71
Transportation and Utilities	1,419	2.22	3.77
Governmental and Institutional	83	0.13	0.22
Recreational	147	0.23	0.39
Agricultural	32,438	50.68	86.16
Water, Woodland, and Wetland	2,467	3.85	6.54
Total	37,653	58.83	100.00

[a] This sub-watershed comprises the drainage area above the USGS water stage recorder station, "Root River Canal near Franklin," located at CTH G in the Town of Raymond.

Source: SEWRPC.

Table C-4

SUMMARY OF EXISTING LAND USE
IN THE RACINE SUB-WATERSHED[a]
OF THE ROOT RIVER WATERSHED (1963)

Use Category	Acres	Square Miles	Percent of Sub-Watershed Area
Residential Density			
Low	0	0.00	0.00
Medium	128	0.20	2.43
High	1,937	3.02	36.66
Subtotal	*2,065*	*3.22*	*39.09*
Commercial	160	0.25	3.03
Industrial	159	0.25	3.03
Mining	0	0.00	0.00
Transportation and Utilities	1,261	1.97	23.91
Governmental and Institutional	395	0.62	7.52
Recreational	572	0.89	10.80
Agricultural	313	0.49	5.95
Water, Woodland, and Wetland	349	0.55	6.67
Total	5,274	8.24	100.00

[a] This sub-watershed comprises the drainage area below the USGS water stage recorder station, "Root River at Racine," located at STH 38 in the Town of Mount Pleasant.

Source: SEWRPC.

Appendix D

TABULATION OF STATISTICAL DATA RESULTING FROM ANALYSES OF WATER QUALITY SAMPLES COLLECTED AT SIX STATIONS ON THE ROOT RIVER, JANUARY 1964 -- FEBRUARY 1965

Table D-1

CHEMICAL, BIOCHEMICAL, AND BACTERIOLOGICAL ANALYSES OF WATER SAMPLES COLLECTED AT SIX STATIONS ON THE ROOT RIVER (January 1964-February 1965)

SEWRPC SAMPLING STATION RT 1, ROOT RIVER AT W. GRANGE AVENUE

Parameter	Dates of Sampling													
	30 Jan 64	19 Feb 64	25 Mar 64	08 Apr 64	25 May 64	11 Jun 64	16 Jul 64	06 Aug 64	11 Sep 64	02 Oct 64	05 Nov 64	03 Dec 64	06 Jan 65	03 Feb 65
Silica			12	8			2	6	4					
Iron				0.07					0.16					
Manganese									0.00					
Calcium			91	107			43	136	82					
Magnesium			49	51			32	61	52					
Sodium			135	0			55	90	80					
Bicarbonate			330	255			215	435	365					
Carbonate			20	10			0	0	0					
Sulfate			78	155			75	280	168					
Chloride			240	30			80	100	85					
Nitrite			0.0	0.0			0.0	0.0	0.0					
Nitrate									1.3				3.5	2.1
Detergents			0.2	0.1			0.4	0.1	0.0					
Dissolved Solids			785	485			390	890	650					
Hardness			428	476			240	592	419					
Noncarbonate Hardness			125	250			65	235	120					
Calcium Hardness			226	267			106	341	204					
Magnesium Hardness			202	209			134	251	215					
Alkalinity (P)			10.0	5.0			0.0	0.0	0.0					
Alkalinity (M)			290	220			175	355	300					
Specific Conductance			1320	930			566	1240	960					
Hydrogen-Ion			8.5	8.4			7.2	7.8	7.6					
Color			40	30			35	45	20					
Turbidity			2	20			7	35	25					
Biochemical Oxygen Demand			7.2	2.9	3.7	3.7	1.9	5.6	3.7	4.0	4.5	1.3	2.9	3.6
Dissolved Oxygen			12.7	10.4	4.9	5.9	5.1	6.2	4.4	2.6	3.1	9.6	9.0	3.9
Membrane Filter Coliform Count[a]			10.0-	20.0	12.0	0.8	2.0	2.4	3.0	10.0	86.0	50.0	20.0	2.0
Temperature °F			41	38	64	59	74	74	63	59	50	32	32	32

[a] All measurements in thousands.

Source: Wisconsin State Laboratory of Hygiene; SEWRPC.

Table D-1 (continued)

SEWRPC SAMPLING STATION RT 2. ROOT RIVER AT W. RYAN ROAD (STH 100)

Parameter	Dates of Sampling													
	30 Jan 64	19 Feb 64	25 Mar 64	08 Apr 64	25 May 64	11 Jun 64	16 Jul 64	06 Aug 64	11 Sep 64	02 Oct 64	05 Nov 64	03 Dec 64	06 Jan 65	03 Feb 65
Silica		16		6					11					
Iron				0.01					0.14					
Manganese									0.00					
Calcium		81		130					100					
Magnesium		33		60					47					
Sodium		170		15					85					
Bicarbonate		435		190					355					
Carbonate		0		5					30					
Sulfate		105		364					182					
Chloride		170		45					65					
Nitrite		0.0		0.0					0.2					
Nitrate									14.4				8.6	0.6
Detergents		0.5		0.1					0.4					
Dissolved Solids		790		720					710					
Hardness		339		572					445					
Noncarbonate Hardness		0		410					105					
Calcium Hardness		202		325					250					
Magnesium Hardness		137		247					195					
Alkalinity (P)		0.0		2.5					15.0					
Alkalinity (M)		355		160					320					
Specific Conductance		1360		1040					1050					
Hydrogen-Ion		7.0		7.6					7.6					
Color		25		40					25					
Turbidity		7		2					7					
Biochemical Oxygen Demand		65.3	4.3	1.9	4.0	3.3	4.9	4.1	2.8	4.4	12.9	2.4	3.5	6.2
Dissolved Oxygen		0.0	6.9	9.2	1.2	1.9	0.9	1.2	1.7	3.7	8.9	1.0	7.0	0.6
Membrane Filter Coliform Count[a]		1700.0	100.0-	32.0	6.0	0.3	4.0	0.3	0.1	7.0	0.1-	3.0	80.0	19.0
Temperature °F		32	39	39	67	63	68	72	66	58	53	32	34	32

[a] All measurements in thousands.

Source: Wisconsin State Laboratory of Hygiene; SEWRPC.

Table D-1 (continued)

SEWRPC SAMPLING STATION RT 3, ROOT RIVER AT SIX MILE ROAD (CTH G)

Parameter	Dates of Sampling												
	30 Jan 64	19 Feb 64	25 Mar 64	08 Apr 64	25 May 64	11 Jun 64	16 Jul 64	06 Aug 64	11 Sep 64	02 Oct 64	05 Nov 64	03 Dec 64	06 Jan 65	03 Feb 65
Silica		10		7					5					
Iron				0.02					0.07					
Manganese.									0.00					
Calcium.		106		95					84					
Magnesium.		43		42					48					
Sodium		160		70					95					
Bicarbonate.		310		240					345					
Carbonate.		0		10					10					
Sulfate.		190		200					149					
Chloride		240		100					115					
Nitrite.		0.0		0.0					0.3					
Nitrate.									5.3				5.6	10.2
Detergents		0.7		0.1					0.6					
Dissolved Solids		905		640					680					
Hardness		442		407					409					
Noncarbonate Hardness.		185		195					105					
Calcium Hardness		264		236					210					
Magnesium Hardness		178		171					199					
Alkalinity (P)		0.0		5.0					5.0					
Alkalinity (M)		255		205					295					
Specific Conductance		1600		924					1040					
Hydrogen-Ion		7.2		7.6					7.6					
Color.		20		30					20					
Turbidity.		2		10					5					
Biochemical Oxygen Demand.		14.8	2.5	4.1	8.0	2.6	2.6	5.2	3.3	2.9	2.6	8.2	5.1	10.2
Dissolved Oxygen		1.6	8.0	9.9	5.7	7.2	6.4	3.9	3.2	2.6	3.7	6.5	9.0	0.7
Membrane Filter Coliform Count[a]. . .		1100.0	10.0	77.0	230.0	5.0	5.0	7.0	5.0	18.0	1.7	600.0	90.0	340.0
Temperature.°F		32	39	39	68	64	78	75	66	59	51	32	33	32

[a] All measurements in thousands.

Source: Wisconsin State Laboratory of Hygiene; SEWRPC.

Table D-1 (continued)

SEWRPC SAMPLING STATION RT 4, ROOT RIVER AT W. COUNTY LINE ROAD

Parameter	Dates of Sampling													
	30 Jan 64	19 Feb 64	25 Mar 64	08 Apr 64	25 May 64	11 Jun 64	16 Jul 64	06 Aug 64	11 Sep 64	02 Oct 64	05 Nov 64	03 Dec 64	06 Jan 65	03 Feb 65
Silica			8	6	1	2	5	6	2	2	4	7	6	11
Iron				0.04					0.24					
Manganese.									0.04					
Calcium.			117	97	122	117	103	118	92	97	85	100	94	119
Magnesium.			52	47	56	57	47	49	45	45	46	41	46	53
Sodium			140	80	90	90	110	65	100	110	120	100	65	100
Bicarbonate.			275	195	355	390	355	365	330	330	360	330	255	420
Carbonate.			30	20	0	0	0	0	30	0	0	0	0	0
Sulfate.			233	282	288	224	236	239	168	200	182	212	250	212
Chloride			205	85	100	120	105	65	90	130	120	100	65	120
Nitrite.			0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0
Nitrate.									3.9	5.4		4.2	6.5	0.9
Detergents			0.1	0.1	0.2	0.5	0.7	0.1	0.5	0.5	2.0	0.4	0.6	
Dissolved Solids			920	710	830	800	780	720	690	750	740	725	660	820
Hardness			507	438	534	527	449	496	414	426	404	419	425	517
Noncarbonate Hardness.			230	245	245	205	160	195	95	155	110	150	215	170
Calcium Hardness			291	243	305	291	257	294	230	241	213	249	234	298
Magnesium Hardness			216	195	229	236	192	202	184	185	191	170	191	219
Alkalinity (P)			15.0	10.0	0.0	0.0	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0
Alkalinity (M)			255	180	290	320	290	300	300	270	295	270	210	345
Specific Conductance			1290	920	1180	1280	1020	1050	1030	1090	1100	1040	906	1320
Hydrogen-Ion			8.3	8.1	7.4	8.0	7.8	7.4	7.8	7.6	7.8	7.4	7.4	7.2
Color.			40	30	35	25	30	65	25	20	15	40	60	35
Turbidity.			2	7	5	2	5	25	55	20	7	10	7	8
Biochemical Oxygen Demand.			4.4	3.9	2.3	2.6	5.1	7.8	3.3	5.7	8.3	5.4	4.5	11.4
Dissolved Oxygen			9.0	9.5	9.4	6.6	4.7	4.9	5.0	6.9	9.4	5.5	9.1	0.6
Membrane Filter Coliform Count[a]. . .			10.0-	47.0	1.0	0.1	1.0-	1.2	7.0	23.0	3.0	280.0	40.0	60.0
Temperature °F			39	39	70	66	77	72	68	59	53	32	32	32

[a] All measurements in thousands.

Source: Wisconsin State Laboratory of Hygiene; SEWRPC.

Table D-1 (continued)

SEWRPC SAMPLING STATION RT 5, ROOT RIVER AT NICHOLSON ROAD

Parameter	Dates of Sampling													
	30 Jan 64	19 Feb 64	25 Mar 64	08 Apr 64	25 May 64	11 Jun 64	16 Jul 64	06 Aug 64	11 Sep 64	02 Oct 64	05 Nov 64	03 Dec 64	06 Jan 65	03 Feb 65
Silica		12		8					2					
Iron				0.06					0.15					
Manganese.									0.00					
Calcium.		81		92					98					
Magnesium.		57		43					46					
Sodium		165		50					115					
Bicarbonate.		345		205					370					
Carbonate.		0		0					10					
Sulfate.		200		224					212					
Chloride		215		80					100					
Nitrite.				0.0					0.1					
Nitrate.									2.1				6.9	3.4
Detergents		0.6		0.1					0.0					
Dissolved Solids		900		595					770					
Hardness		435		407					435					
Noncarbonate Hardness.		150		235					115					
Calcium Hardness		202		229					245					
Magnesium Hardness		233		178					190					
Alkalinity (P)		0.0		0.0					5.0					
Alkalinity (M)		285		170					315					
Specific Conductance		1500		850					1070					
Hydrogen-Ion		7.1		7.8					8.3					
Color.		15		40					25					
Turbidity.		3		20					15					
Biochemical Oxygen Demand.		18.8+	3.6	4.8	2.7	0.6	2.3	9.4	5.5	5.7	5.6	7.4	9.7	8.8
Dissolved Oxygen		0.0	13.2	9.8	10.3	9.9	8.5	14.1	6.3	5.0	6.6	7.5	8.3	1.3
Membrane Filter Coliform Count[a]. . .		1000.0	20.0	42.0	45.0	2.0	21.0	47.0	390.0	280.0	20.0	150.0	600.0	140.0
Temperature °F		32	40	41	72	66	77	77	67	59	53	32	32	32

[a] All measurements in thousands.

Source: Wisconsin State Laboratory of Hygiene; SEWRPC.

Table D-1 (continued)

SEWRPC SAMPLING STATION RT 6, ROOT RIVER AT STH 38

Parameter	Dates of Sampling													
	30 Jan 64	19 Feb 64	25 Mar 64	08 Apr 64	25 May 64	11 Jun 64	16 Jul 64	06 Aug 64	11 Sep 64	02 Oct 64	05 Nov 64	03 Dec 64	06 Jan 65	03 Feb 65
Silica	6	8	5	8	1	2	0	0	1	2	0	6	5	10
Iron				0.02					0.52					
Manganese.									0.03					
Calcium.	62	103	111	91	118	101	91	98	96	93	95	77	71	118
Magnesium.	26	50	54	42	57	56	55	45	50	42	42	32	35	53
Sodium	135	175	80	55	70	100	60	55	70	110	120	100	55	90
Bicarbonate.	195	380	270	220	345	310	360	295	340	360	400	295	215	390
Carbonate.	0	0	30	0	0	5	0	0	0	0	0	0	0	0
Sulfate.	129	212	220	224	276	264	174	224	191	191	191	155	160	212
Chloride	185	220	120	70	80	115	80	55	85	105	100	100	65	120
Nitrite.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
Nitrate.									1.9	2.7	1.9	3.8	6.2	1.0
Detergents	1.0	0.6	0.2	0.1	0.2	0.6	0.1	0.0	0.3	0.4	0.8	0.3	0.4	
Dissolved Solids	640	955	750	600	770	800	635	620	665	720	750	620	505	795
Hardness	260	462	500	397	531	483	452	431	447	404	409	324	320	514
Noncarbonate Hardness.	100	150	230	215	245	220	155	190	165	110	80	85	145	195
Calcium Hardness	154	257	277	226	295	253	226	245	240	231	237	192	176	295
Magnesium Hardness	106	205	223	171	236	230	226	186	207	173	172	132	144	219
Alkalinity (P)	0.0	0.0	15.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alkalinity (M)	160	310	250	180	285	260	295	240	280	295	330	240	175	320
Specific Conductance	960	1520	1120	856	1070	1070	880	930	1020	968	1040	904	728	1250
Hydrogen-Ion	7.3	7.2	8.5	7.1	7.4	8.2	7.8	7.7	8.3	7.8	8.2	7.6	7.4	7.2
Color.	35	15	70	30	40	15	60	45	30	20	20	40	85	30
Turbidity.	7	2	2	10	7	10	15	65	45	25	25	40	20	6
Biochemical Oxygen Demand.	5.1	4.3	3.5	5.7	4.7	2.7	4.0	8.1	6.3	5.7	5.5	3.8	5.1	4.8
Dissolved Oxygen	9.6	11.5	14.6	12.3	9.0	7.9	8.1	7.5	8.1	9.3	10.5	12.0	12.3	7.3
Membrane Filter Coliform Count[a]. . .	32.0	0.4	0.7	21.0	10.0	1.5	6.0	3.0	26.0	17.0	1.0	16.0	20.0	2.0
Temperature °F	33	32	40	41	68	69	77	76	67	59	52	32	34	32

[a] All measurements in thousands.

Source: Wisconsin State Laboratory of Hygiene; SEWRPC.

Table D-1 (supplement)

THE ROUNDING OF NUMBERS OBTAINED FROM THE RESULTS OF CHEMICAL WATER ANALYSES[a]

Parameter	Rounding Of Numbers
Silica.	Nearest whole number
Iron.	Nearest 1/100 ppm
Manganese	Nearest 1/100 ppm
Calcium	Nearest whole number
Magnesium	Nearest whole number
Sodium.	Nearest 5 ppm
Bicarbonate	Nearest 5 ppm
Carbonate	Nearest 5 ppm; 2.5 ppm is an estimate only.
Sulfate	Nearest whole number
Chloride.	Nearest 5 ppm
Nitrite	Nearest 1/10 ppm
Nitrate	Nearest 1/10 ppm
Detergents.	Nearest 1/10 ppm
Dissolved Solids.	Nearest 5 ppm; nearest 10 ppm at 1,000 ppm and larger.
Hardness.	Nearest whole number
Noncarbonate Hardness	Nearest 5 ppm
Calcium Hardness.	Nearest whole number
Magnesium Hardness.	Nearest whole number
Alkalinity, phenolphthalein (P) .	Nearest 2.5 ppm for numbers below 5 ppm. Nearest 5 ppm for concentrations above 5 ppm.
Alkalinity, methyl-orange (M) . .	Nearest 5 ppm
Specific Conductance at 25°C. . .	Nearest even number; nearest 10 ppm at 1,000 ppm and larger.
Hydrogen-Ion (pH)	Nearest 1/10 unit of measurement
Color	Nearest whole number
Turbidity	Nearest whole number
Biochemical Oxygen Demand	Nearest 1/10 ppm
Dissolved Oxygen.	Nearest 1/10 ppm
Membrane Filter Coliform Count. .	Nearest 100 MFCC/100 ml
Temperature	Nearest whole degree Fahrenheit

[a] The results of the water analyses run by the Commission on the 28 parameters listed above are rounded to conform to the level of accuracy involved in the analytical methods.

Source: SEWRPC.

Table D-2

INDEX TO AGENCY STUDIES OF WATER QUALITY CONDITIONS

ROOT RIVER WATERSHED, (1951-1965)

Study Number	Agency	Study Period	Geographic Area of Coverage	Study Subject and/or Publication Title	Scope and Contents	Results and/or Conclusions
1	U.S. Geological Survey	1951	Root River near Hales Corners and Oak Creek	"Water Resources of the Milwaukee Area, Wisconsin," U.S. Geological Survey Circular 247	Spot sampling and analyses to determine chemical and physical characteristics.	The analyses showed a very hard water with a fairly high mineral content.
2	The State of Wisconsin Committee on Water Pollution	1953-1954	Root River and tributaries within Waukesha and Milwaukee counties	"Report of Investigations of Pollution of Surface Waters in Milwaukee County and That Portion of the Root River System Draining From Waukesha Through Milwaukee County"	A stream sampling and testing program which involved the determination of water quality conditions and the identification of probable sources of pollution.	Several sources of untreated and treated wastes were identified and described. Stream survey data indicated "unsatisfactory" conditions resulting from sewage from residential developments in the City of New Berlin and the community of Tess Corners.
3	The State of Wisconsin Committee on Water Pollution	1954-1955	Root River and tributaries within Racine County	"Report of Investigations of Pollution of Surface Waters in the Fox (Ill.), Des Plaines, and Root River Basins, and Lake Michigan Waters, From Above Racine to the Wisconsin-Illinois Line"	A stream sampling and testing program which involved the determination of water quality conditions and the identification of probable sources of pollution.	Several sources of untreated and treated wastes were identified and described. Stream survey data indicated "unsatisfactory" conditions in Root River Canal and in the Root River within the City of Racine.
4	The State of Wisconsin Committee on Water Pollution	Summer 1962	Root River and tributaries	"Report on a Field Investigation of Surface Water Quality in Southeastern Wisconsin Conducted in the Summer of 1962"	A stream sampling and testing program which involved those parameters which could be observed or tested in the field; viz., biota, pH, tem., D.O., Cl., and spec. cond.	Pollution and "unsatisfactory" conditions were indicated on the Root River Canal below the Village of Union Grove.
5	Metropolitan Sewerage Commission of the County of Milwaukee	Summers of 1962-1964	Root River and tributaries above Milwaukee-Racine County line	Water quality streams survey. Unpublished	Program consists of weekly water sampling and testing program of standard parameters and observations of biota.	Uninterpreted; quantitative data is available.
6	Metropolitan Sewerage Commission of the County of Milwaukee	September 1964	Root River tributaries within City of Franklin	Spot sampling and testing program. Unpublished	Samples were collected in vicinity of suspected sources of pollution and tests made for those parameters which indicate pollution from human excrement.	Uninterpreted; quantitative data is available.
7	The State of Wisconsin Committee on Water Pollution	4/20/61 to Date (ongoing program)	Root River at Racine	State water quality monitoring program. Unpublished	Samples are collected monthly at one site on the Root River within the City of Racine (Marquette St. Bridge) and field and laboratory analyses made of standard quality parameters, including: total organic nitrogen, free ammonia, and soluble phosphorus.	Uninterpreted; quantitative data is available.

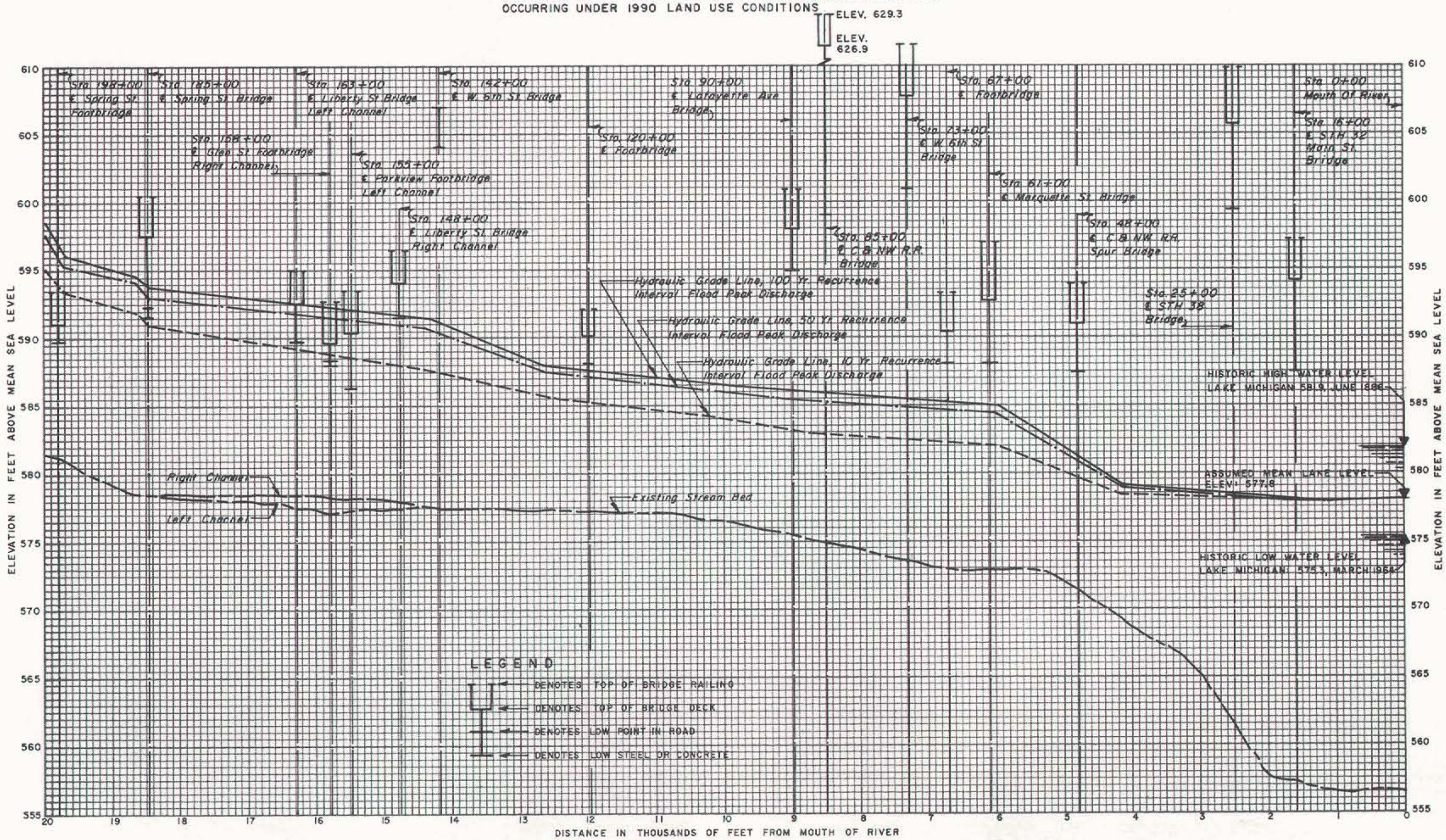
Source: SEWRPC.

Appendix E

HIGH WATER AND STREAM BED PROFILES OF THE ROOT RIVER

Figure E-1

HIGH WATER AND STREAM BED PROFILES
OF THE
ROOT RIVER
FROM STA. 0+00 TO STA. 200+00
RACINE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H.A.R. DATE: 11 JULY 1966
CHECKED: K.W.B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS
OCCURRING UNDER 1990 LAND USE CONDITIONS



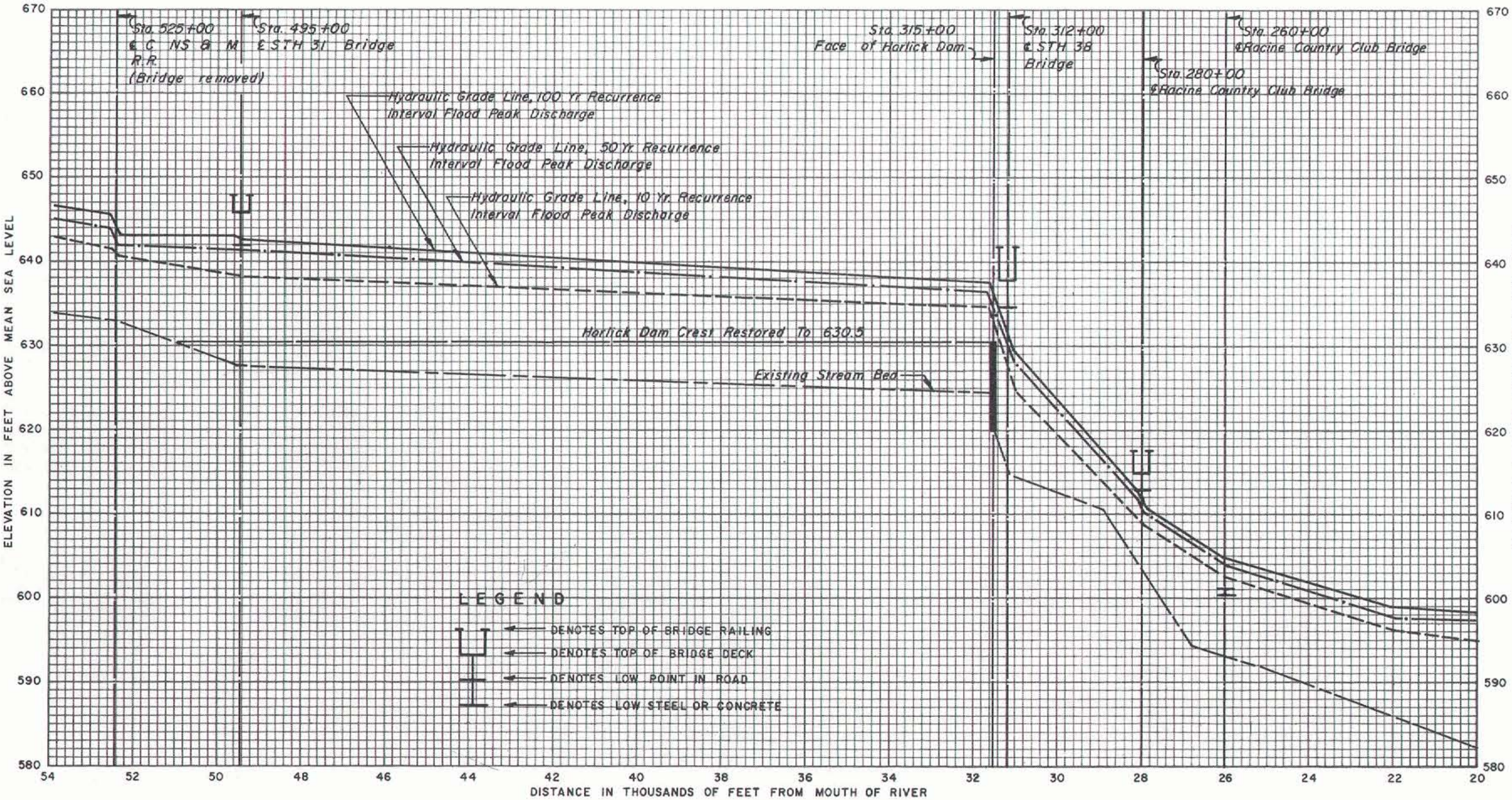
NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) — 1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) — 580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES OF THE ROOT RIVER

FROM STA. 200+00 TO STA. 540+00
RACINE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS OCCURRING UNDER 1990 LAND USE CONDITIONS

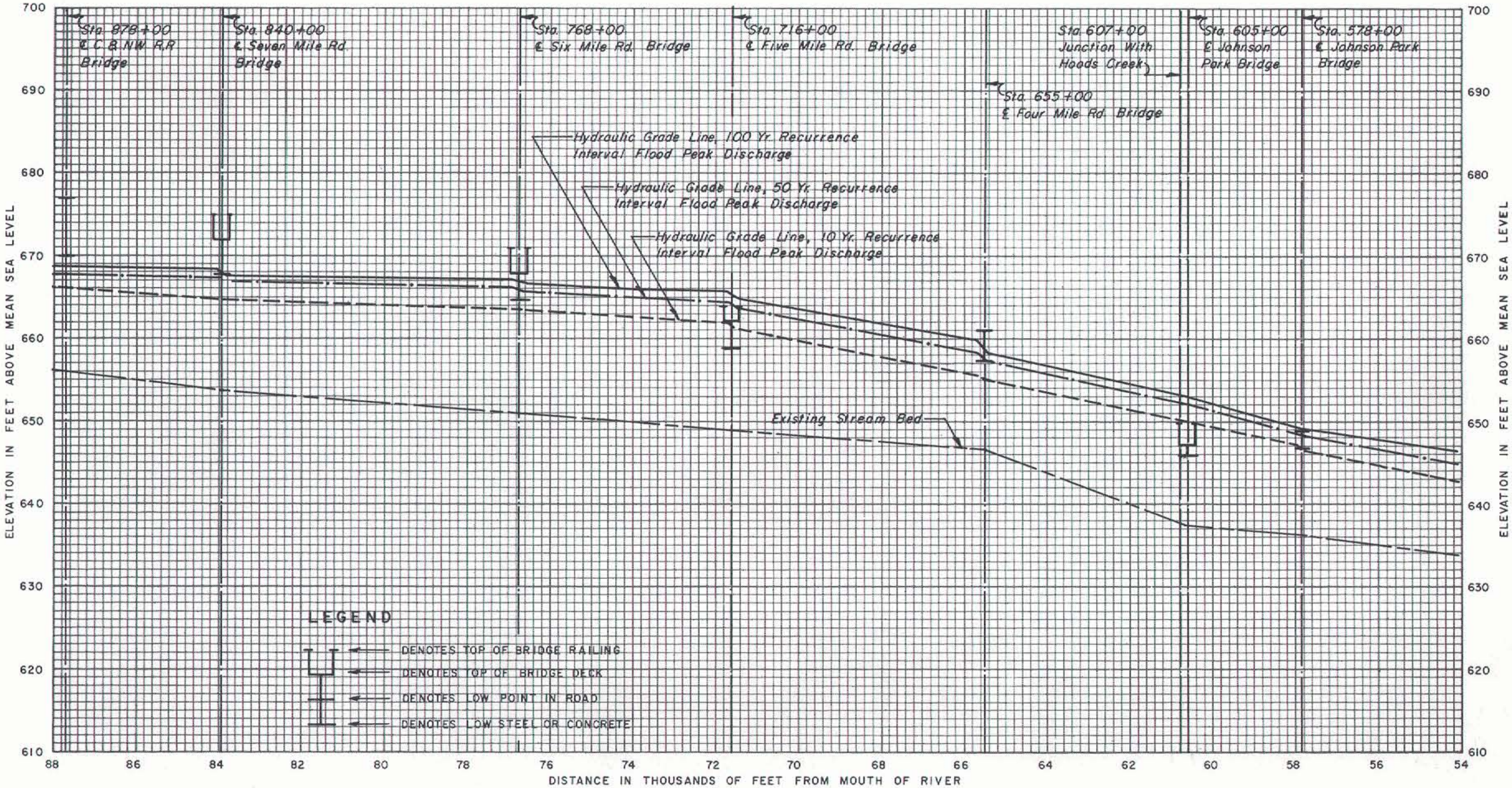


NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment)—1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) — 580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES
OF THE
ROOT RIVER
FROM STA. 540+00 TO STA. 880+00
RACINE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS
OCCURRING UNDER 1990 LAND USE CONDITIONS



NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) – 1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) – 580.710.

Source: Harza Engineering Company; SEWRPC.

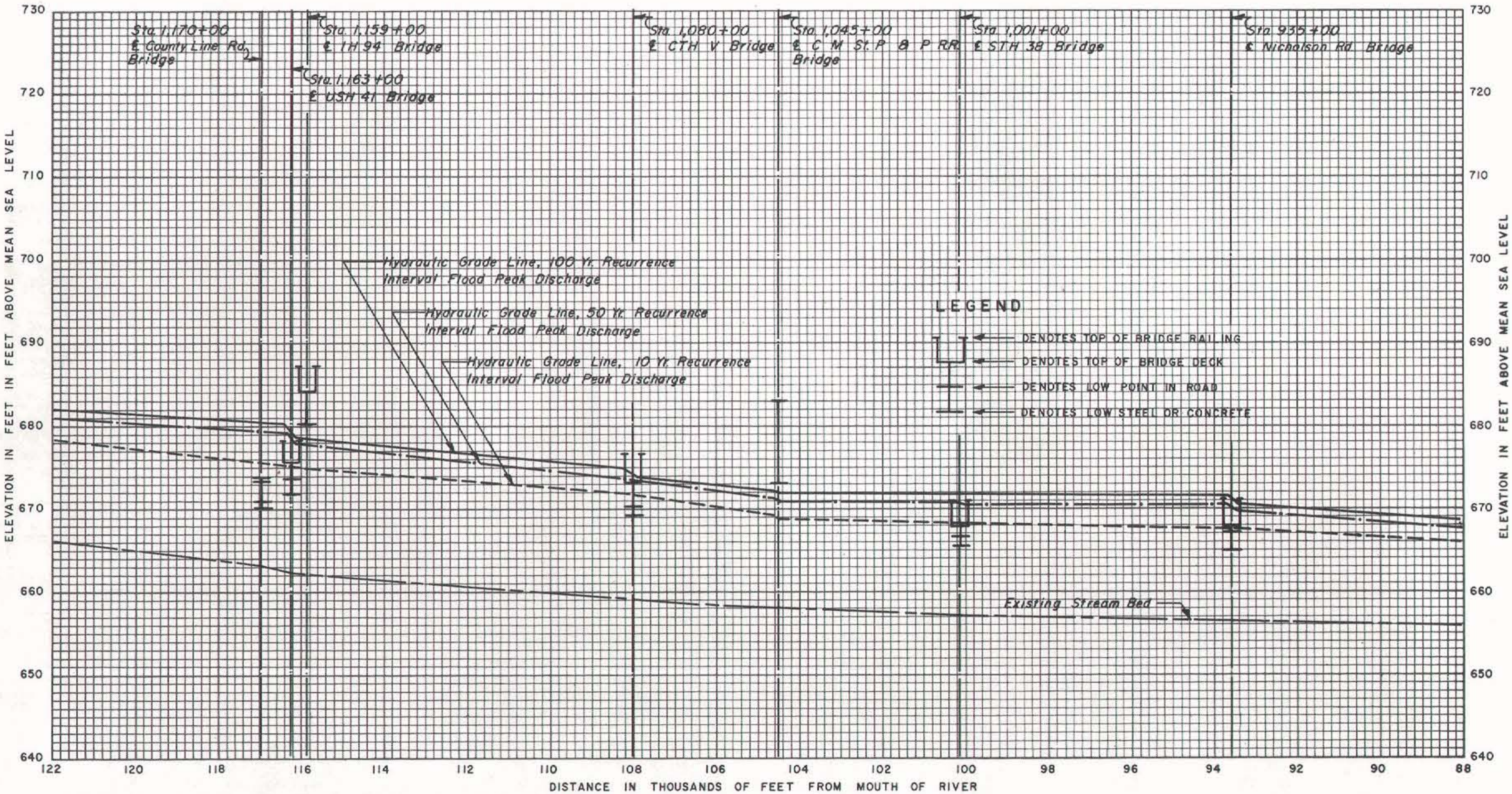
Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES

OF THE

ROOT RIVER

FROM STA. 880+00 TO STA. 1,220+00
RACINE AND MILWAUKEE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS
OCCURRING UNDER 1990 LAND USE CONDITIONS



NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) −1.3 feet.
Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum (1929 Adjustment) − 580.560
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) − 580.710

Source: Harza Engineering Company; SEWRPC

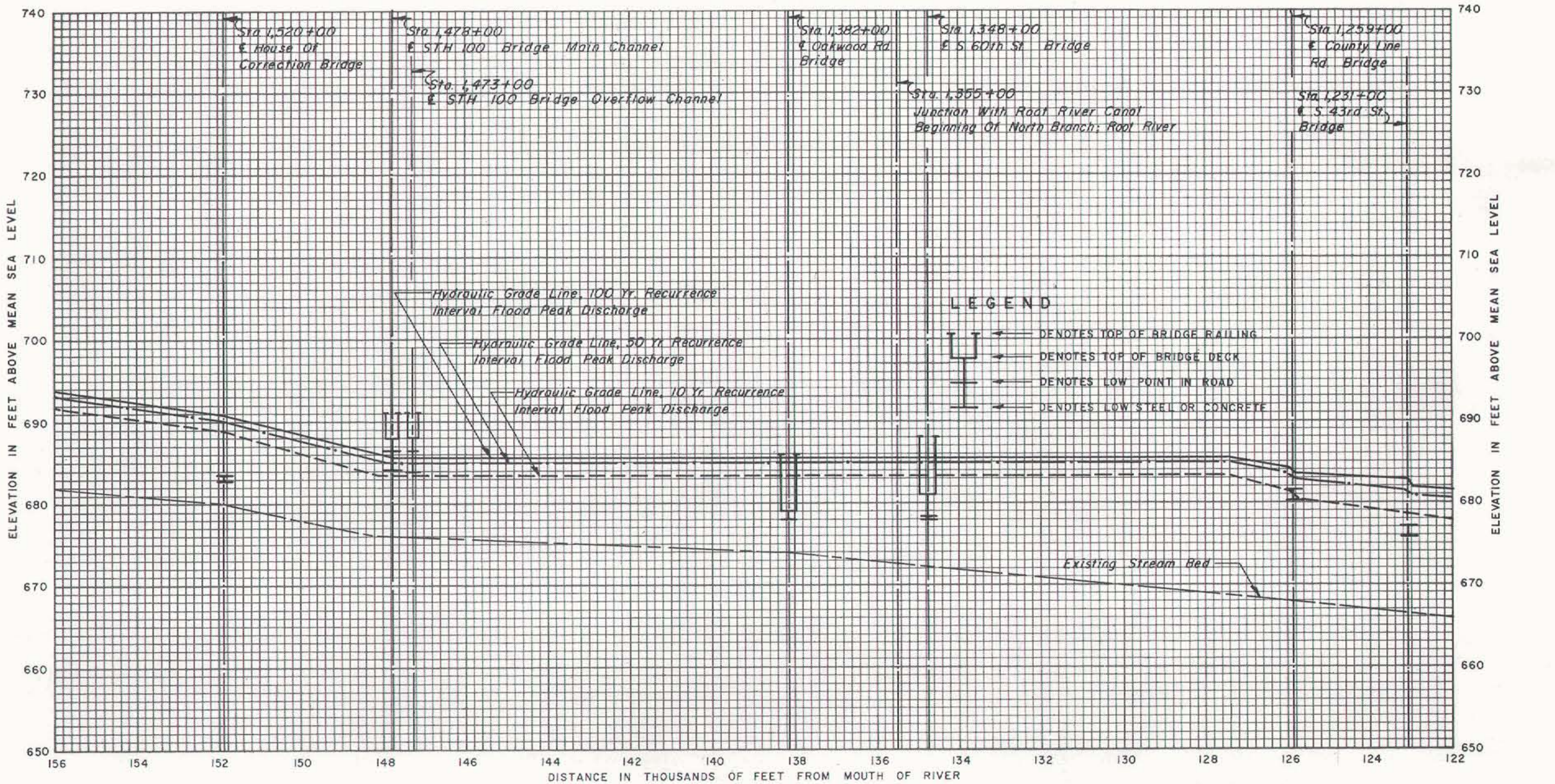
Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES

OF THE

ROOT RIVER

FROM STA. 1,220+00 TO STA. 1,560+00
RACINE AND MILWAUKEE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS OCCURRING UNDER 1990 LAND USE CONDITIONS



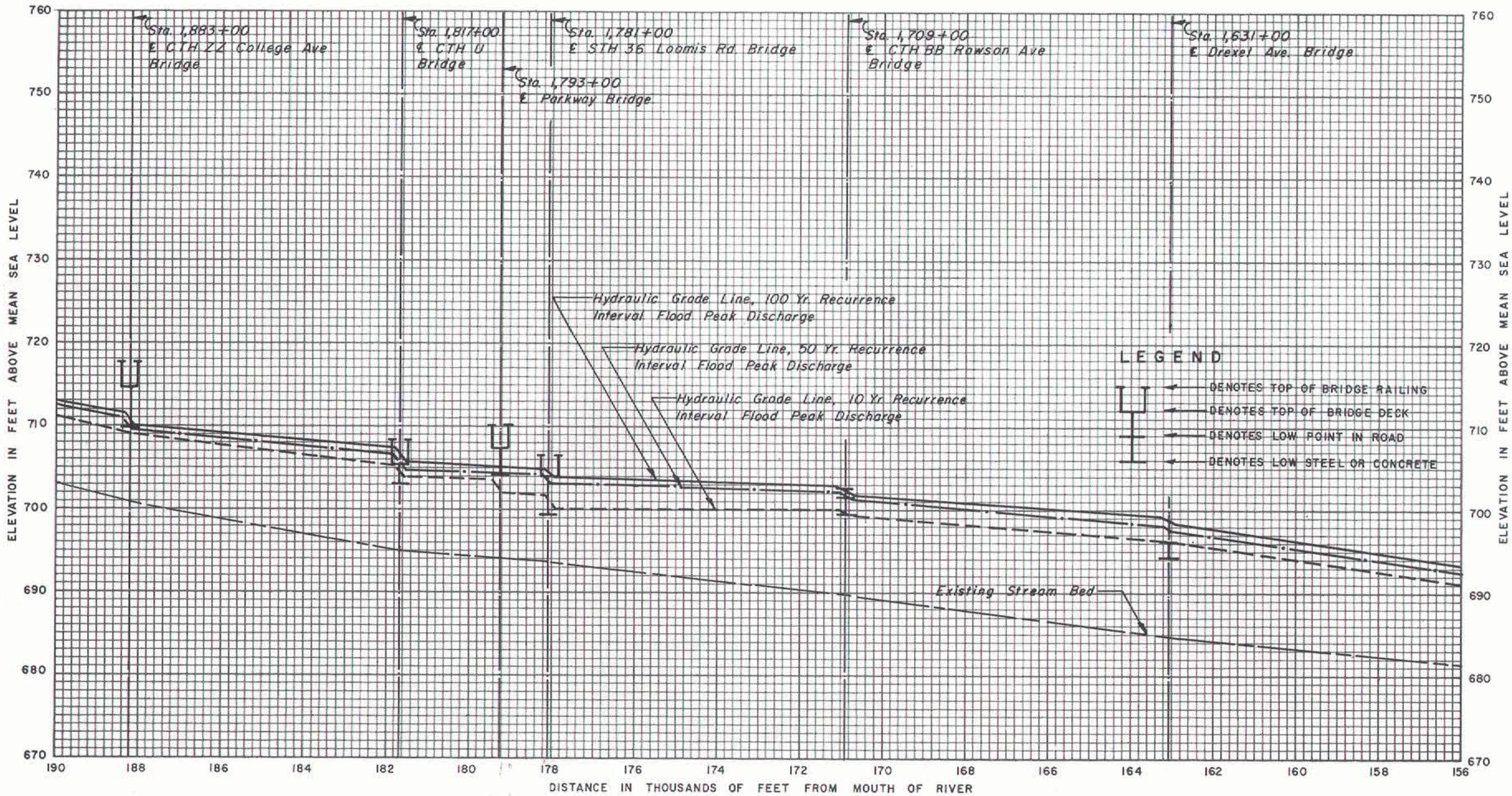
NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) —1.3 feet.
Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum (1929 Adjustment)— 580.560.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment)—580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES
OF THE
NORTH BRANCH; ROOT RIVER

FROM STA. 1,560+00 TO STA. 1,900+00
MILWAUKEE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS
OCCURRING UNDER 1990 LAND USE CONDITIONS



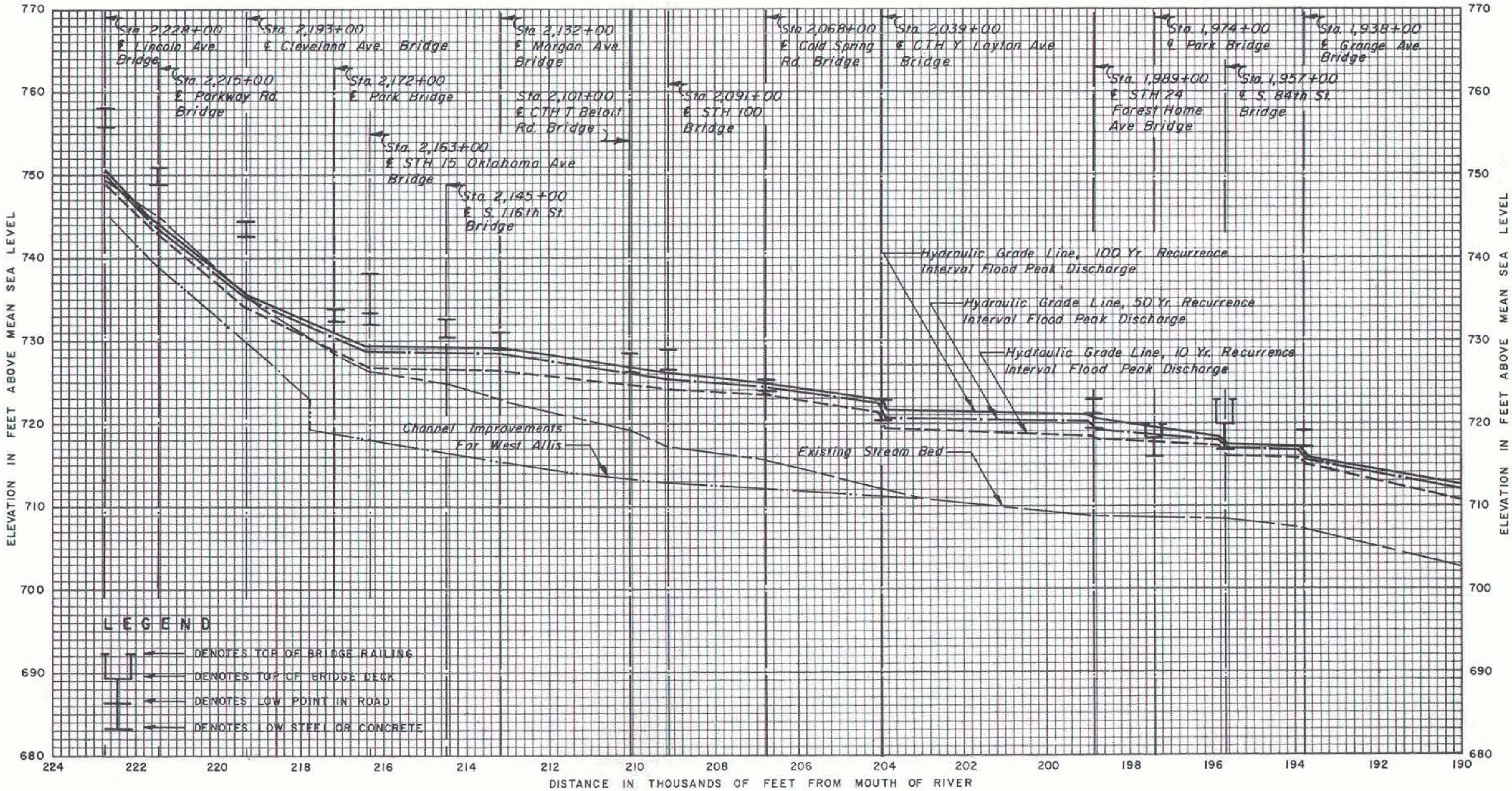
NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) – 1.3 feet.
Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum (1929 Adjustment) – 580.560.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES
OF THE
NORTH BRANCH; ROOT RIVER

FROM STA. 1,900+00 TO STA. 2,240+00
MILWAUKEE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS OCCURRING UNDER 1990 LAND USE CONDITIONS



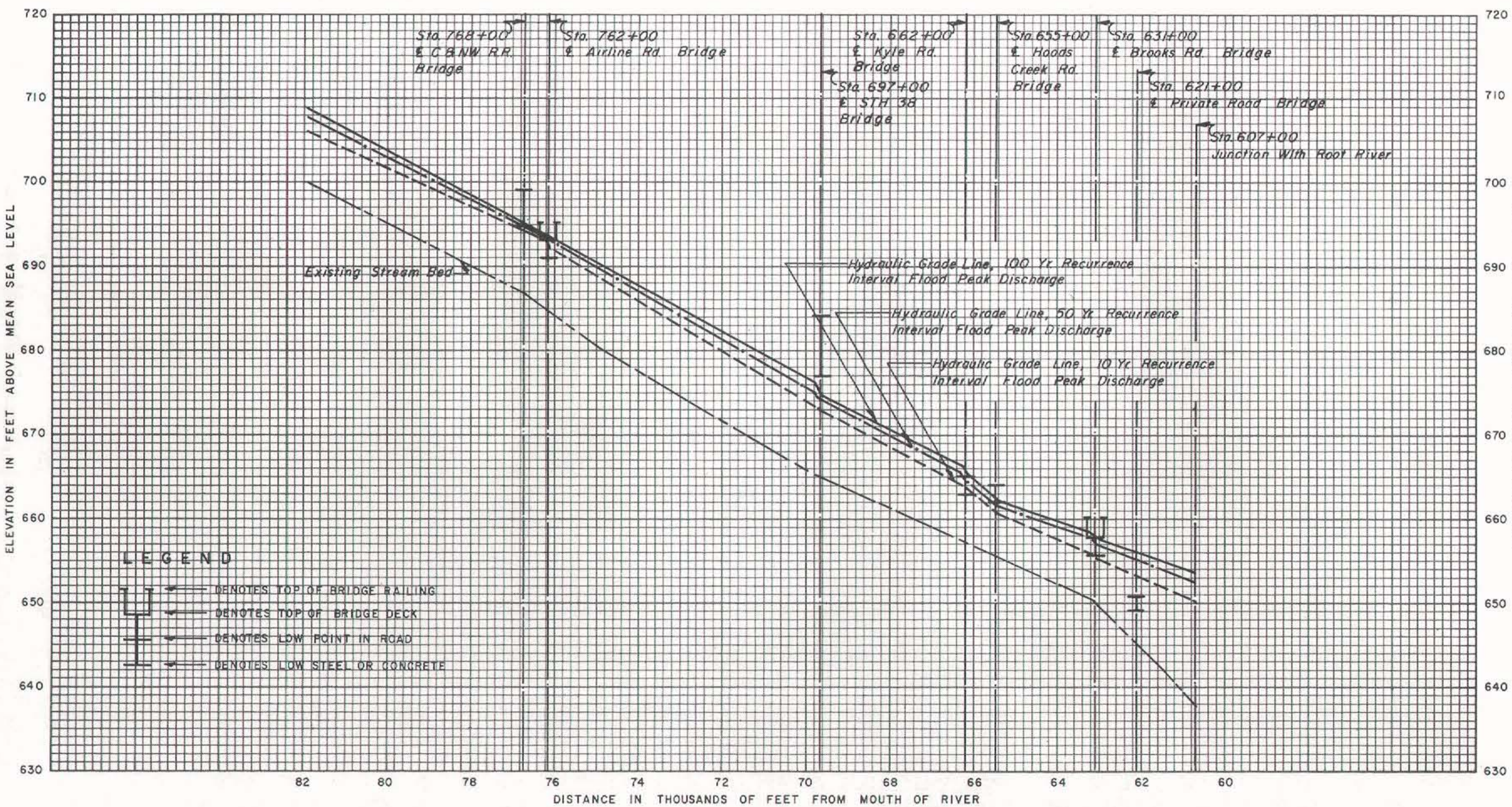
NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) − 1.3 feet.
Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum (1929 Adjustment) − 580.560.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES
OF
HOODS CREEK

FROM STA. 607+00 TO STA. 820+00
RACINE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS
OCCURRING UNDER 1990 LAND USE CONDITIONS



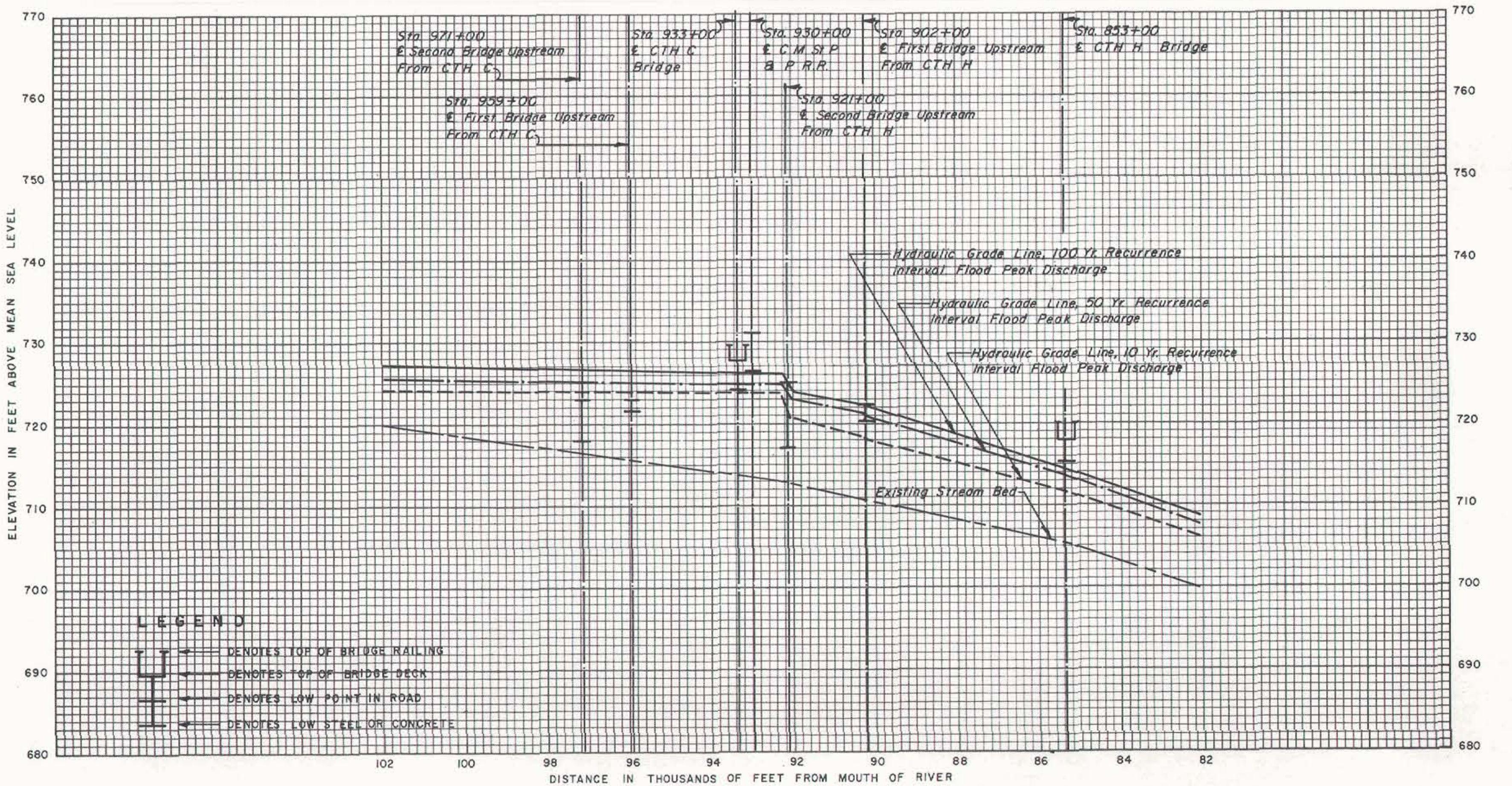
NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment)—1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) — 580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES
OF
HOODS CREEK

FROM STA. 820+00 TO STA. 1,020+00
RACINE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS OCCURRING UNDER 1990 LAND USE CONDITIONS



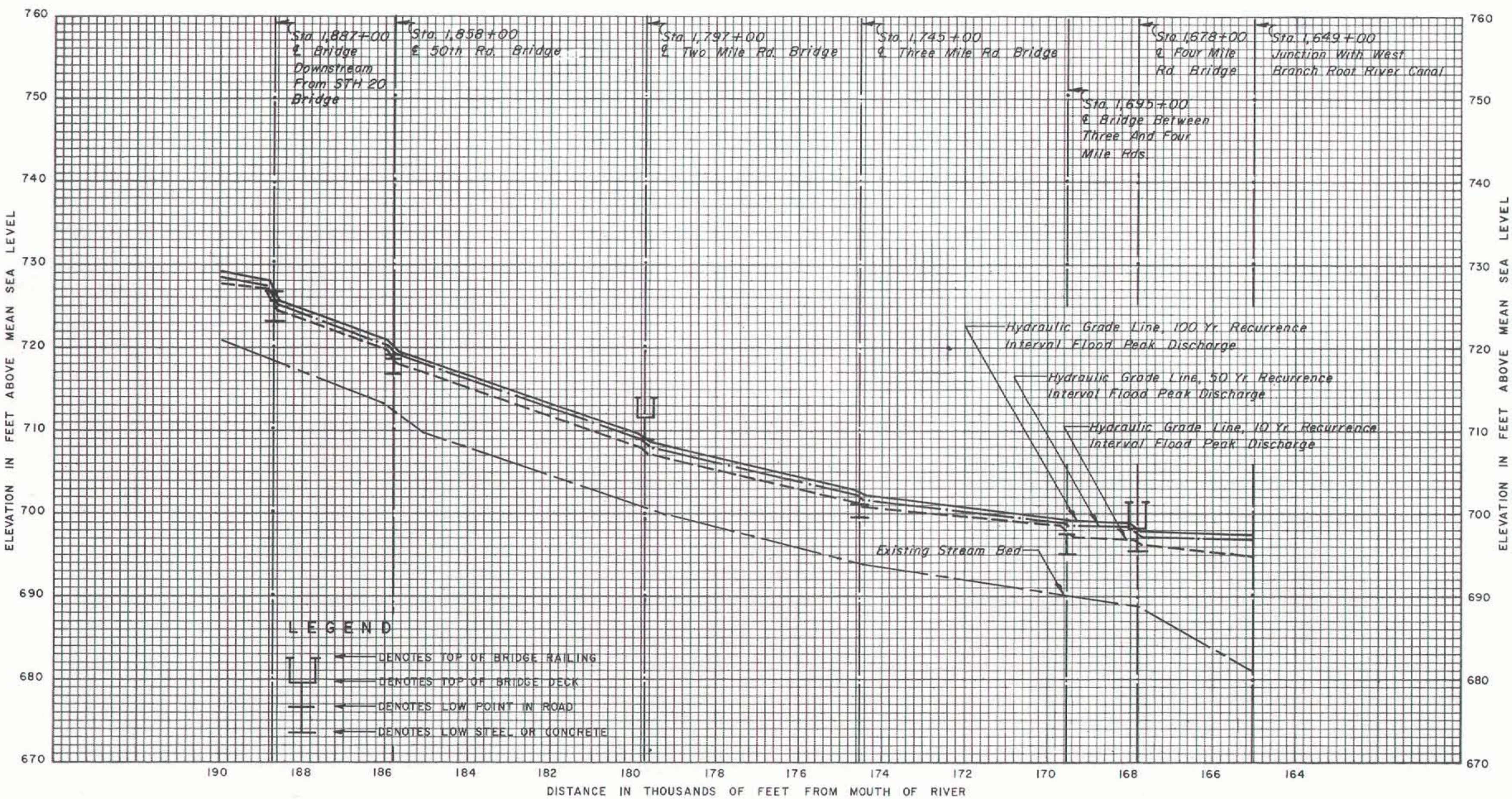
NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment)—1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment)— 580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES
OF THE
EAST BRANCH; ROOT RIVER CANAL

FROM STA. 1,649+00 TO STA. 1,900+00
RACINE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS
OCCURRING UNDER 1990 LAND USE CONDITIONS



NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment)—1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment)— 580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES

OF THE

EAST BRANCH; ROOT RIVER CANAL

FROM STA. 1,900+00 TO STA. 2,154+00

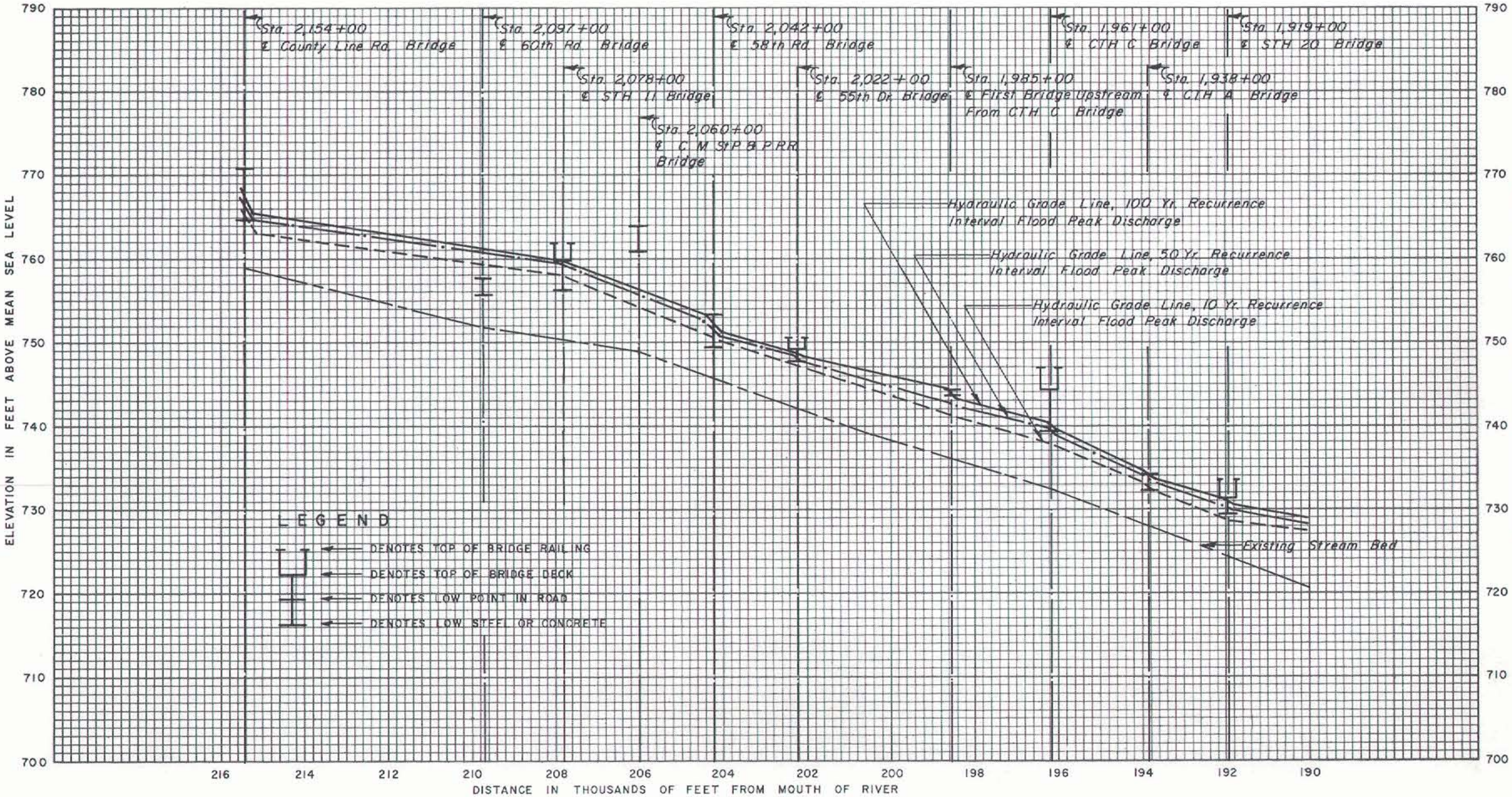
RACINE COUNTY, WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

DRAWN: H. A. R. DATE: 11 JULY 1966

CHECKED: K. W. B. DATE: 11 JULY 1966

HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS OCCURRING UNDER 1990 LAND USE CONDITIONS



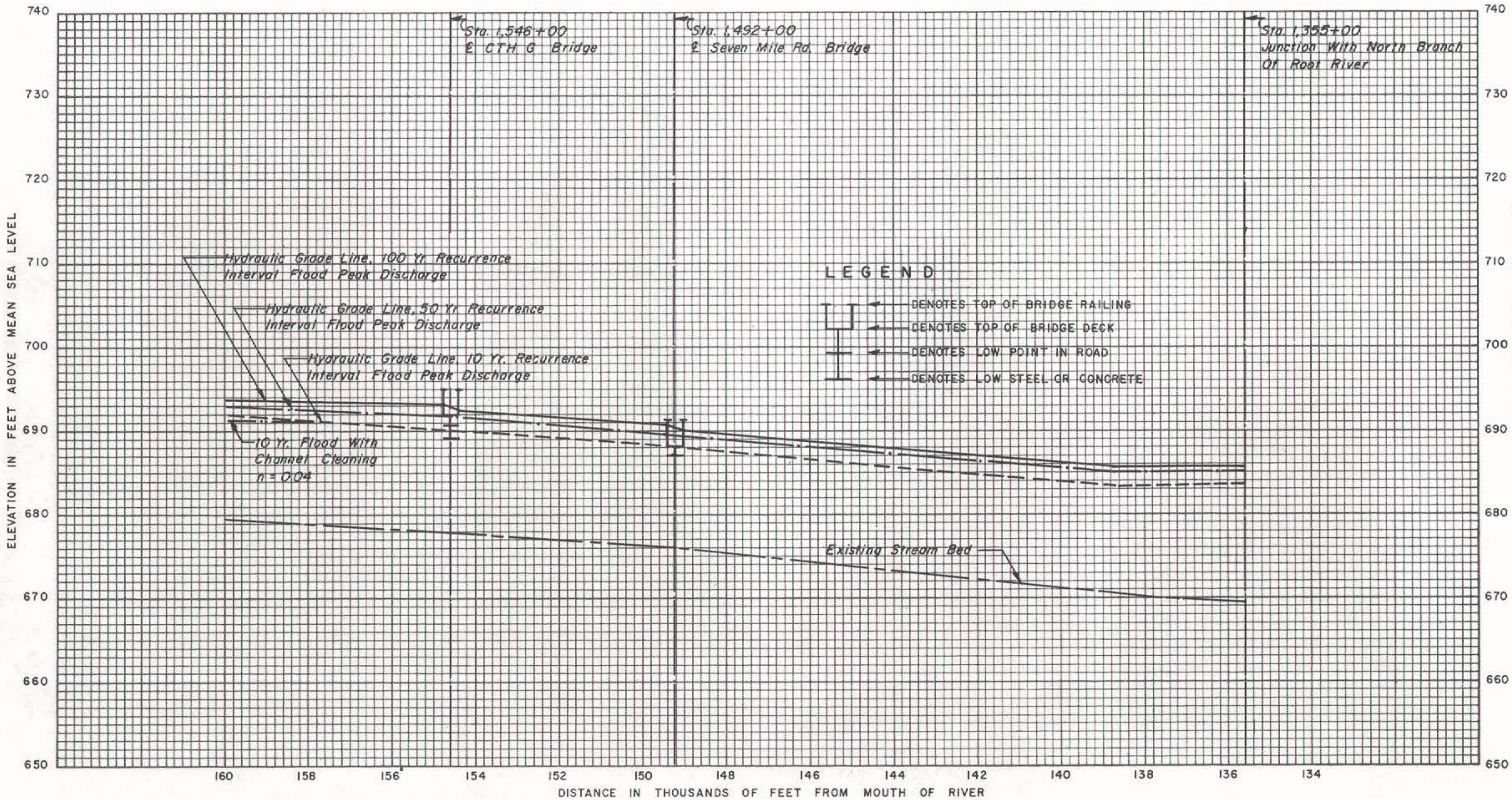
NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) − 1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) − 580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES
OF THE
ROOT RIVER CANAL

FROM STA. 1,355+00 TO STA. 1,600+00
RACINE AND MILWAUKEE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H. A. R. DATE: 11 JULY 1966
CHECKED: K. W. B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS
OCCURRING UNDER 1990 LAND USE CONDITIONS



NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) — 1.3 feet.
Milwaukee Metropolitan Sewerage Commission = Mean Sea Level Datum (1929 Adjustment) — 580.560.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) — 580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES

OF THE

ROOT RIVER CANAL & WEST BRANCH; ROOT RIVER CANAL

FROM STA. 1,600+00 TO STA. 1,860+00

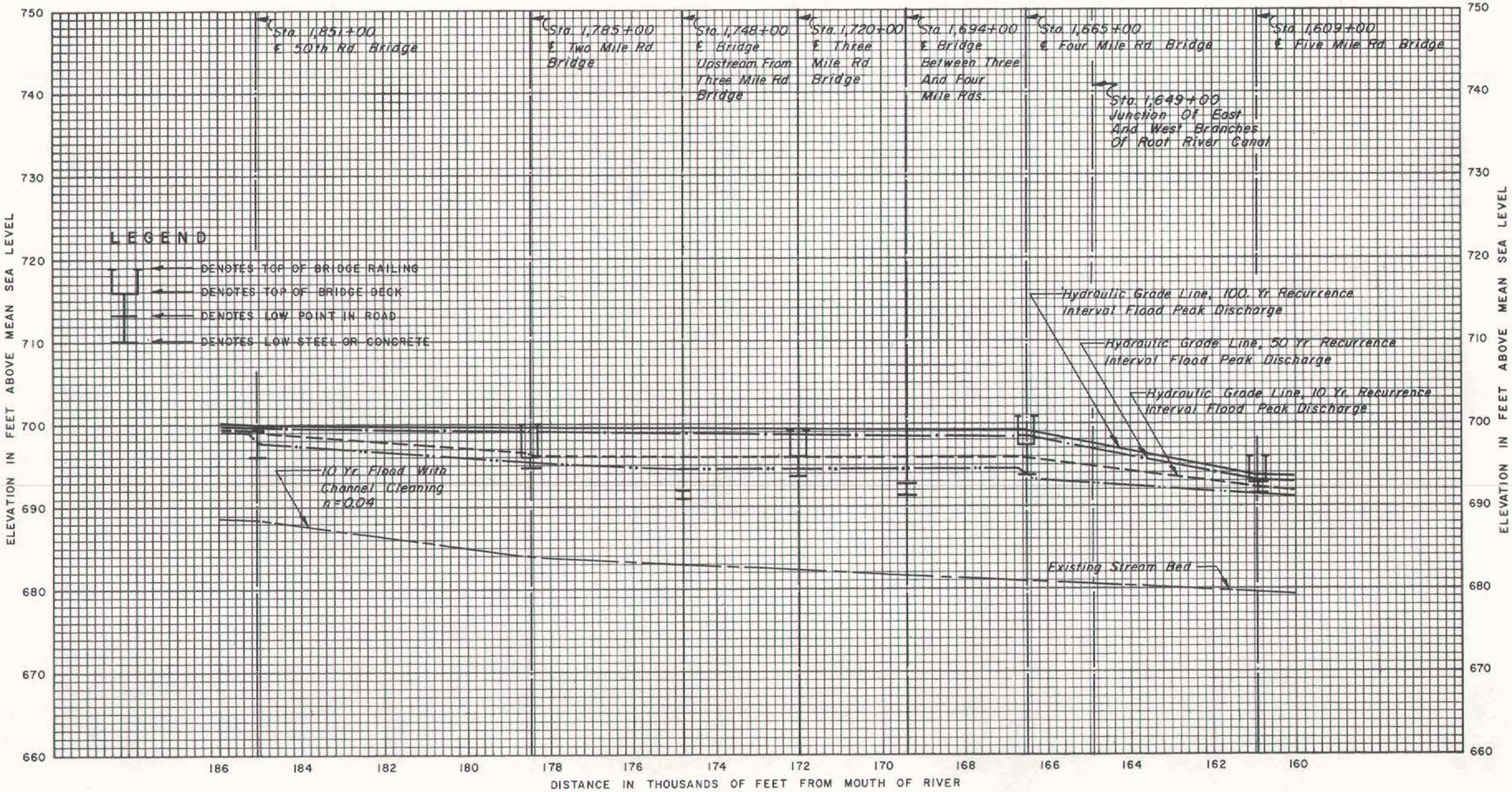
RACINE COUNTY, WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

DRAWN: H.A.R. DATE: 11 JULY 1966

CHECKED: K.W.B. DATE: 11 JULY 1966

HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS OCCURRING UNDER 1990 LAND USE CONDITIONS



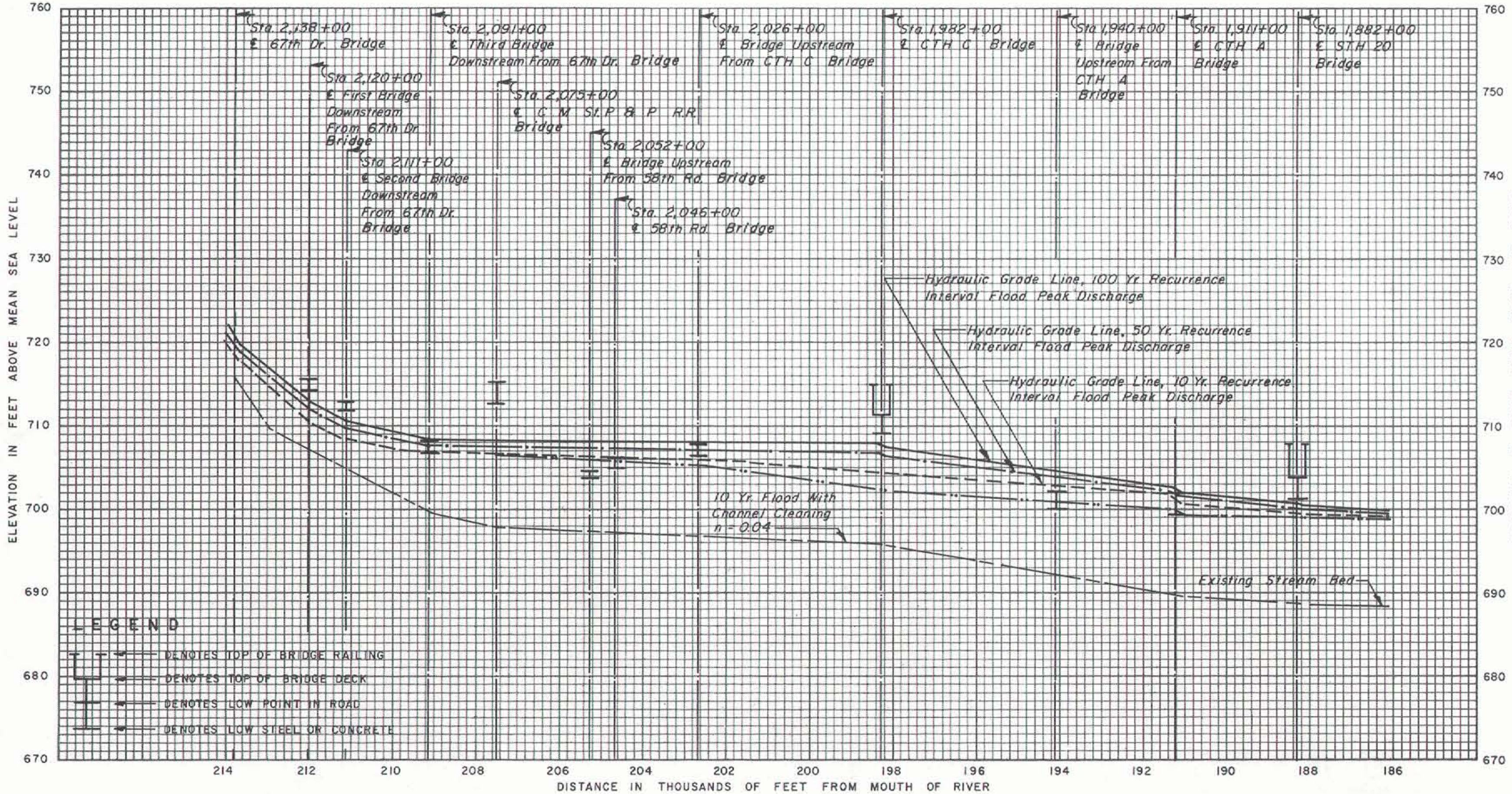
NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) − 1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) − 580.710.

Source: Harza Engineering Company; SEWRPC.

Figure E-1 (continued)

HIGH WATER AND STREAM BED PROFILES
OF THE
WEST BRANCH; ROOT RIVER CANAL

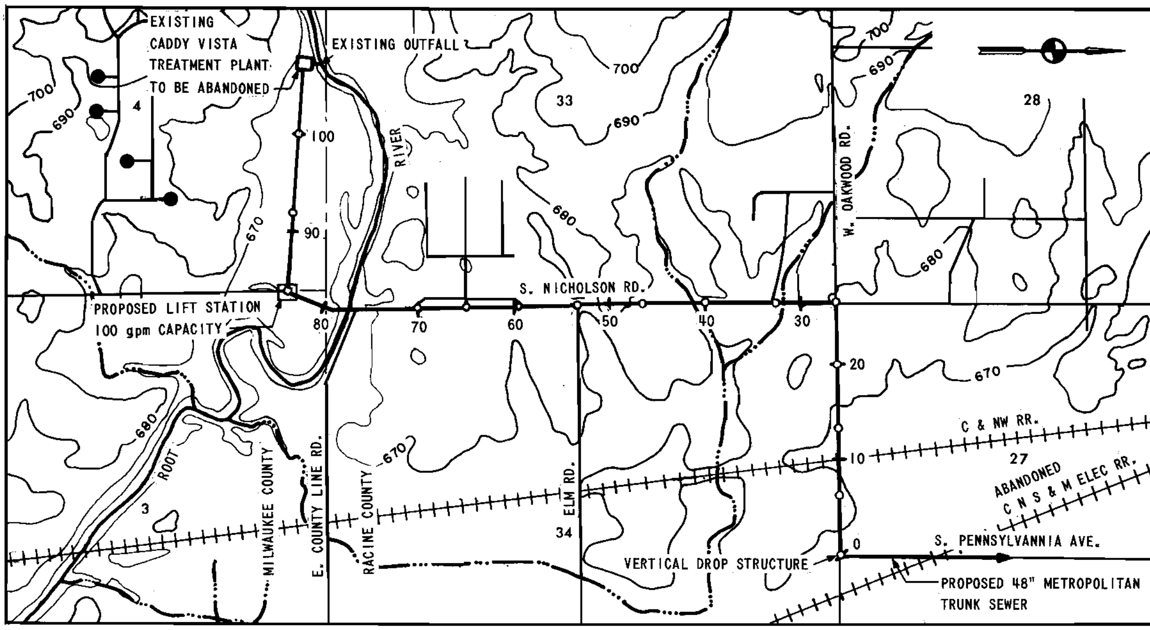
FROM STA. 1,860+00 TO STA. 2,140+00
RACINE COUNTY, WISCONSIN
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
DRAWN: H.A.R. DATE: 11 JULY 1966
CHECKED: K.W.B. DATE: 11 JULY 1966
HYDRAULIC GRADE LINES REPRESENT PEAK DISCHARGE CONDITIONS
OCCURRING UNDER 1990 LAND USE CONDITIONS



NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment)—1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment)—580.710.

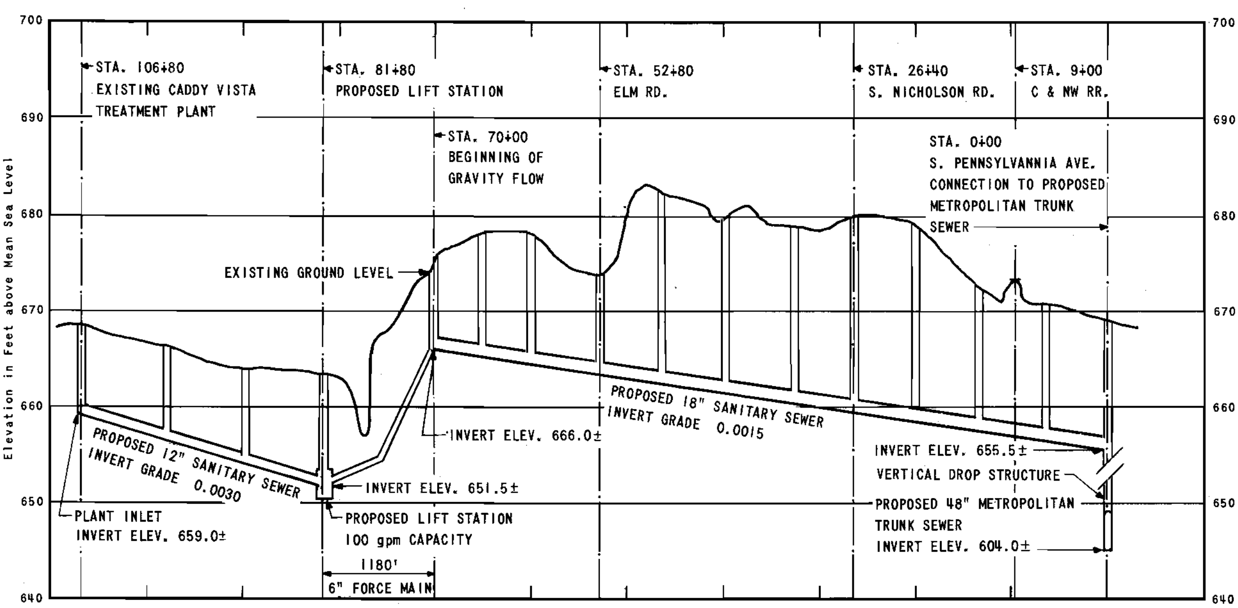
Source: Harza Engineering Company; SEWRPC.

Figure E-2
PROPOSED SEWER CONNECTION FROM CADDY VISTA
TO MILWAUKEE METROPOLITAN SEWERAGE SYSTEM



PLAN

Scale: 1 Inch = 2000 Feet



PROFILE

Scale: Horizontal, 1 Inch = 2000 Feet
Vertical, 1 Inch = 20 Feet

NOTE: In absence of sanitary sewer system plan; plan and profile are intended only to indicate feasibily of connection using available existing rights-of-way. Actual connection should be designed as an integral part of sanitary sewer system plan for the city of Oak Creek.

International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) - 1.3 feet.

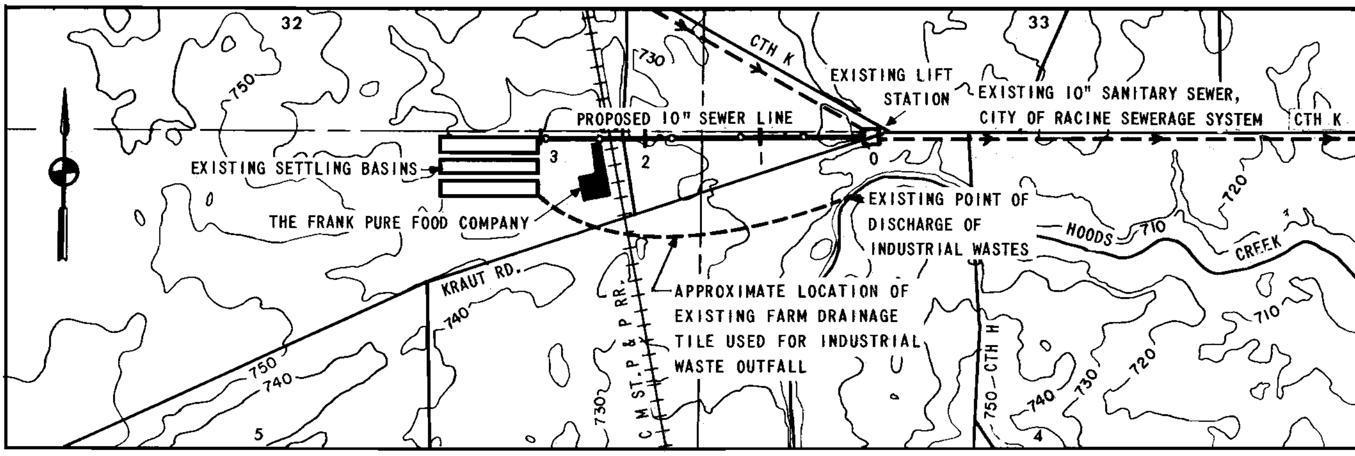
Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum (1929 Adjustment) - 580.560.

Racine City Datum = Mean Sea Level Datum (1929 Adjustment) - 580.710.

SOURCE: Harza Engineering Company; SEWRPC.

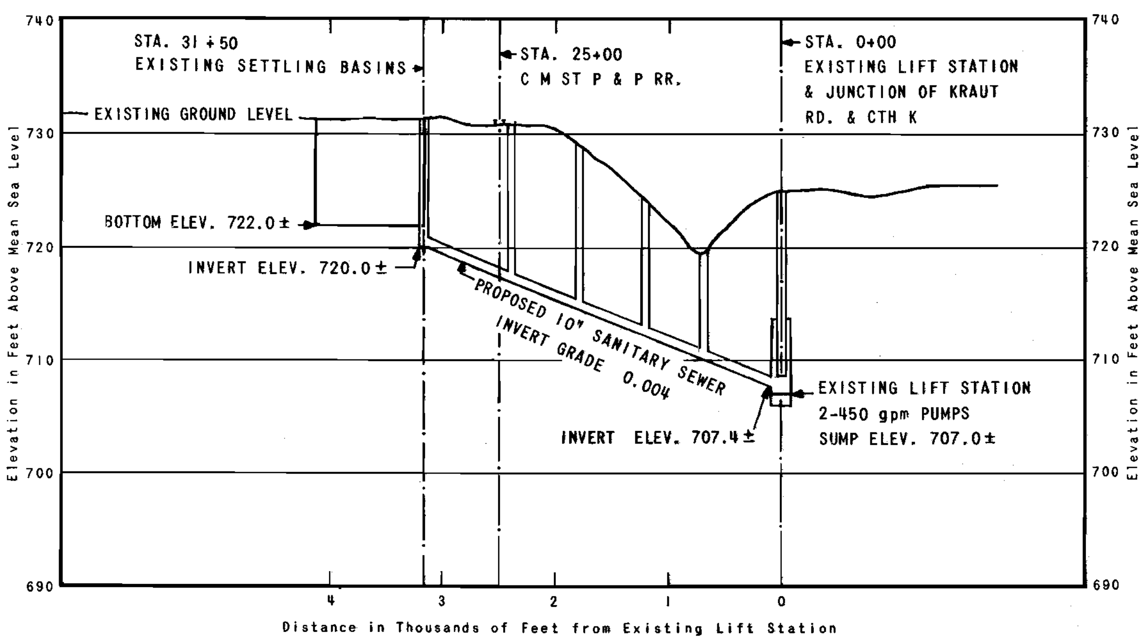
Figure E-3

PROPOSED SEWER CONNECTION FROM THE FRANK PURE FOOD COMPANY PLANT TO THE CITY OF RACINE SEWER SYSTEM



PLAN

Scale: 1 Inch = 2000 Feet



PROFILE

Scale: Horizontal, 1 Inch = 2000 Feet
Vertical, 1 Inch = 20 Feet

NOTE: International Great Lakes Datum (1955) = Mean Sea Level Datum (1929 Adjustment) - 1.3 feet.
Racine City Datum = Mean Sea Level Datum (1929 Adjustment) - 580.710.

Source: Harza Engineering Company; SEWRPC.

Appendix F

DERIVATION OF STAGE-AREA-DISCHARGE CURVES

Use

Curves relating river stage, cross-sectional area, and discharge at 111 selected points in the perennial stream channel system of the Root River watershed were prepared as a part of the hydrologic and hydraulic analyses undertaken under the Root River study (see Figures 18 and 19 for typical curves). These curves fulfill two functions: 1) they establish the channel conveyance and flood plain storage properties necessary for flood routing, and 2) they establish the water surface-discharge relationships necessary for the preparation of flood inundation maps.

Sources of Basic Data

The dimensions and elevations shown on the typical curves presented in Figures 18 and 19 are based upon field surveys at the selected stations on the perennial stream channels and upon analyses of topographic maps covering the area extending from the station halfway upstream and downstream toward adjacent stations. The field surveys established the shape, dimensions, and elevations of the channel cross section, the roadway profile, and the waterway opening at the station. Complete measurements, including bottom of structure and roadway elevations, skewness, and normal direction of flow, were obtained at all bridges. Topographic maps were used to estimate representative overbank characteristics. A continuous profile of elevations from station to station along the stream course was constructed from field surveys and from a compilation of available horizontal and vertical control data. The field surveys also included an inspection of channel characteristics and vegetative growth for determination of n factors to be applied in the Manning equation.

In the representative cross sections used for determination of channel conveyance, channel bottoms are presented as flat and level; and channel shapes are generally presented as symmetrical. This method was considered to provide the best representation of channel conditions throughout the reach length, based on measured cross sections and field interpretation of conditions between measured sections.

Derivation of the Stage-Area and Downstream Stage-Discharge Curves

The Manning equation was used in constructing the stage-area curve of the station and the downstream stage-discharge curve. This equation was solved for selected stages in order to define accurately the shape of the area- and stage-discharge curves. The successive steps in derivation of the curves are indicated by the calculations shown on Figures 18 and 19. The following information provides a guide to the calculations shown.

Area-Discharge Curve: Area, A, is obtained from the representative cross section of the waterway opening as the area of streamflow corresponding to each stage. In the sample calculations, shown on Figures 18 and 19, the cross-sectional areas of channel and of overbank flow are tabulated separately and must be summed before the stage-area curve is plotted.

Stage-Discharge Curve:

1. Slope, s, of the energy gradeline in feet per foot is assumed to be equal to the average slope of the channel bed in the reach immediately downstream from the designated station.

2. Selection of the friction factor, n, is based on summer conditions when vegetative growth is full, following the procedure outlined in Table 14.

3. All depths shown are from the deepest point of the channel to the water surface.

4. The wetted perimeter, W. P., is the cross-sectional length of the channel bed and flood plain which is in contact with streamflow at the stage under consideration and is obtained by scaling the plotted cross sections. The W. P. of the overbank section, in the rather gentle slopes prevailing in the Root River flood plain, is assumed to be equal to the horizontal distance of inundation of the flood plain in the line of cross section.

5. The hydraulic radius or hydraulic mean depth, R, is equal to the cross-sectional area of flow, A, at the stage under consideration divided by the wetted perimeter, W. P.

6. The Manning equation is then solved for channel flow, Qc, and overbank flow, Qo, which are summed to derive the total flow, Qt, used in plotting the stage-discharge curve.

Derivation of Discharge Curves Showing the Effects of Structures at the Station

The head loss or backwater effect of the waterway opening was calculated both for open channel conditions when bridges and culverts flow partly full and for orifice conditions when waterway openings would be flowing full. These computations were used to develop the "upstream" curve, which indicates the backwater effect caused by the structure and conveyance capabilities of the waterway opening. Under open-channel flow conditions, two computational procedures were used: one for culverts and one for bridge openings. Culverts were defined as having a length parallel to the direction of flow greater than the span normal to the direction of flow.

Open-Channel Flow in Culverts: The Manning equation was used to determine open-channel flow quantities for waterway openings which function as culverts. For a selected discharge, a mid-culvert water surface elevation slightly higher than the downstream water surface elevation was assumed and the slope of the energy gradeline determined. This process was repeated until the assumed water surface elevation was verified. The procedure was applied for selected discharges until the culvert was flowing full, at which point orifice flow conditions exist and the Manning equation is no longer applicable.

Open-Channel Flow in Bridge Openings: The procedure recommended by the U. S. Bureau of Public Roads in Hydraulic Design Series No. 1, Hydraulic of Bridge Waterways, was followed in the calculation of head losses for bridges flowing partly full. The basic equation for determination of the backwater effect of such a bridge opening is:

$$h_1^* = K^* \frac{Vn_2^2}{2g}$$

where: h_1^* = Total backwater in feet

K = Total backwater coefficient = Kb + Kp + Ke + Ks

Kb = Base coefficient (conveyance)

Kp = Coefficient for piers

Ke = Coefficient for eccentricity

Ks = Coefficient for skew

Vn_2 = Average velocity in constriction of flow at downstream stage

g = Acceleration of gravity = 32.2 ft/sec^2

When the computations reached the stage where the bridge started to flow full, it was treated as an orifice.

Orifice Flow: The general equation for the head loss, h, caused by orifice flow is:

$$\Delta h = Q^2/2gC^2A$$

where: Q = Discharge in cubic feet per second;

and: C = Coefficient of discharge as given in King's Handbook of Hydraulics; and

A = Area of the submerged waterway opening in sq. ft.

The orifice flow analysis is begun with routing through the orifice, a slightly larger discharge than the last discharge used in open-channel flow. Δh is thus determined and is added to the downstream water surface elevation to obtain the upstream water surface elevation. If the downstream elevation, as determined by the downstream rating curve, is less than the crown elevation of the waterway opening, the crown elevation is used as the downstream elevation. This is a valid assumption because "C" does not change greatly when the length of a waterway opening, which flows full, changes. When the upstream water surface becomes higher than the road surface elevation, the value of "C" is multiplied by 0.8 to account for the loss of available head by flow over the roadway embankment.

Free Flow Over a Roadway or Embankment: Streamflow over a roadway is considered as flow over a broad crested weir, and the equation used to calculate flow was that for trapezoidal broad crested weir:

$$Q = h_e^{3/2} (K_1 + K_2 h_e)$$

where: Q = Discharge in cubic feet per second.

and: h_e = Difference in upstream water surface elevation and roadway elevation;

k_1 = 3.1 CT_1;

k_2 = 1.24 C(A + B);

T_1 = Length of level section of road

C = 0.80 to 0.90 for road and highway fills;

A & B = Horizontal component of road slope; and

Using the field survey notes, the centerline profile of the roadway was drawn as approximating a trapezoidal section. A and B are determined as the horizontal components of the side slopes; and a separate rating curve was prepared for flow over roadways, as shown in Figures 18 and 19.

Total Flow at Station: The total flow at the site of a structure, Ot', is then equal to the sum of free flow over the road, Qf, plus open channel flow, Oo, or orifice flow, Qo'. The point of intersection of the Ot' curve with the Qt curve is that stage at which the structures have little or no effect on streamflow and upstream stage equals downstream stage. In reference to Figures 18 and 19, it is to be noted that at high water stages the backwater effect from the roadway embankment and the bridge structures becomes negligible. Consequently, above a certain stage the downstream stage-discharge curve also applies to discharges above the station; and, accordingly, the upper segment of the stage-discharge curve is labeled as an "upstream and downstream" curve.

Appendix G

HYDRAULIC DATA SUMMARY FOR BRIDGES OVER THE ROOT RIVER

Table G-1

HYDRAULIC ANALYSIS SUMMARY NORTH BRANCH ROOT RIVER

10 YEAR RECURRENCE FLOOD, 1990 CONDITIONS[a]

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening		Replacement Waterway Opening	
								Bridge Head Loss (feet)	Depth on Road at Bridge (feet)	Bridge Head Loss (feet)	Depth on Road at Bridge (feet)
Lincoln Avenue	1930	10	--[c]	4,400	430	749.2	-6.8	--	--	0.1	-8.6
Parkway Road	1937	10	--[c]	6,200	460	743.5	-7.5	--	--	0.1	-7.7
W. Cleveland Avenue.	1936	50	--[c]	5,600	500	734.2	-6.8	--	--	0.1	-8.3
STH 15	1932	50	--[c]	3,850	1,600	727.0	-4.0	--	--	0.1	-6.4
S. 116th Street.	1919	10	--[c]	4,150	1,630	726.7[f]	-4.7	--	--	0.1	-5.0
W. Morgan Avenue	1926	10	--[c]	2,300	1,665	726.4	-1.6	--	--	0.1	-3.3
W. Beloit Road	1927	50	--[c]	1,100	1,735	724.8[f]	1.4	--	--	0.1	-4.2
STH 100.	1959	50	--[c]	1,250	1,735	724.5	1.5	--	--	0.1	-3.9
W. Cold Spring Road.	1926	50	--[c]	1,250	1,805	723.8	1.8	--	--	0.1	-1.7
W. Layton Avenue	1939	50	Yes	150	2,090	721.3	3.3	2.0	-0.7	0.1	-2.7
W. Forest Home Avenue.	1963	50	No	460	2,050	718.7	3.4	0.3	-2.2	--	--
S. 84th Street	1930	50	Yes	180	2.015	717.4	4.1	1.3	-0.2	0.1	-1.5
W. Grange Avenue	1928	50	Yes	150	1,870	716.0	4.0	1.0	-0.8	0.1	-1.8
W. College Avenue.	1939	10	No	220	1,685	709.0	4.0	0.1	-5.4	--	--
S. 76th Street	1934	50	Yes	270	2,870	705.2	4.9	1.3	-0.4	0.1	-1.7
Parkway Road	1890	10	No	130	2,730	703.8	5.3	1.4	0.5	--	--
W. Loomis Road	1933	50	Yes	110	2,530	701.8	3.8	2.0	-1.8	0.1	-3.8
W. Rawson Avenue	1957	50	No	170	2,560	700.1	6.6	0.5	-2.2	--	--
W. Drexel Avenue	1960	50	Yes	160	2,675	696.3	6.3	0.1	1.9	0.1	-2.0
STH 100.	1934	50	No	200	3,225	683.5[f]	2.1	0.7	-3.8	--	--

50 YEAR RECURRENCE FLOOD, 1990 CONDITIONS[a]

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening		Replacement Waterway Opening	
								Bridge Head Loss (feet)	Depth on Road at Bridge (feet)	Bridge Head Loss (feet)	Depth on Road at Bridge (feet)
Lincoln Avenue	1930	10	--[c]	4,400	670	750.2	-5.8	--	--	0.1	-7.6
Parkway Road	1937	10	--[c]	6,200	715	744.4	-6.6	--	--	0.1	-6.8
W. Cleveland Avenue.	1936	50	--[c]	5,600	775	735.1	-5.9	--	--	0.1	-7.4
STH 15	1932	50	--[c]	3,850	2,500	728.7	-2.3	--	--	0.1	-4.7
S. 116th Street.	1919	10	--[c]	4,150	2,515	728.7[f]	-3.1	--	--	0.1	-3.4
W. Morgan Avenue	1926	10	--[c]	2,300	2,530	728.7	0.7	--	--	0.1	-1.0
W. Beloit Road	1927	50	--[c]	1,100	2,555	726.2[f]	2.3	--	--	0.1	-3.3
STH 100.	1959	50	--[c]	1,250	2,555	725.7	2.7	--	--	0.1	-2.7
W. Cold Spring Road.	1926	50	--[c]	1,250	2,585	724.8	2.8	--	--	0.1	-0.7
W. Layton Avenue	1939	50	Yes	150	2,975	722.7	3.9	2.8	0.7	0.1	-2.1
W. Forest Home Avenue.	1963	50	No	460	3,075	720.4	4.3	1.1	-0.5	--	--
S. 84th Street	1930	50	Yes	180	3,010	718.3	5.0	1.3	0.7	0.3	-0.3
W. Grange Avenue	1928	50	Yes	150	2,770	717.3	4.8	1.5	0.5	0.3	-0.7
W. College Avenue.	1939	10	No	220	2,460	710.7	4.6	1.1	-3.7	--	--
S. 76th Street (CTH U)	1934	50	Yes	270	3,950	706.7	5.7	2.0	1.1	0.4	-0.5
Parkway Road	1890	10	No	130	3,940	704.5[f]	6.3	0.9	0.9	--	--
W. Loomis Road	1933	50	Yes	110	3,910	704.4	4.6	3.8	0.8	0.1	-3.0
W. Rawson Avenue	1957	50	No	170	4,310	702.4	8.4	1.0	0.2	--	--
W. Drexel Avenue	1960	50	Yes	160	4,515	698.3	7.9	0.1	3.5	0.4	0.0
STH 100.	1934	50	No	200	5,460	685.0	3.1	1.9	-1.6	--	--

100 YEAR RECURRENCE FLOOD, 1990 CONDITIONS[a]

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening		Replacement Waterway Opening	
								Bridge Head Loss (feet)	Depth on Road at Bridge (feet)	Bridge Head Loss (feet)	Depth on Road at Bridge (feet)
Lincoln Avenue	1930	10	--[c]	4,400	800	750.6	-5.4	--	--	0.1	-7.2
Parkway Road	1937	10	--[c]	6,200	850	744.8	-6.2	--	--	0.1	-6.4
W. Cleveland Avenue.	1936	50	--[c]	5,600	925	735.6	-5.4	--	--	0.1	-6.9
STH 15	1932	50	--[c]	3,850	2,975	729.6	-1.4	--	--	0.1	-3.8
S. 116th Street.	1919	10	--[c]	4,150	2,990	729.5[f]	-2.2	--	--	0.1	-2.5
W. Morgan Avenue	1926	10	--[c]	2,300	3,010	729.4	1.4	--	--	0.1	-0.3
W. Beloit Road	1927	50	--[c]	1,100	3,040	727.0[f]	2.7	--	--	0.1	-2.9
STH 100.	1959	50	--[c]	1,250	3,040	726.2	3.2	--	--	0.1	-2.2
W. Cold Spring Road.	1926	50	--[c]	1,250	3,075	725.2	3.2	--	--	0.1	-0.3
W. Layton Avenue	1939	50	Yes	150	3,540	723.0	4.2	2.8	1.0	0.5	-1.4
W. Forest Home Avenue.	1963	50	No	460	3,660	721.2	4.8	1.4	0.3	--	--
S. 84th Street	1930	50	Yes	180	3,585	718.5	5.3	1.2	0.9	0.8	0.4
W. Grange Avenue	1928	50	Yes	150	3,295	717.5	5.1	1.4	0.7	0.9	0.2
W. College Avenue.	1939	10	No	220	2,930	711.5	5.0	1.5	-3.0	--	--
S. 76th Street (CTH U)	1934	50	Yes	270	4,700	707.2	6.6	1.6	1.6	1.2	1.2
Parkway Road	1890	10	No	130	4,685	705.2[f]	6.8	0.6	1.1	--	--
W. Loomis Road	1933	50	Yes	110	4,665	704.8	5.0	3.8	1.2	0.4	-2.2
W. Rawson Avenue	1957	50	No	170	5,135	703.0	9.2	0.8	0.8	--	--
W. Drexel Avenue	1960	50	Yes	160	5,370	699.4	8.5	0.1	4.1	0.9	1.1
STH 100.	1934	50	No	200	6,500	685.5	3.4	2.1	-1.1	--	--

Table G-2

HYDRAULIC ANALYSIS SUMMARY ROOT RIVER MAIN STEM

10 YEAR RECURRENCE FLOOD, 1990 CONDITIONS

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening: Bridge Head Loss (feet)	Existing Waterway Opening: Depth on Road at Bridge (feet)	Replacement Waterway Opening: Bridge Head Loss (feet)	Replacement Waterway Opening: Depth on Road at Bridge (feet)
W. County Line Road.	1910[b]	50	Yes	520	4,200	681.6	6.8	0.8	0.0	0.1	-2.7
S. 43rd Street	1910[b]	50	Yes	1,210	4,200	678.7	4.7	0.1	1.5	0.1	-2.8
W. County Line Road.	1910[b]	50	Yes	720	4,215	675.4[f]	3.1	0.1	3.1	0.1	-2.4
USH 41	1931	10	Yes	720	4,215	675.0	7.0	0.1	1.6	0.1	0.0
IH 94.	1963	100	No	720	4,215	674.7	7.0	0.1	- 9.0	--	--
CTH V.	1927	50	Yes	530	4,260	671.7	5.7	0.1	1.7	0.1	-2.3
C. M. St. P. & P. R.R.	1900	--	--	165	4,300	669.1	6.9	0.2	-13.9	--	--
Howell Avenue (STH 38)	1929	50	Yes	270	4,430	668.2	7.2	0.1	1.2	0.1	-2.3
S. Nicholson Road.	1918	50	Yes	360	4,600	667.4	7.4	0.1	0.4	0.1	-3.1
C. & NW. R.R..	1912	--	--	750	4,590	666.0	5.0	0.1	-11.0	--	--
E. Seven Mile Road	1960	50	No[d]	870	4,585	664.6	5.6	0.1	- 1.6	0.1	-5.4
E. Six Mile Road	1940[b]	50	No	1,020	4,570	663.4	5.4	0.1	- 3.6	--	--
E. Five Mile Road.	1950	50	Yes	1,710	4,550	662.0	4.3	0.7	0.0	0.1	-3.7
E. Four Mile Road.	1950	50	No	4,350	4,525	655.4	0.1	0.3	- 5.9	--	--
Johnson Park	--	--	--	710	4,950	650.0	7.0	0.1	6.0	--	--
Johnson Park	--	--	--	1,090	4,950	647.4	4.8	0.6	0.7	--	--
STH 31	--	50	No	1,790	4,930	638.5	3.5	0.1	- 7.5	--	--
STH 38	--	50	No	20,000+	4,910	628.0	-7.5	0.5	-10.3	--	--
Racine Country Club.	--	--	--	1,390	4,910	609.4	2.8	0.6	- 4.9	--	--
Racine Country Club.	--	--	--	570	4,905	602.4	2.4	0.1	1.1	--	--
Park Bridge.	1939	--	--	2,340	4,900	593.4	3.4	0.1	0.1	--	--
Spring Street.	1920	50	Yes	1,750	4,900	591.8	4.2	0.6	- 0.4	0.1	-3.8
Liberty Street	1905	10	No	1,550	2,450	589.6[f]	1.8	0.1	- 0.3	--	--
Glen Street.	1946	--	--	1,900	2,450	588.8[f]	0.9	0.4	- 0.7	--	--
Parkview Bridge.	1925	--	--	600	2,450	588.6	4.8	0.8	- 1.1	--	--
Park Bridge.	1905	10	No	1,420	2,450	588.0[f]	1.8	0.1	- 7.2	--	--
6th Street	1928	10	No	7,500	4,900	587.7[f]	-2.2	0.1	- 3.9	--	--

50 YEAR RECURRENCE FLOOD, 1990 CONDITIONS

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening: Bridge Head Loss (feet)	Existing Waterway Opening: Depth on Road at Bridge (feet)	Replacement Waterway Opening: Bridge Head Loss (feet)	Replacement Waterway Opening: Depth on Road at Bridge (feet)
W. County Line Road.	1910[b]	50	Yes	520	7,230	683.7	8.8	0.9	2.1	0.4	-0.2
S. 43rd Street	1910[b]	50	Yes	1,210	7,230	681.4	7.1	0.1	3.9	0.3	-0.1
W. County Line Road.	1910[b]	50	Yes	720	7,200	679.0[f]	5.0	0.1	5.0	0.4	-0.1
USH 41	1931	10	Yes	720	7,200	678.8	9.7	0.1	4.3	1.1	3.8
IH 94.	1963	100	No	720	7,200	677.5	9.7	0.1	- 6.3	--	--
CTH V.	1927	50	Yes	530	7,330	673.6	7.4	0.1	3.4	0.2	-0.4
C. M. St. P. & P. R.R.	1900	--	--	165	7,380	671.2	8.7	0.5	-11.8	--	--
Howell Avenue (STH 38)	1929	50	Yes	270	7,850	670.5	9.2	0.1	3.2	0.3	0.0
S. Nicholson Road.	1918	50	Yes	360	7,840	670.2	9.8	0.1	2.8	0.4	-0.3
C. & NW. R.R..	1912	--	--	750	7,830	667.7	6.7	0.1	- 9.3	--	--
E. Seven Mile Road	1960	50	No[d]	870	7,830	667.1	7.8	0.1	0.6	0.3	-2.9
E. Six Mile Road	1940[b]	50	No	1,020	7,820	666.0	7.6	0.4	- 1.0	--	--
E. Five Mile Road.	1950	50	Yes	1,710	7,760	664.6	7.1	0.1	2.1	0.5	-0.4
E. Four Mile Road.	1950	50	No	4,350	7,700	658.5	2.4	1.1	- 2.8	--	--
Johnson Park	--	--	--	710	8,400	652.4	9.4	0.1	8.4	--	--
Johnson Park	--	--	--	1,090	8,400	648.6	6.6	0.1	1.9	--	--
STH 31	--	50	No	1,790	8,380	641.6	6.6	0.1	- 4.4	--	--
STH 38	--	50	No	20,000+	8,350	630.0	-5.8	0.8	- 8.3	--	--
Racine Country Club.	--	--	--	1,390	8,340	611.7	4.0	1.7	- 2.6	--	--
Racine Country Club.	--	--	--	570	8,340	604.3	4.3	0.1	3.0	--	--
Park Bridge.	1939	--	--	2,340	8,330	595.4	5.4	0.1	2.1	--	--
Spring Street.	1920	50	Yes	1,750	8,330	594.3	6.2	1.1	2.1	0.4	-1.4
Liberty Street	1905	10	No	1,550	4,000	592.1[f]	3.4	0.1	1.3	--	--
Glen Street.	1946	--	--	1,900	4,330	591.6[f]	2.9	0.3	1.2	--	--
Parkview Bridge.	1925	--	--	600	4,000	591.4[f]	7.0	1.0	1.3	--	--
Park Bridge.	1905	10	No	1,420	4,330	591.0[f]	3.4	0.8	- 4.8	--	--
6th Street	1928	10	No	7,500	8,330	590.7[f]	0.6	0.1	- 1.1	--	--

Table G-2 (continued)

100 YEAR RECURRENCE FLOOD, 1990 CONDITIONS

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening: Bridge Head Loss (feet)	Existing Waterway Opening: Depth on Road at Bridge (feet)	Replacement Waterway Opening: Bridge Head Loss (feet)	Replacement Waterway Opening: Depth on Road at Bridge (feet)
W. County Line Road	1910[b]	50	Yes	520	8,600	684.3	9.6	0.4	2.4	0.6	0.8
S. 43rd Street	1910[b]	50	Yes	1,210	8,600	683.0	8.0	0.1	4.8	1.0	1.5
W. County Line Road	1910[b]	50	Yes	720	8,570	680.2[f]	5.7	0.1	5.7	0.7	0.9
USH 41	1931	10	Yes	720	8,570	680.0	10.4	0.1	5.0	1.6	5.0
IH 94	1963	100	No	720	8,570	678.3	10.4	0.1	- 5.6	--	--
CTH V	1927	50	Yes	530	8,730	674.6	7.8	0.1	3.8	0.8	0.6
C. M. St. P. & P. R.R.	1900	--	--	165	8,790	672.0	9.4	0.6	-11.0	--	--
Howell Avenue (STH 38)	1929	50	Yes	270	9,030	671.6[f]	9.9	0.1	3.9	0.7	1.1
S. Nicholson Road	1918	50	Yes	360	9,340	671.6	10.6	0.1	3.6	1.0	1.1
C. & NW. R.R.	1912	--	--	750	9,330	668.4	7.4	0.1	- 8.6	--	--
E. Seven Mile Road	1960	50	No[d]	870	9,325	668.2	8.5	0.1	1.3	0.7	-1.8
E. Six Mile Road	1940[b]	50	No	1,020	9,310	666.9	8.4	0.5	- 0.1	--	--
E. Five Mile Road	1950	50	Yes	1,710	9,235	665.8	8.0	0.1	3.0	0.8	0.8
E. Four Mile Road	1950	50	No	4,350	9,160	659.8	3.2	1.6	- 1.5	--	--
Johnson Park	--	--	--	710	10,000	653.2	10.2	0.1	9.2	--	--
Johnson Park	--	--	--	1,090	10,000	649.2	7.2	0.1	2.5	--	--
STH 31	--	50	No	1,790	9,980	643.0	7.4	0.6	- 3.0	--	--
STH 38	--	50	No	20,000+	9,940	632.0	-4.0	1.0	- 6.3	--	--
Racine Country Club	--	--	--	1,390	9,930	613.0	4.5	2.5	- 1.3	--	--
Racine Country Club	--	--	--	570	9,930	604.9	4.9	0.1	3.6	--	--
Park Bridge	1939	--	--	2,340	9,920	596.2	6.2	0.1	2.9	--	--
Spring Street	1920	50	Yes	1,750	9,920	594.5	6.8	0.7	2.3	0.7	-0.5
Liberty Street	1905	10	No	1,550	4,750	592.9[f]	4.0	0.1	1.9	--	--
Glen Street	1946	--	--	1,900	5,150	592.4[f]	3.5	0.3	1.8	--	--
Parkview Bridge	1925	--	--	600	4,500	592.2[f]	8.1	0.3	1.7	--	--
Park Bridge	1905	10	No	1,420	5,150	591.8[f]	4.1	1.1	- 3.8	--	--
6th Street	1928	10	No	7,500	9,920	591.5[f]	1.8	0.1	0.1	--	--

Table G-3

HYDRAULIC ANALYSIS SUMMARY ROOT RIVER CANAL SYSTEM

10 YEAR RECURRENCE FLOOD, 1990 CONDITIONS[a]

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening: Bridge Head Loss (feet)	Existing Waterway Opening: Depth on Road at Bridge (feet)	Replacement Waterway Opening: Bridge Head Loss (feet)	Replacement Waterway Opening: Depth on Road at Bridge (feet)
East Branch											
W. County Line Road	1930[b]	10	No	460	130	765.5[f]	-4.2	1.6	-6.2	--	--
60th Road	1930[b]	10	No	190	175	759.5[f]	-0.2	0.3	0.1	--	--
STH 11	1940[b]	50	No	260	195	758.1	-1.1	0.4	-1.8	--	--
C. M. St. P. & P. R.R.	1920[b]	--	--	350	200	754.3	-1.7	0.1	-9.7	--	--
58th Road	1940	10	No	190	220	750.8	0.3	0.5	-2.6	--	--
55th Drive	1940[b]	10	No	180	230	747.4	0.4	0.1	-2.1	--	--
CTH C	1939	50	No	450	270	737.9	-1.4	0.3	-6.4	--	--
CTH A	1930[b]	50	Yes	220	355	733.2	0.8	0.4	-1.0	0.1	-1.4
STH 20	1930[b]	50	No	360	355	728.9	-0.1	0.1	-2.5	--	--
50th Road	1960	10	Yes	170	410	719.7[f]	1.2	1.0	0.2	0.1	-0.8
W. Two Mile Road	1920[b]	10	No	250	500	707.5	1.2	0.3	-4.0	--	--
W. Three Mile Road	1935[b]	10	Yes	240	590	701.1	1.7	0.4	0.2	0.1	-0.2
W. Four Mile Road	1940[b]	50	No	350	690	696.8	1.3	0.5	-1.8	--	--
West Branch											
67th Drive	1940[b]	10	No	670	135	718.5[f]	-3.6	1.0	-2.7	--	--
C. M. St. P. & P. R.R.	1919	--	--	110	215	706.8[f]	1.3	0.1	-10.2	--	--
58th Road	1930[b]	10	No	170	285	706.2[f]	1.1	0.1	0.1	--	--
CTH C	1939	50	No	790	355	704.4	-3.6	0.1	-7.0	--	--
CTH A	1940[b]	50	Yes	140	560	701.6	2.9	0.7	-0.4	0.1	-2.4
STH 20	1910[b]	50	No	190	625	699.8	1.8	0.1	-4.2	--	--
50th Road	1920[b]	10	Yes	280	955	699.2	2.4	0.8	0.2	0.1	-1.1
W. Two Mile Road	1920[b]	10	Yes	260	955	696.5[f]	3.0	0.1	3.0	0.1	-0.4
W. Three Mile Road	1935[b]	10	Yes[d]	340	990	696.1[f]	3.0	0.1	1.0	0.1	-2.0
W. Four Mile Road	1940[b]	50	Yes	330	1,160	696.0	5.2	0.1	-1.0	0.1	-3.8
Main Root River Canal											
W. Five Mile Road	1965	10	No	340	1,900	692.0	4.0	0.1	0.0	--	--
CTH G	1949	50	Yes[d]	200	1,910	690.1	6.0	0.1	-0.3	0.1	-1.9
W. Seven Mile Road	1965	50	Yes	320	1,910	688.0	5.0	0.1	1.0	0.1	-3.0

Table G-3 (continued)

50 YEAR RECURRENCE FLOOD, 1990 CONDITIONS[a]

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening: Bridge Head Loss (feet)	Existing Waterway Opening: Depth on Road at Bridge (feet)	Replacement Waterway Opening: Bridge Head Loss (feet)	Replacement Waterway Opening: Depth on Road at Bridge (feet)
East Branch											
W. County Line Road	1930[b]	10	No	460	220	767.3	-2.5	2.3	-3.8	--	--
60th Road	1930[b]	10	No	190	290	761.0[f]	0.9	0.1	0.9	--	--
STH 11	1940[b]	50	No	260	320	759.9	0.4	0.7	0.0	--	--
C. M. St. P. & P. R.R.	1920[b]	--	--	350	330	755.8	-0.2	0.1	-8.2	--	--
58th Road	1940	10	No	190	360	752.5	1.1	1.4	-0.9	--	--
55th Drive	1940[b]	10	No	180	380	748.4	1.1	0.3	-1.1	--	--
CTH C	1939	50	No	450	445	739.7	0.0	0.7	-4.6	--	--
CTH A	1930[b]	50	Yes	220	580	734.3	1.5	0.8	0.1	0.1	-0.7
STH 20	1930[b]	50	No	360	580	730.4	1.0	0.4	-1.0	--	--
50th Road	1960	10	Yes	170	800	720.3[f]	2.1	0.4	0.5	0.7	0.8
W. Two Mile Road	1920[b]	10	No	250	870	708.9	2.3	0.6	-2.6	--	--
W. Three Mile Road	1935[b]	10	Yes	240	960	702.0	2.7	0.1	0.8	0.3	1.1
W. Four Mile Road	1940[b]	50	No	350	1,110	698.5	2.3	1.2	-0.1	--	--
West Branch											
67th Drive	1940[b]	10	No	670	235	720.0[f]	-2.7	1.2	-1.6	--	--
C. M. St. P. & P. R.R.	1919	--	--	110	360	707.5[f]	2.1	0.1	-9.4	--	--
58th Road	1930[b]	10	No	170	470	707.2[f]	1.8	0.1	0.8	--	--
CTH C	1939	50	No	790	590	706.8	-1.4	0.2	-4.6	--	--
CTH A	1940[b]	50	Yes	140	950	702.6	3.9	0.7	0.6	0.1	-1.1
STH 20	1910[b]	50	No	190	1,040	700.6	2.3	0.3	-3.4	--	--
50th Road	1920[b]	10	Yes	280	1,600	699.7	3.5	0.2	0.7	0.6	0.5
W. Two Mile Road	1920[b]	10	Yes	260	1,540	698.9[f]	3.8	0.1	3.8	0.8	1.4
W. Three Mile Road	1935[b]	10	Yes[d]	340	1,600	698.8[f]	4.0	0.1	2.0	1.2	0.0
W. Four Mile Road	1940[b]	50	Yes	330	1,870	698.5	7.2	0.1	1.0	0.1	-1.4
Main Root River Canal											
W. Five Mile Road	1965	10	No	340	3,070	693.1	5.0	0.1	1.1	--	--
CTH G	1949	50	Yes[d]	200	3,080	692.0	8.0	0.1	1.6	0.1	0.0
W. Seven Mile Road	1965	50	Yes	320	3,080	689.4	6.4	0.1	2.4	0.1	-1.6

100 YEAR RECURRENCE FLOOD, 1990 CONDITIONS[a]

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening: Bridge Head Loss (feet)	Existing Waterway Opening: Depth on Road at Bridge (feet)	Replacement Waterway Opening: Bridge Head Loss (feet)	Replacement Waterway Opening: Depth on Road at Bridge (feet)
East Branch											
W. County Line Road	1930[b]	10	No	460	260	768.5	-1.9	2.9	-2.6	--	--
60th Road	1930[b]	10	No	190	345	761.4[f]	1.2	0.1	1.2	--	--
STH 11	1940[b]	50	No	260	380	760.0	0.6	0.6	0.1	--	--
C. M. St. P. & P. R.R.	1920[b]	--	--	350	395	756.3	0.3	0.1	-7.7	--	--
58th Road	1940	10	No	190	430	753.4	1.3	2.1	0.0	--	--
55th Drive	1940[b]	10	No	180	455	748.8	1.4	0.4	-0.7	--	--
CTH C	1939	50	No	450	530	740.5	0.4	1.1	-3.8	--	--
CTH A	1930[b]	50	Yes	220	695	734.5	1.8	0.7	0.3	0.1	-0.3
STH 20	1930[b]	50	No	360	695	731.5[f]	1.4	0.5	-0.5	--	--
50th Road	1960	10	Yes	170	950	721.0[f]	2.3	0.3	0.6	1.1	1.4
W. Two Mile Road	1920[b]	10	No	250	1,040	709.4	2.7	0.7	-2.1	--	--
W. Three Mile Road	1935[b]	10	Yes	240	1,140	702.5	3.1	0.1	1.2	0.4	1.6
W. Four Mile Road	1940[b]	50	No	350	1,320	699.0	2.6	1.4	0.4	--	--
West Branch											
67th Drive	1940[b]	10	No	670	280	721.3[f]	-2.4	2.6	0.1	--	--
C. M. St. P. & P. R.R.	1919	--	--	110	430	708.2[f]	2.2	0.2	-9.1	--	--
58th Road	1930[b]	10	No	170	560	708.1[f]	2.1	0.1	1.1	--	--
CTH C	1939	50	No	790	705	707.7	-0.5	0.2	-3.7	--	--
CTH A	1940[b]	50	Yes	140	1,130	702.8	4.1	0.7	0.8	0.3	-0.4
STH 20	1910[b]	50	No	190	1,240	701.0	2.4	0.6	-3.0	--	--
50th Road	1920[b]	10	Yes	280	1,900	700.0	4.0	0.1	1.0	0.8	1.0
W. Two Mile Road	1920[b]	10	Yes	260	1,830	699.5[f]	4.2	0.1	4.2	1.2	2.2
W. Three Mile Road	1935[b]	10	Yes[d]	340	1,900	699.2[f]	4.4	0.1	2.4	1.0	0.2
W. Four Mile Road	1940[b]	50	Yes	330	2,230	698.8	7.8	0.1	1.6	0.8	0.2
Main Root River Canal											
W. Five Mile Road	1965	10	No	340	3,660	693.5	5.5	0.1	1.5	--	--
CTH G	1949	50	Yes[d]	200	3,670	693.0	8.6	0.1	2.2	0.4	1.0
W. Seven Mile Road	1965	50	Yes	320	3,670	690.7	7.1	0.1	3.1	0.6	-0.3

Table G-4

HYDRAULIC ANALYSIS SUMMARY HOODS CREEK

10 YEAR RECURRENCE FLOOD, 1990 CONDITIONS

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening		Replacement Waterway Opening	
								Bridge Head Loss (feet)	Depth on Road at Bridge (feet)	Bridge Head Loss (feet)	Depth on Road at Bridge (feet)
STH 20	1964	50	No	1,070	106	724.1[f]	-7.0	0.1	-12.0	--	--
CTH C.	1920[b]	50	No	1,070	290	723.8[f]	-5.4	0.1	- 8.1	--	--
C. M. St. P. & P. R.R.	1900[b]	--	--	870	290	723.7[f]	-4.8	0.1	-11.3	--	--
CTH H.	1920[b]	50	No	960	405	711.8	-3.2	0.1	- 6.6	--	--
C. & NW. R.R..	1900[b]	--	--	170	560	694.0[f]	1.2	0.4	- 6.4	--	--
Airline Road	1935	10	No	240	560	692.8	1.9	0.9	- 0.3	--	--
STH 38	1965	50	No	180	710	673.3	2.9	0.4	-10.2	--	--
Kyle Road.	1930[b]	10	Yes	120	725	664.1	3.1	0.1	1.1	0.1	0.0
Hoods Creek Road	1940[b]	10	No	260	730	660.7	1.5	0.2	- 3.1	--	--
Brook Road	1930[b]	10	No	630	740	655.7	0.4	0.3	- 1.8	--	--

50 YEAR RECURRENCE FLOOD, 1990 CONDITIONS

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening		Replacement Waterway Opening	
								Bridge Head Loss (feet)	Depth on Road at Bridge (feet)	Bridge Head Loss (feet)	Depth on Road at Bridge (feet)
STH 20	1964	50	No	1,070	180	725.4[f]	-5.9	0.1	-10.9	--	--
CTH C.	1920[b]	50	No	1,070	480	724.9[f]	-3.6	0.1	- 6.3	--	--
C. M. St. P. & P. R.R.	1900[b]	--	--	870	480	724.8[f]	-2.9	0.1	- 9.4	--	--
CTH H.	1920[b]	50	No	960	660	713.8	-1.5	0.3	- 4.6	--	--
C. & NW. R.R.	1900[b]	--	--	170	910	694.8[f]	1.6	1.0	- 5.4	--	--
Airline Road	1935	10	No	240	910	693.6	2.9	0.7	0.5	--	--
STH 38	1965	50	No	180	1,170	675.1	4.2	0.9	- 8.4	--	--
Kyle Road.	1930[b]	10	Yes	120	1,190	665.7	4.2	0.1	2.2	0.5	1.7
Hoods Creek Road	1940[b]	10	No	260	1,200	661.8	2.3	0.5	- 2.0	--	--
Brook Road	1930[b]	10	No	630	1,220	657.8	1.8	1.0	0.3	--	--

100 YEAR RECURRENCE FLOOD, 1990 CONDITIONS

Location	Construction Date of Existing Bridge	Recommended Design Frequency Standard (years)	Replacement Required by Application of Standard	Bank Full Discharge (CFS)	Instantaneous Peak Discharge (CFS)	Elevation of Upstream Water Level, Feet Above (msl)[e]	Overbank Depth (feet)	Existing Waterway Opening		Replacement Waterway Opening	
								Bridge Head Loss (feet)	Depth on Road at Bridge (feet)	Bridge Head Loss (feet)	Depth on Road at Bridge (feet)
STH 20	1964	50	No	1,070	213	727.1[f]	-5.5	0.1	-10.5	--	--
CTH C.	1920[b]	50	No	1,070	575	726.0[f]	-2.9	0.1	- 5.6	--	--
C. M. St. P. & P. R.R.	1900[b]	--	--	870	575	725.9[f]	-2.1	0.1	- 8.6	--	--
CTH H.	1920[b]	50	No	960	780	714.5	-0.8	0.3	- 3.9	--	--
C. & NW. R.R..	1900[b]	--	--	170	1,085	695.2[f]	1.8	1.3	- 4.9	--	--
Airline Road	1935	10	No	240	1,085	693.8	3.2	0.6	0.7	--	--
STH 38	1965	50	No	180	1,390	676.0	4.6	1.4	- 7.5	--	--
Kyle Road.	1930[b]	10	Yes	120	1,420	666.2	4.6	0.1	2.6	0.6	2.2
Hoods Creek Road	1940[b]	10	No	260	1,430	662.3	2.6	0.7	- 1.5	--	--
Brook Road	1930[b]	10	No	630	1,450	658.4	2.3	1.1	0.9	--	--

[a] Discharge data are based on the following assumptions: 1) channel improvements will be made on the North Branch from W. Lincoln Avenue in the City of West Allis to W. Layton Avenue in the City of Greenfield, and 2) each of the recommended land use and water control facility elements of the 1990 watershed plan will be implemented. Stage data are also based on these assumptions, with the exception that the effects on stage are given for the most critical of two possible structural conditions at the bridge location: 1) 1990 condition discharges on the existing bridge waterway opening, and 2) 1990 condition discharges on a replacement bridge waterway opening, if such is required to meet the standards set forth in this report. Head loss, overbank depth, and depth on road are based on hydraulic conditions at the site and do not include the effect of backwater from downstream bridges or Lake Michigan. Profiles and footnote f indicate areas of backwater effect.

[b] Exact date of construction unestablished; date estimated by on-site inspection of structure.

[c] Committed decision to improve the channel of the North Branch between W. Lincoln Avenue and W. Layton Avenue will necessitate replacement of these bridges.

[d] Bridge waterway opening adequate; elevation of roadbed required.

[e] Milwaukee Metropolitan Sewerage Commission Datum = Mean Sea Level Datum -580.560 feet; City of Racine Datum = Mean Sea Level Datum -580.710 feet.

[f] Water surface elevation includes effect of backwater from downstream bridges or from Lake Michigan.

Source: Harza Engineering Company.

Appendix H

HYDROLOGIC GROUPING OF SOILS OF THE ROOT RIVER WATERSHED

Table H-1

INFILTRATION CLASSIFICATION OF ROOT RIVER WATERSHED SOILS

Hydrologic Group A

Soil Mapping Number	Soil Type (Wisconsin)
133	Spinks Fine Sand
134	Spinks Loamy Fine Sand
419	Beach Sand

Hydrologic Group B

Soil Mapping Number	Soil Type (Wisconsin)
5	Huntsville Silt Loam
12	Wea Silt Loam
16	Rome Silt Loam
18	Tuscola Silt Loam
19	Tuscola Fine Sandy Loam
21	Hebron Loam
21Y	Hebron Loam
22	Hebron Sandy Loam
24	Hebron Silt Loam
31	Rome Loam
33	Salter Fine Sandy Loam
33Z	Hebron Sandy Loam
34	Salter Silt Loam
35Z	Mosel Sandy Loam
41	Tichigan Silt Loam
42	Hahns Silt Loam
44	Jericho Silt Loam
54	Lawson Silt Loam
59	Wasepi Sandy Loam
70	Fox Sandy Loam
70V	Sisson Sandy Loam
70Y	Hebron Sandy Loam
72	Fox Loam
72R	Fox Loam, Bedrock Substratum
72Y	Fox Loam, Loamy Substratum
72Z	Hebron Loam
73	Fox Silt Loam
73V	Sisson Silt Loam
73Y	Fox Silt Loam, Loamy Substratum
73Z	Hebron Silt Loam
76	Will Silt Loam
82	Juneau Silt Loam
106	Lorenzo Silt Loam
106Z	Rome Loam
110	Lorenzo Loam
110Y	Rome Loam
110Z	Rome Loam
119Y	Warsaw Silt Loam, Loamy Substratum
119Z	Warsaw Silt Loam, Clayey Substratum
120	Warsaw Loam
120Y	Warsaw Silt Loam, Loamy Substratum
122	Lorenzo Sandy Loam
123	Tippicanoe Silt Loam
126Y	Ehler Silt Loam

Hydrologic Group B (continued)

Soil Mapping Number	Soil Type (Wisconsin)
140	Oshkosh Silt Loam
161	Dodge Silt Loam
170	Casco Sandy Loam
170Y	Casco Sandy Loam, Loamy Substratum
170Z	Casco Sandy Loam, Clayey Substratum
172	Casco Loam
172V	Sisson Silt Loam
172Y	Boyer Sandy Loam
173	Casco Silt Loam
173Z	Casco Silt Loam, Clayey Substratum
191	Parr Loam and Silt Loam (shallow phase)
206	Knowles Silt Loam, Shallow Variety
208	Knowles Silt Loam, Shallow Variety
212	Ehler Silt Loam
218V	Ehler Silt Loam
243	Calamus Silt Loam
266	Sisson Silt Loam
267	Sisson Sandy Loam
269	Warsaw Sandy Loam
270	Hackett Sandy Loam (dark surface)
276	Boyer Sandy Loam
276Y	Boyer Sandy Loam
277Y	Boyer Sandy Loam (dark surface) Loamy Substratum
277Z	Boyer Sandy Loam (dark surface) Clayey Substratum
278	Clyman Silt Loam
282	Casco-Rodman Loams Complex
288	Hackett Loamy Sand
289	Hackett Sandy Loam
306	Knowles Silt Loam
316	Boyer Loamy Sand
316Y	Boyer Sandy Loam (dark surface)
323	Ionia Sandy Loam
325	Varna Silt Loam
3251	Elliott Silt Loam
327	Walkill Silt Loam
331	Markham-Elliott Silt Loam
332	Kane Silt Loam
332Y	Kane Silt Loam
333	Eagle Silt Loam
333Y	Eagle Silt Loam
333Z	Rome Silt Loam
334	Eagle Loam
335	Ionia Silt Loam
335Y	Ionia Silt Loam
336	Markham Silt Loam
345	Nenno Silt Loam

Table H-1 (continued)

Hydrologic Group B (continued)

Soil Mapping Number	Soil Type (Wisconsin)
360	Hochheim Silt Loam
362	Theresa Silt Loam
364	Lamertine Silt Loam
369	Mosel Silt Loam
370	Mosel Sandy Loam
371	Mosel Loam
380	Boyer Loamy Sand (prairie)
380Z	Tustin Sandy Loam
450	Houghton Muck
451	Houghton Mucky Peat
452	Adrian Muck
454	Palms Muck
455	Palms Mucky Peat
456	Willette Muck (Ogden)
457	Willette Mucky Peat (Ogden)
458	Edwards Muck
459	Edwards Muck
461	Muck

Hydrologic Group C

Soil Mapping Number	Soil Type (Wisconsin)
7W	Orion Silt Loam
11	Alluvial Lands
11W	Alluvial Lands
26	Kibbie Fine Sandy Loam (dark surface)
27	Kibbie Silt Loam (dark surface)
35	Shiocton Silt Loam
37	Kibbie Fine Sandy Loam
38	Kibbie Silt Loam
39	Saylesville Loam
40	Saylesville Silt Loam
42Y	Hahns Silt Loam, Loamy Substratum
46	Shiocton Silt Loam
51	Aztalan Loam
52	Aztalan Sandy Loam
53	Aztalan Silt Loam
78	Wasepi Loam
78V	Kibbie Silt Loam
78Y	Wasepi Loam
109	Fabius Loam (dark phase)
109V	Fabius Loam (dark phase)
109Y	Fabius Loam (dark phase)
109Z	Fabius Loam (dark surface) Clayey Substratum
174	Fabius Loam
174R	Fabius Loam, Bedrock Substratum
174Z	Fabius Loam, Clayey Substratum
175	Fabius Sandy Loam
182	Fabius Silt Loam
182Z	Mosel Silt Loam
203	Matherton Loam
203V	Kibbie Silt Loam
203Y	Matherton Loam
203Z	Matherton Loam, Clayey Substratum
204	Knowles Loam
233	Matherton Loam

Source: USDA, Soil Conservation Service Surveys and Data.

Hydrologic Group C (continued)

Soil Mapping Number	Soil Type (Wisconsin)
233V	Kibbie Silt Loam
233Y	Matherton Loam
233Z	Matherton Loam, Clayey Substratum
234	Matherton Sandy Loam
284	Rimer Sandy Loam
295	Morley-Beecher Silt Loam Complex
297	Morley Silt Loam
299	Blount Silt Loam
311	Manawa Loam
324	Ionia Loam
324Y	Ionia Loam
324Z	Ionia Loam, Clayey Substratum
328	Pistakee Silt Loam
335Z	Ionia Loam, Clayey Substratum
3361	Beecher Silt Loam
346	Kane Loam
346Y	Kane Loam
363	Mayville Silt Loam
366	Hochheim-Theresa Loam Complex
397	Morley (pink) Silt Loam
399	Blount (pink) Silt Loam

Hydrologic Group D

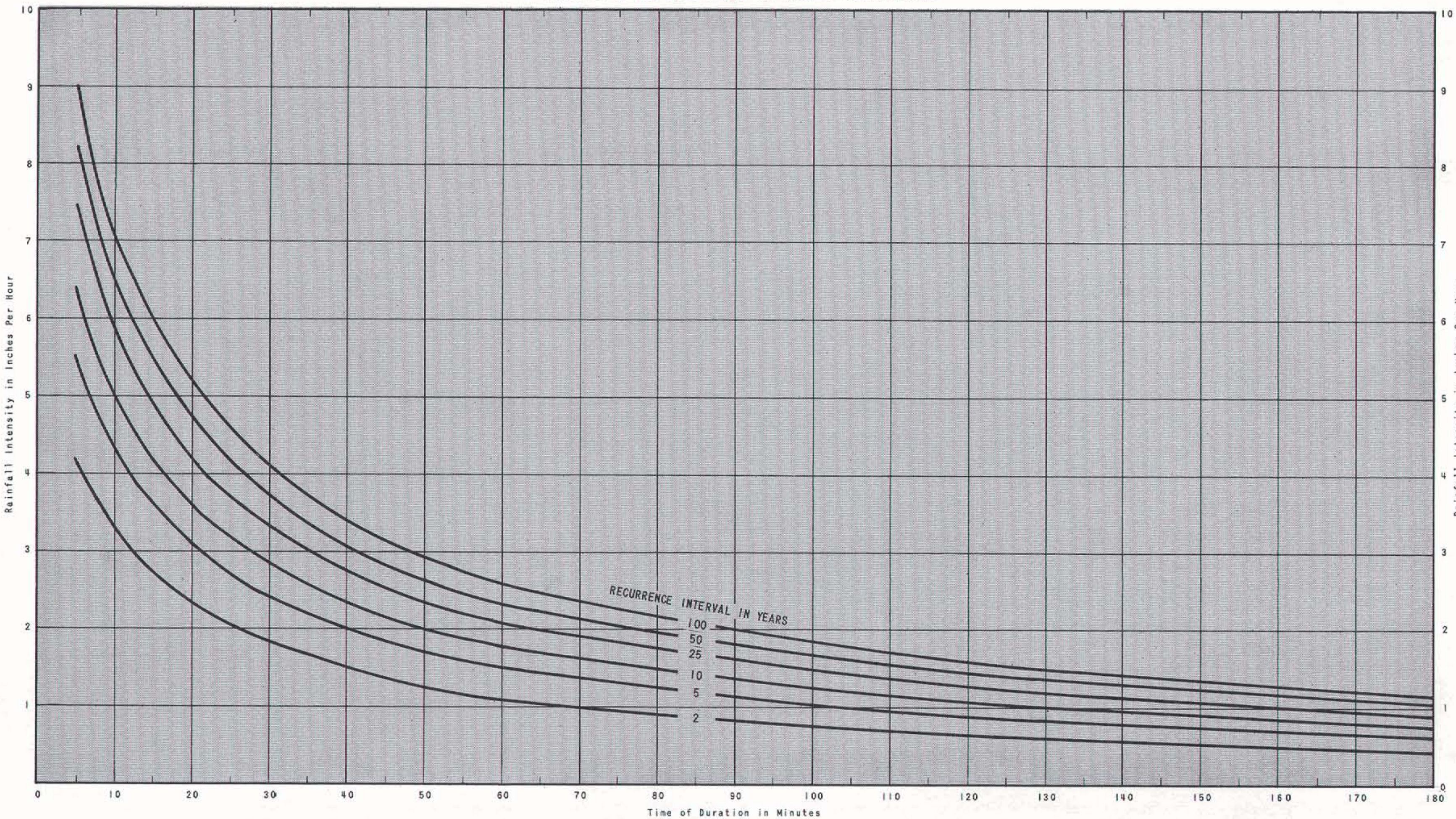
Soil Mapping Number	Soil Type (Wisconsin)
4	Marsh
5W	Otter Silt Loam
28	Colwood Fine Sandy Loam
29	Colwood Silt Loam
49	Keowns Fine Sandy Loam
49Y	Keowns Fine Sandy Loam
63	Kokomo Silt Loam
76V	Colwood Silt Loam
76Y	Navan Silt Loam
76Z	Will Silt Loam, Clayey Substratum
80	Will Loam
80Y	Will Loam
80Z	Will Silt Loam, Clayey Substratum
126	Westland Silt Loam
176Z	Navan Loam
181	Mussey Silt Loam
181Y	Mussey Silt Loam
181Z	Navan Silt Loam
213	Elba Silt Loam
214	Elba Silty Clay Loam
217	Bono Silty Clay Loam
218	Bono Silty Clay
231	Brockston Silt Loam
298	Ashkum Silty Clay Loam
300	Ashkum-Beecher Silt Loam Complex
326	Abington Silt Loam
326Z	Elba Silt Loam
330	Navan Loam
338	Peotone Silty Clay Loam
339	Abington Silty Clay Loam
340	Navan Silt Loam
340Z	Navan Silt Loam
398	Ashkum Silt Loam

Appendix I

RAINFALL AND RUNOFF DATA FOR STORM WATER DRAINAGE AND FLOOD-CONTROL FACILITY DESIGN

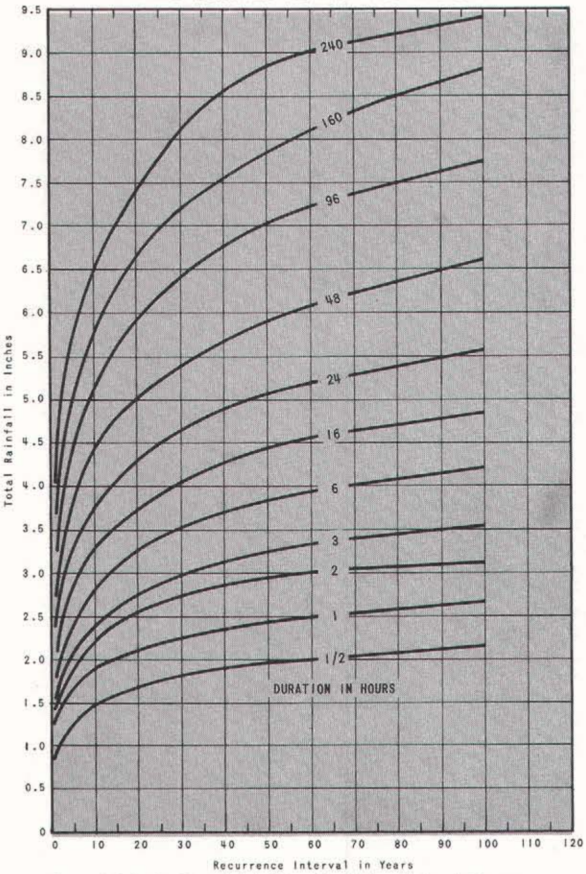
Figure I-1

POINT RAINFALL INTENSITY-DURATION-FREQUENCY RELATIONSHIPS
MILWAUKEE, WISCONSIN (1903-1951)
APPLICABLE TO THE REGION AND THE ROOT RIVER WATERSHED



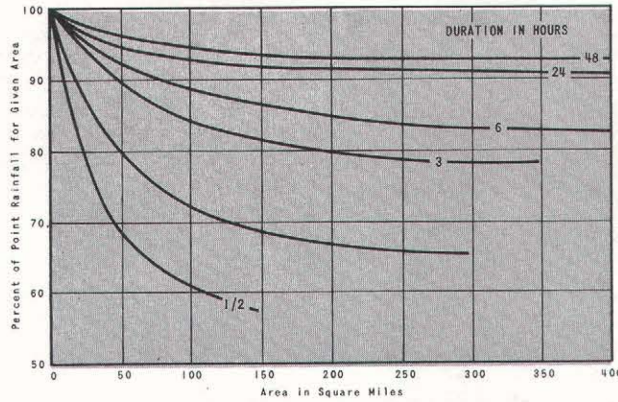
Source: U.S. Weather Bureau Technical Paper No. 40; SEWRPC.

Figure I-2
POINT RAINFALL DEPTH-DURATION-FREQUENCY RELATIONSHIPS
IN THE REGION AND THE ROOT RIVER WATERSHED



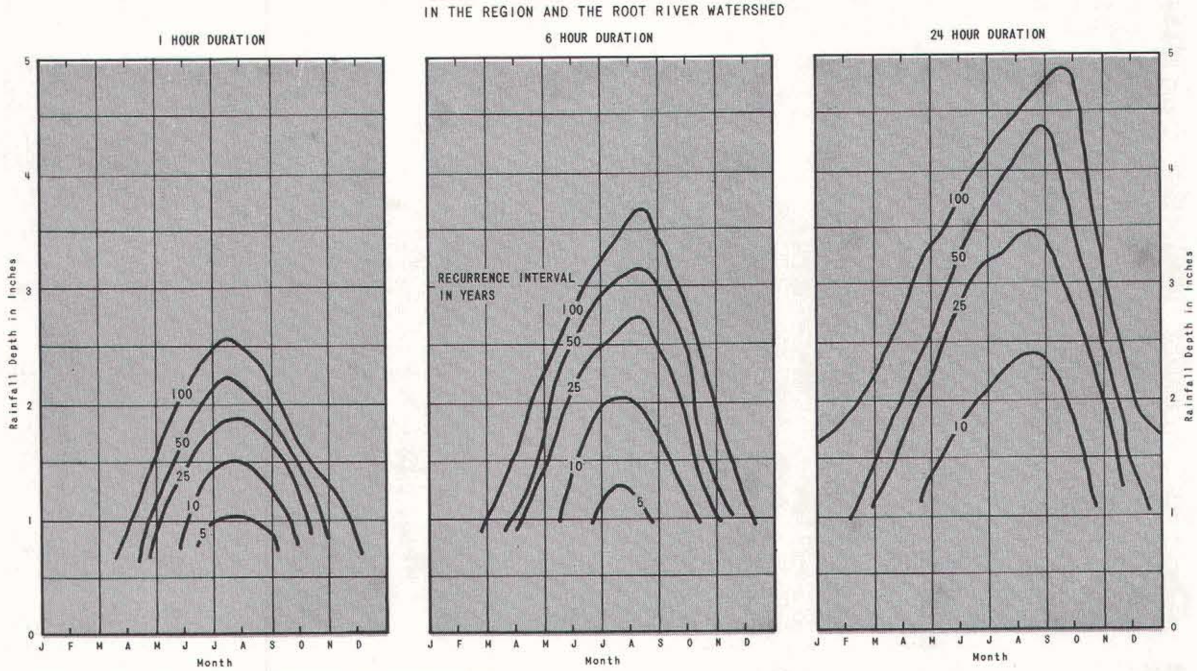
Source: U.S. Weather Bureau Technical Paper No. 40; Harza Engineering Company.

Figure I-3
RAINFALL DEPTH-DURATION-AREA RELATIONSHIPS
IN THE REGION AND THE ROOT RIVER WATERSHED



Source: U.S. Weather Bureau Technical Papers Nos. 40 and 49; Harza Engineering Company.

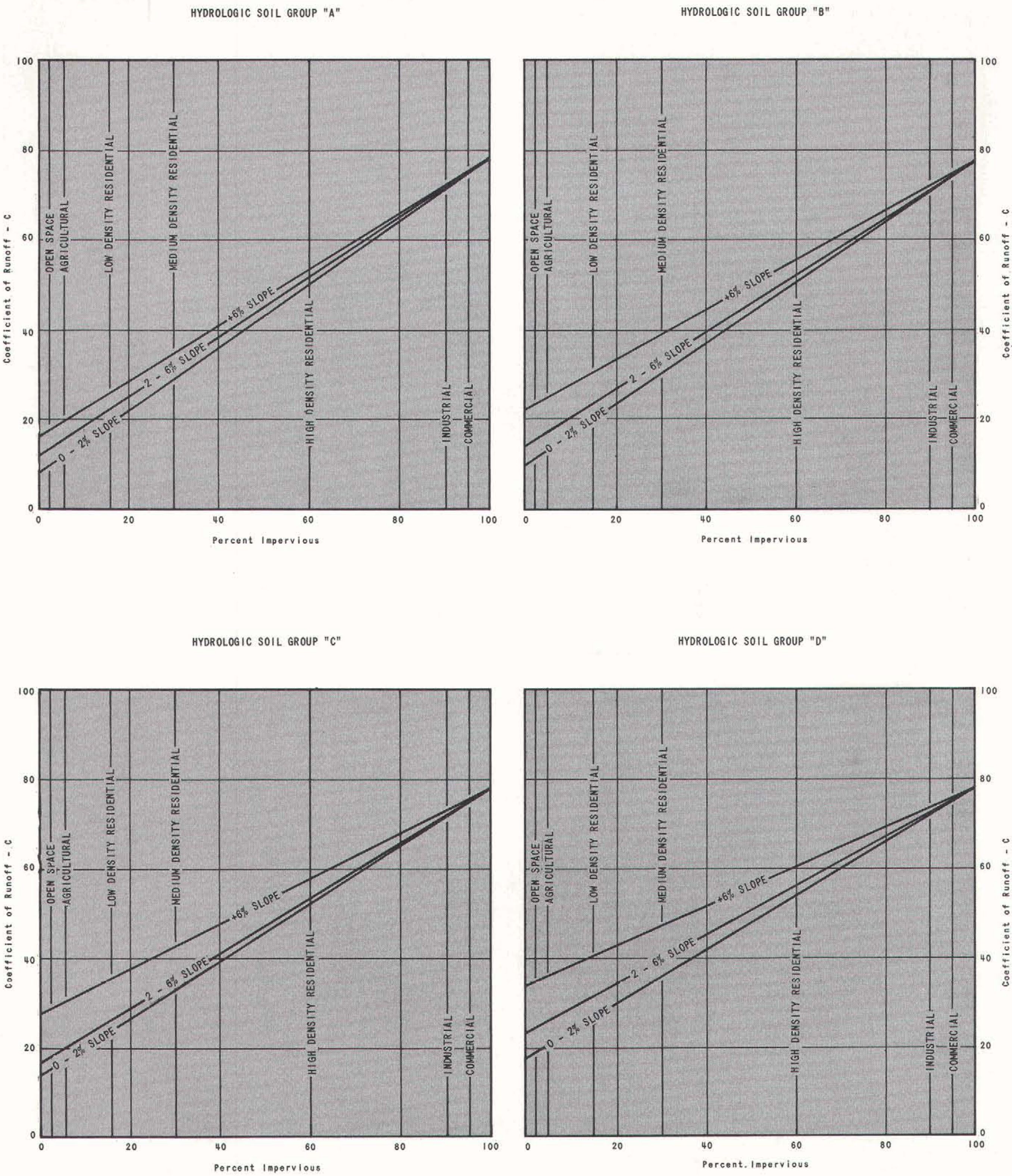
Figure I-4
SEASONAL VARIATION OF RAINFALL FREQUENCY
IN THE REGION AND THE ROOT RIVER WATERSHED



Source: U.S. Weather Bureau Technical Paper No. 40; Harza Engineering Company.

Figure I-5

COEFFICIENT OF RUNOFF CURVES
FOR HYDROLOGIC SOIL GROUPS



Source: SEWRPC.

Table I-1

WEIGHTED RUNOFF COEFFICIENTS FOR USE IN THE RATIONAL FORMULA

Land Use	Percent Impervious Area	Hydrolic Soil Group											
		A			B			C			D		
		Slope Range (percent)			Slope Range (percent)			Slope Range (percent)			Slope Range (percent)		
		0 - 2	2 - 6	6 & Over	0 - 2	2 - 6	6 & Over	0 - 2	2 - 6	6 & Over	0 - 2	2 - 6	6 & Over
Industrial	90	0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial	95	0.71 0.88	0.71 0.89	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
High-Density Residential.	60	0.47 0.58	0.49 0.60	0.50 0.61	0.48 0.59	0.50 0.61	0.52 0.64	0.49 0.60	0.51 0.62	0.54 0.66	0.51 0.62	0.53 0.64	0.56 0.69
Medium-Density Residential.	30	0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Low-Density Residential.	15	0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.28 0.35	0.35 0.46
Agriculture.	5	0.08 0.14	0.13 0.18	0.16 0.22	0.11 0.16	0.15 0.21	0.21 0.28	0.14 0.20	0.19 0.25	0.26 0.34	0.18 0.24	0.23 0.29	0.31 0.41
Open Space	2	0.05 0.11	0.10 0.16	0.14 0.20	0.08 0.14	0.13 0.19	0.19 0.26	0.12 0.18	0.17 0.23	0.24 0.32	0.16 0.22	0.21 0.27	0.28 0.39
Freeways and Expressways.	70	0.57 0.70	0.59 0.71	0.60 0.72	0.58 0.71	0.60 0.72	0.61 0.74	0.59 0.72	0.61 0.73	0.63 0.76	0.60 0.73	0.62 0.75	0.64 0.78

Source: SEWRPC.

Appendix J

FLOOD DAMAGE SURVEY FORMS

Figure J-1

SURVEY OF FLOOD DAMAGE

FORM 1

PUBLIC BUILDINGS AND GROUNDS

Serial Number

River | Period of Flood | Date of Crest | Bldg. No. ____ of ____ Bldgs.

County or City | Flood Zone | Flood Crest ____ ft. on ____ gage

Name of Public Agency | Person Interviewed

Address of Property Appraised

Damage	Cost Estimates Sub-total	Cost Estimates Total	Remarks
Direct			
Building:			
Foundation	$		
Superstructure			
Improvements			
Decorations			
Other ____			
Contents:			
Furnishings			
Equipment			
Supplies			
Records, etc.			
Miscellaneous:			
Minor Bldgs., Contents			
Other Improvements			
Grounds			
Parks & Playgrounds			
Cars, Trucks, etc.			
Total Direct		$	
Indirect			
Loss of Earnings by Employees	$		
Cost of Flood Fighting			
Evacuation & Reoccupation			
Other ____			
Total Indirect		$	
Grand Total		$	

Relevant Data

Value of Building ____ Value of Contents ____ No. of Persons Disrupted from Work ____
Size of Bldg. ____ x ____ ft. No. of Floors ____ Max. Ht. of Water from Ground at Bldg. ____ ft.
Condition of Bldg. Good ____ Fair ____ Poor ____
No. of Days Water in Basement ____ on First Floor ____ on Second Floor ____
No. of Days Use of Facilities Prevented by Flood ____
Ht. of Floors Above or Below Ground (feet) B ____ 1 ____ 2 ____ 3 ____
Percentage of Value of Contents by Floors B ____ 1 ____ 2 ____ 3 ____
Percentage of Total Losses to Bldg. and Contents by Floors B ____ 1 ____ 2 ____ 3 ____

Data Collected/Submitted by: | Title | Date

Signature

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SURVEY OF FLOOD DAMAGE

FORM 2

RAILROADS

Serial Number

River | Period of Flood | Date of Crest | Flood Crest ____ ft. on ____ gage

County | Flood Zone | Other Zones Reported

Railroad | Person Interviewed

Section ____ to ____ | Length of Section | Length Submerged | Depth Submerged ____ ft.

Damage	Cost Estimates Sub-total	Cost Estimates Total	Remarks
Direct			
Roadway:			
Roadbed or Embankment	$		
Track			
Electric Power Line			
Culverts			
Signal System			
Switching System			
Other ____			
Rolling Stock			
Minor Bldgs., Contents, Grounds item			
Outdoor Equipment(stationary) item			
Goods in Transit			
Total Direct		$	
Indirect			
Extra Cost of Maintaining Emergency Service	$		
Loss of Profits to R.R. & Shipper by Interruption of Business			
Loss of Earnings by Employees			
Cost of Flood Fighting			
Evacuation & Reoccupation			
Other ____			
Total Indirect		$	
Grand Total		$	

Relevant Data

Number of Days Track Submerged at Lowest Point ____ Number of Days Service Suspended ____
Number of Parallel Tracks ____

Data Collected/Submitted by: | Title | Date

Signature

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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

SURVEY OF FLOOD DAMAGE

FORM 3

STREETS AND HIGHWAYS

Serial Number

River | Period of Flood | Date of Crest | Name of Street/Highway

County or City | Flood Zone | Flood Crest ____ ft. on ____ gage

Section from ____ to ____ | State or U. S. Route No. | Length of Section

Length Submerged | Other Zones Reported | Depth Submerged ____ ft.

Damage	Cost Estimates Sub-total	Cost Estimates Total	Remarks
Direct			
Roadway:			
Embankment	$		
Shoulders			
Roadbed			
Pavement			
Other Surface			
Culverts			
Signposts & Fences			
Cleanup			
Other ____			
Total Direct		$	
Indirect			
Temporary Repairs (Net Cost)	$		
Rerouting Traffic			
Highway Dept. Patrols			
Cost of Flood Fighting			
Total Indirect		$	
Grand Total		$	

Relevant Data

Number of Days Lowest Point of This Section Was Submerged ____
Number of Days Traffic Was Interrupted ____
Length of Highway Damaged ____
Type of Surface ____ Width of Surface ____
Condition of Surface Before Flood ____ Good ____ Fair ____ Poor
Average Daily Traffic Before Flood ____ Cars ____ Buses and Trucks
Route of Detour ____

Increased Distance of Detour ____ Miles
Losses Prevented by Emergency Preparation ____
Intangibles (Effect on Fire Protection, Ambulance and School Bus Service, etc.) ____

Data Collected/Submitted by: | Title | Date

Signature

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SURVEY OF FLOOD DAMAGE

FORM 4

BRIDGES

Serial Number

River | Period of Flood | Date of Crest | Owner

County or City | Flood Zone | Flood Crest ____ ft. on ____ gage

Damage	Cost Estimates Sub-total	Cost Estimates Total	Remarks
Direct			
Piers & Abutments	$		
Superstructure			
Approaches			
Utilities			
Other ____			
Total Direct		$	
Indirect			
Temporary Structure or Repairs (net cost)	$		
Extra Cost of Emergency Rail Service			
Rerouting:			
Highway Dept. Patrols			
Trucking Companies or Railroads			
Shippers by Truck or Rail			
Other Travelers			
Loss of Earnings by Transportation Employees			
Cost of Flood Fighting			
Total Indirect		$	
Grand Total		$	

Relevant Data

Height of Flood Above or Below Bridge Flood ____ Feet Above ____ Below ____
Maximum Head on Bridge ____ Feet (refer to low steel) ____
Number of Days Superstructure Submerged ____
Parts of Bridge Damaged Beyond Repair ____
Type of Structure ____
Age of Structure ____ Years Condition of Structure Good ____ Fair ____ Poor ____
Original Cost of Structure $ ____
Estimated Remaining Useful Life Just Prior to Flood ____ Years ____
Number of Hours Warning of Flood Stage ____
Losses Prevented by Emergency Preparation ____
Debris or Ice Jam Conditions ____
Route of Detour ____

Increased Distance of Detour ____ Miles
Average Daily Traffic Count Before Flood ____ Cars ____ Buses & Trucks
Intangibles (Effect on Fire Protection, Ambulance and School Bus Service, etc.) ____

Data Collected/Submitted by: | Title | Date

Signature

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Figure J-1 (continued)

FORM 5

SURVEY OF FLOOD DAMAGE

UTILITIES AND COMMUNICATIONS

Serial Number

Gas Electric Telephone Telegraph Steam Water Oil

River | Period of Flood | Date of Crest | Location of Damage

Owner or Agency | Represented by | Flood Zone

Other Zones Reported On | Flood Crest at ____ ft. on ____ gage | Depth Submerged ____ ft.

Property Damaged (use separate sheet for each major subdivision)

Damage	Cost Estimates Sub-total	Total	Remarks
Direct (itemize)			
Plant	$____		____
Other Bldgs. & Contents	____		____
Loss of Records	____		____
Equipment (specify)	____		____
Lines or Mains (ft.)	____		____
Other____	____		____
Total Direct		$____	
Indirect			
Emergency Repairs & Services (additional net cost)	$____		____
Lost Production	____		____
Lost Profit	____		____
Loss of Wages to Employees	____		____
Cost of Flood Fighting or Emergency Precautions	____		____
Evacuation & Reoccupation	____		____
Cleanup	____		____
Other____	____		____
Total Indirect		$____	
Grand Total		$____	

Relevant Data

Number of Days Interruption to Normal Service ____ All Service ____
Parts of Utility Damaged Beyond Repair ____
Age of Pertinent Items ____
Condition of Pertinent Items ____
Original Costs of Pertinent Items ____
Estimated Remaining Useful Life Prior to Flood ____ Years
Number Hours Warning of Flood Stage ____
Emergency Precautions Taken ____
Losses Prevented by Emergency Precautions ____

Data Collected/Submitted by: | Title | Date

Signature

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

FORM 6

SURVEY OF FLOOD DAMAGE

RELIEF AND HEALTH EXPENDITURES BY PUBLIC AGENCIES

Serial Number

River | Period of Flood | Flood Zone

County | Township

Official Supplying Information

Agency | Name

Indirect Losses	Expenditures	
Evacuation, Rescue, and Reoccupation	$____	
Emergency Supplies	____	
Food	____	
Clothing	____	
Shelter	____	
Total		$____
Administration of Rescue Camps	$____	
Medical, Surgical & Hospital Care	____	
Policing	____	
Cleanup (public)	____	
Public Health Protection of Water Supplies	____	
Other Sanitary Measures	____	
Total		$____
Grand Total		$____

Relevant Data

Sickness and Injury Incident to Flood, Including Drownings

Nature of Sickness or Injury	Number Cases	Number Recovered	Percent Recovered	Deaths

Remarks
Number of Cases of Illness and Injury Receiving No Treatment
Number of Persons Immunized Against:
Typhoid | Small Pox | Diptheria | Tetanus | Others
Remarks

Data Collected/Submitted by: | Title | Date

Signature

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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

FORM 7

SURVEY OF FLOOD DAMAGE

AGRICULTURAL DAMAGES

Serial Number

River | Period of Flood | Date of Crest | Total Acreage: Owned / Cultivated

State | County | Township | Acreage Flooded: Cultivated / Other

Flood Zone | Occupant Name | Owner Name | Flood Stage ____ ft. on ____ gage

Damage	Cost Estimates Sub-total	Total	Remarks
Direct			
Crops in Ground	$____		____
Stored Crops	____		____
Feed & Supplies	____		____
Livestock	____		____
Livestock Products	____		____
Farm Machinery & Equipment	____		____
Cars, Trucks, Wagons, etc.	____		____
Fences	____		____
Farm Roads, Bridges	____		____
Misc. Outdoor Improvements	____		____
Drainage & Irrigation Works	____		____
Land by:			
Bank Erosion	____		____
Sheet Erosion	____		____
Infertile Deposition	____		____
Other ____	____		____
Total Direct		$____	

Item No.	Item	Damaged Crops				
	Actual Crop Damage					
1	Acreage Damaged	____				
2	Stage of Maturity Percent	____				
3	Expended Yield Per Acre (based on average non-flood year; state unit)	____	____	____	____	____
4	Unit Value at Current Prices	$____	$____	$____	$____	$____
5	Direct Crop Loss if No Replant Is Possible (item 1 x 3 x 4)	$____	$____	$____	$____	$____
6	Unexpected Cash Expenses (cultivating, harvesting, etc.) of Damaged Crop on Total Acreage	$____	$____	$____	$____	$____

Relevant Data

Data Collected/Submitted by: | Title | Date

Signature

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

FORM 8

SURVEY OF FLOOD DAMAGE

NON-PUBLIC BUILDING AND GROUNDS

Serial Number

Farm | Residence | Commercial | Manufacturing

River | Period of Flood | Date of Crest | Bldg. No.____of____Bldgs.

City | State | Flood Zone | Flood Stage ____ ft. on ____ gage

Name of Owner | Address

Name of Occupant | Address

Type of Business

Damage	Cost Estimates Sub-total	Total	Remarks
Direct			
Building:			
Foundation	$____		____
Superstructure	____		____
Improvements	____		____
Decorations	____		____
Other	____		____
Contents:			
Furnishings	____		____
Personal Effects	____		____
Equipment	____		____
Stock	____		____
Raw Materials or Supplies	____		____
Finished Product	____		____
Records	____		____
Miscellaneous:			
Minor Bldgs., Contents	____		____
Cars, Trucks, etc.	____		____
Grounds & Improvements	____		____
Total Direct		$____	
Indirect			
Loss of Profits Due to Interruption of Business	$____		____
Increased Costs of Operations	____		____
Loss of Earnings by Employees or Occupants	____		____
Cost of Flood Fighting	____		____
Evacuations & Reoccupation	____		____
Other (specify)____	____		____
Total Indirect		$____	
Grand Total		$____	

Relevant Data

Value of Bldg.____Value of Contents____No. of Persons Affected by Flood____
Condition of Bldgs.____Good____Fair____Poor No. of Days out of Business____Use____
Size of Bldgs.____No. of Floors____Max. Ht. of Water from Ground at Bldg.____ft.
Loss Prevented by Evacuation or Emergency Preparations____No. of Hours Warning of Flood Stage
No. of Days Water in Basement____on First Floor____on Second Floor____
Damage Occurred by Direct ____ Overflow____Sewer Back-up____ Seepage____
Ht. of Floors Above or Below Ground (feet) B____1____2____3____
Percentage of Value of Contents by Floors B____1____2____3____
Percentage of Total Losses to Bldg. and Contents by Floors B____1____2____3____
Was____Stand-Pipe____Flap-Gates on Premises____Yes____No
Pumping Facilities Effective in Reducing Extent of Damages____
Data Collected/Submitted by: | Title | Date

Signature

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Appendix K

FLOOD DAMAGE AND FLOOD DAMAGE DERIVATION DATA

Table K-1

HISTORICAL FLOOD LOSSES

PUBLIC SECTOR

Agency	Individual Reporting	Time of Damaging Flood	Costs of Damage (in dollars)		Reason for Expenditure
			Direct	Indirect	
Milwaukee County Park Commission	Robert Mikula, County Landscape Architect	--	--	--	--
Milwaukee County *Highway Department*	S.N. Brickhouse, Chief of Planning Section	Spring, 1960	500	None	Road Repair
Racine County Highway Department	James Lavin, Acting County Highway Engineer	--	--	--	--
Franklin, City of	Frank Wellstein, City Engineer	Annual	200	None	Road Repair
Greendale, Village of	Philip Dinauer, Village Engineer	Annual	None	100	Traffic Control
Greenfield, City of	H.C. Webster, Consulting Engineer Walter Steusser, City Superintendent of Streets	Spring, 1960	425	None	Pumping of Flooded Basements
Hales Corners, Village of	Paul C. Steinert, Village Manager Elmer Faehrman, Superintendent of Streets	--	--	--	--
Oak Creek, City of	Richard Hay, City Engineer Edgar Boers, City Superintendent of Streets	Spring, 1959 Spring, 1960 Spring, 1961	None None None	200 200 200	Barricading Flooded Streets
Racine, City of	William Chadwick, City Engineer Fred Larson, City Director of Public Works	Spring, 1960 Spring, 1962	5,000 1,500	1,000 1,000	1. Basement Pumping 2. Dynamiting of Ice Jams 3. Clean Up
West Allis, City of	Peter Burbach, City Engineer R.E. Hahn, City Superintendent of Public Works	July, 1955 March-April, 1960 August, 1960 July 17-18, 1964 July 25, 1964	4,000 4,000 4,000 4,000 2,000	None None None None None	1. Basement Pumping 2. Clean Up 3. Road Repair
Caledonia, Town of	Virginia Healy, Town Clerk	Spring, 1960	2,500	None	1. Basement Pumping 2. Replacing Gravel
Mount Pleasant, Town of	Kermit Hanson, Town Clerk	--	--	--	--
Raymond, Town of	Leo Jorgensen, Chairman of Town Board	--	--	--	--
Yorkville, Town of	Willard Savage, Chairman of Town Board	--	--	--	--
Wisconsin Highway Commission Milwaukee District	Thomas A. Winkel, District Urban Planning Supervisor	Spring, 1960	6,237.31	None	Bridge and Road Repair
Wisconsin Highway Commission Racine Distict	Roy Lovejoy, District Chief Maintenance Engineer	Spring, 1960	7,000	65,000[a]	1. Traffic Control and Road Repair 2. Road User Detour Costs
Wisconsin Motor Vehicle Department (Highway Patrol)	Dan F. Schutz, Director	--	--	--	--
Wisconsin National Guard	Major General Ralph J. Olson	--	--	--	--
Wisconsin Public Service Commission	R.E. Purucker, Chief Engineer	--	--	--	--
American Red Cross	Robert G. Wick, Executive Director, Milwaukee-Waukesha Chapter	Spring, 1960	None	4,956.54[b]	Relief and Health Services
U.S. Coast Guard	Roger D. Gilliver, Officer-in-Charge	--	--	--	--
Chicago and Northwestern Railway Co.	G.W. Smith, *Division Engineer*	*Spring*, 1960	200	800	Track Repair and Train Rerouting
Wisconsin Telephone Company	--	--	--	--	--
Wisconsin Electric Power Company	--	--	--	--	--

[a] Calculated by Harza Engineering Company from road closure, detour, and vehicle density information.

[b] This is not included in the Racine Public Sector total because it has been taken into account under evacuation costs in the Private Sector.

Source: SEWRPC.

Table K-2

RESIDENCE FLOOD DAMAGE

Current Dollar Value	Items	Total Value of Furniture	Basement Damage	Dollar Damage at Depth Flooded Over First Floor																		
				.0'-.4'	.5'-1.4'	1.5'-2.0'	2.5'	3.0'	3.5'	4.0'	4.5'	5.0'	5.5'	6.0'	6.5'	7.0'	7.5'	8.0'	8.5'	9.0'	9.5'	10.0'
1,000	Floors and Walls			75	85	95	105	115	125	135	140	150	160	170	180	190	200	250	250	250	250	250
	Furniture	$ 330		165	215	250	250	250	260	265	275	280	280	280	280	280	280	280	280	280	280	280
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		$110	400	460	505	520	530	555	570	590	605	620	630	645	655	670	720	725	725	730	730
1,500	Floors and Walls			110	125	140	155	170	185	200	210	225	240	255	270	285	300	375	375	375	375	375
	Furniture	495		240	310	360	365	370	385	395	410	420	420	420	420	420	420	420	420	420	420	420
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		120	520	605	670	695	715	750	775	805	830	850	865	885	900	920	995	1000	1000	1005	1005
2,000	Floors and Walls			150	170	190	210	225	245	265	285	305	325	340	360	380	400	500	500	500	500	500
	Furniture	660		315	405	475	485	495	515	530	545	560	560	560	560	560	560	560	560	560	560	560
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		130	645	755	845	880	905	950	985	1025	1060	1085	1100	1125	1145	1170	1270	1275	1275	1280	1280
2,500	Floors and Walls			185	210	235	260	280	305	330	355	380	405	430	450	475	500	625	625	625	625	625
	Furniture	830		380	500	590	605	620	645	665	685	705	705	705	705	705	705	705	705	705	705	705
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		140	755	900	1015	1060	1095	1150	1195	1245	1290	1320	1345	1370	1395	1425	1550	1555	1555	1560	1560
3,000	Floors and Walls			220	250	280	310	335	365	395	425	455	485	510	540	570	600	750	750	750	750	750
	Furniture	1000		450	600	700	725	750	750	800	825	850	850	850	850	850	850	850	850	850	850	850
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		150	870	1050	1180	1240	1290	1325	1405	1465	1520	1555	1580	1615	1645	1680	1830	1835	1835	1840	1840
3,500	Floors and Walls			255	290	325	360	390	425	460	495	530	565	595	630	665	700	875	875	875	875	875
	Furniture	1150		505	670	785	825	865	895	920	950	980	980	980	980	980	980	980	980	980	980	980
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		160	970	1170	1320	1400	1470	1540	1600	1670	1735	1775	1805	1845	1880	1920	2095	2100	2100	2105	2105
4,000	Floors and Walls			290	330	370	410	445	485	525	565	605	645	680	720	760	800	1000	1000	1000	1000	1000
	Furniture	1300		560	740	870	925	975	1010	1040	1075	1105	1105	1105	1105	1105	1105	1105	1105	1105	1105	1105
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		165	1065	1285	1455	1555	1640	1720	1790	1870	1940	1985	2020	2065	2105	2150	2350	2355	2355	2360	2360
4,500	Floors and Walls			330	375	420	460	505	550	595	635	680	725	770	810	855	900	1125	1125	1125	1125	1125
	Furniture	1475		620	825	960	1035	1105	1145	1180	1220	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255	1255
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		175	1175	1425	1605	1725	1840	1930	2010	2095	2175	2225	2270	2315	2360	2410	2635	2640	2640	2645	2645
5,000	Floors and Walls			375	425	470	520	570	615	665	710	760	810	860	905	950	1000	1250	1250	1250	1250	1250
	Furniture	1650		680	910	1050	1145	1240	1280	1320	1365	1405	1405	1405	1405	1405	1405	1405	1405	1405	1405	1405
	Lawn			50	50	50	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90
	TOTAL with Basement		185	1290	1570	1755	1905	2050	2140	2230	2325	2415	2470	2520	2570	2615	2670	2720	2725	2725	2730	2730
5,500	Floors and Walls			410	465	515	560	625	675	730	780	835	890	940	995	1045	1100	1375	1375	1375	1375	1375
	Furniture	1825		730	985	1130	1250	1370	1415	1460	1505	1550	1550	1550	1550	1550	1550	1550	1650	1550	1550	1650
	Lawn			55	55	55	60	60	65	65	70	70	75	75	80	80	85	85	90	90	95	95
	TOTAL with Basement		190	1385	1695	1890	2070	2245	2345	2445	2545	2645	2705	2755	2815	2865	2925	3200	3205	3205	3210	3210
6,000	Floors and Walls			440	500	555	615	675	735	790	850	910	965	1025	1085	1140	1200	1500	1500	1500	1500	1500
	Furniture	2000		780	1060	1210	1355	1500	1550	1600	1650	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
	Lawn			60	60	60	65	65	70	70	75	75	80	80	85	85	90	90	95	95	100	100
	TOTAL with Basement		200	1480	1820	2025	2235	2440	2555	2660	2775	2885	2945	3005	3070	3125	3190	3490	3495	3495	3500	3500

Source: USDA.

Table K-2 (continued)

Current Dollar Value	Items	Total Value of Furniture	Basement Damage	Dollar Damage at Depth Flooded Over First Floor .0'-.4'	.5'-1.4'	1.5'-2.0'	2.5'	3.0'	3.5'	4.0'	4.5'	5.0'	5.5'	6.0'	6.5'	7.0'	7.5'	8.0'	8.5'	9.0'	9.5'	10.0'
6,500	Floors and Walls			475	540	600	665	730	795	855	920	985	1045	1110	1175	1235	1300	1625	1625	1625	1625	1625
	Furniture	$2150		815	1105	1270	1445	1615	1670	1720	1775	1830	1830	1830	1830	1830	1830	1830	1830	1830	1830	1830
	Lawn			65	65	65	70	70	75	75	80	80	85	85	90	90	95	95	100	100	105	105
	TOTAL with Basement		$210	1565	1920	2145	2390	2625	2750	2860	2985	3105	3170	3235	3305	3365	3435	3760	3765	3765	3770	3770
7,000	Floors and Walls			510	580	645	715	785	855	920	990	1060	1125	1195	1265	1330	1400	1750	1750	1750	1750	1750
	Furniture	2300		850	1150	1330	1530	1725	1785	1840	1900	1955	1955	1955	1955	1955	1955	1955	1955	1955	1955	1955
	Lawn			70	70	70	75	75	80	80	85	85	90	90	95	95	100	100	105	105	110	110
	TOTAL with Basement		225	1655	2025	2270	2545	2810	2945	3065	3200	3325	3395	3465	3540	3605	3680	4030	4035	4035	4040	4040
8,000	Floors and Walls			580	660	735	815	895	975	1050	1130	1210	1285	1365	1445	1520	1600	2000	2000	2000	2000	2000
	Furniture	2650		925	1270	1450	1720	1990	2055	2120	2190	2255	2255	2255	2255	2255	2255	2255	2255	2255	2255	2255
	Lawn			80	80	80	85	85	90	90	95	95	100	100	105	105	110	110	115	115	120	120
	TOTAL with Basement		250	1835	2260	2515	2870	3220	3370	3510	3665	3810	3890	3970	4055	4130	4215	4615	4620	4620	4625	4625
9,000	Floors and Walls			640	730	820	910	995	1085	1175	1265	1355	1445	1535	1620	1710	1800	2250	2250	2250	2250	2250
	Furniture	3000		1020	1380	1560	1905	2250	2325	2400	2475	2550	2550	2550	2550	2550	2550	2550	2550	2550	2550	2550
	Lawn			90	90	90	95	95	100	100	105	105	110	110	115	115	120	120	125	125	130	130
	TOTAL with Basement		275	2025	2475	2745	3185	3615	3785	3950	4120	4285	4380	4470	4560	4650	4745	5195	5200	5200	5205	5205
10,000	Floors and Walls			685	785	890	990	1090	1190	1290	1395	1495	1595	1695	1800	1900	2000	2500	2500	2500	2500	2500
	Furniture	3300		1090	1480	1680	2080	2475	2560	2640	2725	2805	2805	2805	2805	2805	2805	2805	2805	2805	2805	2805
	Lawn			100	100	100	105	105	110	110	115	115	120	120	125	125	130	130	135	135	140	140
	TOTAL with Basement		305	2180	2670	2975	3480	3975	4165	4345	4540	4720	4825	4925	5035	5135	5240	5740	5745	5745	5750	5750
11,000	Floors and Walls			735	860	960	1075	1185	1300	1410	1525	1635	1750	1860	1975	2085	2200	2750	2750	2750	2750	2750
	Furniture	3650		1170	1610	1820	2280	2740	2830	2920	3015	3105	3105	3105	3105	3105	3105	3105	3105	3105	3105	3105
	Lawn			110	110	110	115	115	120	120	125	125	130	130	135	135	140	140	145	145	150	150
	TOTAL with Basement		345	2360	2915	3235	3815	4385	4595	4795	5010	5210	5330	5440	5560	5670	5790	6340	6345	6345	6350	6350
12,000	Floors and Walls			775	900	1025	1150	1275	1400	1525	1650	1775	1900	2025	2150	2275	2400	3000	3000	3000	3000	3000
	Furniture	4000		1240	1720	1960	2480	3000	3100	3200	3300	3400	3400	3400	3400	3400	3400	3400	3400	3400	3400	3400
	Lawn			120	120	120	125	125	130	130	135	135	140	140	145	145	150	150	155	155	160	160
	TOTAL with Basement		390	2525	3130	3495	4145	4790	5020	5245	5475	5700	5830	5955	6085	6210	6340	6940	6945	6945	6950	6950
13,000	Floors and Walls			820	955	1095	1230	1370	1505	1640	1780	1915	2050	2190	2325	2465	2600	3250	3250	3250	3250	3250
	Furniture	4300		1290	1805	2065	2645	3225	3335	3440	3550	3655	3655	3655	3655	3655	3655	3655	3655	3655	3655	3655
	Lawn			130	130	130	135	135	140	140	145	145	150	150	155	155	160	160	165	165	170	170
	TOTAL with Basement		425	2665	3315	3715	4435	5155	5405	5645	5900	6140	6280	6420	6560	6700	6840	7490	7495	7495	7500	7500
14,000	Floors and Walls			860	1010	1160	1310	1455	1605	1755	1905	2055	2205	2350	2500	2650	2800	3500	3500	3500	3500	3500
	Furniture	4600		1330	1890	2160	2805	3450	3565	3680	3795	3910	3910	3910	3910	3910	3910	3910	3910	3910	3910	3910
	Lawn			140	140	140	145	145	150	150	155	155	160	160	165	165	170	170	175	175	180	180
	TOTAL with Basement		460	2790	3500	3920	4720	5510	5780	6045	6315	6580	6735	6880	7035	7185	7340	8040	8045	8045	8050	8050
15,000	Floors and Walls			900	1060	1225	1385	1545	1710	1870	2030	2190	2355	2515	2675	2840	3000	3750	3750	3750	3750	3750
	Furniture	4950		1390	1980	2280	3000	3715	3840	3960	4085	4210	4210	4210	4210	4210	4210	4210	4210	4210	4210	4210
	Lawn			150	150	150	155	155	160	160	165	165	170	170	175	175	180	180	185	185	190	190
	TOTAL with Basement		505	2945	3695	4160	5045	5920	6215	6495	6785	7070	7240	7400	7565	7730	7895	8645	8650	8650	8655	8655
16,000	Floors and Walls			960	1140	1310	1470	1650	1820	2000	2160	2340	2510	2690	2850	3020	3200	4000	4000	4000	4000	4000
	Furniture	5280		1490	2110	2432	3200	3970	4100	4220	4350	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
	Lawn			160	160	160	160	160	180	180	180	180	180	180	190	190	190	190	190	190	210	210
	TOTAL with Basement		540	3150	3950	4442	5370	6320	6640	6940	7230	7560	7730	7910	8080	8250	8430	9230	9230	9230	9250	9250

Source: USDA.

Table K-2 (continued)

Current Dollar Value	Items	Total Value of Furniture	Basement Damage	Dollar Damage at Depth Flooded Over First Floor																		
				.0'-.4'	.5'-1.4'	1.5'-2.0'	2.5'	3.0'	3.5'	4.0'	4.5'	5.0'	5.5'	6.0'	6.5'	7.0'	7.5'	8.0'	8.5'	9.0'	9.5'	10.0'
17,000	Floors and Walls	$5610		1020	1210	1390	1560	1750	1940	2120	2300	2480	2670	2860	3030	3210	3400	4250	4250	4250	4250	4250
	Furniture			1580	2240	2580	3400	4220	4350	4490	4620	4780	4780	4780	4780	4780	4780	4780	4780	4780	4780	4780
	Lawn			170	170	170	170	170	190	190	190	190	190	190	200	200	200	200	200	200	220	220
	TOTAL with Basement		$580	3350	4200	4720	5710	6720	7060	7380	7690	8030	8220	8410	8590	8770	8960	9810	9810	9810	9830	9830
18,000	Floors and Walls	5940		1080	1280	1480	1660	1850	2050	2250	2430	2630	2830	3020	3200	3400	3600	4500	4500	4500	4500	4500
	Furniture			1670	2380	2740	3600	4460	4610	4750	4900	5060	5060	5060	5060	5060	5060	5060	5060	5060	5060	5060
	Lawn			180	180	180	180	180	200	200	200	200	200	200	220	220	220	220	220	220	230	230
	TOTAL with Basement		610	3540	4450	5010	6050	7100	7470	7810	8140	8500	8700	8890	9090	9290	9490	10390	10390	10390	10400	10400
19,000	Floors and Walls	6270		1140	1350	1560	1750	1960	2170	2380	2560	2770	2980	3190	3380	3590	3800	4750	4750	4750	4750	4750
	Furniture			1770	2510	2890	3800	4710	4860	5020	5170	5340	5340	5340	5340	5340	5340	5340	5340	5340	5340	5340
	Lawn			190	190	190	190	190	210	210	210	210	210	210	230	230	230	230	230	230	250	250
	TOTAL with Basement		650	3750	4700	5290	6390	7510	7890	8260	8590	8970	9180	9390	9600	9810	10020	10970	10970	10970	10990	10990
20,000	Floors and Walls	6600		1200	1420	1640	1840	2060	2280	2500	2700	2920	3140	3360	3560	3780	4000	5000	5000	5000	5000	5000
	Furniture			1860	2640	3040	4000	4960	5120	5280	5440	5620	5620	5620	5620	5620	5620	5620	5620	5620	5620	5620
	Lawn			200	200	200	200	200	220	220	220	220	220	220	240	240	240	240	240	240	260	260
	TOTAL with Basement		680	3940	4940	5560	6720	7900	8300	8680	9040	9440	9660	9880	10100	10320	10540	11540	11540	11540	11560	11560
21,000	Floors and Walls	6930		1260	1490	1720	1930	2160	2390	2625	2840	3070	3300	3530	3740	3970	4200	5250	5250	5250	5250	5250
	Furniture			1950	2770	3190	4200	5210	5380	5540	5710	5900	5900	5900	5900	5900	5900	5900	5900	5900	5900	5900
	Lawn			210	210	210	210	210	230	230	230	230	230	230	250	250	250	250	250	250	270	270
	TOTAL with Basement		710	4130	5180	5830	7050	8290	8710	9105	9490	9910	10140	10370	10600	10830	11060	12110	12110	12110	12130	12130
22,000	Floors and Walls	7260		1320	1560	1800	2020	2270	2510	2750	2970	3210	3450	3700	3920	4160	4400	5500	5500	5500	5500	5500
	Furniture			2050	2900	3340	4400	5460	5630	5810	5980	6180	6180	6180	6180	6180	6180	6180	6180	6180	6180	6180
	Lawn			220	220	220	220	220	240	240	240	240	240	240	260	260	260	260	260	260	290	290
	TOTAL with Basement		750	4340	5430	6110	7390	8700	9130	9550	9940	10380	10620	10870	11110	11350	11590	12690	12690	12690	12720	12720
23,000	Floors and Walls	7590		1380	1630	1890	2120	2370	2620	2875	3100	3360	3610	3860	4090	4350	4600	5750	5750	5750	5750	5750
	Furniture			2140	3040	3500	4600	5700	5890	6070	6260	6460	6460	6460	6460	6460	6460	6460	6460	6460	6460	6460
	Lawn			230	230	230	230	230	250	250	250	250	250	250	280	280	280	280	280	280	300	300
	TOTAL with Basement		780	4530	5680	6400	7730	9080	9540	9975	10390	10850	11100	11350	11610	11870	12120	13270	13270	13270	13290	13290
24,000	Floors and Walls	7920		1440	1700	1970	2210	2470	2740	3000	3240	3500	3770	4030	4270	4540	4800	6000	6000	6000	6000	6000
	Furniture			2230	3170	3650	4800	5950	6140	6340	6530	6740	6740	6740	6740	6740	6740	6740	6740	6740	6740	6740
	Lawn			240	240	240	240	240	260	260	260	260	260	260	290	290	290	290	290	290	310	310
	TOTAL with Basement		820	4730	5930	6680	8070	9480	9960	10420	10850	11320	11590	11850	12120	12390	12650	13850	13850	13850	13870	13870
25,000	Floors and Walls	8260		1500	1780	2050	2300	2580	2850	3120	3380	3650	3920	4200	4450	4720	5000	6250	6250	6250	6250	6250
	Furniture			2320	3300	3800	5000	6200	6400	6600	6800	7020	7020	7020	7020	7020	7020	7020	7020	7020	7020	7020
	Lawn			250	250	250	250	250	270	270	270	270	270	270	300	300	300	300	300	300	320	320
	TOTAL with Basement		850	4920	6180	6950	8400	9880	10370	10840	11300	11790	12060	12340	12620	12890	13170	14420	14420	14420	14440	14440
26,000	Floors and Walls	8580		1560	1850	2130	2390	2680	2960	3250	3510	3800	4080	4370	4630	4910	5200	6500	6500	6500	6500	6500
	Furniture			2420	3430	3950	5200	6450	6660	6860	7070	7310	7310	7310	7310	7310	7310	7310	7310	7310	7310	7310
	Lawn			260	260	260	260	260	290	290	290	290	290	290	310	310	310	310	310	310	340	340
	TOTAL with Basement		880	5120	6420	7220	8730	10270	10790	11280	11750	12280	12560	12850	13130	13410	13700	15000	15000	15000	15030	15030
27,000	Floors and Walls	8910		1620	1920	2210	2480	2780	3080	3380	3640	3940	4240	4540	4810	5100	5400	6750	6750	6750	6750	6750
	Furniture			2510	3560	4100	5400	6700	6910	7130	7340	7590	7590	7590	7590	7590	7590	7590	7590	7590	7590	7590
	Lawn			270	270	270	270	270	300	300	300	300	300	300	320	320	320	320	320	320	350	350
	TOTAL with Basement		920	5320	6670	7500	9070	10670	11210	11730	12200	12750	13050	13350	13640	13930	14230	15580	15580	15580	15610	15610
28,000	Floors and Walls	9240		1680	1990	2300	2580	2880	3190	3500	3780	4090	4400	4700	4980	5290	5600	7000	7000	7000	7000	7000
	Furniture			2600	3700	4260	5600	6940	7170	7390	7620	7870	7870	7870	7870	7870	7870	7870	7870	7870	7870	7870
	Lawn			280	280	280	280	280	310	310	310	310	310	310	340	340	340	340	340	340	360	360
	TOTAL with Basement		950	5510	6920	7790	9410	11050	11620	12150	12660	13220	13530	13830	14140	14450	14760	16160	16160	16160	16180	16180
29,000	Floors and Walls	9570		1740	2060	2380	2670	2990	3310	3625	3920	4230	4550	4870	5160	5480	5800	7250	7250	7250	7250	7250
	Furniture			2700	3830	4410	5800	7190	7420	7660	7890	8150	8150	8150	8150	8150	8150	8150	8150	8150	8150	8150
	Lawn			290	290	290	290	290	320	320	320	320	320	320	350	350	350	350	350	350	380	380
	TOTAL with Basement		990	5720	7170	8070	9750	11460	12040	12595	13120	13690	11010	14330	14650	14970	15290	16740	16740	16740	16770	16770
30,000	Floors and Walls	9900		1800	2130	2460	2760	3090	3420	3750	4050	4380	4710	5040	5340	5670	6000	7500	7500	7500	7500	7500
	Furniture			2790	3960	4560	6000	7440	7680	7920	8160	8430	8430	8430	8430	8430	8430	8430	8430	8430	8430	8430
	Lawn			300	300	300	300	300	330	330	330	330	330	330	360	360	360	360	360	360	390	390
	TOTAL with Basement		1020	5910	7410	8340	10080	11850	12450	13020	13560	14160	14490	14820	15150	15480	15810	17310	17310	17310	17340	17340

Source: USDA.

Table K-2 (continued)

Foundation Damage								
House Value	1-Side Failure	2-Side Failure	House Value	1-Side Failure	2-Side Failure	House Value	1-Side Failure	2-Side Failure
$1,000	$ 65	$ 95	$ 7,000	$250	$375	$19,000	$480	$ 720
1,500	80	120	8,000	270	405	20,000	500	760
2,000	100	150	9,000	280	420	21,000	520	800
2,500	120	180	10,000	300	450	22,000	550	840
3,000	145	220	11,000	315	475	23,000	580	870
3,500	160	240	12,000	330	495	24,000	600	910
4,000	175	265	13,000	345	520	25,000	620	950
4,500	190	285	14,000	365	550	26,000	650	990
5,000	205	310	15,000	380	570	27,000	680	1,030
5,500	220	330	16,000	400	610	28,000	700	1,060
6,000	230	345	17,000	420	650	29,000	720	1,100
6,500	240	360	18,000	450	680	30,000	750	1,140

NOTE: All information pertaining to properties valued at less than $16,000 was provided by the Division Office, Army Corps of Engineers, Omaha, Nebraska.

Source: USDA.

Table K-3

CURRENT AGRICULTURAL CROP PRICES

Commodity	Unit	Price	Remarks
Field Crops:			
Hay (all).	ton	$18.90	1963 Calendar Year Average
Oats	bu.	0.67	1963 Calendar Year Average
Corn (grain)	bu.	1.13	1963 Calendar Year Average
Soybeans (for beans)	bu.	2.41	1963 Calendar Year Average
Wheat (all).	bu.	1.85	1963 Calendar Year Average
Barley	bu.	0.99	1963 Calendar Year Average
Truck:			
Cabbage (all).	cwt	$ 1.85	1962 Season Average
Potatoes	cwt	2.19	1963 Calendar Year Average

Source: USDA.

Table K-4

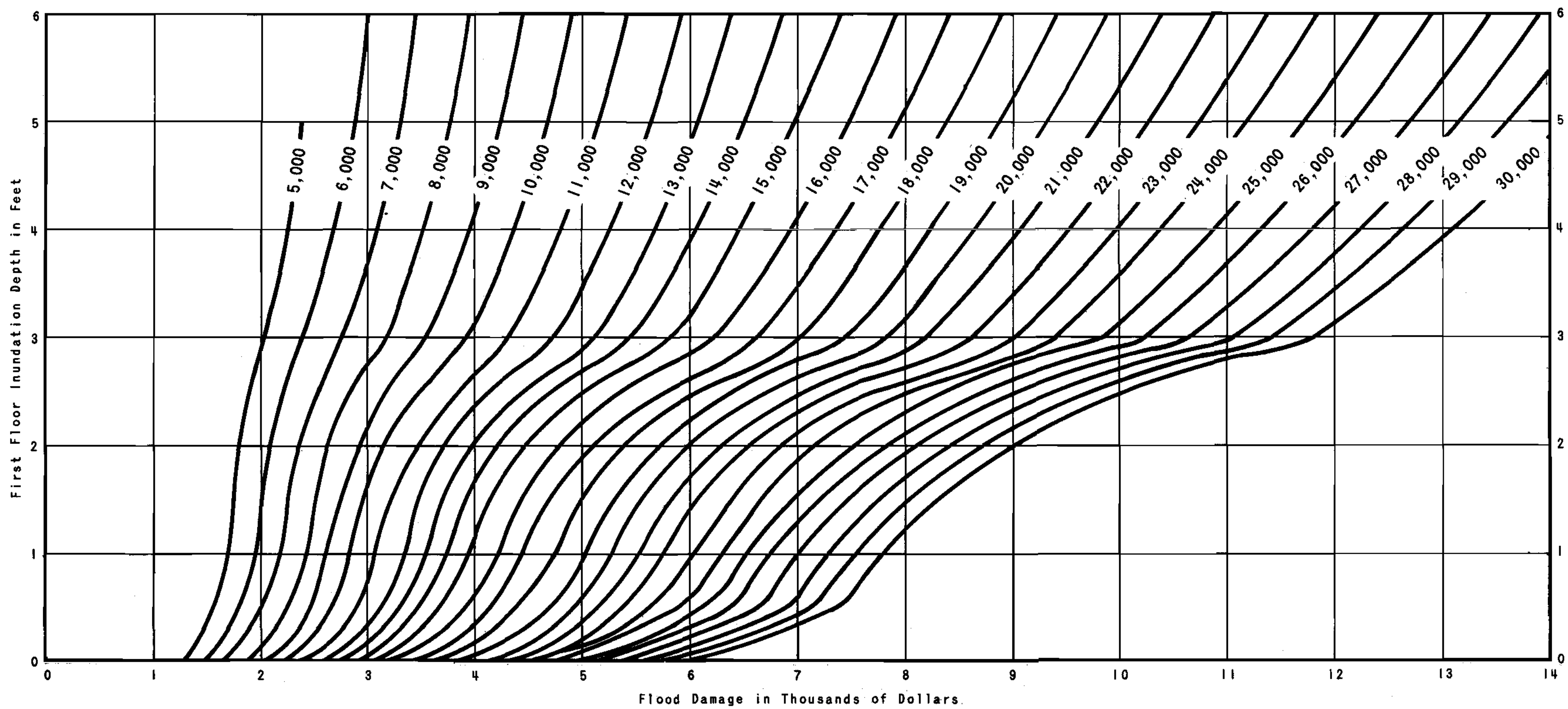
AGRICULTURAL CROP YIELDS FOR RACINE COUNTY

Crop	Unit	Yield	Remarks
Field Crops:			
Hay (all).	ton	3.0	1960-1964 Test Yield Average
Oats	bu.	90	1960-1964 Test Yield Average
Corn (grain)	bu.	85	1960-1964 Test Yield Average
Soybeans (for beans)	bu.	30	1960-1963 Test Yield Average
Wheat (all).	bu.	45	1960-1963 Weighted Values of Test Yield Average
Barley	bu.	60	1960-1964 Test Yield Average
Truck:			
Cabbage (all).	cwt	360	1960-1964 Test Yield Average
Potatoes	cwt	300	1960-1964 Test Yield Average

Source: University of Wisconsin Cooperative Extension Service.

Figure K-1

STAGE-DAMAGE RELATIONSHIPS FOR RESIDENTIAL PROPERTY IN THE ROOT RIVER WATERSHED (1965)



NOTE: Includes Basement and Lawn Damages.

Source: SEWRPC.

Appendix L

MODEL LAND USE CONTROL REGULATIONS FOR FLOOD PLAINS AND ENVIRONMENTAL CORRIDORS

Appendix L-1

EXCERPTS FROM REVISED "MODEL LAND DIVISION ORDINANCE" APPENDIX A, LAND DEVELOPMENT GUIDE, SEWRPC, 1963

SECTION 2.6 Land Suitability
No land shall be subdivided for any use where the *Village Plan Commission*[1] finds that the land has severe or very severe limitations for such use by reason of flooding, concentrated runoff, inadequate drainage, adverse soil or rock formation, unfavorable topography, low bearing strength, slow permeability, erosion susceptibility, or any other feature likely to be harmful to the health, safety, prosperity, aesthetics, and general welfare of this community.

The Village Plan Commission, in applying the provisions of this section, shall in writing recite the particular facts upon which it bases its conclusions that the land is not suitable for certain uses.

Lands Lying within or at less than two (2) feet above the one hundred (100)-year recurrence interval flood shall not be subdivided for residential, commercial, or industrial use.

The Applicant shall have an opportunity to present evidence contesting such finding if he so desires. Thereafter the *Village Plan Commission* may affirm, modify, or withdraw its finding.

The Village Plan Commission may request the County Soil and Water Conservation District to provide expert assistance from regional, state, or federal agencies which are assisting the District under a "Memorandum of Understanding."

SECTION 4.2 Overflow Area Boundaries for a one hundred (100)-year recurrence interval flood based upon hydraulic and hydrologic engineering studies.

SECTION 7.1 Elevations of streets passing through flood areas shall be at least two (2) feet above the one hundred (100)-year recurrence interval flood level and shall be designed so as to have minimum adverse effect on flood flows or velocities.

[1] Words, terms, or numbers appearing in italics are provided as examples only and may be changed or omitted to best meet the desires and needs of individual communities.

Appendix L-2

EXCERPTS FROM REVISED "MODEL ZONING ORDINANCE" APPENDIX A, ZONING GUIDE, SEWRPC, 1964

SECTION 3.3 Residential Districts

R-1 Single-Family Residential District[1]

Principal Uses		One-family dwellings
Conditional Uses		See Section 4.4.
Lot	Width	Minimum *120* ft.
	Area	Minimum *40,000* sq. ft.
Building	Area	Minimum *2,000* sq. ft.
	Height	Maximum *35* ft.
Yards	Street	Minimum *50* ft.
	Rear	Minimum *50* ft.
	Side	Minimum *20* ft.

R-2 Single-Family Residential District

Principal Uses		One-family dwellings
Conditional Uses		See Sections 4.4 and 4.5.
Lot	Width	Minimum *70* ft.
	Area	Minimum *10,000* sq. ft.
Building	Area	Minimum *1,200* sq. ft.
	Height	Maximum *35* ft.
Yards	Street	Minimum *25* ft.
	Rear	Minimum *40* ft.
	Side	Minimum *10* ft.

R-3 Multi-Family Residential District

Principal Uses		Multi-family dwellings
Conditional Uses		See Sections 4.4 and 4.5.
Lot	Width	Minimum *120* ft.
	Area	Minimum *15,000* sq. ft. with no less than *2,000* sq. ft. per efficiency; *2,500* sq. ft. per one-bedroom unit; *3,000* sq. ft. per two-bedroom unit.
Building	Area	Minimum *500* sq. ft. per family.
	Height	Maximum *35* ft.
Yards	Street	Minimum *35* ft.
	Rear	Minimum *50* ft.
	Side	Minimum *20* ft.

SECTION 3.6 Agricultural District

A-1 Agricultural District

Principal Uses Apiculture, dairying, floriculture, forestry, general farming, grazing, greenhouses, hatcheries, horticulture, livestock raising, nurseries, orchards, paddocks, pasturage, poultry raising, stables, truck farming, and viticulture. Farm dwellings for those resident owners and laborers actually engaged in the principal permitted uses are accessory uses and shall comply with all the provisions of the *R-2 Residential District*.

Conditional Uses		See Sections 4.4 and 4.7.
Farm	Frontage	Minimum *200* ft.
	Area	Minimum *10* acres.
Structure	Height	Maximum *50* ft.
Yards	Street	Minimum *80* ft.
	Rear	Minimum *50* ft.
	Side	Minimum *50* ft.

SECTION 3.7 Conservancy District

C-1 Conservancy District

Principal Uses *Fishing; hunting; preservation of scenic, historic, and scientific areas; public fish hatcheries; soil and water conservation; sustained yield forestry; stream bank and lake shore protection; water retention; and wildlife preserves.*

SECTION 3.7 Conservancy District (continued)

Conditional Uses — Drainage; water measurement and water control facilities; grazing; accessory structures, such as hunting or fishing lodges; orchards; truck farming; utilities; and wildcrop harvesting. The above uses shall not involve the dumping, filling, cultivation, mineral, soil or peat removal or any other use that would disturb the natural fauna, flora, watercourses, water regimen, or topography.

Structures — None permitted except accessory to the principal or conditional uses.

SECTION 3.9 Park District

P-1 Park District

Principal Uses — Parks, arboretums, playgrounds, fishing, wading, swimming, beaches, skating, sledding, sustained yield forestry, wildlife preserves, soil and water conservation, water measurement, and water control facilities.

Conditional Uses — All structures; see Sections 4.4 and 4.9.

[1] Words, terms, or numbers appearing in italics are provided as examples only and may be changed or omitted to best meet the desires and needs of individual communities.

Appendix L-3

EXCERPTS FROM REVISED "MODEL ZONING ORDINANCE" APPENDIX A, ZONING GUIDE, SEWRPC, 1964

SECTION 4.0

SECTION 4.1 Permit

The Village Plan Commission[1] may authorize the *Zoning Inspector* to issue a conditional use permit for conditional uses after review and a public hearing, provided that such conditional uses and structures are in accordance with the purpose and intent of this Ordinance and are found to be not hazardous, harmful, offensive, or otherwise adverse to the environment or the value of the neighborhood or the community.

SECTION 4.2 Application

Applications for conditional use permits shall be made in duplicate to the *Zoning Inspector* on forms furnished by the *Zoning Inspector* and shall include the following:

Names and Addresses of the applicant, owner of the site, architect, professional engineer, contractor, and all opposite and abutting property owners of record.

Description of the Subject Site by lot, block, and recorded subdivision or by metes and bounds; address of the subject site; type of structure; proposed operation or use of the structure or site; number of employees; and the zoning district within which the subject site lies.

Plat of Survey prepared by a registered land surveyor showing all of the information required under Section 2.3 for a *Zoning Permit* and existing and proposed landscaping.

Additional Information as may be required by the *Village Plan Commission; Village Engineer; Zoning, Building, Plumbing, or Health Inspectors.*

Fee Receipt from the *Village Treasurer* in the amount of *Twenty-Five Dollars ($25).*

SECTION 4.2 Review and Approval

The *Village Plan Commission* shall review the site, existing and proposed structures, architectural plans, neighboring uses, parking areas, driveway locations, highway access, traffic generation and circulation, drainage, sewerage and water systems, and the proposed operation.

Any Development within *five hundred (500)* feet of the existing or proposed rights-of-way of freeways, expressways, interstate and controlled access trafficways and within *fifteen hundred (1,500)* feet of their existing or proposed interchange or turning lane rights-of-way shall be specifically reviewed by the highway agency that has jurisdiction over the trafficway. The *Village Plan Commission* shall request such review and await the Highway Agency's recommendations for a period not to exceed *sixty (60)* days before taking final action.

Within the Flood Plain all structures and permanent improvements shall require review, public hearing, and approval by the *Village Plan Commission*. Approval shall not be granted unless the applicant can show that such structure or improvement will not impede drainage and will not substantially reduce the floodwater storage capacity of the flood plain.

Within the Floodway all uses and structures shall require review, public hearing, and approval by the *Village Plan Commission*. Approval shall not be granted unless the applicant can show that such use or structure will not obstruct the floodway, increase flood flow velocities, increase the flood stage, or retard the movement of floodwaters.

Conditions, such as landscaping, architectural design, type of construction, construction commencement and completion dates, sureties, lighting, fencing, planting screens, operational control, hours of operation, improved traffic circulation, floodproofing, special anchorages, deed restrictions, highway access restrictions, increased yards, or parking requirements, may be required by the *Village Plan Commission* upon its finding that these are necessary to fulfill the purpose and intent of this Ordinance.

Compliance with all other provisions of this Ordinance, such as lot width and area, yards, height, parking, loading, traffic, highway access, and performance standards, shall be required of all conditional uses. Variances shall only be granted as provided in Section 11.0.

SECTION 4.4 Public and Semipublic Uses

The following public and semipublic uses shall be conditional uses and may be permitted as specified:

Airports, airstrips, and landing fields in the *M-1* and *M-2 Industrial Districts, A-1 Agricultural District,* and *P-1 Park District*, provided the site area is not less than *twenty (20)* acres.

Governmental and Cultural Uses, such as fire and police stations, community centers, libraries, public emergency shelters, parks, playgrounds, and museums, in *all residential and business districts; M-1* and *M-2 Industrial Districts*, and *P-1 Park District*.

Utilities in all districts provided all principal structures and uses are not less than *fifty (50)* feet from any residential district lot line.

Public Passenger Transportation Terminals, such as heliports, bus and rail depots, except airports, airstrips, and landing fields, in all *Business Districts* and the *M-1* and *M-2 Industrial Districts* provided all principal structures and uses are not less than *one hundred (100)* feet from any residential district boundary.

Public, Parochial, and Private Elementary and secondary schools and churches in the *R-2* and *R-3 Residential Districts* and *P-1 Park District* provided the lot area is not less than *two (2)* acres and all principal structures and uses are not less than *fifty (50)* feet from any lot line.

Colleges; Universities; Hospitals; sanitariums; religious, charitable, penal and correctional institutions; cemeteries and crematories in the *A-1 Agricultural District* and *P-1 Park District* provided all principal structures and uses are not less than *fifty (50)* feet from any lot line.

SECTION 4.5 Residential Uses

The following residential and quasi-residential uses shall be conditional uses and may be permitted as specified:

Planned Residential Developments, such as cluster developments in the *R-2 Residential District* and garden apartments, row housing and group housing in the *R-3 Residential District*. The District regulations may be varied provided that adequate open space shall be provided so that the average intensity and density of land use shall be no greater than that permitted for the district in which it is located. The proper preservation, care, and maintenance by the original and all subsequent owners of the exterior design; all common structures, facilities, utilities, access and open spaces shall be assured by deed restrictions enforceable by the *Village*. The following provisions shall be complied with:

Development		Minimum *10* acres.
Lot	Area	Minimum of *2/3* of the minimum lot area for the district in which located. Minimum *3,000* sq. ft. for row houses.
	Width	Minimum of *2/3* of the minimum lot width for the district in which located. Minimum *20* ft. for row houses.
Building	Area	Minimum building area for the district in which located.
	Height	Maximum *35* ft.
	Rooms	All living rooms shall have windows opening onto a yard.
Yards	Street	Minimum *20* ft.
	Rear	Minimum *50* ft.
	Side	Minimum *20* ft. from street rights-of-way, exterior property lines of the development, and other buildings.

Clubs, fraternities, lodges, and meeting places of a noncommercial nature in the *R-3 Residential District* provided all principal structures and uses are not less than *twenty-five (25)* feet from any lot line.

Rest Homes, nursing homes, homes for the aged, clinics, and childrens nurseries in the *R-2* or *R-3 Residential Districts* provided all principal structures and uses are not less than *fifty (50)* feet from any lot line.

Home Occupations and professional offices in the *R-2* or *R-3 Residential Districts*.

SECTION 4.7 Industrial and Agricultural Uses

The following industrial and agricultural uses shall be conditional uses and may be permitted as specified:

Animal Hospitals in the *A-1 Agricultural*, *M-1* and *M-2 Industrial Districts* provided the lot area is not less than *three (3)* acres, and all principal structures and uses are not less than *one hundred (100)* feet from any residential district.

Dumps, Disposal Areas, Incinerators, and sewage disposal plants in the *A-1 Agricultural* and the *M-1* and *M-2 Industrial Districts*. Municipal earth and sanitary land fill operations may be permitted in any district, except within a floodway or flood plain.

Commercial Raising, propagation, boarding, or butchering of animals, such as dogs, mink, rabbits, foxes, goats, and pigs; the commercial production of eggs; and the hatching, raising, fattening, or butchering of fowl in the *A-1 Agricultural District*. Pea vineries, creameries, and condenseries in the *A-1 Agricultural* or *M-1* and *M-2 Industrial Districts*.

SECTION 4.9 Recreational Uses

The following public recreational facilities shall be conditional uses and may be permitted as specified: archery ranges, bathhouses, beaches, boating, camps, conservatories, driving ranges, firearm ranges, golf courses, gymnasiums, hunting, ice boating, marinas, music halls, polo fields, pools, riding academies, skating rinks, sport fields, stadiums, swimming pools, and zoological and botanical gardens in the *P-1 Park District* provided that the lot area is not less than *three (3)* acres and all structures are not less than *fifty (50)* feet from any district boundary.

Commercial Recreation Facilities, such as arcades, bowling alleys, clubs, dance halls, driving ranges, gymnasiums, lodges, miniature golf, physical culture, pool and billiard halls, racetracks, rifle ranges, turkish baths, skating rinks, and theaters are conditional uses and may be permitted in the *B-2*, *B-3*, or *B-4 Business Districts*.

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[1] Words, terms, or numbers appearing in italics are provided as examples only and may be changed or omitted to best meet the desires and needs of individual communities.

Appendix L-4

EXCERPTS FROM REVISED "MODEL ZONING ORDINANCE" APPENDIX A, ZONING GUIDE, SEWRPC, 1964

SECTION 2.3 Zoning Permit

Plat of Survey prepared by a registered land surveyor showing the location, boundaries, dimensions, elevations, uses, and size of the following: subject site; existing and proposed structures; existing and proposed easements, streets, and other public ways; off-street parking, loading areas and driveways; existing highway access restrictions; existing and proposed street, side and rear yards; channel, floodway and flood plain boundaries. In addition, the plat of survey shall show the location, elevation, and use of any abutting lands and their structures within *forty (40)*[1] feet of the subject site.

SECTION 2.6 Flood Land Restrictions

In addition to the use and site restrictions applicable to a District, the following restrictions and regulations shall apply to flood plains, floodways, and channels:

Within the Flood Plains, dumping, filling, residential uses, and the sheltering and confining of animals are prohibited.

Within the Floodways dumping, filling, residential uses, and the sheltering and confining of animals are prohibited. All structures are prohibited except navigational structures, public water measuring and water control facilities, bridges, and utilities.

Within the Channel. In addition to the above restrictions, all structures in the channel require a permit from the Public Service Commission pursuant to Section 30.12(2) of the Wisconsin Statutes; and any bulkheads, wharves, or piers shall comply with bulkhead or pierhead lines established by the Village pursuant to Sections 30.12(2) of the Wisconsin Statutes; and any bulkheads, wharves, or piers shall comply with bulkhead or pierhead lines established by the *Village* pursuant to Sections *30.11 or 30.13 of the Wisconsin Statutes.*

All Structures and permanent improvements are conditional uses requiring review, public hearing, and approval by the *Village Plan Commission* in accordance with Section 4.0. Such structures shall not involve the storage of materials that are buoyant, flammable, explosive, or injurious to human, animal, or plant life. All buildings shall have their lowest floor constructed at an elevation of no less than two (2) feet above the level of the one *hundred (100)-year recurrence interval flood.*

Appendix L-4 (continued)

SECTION 13.0 Definitions

Channel is that portion of a watercourse normally occupied by the stream under average annual flow conditions.

Floodway is that area including the channel of a watercourse required to effectively carry and discharge floodwaters and delineated as the area covered by the ten (10)-year recurrence interval flood.

Flood Plain is that relatively flat area or lowland area excluding the floodway that is inundated by the one hundred (100)-year recurrence interval flood and, where such data is not available, the maximum flood of record.

[1] Words, terms, or numbers appearing in italics are provided as examples only and may be changed or omitted to best meet the desires and needs of individual communities.

Appendix L-5

EXCERPTS FROM REVISED "MODEL ZONING ORDINANCE" APPENDIX A, ZONING GUIDE, SEWRPC, 1964

SECTION 8.1 Existing Nonconforming Uses

The lawful nonconforming use of a structure, land, or water existing at the time of the adoption or amendment of this Ordinance may be continued although the use does not conform with the provisions of this Ordinance; however:

Only That Portion of the land or water in actual use may be so continued and the structure may not be exceeded, enlarged, reconstructed, substituted, moved, or structurally altered except when required to do so by law or order or so as to comply with the provisions of this Ordinance.

Total Lifetime Structural Repairs or alterations shall not exceed fifty (50) percent of the *Village's*[1] assessed value of the structure at the time of its becoming a nonconforming use unless it is permanently changed to conform to the use provisions of this Ordinance.

Substitution of New Equipment may be permitted by the *Board of Zoning Appeals* if such equipment will reduce the incompatibility of the nonconforming use with the neighboring uses.

SECTION 8.2 Abolishment or Replacement

If such nonconforming use is discontinued or terminated for a period of twelve (12) months, any future use of the structure, land, or water shall conform to the provisions of this Ordinance. When a nonconforming use or structure is damaged by fire, explosion, flood, the public enemy, or other calamity, to the extent of more than fifty (50) percent of its current assessed value, it shall not be restored except so as to comply with the use provisions of this Ordinance.

A Current File of all nonconforming uses shall be maintained by the *Zoning Inspector* listing the following: owner's name and address; use of the structure, land, or water; and assessed value at the time of its becoming a nonconforming use.

SECTION 8.3 Existing Nonconforming Structures

The lawful nonconforming structure existing at the time of the adoption or amendment of this Ordinance may be continued although its size or location does not conform with the lot width, lot area, yard, height, parking and loading, and access provisions of this Ordinance; however, it shall not be extended, enlarged, reconstructed, moved, or structurally altered except when required to do so by law or order or so as to comply with the provisions of this Ordinance.

SECTION 8.4 Changes and Substitutions

Once a nonconforming use or structure has been changed to conform, it shall not revert back to a nonconforming use or structure. Once the *Board of Zoning Appeals* has permitted the substitution of a more restrictive nonconforming use for an existing nonconforming use, the substituted use shall lose its status as a legal conforming use and become subject to all the conditions required by the *Board of Zoning Appeals*.

[1] Words, terms, or numbers appearing in italics are provided as examples only and may be changed or omitted to best meet the desires and needs of individual communities.

Appendix L-6

SUGGESTED FLOODWAY AND FLOOD PLAIN DISTRICTS

SECTION 3.1 Establishment

Boundaries of These Districts are hereby established as shown on a map entitled "Zoning Map, *Village of*[1]________, Wisconsin," dated ________, which accompanies and is a part of this Ordinance. Such boundaries shall be construed to follow: corporate limits; U.S. Public Land Survey lines; lot or property lines; centerlines of streets, highways, alleys, easements, and railroad rights-of-way or such lines extended; and the limits of floodwaters occurring during the ten (10)- or one hundred (100)-year recurrence intervals unless otherwise noted on the Zoning Map.

3.8 F-1 Floodway District

Principal Uses — Drainage, movement of floodwater, navigation, stream bank protection, hunting, fishing, wildlife preserves, public water measurement and water control facilities; agricultural uses such as grazing, general farming, horticulture, outdoor plant nurseries, pasturage, sod farming, truck farming, viticulture, and wildcrop harvesting, except the sheltering and confining of animals.

Conditional Uses — Utilities; open uses, such as archery and firearm ranges, boat launching facilities, parks, sport fields, beaches, camping, playgrounds, skating rinks, golf courses, driving ranges, open markets and transient amusement uses; all permitted structures; dumping or filling accessory to the above principal and conditional uses provided that the applicant shows that such dumping and filling will not obstruct the floodway, increase flood flow velocities, retard the movement of floodwaters, or increase the flood stage.

Structures — None permitted except navigation structures, public water measurement and water control facilities, boat launching ramps, bridges, accessory uses and utilities. In addition, structures in the channel require a permit from the Public Service Commission pursuant to Section 3012(2) of the Wisconsin Statutes; and any bulkheads, wharves, or piers shall comply with bulkhead and pierhead lines established by the *Village* pursuant to Sections 30.11 and 30.13 of the Wisconsin Statutes. Accessory structures to the above principal and conditional uses are permitted provided that the applicant shows the necessity for such accessory structures and further shows that such accessory structures will not obstruct the floodway, impede draining, increase flood flow velocities, retard the movement of floodwaters or increase the flood stage. Accessory buildings shall not exceed fifteen (15) feet in height nor five hundred (500) square feet in floor area.

SECTION 3.8 F-2 Flood Plain District

Principal Uses All principal uses permitted in the F-1 Floodway District, impoundments, sustained yield forestry and fish hatcheries. All other principal uses permitted in the A-1 Agricultural District except residential and the sheltering and confining of animals provided such uses are adjacent to an Agricultural District. These uses shall not involve dumping or filling and shall not include the storage of materials that are buoyant, flammable, explosive, or injurious to human, animal, or plant life nor substantially reduce the floodwater storage capacity of the flood plain.

Conditional Uses All conditional uses permitted in the F-1 Floodway District, and all uses permitted in the P-1 Park District except the sheltering and confining of animals; all structures; parking; warehousing, storage and loading areas when such uses are adjacent to a Business or Industrial District. These uses shall not include the storage of materials that are buoyant, flammable, explosive, or injurious to human, animal, or plant life nor substantially reduce the floodwater storage capacity of the flood plain. Dumping or filling accessory to the above principal and conditional uses provided that the applicant shows that such dumping and filling would not impede drainage, nor substantially reduce the floodwater storage capacity of the flood plain.

Structures All buildings shall have their lowest floors constructed at an elevation no less than two (2) feet above the level of the one hundred (100)-year recurrence interval flood.

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[1] Words, terms, or numbers appearing in italics are provided as examples only and may be changed or omitted to best meet the desires and needs of individual communities.

Appendix M

DERIVATION OF MONETARY BENEFITS ACCRUING FROM PLEASURE DRIVING AND PICNICKING

Monetary benefits accruing from pleasure driving and picnicking may be estimated by establishing present and future user levels and applying unit benefits to these levels to obtain total benefits. The forecast of pleasure driving activity prepared for the Root River watershed study was based on projections of such driving activity prepared by the State Highway Commission of Wisconsin and reported in Wisconsin Scenic Roads and Parkways Study, January 1965. The present utilization of the existing 7.9 miles of Root River Parkway in Milwaukee County was established by field surveys and projected to 1990 when an additional 14.8 miles of parkway will have been completed if the plan recommendations are fully implemented. The present and forecast future average daily traffic on the Milwaukee County portion of the Root River Parkway was estimated by the State Highway Commission as:

Year 1962	1,250 vehicle trips
Year 1975	2,500 vehicle trips
Year 1990	4,500 vehicle trips
Post 1990	4,500 vehicle trips

It is assumed that 70 percent of the total trips are made for social and recreational purposes. On the basis of these data, parkway utilization for pleasure driving was projected to 1990 by straight line interpolation.

Presently (1966), the completed portion of the Root River Parkway has an average of about 50 picnic tables per mile. It was assumed that the future parkway would average 40 tables per mile. Field surveys have shown that the average picnic table utilization in Whitnall Park in 1964 was 690 people per table per year. Picnic facilities on the parkway probably would be less elaborate; therefore, the average use rate of parkway picnic tables was assumed at 350 people per table per year. The park to be developed along Hoods Creek would have approximately 60 picnic tables, each of which would have a visitation of 350 persons per year.

Monetary benefits attributable to pleasure driving were established by applying a unit monetary value of $1.00 per vehicle trip, based on an assumption of $0.25 value to each of four persons comprising the average pleasure driving trip load. The selection of these unit values and trip load factors was based upon field survey data compiled by the U. S. Bureau of Outdoor Recreation and recommended units published in U. S. Senate Document No. 97, Supplement No. 1. Monetary benefits attributable to picnicking were established by applying a unit monetary value of $1.00 per person per user day, consistent with current practices of the Wisconsin Conservation Commission and other agencies concerned with such usage.

Appendix N

FLOOD HAZARD MAPS

While a watershed plan setting forth the general location and characteristics of areas subject to inundation and of proposed water control facilities is necessary as a statement of how best to achieve agreed-upon long-range development objectives, it is, however, quite ineffective as a sound basis for plan implementation through advance reservation and acquisition of land and for the extension of technical assistance and advice to local units and agencies of government. It was, therefore, pointed out in the original Root River Watershed Planning Program Prospectus that the advance reservation of right-of-way and the proper extension of technical assistance, as well as the staged construction of water control facilities, required the preparation of more precise and definitive plans setting forth the ultimate development of certain reaches of the riverine areas of the Root River watershed. In the case of areas subject to inundation, such plans should show the precise and accurate location of the 100-year and 10-year recurrence interval flood inundation lines, while, with respect to water control facilities, such plans should set forth proposals as to centerline location and ultimate right-of-way required. The preparation of such precise plans requires large-scale topographic maps for those reaches of the riverine areas affected.

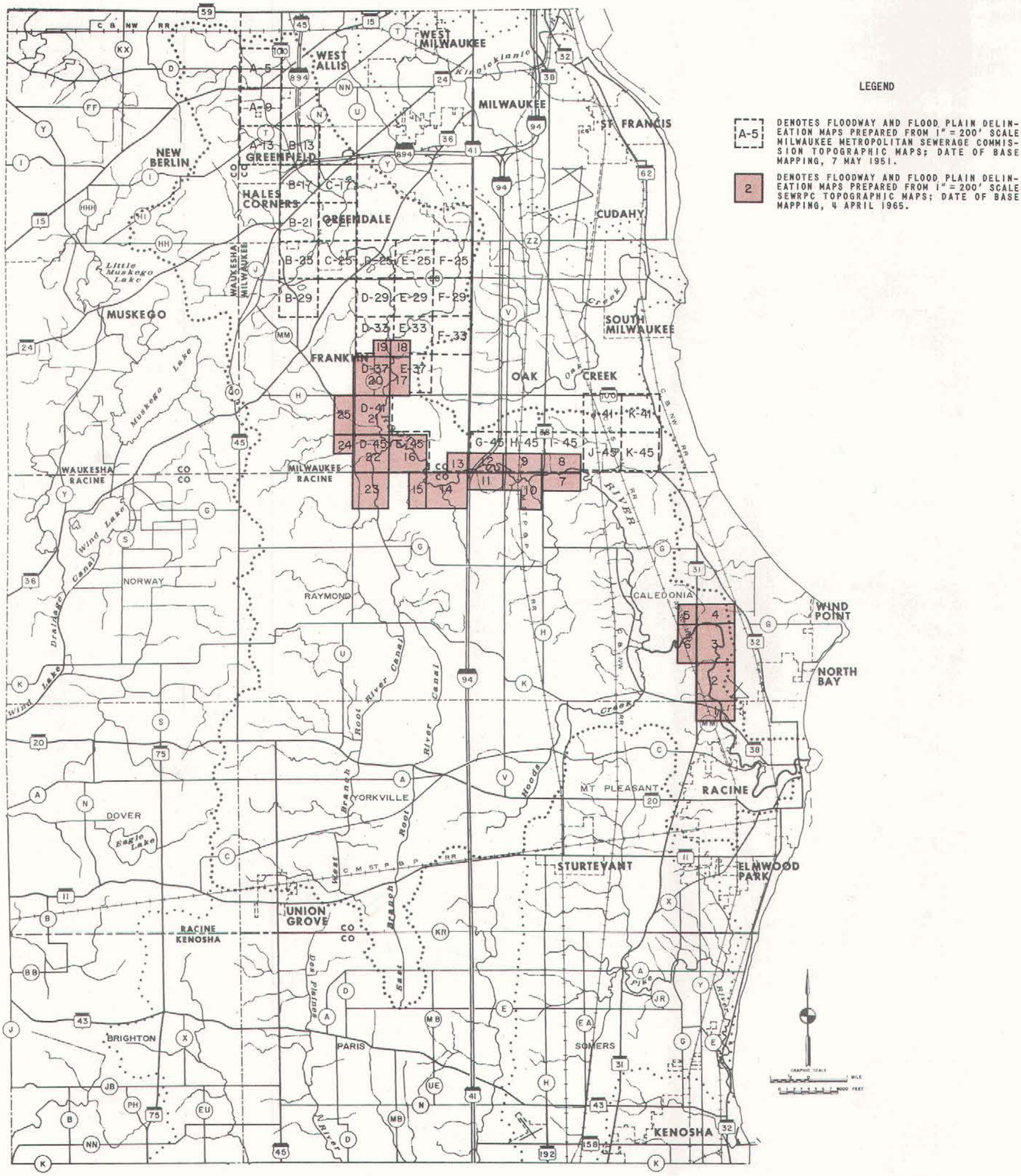
Consequently, precise planning base maps were prepared under the Root River Study for about 14.5 square miles of riverine area. These maps consist of 1" = 200' scale, four foot-two foot contour interval maps, based upon a monumented control survey network which relates the U. S. Public Land Survey system to the State Plane Coordinate System, thus permitting the accurate correlation of topographic and cadastral (property boundary line) data and, more importantly, the accurate reproduction in the field of lines shown on the maps. These maps were prepared for those riverine areas expected to experience the most rapid urbanization within the next decade, as well as for the major area of recommended public works construction, namely, the Oakwood Lake Reservoir area (see Index, Map N-1), and show the 100-year and 10-year recurrence interval flood inundation lines which may be expected under the land use and water control facility development recommended in the watershed plan.

The precise planning base maps were prepared to meet recommended specifications for official mapping set forth in SEWRPC Planning Guide No. 2, Official Mapping Guide, and provide a sound basis for the preparation of detailed local development plans and plan implementation devices, with particular emphasis upon the reservation of land for the ultimate construction of the recommended reservoir and the protection of the floodways and flood plains through locally enacted and administered land use controls. A sample map is shown as Map N-2.

Copies of the precise planning base maps may be obtained from the Southeastern Wisconsin Regional Planning Commission, together with attendant horizontal and vertical control survey data.

Map N-1

FLOOD HAZARD AND TOPOGRAPHIC MAP
SHEET INDEX
ROOT RIVER WATERSHED
AUGUST 25, 1966



Map N-2

TOPOGRAPHIC MAP
PORTION OF ROOT RIVER WATERSHED
MILWAUKEE COUNTY, WISCONSIN