PLANNING REPORT NO. 44

A COMPREHENSIVE PLAN FOR THE DES PLAINES RIVER WATERSHED

Part One

Chapters 1-10

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Special acknowledgment is due Dr. Kurt W. Bauer, PE, RLS, AICP, Executive Director Emeritus, and Mr. Michael G. Hahn, PE, and Mr. Ronald J. Printz, PE, Principal Engineers, for their efforts in the conduct of this study and the preparation of this report.

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Special acknowledgment is due Mr. O. Fred Nelson, retired General Manager of the Kenosha Water Utility, who served on the Committee during much of the planning process.

PLANNING REPORT NUMBER 44

A COMPREHENSIVE PLAN FOR THE DES PLAINES RIVER WATERSHED

Part One of Three Parts
Chapters 1–10

Prepared by the

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STATEMENT OF THE CHAIRMAN

This report documents the findings and recommendations of a study of the serious and costly flooding, water pollution, and related land use problems of the Des Plaines River watershed. The study was undertaken by the Regional Planning Commission in response to formal requests received from Kenosha and Racine Counties. The conduct of the study was guided by the Des Plaines River Watershed Committee, a Committee of 19 elected and appointed public officials and concerned citizens from throughout the watershed created by the Commission for this purpose. The study was intended to produce a comprehensive plan, a plan designed to assist the local, State, and Federal units and agencies of government concerned in managing in a cost-effective and environmentally sound manner the water resources of this watershed.

This report presents a summary of the factual findings of the planning and engineering inventories conducted under the watershed study; identifies and, to the extent possible, quantifies the water resource-related problems of the watershed; presents pertinent forecasts of anticipated growth and change within the watershed; sets forth recommended watershed development objectives, principles, and standards; presents a comparative evaluation of alternative floodland and stormwater management, water quality management, fisheries management, and related land use plan elements; and presents a recommended comprehensive plan for the development of the watershed. This report also specifically identifies the actions which must be taken by each of the units and agencies of government concerned to carry out the recommended plan over time. Full implementation of the recommended plan set forth herein will result in resolution of the costly and disruptive flooding, water pollution, and sedimentation problems of the Des Plaines River watershed, will avoid the creation of new problems of this sort within the watershed, and will restore and maintain a more balanced warmwater fishery within the watershed.

As is true of all of the Commission's plans, the Des Plaines River watershed plan is advisory to the local, State, and Federal units of government concerned. The watershed plan is intended to provide a point of departure against which development proposals within the watershed can be evaluated by concerned officials and interested citizens as such proposals arise. Upon formal adoption of the watershed plan by the Commission, an official copy thereof will be transmitted to all affected units and agencies of government, along with a request for consideration and formal adoption of the plan and subsequent appropriate implementing action. Full implementation of the watershed plan will require the cooperative action of all of the units and agencies of government operating within the watershed.

In its continuing role of acting as a center for cooperative, areawide planning within southeastern Wisconsin, the Commission stands ready to provide such assistance as may be requested of it to the various units and agencies of government concerned in implementation of the Des Plaines River watershed plan.

Respectfully submitted,

Thomas H. Buestrin
Chairman

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Chapter I

INTRODUCTION

The Des Plaines River watershed study is the eighth comprehensive watershed planning program to be carried out by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). Since this watershed study is an integral part of the overall work program of the Commission, an understanding of the need for, and objectives of, regional planning and the manner in which these needs and objectives are being met in Southeastern Wisconsin is necessary for a proper appreciation of the Des Plaines River watershed study and its findings and recommendations.

NEED FOR REGIONAL PLANNING

In recent years, regional planning has become increasingly accepted as a necessary governmental function in most of the large urban areas of the United States. This tendency reflects growing awareness that certain pressing problems of physical and economic development and of environmental deterioration transcend the geographic limits, as well as the fiscal capabilities, of local units of government and require the cooperation of all units and agencies of government concerned for sound resolution.

The term "region," as it is used in this context, applies to an area larger than a county but smaller than a state, united by economic interests and geography and by common problems brought about by rapid urbanization and changing regional settlement patterns. A regional basis is unquestionably necessary to provide a meaningful technical approach to the sound development of such areawide systems of public works as highway and transit, sewerage and water supply, and park and related open space facilities. A regional basis is also necessary to a sound approach to the resolution of such areawide problems as flooding, air and water pollution, deterioration or destruction of the natural resource base, and rapidly changing land use.

State, community, and private interests all are vitally affected by such areawide problems and by proposed solutions to these problems. It appears neither desirable nor possible for any one level or agency of government to impose the decisions required to solve these areawide problems. Such decisions can better come from a consensus of the various levels and agencies of government and the private interests concerned, on the basis of a common concern for the welfare of the entire Southeastern Wisconsin Region. Regional planning is imperative for promoting such a consensus and the necessary cooperation between urban and rural, local and state, and private and public interests.

THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission represents an attempt to provide the necessary areawide planning services for one of the largest 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 economical development of Southeastern Wisconsin. The role of the Commission is entirely advisory; 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, three from each county within the Region, who serve without pay.

The powers, duties, and functions of the Commission and the qualifications of the Commissioners are carefully set forth in 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, with the budget apportioned among the seven 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 organizational structure of the Commission and its relationship to the constituent units and agencies of government comprising or operating within the Region are shown in Figure 1.

THE REGIONAL PLANNING CONCEPT IN SOUTHEASTERN WISCONSIN

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

1. <u>Inventory</u>
   The collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis so that, using such data, the various levels and agencies of government and private investors operating within the Region can better make decisions concerning community developments.

2. <u>Plan Design</u>
   The preparation of a framework of long-range plans for the physical development of the Region, with these plans 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.

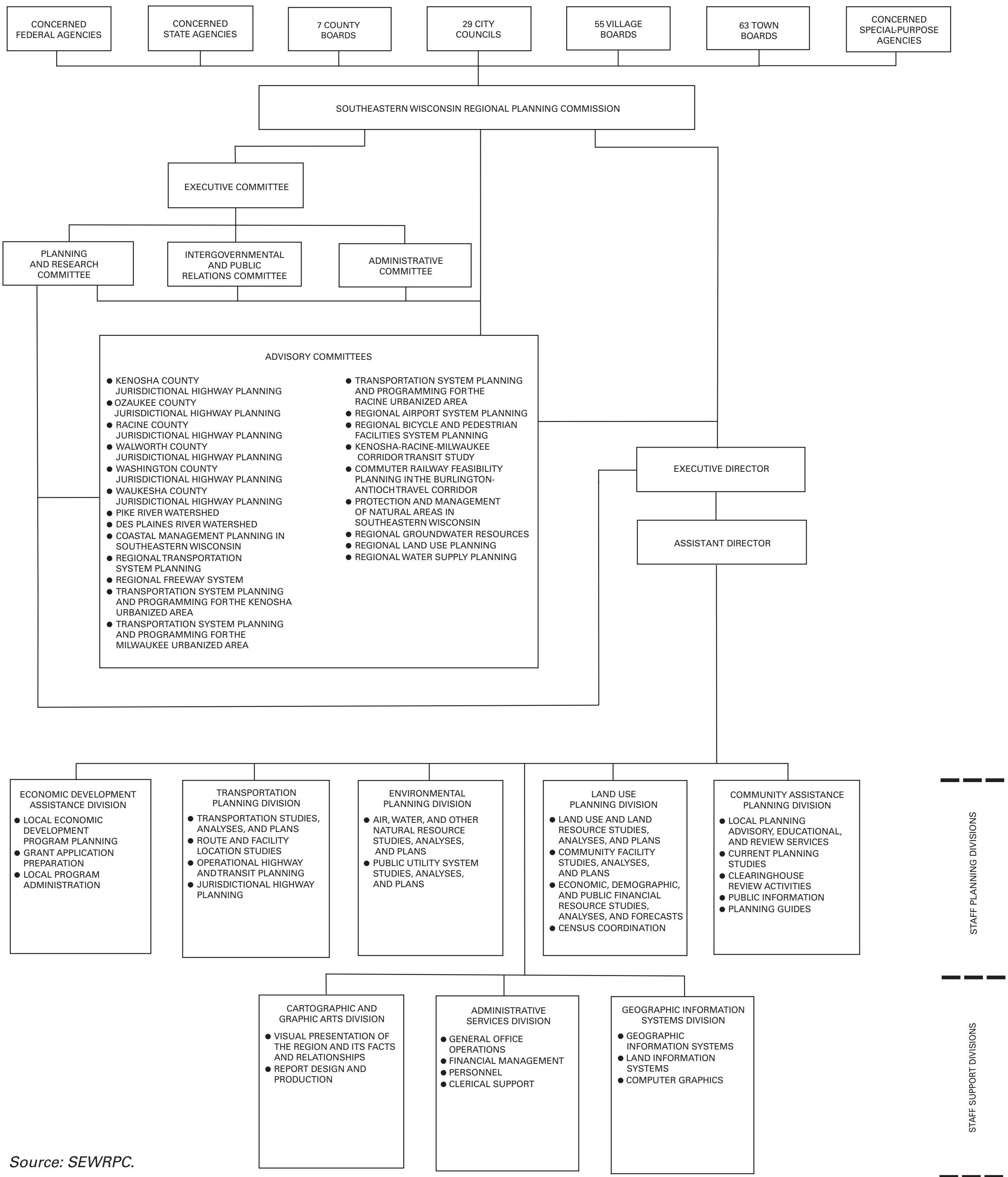
3. <u>Plan Implementation</u>
   The provision of a center for the coordination of the many planning and plan implementation activities carried on by the various levels and agencies of government operating within the Region. To this end, all Commission work programs are intended to be carried out within 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 levels.

THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is composed of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Exclusive of Lake Michigan, these seven

Figure 1

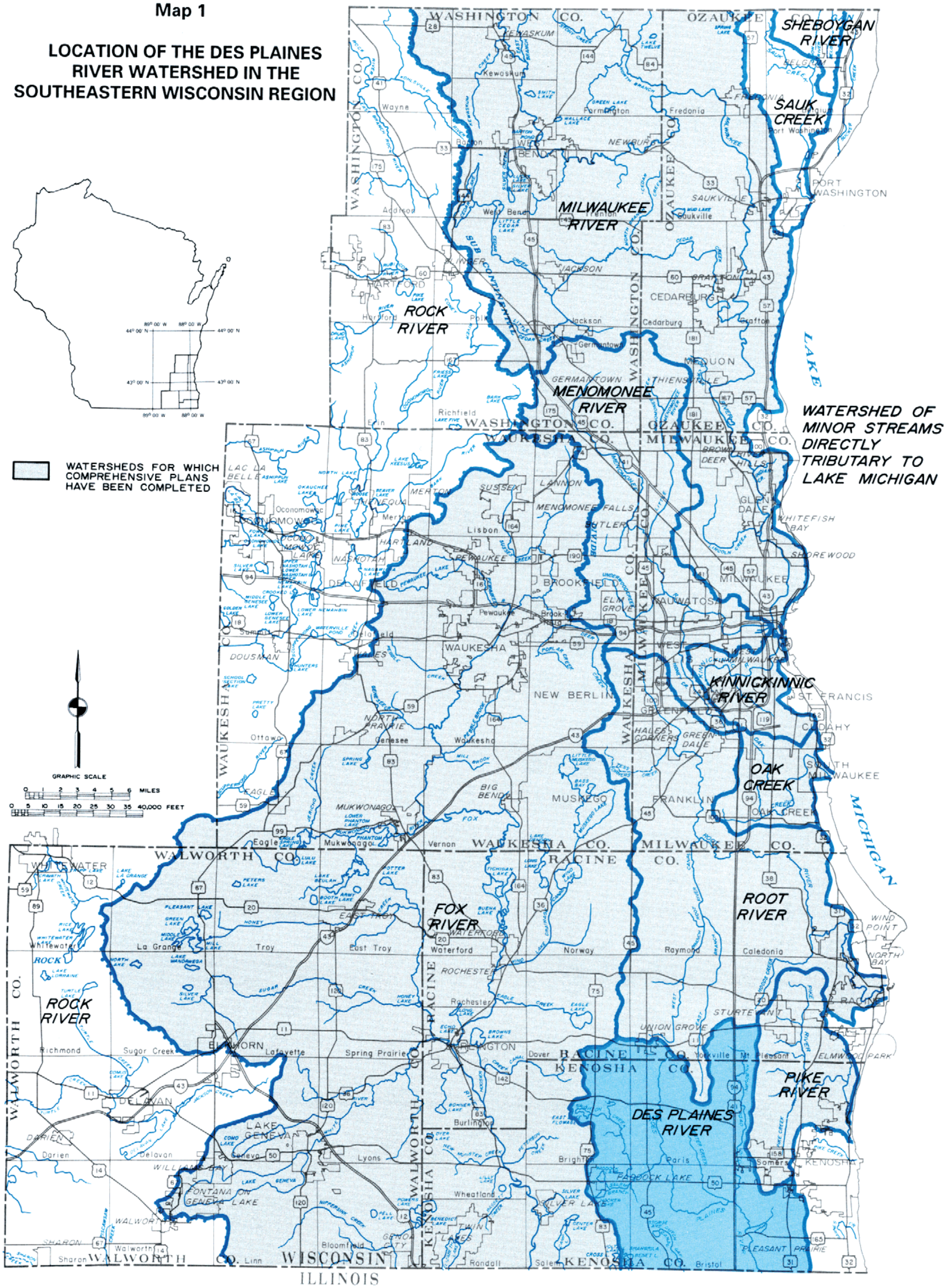
SEWRPC ORGANIZATIONAL CHART



Source: SEWRPC.

Map 1

LOCATION OF THE DES PLAINES RIVER WATERSHED IN THE SOUTHEASTERN WISCONSIN REGION



The Des Plaines River watershed is an integral part of the highly urbanized seven-county Southeastern Wisconsin Region. This Region, while comprising only 5 percent of the total area of the State, contains about 36 percent of the State's population and provides employment for about 38 percent of the State's labor force. The Des Plaines River is the sixth largest of the 11 major watersheds located wholly or partly within the Region. About 1.1 percent of the 1990 population of the Region resides within this urbanizing watershed, which comprises about 5 percent of the area of the Region.

Source: SEWRPC.

counties have a total area of 2,689 square miles, together comprising about 5 percent of the total land area of the State. About 36 percent of the State population, however, resides within these seven counties, which contain three of the 13 metropolitan areas contained either wholly or partially in the State. The Region contains approximately 37 percent of all the tangible wealth in the State as measured by equalized valuation and represents the greatest wealth-producing area of the State, with about 38 percent of the State labor force employed within the Region. The seven-county Region contains 154 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 natural watersheds.

Geographically, the Region is located in a relatively good position for 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 a recreational attraction and an integral part of the 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. Many of the most important industrial areas and heaviest population concentrations in the Midwest lie within a 250-mile radius of the Region; over 33 million people reside within this radius.

COMMISSION WORK PROGRAMS

The Des Plaines River watershed planning program was conducted within the context of, and has been fully coordinated with, the Commission's ongoing comprehensive planning program for Southeastern Wisconsin. It is appropriate to review briefly particularly pertinent aspects of the Commission's past and current work programs inasmuch as some of the data obtained from, and some of the analytic techniques developed under, those programs were used in the Des Plaines River watershed planning program. Certain adopted regional plan elements, moreover, provided a framework within which the Des Plaines River watershed planning program was conducted.

In this respect, the water control facility recommendations contained within the Des Plaines River watershed plan are based in part on, and are coordinated with, land use, transportation system, sewerage and water supply system, and park and open space reservation recommendations included in other Commission plans.

As part of its data collection efforts, the Commission has maintained current base maps and aerial photographs of the entire Region and has worked with the Counties and other units of government involved to obtain large-scale topographic mapping and related control survey data for about 67 percent of the Region, including all of the Des Plaines River watershed. The Commission has also developed a bank of basic data pertinent to sound water resource-related planning. These data include, among others, detailed operational soils survey and soils capability information; rainfall intensity, duration, and frequency data; historic and current land use; and environmentally sensitive area delineations.

Regional planning programs undertaken by the Commission, all directed toward the preparation of major elements of a comprehensive plan for the physical development of the Region, all pertinent to watershed planning, include, among others: regional land use; regional transportation system; regional park, outdoor recreation, and related open space; and regional water quality management plans. In addition, comprehensive watershed planning programs have been completed by the Commission for the Root, Fox, Milwaukee, Menomonee, Kinnickinnic, and Pike River and the Oak Creek watersheds. Subregional plans which have been prepared by the Commission pertinent to the Des Plaines River watershed planning program include the comprehensive plan for the Kenosha Urban Planning District and the integrated sanitary sewerage and water supply system plans completed for the greater Racine and Kenosha areas.

THE DES PLAINES RIVER WATERSHED STUDY

The Des Plaines River watershed within Southeastern Wisconsin encompasses approximately 133 square miles, or 5 percent of the seven-county planning area. About 1.1 percent of the 1990 population of the Southeastern Wisconsin Region resides within the watershed. The problems of this watershed typify those found in areas experiencing changing land use patterns and water resource-related problems and have a direct effect on the property and general welfare of the residents of the watershed.

This is the second such study to be conducted by the Commission on a headwater portion of an interstate river basin; the first was the Fox River study. In its study of the Des Plaines River basin, the Commission has focused attention primarily on the 133-square-mile watershed area which lies within Wisconsin, while cognizant of the interrelationship between this area and the 1,977-square-mile watershed area which lies within Illinois (see Map 2). Although the watershed planning area chosen for study by the Commission comprises only 6.7 percent of the total Des Plaines River watershed, this area forms a rational and viable planning unit for the following reasons:

1. The watershed planning area chosen by the Commission comprises the total Des Plaines River watershed area lying within Wisconsin and is, therefore, a jurisdictionally sound unit possessing a community of interest within the Southeastern Wisconsin Region. The Commission was able, therefore, to provide regional planning data previously collected under other regional planning work programs for the entire watershed planning unit, to prepare and adopt a watershed development plan for an intraregional area, and, most importantly, will be jurisdictionally able to guide the implementation of the watershed development plan.

2. The watershed planning area comprises all of the headwater area of the watershed, thus assuring that solutions to the water resource-related problems which emanate from the upper watershed reaches, but are capable of being transmitted downstream, can be effectively resolved within the framework of the watershed study.

Initiation of the Des Plaines River Watershed Study

By resolution adopted on February 19, 1991, the Kenosha County Board formally requested the Southeastern Wisconsin Regional Planning Commission to investigate the need for a comprehensive study of the Wisconsin portion of the Des Plaines River watershed, a study looking to the ultimate resolution of the flooding, water pollution, and related problems existing within that watershed and affecting the property and general welfare of its residents. This request recognized that these problems can best be resolved within the context of a cooperative, long-range, comprehensive watershed planning effort, involving all of the units and agencies of government concerned. Accordingly, on April 17, 1991, the Commission acted to create the Des Plaines River Watershed Committee, comprised of 19 public officials and citizen leaders from within the watershed and including concerned public officials from Northeastern Illinois (see Appendix A). The Commission charged that Committee with assisting the Commission in its study of the water-related problems of the watershed.

The Des Plaines River Watershed Committee held its organizational meeting on July 2, 1991, and commenced immediately to prepare a prospectus for the required comprehensive watershed planning program.[1]

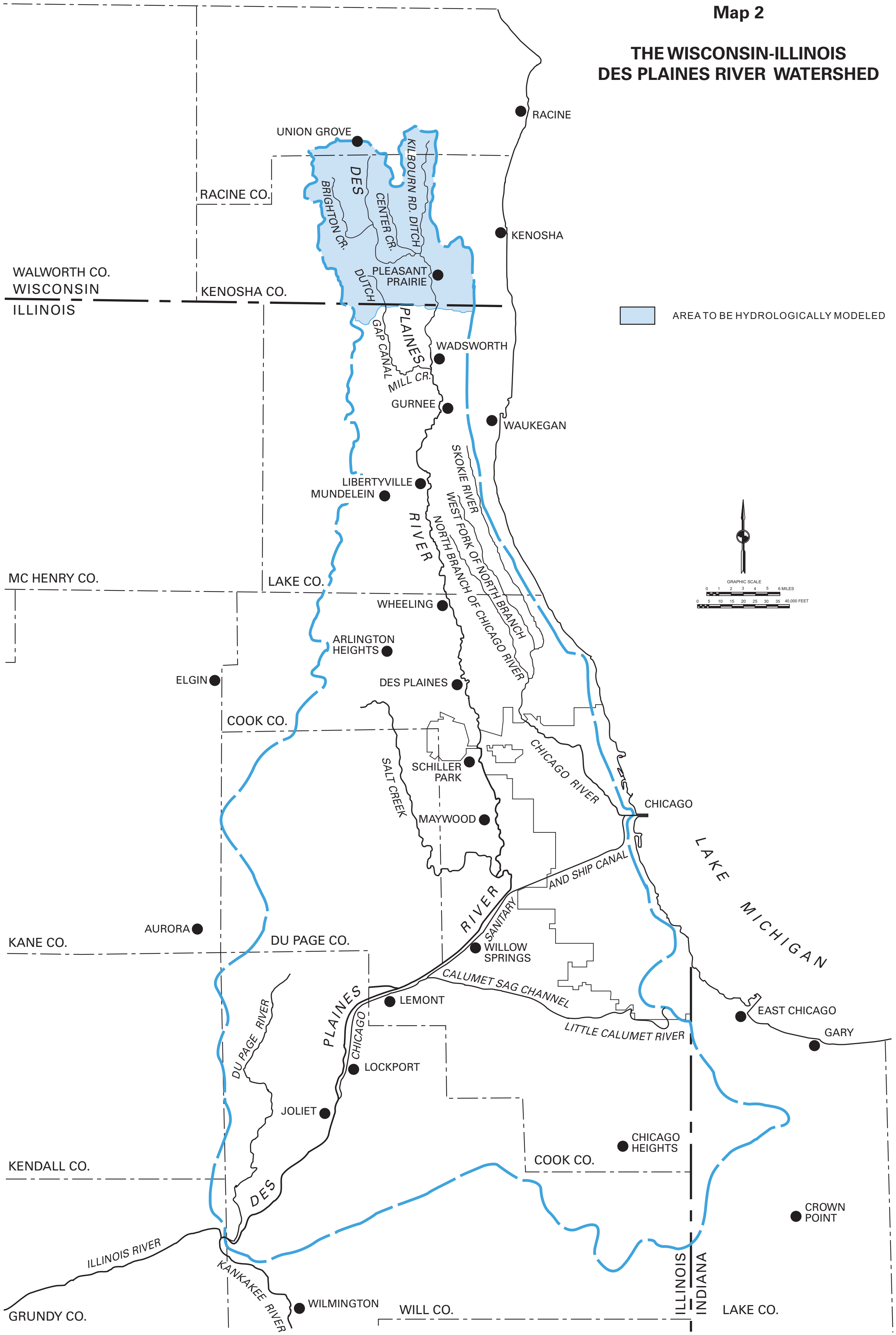
In the prospectus the Committee identified and described five serious resource-related problems within the watershed that require areawide study and resolution: 1) flooding, stormwater management, and attendant damages, 2) water pollution, 3) changing land use, not only in the riverine areas, but also over the entire watershed, 4) a deteriorating natural resource base, and 5) soil erosion. The Committee completed the prospectus on July 17, 1991, and recommended that the Southeastern Wisconsin Regional Planning Commission and Kenosha and Racine Counties approve the prospectus and seek the funding necessary to perform the required study.

The prospectus prepared by the Committee was transmitted on November 19, 1991, to the governmental agencies concerned for their consideration and action, and was endorsed by the Commission on December 4, 1991. A formal agreement governing the conduct of the study was entered into between Kenosha and Racine Counties and

[1]*See SEWRPC,* Des Plaines River Watershed Planning Program Prospectus*, September 1991.*

Map 2

THE WISCONSIN-ILLINOIS DES PLAINES RIVER WATERSHED



This study focuses on the 133-square-mile Des Plaines River watershed area, which lies within Wisconsin, while cognizant of the interrelationship between this area and the 1,977-square-mile watershed area which lies within Illinois.

Source: SEWRPC.

the Commission on April 13, 1994. The total study cost of $278,100 was, as agreed upon in the aforementioned agreement, apportioned between Kenosha and Racine Counties on the basis of equalized property valuation.

The prospectus was not a finished study design. It was a preliminary design prepared to obtain support and financing for the necessary study, an objective which was fully achieved. Major work elements, a staff organization, a time schedule, and cost estimates were set forth in the prospectus. Work on the study began in 1994.

Study Objectives

The primary objective of the Des Plaines River watershed planning program is to help abate the water-resource and water resource-related problems of the Des Plaines River basin by developing a workable plan to guide the staged development of multi-purpose water-resource facilities and related conservation and management programs for the watershed. To be effective, this plan must be amenable to cooperative adoption and joint implementation by all levels and agencies of government concerned. It must be capable of functioning as a practical guide for making decisions on both land and water-resource development within the watershed so that, through such development, the major water-resource and water resource-related problems within the watershed may be abated and the full development potential of the watershed realized. More specifically, the objectives of the planning program are:

1. To prepare a design year 2010 land use plan for the Des Plaines River watershed incorporating the results of previously prepared regional, subregional, and local planning efforts and to promote the rational adjustment of land uses in this urbanizing watershed to the conveyance, storage, and waste assimilation capabilities of the water resources of the basin.[2]

2. To prepare a plan for the management of floodlands along the major waterways of the Des Plaines River watershed, including measures for the mitigation of existing and potential future flood management problems.

3. To prepare a plan which: a) considers potential stormwater management alternatives which may be expected to have significant impacts on alternative measures developed to address flood problems, b) provides hydraulically adequate outlets for stormwater management facilities, c) sets forth specific guidelines to be used in addressing stormwater management problems, including the best means of treating development proposals pending completion of subsequent detailed local stormwater management plans, and d) provides a watershedwide framework for the evaluation of such local stormwater management plans.

4. To prepare a plan for the management of surface water quality for the Des Plaines River watershed, incorporating measures to abate existing pollution problems and elements intended to prevent future pollution problems. Local refinement and detailing of sanitary sewer service areas, as well as other local actions to implement the adopted regional water quality management plan, will be incorporated and properly reflected in the watershed planning process.

5. To prepare a plan for the preservation of public open space, including measures for the preservation and enhancement of the remaining woodlands, wetlands, and fish and wildlife habitat of the watershed.

6. To prepare a plan which reduces soil erosion in the Des Plaines River watershed through the integration of stormwater management and construction erosion-control practices in urban areas, agricultural land management practices in rural areas, and streambank erosion control measures.

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[2] *The year 1990 is the year used for the establishment of existing land use, population, and economic conditions. Special inventories for some other areas of interest used different base years, as indicated in this report.*

Coordination with Floodland Management and Flood Control Efforts in the Illinois Portion of the Des Plaines River Watershed

Heavily urbanized and rapidly urbanizing areas of the Des Plaines River watershed in the State of Illinois have experienced widespread flood damage. The Chicago District of the U.S. Army Corps of Engineers (USCOE) has prepared a Phase I flood control feasibility study for portions of the Upper Des Plaines River watershed in Illinois. The analyses performed under the watershed study documented herein were coordinated with that study in order to avoid duplication of effort, in order to achieve consistency between the findings and recommendations of the two studies, and in order to avoid creating or exacerbating downstream flooding problems in Illinois. In addition, the watershed study analyses were coordinated with the stormwater management planning program of the Lake County, Illinois, Stormwater Management Commission.

At the request of municipalities, counties, and local citizen organizations in Illinois and Wisconsin, including Kenosha County, the USCOE is beginning work on a Phase II multi-purpose feasibility study that will expand on the Phase I study by addressing flood damage reduction, environmental restoration and protection, water quality, and recreation in the Upper Des Plaines River watershed. That study was authorized by Section 419 of the Water Resources Development Act of 1999, which calls for the "maximum use of data in existence on the date of enactment of (the) Act." Because the scopes and objectives of the Phase II study for the entire Upper Des Plaines River watershed and the watershed study described herein are very similar, the USCOE intends to make maximum use of the inventories and analyses conducted under this study of the Wisconsin portion of the watershed.

As a potential local sponsor of the study, the Kenosha County Director of Planning and Development serves on the study Project Management Team.[3] The Commission staff served on the Sponsors and Stakeholders Alliance committee that prepared a scope of work to guide preparation of the Phase II study and the Commission staff currently serves on the Advisory Committee for the study as well as on the hydrology and hydraulics subcommittee.

Staff, Cooperating Agencies, Consultants, and Committee Structure

The basic organizational structure for the study is outlined in Figure 2 and consists of the cooperating State and Federal agencies, a consultant, and Commission staff, along with the designated responsibilities of these agencies, the consultants, and Commission staff in the conduct of major elements of the planning study.

A comprehensive watershed planning program necessarily covers a broad spectrum of related governmental and private development programs, and thus no agency, whatever its function or authority, can operate independently in the conduct of a watershed study. The basic Commission organization provides for the attainment of the necessary interagency coordination through the establishment of advisory committees, as well as through interagency staff assignments.

One such advisory committee created by the Commission for watershed planning is the Des Plaines River Watershed Committee (see Appendix A). The purpose of this Committee is to involve actively governmental bodies, technical agencies, and private interest groups within the watershed in the planning study. The Committee is intended to assist the Commission in determining and coordinating public policies involved in the conduct of the study and in the resultant plans and plan implementation programs. Active involvement of State and Federal, as well as of local, public officials in the watershed planning program through this Committee is particularly important to any ultimate implementation of the watershed plans in view of the advisory role of the Commission in shaping regional and subregional development. The Watershed Committee also performs an important educational function in familiarizing local leadership within the watershed with the study and its findings, in generating an understanding of basic watershed development objectives and implementation procedures, and in encouraging plan implementation.

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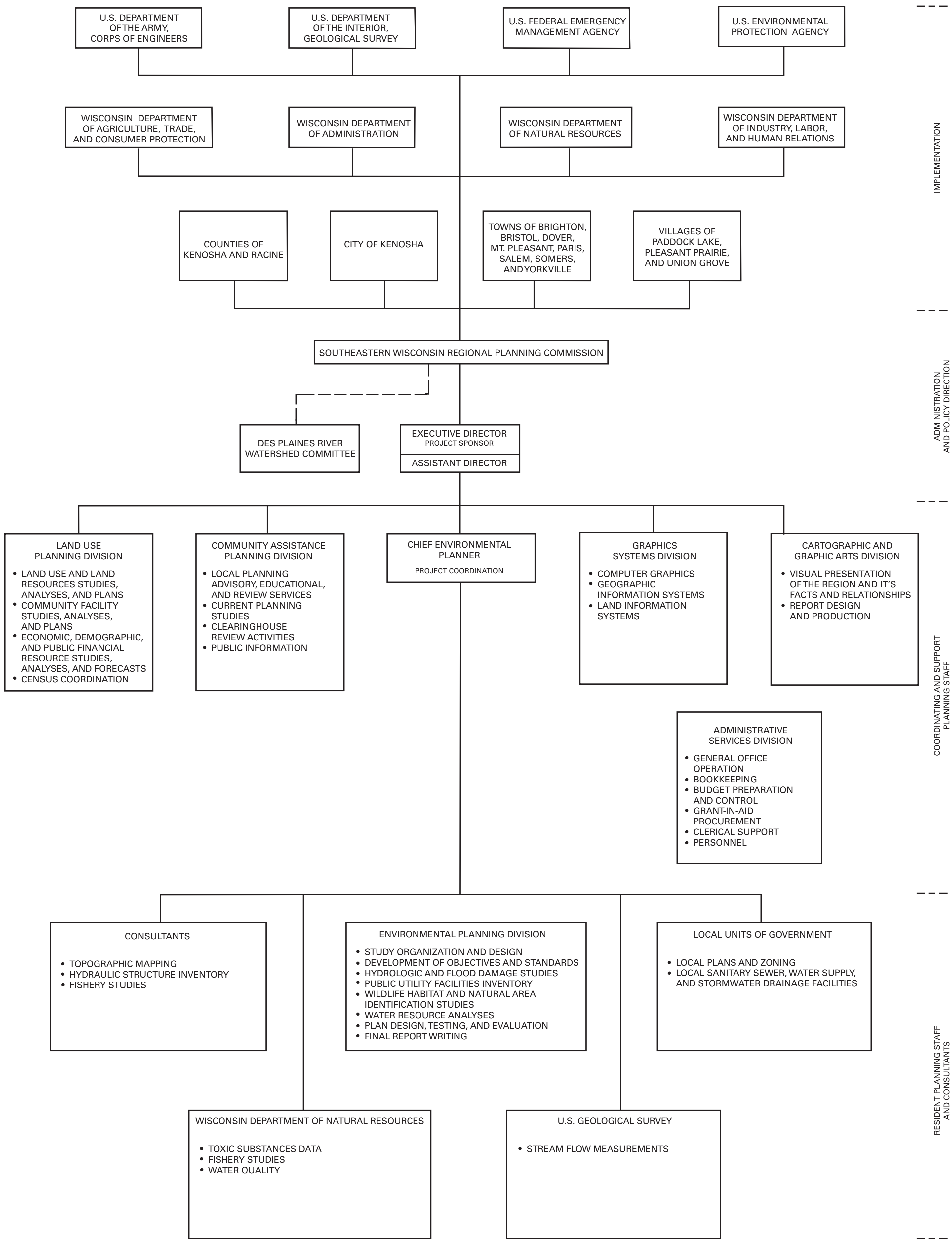
[3] *As of September 2001, a Feasibility Study Cost Share Agreement between the USCOE and local sponsors, including Kenosha County, Wisconsin; Cook County, Illinois; Lake County, Illinois; and the Illinois Department of Natural Resources, had been drafted, but not formally executed.*

Figure 2

ORGANIZATIONAL STRUCTURE FOR THE DES PLAINES RIVER WATERSHED PLANNING PROGRAM



Source: SEWRPC.

The watershed planning work program was conducted by the resident Commission staff, supplemented as needed by contractual services provided by a consulting engineering firm. The Commission staff managed and directed all phases of the engineering and planning work. More specifically, the Commission staff was responsible for preparation of the detailed study design; formulation of watershed development objectives, principles, and standards; conduct of certain inventories; conduct of all analyses of the inventory data to identify the problems and development potential of the watershed; synthesis and evaluation of alternative plan elements; and report preparation.

The efforts of the Commission professional and supporting staff were supplemented with the services of a specialist in the area of surveying and mapping and a fisheries biologist. A contractual agreement was executed with the firm of Ayres and Associates, for the provision of physical data and related vertical control survey information on selected hydraulic structures in the watershed. With the assistance of Commission staff, Mr. Marlin Johnson, an Associate Professor in the Department of Biological Sciences at the University of Wisconsin Center-Waukesha County, performed the inventory and evaluation of the fishery resources, as summarized in Chapter III of this report and presented in Appendix B of this report.

Scheme of Presentation

The major findings and recommendations of the Des Plaines River watershed planning program are documented and presented in this report. The report first sets forth the basic concepts underlying the study and the factual findings of the extensive inventories conducted under the study. It identifies and, to the extent possible, quantifies the developmental and environmental problems of the watershed and sets forth forecasts of future economic activity, population growth, and land use and concomitant environmental problems. The report presents alternative plan elements for floodland management, stormwater management aspects that are interrelated with flood control issues, pollution abatement, and land use. It sets forth a recommended plan for the development of the watershed based upon regional and watershed development objectives adopted by the Watershed Committee and the Commission. In addition, it contains financial and institutional analyses and specific recommendations for plan implementation. This report is intended to allow for careful, critical review of the alternative plan elements by public officials, agency staff personnel, and citizen leaders within the watershed and to provide the basis for plan adoption and implementation by the Federal, State, and local agencies of government concerned.

This report can only summarize briefly the large volume of information assembled in the extensive data collection, analysis, and forecasting phases of the Des Plaines River watershed study. Although the reproduction of all this information in report form is impractical because of the magnitude and complexity of the data collected and analyzed, all the basic data are on file in the Commission offices and are available to member units and agencies of government and to the general public upon specific request. This report, therefore, serves the additional purpose of indicating the types of data which are available from the Commission and which may be of value in assisting Federal, State, and local units of government and private investors in making better decisions about community development within the Region.

Chapter II

BASIC PRINCIPLES AND CONCEPTS

INTRODUCTION

Watershed planning is not new. Plans have been developed in the past for many 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 or hydroelectric power generation, 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. Generally speaking, watershed planning efforts have traditionally employed a narrow range of means to achieve essentially a narrow range of goals, with emphasis on those goals for which attainment could be directly measured in monetary terms.

The application of comprehensive planning principles and practices to water and water-resource-related problems, as described in this report, however, was a relatively new concept at the time of the creation of the Commission in 1960. Consequently, at the time the Commission undertook its first comprehensive watershed planning program, that for the Root River watershed, little practical experience had been accumulated in such comprehensive watershed planning; the now generally accepted principles governing such planning had not been established. Moreover, the need to carry out comprehensive watershed planning as an integral part of a broader regional planning effort required the adaptation and modification of the limited body of watershed planning experience which did exist to the specific needs of the Root River watershed planning program.

These factors necessitated, as part of the Root River watershed study, the development by the Commission of a unique approach to watershed planning, an approach which proved to be sound and which was, therefore, adopted for use in subsequent studies of the Fox, Milwaukee, Menomonee, Kinnickinnic, Pike, and Des Plaines River and the Oak Creek watersheds. This approach can be explained only in terms of the conceptual relationships existing between watershed planning and regional planning and the basic principles applicable to watershed planning set within the broader framework of regional planning. Once this foundation of conceptual relationships and applicable principles has been established, the approach taken to identify the specific problems of the Des Plaines River watershed and to recommend solutions to these problems, as presented herein, can be properly understood.

THE WATERSHED AS A PLANNING UNIT

Planning for water and water-related natural resources can conceivably be carried out for various geographic units, including areas defined by governmental jurisdictions, socioeconomic linkages, or watershed boundaries. None of these is perfect as a planning unit for water and water-related resources. There are many advantages, however, to selecting the watershed as a water and water-related resources planning unit because many problems of both rural and urban development and of natural resource conservation are water-oriented and because the watershed is a natural hydrologic unit.

Floodland management measures and flood control and stormwater management facilities should form a single integrated system over an entire watershed. Streams and watercourses, as hydraulic systems, must be capable of carrying both present and future runoff loads generated by changing land use and changing water-control facility patterns within a watershed. Therefore, flood control and stormwater management problems and facilities can best be considered on a watershed basis. Stormwater management and flood control problems are closely related to other land use and water use problems. Consequently, floodland protection, park and related open space reservation, and recreational needs associated with surface water resources also can best be studied on a watershed basis.

Water supply and sewerage systems frequently involve problems that cross watershed boundaries, but strong watershed implications are involved if the source of water supply is the surface water resources of the watershed, or if the sewerage systems discharge pollutants into the surface water system. Groundwater divides do not necessarily coincide with surface water divides, and, therefore, planning for groundwater use and protection must incorporate both intrawatershed and interwatershed considerations. Changes in land use and transportation requirements ordinarily are not controlled primarily by watershed factors, but can, nevertheless, have major effects on watershed problems. Land use and transportation patterns may significantly affect 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 floodlands 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 community of interest among the residents of the watershed; thus citizen action groups can be formed to assist in solving water-related problems. The existence of a community of interest around which to organize enlightened citizen participation in the watershed planning process is an important factor contributing to the success of such a process.

It may be concluded, therefore, that the watershed is a logical unit for water-resources planning, provided that the relationships existing between the watershed and the surrounding region are recognized. Accordingly, the regional planning program in Southeastern Wisconsin embodies a recognition of the need to consider watersheds within the Region as rational planning units if workable solutions are to be found to intensifying and 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. However, the meaning of the term watershed may be expanded 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 Des Plaines River, must exhibit if it is to form a rational unit for comprehensive water-resources planning. It is thus recognized that a watershed is more than a system of interconnected waterways and floodlands which, in fact, comprise only a small portion of the total watershed area. Land use and supporting utility system development, as well as water resource-related 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 regional planning program in Southeastern Wisconsin also recognizes the need to conduct individual watershed planning programs within the broader framework of areawide, comprehensive regional planning. This is essential for two reasons. First, areawide urbanization and the developmental and environmental problems resulting from such urbanization indiscriminately cross watershed boundaries and exert 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 desired watershed planning program have been provided by the comprehensive areawide planning program of the Commission, such as the regional land use, transportation, park and open space, sanitary sewerage system, and areawide water quality management planning programs. Conversely, within the context of the regional planning program, the comprehensive watershed planning programs of the Commission constitute one of the key elements of the comprehensive regional development plan, namely, long-range plans for water-related community facilities, particularly drainage and flood control facilities. While the proposed watershed plans may be centered on water quality and flood control facilities and on floodland management measures, it must be recognized that these facility plans and management measures must reflect consideration of the related problems of land use and water use and of park and related open space reservation needs. Recognition of the need to relate water-control facility plans and management measures to areawide regional development plans is the primary factor underlying the unique nature of the Commission watershed planning efforts. Ultimate completion of planning studies covering all the watersheds within the Region will provide the Commission with a framework of plans encompassing stormwater management, flood control, and water pollution control facilities as well as floodland management measures properly related to comprehensive, areawide development plans.

THE WATERSHED PLANNING PROBLEM

Although the water resource-related 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 protecting and maintaining the quality of the environment in urban and urbanizing areas. In the past, environmental protection, or what was then more commonly called “resource conservation,” was largely concerned with protecting large natural tracts in rural areas and with the possible future shortages of mineral or other resources resulting from chronic mismanagement. The major problem which environmental protection now faces, however, is occasioned by the ever increasing areawide diffusion of urban development over large areas of the surface of the earth, together with the relentless pursuit by human beings of an ever higher material standard of living.

Enlightened public officials and citizen leaders are gradually becoming aware of this new and pressing need for the protection and, in some cases, the enhancement of the physical environment in urban and urbanizing areas. The need to adjust the physical fabric of urban development to the ability of the underlying natural resource base to sustain such development is critical in urbanizing areas such as the Des Plaines River watershed. In such urbanizing areas, as opposed to more sparsely settled rural areas, the overall quality of the environment becomes highly dependent on present and future land use activities and supporting public facilities; the viable options remaining for environmental protection and enhancement are limited.

The growing awareness of the need for environmental protection in urban areas is often heightened by a major disaster or the imminent threat of such a disaster. In many cases, such as in the Des Plaines River watershed, the initial concern with environmental protection is centered on the highly visible problems of flooding and water pollution. Even then, however, the magnitude and degree of the interrelationship of environmental problems, of one environmental problem to another and of all environmental problems to areawide urbanization, may not always be fully realized.

The ultimate resolution of the environmental problems of the Des Plaines River watershed will require many important public policy determinations. These determinations must be made in recognition of an urbanizing Region which is constantly changing; they should, therefore, be based upon a comprehensive planning process able objectively to 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 effects of different land use and water use and water-control facility construction proposals be evaluated, the best course of action intelligently selected, and the available resources most effectively invested.

The ultimate purposes of such a planning process are twofold: 1) to permit public evaluation and choice of alternative development and environmental protection and enhancement policies and plans and 2) to provide, through the medium of a long-range plan for water-related community facilities, for the full coordination of local, State, and Federal development and environmental protection programs within the Region and within the watersheds of the Region. Important among the goals to be achieved by this process are the protection of floodlands, the protection of water quality and supply, the preservation of land for park and open space, and the general promotion of the wise and judicious use of the limited land and water resources of the watershed and of the Region of which the watershed is an integral part.

BASIC PRINCIPLES

Eight basic principles of watershed planning, based upon the foregoing considerations, were developed by the Commission. Together, these principles form the basis for the specific watershed planning process applied by the Commission in the Root, Fox, Milwaukee, Menomonee, Kinnickinnic, and Pike River and Oak Creek watershed planning programs; they provide the foundation for the planning process applied in the Des Plaines River watershed study. These principles may be stated as follows:

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

2. A comprehensive, multipurpose approach to water-resource development and to the control and 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 areawide regional planning effort and watershed development objectives must be compatible with, and dependent upon, regional development objectives and plans based on those objectives.

4. Planning of water-control facilities must be conducted concurrently with, and inseparably 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 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 solutions within the watershed to water-resource problems. Exporting these 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 an approach as flexible as possible to avoid "dead-end" solutions and should provide latitude for continued adaptation to changing conditions.

THE WATERSHED PLANNING PROCESS

On the basis of the foregoing principles, the Commission has developed 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, hydraulic, and water quality characteristics of the watershed simulated; and the effect of the different courses of action on land use and on the development of water-control facilities evaluated. The watershed planning process not only provides for the integration of all the complex planning and engineering studies required to prepare a comprehensive watershed plan, but also provides a means whereby the various private and public interests concerned may actively participate in the plan preparation. The process thus provides a mechanism for resolving actual and potential conflicts between such interests, a forum in which the various interests may better understand the interrelated problems of the watershed and the alternative solutions available for such problems, and a means whereby all watershed interests may become committed to implementation of the best alternative for the resolution of the problems.

The seven steps involved in this planning process are as follows: 1) study design, 2) formulation of objectives and standards, 3) inventory, 4) analysis and forecast, 5) plan synthesis, 6) plan testing 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 plan involved is to be realized.

The principal 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. 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 3 and 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 forecasts and forecast accuracy, and define the nature of the plans to be prepared and the criteria to be used in their evaluation and adoption. The need for, and objectives of, the Des Plaines River watershed study were set forth in a Commission document titled *Des Plaines River Watershed Planning Program Prospectus*, dated September 1991, prepared by the Commission staff and approved by the Commission's Des Plaines River Watershed Committee (see Appendix A). The prospectus also identified major work elements to be included in the comprehensive watershed study and therefore constituted the basic study design. The prospectus was used by the Commission staff to prepare a more detailed study design for certain parts of the overall study, as necessary for project management purposes, throughout the duration of the study. The study design was refined over the course of the study as a result of continuous staff-level communication with those governmental agencies and private consultants contributing certain specialized services to the Des Plaines River watershed planning program and with the Watershed Committee.

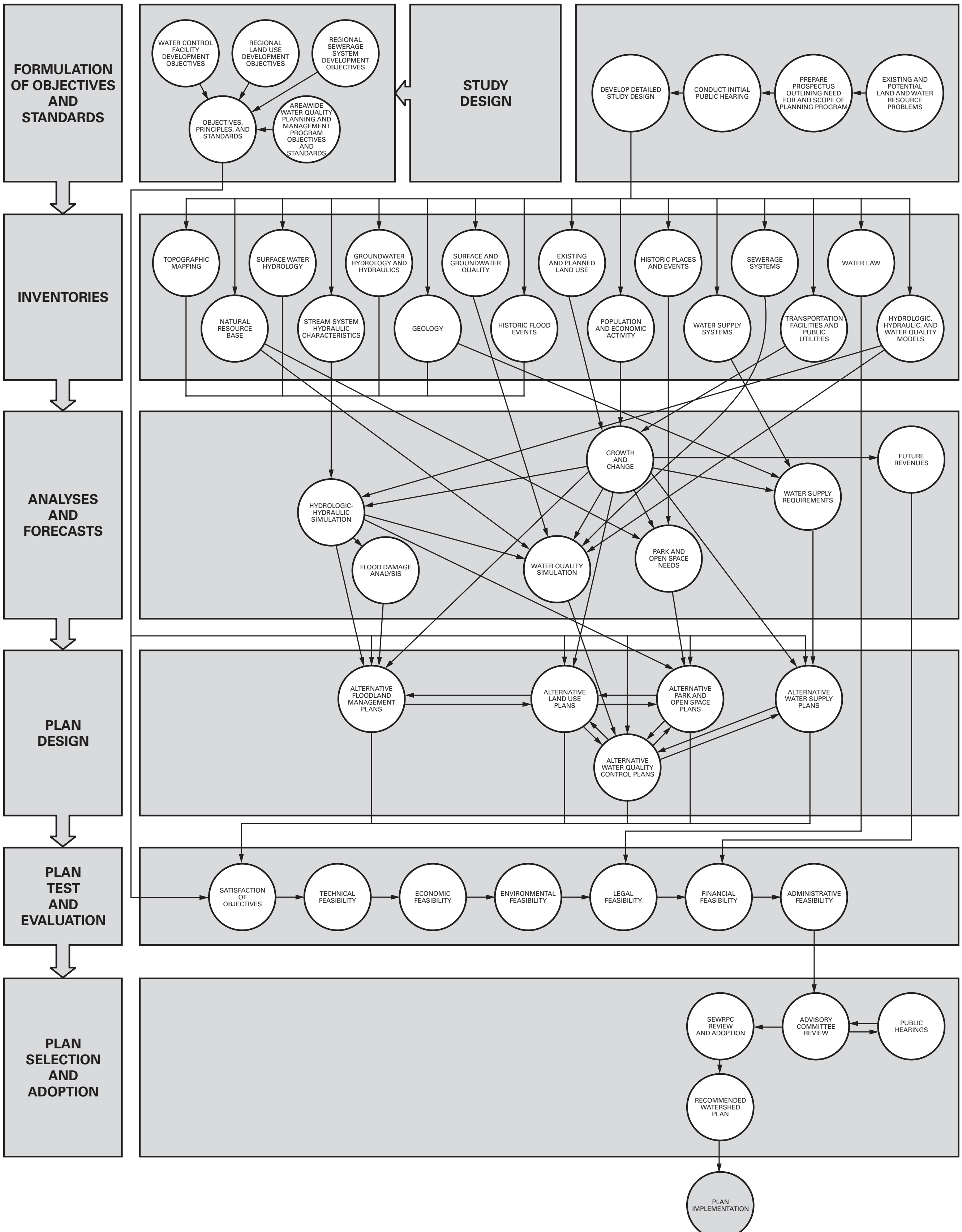
Formulation of Objectives and Standards

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 clearly stated and logically sound, but must also be related in a demonstrable way to alternative physical development proposals. This is essential 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; more particularly, because it is the objective of the Des Plaines 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 testing can a choice be made from among alternatives of a plan which best meets the agreed-upon objectives. Finally, logically conceived and well-expressed objectives must be translated into detailed design standards to provide the basis for plan preparation, testing, and evaluation. Because the formulation of objectives and standards involves both technical and nontechnical policy determinations, all objectives and standards were carefully reviewed and adopted by the Des Plaines River Watershed Committee and by the Regional Planning Commission.

Figure 3

GENERAL STEPS IN A COMPREHENSIVE WATERSHED PLANNING PROGRAM



Source : SEWRPC.

The objectives and standards ranged from general development goals for the watershed as a whole to detailed engineering and planning analytical procedures and design criteria covering rainfall intensity-duration-frequency relationships; computer simulation of hydrology, hydraulics, and water quality; flood frequency analyses; design floods; and economic and financial analyses. Most of the general development goals were superimposed on the watershed study from previous watershed planning programs, the regional land use-transportation planning program, the regional sanitary sewerage system planning program, and the areawide water quality management planning program.

Inventory

Reliable basic planning and engineering data collected on a uniform, watershedwide basis are absolutely essential to the formulation of workable development plans. Consequently, inventory growing out of the study design becomes the first operational step in any planning process. The crucial need for 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 historic and current state of the system being planned.

The sound formulation of comprehensive watershed development plans requires that factual data be developed on topographic features; the quantity of surface and groundwater; precipitation; hydraulic characteristics of the stream system; historic flooding; flood damages; water quality and wastewater sources; water use; soil capabilities; land use; economic activity; population; recreation facilities; fish and wildlife habitat; natural areas; historic sites; transportation, water supply, and sewerage facilities and other public utilities; and water law.

In the Des Plaines River watershed study, the most expedient methods of obtaining adequate information of the necessary quality were followed. These included review of prior publications, perusal of agency files, personal interviews with private citizens and public officials, committee meetings, and original field investigations.

Analyses and Forecasts

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 the determination of future change within the watershed; these basic forecasts can, in turn, be translated into future demands for land, other resources, and water-control facilities. These future demands can then be scaled against the existing supply and both alternative and recommended plans formulated to meet deficiencies.

To illustrate the complexity of this task in comprehensive watershed planning, consider the fact that to prepare a forecast of future floodland management and flood control facility needs it was necessary to analyze and to interrelate the following factors: precipitation characteristics; relationship between basin morphology and runoff; effect of urbanization and soil properties on runoff volume and timing; effect of the hydraulic characteristics of the stream network on streamflow; relationships between streamflow, flood stage, and frequency of flood occurrence; and seasonal influence and influence of floodland storage and conveyance.

Two important considerations involved in the preparation of the necessary forecasts are the target date and accuracy requirements. Both the land use pattern and the floodland management measures must be planned for anticipated demand at some future time.

In the planning of water-control facilities, the design year is usually based on 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 plan design year be scaled to the facility plan design year requirement. In the Des Plaines River watershed study, the necessary forecast period was set as approximately 20 years, both as a very conservative approximation of facility life and as a means for locking the watershed forecast periods into previously determined regional planning forecast periods.

Forecast accuracy requirements depend on the use to be made of the forecasts. 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 in which only the timing, and not the basic structure, of the plans will be affected.

Plan Synthesis

Plan synthesis, or design, forms the heart of the planning process. The most well-conceived objectives; the most sophisticated data collection, processing, and analyses; 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, conduct of inventories, and preparation of forecasts, become inputs into 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 to 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 the hydrologic, hydraulic, and pollution-loading data derived from the land use plan, adopted facility design standards, existing facilities, and new facility costs.

Plan Testing 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 test alternative plans quantitatively in advance of their adoption and implementation. The alternative plans must be rigorously subjected to all necessary levels of review and inspection, including 1) engineering and technical feasibility, 2) environmental impact, 3) economic and financial feasibility, 4) legality, and 5) political acceptability. Devices used to test and evaluate the plans range from digital computer simulation programs to evaluate the hydrologic-hydraulic responses to alternative plan elements developed through interagency meetings and public hearings. Plan test and evaluation should demonstrate clearly which alternative plans or portions of plans are technically sound, economically and financially feasible, legally possible, and politically realistic.

Plan Selection and Adoption

The Des Plaines River watershed study includes development of a land use plan representing a refinement of the year 2010 regional land use plan.[1] Needed refinements of this regional land use plan were based upon the Regional Planning Commission’s land use and transportation system plan for the IH 94 South Freeway corridor,[2] an updated comprehensive plan for the Kenosha Urban Planning District,[3] and applicable local land use plans prepared by Commission staff and by consultants to local units of government. The land use plan is supported by various combinations of water-control facility system plans for both flood control and pollution abatement, thus providing for a number of alternative watershed development plans. The desirability of the recommended comprehensive plan is supported by analyses of some of the consequences that may be expected under conditions of uncontrolled development.

The general approach used for the selection of a recommended plan from among the alternatives considered was to proceed through the use of the Des Plaines River Watershed Committee structure, interagency meetings, and public informational meetings and hearings to a final decision and plan adoption by the Commission in

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[1]*SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010*, January 1992.*

[2]*SEWRPC Community Assistance Planning Report No. 200,* A Land Use and Transportation System Development Plan for the IH 94 South Freeway Corridor, Kenosha, Milwaukee, and Racine Counties*, December 1991.*

[3]*SEWRPC Community Assistance Planning Report No. 212,* A Comprehensive Plan for the Kenosha Urban Planning District, Kenosha County, Wisconsin*, December 1995.*

accordance with the provisions of State enabling legislation. The role of the Commission is to adopt and recommend the final plan to the Federal, State, and local units of government and to private investors concerned for consideration and action. The final decisive step to be taken in the process is acceptance or rejection of the plan by the State, County, and 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 all 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 way to achieve such involvement in the planning process and to arrive at agreement openly among the affected governmental bodies and agencies on objectives and on a final watershed plan which can be cooperatively adopted and jointly implemented.

Chapter III

DESCRIPTION OF THE WATERSHED: MAN-MADE FEATURES AND NATURAL RESOURCE BASE

INTRODUCTION

The water-resource and water-resource-related problems of a watershed, as well as the ultimate solutions to those problems, are a function of the human activities within the watershed and of the ability of the underlying natural resource base to sustain those activities. Comprehensive watershed planning seeks to direct rationally the future course of human actions within the watershed so as to promote the conservation and wise use of the natural resource base. Accordingly, the purpose of this chapter is to describe the natural resource base and the man-made features of the Des Plaines River watershed, thereby establishing a factual base upon which the watershed planning process may proceed. This description of the watershed is presented in two major sections: the first describes the man-made features, the second describes the natural resource base of the watershed.

DESCRIPTION OF THE WATERSHED: MAN-MADE FEATURES

The man-made features of a watershed include its political boundaries, land use pattern, public utility network, and transportation system. Together with the population residing and the economic activities taking place within the watershed, these features may be thought of as the socioeconomic base of the watershed. A description of this socioeconomic base is essential to sound watershed planning. Any attempt to protect or improve the socioeconomic environment must be founded in an understanding, not only of the various demands for land, public facilities, and resources generated by the demographic and economic activities of an area, but also the ability of the existing land use pattern and public facility systems to meet those demands.

In order to facilitate such understanding, a description of the socioeconomic base of the watershed is here presented in five sections. The first section places the watershed in perspective as a rational planning unit within a regional setting by delineating its internal political and governmental boundaries and relating these boundaries to the Region as a whole. The second section describes the demographic and economic base of the watershed in terms of population size, distribution, and composition and in terms of commercial and industrial activity and employment levels and distribution. The third section describes the pattern of land use in the watershed in terms of both historical development and existing (1990) conditions. The fourth and fifth sections describe the public and private utility and transportation facility systems within the watershed. These five elements comprise the man-made features of the watershed.

Regional Setting of Watershed and Political Boundaries

The Des Plaines River watershed within Southeastern Wisconsin, as shown on Map 3, covers approximately 132.9 square miles, or 5 percent of the seven-county Region. The watershed ranks sixth in size of the 11 major natural watersheds located wholly or partly within the Region. The watershed is drained by approximately 69.1 miles of perennial streams, including the Des Plaines River and its tributaries: Jerome Creek, the Kilbourn Road Ditch, Center Creek, Brighton Creek, and the Dutch Gap Canal.

Civil Divisions

Superimposed on the irregular watershed boundary is a pattern of local political boundaries. As shown on Map 3, the watershed lies mostly within Kenosha County, with a small portion in southern Racine County. Twelve civil divisions lie in part or entirely within the Des Plaines River watershed, as also shown on Map 3 and Table 1. Geographic boundaries of the civil divisions are an important factor which must be considered in any areawide planning effort like the Des Plaines River watershed planning program, since the civil divisions form the basic foundation of the public decision-making framework within which intergovernmental, environmental, and developmental problems must be addressed.

Between 1974 and 1990, the City of Kenosha entered into agreements with both the Town of Somers and the Village of Pleasant Prairie setting forth arrangements governing the provision of utility services and providing a basis for establishment of future municipal boundaries. An initial agreement between the City of Kenosha and the former Town of Pleasant Prairie was executed in 1984 and amended in 1988. An initial agreement between the City and the Town of Somers was executed in 1974 and subsequently amended in 1985, 1988, and 1990. The 1990 agreement between the City of Kenosha and the Town of Somers identifies areas of the Town which will remain permanently part of the Town and areas which may be annexed to the City, and, in fact, must be annexed to the City prior to the provision of city sewer and water-supply services. The lands in the Des Plaines River watershed which must be annexed by the City prior to the provision of urban services lie within the Kilbourn Road Ditch subwatershed. The 1988 agreement between the City and the former Town of Pleasant Prairie establishes the boundaries between Kenosha and Pleasant Prairie essentially as they exist today. Under the agreement, much of the former Town land lying in the Kilbourn Road Ditch subwatershed north of STH 50 was attached to the City prior to the incorporation of Pleasant Prairie as a village. In addition, remnants of the former Town of Pleasant Prairie located along CTH K were attached to the Town of Somers. The agreement further identified certain Pleasant Prairie lands located along the Pleasant Prairie-Kenosha border as potential additions to the City; only small portions of the areas so identified have been attached to the City.

Special-Purpose Units of Government

Special-purpose units of government are of particular interest to the watershed planning program. Among these are the legally established, active town sanitary and utility districts created to provide various urban-related services, such as sanitary sewerage, water supply, and solid waste collection and disposal, to designated portions of rural towns with urban service needs. There are five such districts within the Des Plaines River watershed: Town of Bristol Utility District Nos. 1, 3, 4, and 5[1] and Town of Salem Utility District No. 2.

Another special-purpose unit of government of concern to the watershed planning program is the farm drainage district. As shown on Map 4, at one time there were three farm drainage districts within the watershed in Kenosha County. These were the Bristol Farm Drainage District, also known as the Dutch Gap Canal District; the Kilbourn Road Drainage District, which was also referred to as the Tobin Road Drainage District; and Pleasant Prairie Drainage District No. 1. The Kilbourn Road Drainage District was dissolved by order of the Kenosha County Court on December 23, 1953, and the Pleasant Prairie Drainage District No. 1 was also dissolved.[2] Thus, the one remaining legally constituted farm drainage district within the watershed in Kenosha County is the Bristol

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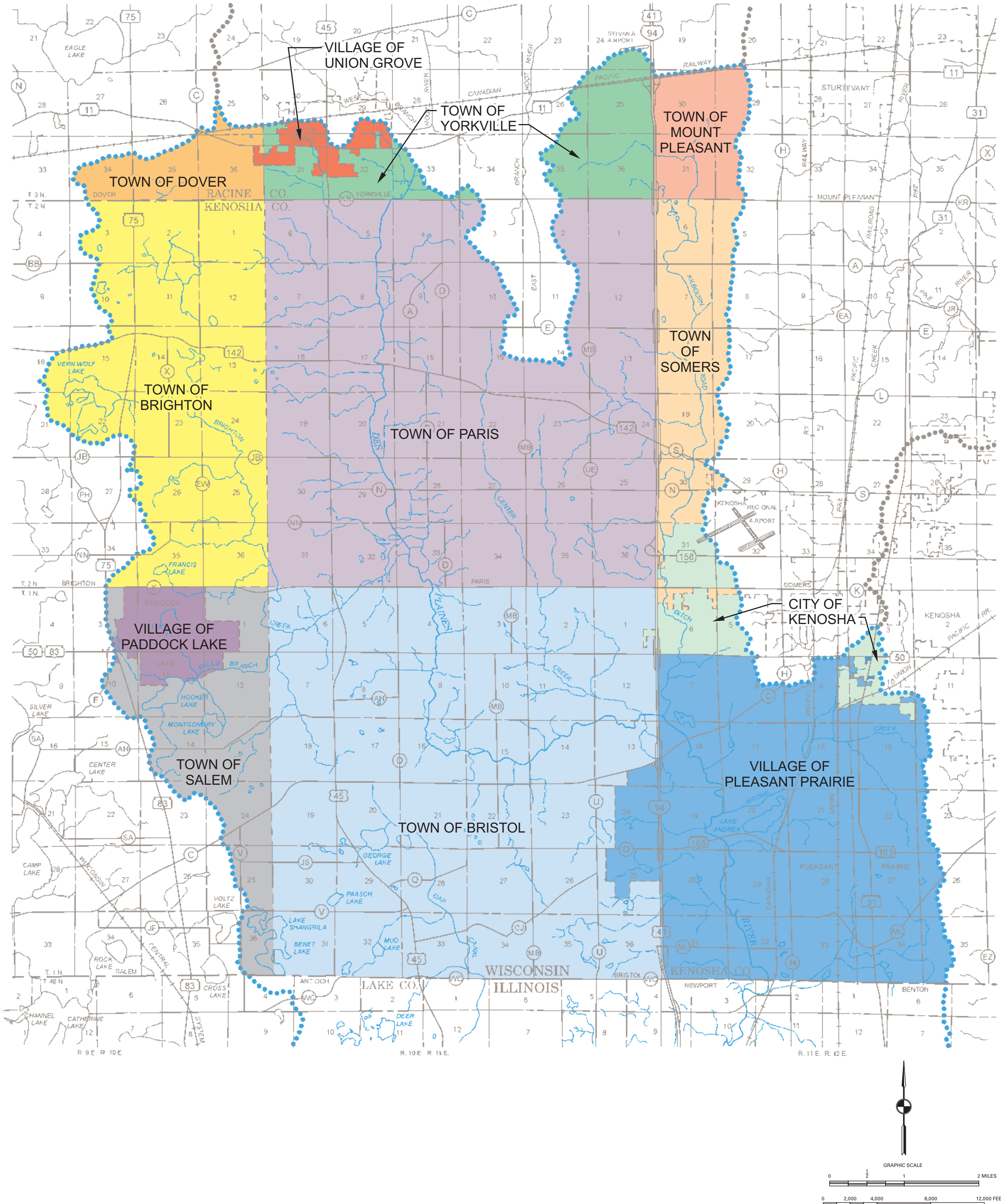
[1]*The Town of Bristol Utility District No. 5 does not operate any conveyance or treatment facilities. It was established for the purpose of raising revenue for a study of the feasibility of constructing a sewerage system, including a sewage treatment plant, to serve the geographic area of the District. The system was not constructed.*

[2]*There are no State, County, Village, or Town records of the date of this final dissolution.*

Map 3

CIVIL DIVISIONS IN THE DES PLAINES RIVER WATERSHED: 2000



The Des Plaines River watershed is a 132.9 square-mile natural surface water drainage basin located within Kenosha and Racine Counties and containing parts of one city, three villages, and eight towns. The watershed is bounded on the north by the Fox and Root River watersheds, on the west by the Fox River watershed, and on the east by the Pike River watershed and areas directly tributary to Lake Michigan.

Source: SEWRPC.

Table 1

AREAL EXTENT OF CIVIL DIVISIONS IN THE DES PLAINES RIVER WATERSHED: 2000

Civil Division	Area within Watershed (square miles)	Percent of Watershed Area within Civil Division	Percent of Civil Division Area within Watershed
Kenosha County			
Cities			
Kenosha	2.86	2.15	12.20
Villages			
Paddock Lake	2.09	1.57	99.06
Pleasant Prairie	21.47	16.15	64.21
Towns			
Brighton	15.28	11.49	42.53
Bristol	34.82	26.19	100.00
Paris	33.18	24.96	92.35
Salem	6.63	4.99	20.44
Somers	5.82	4.38	18.10
Subtotal	122.15	91.89	43.87
Racine County			
Villages			
Union Grove	0.96	0.75	57.05
Towns			
Dover	2.42	1.82	6.69
Mt. Pleasant	2.77	2.08	7.57
Yorkville	4.63	3.46	13.39
Subtotal	10.78	8.11	3.17
Total	132.93	100.00	- -

Source: SEWRPC.

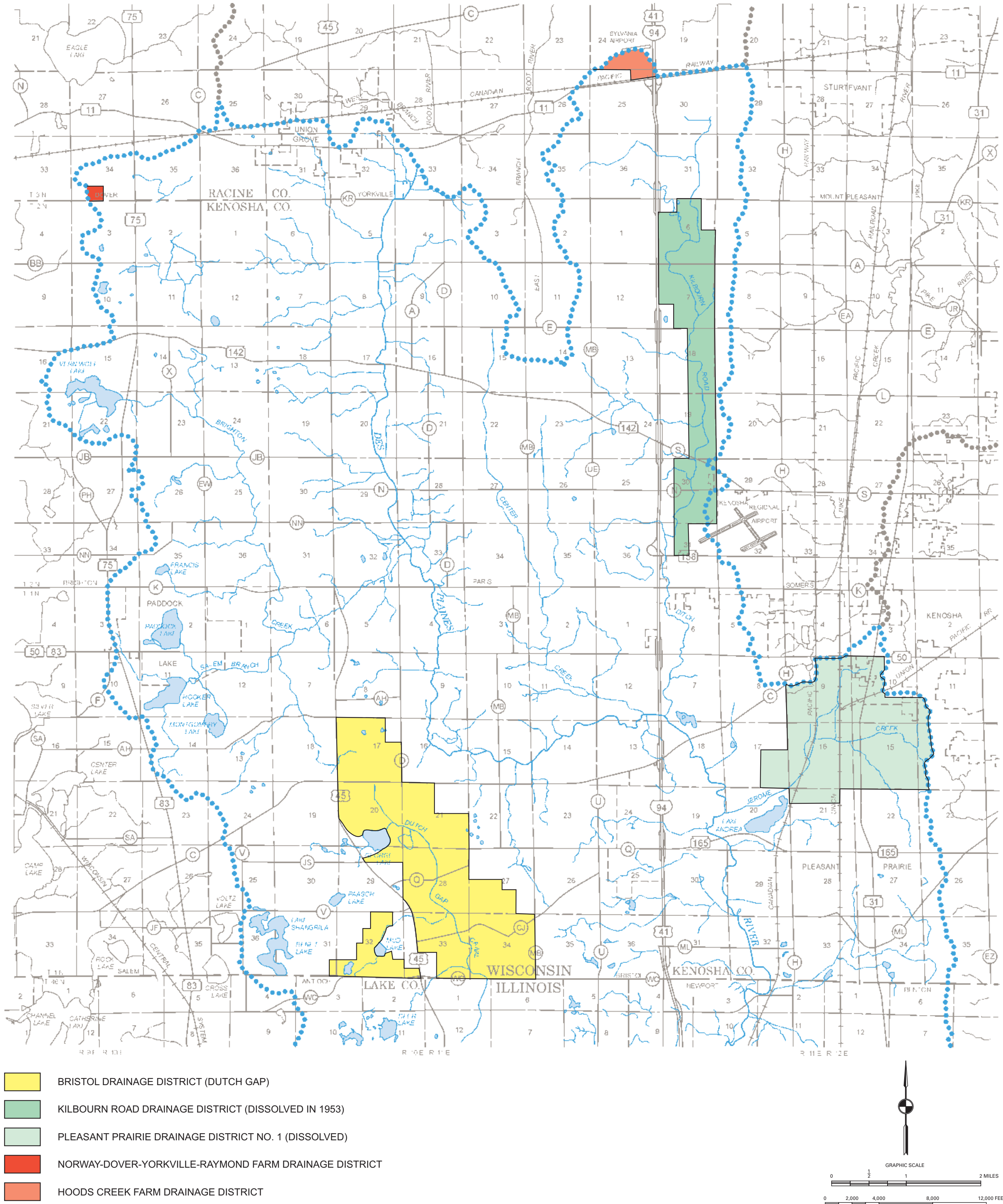
Farm Drainage District. In accordance with Chapter 88 of the Wisconsin Statutes, that drainage district operates under the supervision of the Kenosha County Farm Drainage Board. The Commissioners of the Kenosha County Farm Drainage Board resigned in 1990 and replacement Commissioners were not appointed. Consequently, in recent years the Bristol Farm Drainage District has been inactive.

Very small portions of the Norway-Dover-Yorkville-Raymond Farm Drainage District and the Hoods Creek Farm Drainage District are located within the watershed in Racine County. Those districts operate under the governance of the Racine County Farm Drainage Board.

Inland lake protection and rehabilitation districts are special-purpose units of government created pursuant to Chapter 33 of the Wisconsin Statutes. There are three such districts in the watershed: 1) the George Lake Protection and Rehabilitation Inland District, 2) the Hooker Lake Management District, and 3) the Paddock Lake Inland Lake Protection and Rehabilitation District. Lake protection and rehabilitation district powers include 1) study of existing water-quality conditions to determine the causes of existing or expected future water-quality problems, 2) control of aquatic macrophytes and algae, 3) implementation of lake rehabilitation techniques, including aeration, diversion, nutrient removal or inactivation, dredging, sediment covering, and drawdown, 4) construction and operation of water-level-control structures, 5) control of nonpoint source pollution, and 6) creation, operation, and maintenance of a water safety patrol unit.

Map 4

FARM DRAINAGE DISTRICTS IN THE DES PLAINES RIVER WATERSHED



The one remaining legally constituted district in the watershed in Kenosha County is the Bristol Farm Drainage District. Very small portions of the Norway-Dover-Yorkville-Raymond Farm Drainage District and the Hoods Creek Farm Drainage District are located within the watershed in Racine County.

Source: SEWRPC.

Other Agencies with Resource-Management Responsibilities

Superimposed upon these local and special-purpose units of government are those State and Federal agencies with important responsibilities for resource conservation and management. These include the Wisconsin Department of Natural Resources (DNR); the University of Wisconsin-Extension; the State Board of Soil and Water Conservation Districts; the U.S. Department of the Interior, U.S. Geological Survey; the U.S. Environmental Protection Agency; the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS); and the U.S. Army Corps of Engineers.

Demographic and Economic Base

An understanding of the size, characteristics, and spatial distribution of the resident population is basic to any watershed planning effort because of the direct relationships which exist between population levels and the demand for land, water, and other important elements of the natural resource base, as well as the demand for various kinds of transportation, utility, and community facilities and services. The size and other characteristics of the population of an area are greatly influenced by growth and other changes in economic activity. Population characteristics and economic activity must, therefore, be considered together. It is important to note, however, that because the Des Plaines River watershed is an integral part of the greater Kenosha and Racine urban areas, many of the economic forces that influence population growth within the watershed are centered outside the watershed proper. Thus, an economic analysis for watershed planning purposes must relate the economic activity within the watershed to the economy of the Kenosha and Racine areas and to the Southeastern Wisconsin Region, of which these areas are an integral part. Similarly, the size, distribution, and other characteristics of the population residing within the watershed must be viewed in relation to similar characteristics of the population within the Southeastern Wisconsin Region.

Demographic Base

For comprehensive watershed planning purposes, a demographic inventory should include consideration of population size, distribution, and composition.

Population Size

The 1990 resident population of the watershed was estimated at about 19,650 persons, or about 1 percent of the population of the Region. As shown in Table 2 and Figure 4, the population of the watershed increased by 25 percent between 1960 and 1970. During this same period, Kenosha and Racine Counties experienced 17 and 20 percent increases in resident population, respectively, and the Region experienced a 12 percent increase. Between 1970 and 1980, the populations of the watershed and the Region increased by 21 percent and 1 percent, respectively, while the populations of Kenosha and Racine Counties increased by 4 and 1 percent, respectively. Between 1980 and 1990, the populations of Kenosha and Racine Counties again increased by 4 and 1 percent, respectively, while the populations of the watershed and the Region increased by 8 and 3 percent, respectively. The proportion of the total regional population which resides in the watershed increased from 0.8 percent in 1960 to 1.1 percent in 1990. The higher population growth rate within the watershed reflects the diffusion of urban land use development which has been occurring within the Region for many years. The Des Plaines River watershed is still predominantly rural; but, being located in proximity to the greater Kenosha, Milwaukee, and Racine urban areas, as well as to Northeastern Illinois, is subject to urbanization. The public preference for low-density residential development, as indicated by the findings of attitudinal surveys conducted by the Commission in 1963, 1972, and 1991, and the diffusion of urban development outward from the older urban centers has resulted in high rates of population growth in areas contiguous to cities such as Kenosha, Milwaukee, and Racine.

Population Distribution

The 1960, 1970, 1980, and 1990 resident populations of the watershed are presented by civil division in Table 3. Figure 5 is a graphical representation of the changes in population by civil division over time. The portion of the watershed within Kenosha County, which portion comprises 92 percent of the Des Plaines River watershed by area, experienced a gain of about 6,700 persons, or a 68 percent increase in population, from 1960 to 1990. The remaining 8 percent of the watershed, which lies in Racine County, experienced a 43 percent increase in population, or an increase of about 940 persons. Overall, the population of the watershed increased 63 percent, from 12,024 persons in 1960 to 19,652 persons in 1990.

Table 2

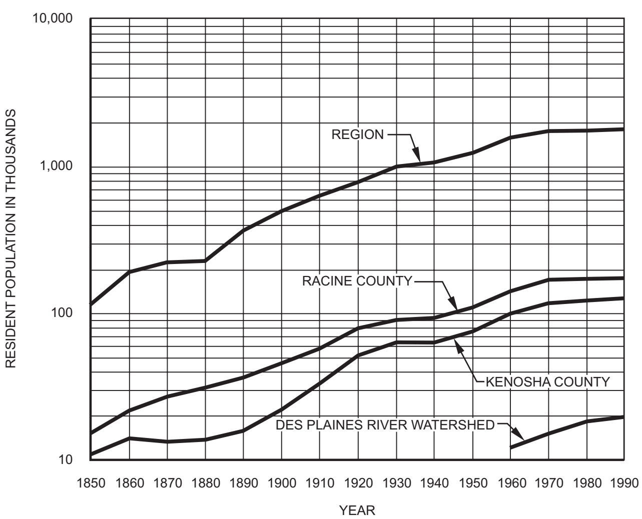
POPULATION IN THE DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: SELECTED YEARS, 1850-1990

Year	Des Plaines River Watershed		Kenosha County		Racine County		Southeastern Wisconsin Region	
	Number	Percent Change during Preceding Period	Number	Percent Change during Preceding Period	Number	Percent Change during Preceding Period	Number	Percent Change during Preceding Period
1850	- -	- -	10,734	- -	14,973	- -	113,389	- -
1860	- -	- -	13,900	29.5	21,360	42.7	190,409	67.9
1870	- -	- -	13,147	-5.4	26,740	25.2	223,546	17.4
1880	- -	- -	13,550	3.1	30,922	15.6	227,119	24.0
1890	- -	- -	15,581	15.0	36,268	17.3	368,774	39.6
1900	- -	- -	21,707	39.3	45,644	25.9	501,808	29.7
1910	- -	- -	32,929	51.7	57,424	25.8	631,161	25.8
1920	- -	- -	51,284	55.7	78,961	37.5	783,681	24.2
1930	- -	- -	63,277	23.4	90,217	14.3	1,006,118	28.4
1940	- -	- -	63,505	0.4	94,047	4.2	1,067,699	6.1
1950	- -	- -	75,238	18.5	109,585	16.5	1,240,618	16.2
1960	12,024	- -	100,615	33.7	141,781	29.4	1,573,614	26.8
1970	15,041	25.1	117,917	17.2	170,838	20.5	1,756,083	11.6
1980	18,226	21.2	123,137	4.4	173,132	1.3	1,764,796	0.5
1990	19,652	7.8	128,181	4.1	175,034	1.1	1,810,364	2.6

Source: U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census, and SEWRPC.

Figure 4

RESIDENT POPULATION OF THE DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: SELECTED YEARS, 1850-1990



Source: U. S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census and SEWRPC.

Approximately 2.86 square miles of the City of Kenosha lie within the Des Plaines River watershed, covering about 2 percent of the watershed. As shown in Table 3, the 1990 population of the portion of the City within the watershed was 1,108 persons, or about 6 percent of the total watershed population. The City limits were not extended into the watershed until after the 1980 Census; thus, no comparison can be made between 1990 and previous population counts.

The areal extent of the Village of Paddock Lake within the watershed is 2.09 square miles, or 1.5 percent of the total watershed area, as shown in Table 1. The 1990 population of the portion of the Village of Paddock Lake within the watershed was 2,662 persons, or about 14 percent of the total watershed population, an 81 percent increase from 1970, when the first Census was taken following incorporation of the Village.

Approximately 21.5 square miles of the Village of Pleasant Prairie lie within the watershed. Thus, the Village covers about 16.2 percent of the watershed

Table 3

DISTRIBUTION OF POPULATION IN THE DES PLAINES RIVER WATERSHED: 1960, 1970, 1980 AND 1990

Civil Division[a]	1960		1970		1980		1990	
	Population	Percent of Total	Population	Percent of Total	Population	Percent of Total	Population	Percent of Total
Kenosha County								
Cities								
Kenosha	- -	- -	- -	- -	- -	- -	1,108	6
Villages								
Paddock Lake[b]	- -	- -	1,470	10	2,207	12	2,662	14
Pleasant Prairie[c]	2,862	24	3,804	25	4,659	26	4,008	20
Towns								
Brighton	619	5	763	5	690	4	721	4
Bristol	2,155	18	2,740	18	3,599	19	3,968	20
Paris	1,404	12	1,682	11	1,548	8	1,425	7
Salem	2,570	21	1,347	9	1,632	9	1,860	9
Somers	232	2	712	5	628	3	781	4
Subtotal	9,842	82	12,518	83	14,963	81	16,533	84
Racine County								
Villages								
Union Grove	1,482	12	1,646	11	2,286	13	2,327	12
Towns								
Dover	240	2	336	2	471	3	416	2
Mt. Pleasant	118	1	152	1	142	1	160	1
Yorkville	342	3	389	3	364	2	216	1
Subtotal	2,182	18	2,523	17	3,263	19	3,119	16
Total	12,024	100	15,041	100	18,226	100	19,652	100

[a] *The civil divisions in the watershed and the boundaries of these civil divisions have changed over time because of incorporations and annexations.*

[b] *The Village of Paddock Lake was incorporated in 1960 after the conduct of the 1960 Census.*

[c] *In 1989, the Town of Pleasant Prairie was divided, with portions being attached to the City of Kenosha, the Town of Somers, and the then newly incorporated Village of Pleasant Prairie. Data presented for 1960, 1970, and 1980 are for the Town of Pleasant Prairie; 1990 data are presented for the Village of Pleasant Prairie.*

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

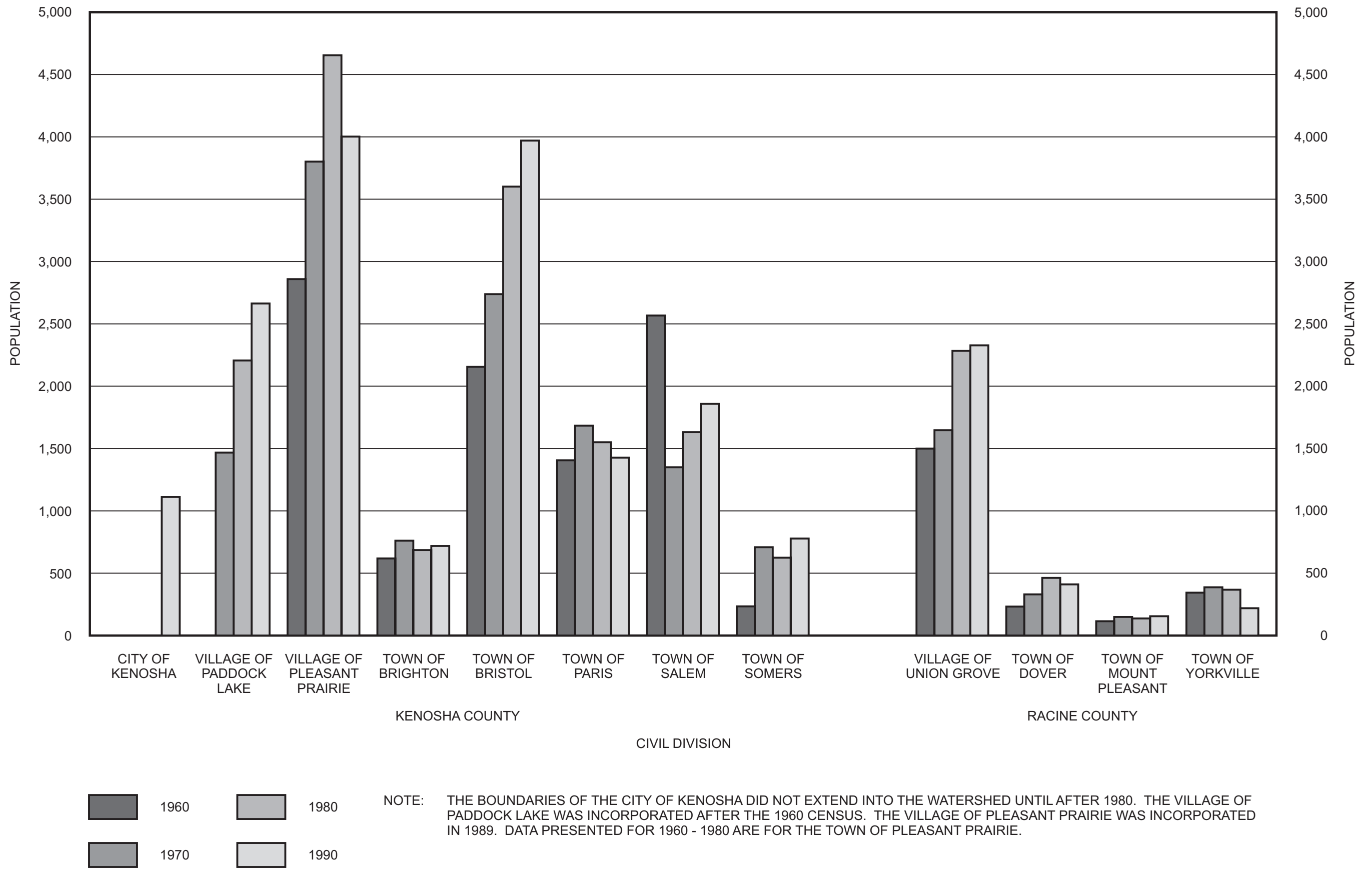
areas. The 1990 Village population within the watershed was 4,008, or about 20 percent of the total watershed population. The Village was incorporated in 1989; thus, no comparison can be made between 1990 and previous population counts. The 1990 Village population, however, represents a 40 percent increase, an increase of 1,146 people, over the 1960 population of the Town of Pleasant Prairie, which comprises the approximate area out of which the Village was incorporated.

The Town of Brighton covers 15.3 square miles of the watershed, or about 12 percent of the total watershed area. The Town population within the watershed, which increased by 16 percent from 1960 to 1990, is 721 persons, or about 4 percent of the total watershed population.

The entire 34.8-square-mile area of the Town of Bristol lies within the Des Plaines River watershed. The Town covers 26 percent of the total watershed area, the largest area encompassed by any one civil division in the study

Figure 5

DISTRIBUTION OF POPULATION IN THE DES PLAINES RIVER WATERSHED: 1960-1990



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

area. The 1990 population of the Town was approximately 3,970 persons, or about 20 percent of the total watershed population, an 84 percent increase from 1960.

The Town of Paris covers 33.2 square miles of the watershed, or about 25 percent of the total watershed area. Table 3 indicates that the Town population fluctuated somewhat between 1960 and 1990, but the overall increase during that period was only 1 percent. The 1990 population of that portion of the Town within the watershed is 1,425 persons, or about 7 percent of the total population of the watershed.

Approximately 6.6 square miles of the Town of Salem lie within the watershed. This represents about 5 percent of the total watershed area. The portion of the Town within the watershed experienced a 48 percent decrease in population between 1960 and 1970 due to the incorporation of the Village of Paddock Lake in 1960, following completion of that year's Census. Between 1970 and 1990, the population of the Town within the watershed rose by 38 percent, to 1,860 persons, or 9 percent of the total population of the watershed.

The Town of Somers, which covers 5.8 square miles of the watershed, or about 4 percent of the total watershed area, had the largest relative increase in population from 1960 to 1990 of any civil division in the watershed.

During that time, the population of the portion of the Town within the watershed increased by 237 percent. Most of that increase occurred between 1960 and 1970, when the population increased by 207 percent. Since 1970, the population has increased by about 10 percent. The 1990 population of the Town within the watershed is 781 persons, or about 4 percent of the total population of the watershed.

In Racine County, the portion of the Village of Union Grove in the Des Plaines River watershed had a 1990 population of 2,327 persons, about a 57 percent increase from the 1960 population. Even though only about 1.0 square mile of the Village falls in the watershed, 12 percent of the population of the watershed resides there.

The 2.4-square-mile portion of the Town of Dover which lies within the watershed experienced a 73 percent population growth rate between 1960 and 1990, the largest percentage increase in the Racine County portion of the watershed. That increase may be attributed almost entirely to the development of Fonk's Mobile Home Park No. 2 in the late 1960s. In 1990, 416 persons, or about 2 percent of the watershed population, resided in the portion of the Town within the watershed.

The Town of Mt. Pleasant covers 2.8 square miles of the watershed, or about 2 percent of the total watershed area. The Town population within the watershed, which increased about 36 percent from 1960 to 1990, is 160 persons, or about 1 percent of the total population of the watershed.

Approximately 4.6 square miles of the Town of Yorkville are located within the watershed. That area represents about 3 percent of the total watershed area. From 1960 to 1980, the population of the Town within the watershed increased by 6 percent, from 342 to 364 persons. From 1980 to 1990, the population decreased by 41 percent, to 216 persons, partly because of the annexation of portions of the Town by the Village of Union Grove. The Town population within the watershed represents 1 percent of the total population of the watershed.

As shown on Map 5, in 1990 most of the Des Plaines River watershed had a density of less than 400 persons per square mile, reflecting the predominantly rural character of the watershed. Only a small portion of the watershed exhibited a population density in excess of 400 persons per square mile. Densities of 400 to 2,999 persons per square mile occurred in parts of the City of Kenosha; the Villages of Paddock Lake, Pleasant Prairie, and Union Grove; and the Towns of Bristol, Dover, Salem, Somers, and Yorkville. Densities of 3,000 to 4,499 persons per square mile occurred in parts of the City of Kenosha and the Village of Union Grove. Densities in excess of 4,500 persons per square mile occurred in a small part of the City of Kenosha.

From 1960 to 1990, the overall population density of the watershed increased by about 63 percent, from about 90 to about 148 persons per square mile. Table 4 presents the overall 1990 watershed population density, together with the population density of those portions of the various minor civil divisions within the watershed and the respective proportion of the watershed population residing in those civil divisions.

Population Composition

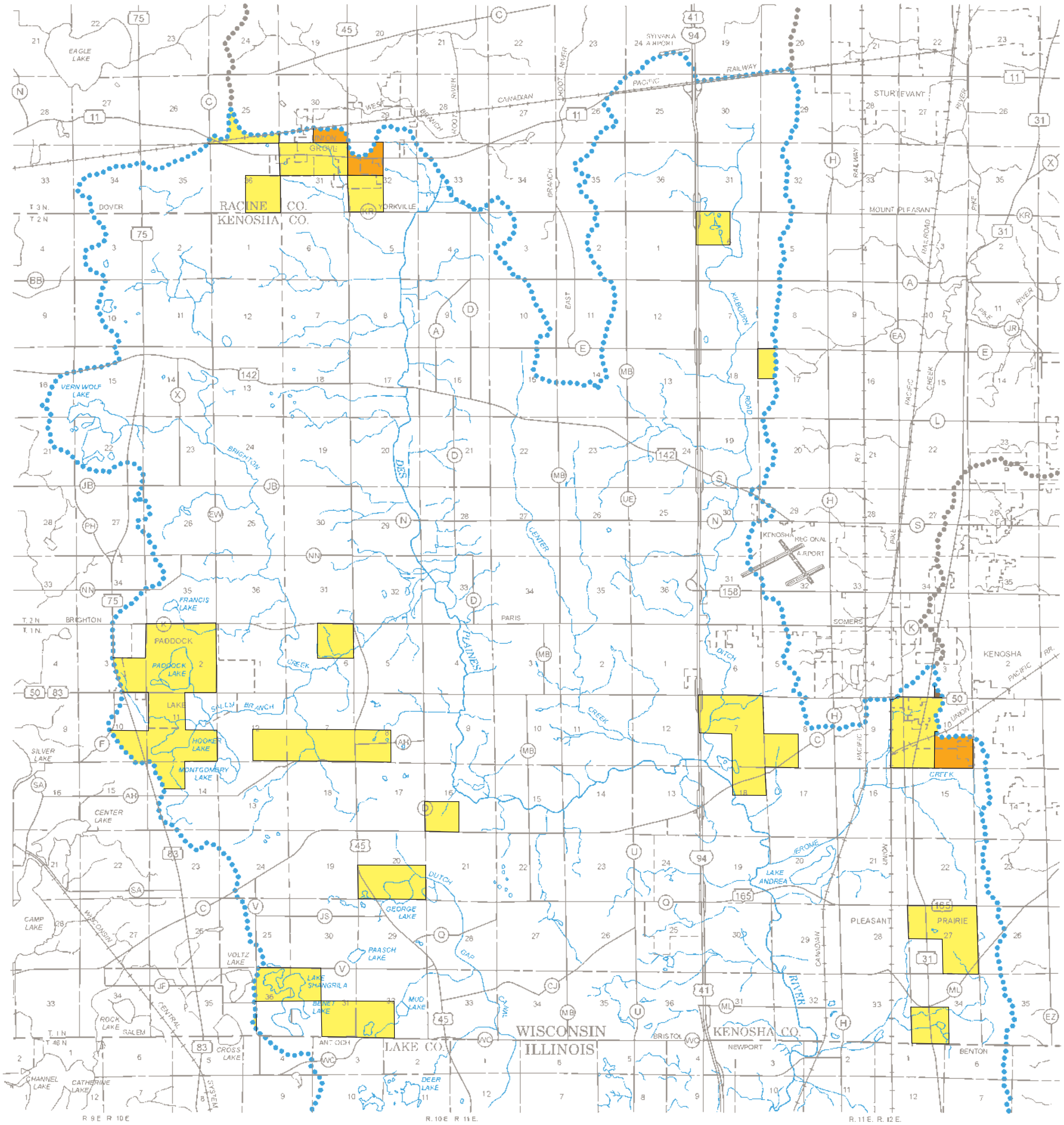
In 1990 the median age of the resident population of the watershed was 33.1 years, while the median ages of the resident populations of Kenosha and Racine Counties were about 32.5 years and 32.8 years, respectively; the median age in the seven-county Southeastern Wisconsin Region as a whole was about 32.8 years. The average household size in the watershed in 1990 was 2.90 persons per household, while the average household sizes in Kenosha and Racine Counties were 2.67 persons and 2.70 persons per household, respectively, and in the Region as a whole, 2.62 persons per household. This reflects the still primarily rural character of the watershed, for larger household sizes are normally more prevalent in rural and rural-urban-fringe areas. In 1990, the average annual income for households within the watershed was estimated at $41,928, somewhat higher than the Kenosha and Racine County averages of $35,789 and $38,129, respectively, and the regional average of $38,541.

Economic Base

The Des Plaines River watershed is located close to the Kenosha and Racine urbanized areas and near the metropolitan Milwaukee area. As such, its economic base cannot be differentiated in any meaningful way from that of the greater Kenosha, Racine, and Milwaukee areas. The resident population of the watershed can readily

Map 5

GROSS POPULATION DENSITY IN THE DES PLAINES RIVER WATERSHED: 1990



PERSONS PER SQUARE MILE

- 4,500 OR MORE
- 3,000 - 4,499
- 400 - 2,999
- LESS THAN 400

GRAPHIC SCALE

0 ½ 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

The 1990 resident population of the Des Plaines River watershed is estimated at 19,650 persons, gross population densities within the watershed range from less than 400 persons per square mile in the still-rural areas of the watershed to more than 4,500 persons per square mile in the urbanized areas from 1960-1990. The overall population density of the watershed increased from about 90 to 148 persons per square mile, an increase of about 58 persons per square mile, or about 64 percent.

Source: SEWRPC.

Table 4

TOTAL POPULATION AND POPULATION DENSITY IN THE DES PLAINES RIVER WATERSHED: 1990

Civil Division	Population within Watershed	Percent of Watershed Population	Area Included in Watershed (square miles)	Percent of Watershed Area within Civil Division	Average Gross Population Density per Square Mile
Kenosha County					
Cities					
Kenosha	1,108	6	2.75	2.07	403
Villages					
Paddock Lake	2,662	14	2.04	1.54	1,305
Pleasant Prairie	4,008	20	20.12	15.13	199
Towns					
Brighton	721	4	15.28	11.50	47
Bristol	3,968	20	36.28	27.29	109
Paris	1,425	7	33.18	24.96	43
Salem	1,860	9	6.68	5.02	278
Somers	781	4	5.82	4.38	134
Subtotal	16,533	84	122.15	91.89	135
Racine County					
Villages					
Union Grove	2,327	12	0.81	0.61	2,873
Towns					
Dover	416	2	2.42	1.82	172
Mt. Pleasant	160	1	2.77	2.08	58
Yorkville	216	1	4.78	3.60	45
Subtotal	3,119	16	10.78	8.11	289
Total	19,652	100	132.93	100.00	148

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

commute to jobs located outside the watershed, while other residents in the greater Kenosha, Racine, and Milwaukee areas can readily commute to jobs within the watershed. In addition, since the watershed is located just north of the Wisconsin-Illinois state line, watershed residents are able to commute to jobs in Northeastern Illinois and Northeastern Illinois residents can commute to jobs in the Wisconsin portion of the watershed.

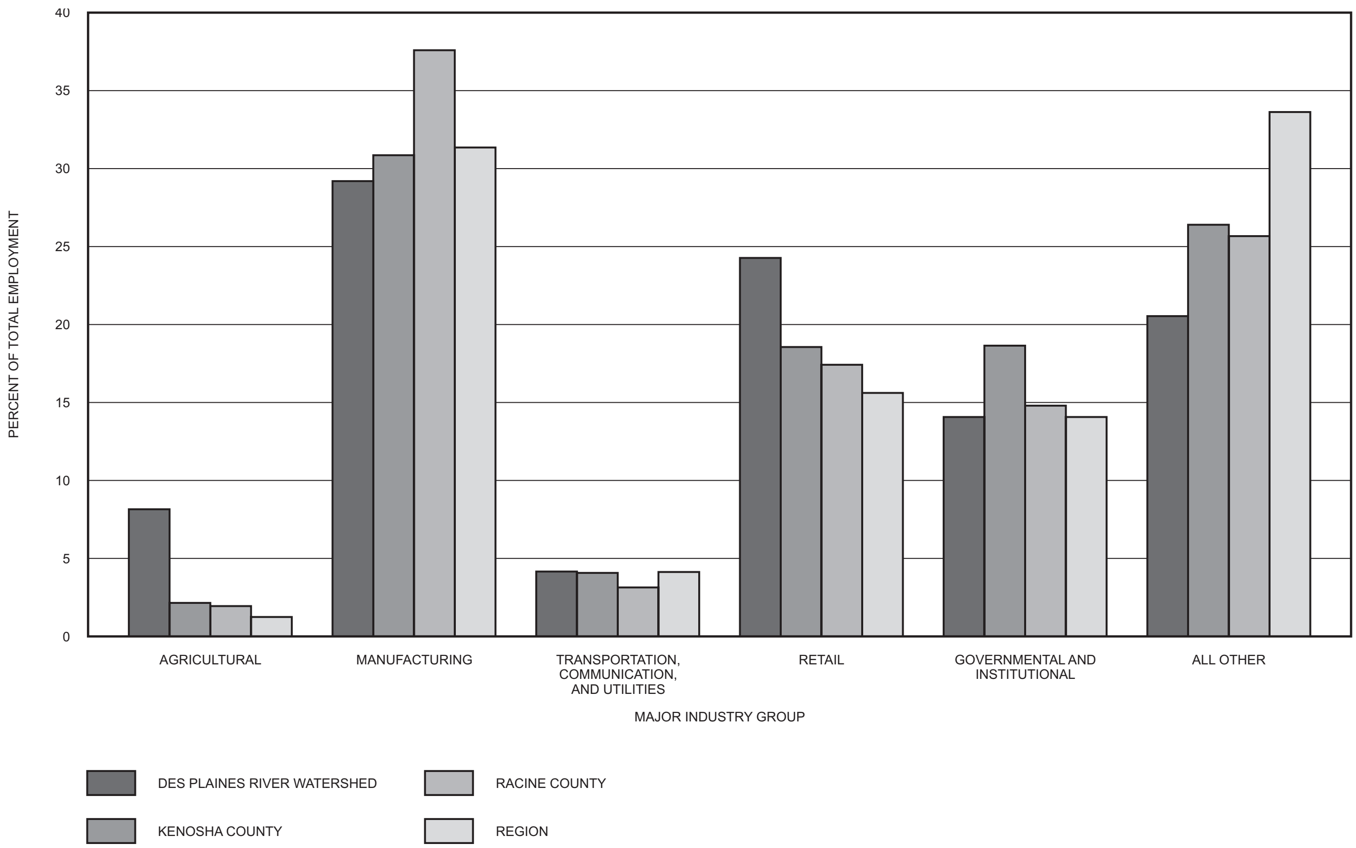
Figure 6 shows the relative concentration of jobs in six major industrial categories in 1990 for the Des Plaines River watershed, Kenosha and Racine Counties, and the Region. Employment within the watershed in six major categories, estimated at 8,200 jobs, is concentrated in two major industry categories. Manufacturing provided the largest number of jobs, about 2,400, or about 29 percent of the total number of jobs. Retail trade provided the next largest number, with about 2,000 jobs, or 24 percent of the total. Of the five major industry categories involved, the next three major industry groups each provided 14 percent or less of the total jobs in the watershed. About 650 jobs, or about 8 percent of the total, were agriculture-related jobs. About 21 percent of all jobs in the watershed did not fall within any of the five major industry categories involved and were therefore placed in a category including “all other” jobs.

Land Use

An important concept underlying the watershed planning effort is that land use development must be adjusted to the ability of the underlying natural resource base to sustain such development. The type, intensity, and spatial

Figure 6

DISTRIBUTION OF TOTAL EMPLOYMENT BY MAJOR INDUSTRY GROUP FOR THE
DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: 1990



Source: U S. Bureau of Economic Analysis and SEWRPC.

distribution of land uses determine, to a large extent, the resource demands within a watershed. Water-resource demands can be correlated directly with the quantity and type of land use, as can water-quality deterioration. The existing land use pattern can best be understood within the context of its historical development. Thus, attention is focused here on historical, as well as existing, land use development and upon both regional and watershed factors influencing land use.

Historical Development

The U.S. Public Land Survey involved the surveying, monumentation, and platting of land in most of the United States according to a rectangular grid. That survey was conducted in the Des Plaines River watershed during 1835 and 1836. The completion of that survey facilitated the settlement of the watershed by European settlers.

The first European settlers came to the Des Plaines River watershed in the 1830s by way of trails established by Native Americans, by way of territorial roads, and later by way of military and plank roads. The first territorial road traversed the same path as the present-day STH 11 and was called the Burlington-Racine Trail. The first military road ran north and south through the watershed and linked Fort Dearborn at present-day Chicago with Fort Howard at present-day Green Bay. In 1839, an additional territorial road opened, running west from Southport (now the City of Kenosha) to Waterford.

Many of the early settlements within the Des Plaines River watershed in Kenosha County occurred in the Township of Paris. The first European immigrants and settlers came from Prussia, Ireland, and Wales and from the States of New York and Connecticut. The European immigrants came across the Atlantic Ocean and down the newly constructed Erie Canal-Great Lakes route. In 1837, Seth Butler Meyrick founded the settlement of Paris, so named in honor of his native town in Oneida County, New York. In 1840, settlers from Connecticut founded the settlement of Kellogg's Corners and built the first Methodist church in Wisconsin.

Additional settlements within the watershed occurred in Bristol, Pleasant Prairie, Salem, and Union Grove. Bristol was first settled by William Higgin and Sereno Fowler in 1835. Horace Woodbridge and Jacob Miller were the first European settlers in Pleasant Prairie, where Jacob Miller kept a tavern on the U.S. Military Plank Road. In 1836, General John Bullen came to Salem and settled on what is locally known as "Bullen's Ridge." The settlement of Salem, which was formerly known as Brooklyn, was established in 1839.

Union Grove's first European settler was John E. Dunham, who arrived in the spring of 1838 and erected a barn and a log home on the Village's main street, south of the present-day Canadian Pacific Railway (former Chicago, Milwaukee, St. Paul & Pacific Railroad) right-of-way. The 1850 population of Union Grove was about 75 persons.

Until 1850, present-day Racine and Kenosha Counties were known and governed as one county, Racine. In January 1850, William S. Strong of Southport, then in old Racine County, led a petition drive to change the name of Southport to Kenosha. When the petition was honored, in 1850, Racine and Kenosha Counties were created.

Historical urban growth in the Des Plaines River watershed during the period from 1850 through 1995 is shown graphically on Map 6. The population of the entire watershed as of 1920 was approximately 8,000 people. As of 1950, the population was about 11,500 persons, an increase of 44 percent from the 1920 level. In 1990, the population was about 19,650 persons, an increase of 71 percent from the 1950 level. As the population continues to grow, more rural farm land is being converted to commercial centers and residential dwelling sites.

Buildings and sites of historical interest and archeological sites known to be located in the watershed are shown on Map 7 and listed in Table 5. Comprehensive planning within the watershed should pursue the protection and restoration of these historical sites and structures, thereby preserving their inherent cultural values.

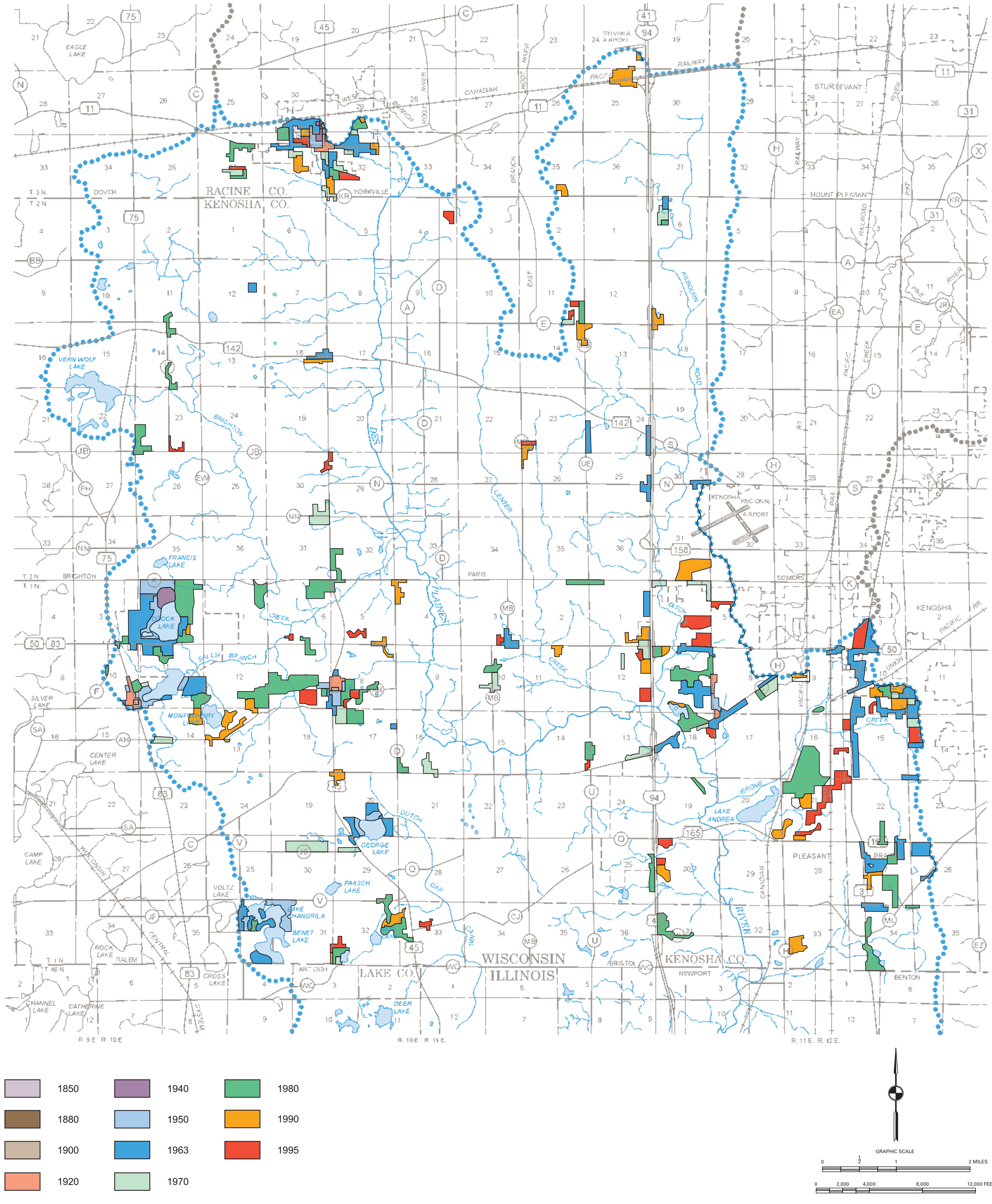
Existing Land Use
The existing land use pattern within the Des Plaines River watershed is shown on Map 8, and the existing land uses are quantified in Table 6.

As indicated in Table 6, about 119 square miles of the watershed, or about 88 percent of the total area of the watershed, was still in rural uses in 1990, with agriculture and related open uses occupying about 92 square miles, or about 68 percent of the total watershed area. In 1990, urban land uses occupied about 16 square miles, or about 12 percent of the total area of the watershed. Residential land use accounted for over seven square miles, or about 5.5 percent of the total watershed area. Also of significance is the transportation, communication, and utilities land use category, which accounted for over six square miles, or about 4.6 percent of the total watershed area.

Table 6 indicates that in 1963 about 20.2 square miles, or 15 percent of the watershed area, consisted of lakes, rivers, streams, wetlands, and woodlands. In 1990, the area falling within those land use categories was about the same as that in 1963, encompassing 19.8 square miles, or 14.7 percent of the watershed area. During the period from 1963 to 1990 the area in the watershed in agricultural and related uses declined from 100.5 square miles to 91.9 square miles and the area in urban land uses increased from 9.6 square miles to 15.9 square miles. The rate of

Map 6

HISTORICAL URBAN GROWTH IN THE DES PLAINES RIVER WATERSHED: 1850-1995

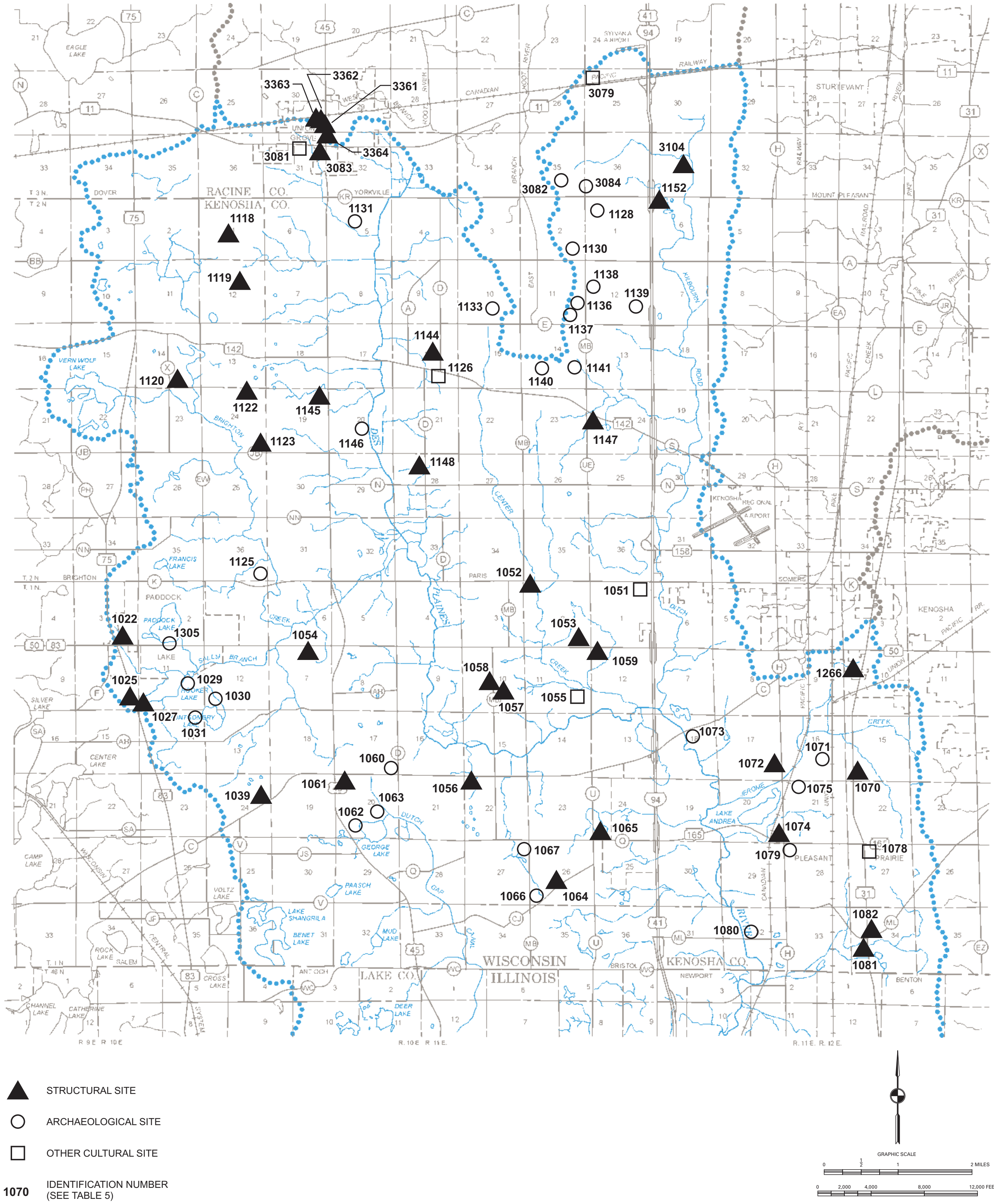


Prior to 1900, the only urban development in the watershed was located in the Village of Union Grove. As of 1920, urban development within the watershed had occurred at scattered sites including the Village of Union Grove; U.S. Public Land Survey Section 8 in the Town of Bristol; Sections 7, 8 and 17 in the Village of Pleasant Prairie, and west of Hooker Lake in the Town of Salem. By 1995, approximately 13 percent of the total watershed area was in urban use.

Source: SEWRPC.

Map 7

HISTORICAL AND ARCHEOLOGICAL SITES IN THE DES PLAINES RIVER WATERSHED: 2000



The protection and restoration of these historical and archeological sites must be given careful consideration in planning for development and redevelopment of the watershed.

Source: State Historical Society of Wisconsin and SEWRPC.

Table 5

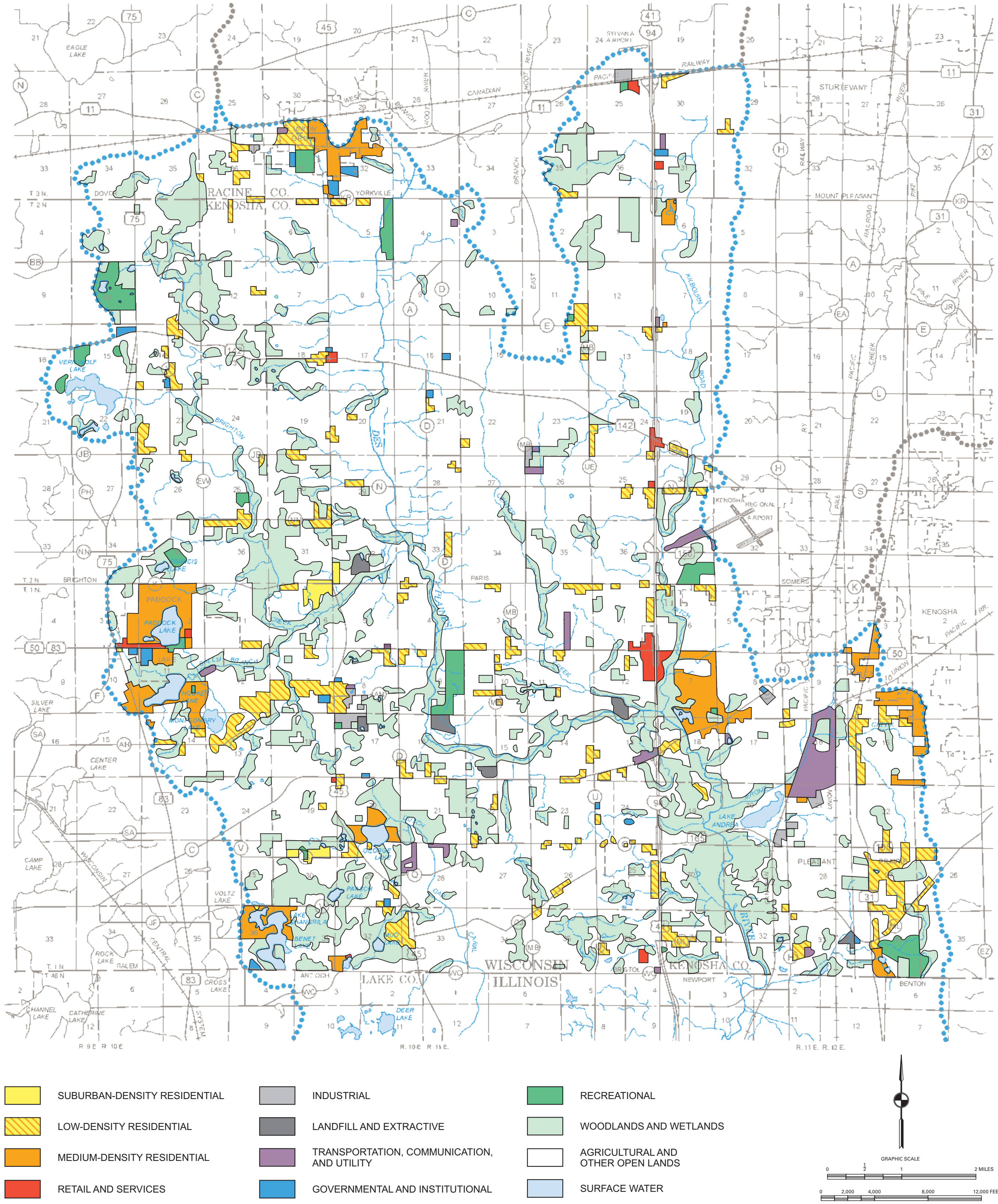
HISTORICAL AND ARCHEOLOGICAL SITES IN THE DES PLAINES RIVER WATERSHED: 2000

Site No.	Township (N)	Range (E)	Section	County	Village or Town	Site Name
1022	1	20	3	Kenosha	Paddock Lake	Frame Greek Revival House
1025	1	20	10	Kenosha	Salem	Frame House with Carved Ornament
1027	1	20	10	Kenosha	Salem	Bar and Insurance Office
1029	1	20	11	Kenosha	Salem	Campsite
1030	1	20	12	Kenosha	Salem	Cemetery
1031	1	20	14	Kenosha	Salem	Village Site
1039	1	20	24	Kenosha	Salem	Greek Revival House
1051	1	21	1	Kenosha	Bristol	Plank Road Site
1052	1	21	2	Kenosha	Bristol	Greek Revival Farmhouse
1053	1	21	2	Kenosha	Bristol	Charles Thompson House
1054	1	21	7	Kenosha	Bristol	Frame Greek Revival House
1055	1	21	11	Kenosha	Bristol	Benedict Prairie
1056	1	21	22	Kenosha	Bristol	Bristol Town Hall
1057	1	21	10	Kenosha	Bristol	New Tribe Mission
1058	1	21	10	Kenosha	Bristol	Italianate Frame House
1059	1	21	12	Kenosha	Bristol	Italianate Frame House
1060	1	21	17	Kenosha	Bristol	Campsite
1061	1	21	20	Kenosha	Bristol	Early Picturesque Farmhouse
1062	1	21	20	Kenosha	Bristol	Campsite
1063	1	21	20	Kenosha	Bristol	Campsite
1064	1	21	26	Kenosha	Bristol	Horton House
1065	1	21	24	Kenosha	Bristol	Wesley Chapel
1066	1	21	26	Kenosha	Bristol	Campsite
1067	1	21	27	Kenosha	Bristol	Campsite
1070	1	22	15	Kenosha	Pleasant Prairie	Congregational Church
1071	1	22	16	Kenosha	Pleasant Prairie	Campsite
1072	1	22	17	Kenosha	Pleasant Prairie	Italianate Frame Farmhouse
1073	1	22	18	Kenosha	Pleasant Prairie	Campsite
1074	1	22	20	Kenosha	Pleasant Prairie	Early Picturesque Farmhouse
1075	1	22	21	Kenosha	Pleasant Prairie	Campsite
1078	1	22	27	Kenosha	Pleasant Prairie	Janbeau Trail Marker
1079	1	22	28	Kenosha	Pleasant Prairie	Campsite
1080	1	22	32	Kenosha	Pleasant Prairie	Campsite
1081	1	22	34	Kenosha	Pleasant Prairie	Octagonal Barn
1082	1	22	34	Kenosha	Pleasant Prairie	Dexter Farmstead
1118	2	20	1	Kenosha	Brighton	Stone Barn
1119	2	20	12	Kenosha	Brighton	Round Barn
1120	2	20	14	Kenosha	Brighton	Large Greek Revival House
1122	2	20	24	Kenosha	Brighton	Fieldstone House
1123	2	20	24	Kenosha	Brighton	Red Brick Queen Anne Farmhouse
1125	2	20	36	Kenosha	Brighton	Campsite
1126	2	21	16	Kenosha	Paris	Civil War Soldiers’ Monument
1128	2	21	1	Kenosha	Paris	Campsite
1130	2	21	2	Kenosha	Paris	Campsite
1131	2	21	5	Kenosha	Paris	Mounds
1133	2	21	10	Kenosha	Paris	Campsite
1136	2	21	11	Kenosha	Paris	Village Worksite
1137	2	21	11	Kenosha	Paris	Campsite
1138	2	21	12	Kenosha	Paris	Campsite
1139	2	21	12	Kenosha	Paris	Campsite
1140	2	21	14	Kenosha	Paris	Campsite
1141	2	21	14	Kenosha	Paris	Campsite
1144	2	21	16	Kenosha	Paris	St. John’s Catholic Church
1145	2	21	19	Kenosha	Paris	Matthew Tom House
1146	2	21	20	Kenosha	Paris	Campsite
1147	2	21	24	Kenosha	Paris	Campsite
1148	2	21	28	Kenosha	Paris	Concrete Block Farmhouse
1152	2	22	6	Kenosha	Somers	Kellogg’s Corners School
1266	1	22	10	Kenosha	Pleasant Prairie	Brick House with Cobblestone Foundation
1305	1	20	2	Kenosha	Paddock Lake	Campsite–Old Settlers’ Park
3079	3	21	25	Racine	Yorkville	Sturtevant Mesic Prairie Remnant
3081	3	21	31	Racine	Union Grove	Old Settlers’ Society Marker
3082	3	21	35	Racine	Yorkville	Campsite
3083	3	21	31	Racine	Union Grove	Union Grove Drain and Tile Company
3084	3	21	36	Racine	Yorkville	Campsite
3104	3	22	31	Racine	Mt. Pleasant	Klinkert Barn
3361	3	21	30	Racine	Union Grove	Union Grove School
3362	3	21	30	Racine	Union Grove	Union Grove Congregational Church
3363	3	21	30	Racine	Union Grove	Thompson House
3364	3	21	31	Racine	Union Grove	Simple Stick Style House

Source: State Historical Society of Wisconsin.

Map 8

GENERALIZED EXISTING LAND USE IN THE DES PLAINES RIVER WATERSHED: 1990



Rural land uses within the Des Plaines River watershed occupy about 119 square miles, or about 88 percent of the total watershed area. Agriculture and related open uses occupy about 92 square miles, or about 68 percent of the total watershed area. Urban land uses occupy about 16 square miles, or about 12 percent of the total watershed area. Residential land use accounts for over seven square miles, or about 5.5 percent of the total watershed area. From 1963 to 1990, approximately 6.3 square miles, or about 5 percent of the watershed, was converted from rural to urban use, resulting in a rate of urbanization of about 0.2 square miles per year.

Source: SEWRPC.

Table 6

LAND USE IN THE DES PLAINES RIVER WATERSHED: 1963, 1970, 1975, 1980, 1985, AND 1990[a]

Land Use Category	1963			1970			1975		
	Area (square miles)	Percent of Watershed	Percent of Major Category	Area (square miles)	Percent of Watershed	Percent of Major Category	Area (square miles)	Percent of Watershed	Percent of Major Category
Urban									
Residential	4.2	3.1	43.8	5.1	3.8	45.5	6.2	4.6	48.1
Commercial	0.1	0.1	1.0	0.1	0.1	0.9	0.1	0.1	0.8
Industrial	0.1	0.1	1.0	0.1	0.1	0.9	0.2	0.1	1.6
Transportation, Communication and Utilities[b]	4.4	3.3	45.9	4.8	3.6	42.8	4.9	3.6	37.9
Governmental and Institutional	0.3	0.2	3.1	0.4	0.3	3.6	0.4	0.3	3.1
Recreational	0.3	0.2	3.1	0.5	0.4	4.5	0.8	0.6	6.2
Unused	0.2	0.1	2.1	0.2	0.1	1.8	0.3	0.2	2.3
Urban Subtotal	9.6	7.1	100.0	11.2	8.4	100.0	12.9	9.5	100.0
Rural									
Agricultural and Related Uses	100.5	74.7	80.5	98.4	73.1	79.8	96.9	72.1	79.7
Lakes, Rivers, and Streams	1.3	1.0	1.0	1.6	1.2	1.3	1.7	1.3	1.4
Wetlands	11.4	8.5	9.1	11.1	8.3	9.0	10.9	8.1	9.0
Woodlands	7.5	5.6	6.0	7.3	5.4	5.9	7.2	5.4	5.9
Landfills, Dumps, and Extractive and Other Open Uses	4.2	3.1	3.4	4.9	3.6	4.0	4.9	3.6	4.0
Rural Subtotal	124.9	92.9	100.0	123.3	91.6	100.0	121.6	90.5	100.0
Total	134.5	100.0	- -	134.5	100.0	- -	134.5	100.0	- -

Land Use Category	1980			1985			1990		
	Area (square miles)	Percent of Watershed	Percent of Major Category	Area (square miles)	Percent of Watershed	Percent of Major Category	Area (square miles)	Percent of Watershed	Percent of Major Category
Urban									
Residential	7.0	5.2	49.3	7.1	5.3	47.7	7.3	5.5	45.9
Commercial	0.2	0.1	1.4	0.2	0.1	1.3	0.3	0.2	1.9
Industrial	0.2	0.1	1.4	0.3	0.2	2.0	0.4	0.3	2.5
Transportation, Communication, and Utilities[b]	5.4	4.0	38.1	5.6	4.2	37.6	6.1	4.6	38.4
Governmental and Institutional	0.4	0.3	2.8	0.4	0.3	2.7	0.4	0.3	2.5
Recreational	0.8	0.6	5.6	1.1	0.8	7.4	1.2	0.9	7.5
Unused	0.2	0.1	1.4	0.2	0.1	1.3	0.2	0.1	1.3
Urban Subtotal	14.2	10.4	100.0	14.9	11.0	100.0	15.9	11.8	100.0
Rural									
Agricultural and Related Uses	95.7	71.2	79.5	95.0	70.7	79.5	91.9	68.3	77.5
Lakes, Rivers, and Streams	1.7	1.3	1.4	1.7	1.3	1.4	1.9	1.4	1.6
Wetlands	10.7	8.0	8.9	10.4	7.7	8.7	10.5	7.8	8.9
Woodlands	7.2	5.4	6.0	7.3	5.4	6.1	7.4	5.5	6.2
Landfills, Dumps, and Extractive and Other Open Uses	5.0	3.7	4.2	5.2	3.9	4.3	6.9	5.1	5.8
Rural Subtotal	120.3	89.6	100.0	119.6	89.0	100.0	118.6	88.2	100.0
Total	134.5	100.0	- -	134.5	100.0	- -	134.5	100.0	- -

[a]*As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b]*Includes all off-street parking.*

Source: SEWRPC.

urbanization during that period was about 0.2 square mile per year. The widespread conversion of land from natural, open space uses to primarily agricultural uses occurred prior to 1963 and the increase in urban lands since 1963 has been primarily the result of the development of agricultural land.

Public and Private Utility Base

Sanitary Sewer Service

As shown on Map 9, in 2000, approximately 11 square miles, or about 8 percent of the total area of the watershed, were provided with public sanitary sewer service. In 2000, there were four public sewage treatment plants located in the Des Plaines River watershed, as shown on Map 9. The two plants which serve the Village of Pleasant Prairie Sanitary District No. 73-1 and the Village of Pleasant Prairie Sewer Utility District D discharged treated effluent to the main stem of the Des Plaines River via small tributaries. The service area of the Town of Bristol Utility District No. 3 was connected to the Pleasant Prairie District D treatment plant. The plant which served the Village of Paddock Lake discharged to Brighton Creek and the plant which formerly served the Town of Salem Utility District No. 1 and which discharged to the Salem Branch of Brighton Creek, was abandoned in 1993 and its service area connected to the Town of Salem Utility District No. 2 sewerage system. The Town of Bristol Utility District No. 4 was also connected to the Town of Salem Utility District No. 2 treatment plant, which was located outside of the watershed. Selected characteristics of the public sewage treatment plants in the Des Plaines River watershed are shown on Table 7.

About 4.4 square miles of the watershed were served by the City of Kenosha sewage treatment plant, located outside the watershed. In addition, a small portion of the watershed was provided with public sewer service by the Village of Union Grove sewerage system, which system also discharged to a sewage treatment plant located outside of the watershed.

In addition to the publicly owned sewage treatment facilities, four private sewage treatment plants were in existence in 2000 in the Des Plaines River watershed. These plants served the following land uses: in Racine County, Hickory Haven Mobile Home Park and, in Kenosha County, Brightondale County Park, Kenosha Beef International, and Rainbow Lake Manor Mobile Home Park.

Water Supply Service

The Des Plaines River watershed is served by five public water supply systems. The service areas of these systems, owned and operated by the City of Kenosha Water Utility, Town of Bristol Water Utilities, Village of Paddock Lake Water Utility, Village of Pleasant Prairie Water Utility, and Village of Union Grove Water Utility, and of the nine privately operated systems, the Bristol Heights Mobile Home Park, Hickory Haven Mobile Home Park, Oakdale Estates Mobile Home Park, Pleasant Prairie Mobile Home Park, Prairie Apartments, Rainbow Lake Manor Mobile Home Park, Shady Nook Mobile Home Park, Glenn Water Systems, and St. Benedict's Abbey water systems, are shown on Map 10. The five public water supply systems operate independent water supply systems. The Kenosha Water Utility provides retail service to both the portion of the City within the watershed and to portions of the Village of Pleasant Prairie. The five public utilities together supply approximately 8,500 persons, or about 43 percent of the total residential population of the watershed. The populations and service areas of each of the five public water supply systems are shown in Table 8. About 50 percent of the population served by public water supplies is supplied with groundwater, while Lake Michigan water provided through the City of Kenosha Water Utility system serves the remaining approximate 50 percent. The privately owned systems utilize shallow dolomite aquifers as the source of supply. The private systems serve approximately 1,400 persons, or 7 percent of the total residential population of the watershed.

Electric Power Service and Gas Service

Electric power is available to all portions of the watershed. It is supplied by the Wisconsin Electric Power Company, which is authorized to provide service throughout the watershed. Natural gas service is also available to all portions of the watershed. The Wisconsin Natural Gas Company is authorized to provide service throughout the watershed.

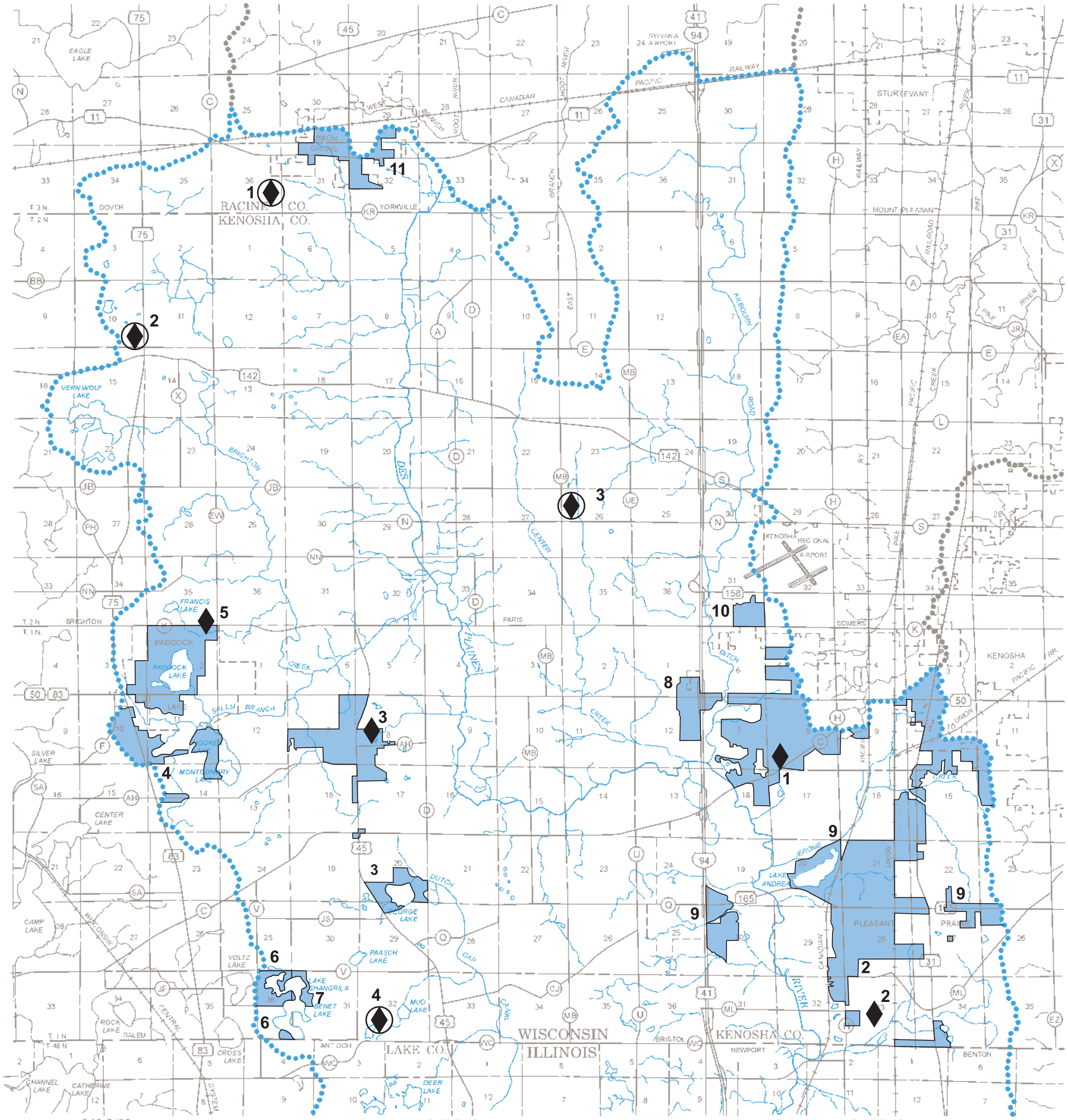
Transportation

Highways

As shown on Map 11, the Des Plaines River watershed is served by an extensive street and highway system. As of 1990, there were 178.5 miles of streets and highways within the watershed. Of this overall total, 119.7 miles, or

Map 9

EXISTING SANITARY SEWERAGE FACILITIES AND SEWER SERVICE AREAS FOR THE DES PLAINES RIVER WATERSHED: 2000



EXISTING PUBLIC SANITARY SEWER SERVICE AREA

EXISTING PUBLIC SEWAGE TREATMENT PLANT

1 VILLAGE OF PLEASANT PRAIRIE SEWER UTILITY DISTRICT D
2 VILLAGE OF PLEASANT PRAIRIE SANITARY DISTRICT NO. 73-1
3 TOWN OF BRISTOL UTILITY DISTRICT NO. 1
4 TOWN OF SALEM UTILITY DISTRICT NO. 1
5 VILLAGE OF PADDOCK LAKE
6 TOWN OF SALEM UTILITY DISTRICT NO. 2
7 TOWN OF BRISTOL UTILITY DISTRICT NO. 4
8 TOWN OF BRISTOL UTILITY DISTRICT NO. 3
9 VILLAGE OF PLEASANT PRAIRIE TO KENOSHA
10 CITY OF KENOSHA
11 VILLAGE OF UNION GROVE

EXISTING PRIVATE SEWAGE TREATMENT PLANT

1 HICKORY HAVEN MOBILE HOME PARK
2 BRIGHTONDALE COUNTY PARK
3 KENOSHA BEEF INTERNATIONAL
4 RAINBOW LAKE MANOR MOBILE HOME PARK

GRAPHIC SCALE
0 ½ 1 2 MILES
0 2,000 4,000 8,000 12,000 FEET

NOTE: THE TOWN OF BRISTOL UTILITY DISTRICT NO. 5 DOES NOT OPERATE ANY CONVEYANCE OR TREATMENT FACILITIES. THUS, NO SEWER SERVICE AREA FOR THAT DISTRICT IS SHOWN ON THIS MAP.

Public sewage treatment facilities serve a total of about 11 square miles within the watershed, or about 8 percent of the total area of the watershed.

Source: SEWRPC.

Table 7

SELECTED CHARACTERISTICS OF EXISTING PUBLIC SEWAGE TREATMENT PLANTS IN THE DES PLAINES RIVER WATERSHED: 1990

Name of Public Sewage Treatment Plant	1990 Estimated Total Area Served (square miles)	1990 Estimated Total Population Served[a]	Date(s) of Construction and Any Major Modification	Sewage Treatment Unit Processes[b]	Name of Receiving Water to Which Effluent Is Disposed	Wisconsin Pollutant Discharge Elimination System Permit Expiration Date
Town of Bristol Utility District No. 1	0.8	1,200	1965, 1971, 1988	Contact stabilization activated sludge, clarification, chlorination	Des Plaines River via Bristol Creek tributary	9/30/05
Village of Paddock Lake	0.8	2,300	1958, 1967, 1988	Oxidation ditch, clarification, microscreen, chlorination, dechlorination, ultraviolet disinfection	Brighton Creek	12/31/05
Village of Pleasant Prairie Sanitary District No. 73-1	0.1	600	1975	Contact stabilization activated sludge, clarification, chemical phosphorus removal, sand filtration, chlorination	Des Plaines River via unnamed tributary	3/31/05
Village of Pleasant Prairie Sewer Utility District D	1.2	1,700	1966, 1985	Oxidation ditch clarification, chlorination, post aeration	Des Plaines River via Pleasant Prairie tributary	6/30/03

Name of Public Sewage Treatment Plant	Hydraulic Loading[c] (mgd)			BOD_5 Loading[c] (pounds per day)			Suspended Solids Loading[c] (pounds per day)		
	Existing			Existing			Existing		
	Average Annual	Maximum Monthly Average	Design Annual Average	Average Annual	Maximum Monthly Average	Design Average Annual	Average Annual	Maximum Monthly Average	Design Average Annual
Town of Bristol Utility District No. 1	0.34	0.49	0.48	366	501	860	450	615	729
Village of Paddock Lake	0.47	0.71	0.49	574	814	570	701	1,148	513
Village of Pleasant Prairie Sanitary District No. 73-1	0.21	0.26	0.40	145	192	800	167	317	- -
Village of Pleasant Prairie Sewer Utility District D	0.50	0.75	0.50	407	499	602	814	1,424	- -

[a]*In addition to the population served by the four sewage-treatment plants in the Des Plaines River watershed, sewerage services are provided to residents in the watershed by the Kenosha Water Utility, the Town of Salem Utility District No. 2, and the Village of Union Grove sewerage system.*

[b]*In addition, plants typically include headworks and miscellaneous processes such as pumping, flow metering and sampling, and screening and grit removal, as well as sludge handling and disposal facilities.*

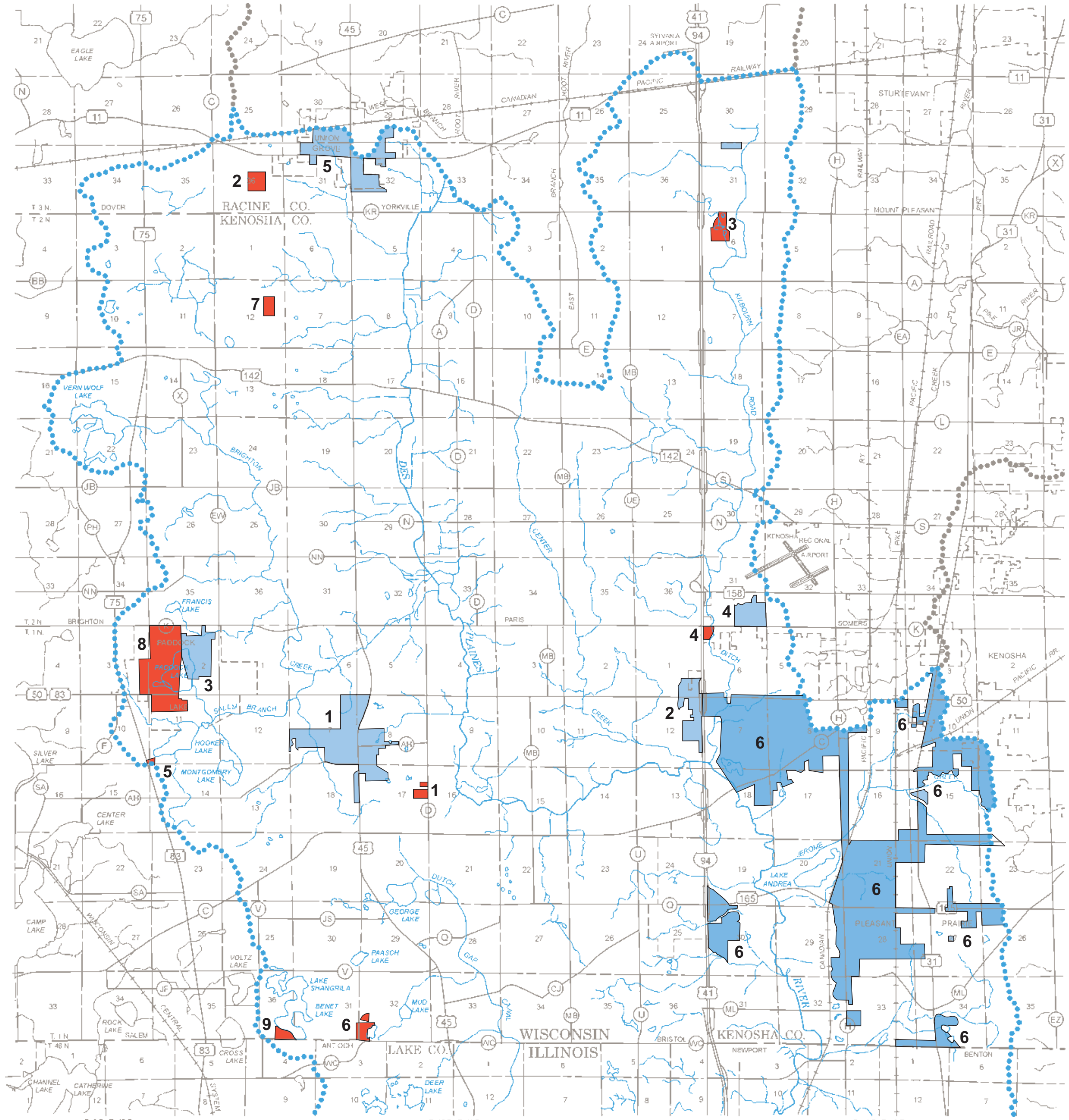
[c]*Loadings data were obtained from the 1990 Wisconsin Department of Natural Resources summary report of discharge monitoring data unless noted.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

67 percent, were classified as arterial streets and highways; of these, 14.0 miles, or 8 percent, were freeways. Average weekday traffic volumes of the overall total were from 57,000 to 60,000 vehicles on IH 94; 2,600 to 6,600 vehicles on USH 45; 5,600 to 11,800 vehicles on STH 11; 7,600 to 22,600 vehicles on STH 31; 14,200 to 31,700 vehicles on STH 50; 2,400 to 3,700 vehicles on STH 75; about 7,200 vehicles on STH 83; 2,500 to 3,200 vehicles on STH 142; about 10,100 vehicles on STH 158; and 1,500 to 5,200 vehicles on STH 165. The extensive street and highway system serves to provide ease of access to lands in residential, commercial, and agricultural uses in the watershed, thus supporting those uses.

Map 10

WATER UTILITIES IN THE DES PLAINES RIVER WATERSHED: 1994



AREAS SERVED BY PUBLIC WATER UTILITIES

1 BRISTOL UTILITY DISTRICT NO. 1
2 BRISTOL UTILITY DISTRICT NO. 3
3 VILLAGE OF PADDOCK LAKE
4 CITY OF KENOSHA WATER UTILITY
5 VILLAGE OF UNION GROVE

6 VILLAGE OF PLEASANT PRAIRIE FROM KENOSHA WATER UTILITY

AREAS SERVED BY PRIVATE WATER UTILITIES

1 BRISTOL HEIGHTS MOBILE HOME PARK
2 HICKORY HAVEN MOBILE HOME PARK
3 OAKDALE ESTATES MOBILE HOME PARK
4 PLEASANT PRAIRIE MOBILE HOME PARK
5 PRAIRIE APARTMENTS
6 RAINBOW LAKE MANOR MOBILE HOME PARK
7 SHADY NOOK MOBILE HOME PARK

8 TWENTY-FIVE SMALL COMMUNITY WELLS OPERATED BY GLENN WATER SYSTEMS OR SMALL GROUPS OF PROPERTY OWNERS (GENERAL AREA SERVED BY PRIVATE UTILITY IS INDICATED. SOME INDIVIDUAL PRIVATE WELLS ARE LOCATED IN THE GENERAL SERVICE AREA.)
9 ST. BENEDICTS ABBEY

GRAPHIC SCALE
0 ½ 1 2 MILES
0 2,000 4,000 8,000 12,000 FEET

Five public water utilities, eight private water utilities, and 25 community wells serve the urban areas of the Des Plaines River watershed.

Source: SEWRPC.

Table 8

SERVICE AREA AND POPULATION FOR PUBLIC WATER SUPPLY SYSTEMS IN THE DES PLAINES RIVER WATERSHED: 1994

Name of Public Water-Supply System	Estimated Area Served (square miles)	Estimated Population Served[a]
City of Kenosha Water Utility	0.79	1,100
Village of Paddock Lake	0.24	1,000
Village of Pleasant Prairie Water Utility	4.94	3,200
Village of Union Grove	0.70	2,300
Town of Bristol Utility Districts Nos. 1 and 3	0.60	900
Total	7.27	8,500

[a]*Based on 1990 population data.*

Source: SEWRPC.

Bus Service

The transportation needs of the resident population of the watershed are largely determined by the distribution of residential development in relation to centers of employment, shopping, and other activities in the greater watershed area. These transportation needs, together with the configuration of the watershed street and highway system, have resulted in the development of two types of bus service within the watershed: urban mass transit and intercity bus service (see Map 12). Urban mass transit service within the watershed is provided by the City of Kenosha Transit Commission, which furnishes service in the extreme southeastern portion of the watershed. Express transit service is provided by Wisconsin Coach Lines, Inc., between the Milwaukee central business district and the City of Kenosha via STH 32. Express bus service reduces the need for commuting residents of the watershed to drive private automobiles into the central areas of Milwaukee County.

Intercity bus service is provided through the watershed by Greyhound Lines, Inc., which operates a route connecting the central business district of Milwaukee with Chicago.

Railway Service

There is scheduled Amtrak passenger rail service over the Canadian Pacific Railway (former Chicago, Milwaukee, St. Paul & Pacific Railroad) trackage between the Amtrak passenger stations in Milwaukee and Sturtevant to the north and Chicago to the south. The main Amtrak passenger station, which is located north of the watershed in Milwaukee, is the only major rail passenger terminal within the Region. Amtrak trains do not make any stops within the watershed, but the Sturtevant station is located about one mile east of the northeastern boundary of the watershed.

Railway freight service is provided to the watershed by both the Union Pacific Railroad and the Canadian Pacific Railway. As shown on Map 12, the rights-of-way of both of these carriers traverse the watershed in a north-south orientation. The Canadian Pacific Railway also operates a spur line partly located in the northern portion of the watershed. This spur line provides limited service to the Village of Union Grove and the unincorporated area of Kansasville in the Town of Dover.

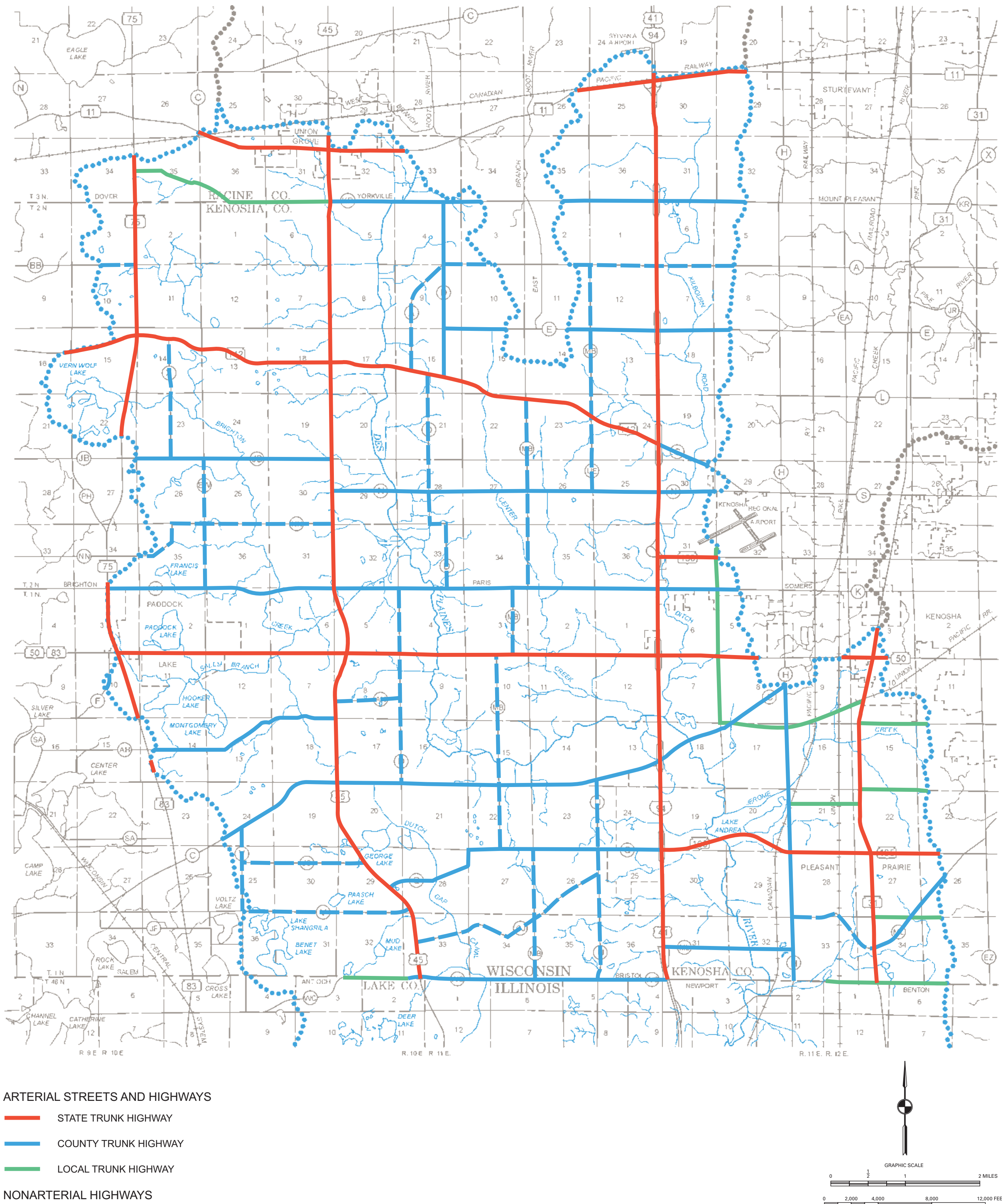
Airport Service

A portion of Kenosha Regional Airport lies within the extreme eastern portion of the Des Plaines River watershed. As of 1994, this airport was one of 11 airports constituting the regional airport system[3] and was classified as a Transport-Corporate airport, which means it is capable of accommodating virtually all general aviation aircraft, including small single-engine piston aircraft, twin-engine piston and turboprop aircraft, and corporate and business jets. Because it is a part of the regional airport system, Kenosha Regional Airport has been designated by the Federal Aviation Administration as a reliever facility to Milwaukee County's General Mitchell International Airport. Currently, the Kenosha airport handles approximately 350 freight, maintenance, and corporate jet operations on an average daily basis. About 200 acres, or 21 percent of the 950-acre airport site, actually lie within the watershed.

[3]*SEWRPC Planning Report No. 38,* A Regional Airport System Plan for Southeastern Wisconsin: 2010*, May 1987.*

Map 11

ARTERIAL STREETS AND HIGHWAYS IN THE DES PLAINES RIVER WATERSHED: 2000



ARTERIAL STREETS AND HIGHWAYS

STATE TRUNK HIGHWAY

COUNTY TRUNK HIGHWAY

LOCAL TRUNK HIGHWAY

NONARTERIAL HIGHWAYS

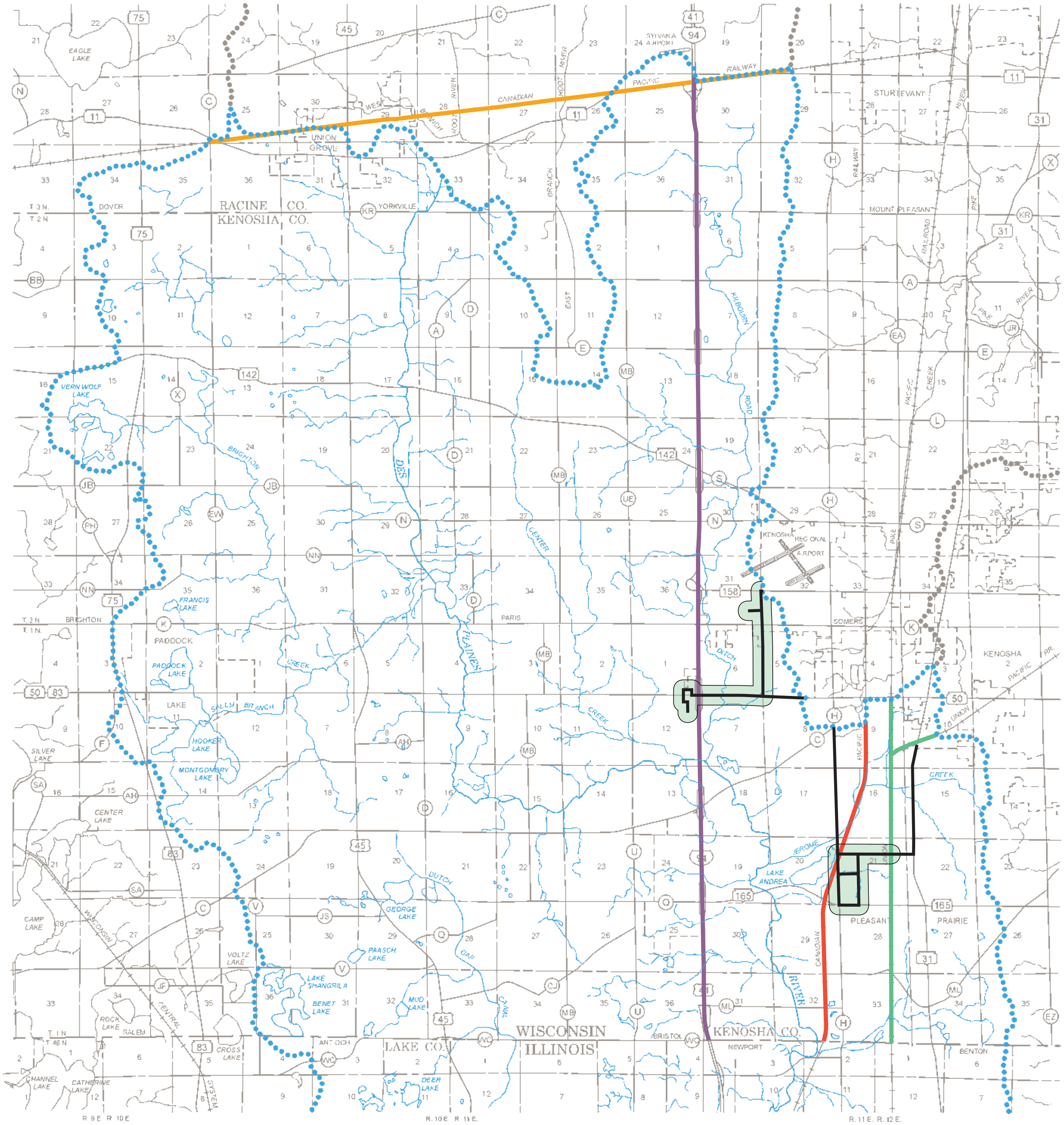
COUNTY TRUNK HIGHWAY

The Des Plaines River watershed is served by an extensive street and highway system.

Source: SEWRPC.

Map 12

RAILROADS AND PUBLIC TRANSIT ROUTES IN THE DES PLAINES RIVER WATERSHED: 2000



LOCAL BUS SERVICE

- STREET WITH LOCAL BUS ROUTE
- LOCAL TRANSIT SERVICE AREA

INTERCITY BUS SERVICE

- GREYHOUND AND UNITED LIMO

RAILROAD LINES

- CANADIAN PACIFIC RAILWAY FREIGHT AND AMTRAK PASSENGER
- CANADIAN PACIFIC RAILWAY FREIGHT
- UNION PACIFIC RAILROAD FREIGHT

GRAPHIC SCALE

0 ½ 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

The Des Plaines River watershed is served by passenger and freight railways. The southeastern portion of the watershed has public bus service, and intercity bus service traverses the watershed from north to south.

Source: SEWRPC.

DESCRIPTION OF THE WATERSHED: NATURAL RESOURCE BASE

The natural resource base is an important determinant of the development potential of a watershed and of its ability to provide a pleasant and habitable environment for all forms of life. The principal elements of the natural resource base which require consideration in watershed planning are climate, physiography, geology, soils, vegetation, water resources, and fish and wildlife resources. Without a proper understanding and recognition of the elements comprising the natural resource base and their interrelationships, human use and alteration of the natural environment proceed at the risk of excessive costs in terms of both monetary expenditures and destruction of nonrenewable or slowly renewable resources. Given the location of the watershed in a rapidly urbanizing region, it is especially important that the natural resource base be a significant consideration in the watershed planning effort, since the areawide diffusion of urban land uses makes the underlying and sustaining resource base highly vulnerable to misuse and destruction.

Accordingly, the spatial distribution, extent, and quality of the natural resources of the watershed pertinent to the planning effort are described in this report. While all the pertinent components of the natural resource base are described in this chapter, some are considered in more detail in later chapters of this report. For example, this chapter provides an overview of the surface-water resources of the watershed, while the findings of detailed hydrologic and hydraulic inventories are described in Chapter V; the findings of an inventory of flood hazards and flood damages are described in Chapter VI; and the findings of a survey of water quality are described in Chapter VII.

Climate

General Climatic Conditions

The midcontinental location of the Southeastern Wisconsin Region, far removed from the moderating effect of the oceans, gives the Region and the watershed a typical continental climate, characterized primarily by a continuous progression of markedly different seasons and a large range in annual temperature. Low temperatures during winter are intensified by prevailing frigid northwesterly winds, while summer high temperatures are reinforced by the warm southwesterly winds common during that season.

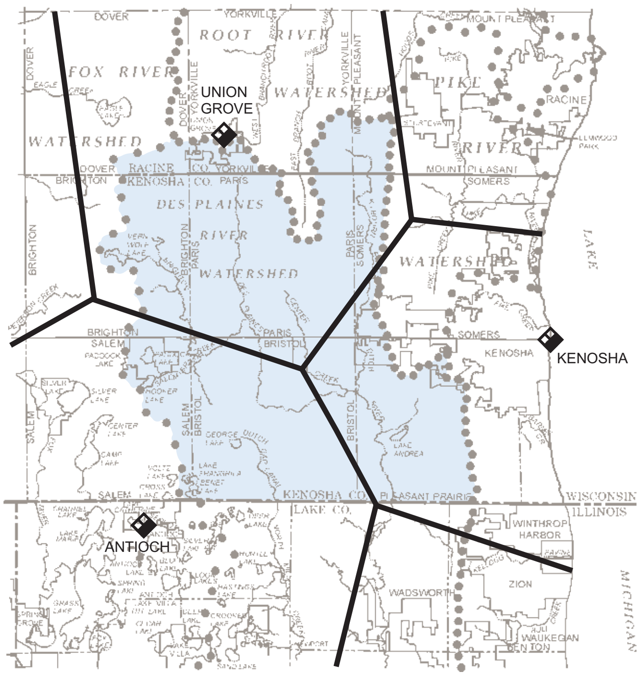
The Region and the watershed are positioned astride cyclonic storm tracks along which low-pressure centers move from the west and southwest. The Region and the watershed also lie in the path of high-pressure centers moving in a generally southeasterly direction. This location at the confluence of major migratory air masses results in the watershed as a whole being influenced by a continuously changing pattern of different air masses, which results in frequent weather changes being superimposed on the large annual range in weather characteristics, particularly in winter and spring, when distinct weather changes normally occur every three to five days. These temporal weather changes consist of marked variations in temperature, type and amount of precipitation, relative humidity, wind speed and direction, and cloud cover.

In addition to these distinct temporal variations in weather, the watershed, in spite of its relatively small size, exhibits spatial variations in weather due primarily to its proximity to Lake Michigan, particularly during the spring, summer, and autumn seasons, when the temperature differential between the Lake water and the land air masses tends to be the greatest. During these periods, the presence of the Lake tends to moderate the climate of the eastern border of the seven-county Southeastern Wisconsin Planning Region in general, and the extreme southeastern portion of the Des Plaines River watershed in particular.

Map 13 and Table 9 show the location of three meteorological stations located near the Des Plaines River watershed, as well as the availability of temperature and other meteorological data. As shown on the map, the stations were used to construct a Thiessen polygon network, which was used to associate land areas with specific meteorological data. Accordingly, the records of these stations were used to characterize the climatological and meteorological conditions in the watershed. Additional pertinent information collected at these stations is presented in Chapter VIII of this report.

Map 13

METEOROLOGICAL STATIONS OF THE NATIONAL WEATHER SERVICE NEAR THE DES PLAINES RIVER WATERSHED: 1994



THIESSEN POLYGON NETWORK USING ALL PRECIPITATION STATIONS

STATIONS REPORTING DAILY PRECIPITATION AND DAILY TEMPERATURES

NOTE: THE ANTIOCH STATION WAS DISCONTINUED ON OCTOBER 31, 1992. THE STATION WAS THEN REACTIVATED ON NOVEMBER 1, 1993.

GRAPHIC SCALE 0 1 2 3 4 5 6 MILES 0 10,000 20,000 30,000 40,000 FEET

The Thiessen polygon network constructed for the National Weather Service observation stations shown above was used to associate land areas with specific meteorological data in the watershed study. This was a necessary requirement for characterizing the meteorologic conditions in the Des Plaines River watershed and for operating the water resources simulation model used to calculate streamflow and stream water quality.

Source: National Weather Service and SEWRPC.

Temperature

Watershed temperatures, which exhibit a large annual range, are relevant to watershed planning. Seasonal temperatures determine the kinds and intensities of the recreational uses to which surface waters and adjacent riverine lands may be put and, consequently, the periods over which the highest levels of water quality should be maintained. More importantly, aerobic and anaerobic biochemical processes fundamental to the self-purification of streams are temperature-dependent, since reaction rates approximately double with each rise of 20 degrees Fahrenheit (°F) in temperature within the temperature range normally encountered in nature. The supply of oxygen available for such processes is a function of oxygen solubility in water or the maximum concentration of oxygen that can be retained in solution, which is also highly dependent on temperature. For example, a stream at or near freezing temperatures can hold about 15 milligrams per liter (mg/l) of dissolved oxygen, but the capacity is reduced by almost one-half at 80°F. The summer period is therefore critical and limiting in both natural and artificially induced aerobic processes, since oxygen demands are at their annual maximum because of accelerated reaction rates while the oxygen supply is at its annual minimum because of solubility limitations associated with high temperatures.

Data for the air temperature observation stations near the Des Plaines River watershed, Antioch, Kenosha, and Union Grove, are presented in Table 10. Monthly temperature data are presented in Figure 7. The air temperature and precipitation data used to develop the related tables and figures presented in this and subsequent sections of this chapter are for various periods of record ranging from 30 years to 122 years. Coincident periods of record were not used because of the widely varying periods of historical record available. Although noncoincident periods of record were used, the monthly and annual summary data presented in this chapter are judged to be sufficiently reliable to portray the watershed temperature and precipitation characteristics. The temperature data illustrate how watershed air temperatures lag approximately one month behind summer and winter solstices during the annual cycle, with the result that July is the warmest month in the watershed and January the coldest. Summer air temperatures throughout the watershed, as reflected by monthly means at the Antioch, Kenosha, and Union Grove stations for July and August, range from 69.7°F to 73.3°F. Average daily maximum temperatures within the watershed for these two months range from 79.0°F to 82.7°F, whereas average daily minimum temperatures vary from 58.5°F to 61.3°F. With respect to minimum daily temperatures, the meteorological station network is not sufficiently dense to reflect the effects of topography. During nighttime hours, cold air, because of its greater density, flows into low-lying areas. Because of this phenomenon, the average daily minimum temperatures in these topographically low areas will be lower than those recorded by the meteorological stations, particularly during the summer months.

Table 9

NATIONAL WEATHER SERVICE METEOROLOGICAL STATIONS NEAR THE DES PLAINES RIVER WATERSHED

Station Identification		Location			Year Operation Began	Data Recorded
Name	National Weather Service Number	County and State	Civil Division	Current Location		
Antioch	0203	Lake, Ill.	Antioch	Antioch[a]	1901	Daily Precipitation, Daily Temperature
Kenosha	4174	Kenosha, Wis.	Kenosha	Sewage Treatment Plant	1945	Daily Precipitation, Daily Temperature
Union Grove	8723	Racine, Wis.	Union Grove	Sewage Treatment Plant	1945	Daily Precipitation, Daily Temperature

[a]*Station closed October 31, 1992.*

Source: National Weather Service and SEWRPC.

Table 10

AIR TEMPERATURE CHARACTERISTICS AT SELECTED LOCATIONS NEAR THE DES PLAINES RIVER WATERSHED

	Observation Station Location									Watershed Summary		
	Antioch (1942-1992)[a]			Kenosha (1948-1993)			Union Grove (1964-1993)					
Month	Average Daily Maximum[b,c]	Average Daily Minimum[b,c]	Mean[d]	Average Daily Maximum[b]	Average Daily Minimum[b]	Mean[d]	Average Daily Maximum[b]	Average Daily Minimum[b]	Mean[d]	Average Daily Maximum[b]	Average Daily Minimum[b]	Mean[d]
January	28.4	10.9	20.7	30.5	14.4	22.5	28.1	10.9	19.5	29.0	12.0	20.9
February	33.0	14.7	24.4	33.5	18.0	25.7	32.5	14.6	23.5	33.0	15.7	24.6
March	43.0	24.7	34.9	41.1	26.0	33.6	42.3	25.4	33.8	42.2	25.4	34.1
April	57.4	36.0	47.7	52.3	36.0	44.7	56.7	35.1	45.8	55.4	35.7	46.1
May	69.3	45.6	58.4	64.0	44.9	54.5	68.4	44.7	56.6	67.2	45.1	56.5
June	78.7	55.2	68.4	74.5	54.8	64.6	78.0	54.0	66.0	77.1	54.6	66.3
July	82.7	60.4	73.3	79.5	61.3	70.4	82.6	60.3	71.5	81.6	60.7	71.7
August	81.0	59.2	71.8	79.0	61.2	70.1	80.9	58.5	69.7	80.3	59.6	70.5
September	73.5	51.8	64.0	71.6	53.2	62.4	73.8	50.5	62.1	73.0	51.8	62.8
October	62.0	40.8	52.9	59.9	42.9	52.3	61.8	39.6	50.7	61.2	41.1	52.0
November	45.7	28.7	38.1	46.4	30.6	38.5	46.5	28.7	37.6	46.2	29.3	38.1
December	32.5	17.0	24.6	34.2	19.0	26.6	33.2	17.1	25.1	33.3	17.7	25.4
Year	57.3	37.1	48.3	55.6	38.5	47.2	57.1	36.6	46.9	56.7	37.4	47.5

[a]*Station closed October 31, 1992.*

[b]*The monthly average daily maximum temperature and the monthly average daily minimum temperature are obtained by using daily measurements to compile an average for each month.*

[c]*Average daily maximum temperatures and average daily minimum temperatures are for the period of 1951-1992.*

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

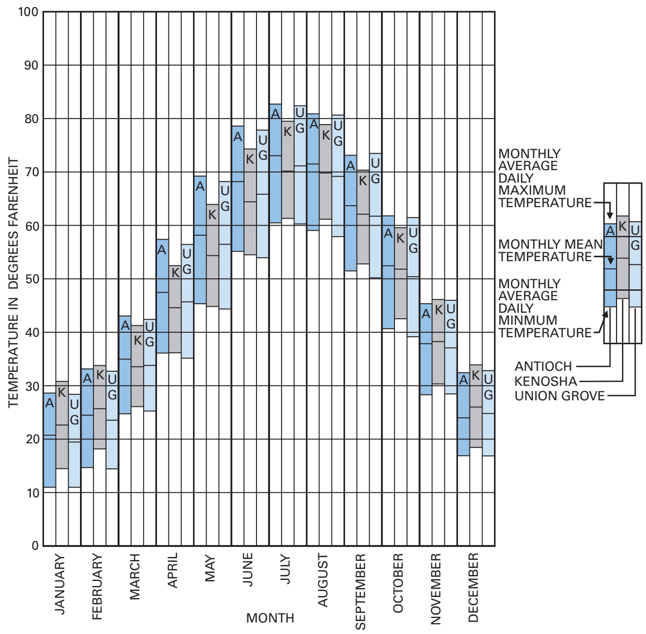
Source: National Climatic Data Center and SEWRPC.

Winter temperatures for the watershed, as measured by monthly means for January and February, range from 19.5°F to 25.7°F. Average daily maximum temperatures within the watershed for these two months vary from 28.1°F to 33.5°F, whereas average daily minimum temperatures range from 10.9°F to 18.0°F.

Extreme high and low temperatures for the watershed, based on 40 years of data recorded at Milwaukee General Mitchell International Airport, located near the watershed, range from a high of 105°F to a low of -26°F. The growing season, which is defined as the number of days between the last 32°F frost in spring and the first freeze in autumn, normally begins in late April and ends in late October.

Figure 7

AIR TEMPERATURE CHARACTERISTICS AT SELECTED LOCATIONS NEAR THE DES PLAINES RIVER WATERSHED



Source: National Climatic Data Center, Wisconsin Statistical Reporting Service, and SEWRPC.

Precipitation

Precipitation within the watershed takes the form of rain, sleet, hail, and snow, ranging from gentle showers of trace quantities to destructive thunderstorms and major rainfall-snowmelt events, which may cause property damage, the inundation of poorly drained areas, and stream flooding. Rainfall events may cause sanitary sewerage systems to surcharge and back up into basements and overflow into surface watercourses. Surcharging of sanitary sewerage systems is caused by the entry of excessive quantities of rain, snowmelt, and groundwater into sanitary sewers via manholes, building sewers, building downspouts, and foundation drain connections and by infiltration through faulty sewer pipe joints, manhole structures, and cracked pipes.

Total precipitation data for the Antioch; Kenosha; and Union Grove observation stations are presented in Table 11. Monthly total precipitation observations are presented graphically in Figure 8. The table and figure illustrate the type of precipitation and the amount that normally occurs near the watershed.

The average annual total precipitation in the watershed and immediate surroundings, based on data from the three stations, is 32.61 inches, expressed as water equivalent, while the average annual snow and sleet measured as snow and sleet is 41.08 inches.

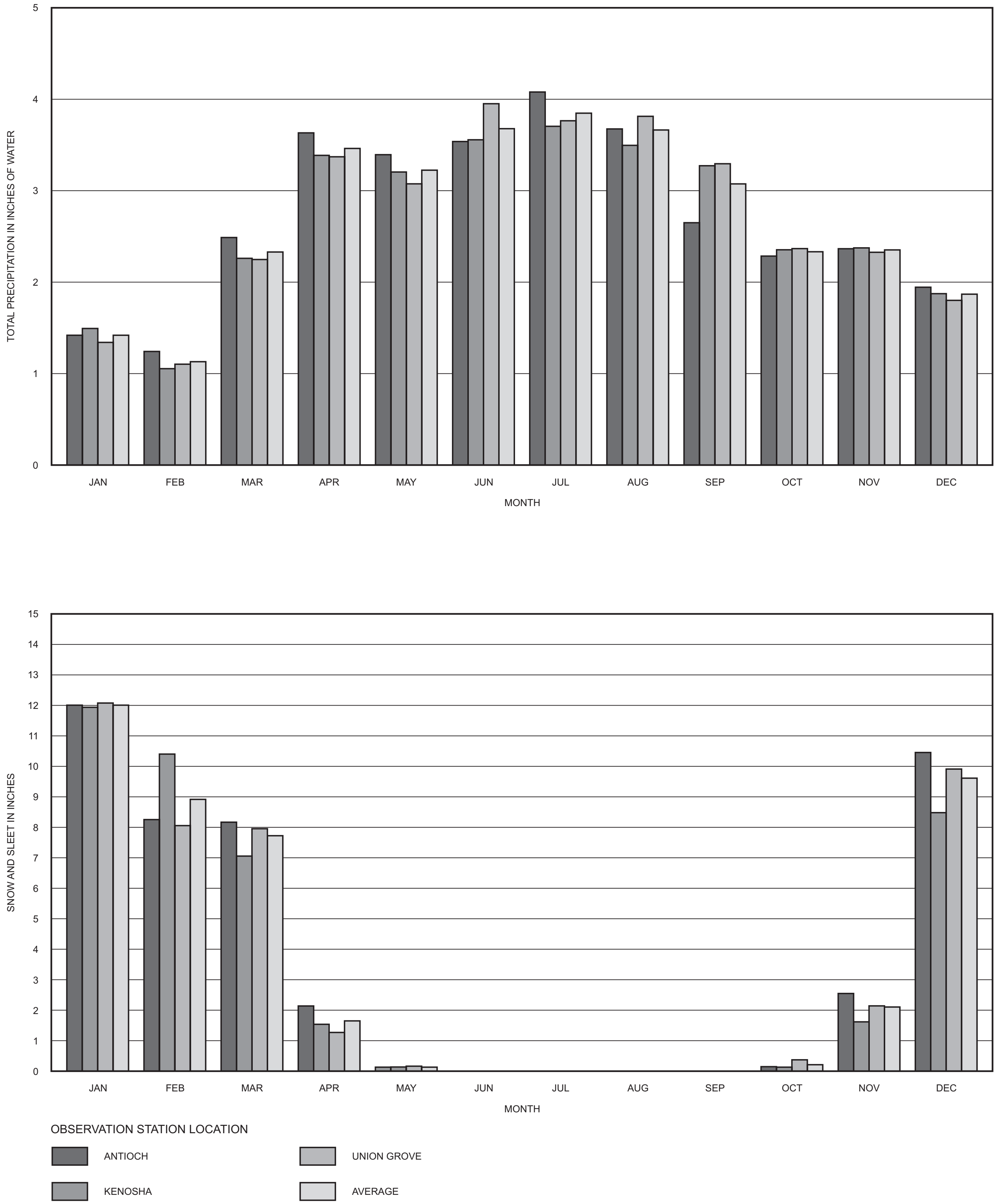
Average total monthly precipitation for the watershed, based on data for the three weather stations, ranges from a low of 1.13 inches in February to a high of 3.87 inches in July. The principal snowfall months are December, January, February, and March, when average monthly snowfalls are 9.64, 11.97, 8.86, and 7.68 inches, respectively; during that time about 90 percent of the average annual snowfall may be expected to occur. Snowfall is the predominant form of precipitation during these months, totaling approximately 56 percent of the total precipitation expressed as water equivalent. Approximately 20 inches, or 61 percent of the average annual precipitation, normally occurs during the late-April through mid-October growing season, primarily as rainfall. Assuming that 10 inches of measured snowfall is equivalent to one inch of water, the average annual snowfall of 41.08 inches is equivalent to 4.1 inches of water; therefore, only 13 percent of the average annual total precipitation occurs as snowfall.

Extreme precipitation event data through 1992 for three long-term weather stations, Milwaukee at General Mitchell International Airport, Waukesha, and Racine, are presented in Table 12. Inasmuch as these long-term records are for stations located reasonably near the Des Plaines River watershed, data from these stations may be considered representative of the extreme precipitation events that have occurred within the watershed.

Annual precipitation within the watershed and the immediate surroundings has varied from a low of approximately 17 inches, or about 53 percent of the area average, to a high of approximately 50 inches, or about 54 percent above the average. Annual seasonal snowfall has varied from a low of approximately five inches, or about 12 percent of the area average, to a high of approximately 109 inches, or about 165 percent above the average. The maximum monthly precipitation recorded at the three stations is 11.41 inches, recorded at Waukesha in July 1952, and the maximum monthly snowfall is 56 inches, measured at Waukesha in January 1918. The

Figure 8

PRECIPITATION CHARACTERISTICS AT SELECTED LOCATIONS NEAR THE DES PLAINES RIVER WATERSHED



Source: National Climatic Data Center, Wisconsin State Climatologist, Village of Union Grove, and SEWRPC.

Table 11

PRECIPITATION CHARACTERISTICS AT SELECTED LOCATIONS NEAR THE DES PLAINES RIVER WATERSHED[a]

Month	Observation Station Location						Watershed Summary			
	Antioch (1941-1992)[b]		Kenosha (1945-1993)		Union Grove (1945-1993)				Average Based on the Thiessen Polygon Method	
	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	Average Total Precipitation	Average Snow and Sleet	Total Precipitation	Snow and Sleet
January	1.42	11.96	1.49	11.91	1.34	12.05	1.42	11.97	1.40	11.99
February	1.24	8.20	1.05	10.37	1.10	8.01	1.13	8.86	1.13	8.61
March	2.50	8.12	2.27	7.00	2.26	7.91	2.34	7.68	2.33	7.76
April	3.65	2.08	3.40	1.49	3.39	1.23	3.48	1.60	3.47	1.52
May	3.41	0.02	3.22	0.09	3.09	0.12	3.24	0.08	3.21	0.09
June	3.56	- -	3.58	- -	3.97	- -	3.70	- -	3.77	- -
July	4.10	- -	3.73	- -	3.79	- -	3.87	- -	3.86	- -
August	3.70	- -	3.52	- -	3.84	- -	3.69	- -	3.73	- -
September	2.67	- -	3.30	- -	3.32	- -	3.10	- -	3.14	- -
October	2.31	0.13	2.38	0.12	2.39	0.37	2.36	0.21	2.37	0.25
November	2.39	2.54	2.40	1.61	2.35	2.14	2.38	2.10	2.37	1.65
December	1.97	10.49	1.90	8.49	1.83	9.94	1.90	9.64	1.89	9.75
Year	34.77	43.54	32.24	41.08	32.67	38.61	32.61	41.08	33.14	40.53

[a]*All precipitation data are expressed in inches.*

[b]*Station closed October 31, 1992.*

Source: U.S. Department of Commerce, National Climatic Data Center; Wisconsin State Climatologist; Village of Union Grove; and SEWRPC.

Table 12

EXTREME PRECIPITATION EVENTS FOR SELECTED LONG-TERM STATIONS NEAR THE DES PLAINES RIVER WATERSHED

Observation Station		Period of Precipitation Records	Total Precipitation (water equivalent, inches)							
			Maximum Annual		Minimum Annual		Maximum Monthly		Maximum Daily	
Name	County		Amount	Year	Amount	Year	Amount	Date	Amount	Date
Milwaukee	Milwaukee	1870-1992	50.36	1876	18.69	1901	10.03	June 1917	6.84[a]	August 6, 1986
Racine	Racine	1895-1992	48.33	1954	17.75	1910	10.98	May 1933	4.00	September 11, 1933
Waukesha	Waukesha	1892-1992	43.57	1938	17.30	1901	11.41	July 1952	5.09	July 18, 1952

Observation Station		Period of Precipitation Records	Snowfall (inches)							
			Maximum Annual		Minimum Annual		Maximum Monthly		Maximum Daily	
Name	County		Amount	Year	Amount	Year	Amount	Date	Amount	Date
Milwaukee	Milwaukee	1870-1992	109.0[b]	1885-1886	11.0[b]	1884-1885	52.6	January 1918	20.30[c]	February 4-5, 1924
Racine	Racine	1895-1992	85.0	1897-1898	5.0[d]	1901-1902	38.0	February 1898	30.00[c]	February 19-20, 1898
Waukesha	Waukesha	1892-1992	83.0[d]	1917-1918	9.1	1967-1968	56.0	January 1918	20.00[c]	January 5-6, 1918

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

[b]*Maximum and minimum snowfalls for a winter season.*

[c]*Maximum snowfall for a 24-hour period.*

[d]*Estimated from incomplete records.*

Source: U.S. Department of Commerce, National Weather Service; Wisconsin Statistical Reporting Service; and SEWRPC.

maximum 24-hour rainfall is 6.84 inches, as recorded on August 6, 1986, at Milwaukee, while the maximum 24-hour snowfall is 30 inches, measured at Racine on February 19 and 20, 1898.

Snow Cover

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

Table 13 indicates the snow depth at Milwaukee as measured during the 94-year period from 1900 through 1993. It should be emphasized that the tabulated data pertain to snow depth on the ground as measured at the place and time of observation, but are not a direct measure of average snowfall. Recognizing that snowfall and temperatures, and therefore snow accumulation on the ground, vary spatially within the watershed, the data presented in Table 13 should be considered only as an approximation of conditions throughout the watershed. As indicated by the data, snow cover is most likely during the months of December, January, and February, when there is at least a 0.39 probability of having one inch or more of snow cover in Milwaukee. Furthermore, during January and early February, there is at least a 0.31 probability of having five or more inches of snow on the ground. During early March, the time during which severe spring snowmelt-rainfall flood events are most likely to occur, there is at least a 0.31 probability of having one inch or more of snow on the ground.

By using Table 13, the probability that a given snow cover will exist or be exceeded at any given time can be estimated; thus, the data in the table can be useful in planning winter outdoor work and construction activities and in estimating runoff for hydrologic purposes. There is, for example, only a 0.18 probability of having one inch or more of snow cover on November 30 of any year, whereas there is a much higher probability, 0.63, of having that much snow cover on January 15.

Frost Depth

The terms “ground frost” or “frozen ground” refer to that condition in which the ground contains variable amounts of water in the form of ice. Frost influences hydrologic processes, particularly the proportion of rainfall or snowmelt that will run off the land directly to sewerage or stormwater systems and to surface watercourses in contrast to that which will enter and be temporarily detained in the soil. Anticipated frost conditions influence the design of engineered works in that structures and facilities are designed either to prevent the accumulation of water and, therefore, the formation of damaging frost, as in the case of pavements and retaining walls, or to be partially or completely located below the frost-susceptible zone in the soil, as in the case of foundations and water mains. For example, in order to avoid or minimize the danger of structural damage, foundation footings must be placed at a depth sufficient in the ground to be below that zone in which the soil may be expected to contract, expand, or shift as a result of frost actions. The design and construction of sanitary sewers are based on similar considerations.

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

Table 13

SNOW COVER PROBABILITIES AT MILWAUKEE BASED ON DATA FOR 1900-1993

Month	Day	Snow Cover[a]								Average (inches)	
		1.0 Inch or More		5.0 Inches or More		10.0 Inches or More		15.0 Inches or More			
		Number of Occurrences[b]	Probability of Occurrences[c]	Number of Occurrences[b]	Probability of Occurrences[c]	Number of Occurrences[b]	Probability of Occurrences[c]	Number of Occurrences[b]	Probability of Occurrences[c]	Per Occurrence[d]	Overall[e]
November	15	5	0.06	0	0.00	0	0.00	0	0.00	1.3	0.1
	30	16	0.18	2	0.02	1	0.01	0	0.00	2.9	0.5
December	15	41	0.46	14	0.16	0	0.00	0	0.00	3.5	1.5
	31	48	0.51	14	0.15	2	0.02	0	0.00	3.6	1.9
January	15	59	0.63	30	0.31	6	0.07	4	0.04	5.6	3.3
	31	64	0.68	30	0.34	13	0.15	5	0.06	6.3	4.3
February	15	63	0.68	33	0.37	12	0.13	5	0.06	6.2	4.1
	28	37	0.39	12	0.13	4	0.04	1	0.01	4.4	1.2
March	15	29	0.31	9	0.10	4	0.04	0	0.00	3.8	1.2
	31	8	0.09	1	0.01	1	0.01	0	0.00	2.7	0.2

[a]*Data pertain to snow depth on the ground as it was measured at the time and place of observation and are not direct measures of average snowfall.*

[b]*Number of occurrences is the number of times during the period of record when measurements revealed that the indicated snow depth was reached or exceeded on the indicated date.*

[c]*Probability of occurrence for a given snow depth and date is computed by dividing the number of occurrences by 94, the number of years recorded, and is defined as the probability that the indicated snow cover will be reached or exceeded on the indicated date.*

[d]*Average snow cover per occurrence is defined as the sum of all snow cover measurements in inches for the indicated date divided by the number of occurrences for that date,-that is, the number of occurrences in which 1.0 inch or more of snow cover was recorded.*

[e]*Overall average snow cover is defined as the sum of all snow cover measurements in inches for the indicated date divided by 94, that is, the number of observation times.*

Source: U.S. Department of Commerce, National Climatic Data Center; Wisconsin Statistical Reporting Service; and SEWRPC.

Data on frost conditions for the Region are available on a semimonthly basis, from late November through mid-April, as shown in Table 14, and are based upon data for a 33-year period of record extending from 1961 through 1993.[4] These data are provided for representative locations on a semimonthly basis by funeral directors and cemetery officials. Since cemetery soils are normally overlaid by an insulating layer of turf, the frost depths shown in Table 14 should be considered minimum values. Frost depths in excess of four feet have been observed in Southeastern Wisconsin. During the period in which frost depth observations have been made in Southeastern Wisconsin, one of the deepest regionwide frost penetrations occurred in early March 1963, when 25 to 30 inches of frost depth occurred throughout the Region. Even deeper frost depths, over 36 inches, were observed throughout the Region in January and February 1977. The Milwaukee and West Allis City Engineers reported over five feet of frost beneath some city streets in January and February 1977.

The data indicate that frozen ground is likely to exist throughout the watershed for approximately four months each winter season, extending from late November through March, with more than 10 inches of frost normally occurring during January, February, and the first half of March. Historical data indicate that the most severe frost conditions normally occur in February, when 14 or more inches of frost depth may be expected.

Evaporation

Evaporation is the natural process in which water is transformed from the liquid or solid state to the vaporous state and returned to the atmosphere. Total evaporation includes evaporation from water and snow surfaces and directly from the soil and also includes evaporation of precipitation intercepted on, or transpired by, vegetation. The magnitude of, and annual variation in, evaporation from water surfaces and the relation of the evaporation to

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[4]*Data for the period from 1961 through 1988 are from the Wisconsin Agriculture Reporting Service publication* Snow and Frost in Wisconsin. *Data for 1989 through 1993 were acquired from direct communication with the Wisconsin Agricultural Statistics Service in March 1994.*

precipitation is important because of the key role of this process in the hydrologic cycle of the Des Plaines River watershed.

On the basis of the limited pan evaporation data available, pan evaporation for the watershed and environs averages about 29 inches annually, somewhat less than the total annual precipitation. During the period from May through October, the total average pan evaporation of about 24 inches exceeds precipitation. However, pan evaporation is not indicative of total evaporation in the watershed because the area of surface waters in the watershed is much smaller than the total watershed area.

Wind

Over the seasons of the year, prevailing winds in the Region follow a clockwise directional pattern, northwesterly in the late autumn and winter, northeasterly in the spring, and southwesterly in the summer and early autumn. Wind velocities in the Des Plaines River watershed may be expected to be less than five miles per hour about 15 percent of the time, between five and 15 miles per hour about 60 percent of the time, and in excess of 15 miles per hour about 25 percent of the time.

Table 14

AVERAGE FROST DEPTHS IN SOUTHEASTERN WISCONSIN: LATE NOVEMBER TO MID-APRIL

Month and Day	Nominal Frost Depth (inches)[a]
November 30	1.0
December 15	3.6
December 31	6.4
January 15	10.2
January 31	12.7
February 15	14.5
February 28	14.5
March 15	12.5
March 31	7.3
April 1-15	5.2[b]

[a]*Based on 1961-1993 frost-depths data for cemeteries as reported by funeral directors and cemetery officials. Since cemeteries have soils that are overlaid by an insulating layer of turf, the frost depths should be considered minimum values.*

[b]*Average depth from April 1 through April 15.*

Source: *Wisconsin Agricultural Reporting Service,* Snow and Frost in Wisconsin, *October 1978 and November 1989; Wisconsin Agricultural Statistics Service, February 1994; and SEWRPC.*

Daylight and Sky Cover

The annual variation in the time of sunrise and sunset and the daily hours of sunlight for the watershed are presented in Figure 9. Information on expected sky cover in the form of the expected percentage of clear, partly cloudy, and cloudy days each month is also summarized in Figure 9. These daylight and sky-cover data are useful in planning outdoor construction and maintenance work and in analyzing and explaining diurnal changes in observed surface-water quality. For example, marked changes in measured stream dissolved-oxygen levels are normally correlated with the transition from daytime to nighttime conditions, when photosynthetic oxygen production by algae and aquatic plants is replaced by oxygen utilization through respiration by those plants. As illustrated in Figure 9, the duration of daylight ranges from a minimum of 9.0 hours on about December 22, at the winter solstice, to a maximum of 15.4 hours on about June 21, at the summer solstice.

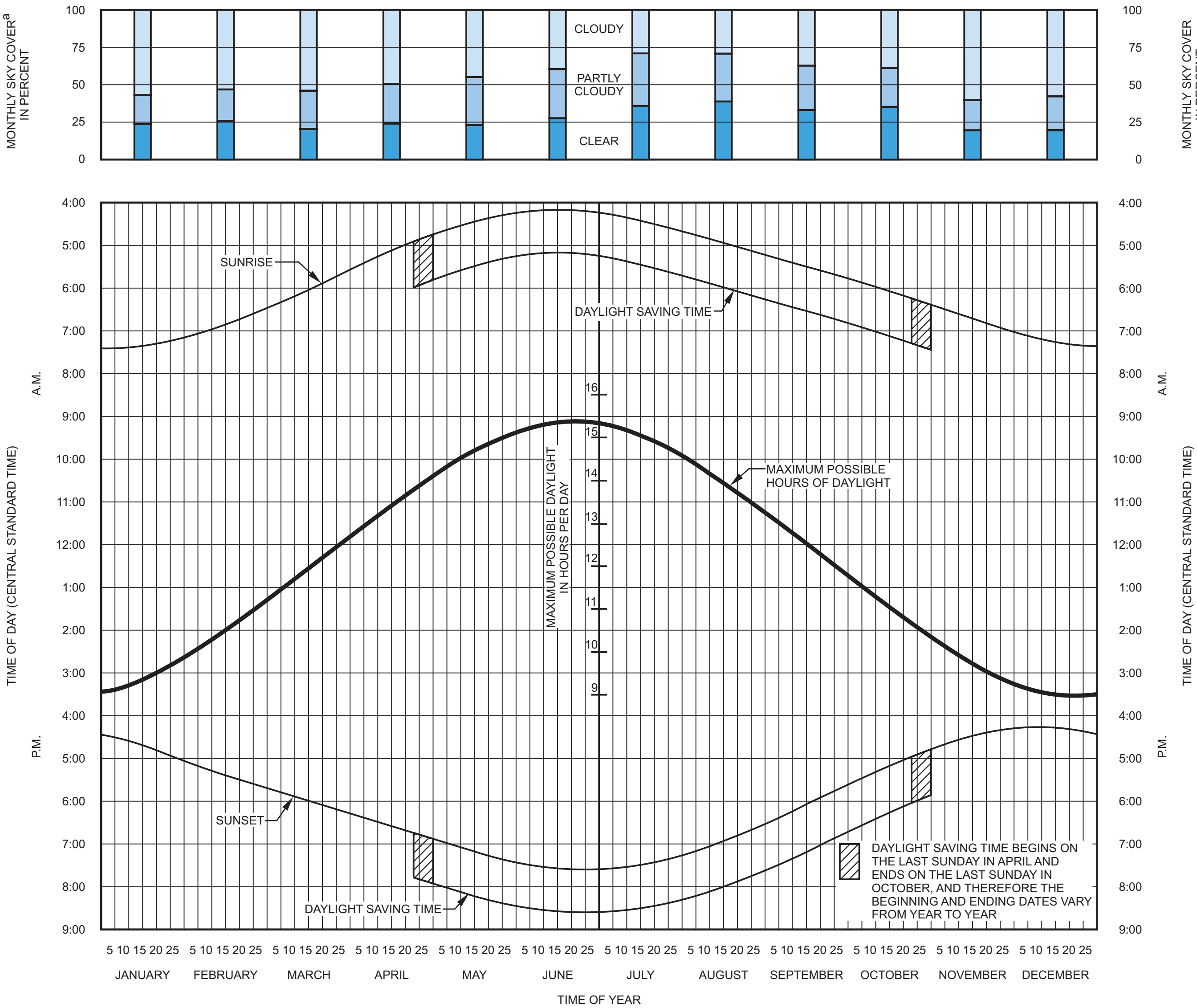
Mean monthly sky cover between sunrise and sunset varies somewhat during the year. The smallest amount of daytime sky cover may be expected to occur during the four-month period from July through October, when the mean monthly daytime sky cover is at, or slightly above, 0.5. Clouds or other obscuring phenomena are most prevalent during the five months from November through March, when the mean monthly daytime sky cover is about 0.7. Furthermore, during the summer months, as shown in Figure 9, about one-third of the days may be expected to be categorized as clear, one-third as partly cloudy, and one-third as cloudy. Greater sky cover occurs in the winter, however, when over one-half of the days are classified as cloudy, with the remainder being about equally divided between "partly cloudy" and "clear" classifications.

Physiography

As already noted, the Des Plaines River watershed encompasses an area of approximately 132.9 square miles. The watershed is roughly rectangular in shape, extending approximately 10 miles in an east-west direction and about 13 miles in a north-south direction.

Figure 9

SUNRISE, SUNSET, AND SKY COVER IN THE DES PLAINES RIVER WATERSHED



[a]BASED ON MILWAUKEE SKY COVER DATA. THE MONTHLY DATA ARE SIMILAR TO THOSE OBSERVED AT MADISON AND AT GREEN BAY, WHICH SUGGESTS THAT THERE IS VERY LITTLE VARIATION IN THIS MONTHLY DATA FOR THE LARGE GEOGRAPHIC REGION RELATIVE TO THE DES PLAINES RIVER WATERSHED, REPRESENTED BY THESE THREE NATIONAL WEATHER SERVICE STATIONS. THEREFORE, THE MILWAUKEE DAYLIGHT AND SKY COVER MONTHLY DATA MAY BE CONSIDERED APPLICABLE TO THE WATERSHED. SKY COVER CONSISTS OF CLOUDS OR OBSCURING PHENOMENA, AND IS EXPRESSED IN TENTHS. A DAY IS CLASSIFIED AS CLEAR IF THE SKY COVER DURING THE DAYLIGHT PERIOD IS 0-0.3, PARTLY CLOUDY IF THE SKY COVER IS 0.4-0.7, AND CLOUDY IF THE SKY COVER IS 0.8-1.0. MONTHLY SKY COVER INDICATES, BY MONTH, THE PERCENT OF DAYS THAT HISTORICALLY HAVE BEEN CLEAR, PARTLY CLOUDY, OR CLOUDY.

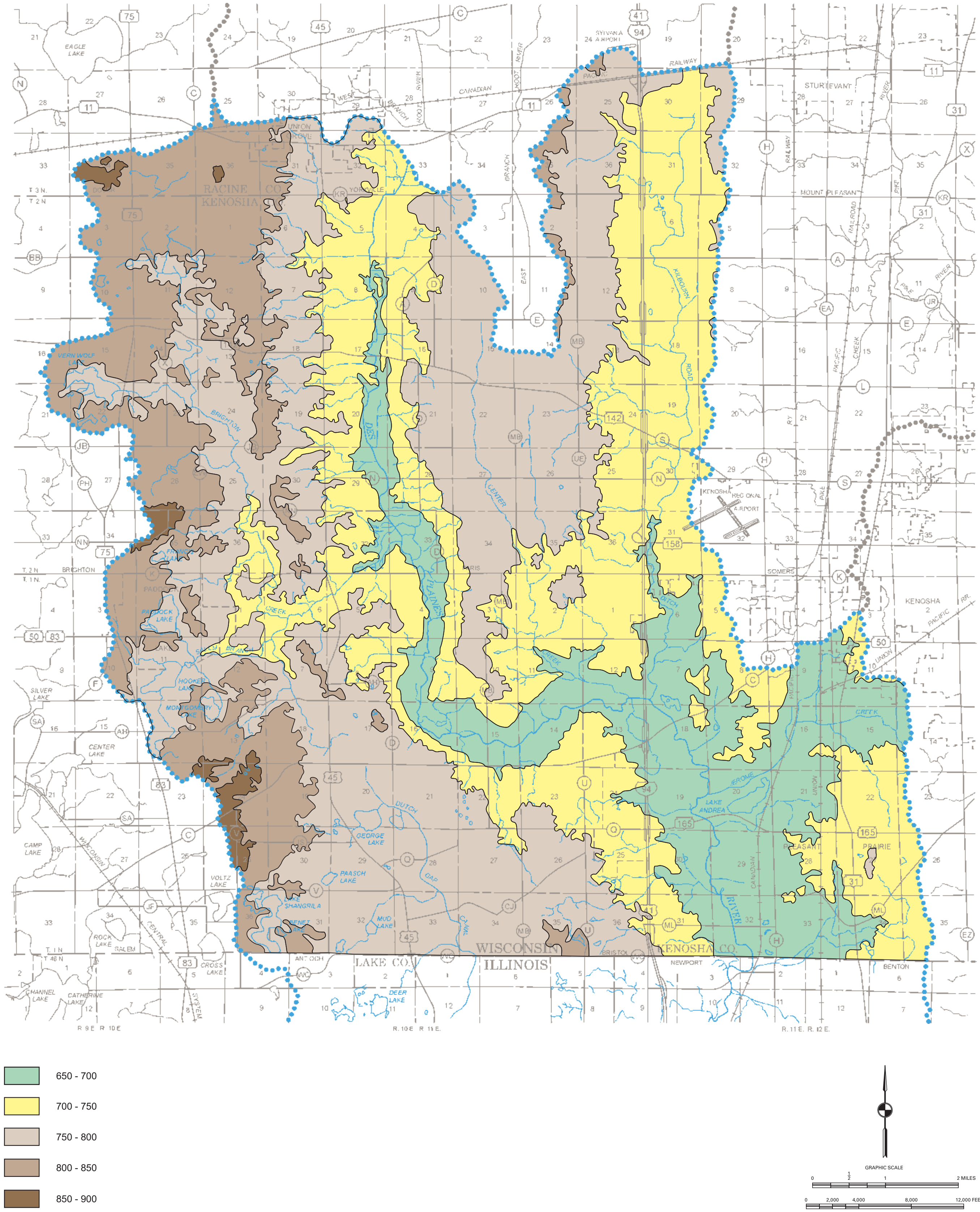
Source: Adapted by SEWRPC from National Weather Service and U. S. Naval Observatory data.

Topographic and Physiographic Features

The variation in elevation within the watershed is shown on Map 14. Watershed physiographic features, or surficial landforms, have been determined largely by the underlying bedrock and the overlying glacial deposits of the watershed. Land slopes in the watershed may be classified into three major groups: slight, 0 to 6 percent; moderate, 7 to 12 percent; and steep, 12 percent or greater. As shown on Map 15, approximately 91 percent of the watershed is characterized as having slight slopes, 7 percent as having moderate slopes, and 1 percent as having steep slopes. Approximately 1 percent of the watershed is classified as "made land," for which slope data are not available.

Map 14

TOPOGRAPHY OF THE DES PLAINES RIVER WATERSHED

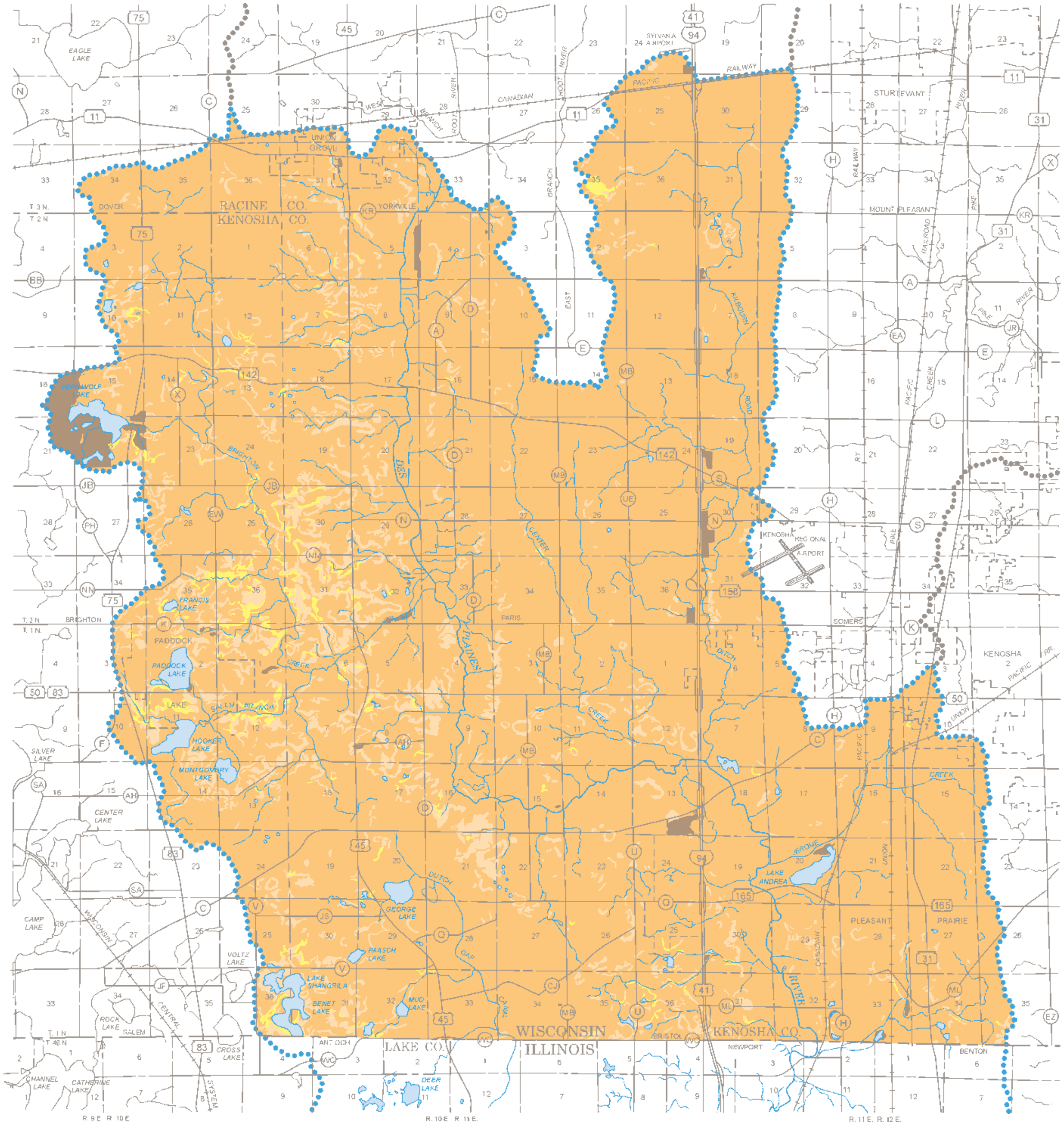


Glacial deposits superimposed on underlying bedrock established the overall topography of the Des Plaines River watershed. Surface elevations in the watershed range from a high of approximately 891 feet above National Geodetic Vertical Datum (mean sea level datum) along the western border to a low of approximately 668 feet above National Geodetic Vertical Datum along the Des Plaines River at the Wisconsin-Illinois border, a maximum relief of approximately 223 feet.

Source: SEWRPC.

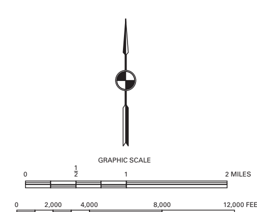
Map 15

LAND SURFACE SLOPES IN THE DES PLAINES RIVER WATERSHED



PERCENT SLOPE

- 0 TO 6
- 7 TO 12
- 13 OR GREATER
- MANMADE
- SURFACE WATER



Approximately 91 percent of the Des Plaines River watershed area is characterized as having slight slopes, 7 percent as having moderate slopes, and about 1 percent as having steep slopes. Approximately 1 percent of the watershed is classified as man-made land for which slope data are not available.

Source: SEWRPC.

The elevations of the surface of the watershed are shown on Map 14. Glacial deposits overlying the bedrock formations form the surface topography of the watershed, consisting primarily of a gently sloping ground moraine, made up of heterogeneous material deposited on the glacial ice. Surface elevations within the watershed range from a high of approximately 891 feet above National Geodetic Vertical Datum of 1929 along the western border of the watershed to approximately 668 feet above National Geodetic Vertical Datum of 1929 at the point on the Des Plaines River where it flows into Illinois, a maximum relief of 223 feet.

Topography is an important consideration in watershed planning since it is one of the most important factors determining the hydrologic response of a watershed to rainfall and rainfall-snowmelt events and since topographic considerations enter into the selection of sites and routes for public utilities and facilities such as sewerage and water supply systems, flood control facilities, and highways. Large-scale topographic mapping at a scale of one inch equals 200 feet with a two-foot contour interval prepared to Regional Planning Commission standards is available for the entire watershed (see Map 16). This mapping, together with Commission one-inch-equals-400-feet was scale ratioed and rectified aerial photographs and orthophotographs, used extensively in the watershed planning process and will be invaluable during implementation of the Des Plaines River watershed plan.

Surface Drainage

The Des Plaines River watershed drains in a generally southeasterly direction to the Wisconsin-Illinois border. The Des Plaines River then travels southerly to its confluence with the Kankakee River, where the two Rivers form the Illinois River. As shown on Map 1 in Chapter I of this report, the watershed is bounded on the north by the Fox and Root River watersheds, on the west by the Fox River watershed, and on the east by the Pike River watershed and areas directly tributary to Lake Michigan.

The characteristics of the surface drainage of the watershed are diverse with respect to channel cross-sectional shape, channel slope, degree of stream sinuosity, and floodland shape and width. The heterogeneous character of the surface drainage system is due partly to the natural effects of glaciation superimposed on the bedrock and partly to the extensive channel modifications and other results of urbanization that are evident throughout the watershed. The configuration of the stream network in the watershed was described earlier in this chapter, and is shown on Map 1 in Chapter I of this report.

Geology

The geology of the Des Plaines River watershed is a complex system of various layers and ages of rock formations. The type and extent of the various bedrock formations underlying the watershed were determined primarily by the environments in which the sediments forming the various rock layers were deposited. The surface of this varied system of rock layers was, moreover, eroded prior to being buried by a blanket of glacial deposits consisting of unconsolidated sand, silt, clay, gravel, and boulders. The bedrock formations underlying the Des Plaines River watershed consist predominantly, in ascending order, of crystalline rocks of the Precambrian era, Cambrian through Silurian sedimentary rocks of the Paleozoic era, and unconsolidated surficial deposits. Only the glacial deposits are exposed in the watershed; there are no known bedrock outcrops in the basin.

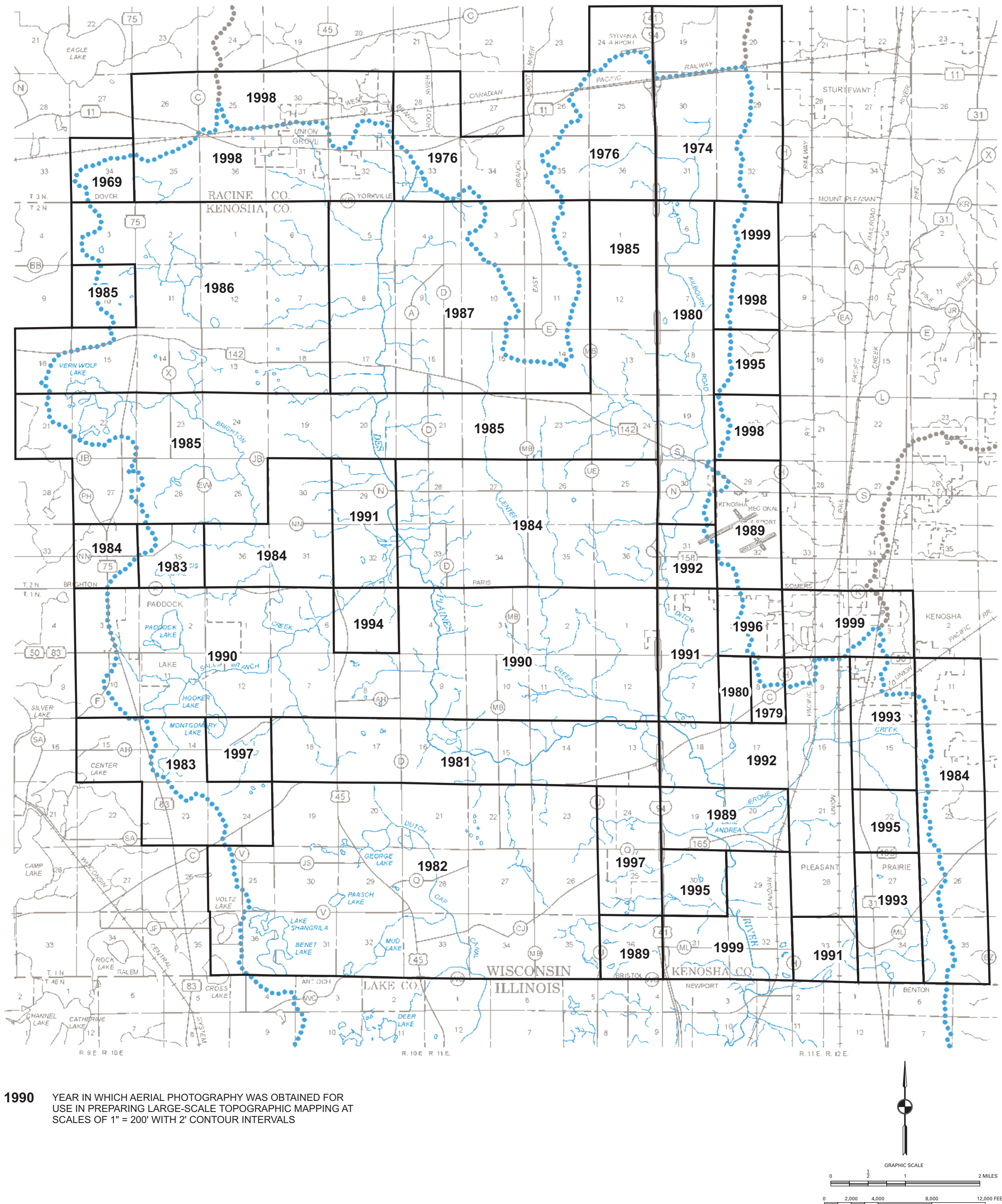
Table 15, which summarizes the stratigraphy of the Des Plaines River watershed, indicates that the unconsolidated surficial deposits have a thickness of 0 to 340 feet and that the underlying dolomite, shale, and sandstone bedrock layers attain a combined thickness in excess of 1,500 feet. Bedrock layers generally slope downward in an easterly direction at about 15 feet per mile. The relationship between the geologic units and the three aquifer systems underlying the watershed is also set forth in Table 15.

Precambrian Rock Units

Precambrian crystalline rocks thousands of feet thick form the basement on which younger rocks were deposited. Little is known of their origin. No wells in the watershed are known to reach the Precambrian basement. The Precambrian rocks were extensively eroded to an uneven surface before the overlying sedimentary formations were deposited. Layered sedimentary rocks overlying the Precambrian rocks consist primarily of sandstone, shale, and dolomite. These rocks were deposited during the Cambrian, Ordovician, and Silurian periods in seas that covered much of the present North American continent.

Map 16

AVAILABILITY OF LARGE-SCALE TOPOGRAPHIC MAPPING OF THE DES PLAINES RIVER WATERSHED: 1999



Large-scale topographic maps prepared to SEWRPC standards are available for the entire watershed. The large-scale mapping was used in a variety of ways during preparation of the watershed plan, including the development of data for the hydrologic-hydraulic simulation modeling effort and the evaluation of sites for alternative water-related public facilities and utilities. The extensive amount of large-scale mapping available will be invaluable to plan implementation.

Source: SEWRPC.

Table 15

STRATIGRAPHY OF THE DES PLAINES RIVER WATERSHED

System	Geologic Unit	Thickness Range (feet)	Dominant Lithology	Hydrologic Unit[a]	Water-Yielding Characteristics
Quaternary	Pleistocene and Holocene	0-340	Clay, silt, sand, gravel, and boulders; possibly locally stratified	Sand and gravel aquifers (unconfined)	Small to moderate yields can be obtained from large sand and gravel aquifers
Silurian	Dolomite, undifferentiated	0-345	Dolomite	Niagara aquifer	Very small to large yields, depending upon the size and number of crevices
Ordovician	Maquoketa shale	180-250	Shale	Aquiclude	Small yields
	Platteville, Decorah, and Galena Formations, undifferentiated	250-345	Dolomite	- -	Small yields from crevices
	St. Peter sandstone	100-200	Sandstone	- -	Moderate yields
	Prairie du Chien Group	0-60	Dolomite	- -	Small yields
Cambrian	Trempealeau Formation	0-120	Dolomite	Sandstone aquifer	Small yields
	Franconia and Galesville sandstone, undifferentiated	60-150	Sandstone	Sandstone aquifer	Moderate to large yields from well-sorted sandstone near the base
	Eau Claire sandstone	340-405	Sandstone	- -	- -
	Mount Simon sandstone	637-1,500+	Sandstone	Sandstone aquifer	Moderate to large yields
Precambrian Rocks	Unknown	Unknown	Crystalline rocks	- -	Not water-bearing

[a]*The combination of the unconfined sand and gravel and dolomite aquifers is sometimes referred to as the "shallow aquifer" and the confined sandstone aquifer is sometimes referred to as the "deep aquifer."*

Source: U.S. Geological Survey and SEWRPC.

Cambrian Rock Units

Cambrian rocks in the watershed are primarily sandstone, but contain some interbedded shale, siltstone, and dolomite. The four Cambrian rock units are the Mount Simon sandstone, which was deposited on the Precambrian surface, the Eau Claire sandstone, undifferentiated Franconia and Galesville sandstone, and the Trempeleau Formation. The four units are present throughout the watershed. The Eau Claire sandstone has a maximum thickness of about 405 feet, whereas the Mount Simon sandstone has a thickness in excess of 1,500 feet, with the total thickness unknown because of the absence of fully penetrating wells or other boreholes. The thickness of the undifferentiated Franconia and Galesville sandstone ranges from 60 to 150 feet and the thickness of the Trempeleau Formation ranges from 0 to 120 feet.

Ordovician Rock Units

Ordovician rocks in the watershed consist of sandstone, dolomite, and shale. The St. Peter sandstone, which was deposited on an eroded surface cut into the underlying Cambrian Formation, has a thickness of between 100 and 200 feet across the watershed. The Platteville, Decorah, and Galena Formations, which were deposited in succession on top of the St. Peter sandstone, are not differentiated in the watershed because of similar lithology and water-bearing attributes. Those formations have a combined maximum thickness of approximately 345 feet. Above them is the relatively impermeable Maquoketa shale, which has a thickness of at least 180 feet throughout the watershed.

Silurian Rock Units

Silurian rocks, consisting of undifferentiated dolomite strata with a thickness of between 0 and 345 feet, overlie the Maquoketa shale. As shown on Map 17, which depicts the topography of the surface of the bedrock, Silurian rocks form the bedrock beneath the glacial deposits in most of the watershed. In part of the western portion of the watershed and in a relatively narrow band located primarily in the Town of Paris between the Des Plaines River and IH 94, the Maquoketa shale forms the bedrock surface.

In those areas where the bedrock surface is formed by Silurian rocks, that surface generally slopes in the same direction as the present surface drainage pattern of the watershed. However, the slope trend of the Silurian rocks is interrupted by those areas where Maquoketa shale forms the bedrock surface. The areas of Maquoketa shale bedrock do not slope in the direction of the surface drainage system, but actually slope downward across subwatershed boundaries toward the east and west watershed divides.

Quaternary Deposits

Unconsolidated deposits of boulders, gravel, sand, silt, and clay overlie the sedimentary rocks. These were deposited during the Pleistocene age by continental glaciers that last covered the watershed about 11,000 years ago. The deposits can be classified according to their origin into till and stratified drift. Till, a heterogeneous mixture of clay, silt, sand, gravel, and boulders, was deposited from ice without the sorting action of water. Most of the watershed is overlain by till in the form of ground moraines. Stratified drift consists primarily of sand and gravel that were sorted and deposited as outwash of glacial meltwater. Local deposits of stratified drift may exist in the watershed in the form of sand and gravel. As shown on Map 18, the thickness of the unconsolidated deposits in the Des Plaines River watershed is variable, generally ranging from 100 to 300 feet. There are no known bedrock outcrops in the watershed.

Holocene materials consist of recent alluvium and marsh deposits. They are found only along streams and in marshy areas and constitute a small fraction of the unconsolidated deposits covering the watershed land surface.

Abandoned Sand and Gravel Pits and Quarries

Inactive sand and gravel pits and dolomite quarries, and more particularly the excavations left as a result of the mining operations concerned, have the potential to serve a variety of needs in the expanding urban area. Lakes and ponds developed in the depressions left by sand, gravel, and dolomite operations could complement contiguous public recreational areas or private residential, commercial, or industrial development. Those depressions that are in an urban setting may also serve as stormwater detention ponds. Carefully selected inactive sand and gravel pits and dolomite quarries could also be preserved, in whole or in part, as scientific sites, oriented to the study of glacial and bedrock geology, or as historic sites intended to inform visitors of the commercial activities of early inhabitants.

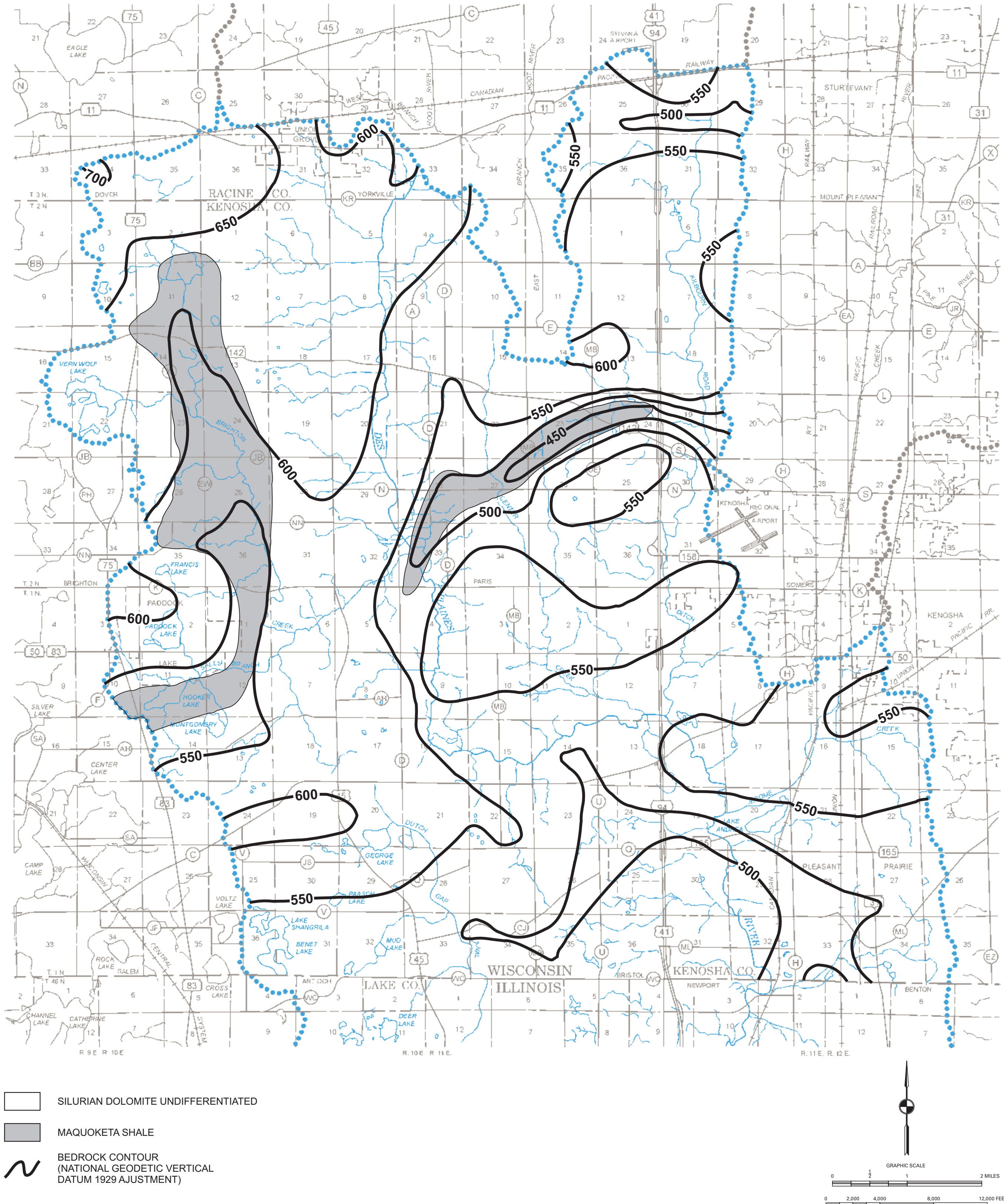
Soils

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

Soil-forming factors, particularly topography and the nature of the parent glacial materials, exhibit wide spatial variations in Southeastern Wisconsin and, therefore, hundreds of different soil types have developed within the Des Plaines River watershed and the Region. In order to assess the significance of these unusually diverse soil types to sound regional development, the Commission in 1963 negotiated a cooperative agreement with the U.S. Soil Conservation Service (now the U.S. Natural Resources Conservation Service) under which detailed operational soil surveys were completed for most of the Region. The results of the soil survey have been published in SEWRPC Planning Report No. 8, *Soils of Southeastern Wisconsin*, June 1966. The regional soil survey not only has resulted in the mapping of soils within the Region in great detail and provided data on the

Map 17

TOPOGRAPHY OF THE SURFACE OF THE BEDROCK IN THE DES PLAINES RIVER WATERSHED

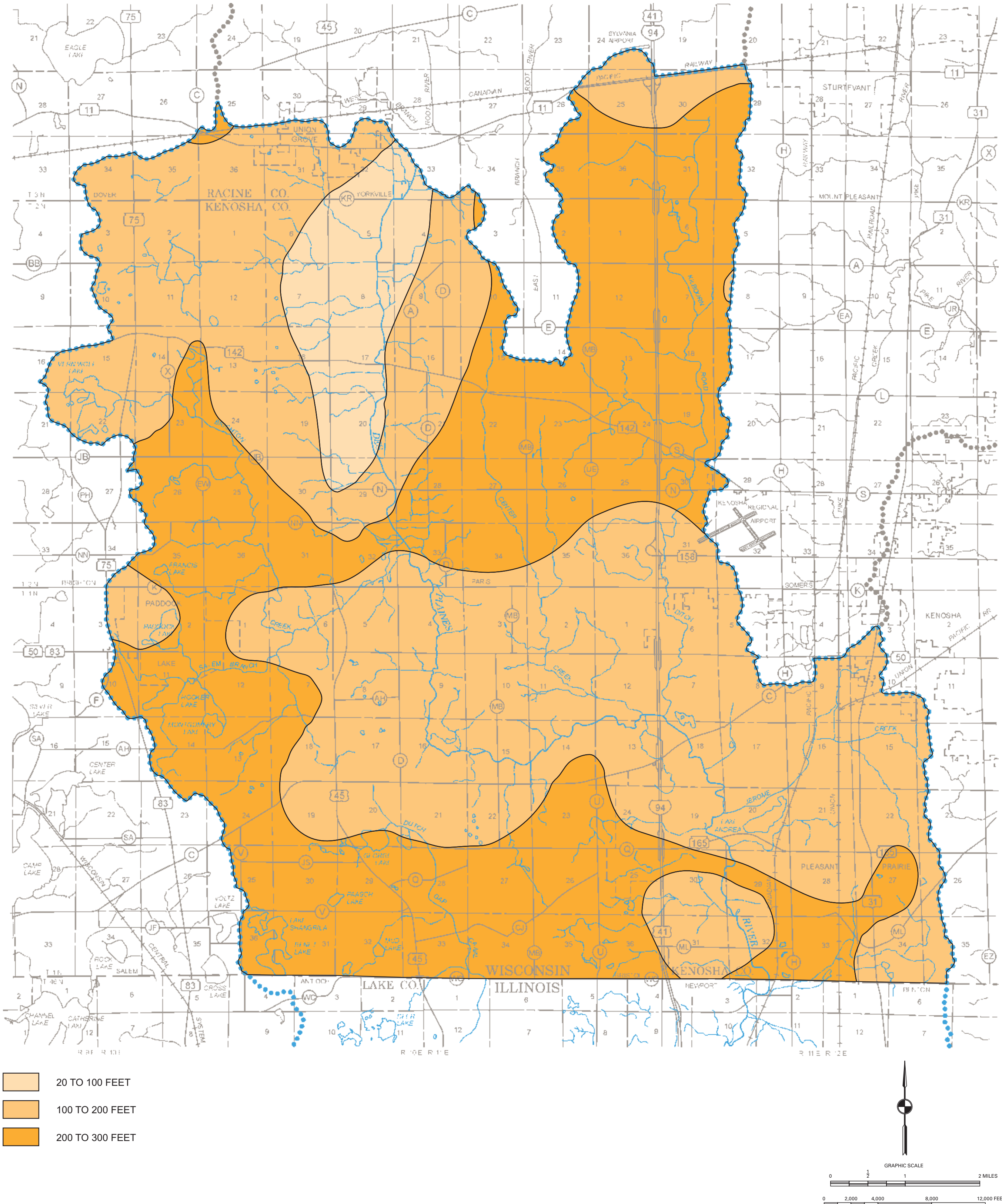


The surface of both the bedrock and the dolomite aquifer is generally located from 100 to 300 feet beneath the ground surface of the Des Plaines River watershed. The bedrock surface dips generally downward in an easterly direction across the watershed at an average slope of about 15 feet per mile. Topographic variations on the surface of the bedrock probably reflect preglacial water and wind erosion. The relatively impermeable Maquoketa shale is positioned immediately below the dolomite aquifer, and two areas of the Maquoketa shale are exposed on the surface of the bedrock. Unconsolidated glacial till, drift, and alluvial deposits lie immediately above the bedrock.

Source: Wisconsin Geological and Natural History Survey and SEWRPC.

Map 18

THICKNESS OF THE GLACIAL DEPOSITS IN THE DES PLAINES RIVER WATERSHED



The thickness of the glacial deposits which form the surface of the watershed and which are composed of clay, silt, sand, gravel, and boulders is variable throughout the basin. The thickness of glacial deposits is an important factor in the planning for and design of subsurface utilities and facilities because it determines whether such facilities will be constructed above or within the underlying bedrock. Consideration of the depth to bedrock is also important for planning and construction of septic tank systems, public sewerage systems, water supply utilities, and other projects involving extensive trenching and excavation.

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

physical, chemical, and biological properties of the soils, but also has provided interpretations of the soil properties for planning, engineering, agricultural, and resource conservation purposes. Detailed soils data are available for the entire area of the Des Plaines River watershed. Map 19 shows the hydrologic soil groups within the watershed. The detailed soils data were utilized in the watershed planning program in the hydrologic modeling, the identification of areas having limitations for urban development utilizing onsite waste disposal systems and for development utilizing public sanitary sewer service, the identification of prime agricultural lands, and the delineation of primary environmental corridors.

Vegetation

Watershed vegetation at any given time is determined by a variety of factors, including climate, topography, soils, proximity to bedrock, drainage, occurrence of fire, and human activities. Because of the temporal and spatial variability of these factors and the sensitivity of different forms of vegetation to these factors, the watershed vegetation has been a changing mosaic of different types. The terrestrial vegetation in the watershed occupies sites which may be subdivided into three broad classifications: wetland, woodland, and grassland.

Wetlands

Wetlands are defined by the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency (EPA), and the Regional Planning Commission as areas that are inundated or saturated by surface water or groundwater at a frequency, and with a duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. This definition is set forth in Titles 33 and 40 of the Code of Federal Regulations. The wetland delineation procedures have been established and are set forth in the 1987 Corps of Engineers wetland delineation manual.[5]

Wetlands are defined by the U.S. Natural Resources Conservation Service (NRCS) as "areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except lands in Alaska identified as having high potential for agricultural development and a predominance of permafrost soils." The Corps of Engineers and EPA definition used by the Commission in the Southeastern Wisconsin Region is essentially the same as the NRCS definition.[6]

A third definition, which is applied by the Wisconsin Department of Natural Resources and is set forth in Chapter 23 of the *Wisconsin Statutes*, defines a wetland as "An area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions." In practice, the WDNR definition differs from the Federal and Commission definitions in that the WDNR considers very poorly drained, poorly drained, and some of the somewhat poorly drained soils as wetland soils meeting its "wet condition" criterion. The Federal and Commission definitions consider only the very poorly drained and poorly drained soils as meeting the "hydric soil" criterion. Thus the State definition, as

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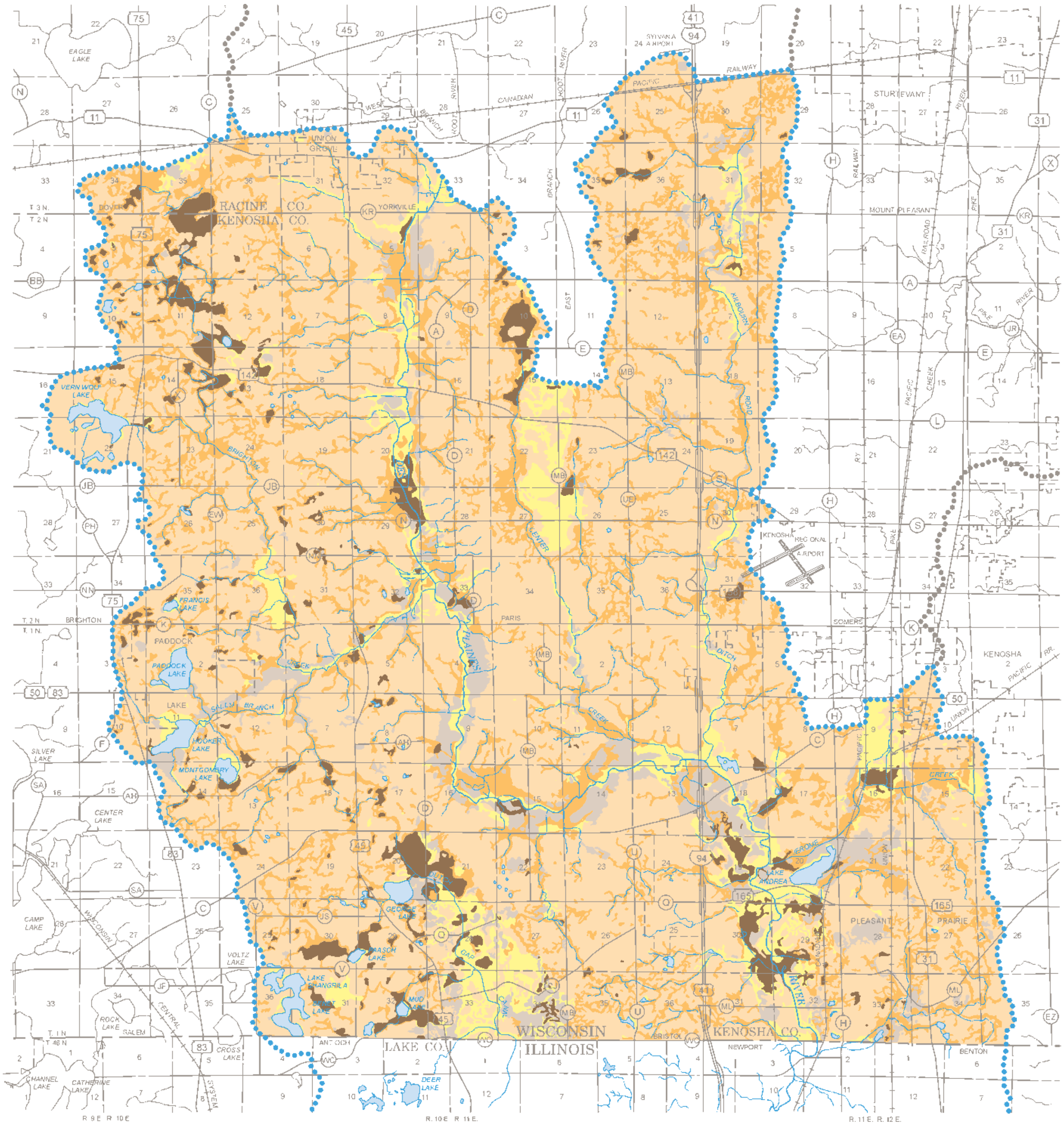
[5]*The diagnostic environmental characteristics of wetlands include 1) a prevalence of hydrophytic vegetation, 2) soils that have been classified as hydric, or that possess characteristics associated with reducing or anaerobic soil conditions, and 3) lands that are permanently or periodically inundated at mean water depths of 6.6 feet or less, or soils that are saturated to the surface for some time during the growing season. According to the 1987 Corps of Engineers manual, these three characteristics must be demonstrated in most instances. However, that manual does allow for some flexibility in applying these criteria, enabling the delineator to exercise appropriate professional judgment in cases where one of the three criteria for wetland identification may not be specifically met, but judgment indicates that the site should nonetheless be classified as a wetland.*

[6]*Lands designated as prior converted cropland, that is, lands that were cleared, drained, filled, or otherwise manipulated to make them capable of supporting a commodity crop prior to December 23, 1985, may meet the criteria of the NRCS wetland definition, but they would not be regulated under Federal wetland programs. If such lands are not cropped, managed, or maintained for agricultural production for five consecutive years, and in that time the land reverts back to wetland, the land would then be subject to Federal wetland regulations.*

Map 19

HYDROLOGIC SOIL GROUPS IN THE DES PLAINES RIVER WATERSHED



GROUP A/D:
WELL DRAINED SOIL/VERY POORLY DRAINED SOIL (WELL-DRAINED IF WATER TABLE IS LOWERED THROUGH PROVISION OF A DRAINAGE SYSTEM. VERY POORLY DRAINED IF WATER TABLE IS NOT LOWERED.)

GROUP B:
MODERATELY DRAINED SOIL

GROUP B/D:
MODERATELY DRAINED SOIL/VERY POORLY DRAINED SOIL (MODERATELY DRAINED IF WATER TABLE IS LOWERED THROUGH PROVISION OF A DRAINAGE SYSTEM. VERY POORLY DRAINED IF WATER TABLE IS NOT LOWERED.)

GROUP C:
POORLY DRAINED SOIL

GROUP D:
VERY POORLY DRAINED SOIL

SURFACE WATER

GRAPHIC SCALE
0 1/2 1 2 MILES
0 2,000 4,000 8,000 12,000 FEET

Poorly drained soils are predominant in the watershed.

Source: SEWRPC.

actually applied is more inclusive than the Federal and Commission definitions in that the Department may include some soils that do not show hydric field characteristics as wet soils but, however, are in fact capable of supporting wetland vegetation, a condition which may occur in some floodlands.[7]

The Wisconsin Wetlands Inventory maps are used in the administration of key State, and some Federal, regulatory programs. In the Southeastern Wisconsin Region, those maps were prepared for the WDNR by Commission staff prior to the adoption by the Department of the current State wetlands definition set forth above. At the time that the Wisconsin Wetlands Inventory maps were prepared, the State wetland definition required that all three wetland identification criteria, those related to wet soils, appropriate hydrologic conditions, and wetland vegetation, be satisfied for a site to be classified as a wetland. Thus, the Wisconsin Wetlands Inventory was developed using procedures consistent with the wetland definition applied by the Army Corps of Engineers, the EPA, and the Regional Planning Commission. The Commission wetland inventory is based on the Wisconsin Wetlands Inventory and is updated every five years as part of the regional land use inventory.

As a practical matter, either the application of the WDNR wetland definition or that of the EPA-Army Corps of Engineers-Regional Planning Commission definition has been found to produce reasonably consistent wetland identifications and delineations in the majority of situations within the Southeastern Wisconsin Region. That consistency is due in large part to a provision in the Army Corps of Engineers wetland delineation manual that allows for the application of professional judgment in cases where satisfaction of the three criteria for wetland identification is unclear.

Woodlands

Woodlands are defined as areas one acre or more in size having 17 or more deciduous trees per acre, each measuring at least four inches in diameter at breast height, and having 50 percent or more tree canopy coverage. In addition, coniferous tree plantations and reforestation projects are identified as woodlands by the Commission.

Grasslands

Grasslands are defined as areas one acre or more in size dominated by upland native or nonnative grasses and having less than 17 trees per acre with a canopy cover of less than 50 percent. The grassland definition does not include trimmed and manicured lawns. Lowland grasslands, such as wet to wet-mesic prairies and disturbed fresh (wet) meadows dominated by reed canary grass (*Phalaris arundinacea*), have been classified for watershed planning purposes as wetlands.

The location, extent, type, and quality of wetland, woodland, and grassland areas are important determinants of the environmental quality of the watershed. Such areas can, for example, support a variety of outdoor recreational activities. They offer aesthetic values, contributing to the beauty and visual diversity of the landscape and functioning as visual and acoustic shields or barriers. Such areas, as well as the vegetation contained within them, serve important ecological functions, since they are typically, on a unit-area basis, biologically the most productive areas of the watershed, provide continuous wildlife range and sanctuary for native biota, and help to maintain surface-water quality by functioning as sediment and nutrient traps.

Pre-European Settlement Vegetation

Before the arrival of European settlers, the vegetation of the watershed predominantly consisted of oak forests, oak savannas, prairies, and open wetlands, including deep and shallow marshes, wet prairies, and sedge meadows. The pre-European settlement distribution pattern of these four general categories of plant communities in the Des Plaines River watershed is shown on Map 20. The oak forests encompassed about 43 percent of the watershed area; the oak savannas encompassed about 17 percent of the watershed area; prairies encompassed

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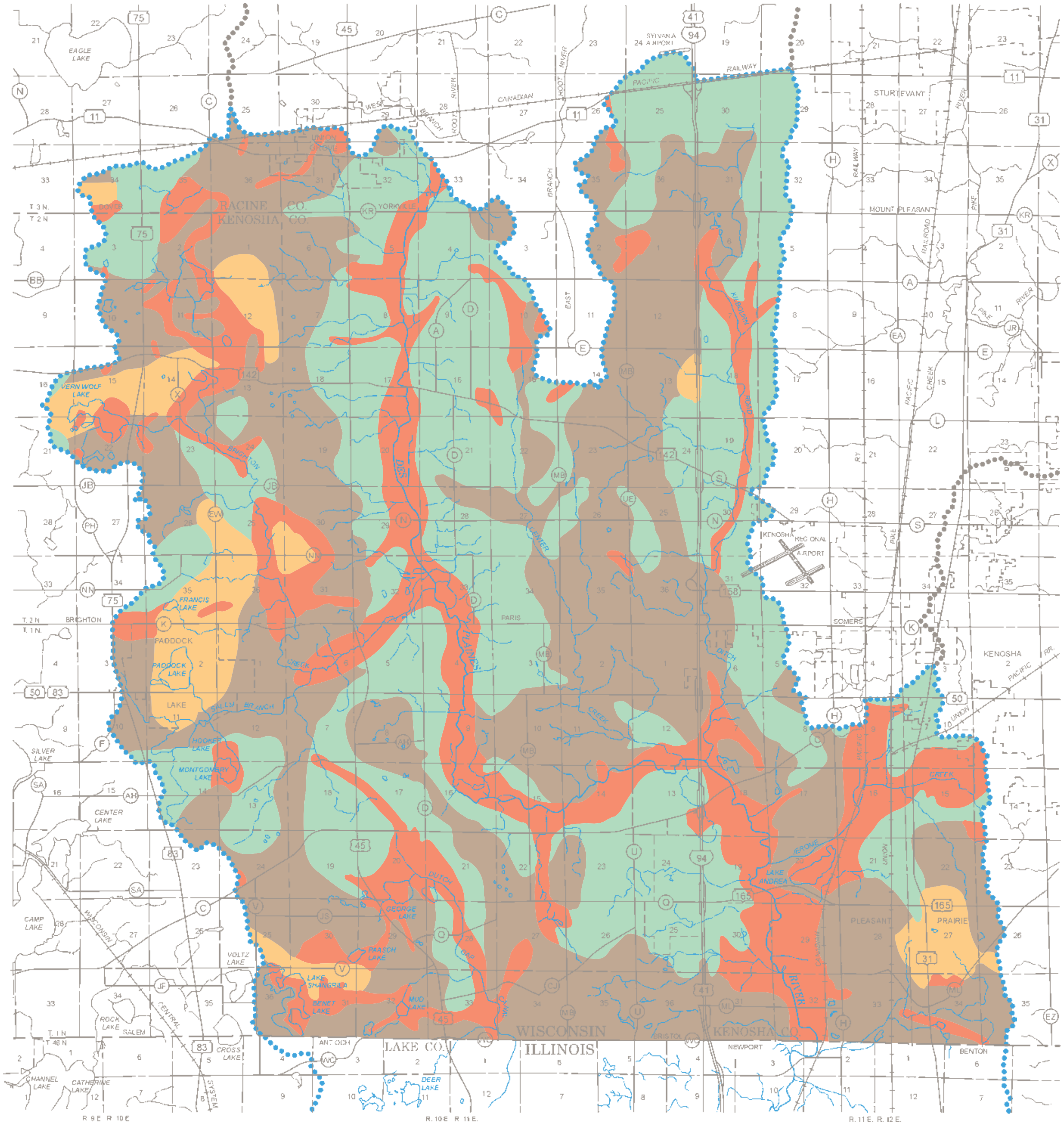
[7] *Although prior converted cropland is not subject to Federal wetland regulations unless cropping ceases for five consecutive years and the land reverts to a wetland condition, the State may consider prior converted cropland to be subject to State wetland regulations if the land meets the criteria set forth in the State wetland definition before it has not been cropped for five consecutive years.*

Map 20

GENERALIZED PRE-SETTLEMENT VEGETATION IN THE DES PLAINES RIVER WATERSHED



PRAIRIE

OAK SAVANNA

OAK FOREST

WETLAND

GRAPHIC SCALE

0 ½ 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

Prior to settlement by Europeans, oak forests encompassed about 17 percent of the watershed area, oak savannas encompassed about 43 percent, prairies encompassed about 26 percent, and wetlands encompassed about 14 percent.

Source: SEWRPC.

about 26 percent of the watershed area; and wetlands encompassed about 14 percent of the watershed area. The pre-European settlement vegetation map is based on information gathered as part of the U.S. Public Land Survey conducted within the watershed just prior to settlement by Europeans in the 1830s.

In order to compare the remnant natural plant communities now existing in the watershed, the four general categories of plant communities which historically existed in the watershed can be described as follows:

1. Oak forests include southern dry and dry-mesic upland woodlands on well-drained soils. Dominant tree species include white, black, and red oaks, black cherry, and shagbark hickory. The relative openness of the canopy permits high light penetration, often resulting in a thick shrub understory of dogwood, hazelnut, viburnum, prickly-ash, currant, and, today, European buckthorn and Eurasian honeysuckle. The herbaceous plants occurring on these sites are primarily late-blooming species, such as aster and goldenrod. Current examples include Merkt Woods and Bristol Woods.

2. Oak savannas are woodlands transitional between forest and grassland and consist of prairie grasses and forbs beneath widely spaced trees, primarily burr oaks. Criteria used to distinguish oak savannas from oak forests have been a tree density of one to 17 trees per acre and a canopy cover of less than 50 percent. The historical existence of oak savannas depended on periodic fires that would kill invading woody species but leave the thick-barked burr oaks unharmed. Fire suppression has allowed woody species to invade those oak savannas that survived agriculturalization, so that today oak savannas with intact prairie ground flora are practically nonexistent. Degraded oak savannas exist in the upland portions of the Harris Tract.

3. The pre-European settlement grasslands of the Des Plaines River watershed consisted of a mixture of two prairie types, mesic and wet-mesic. The mesic, or moderately moist, prairie was a diverse, luxuriant, highly productive native grassland complex dominated by such tall grasses as big bluestem and Indian grass; nitrogen-fixing legumes, including wild indigo, veiny wild pea, and purple prairie-clover; and an array of composites, including asters, compass plant, goldenrods, and blazing-stars. Most species bloomed in middle and late summer. Soils were deep and dark, rich in nutrients, high in organic matter, and of neutral pH. The deep root systems enabled the plants to resist drought, but the community was dependent upon occasional fire to inhibit establishment of woody species. Formerly widespread in Kenosha and Racine Counties, mesic prairies are now extremely rare because the high quality of their soils and the flat or rolling terrain make these areas outstanding for cultivation.

   The wet-mesic prairie was a grassland community intermediate between the wet and mesic prairies. As with the wet prairie, a poorly drained clay or gley layer may impede internal drainage on wet-mesic prairie soils. Typical plant species in the wet-mesic prairie included prairie cordgrass, Canada bluejoint grass, big bluestem grass, Canada wild rye, compass plant, prairie dock, sawtooth sunflower, gray-headed coneflower, stiff goldenrod, azure aster, and wild onion. Historically, wet-mesic prairies have been replaced by southern lowland forests upon cessation of periodic fire. Examples of the once-extensive prairie exist today as remnants along portions of railroad rights-of-way in Racine County.

4. "Wetland vegetation" is an inclusive term that describes a mélange of plant communities on hydric sites, including deep and shallow marshes, sedge meadows, wet prairies, and shrub-carrs. Also included within this category are narrow bands of lowland hardwood trees, such as cottonwoods, willows, and green ashes, that bordered stream reaches. Examples within the watershed today include Schroeder Marsh, Mud Lake Sedge Meadow, and the Des Plaines River Lowlands.

Inventories, including onsite field inspection, of the remaining natural areas that contain examples of the pre-European settlement landscape within the Des Plaines River watershed were conducted by the Commission staff between 1991 and 1993. In addition, the staff conducted a systematic review of its files, pertinent literature, and the Commission 1990 large-scale aerial photography of the watershed and conducted a poll of area biologists and resource managers to determine if any additional natural areas were located within the watershed. The findings of this natural area inventory effort are summarized below.

As set forth in Table 16 and shown on Map 21, 20 natural areas, totaling 1,587 acres, were identified in the watershed. One six-acre natural area is protected under public ownership and one 25-acre natural area is protected under a private conservation ownership; two natural areas, totaling 404 acres, are protected under partial public and private ownership; one 393-acre natural area is protected under partial private, partial public, and partial private conservation ownership; and 15 natural areas, totaling 759 acres, are completely under unprotected private ownership. The 20 natural areas were identified, ranked according to their quality, and classified into one of the following three categories:

1. NA-1 Areas
   NA-1 areas are native biotic communities of statewide significance that contain excellent examples of nearly complete and relatively undisturbed plant and animal communities that are believed to closely resemble those present during pre-European settlement times.

2. NA-2 Areas
   NA-2 areas are native biotic communities that are judged to be of lower than NA-1 significance, perhaps on a county or regional basis. These areas are probably so designated because of evidence of a limited amount of human disturbance. They may also be of a high biotic quality, but of less than the minimum size necessary for an NA-1 ranking. In the future, some NA-2 sites may become of higher significance because of recovery from past disturbance, because of a sudden substantial decrease in the acreage of a once-common type, or after a more detailed inventory.

3. NA-3 Areas
   NA-3 areas are native biotic communities substantially altered by human activities, but yet of local natural area significance. These sites often contain excellent wildlife habitat and also provide refuge for a large number of native plant species that no longer exist in the surrounding region because of land use activities.

Specifically, the classification of an area into one of the foregoing categories is based upon consideration of the diversity of plant and animal species and community types present; the expected structure and integrity of the native plant or animal community; the extent of disturbance from human activities, such as logging, grazing, water-level changes, and pollution; the commonness of the plant and animal communities present; any unique natural features within the area; and the size of the area.

One natural area within the Des Plaines River watershed was ranked NA-1; eight natural areas were ranked NA-2; and 11 natural areas were ranked NA-3. Most of the natural area acreage, 981 acres, or 62 percent, was under private ownership; 388 acres, or 24 percent, were under public ownership; and 218 acres, or 14 percent, were protected through private conservation organizations. The total of 1,587 acres included within designated natural areas represents less than 2 percent of the watershed.

As noted above, in 1836 the largest portion of the Des Plaines River watershed was covered by oak forests (see Table 17). This plant community type covered 43 percent of the watershed, followed by prairies, covering 26 percent; oak savannas, covering 17 percent; and wetlands, covering 14 percent. By 1990, only 13.6 percent of the watershed was covered by natural vegetation. Wetlands and forests accounted for 99.6 percent of this vegetation. The remaining 0.4 percent of the current natural vegetation could be classified as prairie; this represents only 0.2 percent of the original prairies of the watershed. Oak savannas are essentially nonexistent in the watershed today.

The identified natural areas in the Des Plaines River watershed were also classified by the dominant type or types of vegetation present. The four categories used above to describe pre-European settlement vegetation were generally used to classify the existing vegetation. Based on this classification, wetlands represent the dominant

Table 16

KNOWN NATURAL AREAS IN THE DES PLAINES RIVER WATERSHED: 1997

Reference Number on Map 21	Area Name	Classification Code[a]	Location	Ownership	Size (acres)	Description and Comments
K10	Merkt Woods	NA-2	T1N, R21E Sections 8, 17 Town of Bristol	Private	88	A relatively large, good-quality dry-mesic woods, dominated by oaks but with numerous smaller ashes, basswoods, and yellowbud hickories. The ground flora is diverse. One of the larger intact woods in this part of the Region
K11	Benedict Prairie	NA-2 (RSH)	T1N, R21E Section 11 Town of Bristol	University of Wisconsin-Milwaukee	6	A small, but rich, wet-mesic to mesic prairie remnant located along an abandoned railroad right-of-way. The site is burned periodically to reduce weedy invaders
K12	Bristol Woods	NA-2 (RSH)	T1N, R21E Sections 21, 22 Town of Bristol	Kenosha County and private	180	The largest block of woods remaining in this part of the Region. This is a rich and diverse xeric to dry-mesic woods that is recovering from past grazing and selective cutting. Important as nesting habitat for forest-interior-breeding birds
K13	Mud Lake Sedge Meadow	NA-2 (RSH)	T1N, R21E Section 32 Town of Bristol	Private	47	Good-quality wetland complex consisting of shallow marsh, sedge meadow, low prairie, fresh (wet) meadow, and shrub-carr. Species diversity is good, including a number of uncommon species
K18	Friendship Lake Marsh	NA-2	T2N, R20E Sections 12, 13 Town of Brighton	Private	116	Large cattail marsh and sedge meadow surrounding a small, but good-quality, kettle lake. Valuable feeding and nesting habitat for a variety of marshland birds. Recent shoreline construction activities have lowered the ecological value
K20	Harris Marsh and Oak Woods	NA-2	T2N, R20E Section 36 Town of Brighton T2N, R21E Section 31 Town of Paris	University of Wisconsin-Parkside and private	224	A large, good-quality marsh adjacent to Brighton Creek. A grazed former oak opening forms the eastern upland border
K23	Hooker Lake Marsh	NA-3	T1N, R20E Section 11 Town of Salem	Private	45	Deep and shallow cattail marsh on the northwest side of Hooker Lake
K24	Montgomery Lake Marsh	NA-3	T1N, R20E Sections 12, 13 Town of Salem	Private	43	Cattail-dominated deep and shallow marsh bordering Montgomery Lake
K26	Des Plaines River Wetlands	NA-3	T1N, R21E Sections 12, 13 Town of Bristol	Private	64	A one-mile stretch of the Des Plaines River west of IH 94. Wetlands include sedge meadow, shallow marsh, and lowland hardwoods
K27	Salem Road Marsh	NA-3	T1N, R21E Section 18 Town of Bristol	Conservation Club of Kenosha	25	Shallow, cattail-dominated marsh
K28	Lake Russo Prairie Remnant	NA-3 (RSH)	T1N, R22E Section 7 Village of Pleasant Prairie	Private	6	A small, moderate- to good-quality wet-mesic prairie remnant that is suffering disturbance by local residents
K29	Des Plaines River Lowlands	NA-3 (RSH)	T1N, R22E Sections 17, 18, 19, 20 Village of Pleasant Prairie	The Nature Conservancy, Village of Pleasant Prairie, and private	393	Extensive wetland and upland complex along the Des Plaines River, significant because of its open space and wildlife habitat. Contains xeric, or dry, oak woods, mesic and wet-mesic prairie, fresh (wet) meadow, and riverine forest. The State-designated endangered prairie white-fringed orchid (*Platanthera leucophaea*) has been found here
K30	Bain Station Railroad Prairie	NA-3 (RSH)	T1N, R22E Section 9 Village of Pleasant Prairie	Private	6	A small, moderate- to good-quality mesic to wet-mesic prairie remnant along an abandoned railroad right-of-way. Dominated by big bluestem, Indian grass, prairie dock, and goldenrods
K31	Pleasant Prairie Railroad Prairie	NA-3 (RSH)	T1N, R222 Sections 29, 32 Village of Pleasant Prairie	Private	5	Discontinuous remnants of the once-extensive wet-mesic prairie of southern Kenosha County, bordering double tracks. Small patches are of good quality, containing some regionally uncommon species
K35	Section 11 Wetlands and Oak Woods	NA-3	T2N, R20E Sections 11, 12 Town of Brighton	Private	130	A moderate-quality wetland complex, consisting of sedge meadow and cattail marsh, bordered by a disturbed oak woods

Table 16 (continued)

Reference Number on Map 21	Area Name	Classification Code[a]	Location	Ownership	Size (acres)	Description and Comments
K37	Paris (Ehlen) Prairie Remnant	NA-3 (RSH)	T2N, R21E Section 16 Town of Paris	Private	1	A small but generally good-quality remnant of the once-extensive mesic prairie that formerly occupied central Kenosha County. Critical plant species are present
R4	Kansasville Railroad Prairie (partial)	NA-1 (RSH)	T3N, R20E Section 25 Town of Dover T3N, R21E Section 30 Town of Yorkville	Private	7	Discontinuous remnants of mesic prairie located along railroad right-of-way between Union Grove and Kansasville. Small sections are of very high quality, representing the best remaining examples of the once-extensive mesic prairie of central Racine and Kenosha Counties
R12	Schroeder Road Marsh	NA-2	T3N, R20E Section 35 Town of Dover T2N, R20E Section 2 Town of Brighton	Private	75 (plus 109 in Kenosha County)	Large wetland area of shallow cattail marsh and sedge meadow that extends into Kenosha County. Perimeter has been disturbed but interior is intact
R13	Union Grove Railroad Prairie	NA-2 (RSH)	T3N, R21E Sections 25, 26 Town of Yorkville	Private	10	Discontinuous remnants of mesic prairie along railroad right-of-way, extending east from Union Grove to IH 94. Some small patches are of very good quality, containing such uncommon species as wild quinine (*Parthenium integrifolium*) and prairie Indian plantain (*Cacalia tuberosa*), both designated as Athreatened@ in Wisconsin
R40	Sylvania Railroad Prairie	NA-3 (RSH)	T3N, R22E Sections 20, 30 Town of Mt. Pleasant	Private	7	Mesic prairie remnant extending one mile east of IH 94 along railroad right-of-way. Moderate quality, with a good population of wild quinine (*Parthenium integrifolium*), a State-designated threatened species

[a]NA-1 identifies natural area sites of statewide or greater significance
NA-2 identifies natural area sites of countywide or regional significance
NA-3 identifies natural area sites of local significance
RSH, or Rare Species Habitat, identifies those sites which support rare, threatened, or endangered animal or plant species officially designated by the Wisconsin Department of Natural Resources

Source: Wisconsin Department of Natural Resources and SEWRPC.

type of vegetation in the remaining natural areas of the watershed, occupying about 1,109 acres, or 1.3 percent of the total area of the watershed (see Table 17). Clearly, only small remnants of the once extensive and diverse pre-European settlement vegetation of the Des Plaines River watershed remain. Approximately 13.7 percent of the existing natural vegetation is included within designated natural areas, including 9 percent of the existing forests, 16.4 percent of the existing wetlands, and 100 percent of the existing prairies. To the extent practicable, these remnants should be protected and maintained in an essentially natural state.

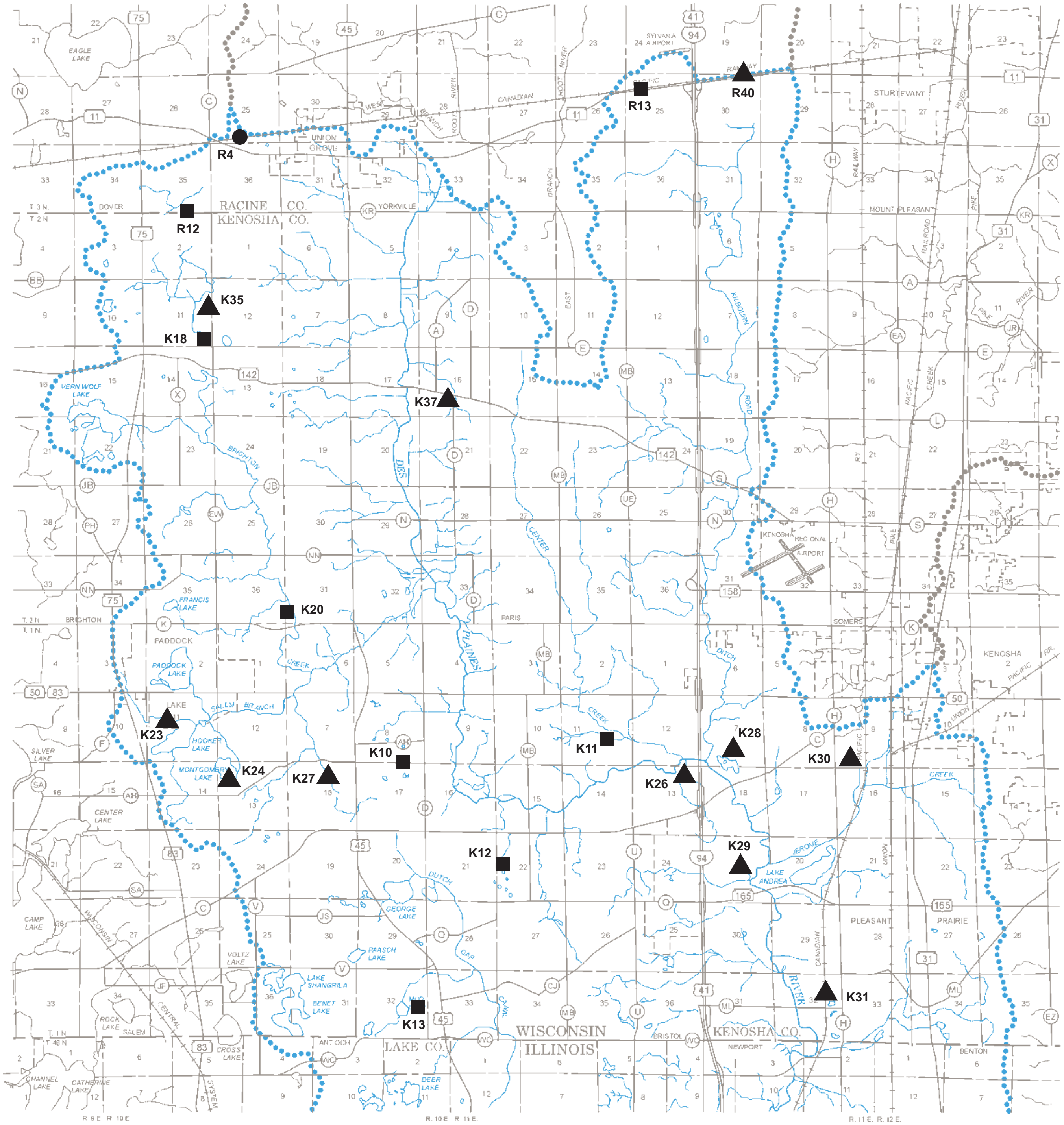
Existing Woodlands

As shown on Map 22 and in Table 18, woodlands in the Des Plaines River watershed cover about 4,760 acres, or about 5.6 percent of the total area of the watershed. Distributed in small stands throughout the watershed, these woodlands provide an attractive natural resource of immeasurable value. These woodlands accentuate the beauty of the stream system and the topography of the watershed and are essential to the maintenance of the overall quality of the environment in the watershed. It is important to note that for watershed planning purposes, all lowland wooded areas, such as wet to wet-mesic hardwoods areas, have been classified as wetlands and are described in the following section of this chapter.

A demand for the conversion to urban uses of the remaining woodland areas within the watershed may be expected, especially for residential development. Real estate interests tend to acquire scenic woodland areas for

Map 21

KNOWN NATURAL AREAS IN THE DES PLAINES RIVER WATERSHED: 1997



- ● NATURAL AREA OF STATEWIDE OR GREATER SIGNIFICANCE (NA-1)
- ■ NATURAL AREA OF COUNTYWIDE OR REGIONAL SIGNIFICANCE (NA-2)
- ▲ NATURAL AREA OF LOCAL SIGNIFICANCE (NA-3)
- **K21** SITE DESIGNATION (SEE TABLE 16). LETTER DESIGNATES KENOSHA OR RACINE COUNTY. NUMBERS ARE THOSE ASSIGNED FOR SEWRPC.

GRAPHIC SCALE

0 ½ 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

Natural areas, totaling 1,587 acres, were identified in the watershed. Five sites, comprising about 52 percent of that area, are protected under either public or private conservation ownership. The remaining 15 sites, comprising 48 percent; are under unprotected private ownership.

Source: SEWRPC.

Table 17

COMPARISON OF PRE-EUROPEAN SETTLEMENT (1836) WITH 1990 VEGETATION IN THE DES PLAINES RIVER WATERSHED

Vegetation Type	Number of Acres in 1836	Percent of Total Watershed Area (1836)	Number of Acres in 1990	Percent of Total Watershed Area (1990)	Number of Acres within Natural Areas in 1990	Percent of the 1836 Area That Was within Natural Areas in 1990	Percent of the 1990 Area That Was within Natural Areas in 1990
Forest	36,402[a]	43	4,760[b]	5.60	427	1.2	9.0
Oak Savanna	14,755	17	0	0.00	0	0.0	- -
Prairie	22,326	26	51	0.06	51	0.2	100.0
Wetlands	11,600	14	6,750	7.93	1,109	9.6	16.4
Total	85,083	100	11,561	13.59	1,587	1.9	13.7

[a]*Oak forest.*

[b]*Includes conifer plantations.*

Source: SEWRPC.

such development, this trend may be expected to accelerate. Severe damage to woodland areas has resulted where developers have subdivided woodland tracts into small urban lots and removed trees to develop subdivisions. Remaining trees are often seriously weakened through the loss of a large portion of the root system or compaction of the soils beneath the tree canopy. It is important to note that woodlands can be substantially preserved during land subdivision through careful construction practices and good subdivision layout and design. However, in the absence of good planning and plan implementation, there is no guarantee that such preservation will take place.

The overall quality of life within the watershed will be greatly influenced by the quality of the environment, as measured in terms of clean air, clean water, scenic beauty, and natural diversity. Woodlands contribute to clean air and water and to the maintenance of a diversity of plant and animal life in association with human life. The existing woodlands of the watershed, which required a century or more to develop, can be destroyed through mismanagement within a comparatively short period of time. Accordingly, careful attention should be given in the urban planning and development process to the preservation and proper management of the remaining woodlands of the Des Plaines River watershed as an important element of the natural resource base.

Existing Wetlands

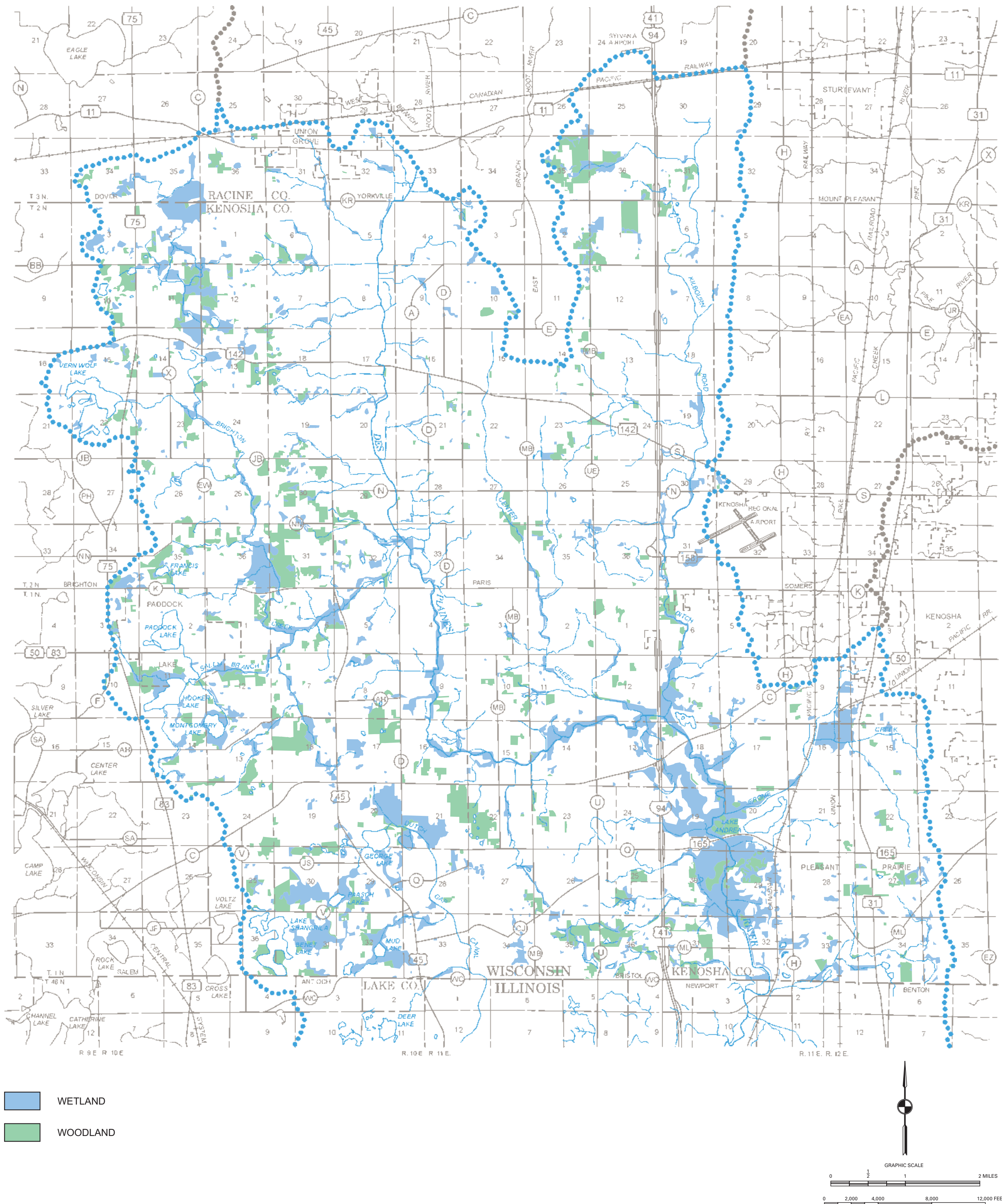
Wetland vegetation typically includes sedges, rushes, cat tails, red-osier dogwoods, and willows. All remaining wetlands within the watershed have been identified by the Southeastern Wisconsin Regional Planning Commission and are shown on Map 22. The total acreage of wetland areas in the watershed over time is set forth in Table 19. Wetlands within the Des Plaines River watershed include deep and shallow marshes, southern sedge meadows, fresh (wet) meadows, wet prairies, shrub-carrs, and southern wet to wet-mesic lowland hardwood acres. Wetlands in the watershed currently cover about 6,750 acres, or 7.9 percent of the total area of the watershed.

Water and wetland areas probably constitute the most important landscape feature within the watershed and can serve to enhance all proximate uses. Their contribution to resource conservation and recreation within the watershed is immeasurable. Recognizing the desirable attributes of wetland areas, continued efforts should be made to protect this resource by discouraging wetland draining, filling, and conversion to incompatible agricultural and urban uses, all costly, both in monetary and environmental terms. Wetlands have an important set of common natural functions that make them ecologically and environmentally valuable resources.

Wetlands affect the quality of water. Aquatic plants change such inorganic nutrients as phosphorus and nitrogen into organic material, storing it in their leaves or in peat, which is composed of plant remains. The stems, leaves,

Map 22

WOODLANDS AND WETLANDS IN THE DES PLAINES RIVER WATERSHED: 1990



Woodlands and wetlands cover about 6 and 8 percent, respectively, of the total area of the watershed. Prior to settlement by Europeans, woodlands covered about 60 percent and wetlands about 14 percent of the total area of the watershed.

Source: SEWRPC.

Table 18

WOODLAND AREAS IN THE DES PLAINES RIVER WATERSHED: 1963, 1970, 1980, AND 1990

Civil Division	Woodland Area								Woodland Area Change					
	1963		1970		1980		1990		1963-1970		1970-1980		1980-1990	
	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent	Acreage	Percent	Acreage	Percent
Kenosha County														
City														
Kenosha....................	49	1.0	49	1.1	49	1.1	52	1.1	0	0.0	0	0.0	3	6.1
Villages														
Paddock Lake	74	1.5	58	1.2	58	1.3	61	1.3	-16	-21.6	0	0.0	3	5.2
Pleasant Prairie	650	13.6	617	13.3	584	12.7	599	12.6	-33	-5.1	-33	-5.3	15	2.6
Towns														
Brighton....................	756	15.8	726	15.7	738	16.0	764	16.0	-30	-4.0	12	1.7	26	3.5
Bristol	1,485	30.9	1,450	31.3	1,446	31.4	1,426	30.0	-35	-2.4	-4	-0.3	-20	-1.4
Paris..........................	991	20.6	951	20.5	929	20.2	1,005	21.1	-40	-4.0	-22	-2.3	76	8.2
Salem........................	409	8.5	404	8.7	406	8.8	449	9.4	-5	-1.2	2	0.5	43	10.6
Somers	23	0.5	20	0.4	43	0.9	44	0.9	-3	-13.0	23	115.0	1	2.3
Subtotal	4,437	92.4	4,275	92.2	4,253	92.4	4,400	92.4	-162	-3.7	-22	-0.5	147	3.5
Racine County														
Village														
Union Grove.............	5	0.1	5	0.1	9	0.2	9	0.2	0	0.0	4	80.0	0	0.0
Towns														
Dover	69	1.4	66	1.4	64	1.4	64	1.3	-3	-4.3	-2	-3.0	0	0.0
Mt. Pleasant..............	37	0.8	35	0.8	35	0.8	35	0.8	-2	-5.4	0	0.0	0	0.0
Yorkville....................	255	5.3	254	5.5	240	5.2	252	5.3	-1	-0.4	-14	-5.5	12	5.0
Subtotal	366	7.6	360	7.8	348	7.6	360	7.6	-6	-1.6	-12	-3.3	12	3.4
Total	4,803	100.0	4,635	100.0	4,601	100.0	4,760	100.0	-168	-3.5	-34	-0.7	159	3.5

Source: SEWRPC.

Table 19

WETLAND AREAS IN THE DES PLAINES RIVER WATERSHED: 1963, 1970, 1980 AND 1990

Civil Division	Wetland Area								Wetland Area Change					
	1963		1970		1980		1990		1963 -1970		1970-1980		1980 -1990	
	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent of Total	Acreage	Percent	Acreage	Percent	Acreage	Percent
Kenosha County														
City														
Kenosha.....................	84	1.2	94	1.3	94	1.4	83	1.2	10	11.9	0	0.0	-11	-11.7
Villages														
Paddock Lake	76	1.0	76	1.1	74	1.1	73	1.1	0	0.0	-2	-2.6	-1	-1.4
Pleasant Prairie	2,007	27.6	2,014	28.3	1,945	28.4	1,982	29.4	7	0.3	-69	-3.4	37	1.9
Towns														
Brighton.....................	1,167	16.0	1,061	14.9	1,003	14.6	990	14.7	-106	-9.1	-58	-5.5	-13	-1.3
Bristol	2,296	31.6	2,355	33.1	2,222	32.4	2,199	32.5	59	2.6	-133	-5.6	-23	-1.0
Paris...........................	910	12.5	760	10.7	730	10.7	633	9.4	-150	-16.5	-30	-3.9	-97	-13.3
Salem	324	4.5	327	4.6	335	4.9	326	4.8	3	0.9	8	2.4	-9	-2.7
Somers	103	1.4	107	1.5	135	2.0	139	2.1	4	3.9	28	26.2	4	3.0
Subtotal	6,967	95.8	6,794	95.5	6,538	95.5	6,425	95.2	-173	-2.5	-256	-3.8	-113	-1.7
Racine County														
Village														
Union Grove..............	6	0.1	6	0.1	6	0.1	7	0.1	0	0.0	0	0.0	1	16.7
Towns														
Dover	145	2.0	150	2.1	160	2.3	165	2.4	5	3.4	10	6.7	5	3.1
Mt. Pleasant	26	0.3	26	0.4	17	0.3	18	0.3	0	0.0	-9	-34.6	1	5.9
Yorkville.....................	130	1.8	137	1.9	125	1.8	135	2.0	7	5.4	-12	-8.8	10	8.0
Subtotal	307	4.2	319	4.5	308	4.5	325	4.8	12	3.9	-11	-3.4	17	5.5
Total	7,274	100.0	7,113	100.0	6,846	100.0	6,750	100.0	-161	-2.2	-267	-3.8	-96	-1.4

Source: SEWRPC.

and roots of these plants also slow the flow of water through a wetland, allowing the silt and other sediment to settle out. Wetlands thus help to protect downstream water resources from siltation and pollution. Wetlands influence the quantity of water. They act to retain water during dry periods and to hold it back during wet weather, thereby stabilizing stream flows and controlling flooding. At a depth of 12 inches, an acre of marsh is capable of holding more than 325,000 gallons of water; it thus helps protect communities against flooding. Wetlands may serve as groundwater recharge and discharge areas.

Wetlands also are important resources for overall ecological health and diversity. They provide essential breeding, nesting, resting, and feeding grounds and provide escape cover for many forms of fish and wildlife. The water present in a wetland is also attractive to upland birds and other animals. These functions give wetlands recreational, research, and educational values; support activities such as trapping, hunting, and fishing; and add aesthetic value to the community.

Table 20

CRITICAL PLANT SPECIES KNOWN TO OCCUR WITHIN THE DES PLAINES RIVER WATERSHED OF WISCONSIN

Endangered Species[a]
Purple milkweed (*Asclepias purpurascens*)
Prairie white-fringed orchid (*Platanthera leucophaea*)[b]
Threatened Species
Sullivant's milkweed (*Asclepias sullivantii*)
Prairie Indian plantain (*Cacalia tuberosa*)
Wild quinine (*Parthenium integrifolium*)
Special Concern Species
Swamp agrimony (*Agrimonia parviflora*)
Downy willow-herb (*Epilobium strictum*)
Marsh blazing-star (*Liatris spicata*)
Waxy meadow-rue (*Thalictrum revolutum*)
Red trillium (*Trillium recurvatum*)

[a]*State-designated status.*

[b]*Also listed as "threatened" in United States and "globally imperiled."*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Existing Grasslands

In 1985, grasslands in the Des Plaines River watershed covered about 4,488 acres, or about 5.3 percent of the total watershed area. Grasslands within the Des Plaines River watershed include prairies, oak savannas, planted brome grass fields, prairie-old fields, and some shrub thicket-grassland complexes, provided the grassland component constitutes 50 percent or more of the vegetative cover. The location and extent of grasslands are ephemeral, changing significantly from year to year as lands are enrolled in, and removed from, agricultural land management programs; as cropping patterns change; and as lands are developed for urban uses. It is important to note that for watershed planning purposes, all lowland grasslands, such as wet to wet-mesic prairies and disturbed fresh (wet) meadows dominated by reed canary grass (Phalaris arundinacea), have been classified as wetlands and have been described in the preceding section of this chapter.

Grasslands provide an attractive resource of immeasurable value. The grasslands of the watershed accentuate the beauty of the watershed topography and are essential to the maintenance of the overall environmental quality of the watershed. As noted above, the overall quality of life within the watershed will be greatly influenced by the quality of the environment, as measured in terms of clean air, clean water, scenic beauty, and natural diversity. Grasslands contribute to clean water and to the maintenance of a diversity of plant and animal life in association with human life. Specifically, grasslands protect the land from erosion by stabilizing the soil and filtering sediment and nutrients during storm events. Further, grasslands provide a unique habitat for a wide variety of rangeland-related species, including grassland-nesting birds, ground squirrels, pheasant, badgers, coyotes, and deer. The existing grasslands and their functions, however, can be destroyed or impaired through mismanagement within a single growing season. For example, grasslands plowed under or cut before mid-June may adversely affect grassland-nesting birds, such as meadowlarks, bobolinks, dickcissels, grasshopper sparrows, and horned larks. Accordingly, careful attention should be given in both the urban planning and development process and the agricultural land management process to the preservation and proper management of the remaining grasslands of the Des Plaines River watershed as an important element of the natural resource base.

Critical Plant Species

Ten critical vascular plant species have been located within the watershed (see Table 20). As designated by the Wisconsin Department of Natural Resources, two of these have been classified as endangered, three as threatened, and five as "special-concern," or "watch," species.

Water Resources

Surface-water resources, streams and their associated floodlands, form the most important element of the natural resource base of the watershed. Their contribution to the economic development, recreational activity, and aesthetic quality of the watershed is immeasurable. The groundwater resources of the Des Plaines River watershed are hydraulically connected to the surface-water resources inasmuch as the former provide the base flow of streams. The groundwater resources constitute the major sources of supply for domestic, municipal, and industrial water users. Indeed, together with the abatement of flooding, the protection, enhancement, and proper development of these invaluable water resources constitute the basis for mounting the Des Plaines River watershed study.

Surface-Water Resources

The surface-water resources of the Des Plaines River watershed, as identified in 1994, consist of lakes, streams, and ponds. There are 18 lakes and ponds greater than two acres in area within the watershed, of which only six lakes are greater than 50 acres in area and are capable of supporting a variety of recreational uses. As set forth in Table 21, the total surface area of these six lakes is 667 acres, or less than 1 percent of the total watershed area. Ponds and other surface waters are present in even smaller proportions, totaling only 169 acres in area within the watershed. These lakes and smaller bodies of water provide residents of the watershed and persons from outside the watershed with a variety of aesthetic and recreational opportunities and also serve to stimulate the local economy by attracting recreational users.

Streams

One of the most interesting, variable, and, occasionally, unpredictable, features of the watershed is its stream system, with its ever-changing, sometimes widely fluctuating, discharges and stages. The stream system of the watershed receives a relatively uniform flow of water from the shallow groundwater reservoir underlying the watershed. This groundwater discharge constitutes the base flow of the streams. Agricultural drain tiles also contribute to this base flow. The streams also periodically receive surface-water runoff from rainfall and snowmelt. This runoff, superimposed on the base flow, sometimes causes the streams to leave their channels and occupy the adjacent floodplains. The volume of water drained annually from the watershed by the stream system is equivalent to about 11 inches of water spread over the watershed, about one-third of the average annual precipitation.

Perennial streams are here defined as those streams which maintain at least a small continuous flow throughout the year except under unusual drought conditions. Intermittent streams are those streams which do not maintain a continuous flow throughout the year in any case other than the exception noted in the above definition of perennial streams. There are 69.1 miles of perennial streams within the watershed. The detailed study of portions of the perennial and intermittent stream system within the watershed constitutes an important element of the watershed planning effort; subsequent chapters of this report develop and describe the important interrelationships between the stream system and other natural and built elements of the watershed. As shown on Map 23 and listed in Table 22, 66.2 miles of perennial streams and 42.5 miles of intermittent streams were analyzed under this study.

The source of the Des Plaines River is in the southwest one-quarter of U.S. Public Land Survey Section 33, Township 3 North, Range 21 East, in the Town of Yorkville, just north of the Racine-Kenosha county line and about 0.75 mile east of the Village of Union Grove. From its source, the River flows in a generally southerly direction for approximately 12.2 miles, to about the center of Section 16, Township 1 North, Range 21 East, in the Town of Bristol; then easterly for about four miles, to its confluence with the Kilbourn Road Ditch just east of IH 94-USH 41 in the Village of Pleasant Prairie; and finally southerly for approximately 5.6 miles, to the Wisconsin-Illinois state line. The River has a perennial stream length of about 20.5 miles.

The origin of Jerome Creek is in the northeast one-quarter of Section 22, Township 1 North, Range 22 East, in the Village of Pleasant Prairie, just south of 93rd Street. The entire length of the Creek is in the Village of Pleasant Prairie. From its origin, the Creek flows about 0.7 mile in a generally northerly direction; then westerly for about 1.9 miles, crossing STH 31 and the Union Pacific Railroad line; then southwesterly for about two miles, to its confluence with the Des Plaines River one-quarter mile north of Kenosha County CTH Q. The Creek has a perennial stream length of about 1.7 miles.

Table 21

PHYSICAL CHARACTERISTICS OF MAJOR LAKES IN THE DES PLAINES RIVER WATERSHED

Lake Name	Surface Area (acres)	Tributary Drainage Area[a] (acres)	Shoreline (miles)	Maximum Depth (feet)	Mean Depth (feet)	Volume (acre-feet)
Benet Lake/Lake Shangrila	186[b]	593	6.20	24	4.7	874.0
Vern Wolf Lake	123	973	3.07	NA	NA	NA
George Lake	59	2,246	1.18	16	6.4	389.4
Hooker Lake	87	1,331	1.90	24	11.3	983.0
Paddock Lake	112	403	3.42	32	11.4	1,277.0
Andrea Lake	100	168	2.10	NA	NA	NA
Total	667	5,714	17.87	- -	- -	3,523.4

NOTE: "N/A" indicates data are not available.

[a]*Includes lake area.*

[b]*Includes six acres in Illinois.*

Source: SEWRPC.

The source of Kilbourn Road Ditch is located about one-half mile east of IH 94-USH 41 in the southwest one-quarter of Section 30, Township 3 North, Range 22 East, Town of Mt. Pleasant, Racine County. From there, the stream flows southerly along IH 94-USH 41 for about 12.6 miles, to its confluence with the Des Plaines River in the southwest one-quarter of Section 7, Township 1 North, Range 22 East, in the Village of Pleasant Prairie. The entire length of the stream is classified as perennial.

Center Creek has its origin on the one-quarter section line between the northeast and northwest one-quarters of Section 15, Township 2 North, Range 21 East, Town of Paris. From its origin it flows southerly for about 5.5 miles, to STH 50; then southeasterly for about two miles, to its confluence with the Des Plaines River, just west of IH 94-USH 41 in the southeast one-quarter of Section 12, Township 1 North, Range 21 East, Town of Bristol. The Creek has a perennial stream length of about 5.6 miles.

The origin of Brighton Creek is in the northeast one-quarter of Section 14, Township 2 North, Range 20 East, Town of Brighton. From its origin, the Creek flows about six miles in a generally southerly direction, to its confluence with the Salem Branch of Brighton Creek in the southwest one-quarter of Section 6, Township 1 North, Range 21 East, Town of Bristol; then about three miles in a generally northeasterly direction, to its confluence with the Des Plaines River in the southwest one-quarter of Section 33, Township 2 North, Range 21 East. Brighton Creek has a perennial stream length of about nine miles.

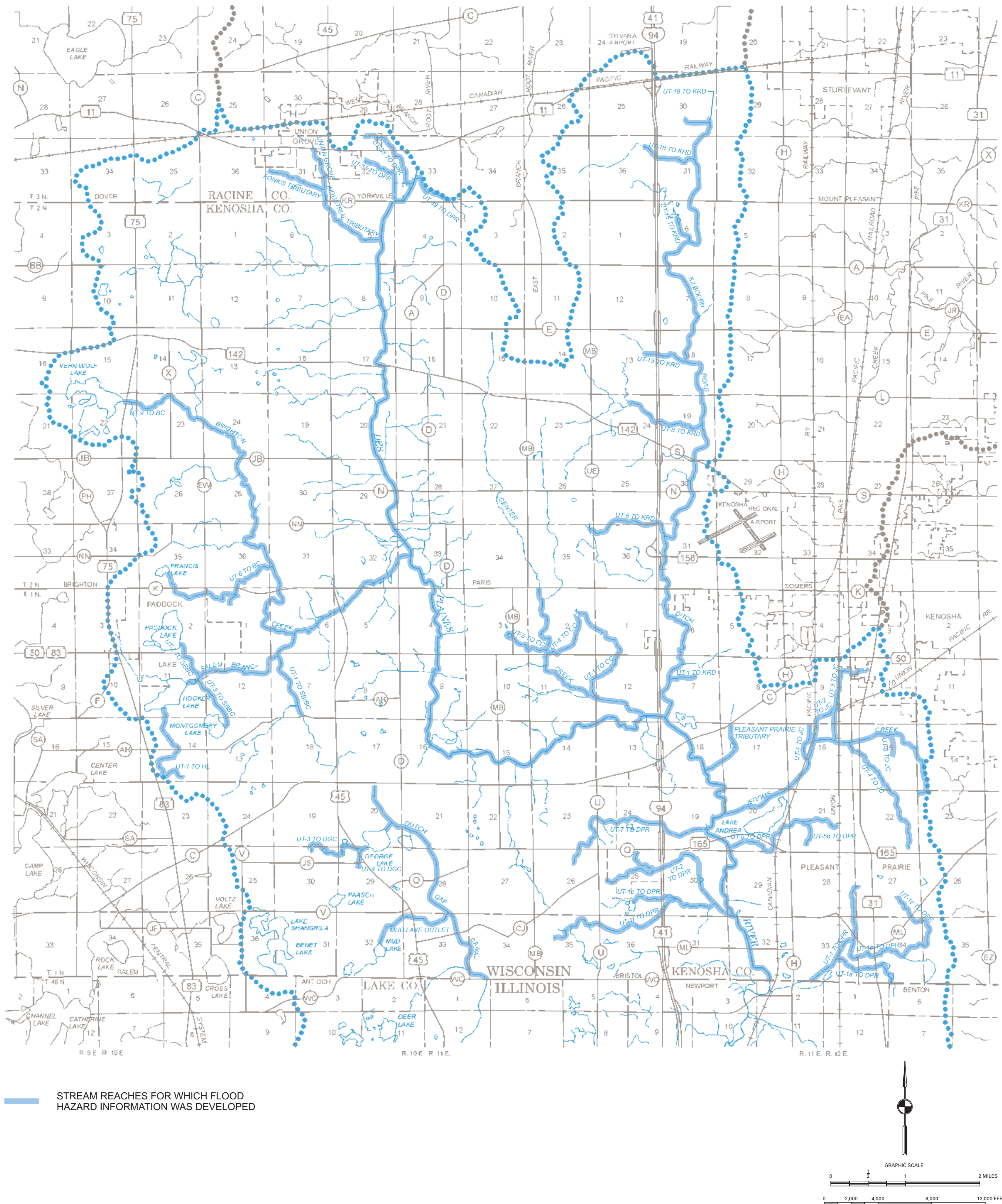
The Dutch Gap Canal, which originates in the northeast one-quarter of Section 20, Township 1 North, Range 21 East, Town of Bristol, has a perennial stream length of 4.1 miles. The Canal flows in a generally southerly direction into Lake County, Illinois, where it is known as North Mill Creek and, farther downstream, as Mill Creek.

Floodlands

The natural floodplain of a river is a wide, flat-to-gently sloping area contiguous with, and usually lying on both sides of, the channel. The floodplain, which is normally bounded on its outer edges by higher topography, is gradually formed over a long period of time by the river during flood stage as that river meanders in the floodplain, continuously eroding material from concave banks of meandering loops while depositing it on the

Map 23

STREAM REACHES FOR WHICH FLOOD HAZARD INFORMATION WAS DEVELOPED



Under the watershed study, flood hazard information was developed for 66.2 miles of perennial streams and 42.5 miles of intermittent streams.

Source: SEWRPC.

Table 22

STREAMS IN THE DES PLAINES RIVER WATERSHED

Stream or Watercourse	Upstream Limit of Study Reach	Total Perennial Stream Length (miles)[a]	Length of Stream Included under Federal Flood Insurance Study and Included under the Watershed Study (miles)		Additional Length of Stream Included under the Watershed Study (miles)	
	Civil Division		Perennial	Intermittent	Perennial	Intermittent
Des Plaines River	Town of Yorkville	20.5	20.3	- -	0.2	1.2
Unnamed Tributary No. 1 to Des Plaines River	Village of Pleasant Prairie	- -	- -	0.7	- -	1.6
Unnamed Tributary No. 1a to Des Plaines River	Village of Pleasant Prairie	- -	- -	- -	- -	1.2
Unnamed Tributary No. 1b to Des Plaines River	Village of Pleasant Prairie	- -	- -	- -	- -	1.1
Unnamed Tributary No. 1c to Des Plaines River	Village of Pleasant Prairie	- -	- -	- -	- -	1.5
Unnamed Tributary No. 1e to Des Plaines River	Town of Bristol	1.3	- -	- -	1.3	1.3
Unnamed Tributary No. 1f to Des Plaines River	Town of Bristol	0.6	- -	- -	0.6	0.4
Unnamed Tributary No. 2 to Des Plaines River	Town of Bristol	0.3	- -	- -	0.3	2.3
Unnamed Tributary No. 2a to Des Plaines River	Town of Bristol	- -	- -	- -	- -	0.5
Unnamed Tributary No. 5 to Des Plaines River	Village of Pleasant Prairie	1.3	- -	- -	1.3	0.9
Unnamed Tributary No. 5b to Des Plaines River	Village of Pleasant Prairie	- -	- -	- -	- -	0.4
Unnamed Tributary No. 7 to Des Plaines River	Town of Bristol	0.2	- -	- -	0.2	1.7
Unnamed Tributary No. 37 to Des Plaines River[b]	Village of Union Grove	- -	- -	0.4[c]	- -	0.4
Unnamed Tributary No. 38 to Des Plaines River	Village of Union Grove	- -	- -	0.6[d]	- -	0.6
Unnamed Tributary No. 39 to Des Plaines River	Town of Paris	- -	- -	0.7[d]	- -	- -
Pleasant Prairie Tributary	Village of Pleasant Prairie	0.8	- -	- -	0.8	0.5
Union Grove Industrial Tributary[e]	Village of Union Grove	- -	- -	0.9[f]	- -	1.3
Fonk's Tributary	Village of Union Grove	- -	- -	0.3[d]	- -	0.4
Jerome Creek	Village of Pleasant Prairie	1.7	1.7[d]	2.1	- -	0.8
Unnamed Tributary No. 1 to Jerome Creek	Village of Pleasant Prairie	0.4	0.4[d]	0.3[d]	- -	- -
Unnamed Tributary No. 2 to Jerome Creek	Village of Pleasant Prairie	- -	- -	0.8[d]	- -	- -
Unnamed Tributary No. 3 to Jerome Creek	Village of Pleasant Prairie	- -	- -	0.7[d]	- -	0.8
Unnamed Tributary No. 4 to Jerome Creek	Village of Pleasant Prairie	- -	- -	0.1	- -	1.9
Unnamed Tributary No. 5 to Jerome Creek	Village of Pleasant Prairie	- -	- -	0.3[d]	- -	- -
Kilbourn Road Ditch	Town of Mt. Pleasant	12.6	12.6[g]	- -	- -	- -
Unnamed Tributary No. 1 to Kilbourn Road Ditch	Village of Pleasant Prairie	0.1	- -	- -	0.1	0.6
Unnamed Tributary No. 5 to Kilbourn Road Ditch	Town of Paris	- -	- -	- -	- -	0.9
Unnamed Tributary No. 8 to Kilbourn Road Ditch	Town of Paris	- -	- -	- -	- -	0.8
Unnamed Tributary No. 13 to Kilbourn Road Ditch	Town of Paris	- -	- -	- -	- -	0.5
Unnamed Tributary No. 15 to Kilbourn Road Ditch	Town of Somers	1.1	0.4	- -	- -	- -
Unnamed Tributary No. 18 to Kilbourn Road Ditch	Town of Yorkville	1.0	0.7	- -	- -	- -
Unnamed Tributary No. 19 to Kilbourn Road Ditch	Town of Mt. Pleasant	0.1	0.1	- -	- -	- -
Center Creek	Town of Paris	5.6[h]	3.7[d]	- -	- -	- -
Unnamed Tributary No. 1 to Center Creek	Town of Bristol	- -	- -	- -	- -	2.2
Unnamed Tributary No. 4 to Center Creek	Town of Bristol	- -	- -	- -	- -	1.0
Unnamed Tributary No. 5 to Center Creek	Town of Bristol	- -	- -	- -	- -	0.8
Brighton Creek	Town of Brighton	9.0	9.0[i]	- -	- -	- -
Salem Branch of Brighton Creek	Town of Salem	2.4	0.3[d]	- -	2.1	- -
Unnamed Tributary No. 1 to Salem Branch of Brighton Creek	Town of Bristol	1.1	- -	- -	1.1	1.0
Unnamed Tributary No. 2 to Salem Branch of Brighton Creek	Village of Paddock Lake	0.8	- -	- -	0.8	- -
Unnamed Tributary No. 3 to Salem Branch of Brighton Creek	Town of Salem	- -	- -	- -	- -	0.7
Unnamed Tributary No. 1 to Hooker Lake	Town of Salem	- -	- -	- -	- -	1.9
Unnamed Tributary No. 6 to Brighton Creek	Village of Paddock Lake	0.7	- -	- -	0.7	1.8
Unnamed Tributary No. 9 to Brighton Creek	Town of Brighton	1.4	1.4	- -	- -	- -
Dutch Gap Canal	Town of Bristol	4.1	4.1[d]	- -	- -	- -
Mud Lake Outlet	Town of Bristol	1.4	1.4[j]	- -	- -	- -
Unnamed Tributary No. 3 to Dutch Gap Canal	Town of Bristol	0.6	- -	- -	0.6	1.2
Unnamed Tributary No. 4 to Dutch Gap Canal	Town of Bristol	- -	- -	- -	- -	0.4
Total	- -	69.1	56.1[k]	7.9[k]	10.1[k]	34.6[k]

[a] *If not indicated otherwise by footnotes, the stream length was measured from large-scale topographic maps.*

[b] *Designated as Unnamed Tributary No. 2 to the Des Plaines River under the Federal flood insurance study.*

[c] *Of this total, 0.2 mile was delineated based on approximate methods.*

[d] *Floodplain delineated based on approximate methods.*

[e] *Designated as Unnamed Tributary No. 1 to the Des Plaines River under the Federal flood insurance study.*

[f] *Of this total 0.6 mile was delineated based on approximate methods.*

[g] *Of this total, 0.3 mile was delineated based on approximate methods.*

[h] *Total from U.S. Geological Survey 7.5-minute quadrangle maps.*

[i] *6.0 miles delineated based on approximate methods.*

[j] *Of this total, 0.4 mile was delineated based on approximate methods.*

[k] *The total length of stream included under the watershed study is 108.7 miles.*

Source: SEWRPC.

convex banks. A river or stream may be expected to occupy and flow on its floodplain on the average of approximately once every two years and, therefore, the floodplain should be considered to be an integral part of a natural stream system.

How much of the natural floodplain will be occupied by any given flood will depend upon the severity of that flood and, more particularly, upon its elevation, or stage. Thus, an infinite number of outer limits of the natural floodplain may be delineated, each set of limits related to a specified flood recurrence interval. The Southeastern Wisconsin Regional Planning Commission, therefore, has for over 40 years recommended that the natural floodplains of a river or stream be more specifically defined as those lands inundated by a flood having a recurrence interval of 100 years, with the natural floodlands being defined as consisting of the river channel plus the 100-year floodplain. A floodway is that designated portion of the floodlands required to convey the 100-year recurrence interval flood discharge. The floodway, which includes the channel, is that portion of the floodlands least suited for human habitation. All fill, structures, and other development that would impair floodwater conveyance by adversely increasing flood stages or velocities, or would themselves be subject to flood damage, should be prohibited in the floodway.

The floodplain fringe is that portion of the 100-year recurrence interval floodplain lying outside the floodway. Floodwater depths and velocities are small in this area compared to those in the floodway and, therefore, in a developed urban floodplain fringe area, further development may be permitted, although restricted and regulated so as to minimize flood damage.

For zoning purposes, the floodplain fringe may be divided into districts related to floodplain storage and natural resource characteristics. Although the floodplain fringe does not convey floodwaters, it does provide a volume of storage which affects the magnitude and timing of flood peaks. If the analyses conducted for the delineation of the floodplain boundaries of a stream, or a system of streams, include consideration of the effect of storage volume in the floodplain fringe, a flood storage zone should be designated. Such a zone may include a conservancy district, which includes wetlands in the floodplain fringe, as well as a storage district, which includes lands located outside of wetlands. The zoning ordinance of a municipality or county within which the stream with a designated flood storage zone is located should set forth requirements for a such zones which, at a minimum, require that no filling be permitted within the flood storage zone unless an equal volume of compensatory storage is provided.

The delineation of the natural floodlands in rural or largely undeveloped watersheds is extremely important to sound planning and development. Flood hazard delineations have many practical uses, including identification of areas which are not well suited to urban development but which could be prime locations for needed park and open space areas, identification of flood hazard areas possibly requiring structural or nonstructural floodland management measures, delineation of hazard areas for flood insurance purposes, and provision of stage and probability data needed to quantify flood damages in monetary terms.

The problems of flooding and attendant damages in the Des Plaines River watershed have been a matter of concern for many years. Historically, flooding of agricultural lands has been the most significant cause of flood damages; however, as urban development has occurred in the watershed, the potential for flooding of urban areas has increased. Flood conditions in the Des Plaines River watershed have been documented in the Federal flood insurance study report for unincorporated areas of Kenosha County.[8] That study was conducted prior to incorporation of the Village of Pleasant Prairie; thus, it includes flood hazard data for the present-day Village. The report includes data on existing condition flood flows and stages, as well as a delineation of the floodlands. Data on historical loadings in the Des Plaines River watershed are not included in the report. The Federal flood insurance studies for Racine County and the City of Kenosha and the Federal flood insurance rate maps for the Village of Union Grove do not include flood hazard information for any streams in the Des Plaines River watershed. No Federal flood insurance study has been prepared for the Village of Paddock Lake.

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[8]Federal Emergency Management Agency, Flood Insurance Study, County of Kenosha, Wisconsin, Unincorporated Areas*, 1981.*

In addition to the Federal flood insurance studies, several additional hydrologic and hydraulic studies of the Des Plaines River watershed have been conducted since 1960. In the case of the latter studies, the resulting reports included information on flood profiles and flood hazard areas in both Wisconsin and Illinois, but consideration of flood control alternatives and flood control recommendations were generally limited to that portion of the watershed within Illinois. Reports of these studies include: 1) *Flood Control Survey Report for the Des Plaines River*, prepared by Consoer, Townsend and Associates for the Forest Preserve District of Cook County, Illinois, in April 1960; 2) *Survey Report for Flood Control and Allied Water Uses in the Illinois River Basin, Illinois*, prepared by the U.S. Army Corps of Engineers North Central and Lower Mississippi River Divisions in 1962; 3) *Des Plaines River Improvement Program, Lake County, Illinois*, undated, prepared by the Lake County Highway Department between 1960 and 1967; 4) *Flood Plain Information Report on the Des Plaines River, Illinois and Wisconsin*, prepared for the Northeastern Illinois Metropolitan Area Planning Commission and the Southeastern Wisconsin Regional Planning Commission by the U.S. Army Corps of Engineers, Chicago District, March 1966; 5) *Feasibility Study Report of the Des Plaines River Watershed Located in Racine and Kenosha County Soil and Water Conservation Districts*, prepared by an interagency feasibility study team in June 1968; 6) *Flood Plain Information Maps and Profiles—Des Plaines River-Lake County, Illinois, Kenosha County, Wisconsin, and Floodwater Management Plan—Des Plaines River Watershed*, prepared by the Des Plaines River Steering Committees with assistance from the U.S. Natural Resources Conservation Service, the U.S. Forest Service, the Metropolitan Sanitary District of Greater Chicago, and the Illinois Department of Conservation, December 1975 and January 1976, respectively; and 7) *Upper Des Plaines River Flood Damage Reduction Study Interim Report* prepared by the U.S. Army Corps of Engineers, Chicago District, June 1999.

None of the past studies resulted in the development of detailed alternative and recommended floodland and stormwater management plans for the Wisconsin portion of the watershed. The purposes of this comprehensive watershed study therefore include the following: the definition of the precise nature of the existing and probable future floodland management problems of the watershed; the identification of the causes of those problems; the proposal of alternative solutions thereto, including consideration of potential stormwater management alternatives which may be expected to have significant impacts on alternative measures to address flood problems; and to recommend the best solution from among the alternatives, together with the most effective means for carrying out that solution. Subsequent closely coordinated local studies should be prepared to address stormwater management problems in detail.

Existing flood problems can be best described in terms of information describing reported historical floods. Such information, valuable to problem definition, is presented in Chapter VI of this report. Floodland management alternatives from which an integrated water resource management plan for the watershed can be synthesized are presented in Chapter XII of this report, which includes a review and evaluation of the technical, economic, financial, legal, and administrative feasibility and political acceptability of each alternative. The recommended floodland management element of the comprehensive plan for the Des Plaines River watershed, along with the basis for the plan synthesis and an analysis of the attendant costs, is also presented in Chapter XII.

Groundwater Resources

The Des Plaines River watershed is richly endowed with groundwater resources. In the rural portions of the watershed, the domestic water supply is provided by the groundwater reservoir. Lake Michigan is the source of the public water supply provided to the City of Kenosha and Village of Pleasant Prairie.

Rock units that yield water in usable amounts to pumped wells and in significant amounts to lakes and streams are called aquifers. The aquifers beneath the watershed differ widely in water-yield capabilities and extend to great depths, probably attaining a thickness in excess of 1,500 feet in portions of the watershed. There are three major aquifers underlying the Des Plaines River watershed. These are, in order from land surface downward, as follows: 1) the sand and gravel deposits in the glacial drift, 2) the shallow dolomite strata in the underlying bedrock, and 3) the Cambrian and Ordovician strata, composed of sandstone, dolomite, and shale. Because of their relative nearness to the land surface, the first two aquifers are sometimes called the “shallow aquifers” and the third aquifer, the “deep aquifer.” Wells tapping these aquifers are referred to as “shallow” or “deep” wells, respectively.

Gradual discharge from the sand-and-gravel aquifer is the primary source of base flow to the Des Plaines River and the other streams and lakes in the watershed.

Recharge to the sand-and-gravel aquifer occurs primarily through infiltration of precipitation that falls on the land surface directly overlying the aquifer. Within the watershed, the rate of recharge to the sand-and-gravel aquifer is relatively slow because of the presence of overlying glacial till of low permeability.

Recharge to the Niagara aquifer occurs primarily through infiltration of precipitation that seeps through the glacial drift above the aquifer. As with the sand-and-gravel aquifer, the rate of recharge is limited by the relatively low permeability of the glacial drift. Some additional recharge to the Niagara aquifer occurs as lateral subsurface inflow from the west.

Recharge to the sandstone aquifer, located in the Cambrian and Ordovician strata occurs in the following three ways: 1) seepage through the relatively impermeable Maquoketa shale, 2) subsurface inflow from natural recharge areas located to the west in Walworth County, and 3) seepage from wells that are hydraulically connected to both the Niagara and the sandstone aquifers. Although the natural gradient of groundwater movement within the sandstone aquifer is from west to east, concentrated pumping in the Chicago area has created a southeasterly gradient.

Springs are areas of concentrated discharge of groundwater at the land surface. Alone, or in conjunction with numerous smaller seeps, they may provide the source of base flow for streams and serve as a source of water for lakes, ponds, and wetlands. Conversely, under certain conditions, streams, lakes, ponds, and wetlands may be sources of recharge that create springs. The magnitude of discharge from a spring is a function of several factors, including the amount of precipitation falling on the land surface, the occurrence and extent of recharge areas of relatively high permeability, and the existence of geologic and topographical conditions favorable to discharge of groundwater to the land surface. Known locations of springs within the watershed are shown on Map 24. The characteristics of those springs are summarized in Table 23.

The occurrence, distribution, movement, use, and quality of groundwater resources and their relationship to surface-water resources and other elements considered in the planning study are discussed further in subsequent chapters of this report.

Fish and Wildlife Resources

Fish and wildlife have educational and aesthetic values, perform important functions in the ecological system, and are the basis for certain recreational activities. The location, extent, and quality of fishery and wildlife areas and the type of fish and wildlife characteristic of those areas are, therefore, important determinants of the overall quality of the environment in the watershed.

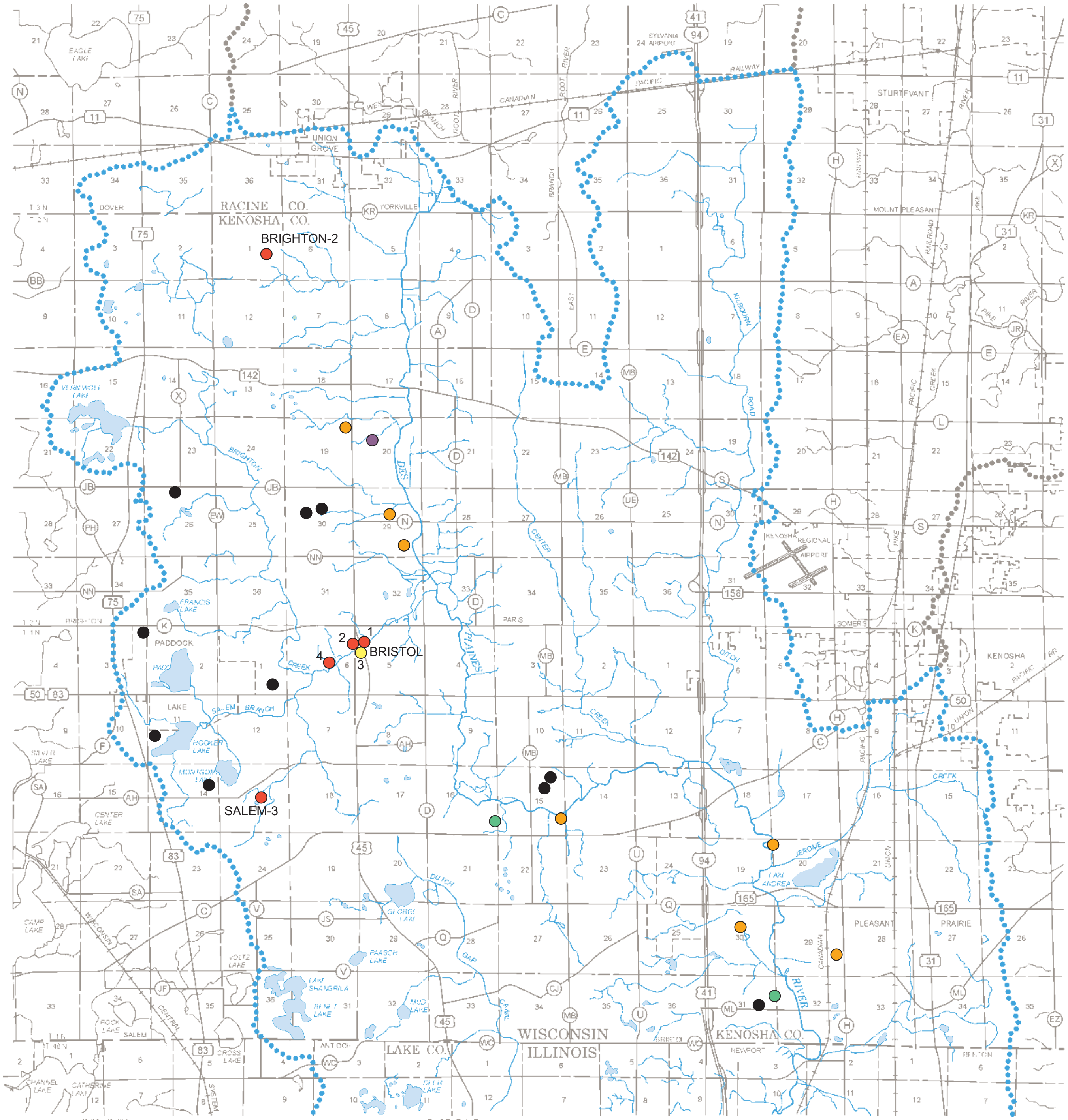
Fishery

The distribution and abundance of fishes in rivers and streams may be used as an indication of both short- and long-term changes in water quality and general in-stream ecological conditions. There are several advantages to using fish life as an indicator of the water quality and general ecological health of a stream system. First, fish occupy the top of the aquatic food chain and their presence, therefore, implies the presence of many other types of plants and animals upon which they feed. Second, fish live continuously for generations in a water body, and therefore over time come to reflect the condition of that water body. Finally, fish have been well studied; therefore, more accurate identification of fish species and more complete descriptions of fish life histories are available than is the case for other aquatic species, permitting relationships between fish and their environment to be well assessed.

In using information about the specific population of fish in a stream system as an indicator of water quality and ecological conditions, that information should be compared with information concerning the natural population of fish in a clean and ecologically sound stream system. Several characteristics of the fish population of a clean and sound environment are important in such a comparison. These characteristics include the presence of fish species

Map 24

LOCATIONS OF SPRINGS AND POTENTIAL GROUNDWATER DISCHARGE SITES IN THE DES PLAINES RIVER WATERSHED



SPRING LOCATION AND DESIGNATION FROM THE WISCONSIN CONSERVATION DEPARTMENT (WCD) 1958-1959 SPRING SURVEY

SPRING LOCATION PROVIDED BY PHIL H. SANDER

SPRING LOCATION AND DESIGNATION FROM BOTH THE WCD 1958-1959 SPRING SURVEY AND PHIL H. SANDER

SPRING LOCATION FROM THE U.S. SOIL CONSERVATION SERVICE (USSCS) 1969 SOIL SURVEY

SPRING LOCATION FROM THE U.S. GEOLOGICAL SURVEY 7.5-MINUTE QUADRANGLE MAP FOR PADDOCK LAKE (PHOTO REVISED 1971)

POTENTIAL GROUNDWATER DISCHARGE AND SEEPAGE SITE BASED ON INTERPRETATION OF THE USSCS 1969 SOIL SURVEY

NOTE: THE U.S. SOIL CONSERVATION SERVICE OF THE U.S. DEPARTMENT OF AGRICULTURE IS NOW KNOWN AS THE U.S. NATURAL RESOURCE CONSERVATION SERVICE

GRAPHIC SCALE

0 ½ 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

Springs and groundwater discharge sites provide a source of baseflow for streams and serve as a source of water for lakes, ponds, and wetlands.

Source: SEWRPC.

Table 23

CHARACTERISTICS OF SPRINGS IN THE DES PLAINES RIVER WATERSHED

Location on Map 24	Date Surveyed	Estimated Flow (gallons per minute)
Brighton 2	August 6, 1959	Dry
Bristol 1	September 4, 1958	7
Bristol 2[a]	September 4, 1958	30
Bristol 3[b]	September 4, 1958	22
Bristol 4[c]	September 4, 1958	10
Salem 3	July 22, 1959	Dry

[a] *22 small springs.*

[b] *Seepage springs in a 0.5-acre wetland.*

[c] *Located in streambed.*

Source: Wisconsin Conservation Department, Wisconsin Geological and Natural History Survey, and SEWRPC.

from all parts of the food chain, including forage fish, which feed on plants and invertebrates, and several levels of predator fish; the presence of a high diversity of species; and a distribution of age classes reflecting a viable breeding population. Particular aquatic habitats should contain representative fish species; for example, riffle areas should contain some combination of darters, dace, and certain species of minnows. The fish species should be spread among the intolerant, tolerant, and very tolerant species with regard to pollution, with the intolerant species dominating under conditions of clean water. Knowing these characteristics of the natural fish population that may be expected to exist in a clean and healthful environment, one may make comparisons with existing and historical populations and thereby assess the degree of deviation from the undisturbed native conditions. Thus, typically, a natural undisturbed fish population has species in each of the three classifications, with the intolerant species, however, being the most numerous. Any deviation may be attributed to the physical and water-quality alterations in the habitat caused by human activities in the watershed tributary to the stream channel system, as well as to human-created changes to the stream channel system itself.

The use of fish as indicators of prevailing water-quality conditions has been an important analytical tool for water-quality evaluation in past watershed studies. Fish species may be categorized on the basis of their tolerance to pollution.[9] However, the ranking of fish species on a pollution-tolerance scale does not provide a precise species-by-species hierarchy of pollution tolerance and, therefore, does not provide an indication of water-quality conditions. Rather, such a ranking is intended to group species in a general way according to their tolerance to pollution. Generally, this pollution tolerance is related to dissolved-oxygen concentrations, silt, or turbidity, although temperature, pH, and toxic substances such as ammonia and pesticides, are also important factors in determining tolerance. Fish classified as very tolerant can withstand large variations in water-quality conditions. and may therefore be expected to be found in both clean water and heavily polluted waters. Fish classified as tolerant can withstand smaller variations in water-quality conditions than very tolerant fish, and may therefore be expected to be found in both clean waters and moderately polluted waters. Fish classified as intolerant are, relative to the other categories, very restricted in the range of water-quality conditions in which they can exist, and therefore may be expected to inhabit only clean waters. Generally, the presence of intolerant fish species indicates good water-quality conditions, with high dissolved-oxygen levels, low turbidity, pH values within a 6.0-to-9.0 standard-units range, water temperatures that do not exceed the natural daily and seasonal fluctuations, and no toxic substances present. Given that a stream network is a dynamic system and fish are mobile animals, less tolerant fish species occasionally may find and temporarily reside in localized niches that are of quality higher than the overall quality of a particular reach of a stream system.

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[9] *The placement of individual species into a pollution tolerance category is based on regional references. For Wisconsin, these include George C. Becker,* Fishes of Wisconsin*, University of Wisconsin Press, Madison, Wisconsin, 1983; Robert Hile and William Bertrand*, "Biological Stream Characterization (B.C.): A Biological Assessment of Illinois Stream Quality," *Illinois State Water Plan Task Force, Springfield, Illinois, 1989; John Lyons,* "Using the Index of Biotic Integrity (BE) to Measure Environmental Quality in Warmwater Streams of Wisconsin," *North Central Forest Experiment Station, St. Paul, Minnesota, 1992; and Philip W. Smith,* The Fishes of Illinois*, University of Illinois Press, Urbana, Illinois, 1979.*

Historical Findings

Data from historical fish surveys of the Des Plaines River watershed are useful in assessing the overall change in the fish population and represent the best indication available of past water-quality conditions. In most cases, where intolerant fish species have been significantly reduced or eliminated, significant alteration in the stream habitat may be assumed, such as channelization; draining of connected wetlands; runoff of fertilizers, sediment, pesticides, and other toxic substances from rural and urban lands; and the discharge of both municipal and industrial wastes.

Historical data from 10 fishery surveys conducted between 1906 and 1980 and covering 73 stations were evaluated and used to assess changes that have occurred over time in the fishery of the Des Plaines River system. Additional historical surveys were conducted on 10 lakes in the watershed. Table 24 shows the chronological record of changes in the presence of all fish species found in the River and its tributaries. Data on the spatial distribution of species in the Des Plaines River and its tributaries and in lakes within the watershed are presented in Appendix B of this report. Figure 10 illustrates the spatial distribution of species for each collection year between 1906 and 1980 and each site within the main stem of the Des Plaines River.

The data presented in Appendix B indicate that 46 fish species were found in the Des Plaines River and its tributaries during the 75 years from 1906 through 1980. Seven of 12 intolerant species were not found in the extensive 1979-1980 surveys, nor were three tolerant species. All the very tolerant species previously reported were still present in the 1979-1980 collections. The biotic integrity of the River has clearly changed over the period from 1906 through 1980.

Existing Fisheries

Fish inventories of the Des Plaines River watershed stream system were conducted by the Commission staff between July 26, 1994, and July 29, 1994, in order to determine the current status of the fishery.[10] These field studies were intended to provide a basis for analyzing the potential for further fishery development within the watershed stream system. No attempt was made to inventory lakes within the watershed.[11] Supporting information regarding the 1994 survey is presented in Appendix B.

Survey Procedure

The 1994 fish survey was accomplished by using a one-quarter-inch mesh seine at each of 26 stations distributed throughout the watershed stream system. The fish survey stations were selected to be representative of the major streams in the watershed, to encompass the full spectrum of natural to channelized conditions, and to provide a basis with which historical fish collections could be compared. The locations of the 26 fish survey stations are shown on Map 25. Information concerning the stations, such as, information on channel width, flow, depth, and water clarity, is provided in Table 25. All fish captured at each survey station were identified by species and counted. Representative specimens of each species were preserved in Formalin for documentation. The specimens are part of the collection of the Milwaukee Public Museum.

Stream Conditions at Time of Survey

Stream inhabitants were under environmental stress at the time of survey. Water levels were very low. Table 25 shows nearly all stations had very turbid water, silt-covered bottoms, no instream vegetation, and very slow to no water current. Turbid water due to suspended silt, clay, and other particles prevents sight-feeding fish from

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[10]*Fish inventories were also conducted on May 17, 1994, by the Wisconsin Department of Natural Resources at two sites along the Pleasant Prairie Tributary. The results of these inventories are set forth in Appendix B.*

[11]*Most past fish surveys in the lakes in the watershed were for the purpose of assessing game fish populations. Thus, nongame fish that may be indicators of lake fishery diversity and water quality were not adequately inventoried. In addition, because of past fish eradication and official and unofficial restocking programs in some of the lakes in the watershed, past fish surveys may have identified species that may not represent viable breeding populations.*

Table 24

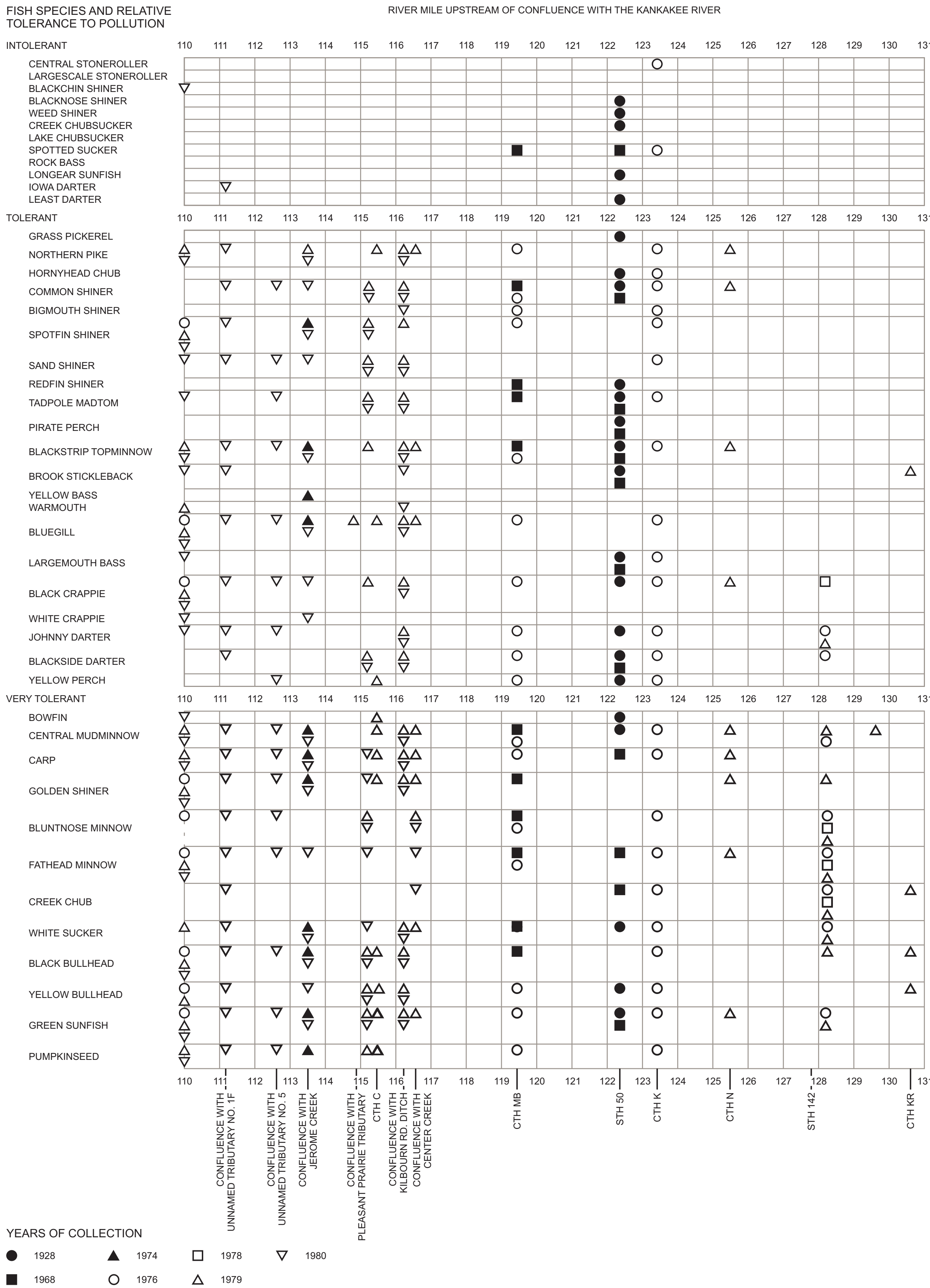
SUMMARY OF HISTORICAL REPORTS OF FISHES COLLECTED IN THE STREAMS OF THE DES PLAINES RIVER WATERSHED

Species According to Their Relative Tolerance to Pollution	Date of Survey										
	1906	1928	1965	1968	1974	1975	1976	1978	1979	1980	1994
Intolerant Species											
Central Stoneroller	- -	- -		X	- -	- -	X	X	X	- -	X
Largescale Stoneroller	- -	- -		- -	- -	- -	X	- -	- -	- -	- -
Blackchin Shiner	- -	- -		- -	- -	- -	- -	- -	- -	X	- -
Blacknose Shiner	- -	X		- -	- -	- -	- -	- -	X	- -	- -
Weed Shiner	- -	X		- -	- -	- -	- -	- -	- -	- -	- -
Creek Chubsucker	X	X		- -	- -	- -	- -	- -	- -	- -	- -
Lake Chubsucker	- -	- -		X	- -	- -	- -	- -	X	X	- -
Spotted Sucker	- -	- -		X	- -	- -	X	- -	- -	- -	- -
Rock Bass	X	- -		- -	- -	- -	- -	- -	- -	- -	- -
Longear Sunfish	- -	X		- -	- -	- -	- -	- -	- -	- -	- -
Iowa Darter	- -	- -	X	- -	- -	- -	- -	- -	X	X	X
Least Darter		X		- -	- -	- -	- -	- -	- -	- -	- -
Tolerant Species											
Grass Pickerel	X	X	- -	X	- -	- -	- -	- -	X	- -	- -
Northern Pike	- -	- -	- -	- -	X	- -	X	X	X	X	X
Hornyhead Chub	X	X	- -	X	- -	- -	X	- -	- -	- -	X
Common Shiner	- -	X	- -	X	- -	- -	X	X	X	X	X
Bigmouth Shiner	- -	- -	- -	- -	- -	- -	X	- -	X	X	- -
Spotfin Shiner	- -	- -	- -	- -	X	- -	X	X	X	X	X
Sand Shiner	- -	- -	- -	- -	- -	- -	X	- -	X	X	X
Redfin Shiner	- -	X	- -	X	- -	- -	- -	- -	- -	- -	- -
Tadpole Madtom	- -	- -	- -	X	- -	- -	X	- -	X	X	X
Pirate Perch	- -	- -	X	- -	X	- -	X	X	X	- -	X
Blackstripe Topminnow	- -	X	X	X	- -	- -	X	- -	X	X	X
Brook Stickleback	- -	- -	- -	- -	X	- -	X	X	X	X	X
Yellow Bass	- -	- -	- -	- -	X	- -	- -	- -	- -	- -	- -
Warmouth	- -	- -	- -	- -	- -	- -	- -	- -	X	X	X
Bluegill	- -	- -	- -	- -	X	- -	X	X	X	X	X
Largemouth Bass	- -	X	- -	X	X	- -	X	- -	- -	X	X
Black Crappie	- -	X	- -	- -	X	- -	X	X	X	X	X
White Crappie	- -	- -	- -	- -	X	- -	- -	- -	X	X	X
Johnny Darter	X	- -	- -	X	- -	- -	X	- -	X	X	X
Blackside Darter	- -	X	- -	X	- -	- -	X	- -	X	X	X
Yellow Perch	- -	X	- -	- -	- -	- -	X	- -	X	X	- -
Very Tolerant Species											
Bowfin		X	- -	- -	- -	- -	- -	- -	X	X	X
Central Mudminnow	X	X	- -	X	X	- -	X	X	X	X	X
Carp			- -	X	X	X	X	X	X	X	X
Golden Shiner			X	X	X	- -	- -	X	X	X	X
Bluntnose Minnow		X	- -	X	X	- -	X	X	X	X	X
Fathead Minnow			X	X	- -	- -	X	X	X	X	X
Creek Chub	X		- -	X	- -	- -	X	X	X	X	X
White Sucker	X	X	- -	X	X	- -	X	- -	X	X	X
Black Bullhead	X		- -	X	X	- -	X	X	X	X	X
Yellow Bullhead	X	X	- -	X	X	- -	X	- -	X	X	X
Brown Bullhead	- -	- -	- -	- -	- -	- -	- -	- -	X	- -	- -
Green Sunfish	X	X	- -	X	X	- -	X	X	X	X	X
Pumpkinseed	X	- -	- -	- -	X	- -	X	- -	X	X	X
Total Number of Species	12	20	5	22	18	1	29	16	34	31	30

Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 10

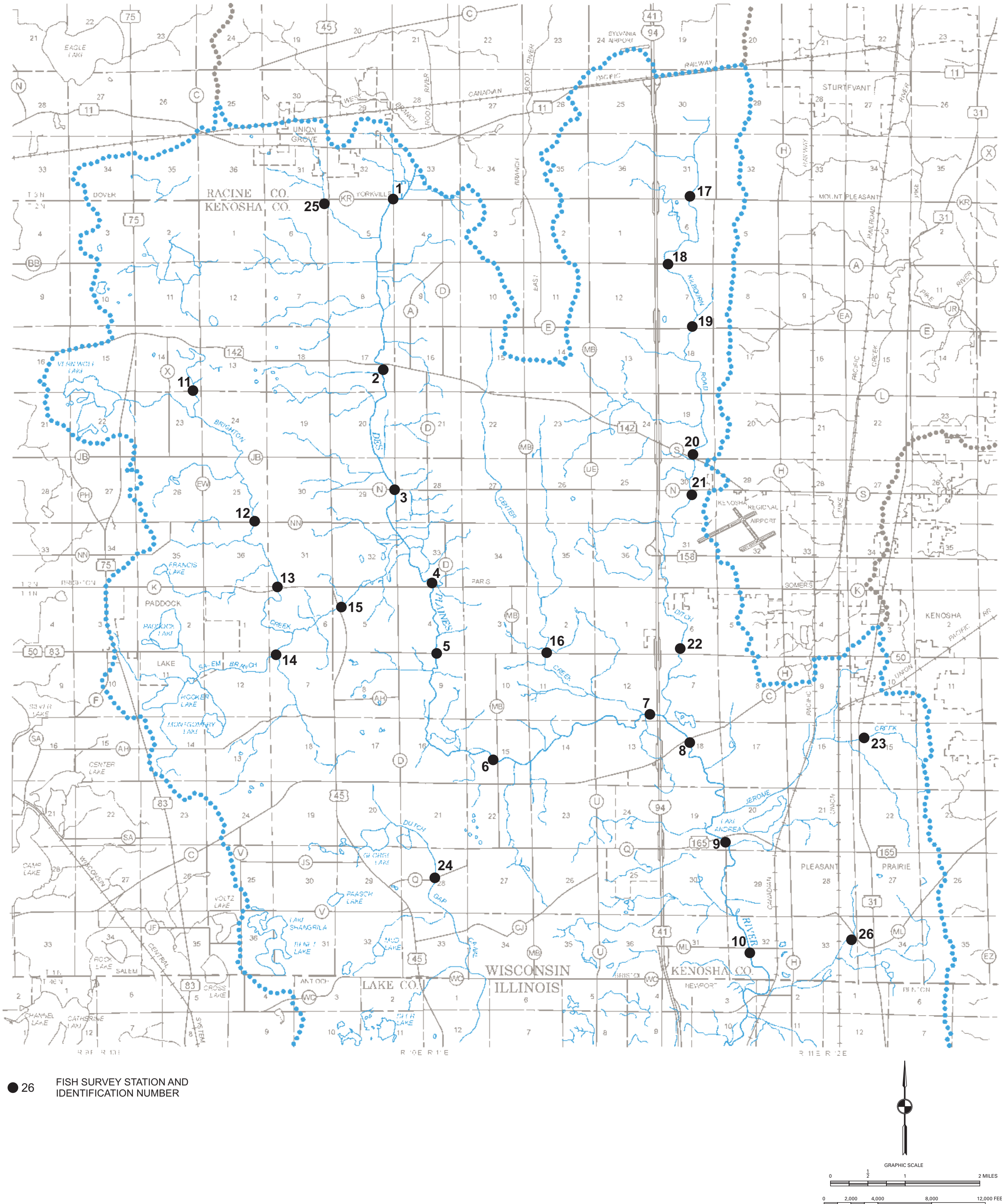
HISTORICAL SPATIAL DISTRIBUTION OF FISHES IN THE DES PLAINES RIVER WATERSHED: 1906-1980



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 25

FISHERY SURVEY STATIONS IN THE DES PLAINES RIVER WATERSHED: 1994



A survey to determine the current status of the fisheries of the streams of the watershed was conducted by the Commission staff at 26 sites in July 1994. Of the total of 2,627 fish sampled, 66 percent were found to consist of species which are very tolerant of water pollution; 31 percent of species which were tolerant of pollution, and 3 percent of species which were intolerant of pollution.

Source: SEWRPC.

Table 25

FISH SURVEY STATIONS IN THE DES PLAINES RIVER WATERSHED: 1994

Watercourse	Civil Division	Station Number	Stream Crossing	River Mile[a]	Vegetal Condition: On Banks	Vegetal Condition: In Stream	Approximate Channel Width (feet)	Current	Temperature(°C)	Channel Bottom Conditions	Observed Water Clarity	Depth (feet)
Des Plaines River Main Stem	Town of Yorkville	1	CTH KR	130.6	Overhanging grass	None	15	None, isolated pool	17	Silt	Very turbid	1.0
	Town of Paris	2	STH 142	127.8	Overhanging grass and few trees	Sparse arrowhead	16 ditched	Very slow	16	Silt	Very turbid	3.0
		3	CTH N	125.5	Overhanging grass	None	35 ditched	Very slow	22	Silt	Very turbid	4.5
		4	CTH K	123.4	Overhanging grass and trees	None	25	Very slow	20	Silt	Very turbid	4.0
	Town of Bristol	5	STH 50	122.3	Overhanging grass	None	35 ditched	None	23	Silt and large rocks	Very turbid	3.0
		6	CTH MB	119.3	Overhanging grass	None	30 ditched	None (no water passing under bridge)	23	Silt	Very turbid	3.0
		7	West frontage road along IH 94	116.0	Overhanging trees	None	30	None	17.5	Silt and large rocks	Very turbid	1.5
	Village of Pleasant Prairie	8	CTH C	115.3	Overhanging grass and few trees	None	50	None, isolated pool	20	Silt, fine gravel, and large rocks	Very turbid	1.5
		9	STH 165	112.6	Overhanging grass	None	70	Very slow	23	Silt	Very turbid	1.5
		10	CTH ML	110.6	Overhanging grassand trees	None	70	Very slow	23	Silt	Very turbid	2.0
Union Grove Industrial Tributary	Town of Paris	25	From CTH KR to USH 45	1.0	Overhanging trees	None	5	Moderate	17	Silt, rubble, and large rocks	Slightly turbid	2.5
Brighton Creek	Town of Brighton	11	18th Street	9.7	Overhanging trees; broken concrete	None	25	None, isolated pool	19.5	Silt, clay, and rubble	Very turbid	2.0
		12	CTH NN	6.6	Overhanging grass	None	30	None, isolated pool	19	Silt and sticks	Very turbid	2.0
	Town of Paris	13	CTH K	5.3	Overhanging grass	Abundant duckweed	20	Very slow	20	Gravel	Slightly turbid	1.0
	Town of Bristol	15	CTH K	1.1	Overhanging grass and trees	None	10	Moderate	21	Gravel	Clear	1.0
Salem Branch of Brighton Creek	Town of Bristol	14	STH 50	0.5	Overhanging grass	Abundant duckweed	20	None, isolated pool	20	Silt	Very turbid	1.0
Center Creek	Town of Bristol	16	STH 50	2.3	Overhanging grass	Filamentous algae	4 ditched	Slow	21	Silt and large rocks	Clear until disturbed	1.0
Kilbourn Road Ditch	Town of Somers	17	CTH KR	10.4	Overhanging grass	Filamentous algae	12 ditched	Very slow	20	Silt	Clear until disturbed	5.0+
		18	CTH A	9.1	Overhanging grass	None	4 ditched	None	17.5	Silt	Turbid	0.75
		19	CTH E	7.9	Overhanging grass	Arrowhead and fila mentous algae	10 ditched	None	22	Silt	Turbid	0.75
		20	STH 142	6.3	Overhanging trees	Filamentous algae	15 ditched	Very slow	20	Silt	Very turbid	2.0
		21	CTH N	5.3	Overhanging grass and trees	None	35 ditched	None, isolated pool	17	Silt and large rocks	Clear until disturbed	2.5
	Village of Pleasant Prairie	22	STH 50	1.3	Overhanging grass	None	15 ditched	None	21.5	Silt and sticks	Very turbid	2.5
Jerome Creek	Village of Pleasant Prairie	23	Frontage road east of STH 31	2.8	Overhanging grass	Abundant filamentous algae	20 ditched	None, isolated pool	22	Silt	Turbid	2.0
Unnamed Tributary No. 1 to Des Plaines River	Village of Pleasant Prairie	26	CTH ML	2.0	Overhanging trees	None	10 ditched	None, isolated pool	17.5	Silt and rocks	Clear until disturbed	2.0
Dutch Gap Canal	Town of Bristol	24	CTH Q	10.0	Overhanging trees	Abundant duckweed	5 ditched	None, isolated pool	18.5	Silt	Black	0.5

[a]For the Des Plaines River, the river miles are measured from the confluence of the Des Plaines River and the Kankakee River in Illinois. Under this system, the Wisconsin-Illinois stateline is located at river mile 109.9. For all tributaries, the river miles are measured from their confluence with the Des Plaines River.

Source: SEWRPC.

locating food and prevents plants from carrying on photosynthesis. Silt smothers plants and small animals normally living on and under stones and sticks and clogs the gills of fish and such invertebrates as aquatic insects, clams and snails, and crustaceans. Furthermore, silt is an unstable substrate that inhibits the establishment of rooted aquatic plants and limits those invertebrate animals requiring firm substrates (snails and many insects). The lack of algae and other aquatic plants disrupts the base of stream food chains; reduces oxygen input into water; and severely limits available shelter and spawning sites for many animals, including fish. Lack of flow creates stagnant, low-oxygen conditions which cannot be tolerated by many stream fishes.

In many situations, the only water available for making collections was in isolated pools with no inflow or outflow. Fishes were concentrated in water less than two feet deep. Such crowded conditions create stressful low-oxygen situations and put severe limits on food supply and shelter. If these shallow pools remained isolated into winter, they would probably freeze solid to the bottom and kill all inhabitants. The entire breeding stock for a reach of a stream may be contained in these isolated pools. The death of these fish may affect the future fishery of a major portion of the stream.

A return visit to the sampling stations in January 1995 revealed a dramatic change. The visit was preceded by a week of thawing temperatures and rain. Where there were isolated pools in July, there was a steady flow of high water in January. Many stations were overflowing their banks. Reed canary grass overhanging the shores in July was under one to two feet of water in January. Such conditions are at least in part a result of the ditching and draining of water-storing wetlands and of the extensive modification and straightening of streams in the watershed. Those actions created a uniform aquatic environment where once there was heterogeneity of alternating riffles, pools, and runs.

Inventory Findings

As indicated in Table 26 and Appendix B, a total of 2,627 fish, representing 29 species, were taken at 26 stations during the 1994 fish survey. The five most common species found, in order of decreasing abundance were carp, black bullhead, brook stickleback, white sucker, and fathead minnow. Figure 11 indicates, in summary form, the fish species captured, the number of each species, and the approximate position of each species on a pollution-tolerance scale for the 26 stations.

Of the total of 2,627 fish, 1,736, or 66 percent, were classified as being very tolerant of water pollution; 823, or 31 percent, were classified as being tolerant; and the remaining 68, or 3 percent, were considered intolerant. There were 38 times as many pollution-tolerant and very tolerant fish taken in the survey as there were pollution-intolerant fish.

A healthy fishery should contain a diversity of species similar to that found in the Des Plaines River watershed in the 1906 and 1928 surveys. The converse condition currently exists in the Des Plaines watershed. Insofar as the fish population serves as an index of stream water-quality condition, the dominance of very tolerant and tolerant fish in the stream system is a manifestation of the poor water-quality conditions that generally exist in the watershed.

Of the 29 species of fish captured at the 26 stations, the following eight species are considered to be of sport-fishing value: northern pike, largemouth bass, bluegill, green sunfish, pumpkinseed, black crappie, and yellow and black bullhead. Considering the watershed as a whole, fish of these eight species amounted to 22 percent of the total number of fish captured. Of these, 383, or 65 percent, were small black bullheads, leaving only 8 percent of the total number of fish to be divided among the remaining seven species. This indicates that the Des Plaines River stream system has a mediocre fishery in need of improvement.

Although the sampling stations were uniformly distributed over the watershed, the number of fish captured at the stations was not uniformly distributed. For example, no fish at all were taken at one station, while 370 fish were taken at another. Half of the stations had under 100 fish, ten had between 100 and 200, two had between 200 and 300, and one had over 300 fish. Descriptions of the fish communities by stream reach are set forth in Appendix B.

Table 26

RESULTS OF FISH SURVEY IN THE DES PLAINES RIVER WATERSHED: JULY 1994

Stream	Number of Species and Populations According to Relative Tolerance to Pollution							
	Very Tolerant		Tolerant		Intolerant		Subtotals	
	Number of Species	Population	Number of Species	Population	Number of Species	Population	Number of Species	Population
Des Plaines Upstream of STH 50 (five stations)	9	668	11	322	1	27	21	1,017
Des Plaines Downstream of STH 50 (five stations)	11	354	9	122	0	0	20	476
Brighton Creek (five stations)	10	181	7	116	1	2	18	299
Center Creek (one station)	5	21	1	1	1	3	7	25
Kilbourn Road Ditch (six stations)	9	365	10	194	0	0	19	559
Jerome Creek (one station)	3	61	1	6	1	5	5	72
Dutch Gap Canal (one station)	5	47	2	2	0	0	7	49
Minor Tributaries (two stations)	4	39	5	60	1	31	10	130
Total	56	1,736	46	823	5	68	29[a]	2,627

[a]*Number of different species.*

Source: SEWRPC.

Evaluation of Inventory Findings

The degraded water-quality condition of the Des Plaines River watershed is further indicated by the loss over time of intolerant species, as set forth in Table 27. The creek chubsucker, a small member of the sucker family, has only been collected twice in all of Wisconsin. Both collections were from the Des Plaines River watershed; two specimens were reported from Salem Branch of Brighton Creek in 1906 and eight specimens from STH 50 crossing of the Des Plaines River in 1928. The species has not been collected since then and is considered extirpated from the State. It apparently reached the northern limits of its range in the Des Plaines River and was eliminated by deteriorated water conditions by the middle of this century.[12] It also is no longer found in the Illinois portion of the watershed.[13]

Two currently threatened species in the State, the longear sunfish and the redfin shiner, were also former members of the Des Plaines River fish fauna. The longear sunfish was last collected in 1928 at the STH 50 crossing. The redfin shiner has been seen as recently as 1968 at the CTH MB crossing. The longear sunfish has never been reported in the Illinois portion of the river. The redfin shiner was last collected in Illinois in 1976.[14] Both have probably disappeared from the watershed.

While there are currently no threatened or endangered fish species in the Des Plaines River watershed, there are three species listed by the Wisconsin Department of Natural Resources, Bureau of Endangered Resources, as

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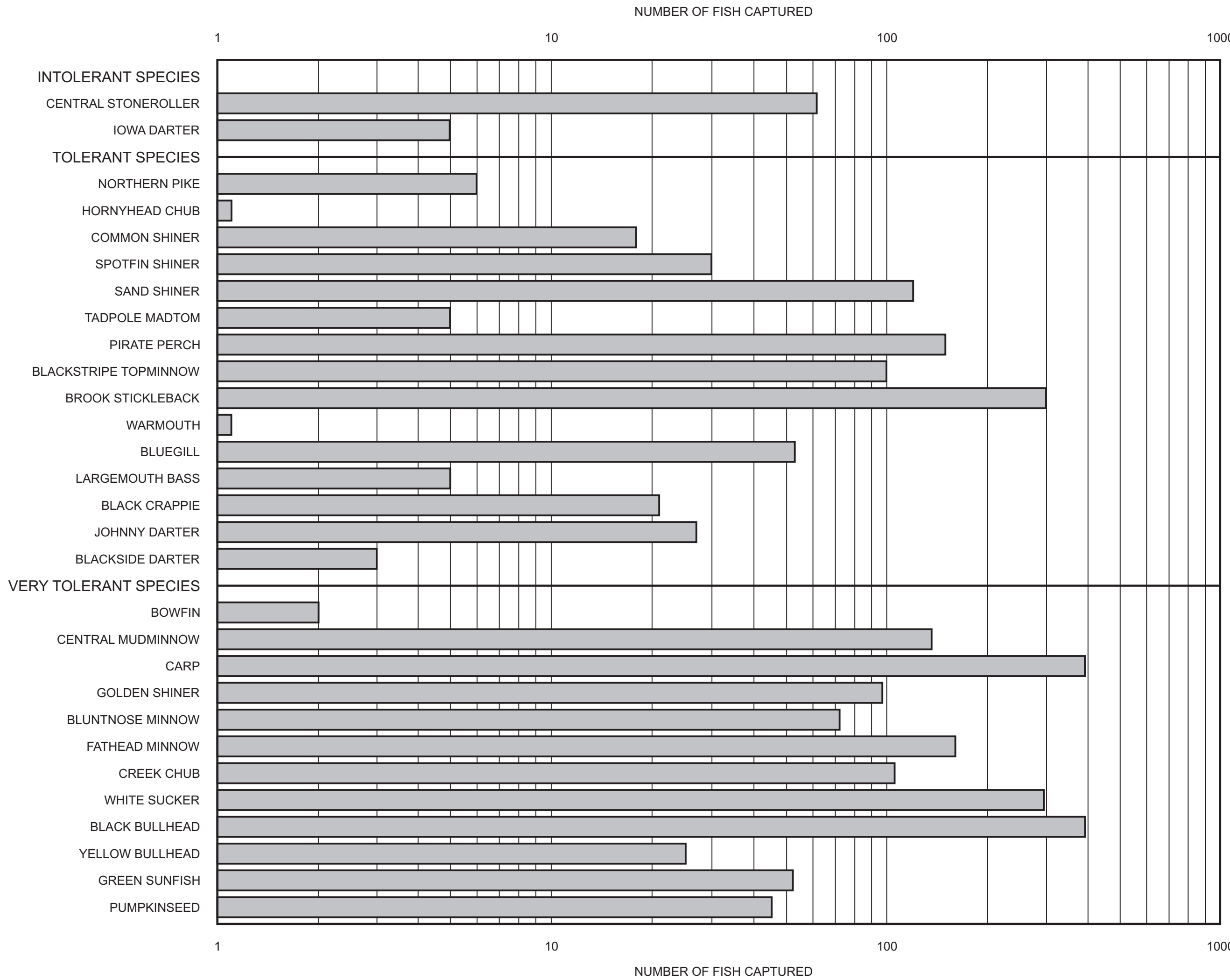
[12]*Becker, George*, Fishes of Wisconsin*, University of Wisconsin Press, Madison, Wisconsin, 1983.*

[13]*Heidinger, Roy C.,* "Fishes in the Illinois Portion of the Upper Des Plaines River,": Transactions of the Illinois State Academy of Science*, Vol. 82, Nos.1 and 2, The Illinois State Academy of Science, Springfield, Illinois, 1989.*

[14]*Ibid.*

Figure 11

RESULTS OF FISH SURVEY CONDUCTED IN THE DES PLAINES RIVER WATERSHED: JULY 1994



Source: Marlin P. Johnson, University of Wisconsin-Waukesha, and SEWRPC.

being of special concern and in need of protection before they become threatened or endangered. These species are the least darter, the lake chubsucker, and the pirate perch.

The least darter is the smallest fish in Wisconsin. Adult length is about one and one-half inches, causing the species to be easily overlooked. It normally occurs in well-vegetated lakes and small shallow streams. Only two records exist in the watershed, one from a 1928 collection at the STH 50 crossing of the main stem and one from Paddock Lake in 1979. No record of the species in the River or tributaries exists since the 1928 date. There have been no recent attempts to determine its current status in Paddock Lake. It has not been reported in the Illinois portion of the river system for several decades.[15]

A second species of State concern is the lake chubsucker, a close relative of the extirpated creek chubsucker. It is frequently found in situations with dense vegetation over bottoms composed of sand or silt mixed with organic debris. The species was reported in 1980 from the lower reaches of Unnamed Tributary No. 5 to the Des Plaines

[15]*Ibid.*

Table 27

COMPARISON OF HISTORICAL FISH SURVEY RESULTS FOR THE DES PLAINES RIVER WATERSHED WITH 1994 SURVEY RESULTS

Stream	Time of Collection	Total Number of Species	Pollution Tolerance			Number of Species in Fish Ecological Categories									Number of Game Species	Ranking of Recreational Fishery	Ranking of Overall Fishery
			Number of Intolerant Species	Number of Tolerant Species	Number of Very Tolerant Species	Minnows	Darters	Sunfishes	Crappies	Suckers	Bullheads	Bass	Pike	Other			
Des Plaines River Upstream of STH 50	Historical	37	7	18	12	17	3	4	1	3	2	1	2	4	10	Good	Good
	1994	21	1	11	9	10	2	3	1	1	2	0	1	1	7	Fair	Fair
Des Plaines River Downstream of STH 50	Historical	33	3	18	12	14	3	4	2	2	2	2	1	3	12	Good	Good to fair
	1994	20	0	9	11	8	1	4	1	1	2	1	0	2	11	Good	Fair
Brighton Creek	Historical	24	4	10	10	12	2	3	0	3	2	0	1	1	5	Fair to poor	Good to fair
	1994	20	1	9	10	10	2	3	0	1	2	0	1	1	6	Fair to poor	Good to fair
Unnamed Tributary No. 8 to Brighton Creek	Historical	5	1	0	4	3	1	1	0	0	0	0	0	0	1	Very poor	Poor
Unnamed Tributary No. 9	Historical	14	3	4	7	6	2	2	0	1	0	0	2	1	4	Poor	Fair
Salem Branch	Historical	21	3	8	10	8	2	4	0	2	2	0	2	1	7	Fair	Fair
	1994	5	0	3	2	4	0	0	0	0	0	1	0	0	1	Poor	Poor
Center Creek	Historical	15	2	4	9	6	1	2	0	1	2	0	1	2	5	Fair to poor	Fair
	1994	7	1	1	5	4	0	1	0	1	0	0	1	0	2	Poor	Poor
Kilbourn Road Ditch	Historical	17	0	6	11	6	1	3	1	1	2	0	1	2	7	Fair	Fair
	1994	19	0	10	9	10	1	3	1	1	1	1	0	1	6	Fair	Fair
Jerome Creek	Historical	21	0	11	10	7	1	3	2	1	2	2	1	2	10	Good	Fair
	1994	5	1	1	3	3	1	0	0	0	1	0	0	0	1	Very poor	Poor
Dutch Gap Canal	Historical	16	0	6	10	4	0	3	1	1	3	0	2	2	9	Fair to good	Fair
	1994	7	0	2	5	3	0	1	1	0	2	0	0	0	4	Poor	Poor
Union Grove Tributary	1994	8	1	4	3	6	0	1	0	1	0	0	0	0	0	None	Poor to fair
Pleasant Prairie Tributary	Historical	10	1	4	5	3	1	2	2	0	1	0	0	1	5	Poor	Poor to fair
	1994[a]	14	0	6	8	4	0	3	1	1	1	1	0	3	6	Poor	Poor to fair
Unnamed Tributary No. 1 to the Des Plaines River	1994	2	0	1	1	1	0	1	0	0	0	0	0	0	0	None	Very poor
Unnamed Tributary No. 2 to the Des Plaines River	Historical	15	2	5	8	6	1	3	1	0	1	0	1	2	6	Fair	Fair
Unnamed Tributary No. 5 to the Des Plaines River	Historical	18	2	7	9	5	1	3	2	1	2	1	1	2	9	Fair to good	Fair

[a]*Survey by the Wisconsin Department of Natural Resources.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

River and from Brighton Creek in 1968 and 1979. It was also collected in the 1970s from Shangrila, George, Paddock, Hooker, and Montgomery Lakes. Presumably, there are still viable populations in some of these lakes. No individuals were found in the 1994 survey of the Des Plaines River main stem and tributaries. It has not been found in the Des Plaines River system in Illinois.[16]

A final species, the pirate perch, not a true perch, is a small fish inhabiting ponds, ditches, and muck-bottomed pools of low-gradient creeks and small rivers. It has been collected in the Des Plaines River system with decreasing frequency since 1928. From 1965 to 1979, it was found in collections from the Des Plaines River main stem, Brighton Creek, Salem Branch, Jerome Creek, Center Creek, and Kilbourn Road Ditch. In Illinois, it has been absent from the River for at least two decades.[17] In the 1994 Regional Planning Commission survey, it was recorded only in Brighton Creek and Kilbourn Road Ditch. Pirate perch were also sampled in the Pleasant Prairie Tributary under the 1994 Wisconsin Department of Natural Resources survey of that stream. Specimens of young and adults collected in one stagnant, isolated pool under the CTH N bridge in Kilbourn Road Ditch totaled 126. It

[16]*Ibid.*

[17]*Ibid.*

is very possible that this pool contained a major portion of the breeding stock of pirate perch in Kilbourn Road Ditch. Any local catastrophe to this isolated pool could have seriously depleted the present and future population in the tributary.

The intermittent nature of water connections within the stream system during periods of low flow places great burden on these special-concern species. Incidental catastrophes causing death to all individuals in isolated situations may eliminate major portions of the population of several species. In addition, species may not repopulate areas if ecological barriers prevent “seed-stock” movement from one area to another. Low water, inappropriate bottom type, lack of vegetative cover, and insufficient oxygen may be as effective at preventing recolonization as would be a dam put across the stream. Known populations of these fish species need to be protected to prevent being extirpated from the watershed.

Concluding Remarks
In the 150 years of human activity which have reshaped the landscape along the Des Plaines River, portions of the River and some tributaries have been transformed from natural, meandering streams with a variety of habitats to modified, channelized streams with uniform conditions.

The fishery of the stream system has responded to these habitat changes primarily through a loss of overall diversity and particularly through a loss of species intolerant of the degraded water-quality conditions. Earliest fish records for the Des Plaines River came from two sites where collections were made in 1906 and 1928. Twenty-five species were found at these two stations, making an average of 12.5 species per station. Six of the 25 species were known to be intolerant of polluted conditions. Very intensive fish surveys carried out in 1979 and 1980 produced a total of 36 species at 39 stations, with five intolerant, 18 tolerant, and 13 very tolerant species. The average number of different species per station was slightly less than one. The 1994 survey yielded 29 species at 26 stations, with two intolerant, 15 tolerant, and 12 very tolerant species averaging slightly more than one species per station. No carp were found in either the 1906 or 1928 collection but were plentiful in recent decades.

The Des Plaines River clearly lacks the complement of fish normally occurring in natural waters. This loss of diversity and of intolerant species is due to a combination of factors:

1. The draining and filling of wetlands adjacent to the stream system, which has resulted in a loss of fish spawning, nursery, and feeding areas.

2. The ditching and realignment of stream channels, which has resulted in a uniform aquatic environment where there was once a great heterogeneity in the form of alternating riffles, pools, and runs. This ditching and realignment of the stream channels has resulted in uniform bottom types and water velocities which limit the types of fish that can normally inhabit a stream system and has thereby reduced the natural diversity.

3. Runoff from agricultural lands and construction sites, which transports sediment into the stream system, filling pools, covering gravel beds and plants, clogging the gills of fish and other aquatic animals, increasing turbidity, interfering with the mating and feeding behavior of fish, and, through abrasive action, sometimes injuring fish.

4. Fluctuations of water flow, which create alternating scouring and stagnant conditions within the stream system. Under low-flow conditions, fish become concentrated in shallow isolated pools where they are placed under great stress for lack of oxygen, food, and shelter. If these pools remain isolated into winter, they can freeze, killing all inhabitants. Since these pools may contain the entire breeding stock of a reach of stream, the future fishery is threatened when the fish in the pools are placed under stress or killed.

5. Runoff waters containing pesticides and fertilizers from urban and rural lands, sewage-treatment plant effluent, industrial discharges, and chemical spills, which have caused a decline in water-quality conditions.

6. The lack of instream vegetation and cover, which has prevented fish from finding shelter from predators and sudden floods. Some fish species may not carry on normal reproductive activities without proper cover. In addition, the lack of vegetative cover for other aquatic organisms may reduce the food resources available to fish, thereby affecting their growth and reproductive capacity.

As a result of these problems, the fish population of the Des Plaines River watershed has reached a point where the natural source of "seed stock" necessary to restore the depopulated areas of the watershed is apparently lacking. Very tolerant fish, such as black bullhead and carp, do well in the stream system; but intolerant species, such as certain shiners and daces, are lacking. Even such tolerant species as largemouth bass, northern pike, and bluegills would be more abundant in the Des Plaines River watershed if a balanced fishery were present.

Various stream reaches were evaluated as to their potential for supporting fish and other aquatic life on the basis of the inventories of the fishery and the physical features of the stream system. The results of these evaluations were considered in establishing the recommended water use objectives set forth in Chapter X of this report.

Wildlife Habitat

Wildlife in the Des Plaines River watershed includes upland game, such as rabbit and squirrel; predators, such as coyote, fox, and raccoon; game birds, such as pheasant; marsh furbearers, such as beaver and muskrat; migratory and resident song birds; and waterfowl. The remaining wildlife habitat areas provide valuable recreation opportunities and constitute an invaluable aesthetic asset to the watershed. The spectrum of wildlife species originally present in the watershed has, along with the habitat, undergone tremendous alterations since settlement by Europeans and the subsequent clearing of forests, plowing of the oak savannas and prairies, and draining of wetlands for agricultural purposes. Modern practices that adversely affect wildlife and wildlife habitat include the excessive use of fertilizers and pesticides, road salting, heavy traffic and resulting disruptive noise levels and damaging air pollution, the introduction of domestic animals, and the fragmentation and isolation of remaining habitat areas for urban and agricultural uses. It is therefore important to protect and preserve remaining wildlife habitat in the watershed.

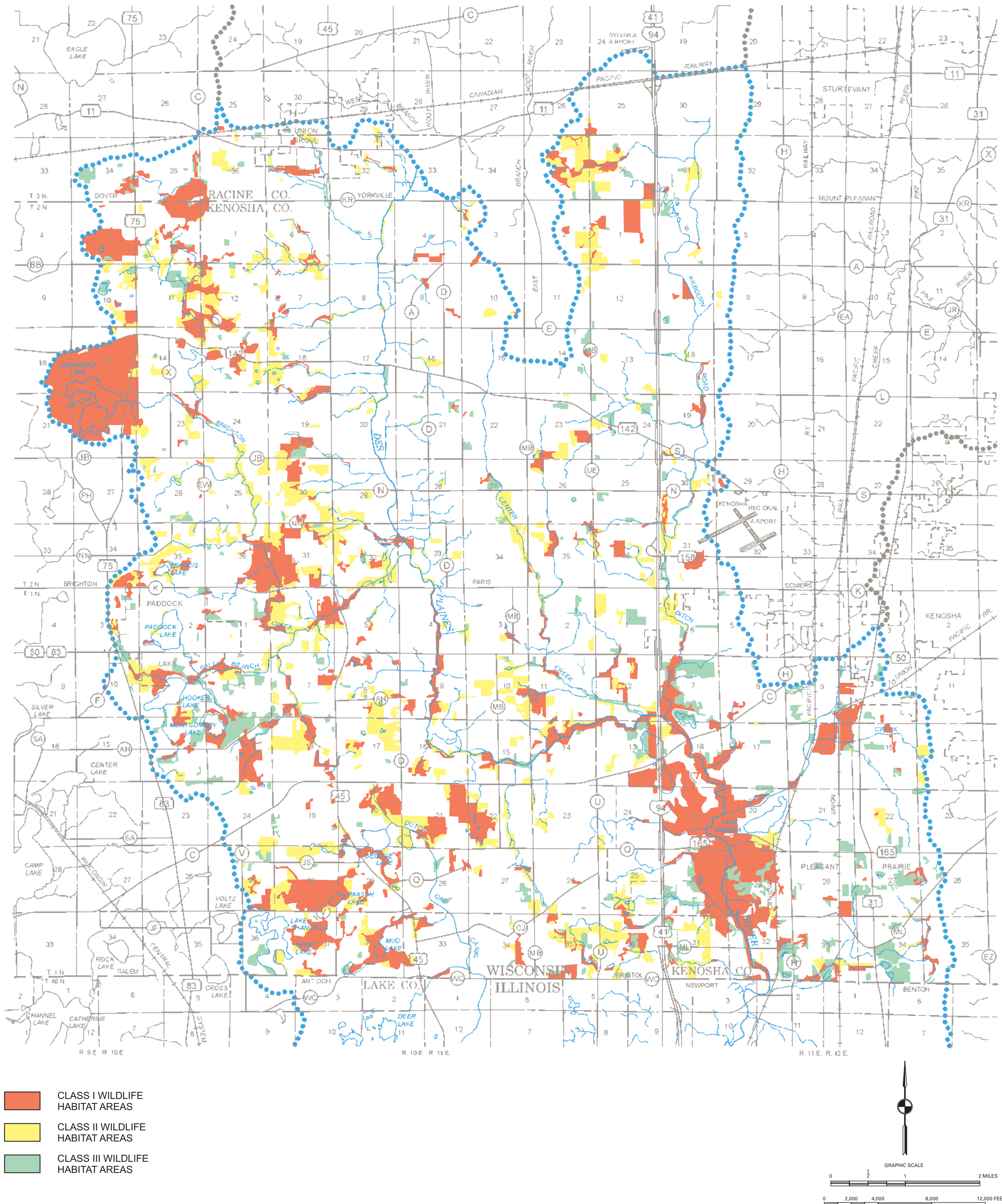
Wildlife habitat areas remaining in the Southeastern Wisconsin Region, including the Des Plaines River watershed, were identified by the Southeastern Wisconsin Regional Planning Commission and the Wisconsin Department of Natural Resources in 1988 and were categorized as either Class I, Class II, or Class III habitat areas. The following five major characteristics were used to identify high value wildlife habitats: balanced diversity, adequate area to meet territorial requirements of major species, vegetation, location, and disturbance.

Class I wildlife habitat areas are habitats of the highest value in the Region in that they contain a good diversity of wildlife, are adequate in size to meet all habitat requirements for the species concerned, and are generally located in proximity to other wildlife habitat areas. Class II wildlife habitat areas generally lack optimal conditions for one of the three aforementioned criteria for a Class I area. However, they do retain a good plant and animal diversity. Class III wildlife habitat are remnant in nature in that they generally lack optimal conditions for two or more of the three aforementioned criteria for Class I wildlife habitat but are, nevertheless, important if located in close proximity to other wildlife habitat areas, if they provide travel corridors linking other habitat areas, if they provide important forage habitat, or if they provide the only available range in an area. It is in this respect that Class III wildlife habitat areas may also serve as regionally significant habitat in Southeastern Wisconsin.

As shown on Map 26, wildlife habitat areas in the Des Plaines River watershed generally occur in association with existing surface water, wetland, and woodland resources located along the Des Plaines River and its tributaries, in the lake area in the western portion of the watershed, in the open space lands associated with the Bong State Recreation Area, and in the University of Wisconsin nature area known as the Harris Tract. As shown in Table 28, in 1985 such areas covered about 17,175 acres, or about 20 percent of the total watershed. Of this

Map 26

WILDLIFE HABITAT IN THE DES PLAINES RIVER WATERSHED: 1985



The spectrum of wildlife species originally present in the watershed has, along with the habitat, undergone tremendous alterations since settlement by Europeans and the subsequent clearing of forests, plowing of the oak savannas and prairies, and draining of wetlands for agricultural purposes. Modern practices that adversely affect wildlife and wildlife habitat include the excessive use of fertilizers and pesticides, road salting, heavy traffic and resulting disruptive noise levels and damaging air pollution, the introduction of domestic animals, and the fragmentation and isolation of remaining habitat areas for urban and agricultural uses. It is therefore important to protect and preserve remaining wildlife habitat in the watershed. Class I, or high-value, habitat areas comprise about 51 percent of the watershed; Class II, or medium-value, areas comprise about 33 percent; and Class III areas comprise about 16 percent.

Source: SEWRPC.

Table 28

WILDLIFE HABITAT IN THE DES PLAINES RIVER WATERSHED: 1985

Civil Division	Class I		Class II		Class III		Total	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Kenosha County								
City								
Kenosha	68	0.4	73	0.4	62	0.4	203	1.2
Villages								
Paddock Lake	72	0.4	47	0.3	66	0.4	185	1.1
Pleasant Prairie	2,255	13.1	341	2.0	1,064	6.2	3,660	21.3
Towns								
Brighton	2,118	12.3	1,013	5.9	169	1.0	3,300	19.2
Bristol	2,397	14.0	2,185	12.7	435	2.5	5,017	29.2
Paris	879	5.1	1,350	7.9	272	1.6	2,501	14.6
Salem	475	2.8	228	1.3	415	2.4	1,118	6.5
Somers	100	0.6	114	0.7	72	0.4	286	1.7
Subtotal	8,364	48.7	5,351	31.2	2,555	14.9	16,270	94.8
Racine County								
Village								
Union Grove	5	0.0	46	0.3	5	0.0	56	0.3
Towns								
Dover	142	0.8	50	0.3	72	0.4	264	1.5
Mt. Pleasant	4	0.0	42	0.2	10	0.1	56	0.3
Yorkville	216	1.3	262	1.5	51	0.3	529	3.1
Subtotal	367	2.1	400	2.3	138	0.8	905	5.2
Watershed Total	8,731	50.8	5,751	33.5	2,693	15.7	17,175	100.0

Source: SEWRPC.

total habitat acreage, about 8,731 acres, or about 51 percent, were rated as Class I habitat; about 5,750 acres, or about 33 percent, were rated as Class II habitat; and about 2,690 acres, or about 16 percent, were rated as Class III habitat. The large amount of high-quality wildlife habitat remaining in the watershed is due largely to the preservation and protection of extensive wetland tracts associated with the lower reaches of the Des Plaines River in the Village of Pleasant Prairie and the University of Wisconsin Harris Tract in the Town of Paris. In addition, the extensive grassland, wetland, and open-water complex associated with the Bong State Recreation Area provides a variety of high-quality habitat areas for a variety of wildlife species. The Regional Planning Commission has long recommended that, to the maximum extent practicable, Class I and II wildlife habitat areas should be maintained in essentially natural, open uses.

Game and Nongame Wildlife Species

The foregoing section described the quantity and quality of the remaining wildlife habitat in the watershed. Fish in the Des Plaines River watershed were described previously in this chapter. This section explicitly describes the remaining wildlife of the watershed, consisting of amphibians, reptiles, birds, and mammals. Each of these classes of the animal kingdom represented in the watershed is described below.

Game species of wildlife include those for which there generally are established hunting or trapping seasons with rules which regulate the numbers and types of individuals that may be harvested and methods by which they may be harvested. It is noted that harvesting of game species is prohibited in certain areas, such as certain areas of the Des Plaines River watershed, because of their proximity of large human populations and the safety hazards associated with the discharge of firearms. Besides being harvested, these animals also provide aesthetic values enjoyed by both hunters and nonhunters. Examples of these types of animals are the white-tailed deer, cottontail rabbit, red fox, and many species of migratory waterfowl.

Nongame species of wildlife include those for which there are laws which preclude their harvest. The principal value of these species is their aesthetic appeal which is also enjoyed by the hunting and nonhunting segments of the population. Examples of these types of animals are songbirds, marsh birds, birds of prey, reptiles, amphibians, and certain mammals.

Although a current field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the Des Plaines River watershed study, it is possible by using existing information, such as the records of EnCAP, Inc., (Environmental Consultants and Planners),[18] habitat field inventories conducted by the Commission staff, and by polling naturalists and wildlife managers familiar with the watershed to prepare a list of the amphibians, reptiles, birds, and mammals which are found or are likely to be found in the watershed under existing conditions. The collation of the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to exist, or which have existed, in the Des Plaines River watershed; associating these lists with the remaining habitat areas, as inventoried; and then projecting the appropriate amphibian, reptile, bird, and mammal species into the watershed. The net result of the application of this technique is a better understanding of which species are normally present under existing conditions and which species could be expected to be lost as urbanization proceeds within the watershed. It should be noted that this procedure does not account for those transient species which may be found in the watershed only on rare occasions.

Amphibians and Reptiles

Although often unseen and unheard, amphibians and reptiles are vital components of the ecologic system of an environmental unit like the Des Plaines River watershed. Amphibians native to the watershed include frogs, toads, and salamanders. Turtles and snakes are reptiles common to the Des Plaines River watershed. Table 29 lists the 13 amphibian and 16 reptile species present in the Des Plaines River watershed and identifies those species most sensitive to urbanization.

Most amphibians and reptiles have definite habitat requirements which are adversely affected by certain agricultural land-management practices and by advancing urban development. One of the major threats to the maintenance of amphibian populations in a changing environment is the destruction of breeding ponds. Many types of frogs and salamanders return to the same breeding site year after year, even if the pond is not there, in which case they cannot breed. When an area is being filled and developed, some ponds must be selectively saved if amphibians are to be maintained. Toads are somewhat of an exception in this respect in that they can better adapt to the changes in environment which normally accompany urbanization than can other species of amphibians. The same problem of maintaining over-wintering sites, or hibernacula, may also be true for certain reptile species.

Another major consideration in the maintenance of both amphibians and reptiles is the protection of migration routes. Many species annually traverse distances of a mile or more from wintering sites to breeding sites to summer foraging grounds. The same pathways may be used each year; if species are to be maintained in the watershed, these pathways must be preserved. Protection of the environmental corridors of the watershed can assist in this respect.

Certain amphibians and reptiles are particularly susceptible to changes in food sources brought about by urbanization. Populations of the western fox snake and eastern milk snake, for example, are very likely to be reduced over time in the watershed because of the potential reduction of the species of rodents upon which they prey. Further, certain amphibians and reptiles are highly sensitive to pesticides and herbicides; for example, hognose snakes feeding on toads from recently sprayed agricultural lands may succumb from only one such feeding.

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[18]*EnCAP, Inc*., Habitat Evaluation of the Upper Des Plaines River and Adjacent Wetlands, 1979-80*, Final Report, Vol. 1-4, EnCAP, De Kalb, Illinois, December 1980.*

Table 29

AMPHIBIANS AND REPTILES KNOWN TO OCCUR IN THE DES PLAINES RIVER WATERSHED: 1995

Scientific (family) and Common Name (species)	Species Reduced or Dispersed with Full Watershed Urbanization	Species Lost with Full Watershed Urbanization
Amphibians		
Ambystomatidae		
Blue-Spotted Salamander (*Ambystoma laterale*)	- -	X
Eastern Tiger Salamander (*Ambystoma tigrinum tigrinum*)	X	- -
Salamandridae		
Central Newt (*Notophthalmus viridescens louisianensis*)	X	- -
Plethodontidae		
Mudpuppy (*Necturus maculosus maculosus*)	X	- -
Bufonidae		
Eastern American Toad (*Bufo americanus americanus*)	X	- -
Hylidae		
Blanchard's Cricket Frog (*Acris crepitans blanchardi*)[a,b]	- -	X
Western Chorus Frog (*Pseudacris triseriata*)	X	- -
Northern Spring Peeper (*Pseudacris crucifer crucifer*)	- -	X
Cope's Gray Treefrog (*Hyla chrysocelis*)	- -	X
Eastern Gray Treefrog (*Hyla versicolor*)	- -	X
Ranidae		
Bullfrog (*Rana catesbeiana*)	- -	X
Green Frog (*Rana clamitans melanota*)	X	- -
Northern Leopard Frog (*Rana pipiens*)	- -	X
Reptiles		
Chelydridae		
Common Snapping Turtle (*Chelydra serpentina serpentina*)	X	- -
Kinosternidae		
Common Musk Turtle (Sternotherus odoratus)	X	- -
Emydidae		
Blanding's Turtle (*Emydonidea blandingi*)[c]	- -	X
Western Painted Turtle (*Chrysemys picta bellii*)	X	- -
Midland Painted Turtle (*Chrysemys picta marginata*)	X	- -
Trionychidae		
Eastern Spiny Softshell Turtle (*Apalone spinifera spinifera*)	- -	X
Colubridae		
Eastern Hognose Snake (*Heterodon platirhinos*)	- -	X
Smooth Green Snake (*Opheodrys vernalis*)	- -	X
Western Fox Snake (*Elaphe vulpina vulpina*)	- -	X
Eastern Milk Snake (*Lampropltis triangulum triangulum*)	- -	X
Butler's Garter Snake (*Thamnophis butleri*)	X	- -
Eastern Plains Garter Snake (*Thamnophis radix radix*)	X	- -
Eastern Garter Snake (*Thamnophis sirtalis sirtalis*)	X	- -
Northern Brown Snake (*Storeria dekayi dekayi*)	X	- -
Northern Red-Bellied Snake (*Storeria occipitomaclata occipitomaclata*)	X	- -
Northern Water Snake (*Nerodia sipedon sipedon*)	X	- -
Viperidae		
Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*)[a]	- -	X

NOTE: Total number of amphibian species: 13. Total number of reptilian species: 16. Number of alien, or nonnative, species: 0.

[a]*Wisconsin designated endangered species.*

[b]*May now be extirpated from the watershed.*

[c]*Wisconsin designated threatened species.*

Source: R. C. Vogt, Milwaukee Public Museum (1981); EnCAP, Inc.; Wisconsin Department of Natural Resources; and SEWRPC.

Birds

A large number of birds representing many species, ranging in size from large game birds to small songbirds, are found in the Des Plaines River watershed. Table 30 lists those birds that would normally be expected to occur in the watershed. Each bird is classified as to whether it is likely to breed within the watershed, forage within the watershed, visit the watershed during the annual migration periods, or spend winter within the watershed. Game birds likely to occur in the watershed include pheasants, woodcocks, common snipes, rails, and a variety of ducks and geese.

Table 30

BIRDS IN THE DES PLAINES RIVER WATERSHED

Scientific (Family) and Common Name	Breeding	Forager	Wintering	Migrant
Gaviidae				
Common Loon	- -	- -	- -	R
Podicipedidae				
Pied-Billed Grebe	X	- -	- -	- -
Horned Grebe	- -	- -	- -	X
Pelecandidae				
American White Pelican	- -	- -	- -	R[a]
Phalacrocoracidae				
Double-Crested Cormorant	- -	X	- -	- -
Ardeidae				
American Bittern	X	- -	- -	- -
Least Bittern	X	- -	- -	- -
Great Blue Heron	X	- -	- -	- -
Great Egret[b]	?	X	- -	- -
Cattle Egret[c]	- -	X	- -	- -
Green-Backed Heron	X	- -	- -	- -
Black-Crowned Night-Heron	X	- -	- -	- -
Gruidae				
Sandhill Crane	X	- -	- -	- -
Anatidae				
Tundra Swan	- -	- -	- -	R
Mute Swan[c]	X	- -	- -	- -
Snow Goose	- -	- -	- -	R
Canada Goose	X	- -	- -	- -
Wood Duck	X	- -	- -	- -
Green-Winged Teal	X	- -	- -	- -
American Black Duck	- -	X	- -	- -
Mallard	X	- -	- -	- -
Northern Pintail	X	- -	- -	- -
Blue-Winged Teal	X	- -	- -	- -
Northern Shoveler	X	- -	- -	- -
Gadwall	- -	- -	- -	X
American Wigeon	X	- -	- -	- -
Canvasback	R	- -	- -	- -
Redhead	X	- -	- -	- -
Ring-Necked Duck	- -	X	- -	- -
Lesser Scaup	- -	X	- -	X
Common Goldeneye	- -	X	- -	X
Bufflehead	- -	X	- -	X
Hooded Merganser	X	- -	- -	- -
Common Merganser	- -	X	- -	X
Red-Breasted Merganser	- -	- -	- -	X
Ruddy Duck	X	- -	- -	- -
Cathartidae				
Turkey Vulture	X	- -	- -	- -
Accipitridae				
Osprey[b]	- -	- -	- -	X
Bald Eagle[b,d]	- -	- -	- -	X
Northern Goshawk	- -	- -	- -	X
Cooper's Hawk	- -	X	- -	- -
Sharp-Shinned Hawk	X	- -	- -	- -
Northern Harrier	X	- -	- -	- -
Red-Shouldered Hawk[e]	R	- -	- -	- -
Broad-Winged Hawk	- -	- -	- -	X
Red-Tailed Hawk	X	- -	- -	- -
Rough-Legged Hawk	- -	- -	- -	X
American Kestrel	X	- -	- -	- -
Merlin	- -	- -	- -	X
Phasianidae				
Gray Partridge[c]	X	- -	- -	- -
Ring-Necked Pheasant[c]	X	- -	- -	- -
Wild Turkey	- -	X	- -	- -
Northern Bobwhite[f]	X	- -	- -	- -
Rallidae				
Virginia Rail	X	- -	- -	- -
Sora	X	- -	- -	- -
Common Moorhen	X	- -	- -	- -
American Coot	X	- -	- -	- -
Charadriidae				
Black-Bellied Plover	- -	- -	- -	X
Lesser Golden-plover	- -	- -	- -	X
Piping Plover[f]	- -	- -	- -	R
Killdeer	X	- -	- -	- -
Scolopacidae				
Greater Yellowlegs	- -	- -	- -	X
Lesser Yellowlegs	- -	- -	- -	X
Solitary Sandpiper	- -	- -	- -	X
Spotted Sandpiper	X	- -	- -	- -

Scientific (Family) and Common Name	Breeding	Forager	Wintering	Migrant
Scolopacidae (continued)				
Upland Sandpiper	X	- -	- -	- -
Marbled Godwit	- -	- -	- -	X[a]
Least Sandpiper	- -	- -	- -	X
Pectoral Sandpiper	- -	- -	- -	X
Short-Billed Dowitcher	- -	- -	- -	R
Long-Billed Dowitcher	- -	- -	- -	R
Common Snipe	X	- -	- -	- -
American Woodcock	X	- -	- -	- -
Wilson's Phalarope	- -	X	- -	- -
Laridae				
Bonaparte's Gull	- -	- -	- -	X
Ring-Billed Gull	- -	X	- -	- -
Herring Gull	- -	X	- -	- -
Common Tern[f]	- -	- -	- -	R
Forster's Tern[f]	R	- -	- -	- -
Black Tern	X	- -	- -	- -
Columbidae				
Rock Dove[c]	X	- -	- -	- -
Mourning Dove	X	- -	- -	- -
Cuculidae				
Black-Billed Cuckoo	X	- -	- -	- -
Yellow-Billed Cuckoo	X	- -	- -	- -
Strigidae				
Eastern Screech Owl	X	- -	- -	- -
Great Horned Owl	X	- -	- -	- -
Snowy Owl	- -	- -	R	- -
Barred Owl	X	- -	- -	- -
Long-Eared Owl	- -	- -	R	- -
Short-Eared Owl	?	- -	X	- -
Northern Saw-Whet Owl	- -	- -	X	- -
Caprimulgidae				
Common Nighthawk	X	- -	- -	- -
Apodidae				
Chimney Swift	X	- -	- -	- -
Trochilidae				
Ruby-Throated Hummingbird	X	- -	- -	- -
Alcedinidae				
Belted Kingfisher	X	- -	- -	- -
Picidae				
Red-Headed Woodpecker	X	- -	- -	- -
Red-Bellied Woodpecker	X	- -	- -	- -
Yellow-Bellied Sapsucker	- -	X	- -	X
Downy Woodpecker	X	- -	- -	- -
Hairy Woodpecker	X	- -	- -	- -
Northern Flicker	X	- -	- -	- -
Pileated Woodpecker	- -	X	- -	- -
Tyrannidae				
Olive-Sided Flycatcher	- -	- -	- -	X
Eastern Wood-pewee	X	- -	- -	- -
Yellow-Bellied Flycatcher	- -	R	- -	- -
Acadian Flycatcher[b]	X	- -	- -	- -
Alder Flycatcher	X	- -	- -	- -
Willow Flycatcher	X	- -	- -	- -
Least Flycatcher	X	- -	- -	- -
Eastern Phoebe	X	- -	- -	- -
Great Crested Flycatcher	X	- -	- -	- -
Eastern Kingbird	X	- -	- -	- -
Alaudidae				
Horned Lark	X	- -	- -	- -
Hirundinidae				
Purple Martin	X	- -	- -	- -
Tree Swallow	X	- -	- -	- -
Northern Rough-Winged Swallow	X	- -	- -	- -
Bank Swallow	X	- -	- -	- -
Cliff Swallow	X	- -	- -	- -
Barn Swallow	X	- -	- -	- -
Corvidae				
Blue Jay	X	- -	- -	- -
American Crow	X	- -	- -	- -
Titmice				
Black-Capped Chickadee	X	- -	- -	- -
Sittidae				
Red-Breasted Nuthatch	- -	- -	X	- -
White-Breasted Nuthatch	X	- -	- -	- -

Table 30 (continued)

Scientific (Family) and Common Name	Breeding	Forager	Wintering	Migrant
Certhiidae				
Brown Creeper	- -	- -	- -	X
Troglodytidae				
House Wren	X	- -	- -	- -
Winter Wren	- -	- -	- -	X
Sedge Wren	X	- -	- -	- -
Marsh Wren	X	- -	- -	- -
Muscicapidae				
Golden-Crowned Kinglet	- -	- -	- -	X
Ruby-Crowned Kinglet	- -	- -	- -	X
Blue-Gray Gnatcatcher	X	- -	- -	- -
Eastern Bluebird	X	- -	- -	- -
Veery	X	- -	- -	- -
Gray-Cheeked Thrush	- -	- -	- -	X
Swainson's Thrush	- -	- -	- -	X
Hermit Thrush	- -	- -	- -	X
Wood Thrush	X	- -	- -	- -
American Robin	X	- -	- -	- -
Mimidae				
Gray Catbird	X	- -	- -	- -
Brown Thrasher	X	- -	- -	- -
Motacillidae				
American Pipit	- -	- -	- -	R
Bombycillidae				
Bohemian Waxwing	- -	- -	R	- -
Cedar Waxwing	X	- -	- -	- -
Lanniidae				
Northern Shrike	- -	- -	- -	R
Loggerhead Shrike[f]	- -	- -	- -	R
Sturnidae				
European Starling[c]	X	- -	- -	- -
Vireonidae				
White-Eyed Vireo	- -	- -	- -	X
Solitary Vireo	- -	- -	- -	X
Yellow-Throated Vireo	X	- -	- -	- -
Warbling Vireo	X	- -	- -	- -
Red-eyed Vireo	X	- -	- -	- -
Emberizidae				
Blue-Winged Warbler	- -	- -	- -	X
Golden-Winged Warbler	- -	- -	- -	X
Tennessee Warbler	- -	- -	- -	X
Orange-Crowned Warbler	- -	- -	- -	X
Nashville Warbler	- -	- -	- -	X
Northern Parula	- -	- -	- -	X
Yellow Warbler	X	- -	- -	- -
Chestnut-Sided Warbler	- -	- -	- -	X
Black-Throated Blue Warbler	- -	- -	- -	X
Yellow-Rumped Warbler	- -	- -	- -	X
Black-Throated Green Warbler	- -	- -	- -	X
Emberizidae (continued)				
Blackburnian Warbler	- -	- -	- -	X
Yellow-Throated Warbler	- -	- -	- -	X
Pine Warbler	- -	- -	- -	X
Prairie Warbler	- -	- -	- -	X
Palm Warbler	- -	- -	- -	X
Bay-Breasted Warbler	- -	- -	- -	X
Blackpoll Warbler	- -	- -	- -	X
Cerulean Warbler[b]	- -	- -	- -	X
Black-and-White Warbler	- -	- -	- -	X
American Redstart	X	- -	- -	- -
Prothonotary Warbler	- -	- -	- -	X
Ovenbird	- -	- -	- -	X
Northern Waterthrush	- -	- -	- -	X
Louisiana Waterthrush	- -	- -	- -	X
Common Yellowthroat	X	- -	- -	- -
Wilson's Warbler	- -	- -	- -	X
Canada Warbler	- -	- -	- -	X
Scarlet Tanager	- -	X	- -	- -
Rose-Breasted Grosbeak	X	- -	- -	- -
Indigo Bunting	X	- -	- -	- -
Dickcissel	X	- -	- -	- -
Rufous-Sided Towhee	X	- -	- -	- -
American Tree Sparrow	- -	- -	X	- -
Chipping Sparrow	X	- -	- -	- -
Field Sparrow	X	- -	- -	- -
Vesper Sparrow	X	- -	- -	- -
Lark Sparrow	X	- -	- -	- -
Savannah Sparrow	X	- -	- -	- -
Grasshopper Sparrow	X	- -	- -	- -
Henslow's Sparrow	R	- -	- -	- -
Fox Sparrow	- -	- -	- -	X
Song Sparrow	X	- -	- -	- -
Lincoln's Sparrow	- -	- -	- -	R
Swamp Sparrow	X	- -	- -	- -
White-Throated Sparrow	- -	- -	- -	X
White-Crowned Sparrow	- -	- -	- -	X
Dark-Eyed Junco	- -	- -	X	- -
Snow Bunting	- -	X	- -	- -
Bobolink	X	- -	- -	- -
Red-Winged Blackbird	X	- -	- -	- -
Eastern Meadowlark	X	- -	- -	- -
Yellow-Headed Blackbird	X	- -	- -	- -
Common Grackle	X	- -	- -	- -
Brown-Headed Cowbird	X	- -	- -	- -
Orchard Oriole	- -	- -	- -	X
Northern Oriole	X	- -	- -	- -
Purple Finch	- -	- -	X	- -
House Finch	X	- -	- -	- -
Common Redpoll	- -	- -	R	- -
Pine Siskin	- -	- -	X	- -
American Goldfinch	X	- -	- -	- -
Evening Grosbeak	- -	- -	R	- -
Passeridae				
House Sparrow[c]	X	- -	- -	- -

NOTE: Total number of bird species: 216. Number of alien, or nonnative, bird species: 7 (3 percent).

NOTE: Breeding: Nesting species
Foraging: Nonnesting species present in summer
Wintering: Present January-February
Migrant: Spring and/or fall transient

NOTE: X B present, not rare
R B rare
? B status uncertain

[a]*Single record reported from the Bong Recreational Area.*

[b]*State-designated threatened species.*

[c]*Alien, or nonnative, bird species.*

[d]*Federally-designated threatened species.*

[e]*Occurs in the watershed as escapes from managed hunt programs.*

[f]*State-designated endangered species.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

There are small isolated populations of waterfowl near the lakes, rivers, and ponds of the watershed, especially mallards and Canada geese. Larger numbers of waterfowl move through during migration, when most of the regional species may also be present. Other species of water-based birds which may occur in the watershed include herons, red-winged and yellow-headed blackbirds, gulls, plovers, and terns. Most of the waterfowl, marsh birds, and wading birds may be expected to be found in and adjacent to the lakes, rivers, and ponds. The numbers and diversity of the migratory birds which occur in the watershed can be attributed to migration patterns associated with the Mississippi flyway, in which the watershed is located, as well as more localized migration corridors which coincide with the Lake Michigan shoreline.

Because of the mixture of lowland and upland woodlots, grasslands, wetlands, and agricultural lands still present in the watershed, along with the favorable summer climate, the watershed supports many other species of birds. Hawks and owls function as major rodent predators within the ecosystem. Swallows, whip-poor-wills, woodpeckers, nuthatches, and flycatchers, as well as several other species, serve as major insect predators. In addition to their ecological roles, birds such as robins, red-winged blackbirds, yellow-headed blackbirds, orioles, cardinals, and mourning doves, in addition to those other species mentioned above, serve as subjects for bird watchers and photographers.

Not all birds are viewed as an asset from an ecological, economic, or social point of view. With the advance of urbanization and conversion of grasslands to croplands the related loss of natural habitat, conditions have become less compatible for the more desirable bird species. House sparrows, starlings, grackles, and pigeons have replaced the more desirable birds in certain areas of the watershed because of their great tolerance for, and adaptability to, urban and intensive agricultural conditions.

Mammals

A variety of mammals, ranging in size from large animals like the northern white-tailed deer to small animals like the cinereous shrew, occur in the Des Plaines River watershed. Table 31 lists 36 mammals, other than domestic mammals, likely to occur in the watershed.

The larger mammals still fairly common in the watershed include white-tailed deer, cottontail rabbits, gray squirrels, woodchucks, beavers, muskrats, minks, weasels, raccoons, red foxes, coyotes, skunks, and opossums. The first three are often considered game mammals, while the rest are classified as fur-bearing mammals.

White-tailed deer generally occur in the larger wooded areas of the watershed. The open meadows and croplands adjacent to such woodlots, as well as the shrub carrs, are also heavily utilized by deer. Human population and associated activities create a stress condition for the deer population. Deer populations and urban conditions are incompatible. When deer wander, or are forced, into residential, commercial, or industrial areas, they typically exhibit panic, running wildly and presenting a threat to people, property, and themselves. Foraging deer sometimes cause damage to gardens, ornamental trees, croplands, and orchards. Deer and automobile collisions often occur on the fringes of urban areas and are another example of the stress conditions that exist when deer inhabit urban-fringe areas.

The cottontail rabbit is an abundant species throughout the watershed. even in urbanized areas. The abundance and activity patterns of rabbits often result in their being one of the most widely viewed mammals in the watershed. However, large populations may cause local problems for gardeners and certain agricultural crops in some areas of the watershed. There is also an abundance of gray squirrels in the watershed. The gray squirrel is found primarily in woodlots and wooded residential sections. Trees of some maturity are required by gray squirrels because natural cavities in such trees are needed both for the rearing of young and for winter protection. Gray squirrels also construct leaf nests, called “drays,” used throughout the year as cover and nursery areas for the young.

Although there are no data available on the actual number of fur-bearing mammals in the watershed, the populations of beavers, muskrats, and minks is believed to be relatively high because of the extent of the remaining surface waters and associated wetlands. Beavers and muskrats are attracted to any significant water area in the watershed, including wetlands, ponds, lakes, creeks, and drainage ditches, all of which may provide suitable habitat. The familiar beaver lodge and muskrat house contribute a certain amount of interest to the landscape and are often used by other wildlife. Waterfowl may make use of the muskrat houses for nesting, and minks and raccoons occasionally use muskrat houses as denning areas. Preservation and improvement of beaver and muskrat habitat would, therefore, benefit certain waterfowl species, minks, and raccoons.

The raccoon is associated with the woodland areas, with stable populations reported within the Des Plaines River watershed. Much of the raccoon's food, however, is water-based, so it makes considerable transient use of surface waters and wetland areas. Scavenging raccoons can become pests in wooded environments that contain urban-fringe development.

The red fox, gray fox, and coyote are more characteristic of mixed habitat of woodlands, brush-lands, grasslands, and farmland areas, with good populations known to occur in, and adjacent to, the watershed. Occasionally, red foxes and coyotes will wander into more urban portions of the watershed, while the gray fox tends to be more shy of urban areas. Most people are tolerant of foxes and coyotes because of their aesthetic appeal, while others, not as well informed, consider them threats to other wildlife, domestic pets, and livestock.

Southern woodchucks are commonly found in the watershed. They prefer the edges of brushy wood-lands, particularly near open fields and croplands. The woodchuck is an extensive burrower. Abandoned woodchuck burrows are often occupied by other mammals, such as cottontail rabbits or skunks, and even red foxes. The woodchuck's diet consists mainly of green vegetable material. Because of its diet, some farmers have reported crop damage in some portions of the watershed.

Skunks, weasels, and opossums are common water-shed fur-bearers. These mammals typically inhabit woodland areas bordering farmlands and grasslands and will venture into wetlands in search of food.

Small mammals relatively common in the watershed include the cinereous shrew, short-tailed shrew, 13-lined ground squirrel, eastern chipmunk, meadow vole, white-footed mouse, and bat. These small mammals, with the exception of bats, are commonly

Table 31

MAMMALS KNOWN TO OCCUR IN THE DES PLAINES RIVER WATERSHED: 2000

Didelphidae *Didelphia marsupialis*CVirginia Opossum
Soricidae *Sorex cinereus*CCinereuos Shrew *Blarina brevicauda*CShort-Tailed Shrew
Vespertilionidae *Myotis lucifugus*CLittle Brown Bat *Lasionycteris noctivagans*CSilver-Haired Bat *Eptesicus fuscus*CBig Brown Bat *Lasiurus borealis*CRed Bat *Lasiurus cinereus*CHoary Bat
Leporidae *Sylvilagus floridanus*CMearn's Cottontail
Sciuridae *Marmota monax*CSouthern Woodchuck *Citellus tridecemlineatus*CStriped Ground Squirrel *Citellus franklinii*CFranklin's Ground Squirrel *Tamias striatus*COhio Chipmunk *Sciurus carolinensis*CMinnesota Gray Squirrel *Sciurus niger*CWestern Fox Squirrel *Glaucomys volans*CSouthern Flying Squirrel
Castoridae *Castor canadensis*CMichigan Beaver
Cricetidae *Peromyscus maniculatus*CPairie Deer Mouse *Peromyscus leucopus*CNorthern White-Footed Mouse *Microtus pennsylvanicus*CMeadow Vole *Microtus ochrogaster*CPrairie Vole *Ondatra zibethicus*CCommon Muskrat
Muridae *Rattus norvegicus*[a]CNorway Rat *Mus musculus*[a]CHouse Mouse
Zapodidae *Zapus hudsonius*CHudsonian Meadow Jumping Mouse
Canidae *Canis latrans*CNortheastern Coyote *Vulpes fulva*CEastern Red Fox *Urocyon cinereoargenteus*CWisconsin Grey Fox
Procyonidae *Procyon lotor*CUpper Mississippi Valley Raccoon
Mustelidae *Mustela erminea*CBang's Short-Tailed Weasel *Mustela rixosa*CAllegheny Least Weasel *Mustela frenata*CNew York Long-Tailed Weasel *Mustela vison*CUpper Mississippi Valley Mink *Taxidea taxus*CJackson's Badger *Mephitis mephitis*CNorthern Plains Skunk
Cervidae *Odocoileus virginianus*CNorthern White-Tailed Deer

NOTE: Total number of mammal species: 36. Number of alien, or nonnative, mammal species: 2 (6 percent).

[a]*Alien, or nonnative, mammal species.*

Source: H.H.T. Jackson, Wisconsin Department of Natural Resources (1961), and SEWRPC.

Table 32

ENDANGERED OR THREATENED ANIMAL SPECIES KNOWN TO OCCUR IN THE DES PLAINES RIVER WATERSHED

Endangered[a]
Fish: None
Amphibians
Blanchard's Cricket Frog (*Acris crepitans blanchardi*)[b]
Reptiles
Eastern Massasauga Rattlesnake (*Sistrurus catenatus*)
Birds
Piping Plover (*Charadrius melodus*)[c]
Common Tern (*Sterna hirundo*)
Forster's Tern (*Sterna forsteri*)
Loggerhead Shrike (*Lanius ludovicianus*)[c]
Yellow-Throated Warbler (*Dendroica dominica*)[d]
Mammals: None
Threatened[e]
Fish
Redfin Shiner (*Notropis umbratilis*)
Reptiles
Blanding's Turtle (*Emydonidea blandingi*)
Birds
Great Egret (*Casmerodius albus*)
Osprey (*Pandion haliaetus*)[d]
Bald Eagle (*Haliaeetus leucocephalus*)[d,f,g]
Acadian Flycatcher (*Empidonax virescens*)
Cerulean Warbler (*Dendroica cerulea*)[d]
Mammals: None

[a]*Wisconsin-designated endangered species.*

[b]*May now be extirpated from the watershed.*

[c]*Rare migrant through the watershed.*

[d]*Migrant through the watershed.*

[e]*Wisconsin-designated threatened species.*

[f]*Wisconsin-designated special concern species*

[g]*Federally-designated threatened species.*

Source: Wisconsin Department of Natural Resources, Milwaukee Public Museum, and SEWRPC.

associated with meadows, fencerows, and utility and transportation rights-of-way. They vary in their importance from insect predators and food sources for larger mammals and raptors, hawks and owls, to pests in croplands, gardens, and lawns.

Good populations of the Franklin's ground squirrel still exist in, and adjacent to, the watershed. However, a significant decline in the Statewide population of this ground squirrel is occurring because of a loss of suitable grassland habitat.

Endangered, Threatened, and Rare Fauna

Thirteen animal species that have been listed as endangered or threatened occur within the watershed (see Table 32). As designated by the Wisconsin Department of Natural Resources, seven of these species have been classified as endangered and seven as threatened. One Wisconsin designated special concern species, the bald eagle (*Haliaeetus leucocephalus*), a migrant species through the watershed, has also been designated as a Federal threatened species.

The Blanchard's cricket frog (*Acris crepitans blanchardi*), listed as an endangered species, may now be extirpated from the watershed. Although calling records were obtained by the Commission staff in the mid-1980s from the University of Wisconsin's Harris Marsh, in the Towns of Brighton and Paris, no recent calling collection records have been obtained in the watershed. Although the reasons for the decline in Wisconsin cricket frog populations are unclear, some biologists suggest it may be related, at least in part, to the drought of 1988.

One bird species on the State list of threatened species, the great egret (*Casmerodius albus*), a showy white wading bird, is commonly seen in the western portion of the watershed. The Commission staff has observed this bird on several occasions feeding in small, shallow ponds and open backwater areas associated with emergent wetlands. No breeding has been documented to date. However, it is strongly suspected to be occurring in some of the watersheds heron rookeries.

The eastern massasauga rattlesnake, also known as the swamp rattler, is on the State list of endangered species. It is one of the smaller North American rattlesnakes, about 18 to 30 inches in length. Its range in the Des Plaines River watershed is essentially restricted to the lower reaches of the main stem, in the Town of Bristol and the Village of Pleasant Prairie, where larger stands of river-bottom lowland hardwoods still occur. Although the eastern massasauga is one of a group of snakes known as the venomous pit vipers, it has shy habits, smaller size, and smaller fangs relative to other pit vipers. Those characteristics result in lower quantities of toxin available for injection, limiting its danger to the human population. Generally, if it is not disturbed, it does not harm humans. The eastern massasauga is the only poisonous snake found in Southeastern Wisconsin and now seems to be restricted within the Region to portions of the Des Plaines River and Turtle Creek (Rock River) watersheds.

In addition, a total of 43 animal species, mostly waterfowl and songbirds, have been listed as species of special concern (see Table 33). Many of these species are restricted to the extensive grassland and wetland areas which remain in the watershed. Preservation of suitable grassland and wetland habitat areas in the watershed will likely help to maintain good populations of these special concern species, thereby contributing to the maintenance of adequate and stable State-wide populations of these species. Conversely, failure to maintain such habitat, given its extensive occurrence within the watershed, could contribute to a substantial decline in such species. The result would be a reclassification of their status from a noncodified special-concern species to a codified Wisconsin designated endangered or threatened species. In this regard, the protection of such habitat is necessary for a balanced maintenance of all species within the watershed.

Wildlife Habitat Changes

As a result of urban and agricultural activity and the associated decrease in woodlands, wetlands, grasslands, and other natural areas, wildlife habitat in the Des Plaines River watershed has been seriously depleted. The habitat that remains generally consists of land parcels that have not to date been considered suitable for cultivation or urban development. Much of the remaining habitat has been modified or has deteriorated; some of these remaining habitat areas are being increasingly encroached upon by encircling urban development and agricultural uses.

As a consequence of the decrease in wildlife habitat, the wildlife population within the watershed has decreased. The fish, amphibian, reptile, bird, and mammal species once abundant in the watershed have diminished in type and quantity wherever intensive urbanization and agricultural land uses have occurred. Certain wildlife species, such as some songbirds, have the capacity to exist in small islands of undeveloped land within the urban and agricultural land complex or to adapt to this type of landscape, but this characteristic is not generally shared by most wildlife.

In order to maintain, and even increase, the existing remnants of wildlife populations within the watershed, the required amount, type, and pattern of habitat must be achieved and a land use pattern must be established within the watershed that preserves the remaining valuable wildlife habitat. It is necessary to remember that all wildlife species are dependent on on each other in one way or another. This means

Table 33

WISCONSIN ANIMAL SPECIES OF SPECIAL CONCERN OCCURRING IN THE DES PLAINES RIVER WATERSHED

Fish
Lake Chubsucker (*Erimyzon sucetta*)
Pirate Perch (*Aphredoderus sayanus*)
Least Darter (*Etheostoma microperca*)
Amphibians:
Bullfrog (*Rana catesbeiana*)
Reptiles:
Butler's Garter Snake (*Thamnophis butleri*)
Birds:
American Bittern (*Botaurus lentiginosus*)
Least Bittern (*Ixobrychus exilis*)
Black-Crowned Night Heron (*Nycticorax nycticorax*)
American Black Duck (*Anas rubripes*)
Northern Pintail (*Anas ac*uta)
Redhead (*Aythya americana*)
Lesser Scaup (*Aythya affinis*)
Common Goldeneye (*Bucephala clangula*)
Common Merganser (*Mergus merganser*)
Red-Breasted Merganser (*Mergus serrator*)[a]
Northern Goshawk (*Accipiter gentilis*)
Cooper's Hawk (*Accipiter cooperii*)
Northern Harrier (*Circus cyaneus*)
Merlin (*Falco columbarius*)
Common Moorhen (*Gallinula chloropus*)
Upland Sandpiper (*Bartramia longicauda*)
Wilson's Phalarope (Phalaropus tricolor)
Black Tern (*Chlidonias niger*)
Long-Eared Owl (*Asio otus*)
Short-Eared Owl (*Asio flammeus*)
Yellow-Bellied Flycatcher (*Empidonax flaviventris*)[b]
Sedge Wren (*Cistothorus platensis*)
Ruby-Crowned Kinglet (*Regulus calendula*)[a]
Swainson's Thrush (*Catharus ustulatus*)[a]
Tennessee Warbler (Vermivora peregrina)[a]
Blackburnian Warbler (*Dendroica fusca*)[a]
Prothonotary Warbler (*Protonotaria citrea*)[a]
Louisiana Waterthrush (*Seiurus motacilla*)
Dickcissel (*Spiza americana*)
Lark Sparrow (*Chondestes grammacus*)
Grasshopper Sparrow (*Ammodramus savannarum*)
Henslow's Sparrow (*Ammodramus henslowii*)[c]
Boblink (*Dolichonyx oryzivorus*)
Orchard Oriole (*Icterus spurius*)[a]
Pine Siskin (*Carduelis pinus*)
Evening Grosbeak (*Coccothraustes vespertinus*)[d]
Mammals:
Franklin's Ground Squirrel (*Citellus franklinii*)
Prairie Vole (*Microtus ochrogaster*)

[a]*Migrant through the watershed.*

[b]*Rare forager in the watershed.*

[c]*Rare breeder in the watershed.*

[d]*Rare winter resident within the watershed.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

that loss of habitat for one species has an adverse effect on certain other species, even though the required habitat for these other species may remain.

Park and Open Space Sites

An inventory of existing park and open space sites in the Des Plaines River watershed was conducted under the watershed planning program. This inventory indicated that there were a total of 74 park and open space sites within the watershed, totaling 5,429 acres, or 8.5 square miles, and about 6 percent of the total area of the watershed. An inventory of site size, ownership, and location is presented in Table 34 and a summary of the distribution by ownership is shown in Table 35. The spatial distribution of existing parks and open space sites is shown on Map 27. Public ownership accounts for 47 sites covering 3,070 acres, or 57 percent of the total park and open space acreage. Nonpublic ownership accounts for the remaining 27 sites encompassing 2,359 acres, or 43 percent of the total acreage. Of the 3,070 acres of park and open space sites in public ownership, 1,787 acres, or about 58 percent, are owned by the State of Wisconsin.

Environmental Corridors

One of the most important tasks completed under the regional planning effort has been the identification and delineation of those areas of the Region in which concentrations of recreational, aesthetic, ecological, and cultural resources occur, resources which should be preserved and protected. Such areas normally include one or more of the following seven elements of the natural resource base which are essential to the maintenance of both the ecological balance and natural beauty of the Region: 1) lakes, rivers, and streams and their associated shorelands and floodlands, 2) wetlands, 3) woodlands, 4) prairies, 5) wildlife habitat areas, 6) wet, poorly drained, or organic soils, and 7) rugged terrain and high-relief topography. While the foregoing elements comprise the integral parts of the natural resource base, there are five additional elements which, although not part of the natural resource base per se, are closely related to, or centered on, that base and are a determining factor in identifying and delineating areas with recreational, aesthetic, ecological, and cultural value: 1) existing park and open space sites, 2) potential park and open space sites, 3) historic sites, 4) significant scenic areas and vistas, and 5) natural and scientific areas. The delineation of these 12 natural resource and natural resource-related elements on a map results in a pattern of relatively narrow, elongated areas which have been termed “environmental corridors” by the Commission.

Primary environmental corridors include a wide variety of such important resource and resource-related elements and are at least 400 acres in size, two miles in length, and 200 feet in width. Secondary environmental corridors connect with primary environmental corridors, and are at least 100 acres in size and one mile in length.

In any consideration of the importance of environmental corridors to the overall ecological health of an area, it is important to point out that because of the many interacting relationships existing between living organisms and their environment, the deterioration or destruction of one important element of the environment may lead to a chain reaction of further deterioration and destruction of other elements. The draining of wetlands, for example, may have far-reaching effects, since it may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas of interconnecting stream systems. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater, which serves as a source of domestic, municipal, and industrial water supply and upon which low flows of rivers and streams may depend. Similarly, the destruction of woodland cover may result in soil erosion, stream siltation, more rapid runoff, and increased flooding, as well as the loss of wildlife habitat. Although the effects of any one of these environmental changes may not in and of itself be overwhelming, the combined effects must eventually lead to serious deterioration of the underlying and supporting natural resource base and of the overall quality of the environment for life. The need to maintain the integrity of the remaining environmental corridors within the Des Plaines River watershed should thus be apparent.

Primary Environmental Corridors

The primary environmental corridors in the Des Plaines River watershed are located in the northwestern one-quarter and the southern one-half of the watershed. These corridors contain most of the remaining valuable woodlands, wetlands, and wildlife habitat areas in the watershed; are, in effect, a composite of the best individual

Table 34

PARK AND OPEN SPACE SITES IN THE DES PLAINES RIVER WATERSHED: 2000

Civil Division	Site Ownership	Number[a]	Site Name	Area[b] (acres)	Location[c]
Kenosha County					
City of Kenosha	Public	474-04	Gangler Park	5	0122-10
	Nonpublic	488-11	Dairyland Greyhound Park	170	0222-31
Village of Paddock Lake	Public	187-03	Old Settlers' Park	16	0120-02
		205-05	Village Park	1	0120-03
		206-08	Salem Central Union High School	21	0120-11
		215-02	Paddock Lake Marsh	5	0120-02
		216-02	Hooker Lake Marsh (part)	27	0120-11
		217-05	Erickson Park	4	0120-02
		218-05	Public Access	1	0120-02
		245-05	North Shore Paddock Lake Community Park	1	0120-02
		246-05	Paddock Lake Dells Subdivision Park	1	0120-02
	Nonpublic	194-12	North Shore Paddock Lake Community Club	1	0120-02
		247-12	Paddock-Hooker Lake Association Park	1	0120-02
Village of Pleasant Prairie	Public	303-02	Kenosha Tourist Information Center	21	0122-30
		306-08	Pleasant Prairie School	1	0122-08
		309-08	Whittier School	2	0122-14
		342-05	Pleasant Prairie Ball Park	6	0122-07
		539-05	Prairie Springs Park	441	0122-20
	Nonpublic	305-10	I&S Plaines (Des Plaines) Wetlands Conservancy	420	0122-29
		465-11	Lagoon Tavern Picnic Ground	10	0122-27
		466-11	Colonial Inn Picnic Ground	5	0122-10
		536-11	Big Oaks Golf Club	260	0122-34
		537-10	Girl Scout Property	161	0122-30
		538-10	Upper Des Plaines River	425	0122-19
Town of Brighton	Public	056-02	University of Wisconsin Nature Area (part)	80	0220-36
		076-03	Brighton Dale Park	276	0220-10
		078-08	Brighton School	8	0220-15
		084-08	Kenosha School Forest	92	0220-22
		431-08	Salem School Forest	48	0220-10
		432-02	Bong State Recreation Area	1,321	0220-16
	Nonpublic	077-10	Union League Boys Club Camp	235	0220-35
		081-10	St. Francis Xavier School	4	0220-14
		083-11	Happy Acres Campground	42	0220-25
		527-10	Kenosha Achievement Center	23	0220-12
Town of Bristol	Public	056-02	University of Wisconsin Nature Area (part)	6	0121-06
		277-06	George Lake Beach	1	0121-20
		279-08	Bristol School	10	0121-07
		280-02	Benedict Prairie	8	0121-11
		282-08	Woodworth School	2	0121-03
		284-06	Richard Hansen Memorial Park	7	0121-17
		286-02	State Wetland Area	160	0121-21
		287-03	Bristol Woods County Park	206	0121-22
		289-06	Lake Shangri-La Beach Subdivision Park	1	0121-31
		291-06	Lake Shangri-La Beach Subdivision Park	1	0121-31
		294-06	Minerva Subdivision Park	1	0121-20
		297-06	Town Land	3	0121-31
		564-06	Park No. 1	1	0121-31
	Nonpublic	276-10	Conservation Club of Kenosha	179	0121-07
		278-11	Bristol Oaks Country Club	152	0121-09
		288-11	Lake Shangri-La Resort	3	0121-31
		290-12	Lake Shangri-La Beach Subdivision Park	1	0121-31
		292-11	Bristol Renaissance Fair	88	0121-36
		295-10	Kenosha Bowmen	42	0121-10
		296-10	Waukegan Bowmen	25	0121-30
Town of Paris	Public	053-08	Paris School	10	0221-21
		056-02	University of Wisconsin Nature Area (part)	126	0221-31
	Nonpublic	051-11	Van's Great Lakes Dragaway	74	0221-05
		054-10	St. John's Catholic School	4	0221-16
		055-12	Sowers Road and Gun Club	17	0221-11
Town of Salem	Public	056-02	University of Wisconsin Nature Area (part)	19	0120-01
		216-02	Hooker Lake Marsh (part)	13	0120-11
		221-06	Montgomery Lake Highlands Subdivision Park	1	0120-14
		223-06	Salem Oaks Subdivision Park	4	0120-11
		224-02	Public Access	1	0120-11
		255-06	Montgomery Lake Highlands Subdivision Park	1	0120-14
		512-06	Lake Shangri-La Beach Subdivision Park	1	0120-36
		513-06	Lake Shangri-La Beach Subdivision Park	1	0120-36
		514-06	Lake Shangri-La Beach Subdivision Park	1	0120-36
	Nonpublic	199-11	JoAnn's Resort	4	0120-36
		222-10	Montgomery Lake Highlands Subdivision Park	2	0120-11

Table 34 (continued)

Civil Division	Site Ownership	Number[a]	Site Name	Area[b] (acres)	Location[c]
Racine County					
Village of Union Grove	Public	385-05	Well No. 3 Park	1	0321-30
		393-08	Union Grove Middle School	9	0321-32
		397-05	Indian Trail Park	1	0321-32
	Nonpublic	561-10	Union Grove Baptist Church	3	0321-32
		563-10	Shepherds Home and School	8	0321-31
Town of Yorkville	Public	377-03	Old Settlers' Park	13	0321-31
		388-03	County Fair Grounds	83	0321-31

NOTE: All school site acreage represents the area developed for outdoor recreational facilities.

[a]*A site identification number, the first three digits of numbers in this column, was assigned to all sites included in the 1973 inventory of park and open space sites in the Region. This inventory is documented in Appendix D of SEWRPC Planning Report No. 27,* A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000. *Additional sites identified and included in the 1993 inventory were assigned a new site number. The ownership code numbers, the final two digits in this column, are divided into public and nonpublic as follows:*

Public		Nonpublic
02 - State	*05 – Village*	*10 – Organizational*
03 - County	*06 – Town*	*11 – Commercial*
04 - City	*08 – School District*	*12 – Private*

[b]*Site does not include the area, if any, outside the Des Plaines River watershed.*

[c]*The location numbers represent the U. S. Public Land Survey Township, Range, and Section in which the site is located.*

Source: SEWRPC.

elements of the natural resource base. They have truly immeasurable environmental and recreational value. The protection of the primary environmental corridors from intrusion by incompatible rural and urban uses, and thereby from degradation and destruction, should be one of the principal objectives of the watershed planning program. The primary environmental corridors should be considered inviolate; their preservation in an essentially open, natural state, including park and open space uses, limited agricultural uses, and country-estate residential uses, will serve to maintain a high level of environmental quality in the watershed, protect its natural beauty, and provide valuable recreation opportunities. As indicated on Map 28, about 10,090 acres, or about 12 percent of the total watershed area, are encompassed within the primary environmental corridors.

A comparison of the area of primary environmental corridor land as a percentage of the area of the watershed with the percentage of primary environmental corridor land in the County and the Region indicates that a relatively small area of the watershed has been classified as primary environmental corridor. As of 1985, about 16 percent of the total area of Kenosha County, 11 percent of the total area of Racine County, and about 17 percent of the total area of the Region was in primary environmental corridor. The importance of preserving the remaining primary environmental corridor lands in the Des Plaines River watershed in natural, open uses should thus be apparent.

Secondary Environmental Corridors

The secondary environmental corridors in the Des Plaines River watershed are located primarily along stream reaches throughout the watershed. These secondary environmental corridors contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive agricultural or urban purposes. Secondary environmental corridors facilitate surface water drainage, maintain "pockets" of natural resource features, and provide corridors for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species. Such corridors are also important to the maintenance of environmental quality and should be preserved in their natural state. As shown on Map 28, about 3,684 acres, or about 4 percent of the watershed, are encompassed within secondary environmental corridors. As

Table 35

SUMMARY OF OWNERSHIP OF PARKS AND OPEN SPACE SITES IN THE DES PLAINES RIVER WATERSHED: 2000

Ownership	Number of		Percent of Public		Percent of Nonpublic		Percent of Total	
	Sites	Acres	Sites	Acres	Sites	Acres	Sites	Acres
Public								
State	9	1,787	19.1	58.1	- -	- -	12.1	32.9
County	5	594	10.7	19.3	- -	- -	6.8	10.9
City	1	5	2.1	0.2	- -	- -	1.4	0.1
Village	9	464	19.1	15.1	- -	- -	12.1	8.5
Town	13	24	27.7	0.8	- -	- -	17.6	0.5
School District	10	203	21.3	6.5	- -	- -	13.5	3.7
Subtotal	47	3,077	100.0	100.0	- -	- -	63.5	56.6
Nonpublic								
Organizational	13	1,531	- -	- -	48.2	64.9	17.6	28.1
Commercial	10	808	- -	- -	37.0	34.3	13.5	14.9
Private	4	20	- -	- -	14.8	0.9	5.4	0.4
Subtotal	27	2,359	- -	- -	100.0	100.0	36.5	43.4
Total	74	5,436	- -	- -	- -	- -	100.0	100.0

Source: SEWRPC.

of 1985, about 3 percent of the total areas of Kenosha and Racine Counties and of the Region was in secondary environmental corridor.

Isolated Natural Areas

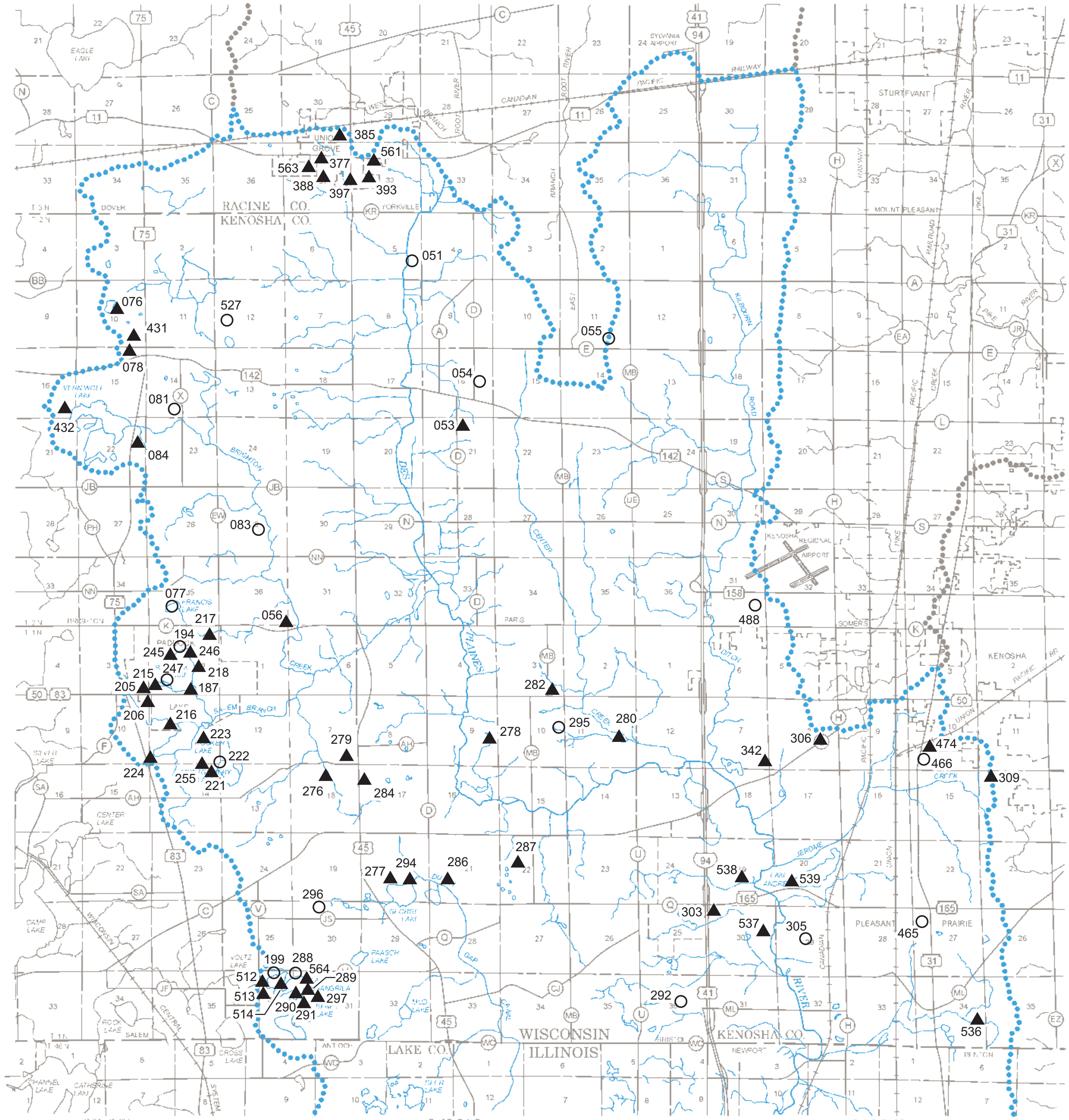
In addition to the primary and secondary environmental corridors, smaller concentrations of natural resource-base elements exist within the watershed area. Although these concentrations are isolated from the environmental corridors by urban development or agricultural uses, they may have important natural values. Isolated natural areas may provide the only available wildlife habitat in an area, provide good locations for local parks and nature study areas, and lend unique aesthetic character or natural diversity to an area. These isolated natural areas should also be protected and preserved in their natural state whenever possible. Isolated areas within the watershed are shown on Map 28. About 1,969 acres, or 2 percent of the watershed area, are encompassed within isolated natural areas that are five acres or greater in size. As of 1985, about 2 percent of the total area of Kenosha County, 3 percent of the total area of Racine County, and 2 percent of the total area of the Region was in isolated natural areas.

SUMMARY

The Des Plaines River watershed is a complex of natural and man-made features that interact to provide a changing environment for human life. Future changes in the watershed ecosystem and the favorable or unfavorable impact of those changes on the quality of life within the watershed will largely be determined by human actions. The Des Plaines River watershed planning program seeks to direct rationally those actions so as to affect favorably the overall quality of life in the watershed. This chapter describes the natural resource base and man-made features of the watershed, thereby establishing a factual base upon which the watershed planning process may be built.

Map 27

PARK AND OPEN SPACE SITES IN THE DES PLAINES RIVER WATERSHED: 2000



PARK AND OPEN SPACE SITES

○ PUBLIC

▲ NONPUBLIC

564 IDENTIFICATION NUMBER (SEE TABLE 34)

GRAPHIC SCALE

0 ½ 1 2 MILES

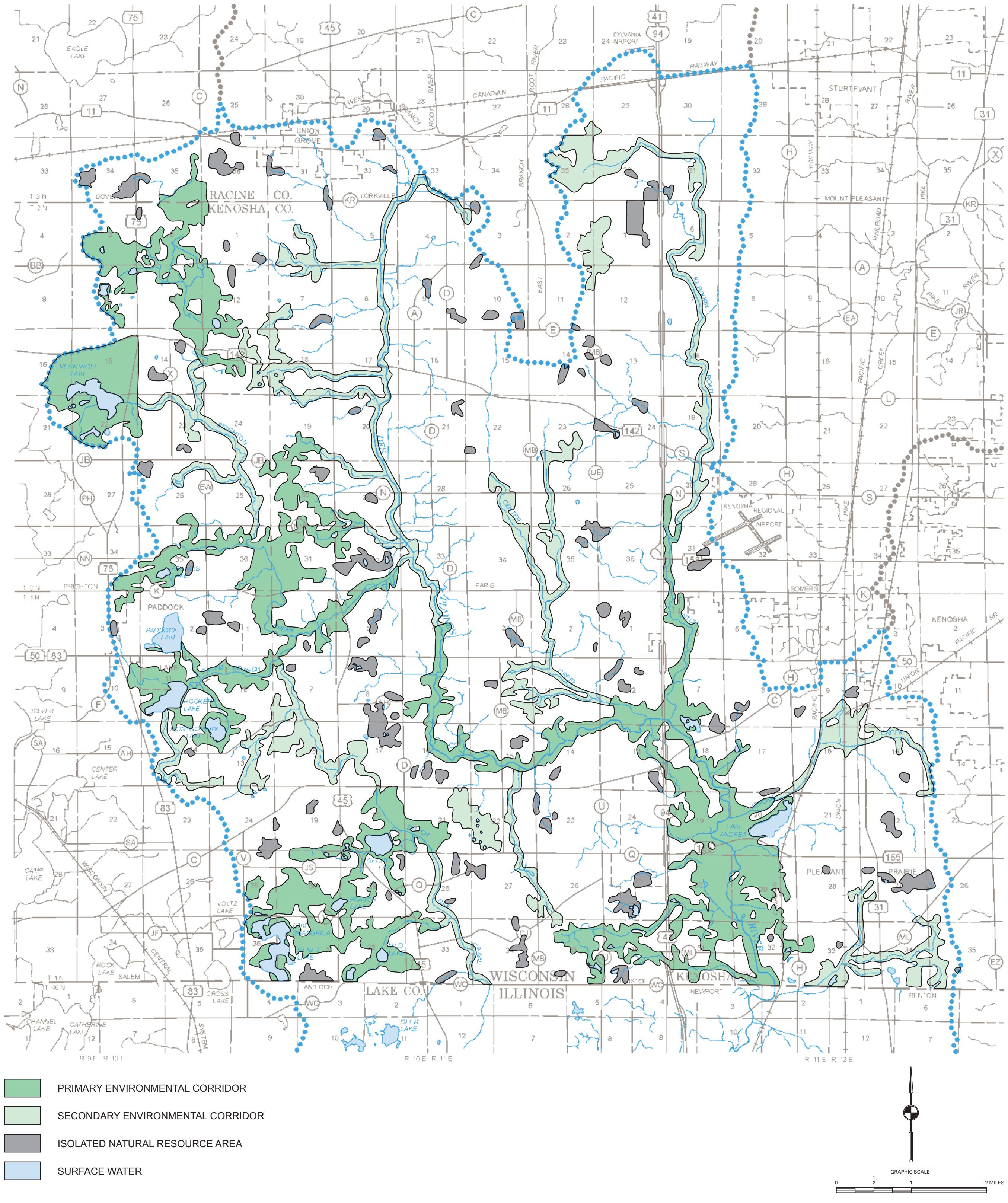
0 2,000 4,000 8,000 12,000 FEET

A total of 74 park and open space sites encompassing 5,436 acres exist in the Des Plaines River watershed. About 57 percent of this land is owned by public entities such as the State, counties, city, villages, towns and school districts. See Table 34 for a listing of the sites.

Source: SEWRPC.

Map 28

ENVIRONMENTAL CORRIDORS IN THE DES PLAINES RIVER WATERSHED: 1990



Environmental corridors encompass almost all of the best remaining valuable woodlands, wetlands, and wildlife habitat areas in the watershed, as well as many of the streams and associated undeveloped shorelands and floodlands; the significant topographical and geological formations; and important ecological, recreational, historic and cultural resources of the watershed. Primary environmental corridors in the watershed include a wide variety of these important resources. Secondary environmental corridors, which generally are less diverse and smaller in size than the primary environmental corridors, also include important resources. The preservation of the natural resources encompassed within the environmental corridors and the protection of such corridors from intrusions by incompatible rural and urban uses, and thereby from degradation and destruction, should be one of the principal objectives of the watershed planning program. In addition to the primary and secondary environmental corridors, other pockets of important natural resources exist within the watershed. Such pockets of isolated natural areas which may provide the only available wildlife habitat in an area, which provide good locations for local parks and nature study areas, and which lend unique aesthetic character and natural diversity to an area—should also be preserved and protected whenever possible. These important environmentally sensitive areas encompass a total areas of about 25 square miles, or about 18 percent of the total area of the watershed.

Source: SEWRPC.

The man-made features of the watershed include its political boundaries; its land use pattern, its public utility network, and its transportation system. These features, along with the resident population and the economic activities within the watershed, may be thought of as the socioeconomic base of the watershed.

The 132.9-square-mile Des Plaines River watershed comprises about 5 percent of the total area of the Southeastern Wisconsin Region and ranks sixth in size among the 11 distinct watersheds located wholly or partly within the Region. The watershed lies in two counties, one city, three villages, and eight towns.

The 1990 resident population of the watershed was estimated at 19,600 persons, or about 1 percent of the total population of the Region. From 1960 to 1970, the population growth rate of the watershed was higher than that of Kenosha County and of the Region. From 1970 to 1980, the population growth rate was significantly higher than that of the Region and of Kenosha and Racine Counties. From 1980 to 1990, the population growth rate was again higher than that of the Region and of Kenosha and Racine Counties, although the rate of growth within the watershed was less than for the 1970 to 1980 period. Population densities within the watershed range from fewer than 400 persons per square mile in the still rural areas of the watershed, to more than 4,500 persons per square mile in the urbanized areas. The median age in the watershed, 33.1 years; household size, 2.90 persons; and household income, $41,928, are somewhat higher than those in Kenosha and Racine Counties and in the Region.

The Des Plaines River watershed is located close to the Kenosha and Racine urbanized areas and near the Milwaukee urbanized area. As such, its economic base cannot be differentiated in any meaningful way from that of the greater Kenosha, Racine, and Milwaukee areas. The residents of the watershed can readily commute to jobs located outside the watershed, while other residents of the greater Kenosha, Racine, and Milwaukee areas can readily commute to jobs located in the watershed. In addition, since the watershed is located just north of the Wisconsin-Illinois state line, watershed residents are able to commute to jobs in Northeastern Illinois and Northeastern Illinois residents can commute to jobs in the Wisconsin portion of the watershed.

Total employment in the watershed in six major industrial groups was estimated at 8,200 jobs in 1990. Of that total, about 2,400 jobs, or 29 percent, are provided in the manufacturing sector. The agricultural sector provides 650 jobs, or 8 percent of the total jobs in the Des Plaines River watershed.

In 1963 urban land uses accounted for 7 percent of the watershed area. By 1990, approximately 12 percent of the total watershed area was in urban use. Residential uses were predominant, followed closely by lands in the transportation, communications, and utilities category. With 88 percent of the watershed still in rural land use as of 1990, the watershed ranks third among the watersheds in the Region in the percentage of rural land uses. Agricultural land uses made up 92 square miles, or 68 percent of the total watershed area.

The public utility base of the watershed consists of its sanitary-sewerage, water-supply, electric, and gas service systems. Adequate supplies of both electric power and natural gas are available to all areas of the watershed. Fifteen public and private sanitary sewerage districts or portions thereof serve about 8 percent of the total area of the watershed and about 8,400 persons, or 43 percent of the total resident population of the watershed. Five public water- supply systems serve the urban areas of the Des Plaines River watershed. They serve about 5 percent of the total area of the watershed and supply approximately 8,500 persons, or about 43 percent of the total resident population of the watershed. There are nine private water utilities in the watershed which serve mobile home parks, apartment buildings, and institutions. These systems serve an estimated 1,400 persons, or 7 percent of the watershed population.

The watershed is well served by an extensive all-weather arterial street and highway system. Two types of bus service are available in the watershed: urban mass transit and intercity bus service. Urban mass transit service is provided by the City of Kenosha Transit System. There is scheduled Amtrak railway passenger train service over the lines of the Canadian Pacific Railway (former Chicago, Milwaukee, St. Paul & Pacific Railroad) between the Amtrak passenger stations in Milwaukee and Sturtevant to the north and Chicago to the south. Railway freight service is provided to the watershed by both the Union Pacific Railroad (former Chicago & North Western Railway) and the Canadian Pacific Railway. Kenosha Regional Airport is a large general aviation airport located partially within the watershed and designated by the Federal Aviation Administration as a reliever facility to Milwaukee County General Mitchell International Airport. About 200 acres, or 21 percent of the total area of the airport, lie within the Des Plaines River watershed.

The natural resource base of the watershed is a composite of climate, physiography, geology, soils, water resources, and fish and wildlife resources. Inasmuch as the underlying and sustaining natural resource base is highly vulnerable to misuse and destruction, good management of the remnants of that resource base must be a primary consideration in the Des Plaines River watershed planning effort.

Because of its mid-continental location, far removed from the moderating effect of the oceans, the Des Plaines River watershed has a climate characterized by a progression of markedly different seasons. An essentially continuous pattern of distinct weather changes occurring at about three-day intervals is superimposed on the seasonal pattern. Lake Michigan also has a moderating effect on the climate because of its proximity to the watershed. Air temperatures in the watershed range from a daily average of about 21 degrees Fahrenheit (°F) in January to 72°F in July. Watershed temperature extremes have ranged from a low of about -26°F to a high of approximately 105°F.

Average annual precipitation within the watershed is 32.6 inches, expressed as water equivalent, and average monthly amounts range from a low of 1.13 inches in February to a high of 3.87 inches in July. The average annual snowfall is 41.08 inches which, when converted to its water equivalent, constitutes 13 percent of the total annual precipitation. About 90 percent of the annual snowfall occurs in the four months of December, January, February, and March. Annual total precipitation in the vicinity of the watershed has varied from a low of 17 inches to a high of 50 inches. Snowfall has, relative to the annual average, historically exhibited a wider variation than has total precipitation, with the annual snowfall ranging from a low of five inches to a high of approximately 109 inches.

There is a 0.31 probability of having five or more inches of snow cover on the ground during January and early February. An average of 10.2 to 14.5 inches of frost penetration normally exists in the watershed during January, February, and the first half of March. Annual potential evaporation in the watershed is about 29 inches, which is less than the total annual precipitation. The direction of prevailing winds follows a clockwise pattern over the seasons of the year, northwesterly in the late fall and winter, northeasterly in the spring, and southwesterly in the summer and early fall.

Daylight in the watershed ranges from a minimum of nine hours on about December 22 to a maximum of 15.4 hours on about June 21. The smallest amount of daytime sky cover occurs from July through October, when the mean monthly daytime sky cover is approximately 0.5, whereas a sky cover of about 0.7 may be expected from November through March.

Watershed topography and physiographic features have been largely determined by the underlying bedrock and overlying glacial deposits. Surface elevations within the watershed range from a high of approximately 891 feet above the National Geodetic Vertical Datum 1929 (Mean Sea Level Datum) along the western border of the watershed to a low of approximately 668 feet above National Geodetic Vertical Datum 1929 at the point the Des Plaines River passes into Illinois, a maximum relief of about 223 feet.

Surface drainage within the watershed is highly diverse with respect to channel cross-sectional shape, channel slope, degree of stream sinuosity, and floodland shape and width. The heterogeneous character of the surface drainage system is due partly to the natural effect of glaciation superimposed on the bedrock and partly to channel modifications and other results of urbanization in the basin.

The geology of the Des Plaines River watershed is a complex system of various layers and ages of rock formations. These formations slope gently down toward the east, and consist predominantly of, in ascending order, Precambrian crystalline rocks; Cambrian through Silurian sedimentary rocks, including sandstone, dolomite, and shale; and unconsolidated surficial deposits, clay, silt, sand, gravel, and boulders.

Streams and associated floodlands comprise some of the most important elements of the natural resource base of the watershed, primarily because of their associated aesthetic, recreational, and economic values. There are about 69 lineal miles of perennial streams within the watershed. There are six major lakes of 50 acres or more in size in the watershed. The streams, lakes, ponds, and wetlands constitute the entire surface water resources of the watershed.

Extensive groundwater resources underlie the Des Plaines River watershed and are an integral part of the much larger groundwater system that lies beneath the Southeastern Wisconsin Planning Region. The aquifers lying beneath the watershed, which attain a combined thickness in excess of 1,500 feet, may be subdivided so as to identify three distinct groundwater sources. In order, from the land surface downward, they are the sand and gravel deposits in glacial drift, the shallow dolomite strata in the underlying bedrock, and the deeper bedrock strata composed of sandstone, dolomite, and shale. The combined groundwater reservoirs are the source of water supply for the rural areas of the watershed, while the gradual discharge from the groundwater reservoir supplies the base flow to Des Plaines River and its tributaries.

Since the early settlement of the Des Plaines River watershed by Europeans, there has been a sharp decrease in the variety and quantity of wildlife because of the decrease in woodlands, grasslands, wetlands, other natural areas, and because of the loss of instream habitat. Most of the remaining wildlife habitat areas are located along the western boundary of the watershed and in scattered portions of the southern one-third. The remaining fish and wildlife resources are particularly significant to the Des Plaines River watershed because of the recreational, educational, economic, and aesthetic value they impart.

There are 74 existing park and open space sites within the watershed, totaling about 5,436 acres, or about 6 percent of the total area of the watershed. Of this total, 47 sites encompassing 3,077 acres, or 57 percent of the total acreage, are in public ownership.

The delineation of selected natural resource and natural resource-related elements in the watershed produces an essentially linear pattern of narrow, elongated areas which have been termed environmental corridors by the Regional Planning Commission. As of 1990, primary and secondary environmental corridors encompassing the best remaining elements of the natural resource base, including the surface waters, associated shorelands and floodlands and the best remaining woodlands, wetlands, wildlife habitat areas, and existing and potential park sites, together with isolated natural areas occupied 15,740 acres, or 24.6 square miles, in the watershed, or 18 percent of the watershed area. This compares with 1985 totals of 21 percent for Kenosha County, 17 percent for Racine County, and 22 percent for the Region as a whole. The preservation of the remaining environmental corridors and isolated natural areas in essentially natural, open uses is necessary to the maintenance of a high level of environmental quality in the Des Plaines River watershed.

Chapter IV

ANTICIPATED GROWTH AND CHANGE IN THE WATERSHED

INTRODUCTION

In any planning effort, forecasts are required of all future conditions which are considered beyond the scope of the plans to be prepared, but which may affect either the design of the plans or the implementation of the plans over time. The future demands on the resources of a watershed are determined primarily by the size and spatial distribution of the future population and economic activity levels in the watershed. Although the spatial distribution of future population and economic activity can be influenced by public land use regulation, and although upper limits can be set on population and economic activity levels through such regulation, the control of changes in population and economic activity levels lies largely beyond the scope of governmental activity, at least at the regional and local levels. Neither the levels of population and employment within an area such as the Des Plaines River watershed nor the rates of change in these levels can be prescribed in a watershed plan. Rather, such levels and changes will be a function of the relative attractiveness of the watershed and of the Region of which the watershed is an integral part and of market-driven development relative to other watersheds within the Region and to other regions of the United States.

In the preparation of the comprehensive plan for the Des Plaines River watershed, therefore, future population and economic activity levels had to be forecast. These forecasts could then be converted to future demands for land within the watershed and then land and water use plans prepared to meet these demands. These land and water use plans, in turn, provided a basis for the preparation of supporting water resource management and related facility plans.

BASIS OF POPULATION, HOUSEHOLD, ECONOMIC ACTIVITY, AND LAND USE DEMAND FORECASTS

The population, household, employment, and land use demand forecasts presented in this chapter are based upon forecasts prepared for, and used in, the preparation of other regional plan elements, including areawide land use, transportation, and sewerage system plans. This use of forecasts prepared for comprehensive, areawide planning purposes helps to assure consistency between the watershed plan and other long-range, areawide plan elements.

The population, household, employment, and land use demand forecasts selected as the basis for the preparation of the Des Plaines River comprehensive watershed plan were based upon regional forecasts developed using an alternative futures approach. Under this approach, alternative future conditions were postulated for the Region considering potential changes in the key external factors affecting the development of the Region, including the cost and availability of energy, individual and family lifestyles, and the ability of the Region to compete with other regions of the United States for development. The range of population and economic activity levels attendant to these alternative future conditions was believed to represent reasonable extremes of future development conditions within the Region. Alternative land use patterns were then developed for each of these future conditions in order to provide a range of spatial distribution of population and economic activity levels within the Region.

Under the alternative futures approach, three alternative future growth scenarios were postulated for Southeastern Wisconsin. The sets of conditions postulated for each "future" were intended to represent consistent, reasonable scenarios of future population change and change in economic activity in the Region through the year 2010. Two scenarios, the "high-growth" scenario and the "low-growth" scenario, were intended to represent reasonable extremes; the third scenario, the "intermediate-growth" scenario, was intended to represent a likely future.

These alternative futures were combined with centralized and decentralized land use scenarios, as described in SEWRPC Planning Report No. 40, *A Regional Land Use Plan for Southeastern Wisconsin: 2010*, January 1992. The recommended year 2010 regional land use plan is based on the use of the intermediate-growth scenario with centralized development. Tables 36, 37, and 38 and Figures 12, 13, and 14 summarize the population, household, and employment changes which may be expected in the Southeastern Wisconsin Region, Kenosha and Racine Counties, and the Des Plaines River watershed under each of the three alternative futures for population and employment set forth in the regional land use plan.

Within the Kenosha Urban Planning District, that portion of Kenosha County located east of IH 94, the regional land use plan has been refined in a local comprehensive land use and transportation system plan, documented in SEWRPC Community Assistance Planning Report No. 212, *A Comprehensive Plan for the Kenosha Urban Planning District*, December 1995. The recommended plan set forth in that report is based on a high-growth scenario with centralized development.

It was determined by the Watershed Committee that the high-growth centralized land use development alternative, as presented in the regional land use plan and as refined by the comprehensive plan for the Kenosha Urban Planning District, would be adopted for land use planning in the Des Plaines River watershed. Under that alternative, population, households, and employment levels in the Des Plaines River watershed are envisioned to increase substantially between 1990 and the plan design year. Selection by the Committee of this higher rate of growth was based upon the following considerations: 1) the continued strong population and employment growth occurring in the greater Kenosha area and the watershed, 2) the potential for continued strong growth, particularly given the location of the watershed in the Chicago-Milwaukee corridor, and 3) the widespread availability of public utility services within the greater Kenosha area and the watershed, which both accommodates and fosters new growth. The spatial distribution of population, households, and economic activity under the high-growth centralized land use scenario is based upon adopted regional and local land use development objectives and is consistent with Federal and State policies which seek to protect environmentally significant areas and prime agricultural lands.

The Committee also concluded that, for purposes of hydrologic and hydraulic modeling to develop flood flows and stages, a land use development scenario providing for complete development, or "buildout," of the planned year 2010 sewer service areas within the watershed would be used. That alternative expands upon the high-growth scenario in that it assumes complete urban development of all planned sanitary sewer service areas within the watershed. Its use was considered to be appropriate for floodland management purposes because it provides a conservative, long-range basis upon which to delineate floodlands and to consider floodland management measures. Such measures should be designed considering relatively long-term conditions, since floodplain management facilities and measures may be expected to have a use of 50 or more years.

Table 36

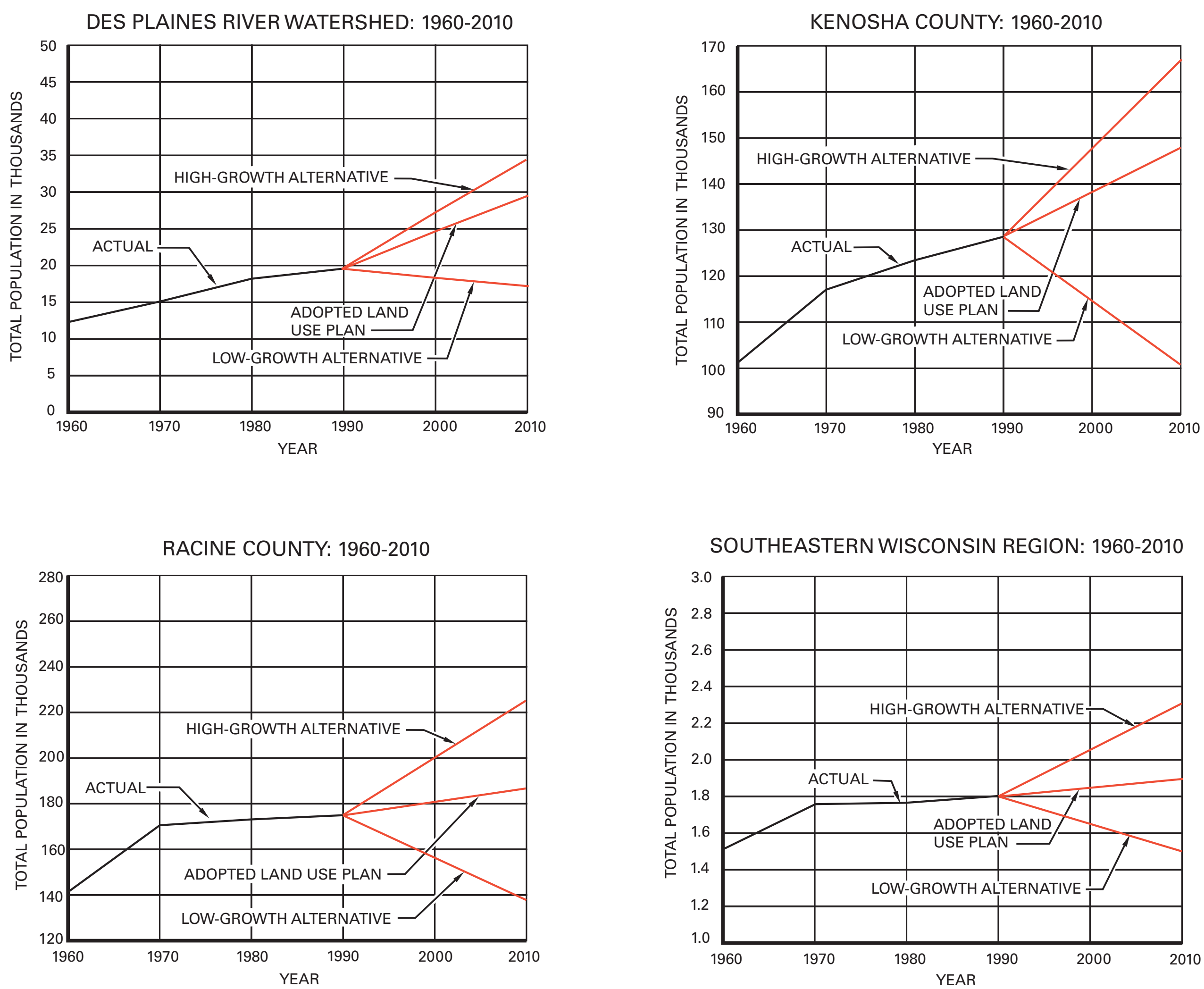
ACTUAL AND ALTERNATIVE FUTURE POPULATION LEVELS IN THE DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: 1970, 1990, 2010

Area	1970 Actual	1990 Actual	1970-1990 Increment		2010 Alternative Future	1990-2010 Increment		2010 Total
			Number	Percent		Number	Percent	
Des Plaines River Watershed	15,040	19,652	4,612	30.7	High-Growth Alternative	15,048	76.6	34,700
					Adopted Land Use Plan	10,048	51.1	29,700
					Low-Growth Alternative	–2,352	-12.0	17,300
Kenosha County	117,917	128,181	10,264	8.7	High-Growth Alternative	38,619	30.1	166,800
					Adopted Land Use Plan	19,719	15.4	147,900
					Low-Growth Alternative	-26,381	-20.6	101,800
Racine County	170,838	175,034	4,196	2.5	High-Growth Alternative	49,666	28.4	224,700
					Adopted Land Use Plan	10,966	6.3	186,000
					Low-Growth Alternative	-35,434	-20.2	139,600
Southeastern Wisconsin Region	1,756,083	1,810,364	54,281	3.1	High-Growth Alternative	505,736	27.9	2,316,100
					Adopted Land Use Plan	100,636	5.6	1,911,000
					Low-Growth Alternative	-293,264	-16.2	1,517,100

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

Figure 12

ACTUAL AND ALTERNATIVE FUTURE POPULATION LEVELS IN THE DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: 1960-2010



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

Table 37

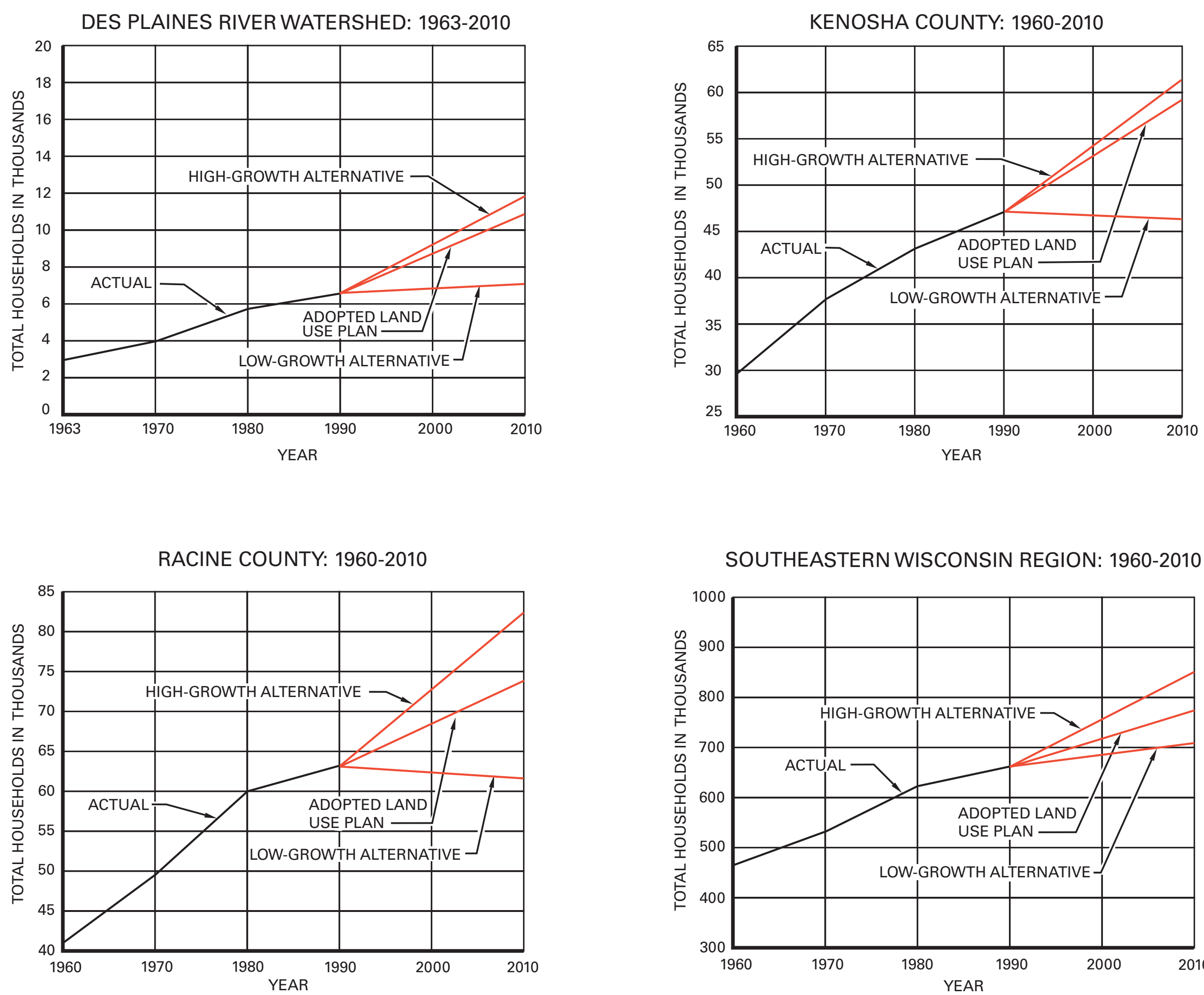
ACTUAL AND ALTERNATIVE FUTURE NUMBER OF HOUSEHOLDS IN THE DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: 1970, 1990, 2010

Area	1970 Actual	1990 Actual	1970-1990 Increment		2010 Alternative Future	1990-2010 Increment		2010 Total
			Number	Percent		Number	Percent	
Des Plaines River Watershed	3,960	6,620	2,660	67.2	High-Growth Alternative Adopted Land Use Plan Low-Growth Alternative	5,280 4,280 530	79.8 64.7 8.0	11,900 10,900 7,150
Kenosha County	35,500	47,000	11,500	32.4	High-Growth Alternative Adopted Land Use Plan Low-Growth Alternative	14,400 12,100 –700	30.6 25.7 –1.5	61,400 59,100 46,300
Racine County	49,800	63,700	13,900	27.9	High-Growth Alternative Adopted Land Use Plan Low-Growth Alternative	17,600 10,200 –700	27.6 16.0 –2.4	81,300 73,900 62,200
Southeastern Wisconsin Region	536,500	676,100	139,600	26.0	High-Growth Alternative Adopted Land Use Plan Low-Growth Alternative	176,600 98,200 25,800	26.1 14.5 3.8	852,700 774,300 701,900

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

Figure 13

ACTUAL AND ALTERNATIVE FUTURE NUMBER OF HOUSEHOLDS IN THE DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: 1960-2010



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

Table 38

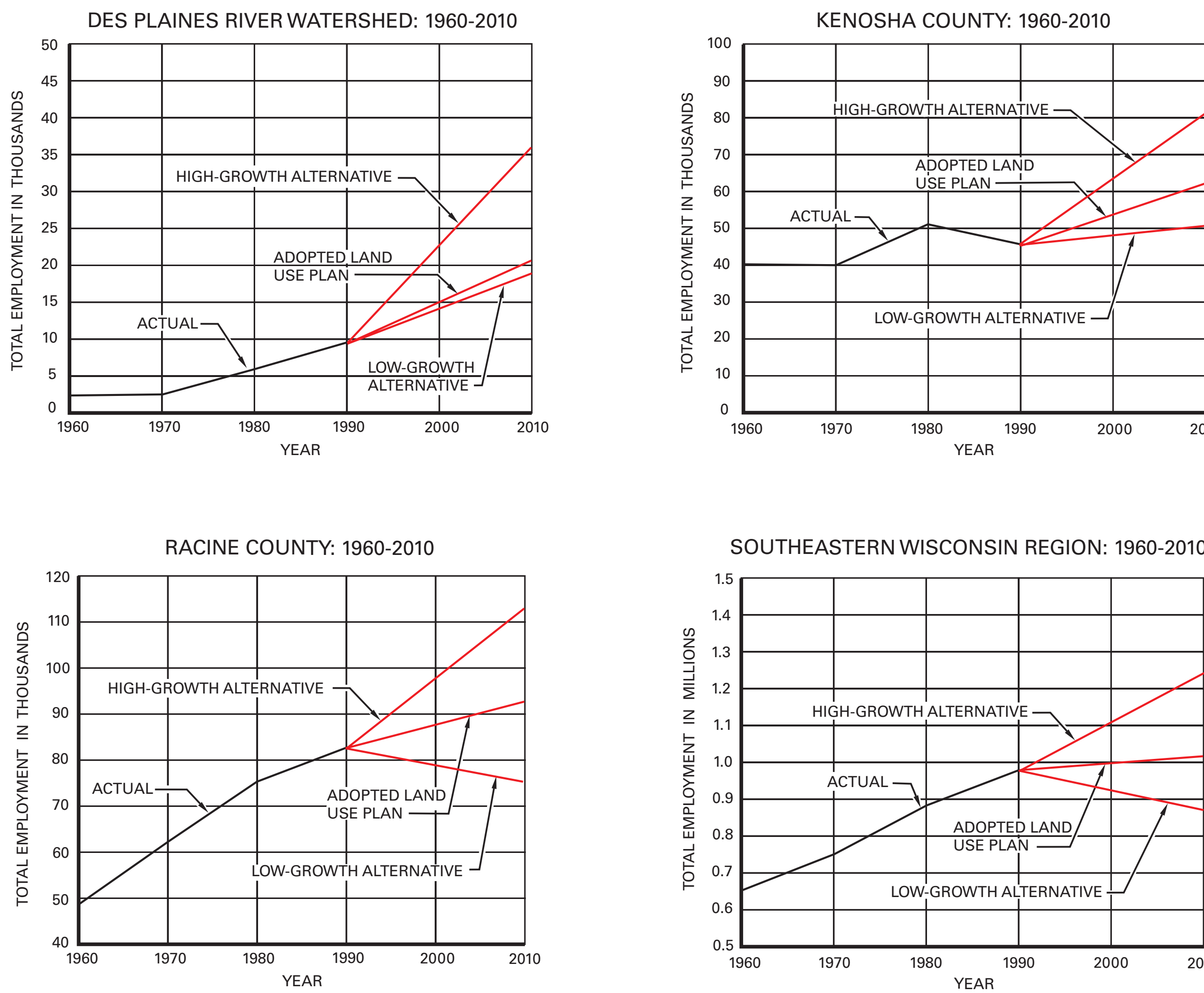
ACTUAL AND ALTERNATIVE FUTURE EMPLOYMENT LEVELS IN THE DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: 1970, 1990, 2010

Area	1970 Actual	1990 Actual	1970-1990 Increment		2010 Alternative Future	1990-2010 Increment		2010 Total
			Number	Percent		Number	Percent	
Des Plaines River Watershed	2,300	8,200	5,900	256.5	High-Growth Alternative Adopted Land Use Plan Low-Growth Alternative	28,500 13,300 11,000	347.6 162.2 134.1	36,700 21,500 19,200
Kenosha County	40,000	46,500	6,500	16.2	High-Growth Alternative Adopted Land Use Plan Low-Growth Alternative	34,300 16,500 3,900	73.8 35.5 8.4	80,800 63,000 50,400
Racine County	62,700	82,200	19,500	31.1	High-Growth Alternative Adopted Land Use Plan Low-Growth Alternative	30,400 9,900 –6,500	37.0 12.0 –7.9	112,600 92,100 75,700
Southeastern Wisconsin Region	753,700	990,300	236,600	31.4	High-Growth Alternative Adopted Land Use Plan Low-Growth Alternative	261,300 104,700 –119,400	26.4 10.6 –12.1	1,251,600 1,095,000 870,900

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

Figure 14

ACTUAL AND ALTERNATIVE FUTURE EMPLOYMENT LEVELS IN THE DES PLAINES RIVER WATERSHED, KENOSHA COUNTY, RACINE COUNTY, AND THE REGION: 1960-2010



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

The areas of the watershed to be developed for urban uses under these two future conditions are shown on Map 29.

POPULATION GROWTH

As shown in Table 39, the resident population of the Des Plaines River watershed increased from about 15,040 persons in 1970 to about 19,650 persons in 1990, an increase of 4,610 persons, or about 31 percent, over the 20-year period. As also shown in Table 39, based upon the adopted high-growth centralized development land use alternative, the population of the watershed may be expected to increase from the 1990 level of 19,650 persons to 33,500 persons by the plan design year 2010, an increase of 13,850 persons, or about 70 percent, over the 20-year period. Based on the sewer service area buildout alternative, the population of the watershed would increase from the 1990 level of 19,650 persons to 45,500 persons at full buildout, an increase of 25,850 persons, or about 132 percent.

GROWTH IN NUMBER OF HOUSEHOLDS

As shown in Table 39, the number of households in the Des Plaines River watershed increased from a level of about 3,960 in 1970 to about 6,620 in 1990, an increase of 2,660, or about 67 percent, over the 20-year period. As also shown in Table 39, based upon the adopted high-growth centralized development land use alternative, the number of households in the watershed may be expected to increase from the 1990 level of 6,620 to 11,500 by the plan design year 2010, an increase of 4,880 persons, or about 74 percent, over the 20-year period. Based on the sewer service area buildout alternative, the number of households in the watershed would increase from the 1990 level of 6,620 to 16,300 persons at full buildout, an increase of 9,680 persons, or about 146 percent.

EMPLOYMENT GROWTH

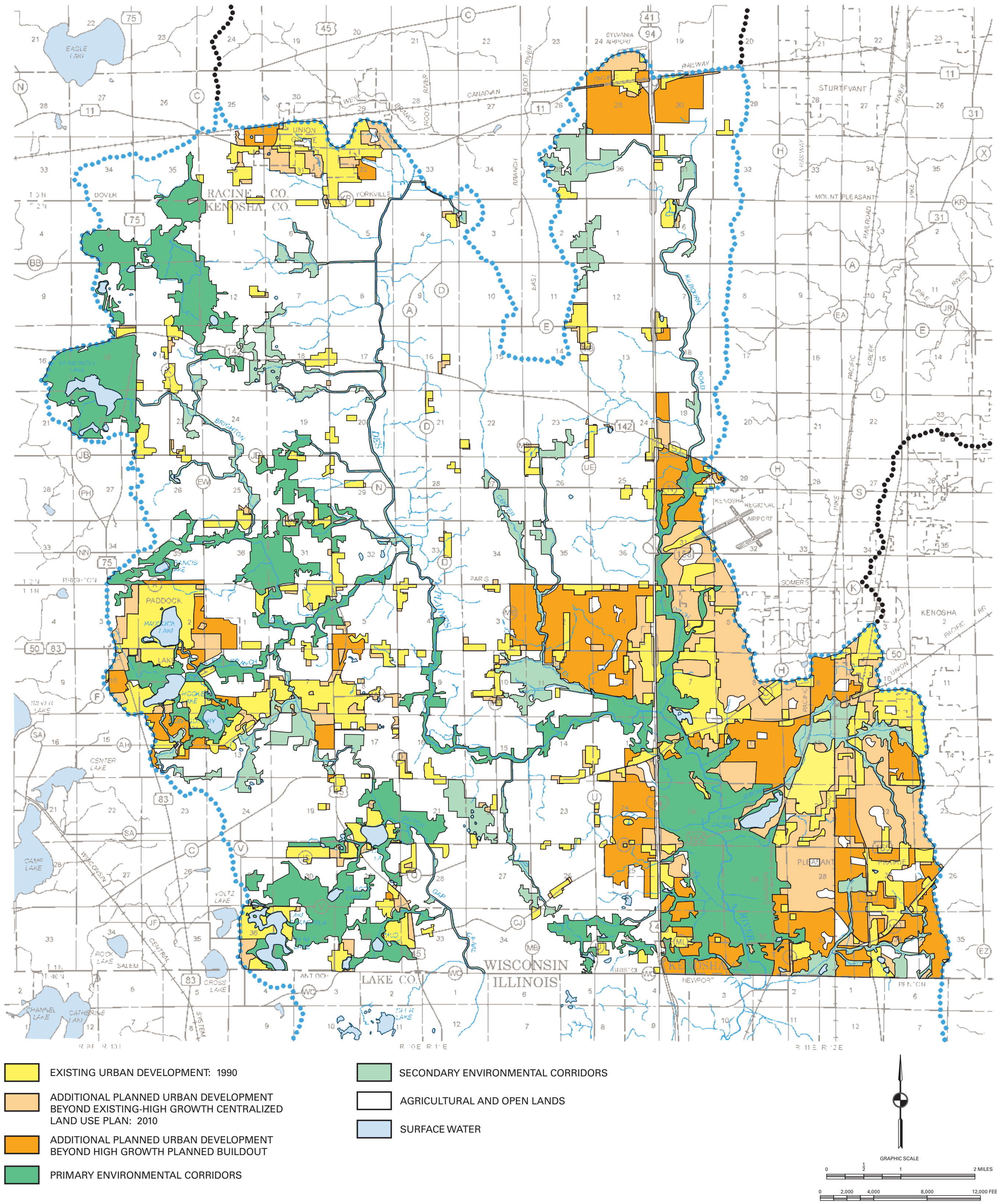
Economic activity, as measured in terms of employment opportunities, is not linked functionally to watershed patterns within Southeastern Wisconsin. Rather, the forces determining economic activity originate and are sustained over the entire urbanizing Region. As shown in Table 39, employment in the watershed increased from a level of 2,300 jobs in 1970 to about 8,200 jobs in 1990, an increase of about 5,900 jobs, or 256 percent, over the 20-year period. Under the high-growth centralized development land use alternative, the number of jobs within the watershed is expected to increase from 8,200 in 1990 to about 36,700 by the plan design year 2010, an increase of about 28,500 jobs, or 348 percent. Based on the sewer service area buildout alternative, the number of employment opportunities in the watershed would increase from the 1990 level of 8,200 jobs to 57,100 jobs at full buildout, an increase of 48,900 employed persons, or about 596 percent.

LAND USE DEMAND

In order to accommodate the forecast 70 percent increase in resident population, 74 percent increase in households, and 348 percent increase in employment between 1990 and the year 2010 in the Des Plaines River watershed under the adopted high-growth centralized development land use alternative, a continued conversion of land from rural to urban use may be expected within the watershed. Between 1970 and 1990, approximately 4.7 square miles of land were converted from rural to urban use within the watershed, increasing the proportion of the total area of the watershed in urban use from about 8 percent, or about 11.2 square miles, in 1970 to 12 percent, or about 15.9 square miles, in 1990. As shown in Table 40, under the high-growth centralized land use alternative, the conversion of an additional 6.4 square miles of land from rural to urban use may be expected within the watershed between 1990 and the plan design year 2010, an increase of about 40 percent in urban use. By the plan design year, approximately 22.3 square miles, or about 17 percent, of the approximately 134.5-square-mile watershed, as determined by U. S. Public Land Survey quarter section approximation, may be expected to be in urban use. Under the sewer service area buildout land use alternative, the conversion of an additional 14.3 square miles of land from rural to urban use may be expected within the watershed between 1990 and the attainment of full buildout conditions in the planned sanitary sewer service areas, an increase of about

Map 29

EXISTING AND ANTICIPATED DEVELOPMENT IN THE DES PLAINES RIVER WATERSHED 1990 EXISTING, 2010 HIGH-GROWTH CENTRALIZED, AND BUILDOUT ALTERNATIVES



The high-growth centralized land use development alternative was adopted for land use planning in the Des Plaines River watershed. For purposes of hydrologic and hydraulic modeling to develop flood flows and stages along streams in the watershed, a land use development scenario providing for complete development, or buildout, of the planned year 2010 sewer service areas was adopted.

Source: SEWRPC.

Table 39

FORECAST POPULATION, HOUSEHOLD, AND EMPLOYMENT LEVELS IN THE DES PLAINES RIVER WATERSHED

Item	1970	Existing 1990			Forecast High-Growth Centralized Land Use Alternative: 2010			Buildout Alternative		
		Total Number	Increase Relative to 1970	Percent Increase	Total Number	Increase Relative to 1990	Percent Increase	Total Number	Increase Relative to 1990	Percent Increase
Population	15,040	19,652	4,612	30.7	33,500	13,848	70.5	45,500	25,848	131.5
Households	3,960	6,620	2,660	67.2	11,500	4,880	73.7	16,300	9,680	146.2
Employment	2,300	8,200	5,900	256.5	36,700	28,500	347.6	57,100	48,900	596.3

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

Table 40

EXISTING AND PLANNED LAND USE IN THE DES PLAINES RIVER WATERSHED: ACTUAL 1990, PLANNED 2010, AND BUILDOUT ALTERNATIVES[a]

Land Use Category[c]	1970		Existing1990		Change 1970-1990		Year 2010: High-Growth Centralized Land Use				Buildout Land Use Alternative[b]			
							2010		Change 1990-2010		Planned		Change 1990-Planned Buildout	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Urban														
Residential	3,265	3.8	4,705	5.5	1,440	44.1	6,389	7.4	1,684	35.8	8,380	9.7	3,675	78.1
Commercial	118	0.1	294	0.3	176	149.2	920	1.1	626	212.9	2,050	2.4	1,756	597.3
Industrial	99	0.1	301	0.3	202	204.0	1,496	1.7	1,195	397.0	2,800	3.2	2,499	830.2
Transportation, Communication, and Utilities[c]	2,991	3.6	3,691	4.4	700	23.4	4,117	4.8	426	11.5	4,603	5.3	912	24.7
Governmental and Institutional	248	0.3	275	0.3	27	10.9	324	0.4	49	17.8	394	0.5	119	43.3
Recreation	348	0.4	768	0.9	420	120.7	1,000	1.1	232	30.2	1,089	1.3	321	41.8
Unused	104	0.1	154	0.2	50	48.1	45	0.1	-109	-70.8	- -	- -	-154	-100.0
Subtotal	7,173	8.4	10,188	11.9	3,015	42.0	14,291	16.6	4,103	40.3	19,316	22.4	9,128	89.6
Rural														
Agricultural and Related	62,989	73.1	58,793	68.3	-4,196	-6.6	56,672	65.8	-2,121	-3.6	52,608	61.1	-6,185	-10.5
Lakes, Rivers, Streams, and Wetlands	8,155	9.5	7,953	9.2	-202	-2.5	7,736	9.0	-217	-2.7	7,736	9.0	-217	-2.7
Woodlands	4,652	5.4	4,765	5.5	113	2.4	4,658	5.4	-107	-2.2	4,658	5.4	-107	-2.2
Open Lands, Landfills, Dumps, and Extractive	3,133	3.6	4,403	5.1	1,270	40.5	2,745	3.2	-1,658	-37.6	1,784	2.1	-2,619	-59.5
Subtotal	78,929	91.6	75,914	88.1	3,015	3.8	71,811	83.4	-4,103	-5.4	66,786	77.6	-9,128	-12.0
Total	86,102	100.0	86,102	100.0	- -	- -	86,102	100.0	- -	- -	86,102	100.00	- -	- -

[a]*As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b]*Assume full development of all planned sewer service areas in the watershed.*

[c]*Parking included in associated use.*

Source: SEWRPC.

90 percent in urban land use. When buildout conditions are realized, approximately 30.2 square miles, or about 22 percent of the watershed, may be expected to be in urban use.

SUMMARY

It was determined by the Watershed Committee that the high-growth centralized alternative, as refined by the comprehensive plan for the Kenosha Urban Planning District, would be adopted for land use planning in the Des Plaines River watershed. The Committee also concluded that, for purposes of hydrologic and hydraulic modeling to develop flood flows and stages, a complete development, or buildout, land use alternative would be adopted. That alternative assumes complete urban development of all planned sanitary sewer service areas within the watershed as shown on Map 29.

The adopted high-growth centralized land use alternative for the Des Plaines River watershed envisions substantial increases in watershed population and employment. The resident population of the watershed may be expected to increase from the 1990 level of 19,650 persons to about 33,500 persons by the year 2010, an increase of 13,850 persons, or about 70 percent, over the 20-year period. The number of households in the watershed may be expected to increase from the 1990 level of 6,620 to about 11,500 by the year 2010, an increase of 4,880, or about 70 percent. Employment in the watershed may be expected to increase from the 1990 level of 8,200 jobs to about 36,700 jobs by the year 29010, an increase of 28,500 jobs, or about 348 percent. The anticipated growth in population, households, and employment under the high-growth centralized land use alternative may be expected to require the conversion of 6.4 square miles of land from rural to urban use within the watershed between 1990 and 2010., increasing the total amount of land in urban use within the watershed from 15.9 square miles, or 12 percent of the watershed, in 1990 to 22.3 square miles, or about 17 percent of the total area of the watershed, by the year 2010.

Under the buildout land use alternative, the resident population of the watershed would increase from the 1990 level of 19,650 persons to about 45,500 persons at full buildout, an increase of 25,850 persons, or about 132 percent. The number of households in the watershed would increase from the 1990 level of 6,620 to about 16,300, an increase of 9,680, or about 146 percent. Employment in the watershed may be expected to increase from the 1990 level of 8,200 jobs to about 57,100 jobs, an increase of 48,900 jobs, or about 596 percent. The anticipated growth in population and employment under the buildout land use scenario would require the conversion of 14.3 square miles of land from rural to urban use within the watershed, increasing the total amount of land in urban use within the watershed from 15.9 square miles, or 12 percent, of the watershed in 1990 to 30.2 square miles, or about 22 percent, of the total area of the watershed at the attainment of full buildout conditions in the planned sanitary sewer service areas.

Chapter V

HYDROLOGY AND HYDRAULICS

INTRODUCTION

Hydrology may be defined as the study of the physical behavior of the water resource from its occurrence as precipitation to its entry into streams and lakes, or its return to the atmosphere via evapotranspiration. In accordance with this definition, an inventory and analysis of the hydrology of a watershed should include consideration of precipitation, evapotranspiration, and other elements of the hydrologic budget; examination of such factors as soil types and land use that affect rainfall-runoff relationships; review of stream gaging records to ascertain the volume and timing of that portion of the precipitation that ultimately reaches the surface water system of the watershed as runoff; and determination of the volume of water that moves to and from, and is contained within, the aquifers lying beneath the watershed.

Hydraulics may be defined as the study of those factors that affect the physical behavior of water as it flows within stream channels and associated natural floodlands; under and over bridges, culverts and dams; through lakes and other impoundments; and within the aquifer system of the watershed. In accordance with this definition, an inventory and analysis of the hydraulics of a watershed may include examination of the length, slope, flow resistance, and other characteristics of both natural and modified stream reaches within the watershed; determination of the hydraulic significance of the numerous and varied hydraulic structures—bridges, culverts, dams, channelized sections—located throughout the stream system; and determination of the flow characteristics of the aquifers underlying the watershed.

Comprehensive planning for the wise use and development of the land and water resources of the Des Plaines River watershed requires knowledge and understanding of the relationships existing among the many natural and man-made features that together comprise the hydrologic-hydraulic system of the watershed. The objective of this chapter is to present a description of the hydrologic-hydraulic system of the Des Plaines River watershed, with emphasis upon the behavioral characteristics of that system pertinent to comprehensive watershed planning. An understanding of this system is important to the watershed planning process inasmuch as the system and its behavior form the framework within which all the water resource and water resource-related problems of the watershed must be analyzed and resolved. Because of the close interdependence between the various elements of the hydrologic and hydraulic systems of a watershed, any planned modification to, or development of, one of these elements must consider the potential effects on the other elements. Only by considering the hydrologic-hydraulic system as a whole can a sound, comprehensive watershed plan be prepared and the water-related problems of the basin ultimately abated.

Digital computer simulation was used in the Des Plaines River watershed study to accomplish the necessary integrated analysis of the hydrologic-hydraulic system of the watershed. The primary purpose of inventorying and analyzing the hydrologic and hydraulic data and information as presented in this chapter was to provide the data required by the hydrologic-hydraulic simulation model.

HYDROLOGY OF THE WATERSHED

The Hydrologic Cycle

The quantity and quality of water at a particular location within the Des Plaines watershed vary greatly with time. These variations may occur rapidly or slowly and may occur in the atmosphere, on the land, in the surface waters, or in the groundwater of the watershed. Moreover, these variations may involve water in all its states—solid, liquid, and vapor. This continuous, unsteady pattern of circulation of the water resource from the atmosphere to and under the land surface and, by various processes, back to the atmosphere is known as the hydrologic cycle.

Precipitation is the primary source of all water in the Des Plaines River watershed. Part of the precipitation runs directly off the land surface into stream channels and is ultimately discharged from the watershed; part is temporarily retained in snow packs, ponds, and depressions in the soil or on vegetation, and is subsequently transpired or evaporated; while the remainder is retained in the soil or passed through the soil into a zone of saturation or groundwater reservoir. Some water is retained in the groundwater system; but in the absence of groundwater development, much eventually returns to the surface through conveyance in agricultural drain tile systems or as seepage or spring discharge into ponds and surface channels. This discharge constitutes the entire natural flow of surface streams in the Des Plaines River watershed during extended periods of dry weather.

With the exception of the groundwater in the deep sandstone aquifer underlying the watershed, all of the water on the land surface and underlying the Des Plaines River basin generally remains an active part of the hydrologic system. In the deep aquifer, water is held in storage beneath the nearly impermeable water-tight Maquoketa shale formation and is, therefore, taken into the hydrologic cycle in only a very limited way. Since the recharge area of the deep aquifer lies entirely west of the Des Plaines River watershed, artificial movement through wells and minor amounts of leakage through the shale beds provide the only connection between this water and the surface water and shallow groundwater resources of the watershed.

The Water Budget: Quantification of the Hydrologic Cycle

A quantitative statement of the hydrologic cycle, termed the water budget, is commonly used to equate the total gain, loss, and change in storage of the water resource in a watershed over a given time period. Water is gained by a basin from precipitation and subsurface inflow, while water is lost as a result of evaporation, transpiration, and surface and subsurface outflow. A change in surface and groundwater storage results from an imbalance between inflow and outflow. The complete hydrologic budget applicable to the watershed for any time interval may be expressed by the equation:

$$P - GW - E - T - R = S$$

in which the individual terms are volumes expressed in inches of water over the entire area of the watershed and are defined as follows:

P = precipitation on the watershed.
GW = net inflow or outflow of groundwater from the aquifer beneath the watershed.
E = evaporation from the watershed.[1]
T = transpiration from the watershed.[1]

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[1]*Evaporation is the process by which water is transformed from the liquid or solid state to the vapor state and returned to the atmosphere. Transpiration is the process by which water in the liquid state moves up through plants, is transformed to the vapor state, and returned to the atmosphere. Evapotranspiration is the sum of the two processes.*

R = runoff from the watershed measured as streamflow.
S = net change in total surface and groundwater storage.

Quantitative data, however, are normally available for only some of the elements of the hydrologic budget. Quantitative measurements, or estimates, compiled for the Des Plaines River watershed include precipitation, streamflow, evaporation, and groundwater levels; but the records of each of the phenomena are incomplete or of a relatively short duration. It is necessary, therefore, to express the hydrologic budget on an average annual water-year basis in a simplified form which includes the most significant components of the hydrologic cycle and excludes those components for which sufficient data are not available. A water-year time frame—October 1 of a given year through September 30 of the following year—is used because the beginning and end of that period normally correspond to low and stable streamflows and groundwater levels; moreover, since water in the deep sandstone aquifer is taken into the hydrologic cycle in only a very limited way because there is little seepage through the relatively impermeable overlying Maquoketa shale, a hydrologic budget for the Des Plaines River watershed can be developed considering only the surface and shallow groundwater supplies. In its simplest form, then, the long-term hydrologic budget for the Des Plaines River watershed may be expressed by the equation:

$$ET = P - R$$

where evaporation and transpiration have been combined into one variable, ET, denoting evapotranspiration, and where net groundwater flow out of the watershed has been assumed to be zero, as has the net change in the total surface and groundwater stored within the watershed. Because of seasonal variations in the behavior of the phases of the hydrologic cycle, this simplified equation is generally not valid for time durations of less than a year.

As stated in Chapter III of this report, and based upon records from 1940 through 1993, the average annual precipitation over the watershed is 32.6 inches. Streamflow records collected from October 1, 1966, through September 30, 1994, at the U.S. Geological Survey (USGS) gaging station on the Des Plaines River at Russell, Illinois (Station Number 05527800) located just downstream of the Wisconsin-Illinois state line, indicate that the average annual discharge at that location is about 98.4 cubic feet per second (cfs), equivalent to 10.1 inches of water spread uniformly over the land surface of the watershed upstream from the gaging station. Substitution of these values for precipitation and runoff into the simplified hydrologic budget equation indicates an average annual evapotranspiration of 22.5 inches. Therefore, on an average annual water-year basis, about 69 percent of the precipitation that falls on the Des Plaines River watershed is returned to the atmosphere by the evapotranspiration process, while the remaining 31 percent leaves the watershed as streamflow.

Atmospheric Phase of the Hydrologic Cycle

The processes of precipitation and evapotranspiration constitute the atmospheric phase of the hydrologic cycle of the Des Plaines River watershed. On a water-year basis, precipitation accounts for essentially all the water entering the watershed while evapotranspiration is the process by which most of the water leaves the watershed.

Precipitation

As already noted, the average annual total precipitation for the Des Plaines River watershed, based on data from the Antioch, Illinois and from the Kenosha and Union Grove, Wisconsin, observation stations located near the watershed is 32.6 inches; while the average annual snow and sleet fall is 41.1 inches measured as snow and sleet. The locations of the three observation stations are shown on Map 13; and the availability of temperature and other meteorological data is listed in Table 9 in Chapter III. That chapter also discusses the significance of precipitation data in the watershed planning process, and includes information on precipitation-related climatic factors such as temperature, snow cover, and frost depth. Chapter X discusses the results of various statistical analyses of the basic precipitation data, with the results being presented in graphical and tabular form in Appendix D of this report. That appendix includes point rainfall-intensity-duration-frequency relationships in both graphical and tabular form and depth-duration-area relationships in tabular form.

Evapotranspiration
Annual evaporation from water surfaces, such as ponds and streams, within the Des Plaines River watershed approximates 29 inches, roughly equal to the average annual precipitation of about 33 inches. The average annual evapotranspiration, as calculated in the hydrologic budget for the watershed, is about 22 inches. The seven-inch difference between the potential for evaporation from a free water surface and long-term evapotranspiration over the watershed occurs because evapotranspiration from soils and plants, depending upon such factors as land cover, temperature, available water, and soil conditions, is normally less than evaporation from free water surfaces.

Surface Water Phase of the Hydrologic Cycle
The surface water resources of the Des Plaines River watershed are composed of lakes, streams, and ponds. There are 18 lakes and ponds having a surface area of two acres or more in the watershed. Of that total, six lakes are classified as major lakes, having a surface area of 50 acres or more.

Monitoring Stations
Streamflow is unique among the components of the hydrologic cycle in that it is the only component so confined as to pass a readily identifiable location and is, therefore, amenable to relatively precise measurement of its total quantity. As shown on Map 30 and as listed in Table 41, the closest stream stage and discharge monitoring station to the Wisconsin portion of the watershed is the U.S. Geological Survey station located on the Des Plaines River at Russell, Illinois, approximately 0.8 mile downstream of the Wisconsin-Illinois state line. An additional USGS streamflow gaging station which receives flow from the Wisconsin portion of the Des Plaines River watershed is located on Mill Creek at Old Mill Creek, Illinois.[2]

Streamflow generally is not measured directly at discharge monitoring stations but is usually derived from measurements of stage, that is, of water surface elevation at monitoring stations along a stream. In order to convert a measured stage to its corresponding discharge, a stage-discharge relationship must be developed for each monitoring site. Such relationships change over time due in part to changes in stream and floodplain morphology and changes in channel and overbank roughness.

Stage-discharge relationships are normally constructed by making field measurements of flow velocity for a wide range of river stages. Under the traditional and most widely used method of discharge measurement, discharge is determined for each stage by partitioning the total flow cross-section into subareas, using a meter to measure the flow velocity in each subarea, multiplying the velocity by the area for each subarea to obtain subarea discharge, and summing the discharges for all subareas to obtain the total discharge.

Stage at a stream gage is determined by various types of indicators, with the readings made at intervals by an observer or recorded by automatic instruments. Stage indicators are classified according to the method by which the stage is measured and by the manner in which it is read. The principal types are staff gages, crest stage indicators, wire weight gages, and continuous recording gages.[3]

U.S. Geological Survey Stage and Discharge Stations
Discharges determined from stage observations at the two U.S. Geological Survey stations pertinent to this study are published by the USGS in a series of annual publications entitled "Water Resources Data for Illinois." Discharges for the Russell gage are also published by the USGS in "Water Resources Data for Wisconsin." Table 41 lists the sites near the Wisconsin portion of the Des Plaines River watershed where streamflow data have

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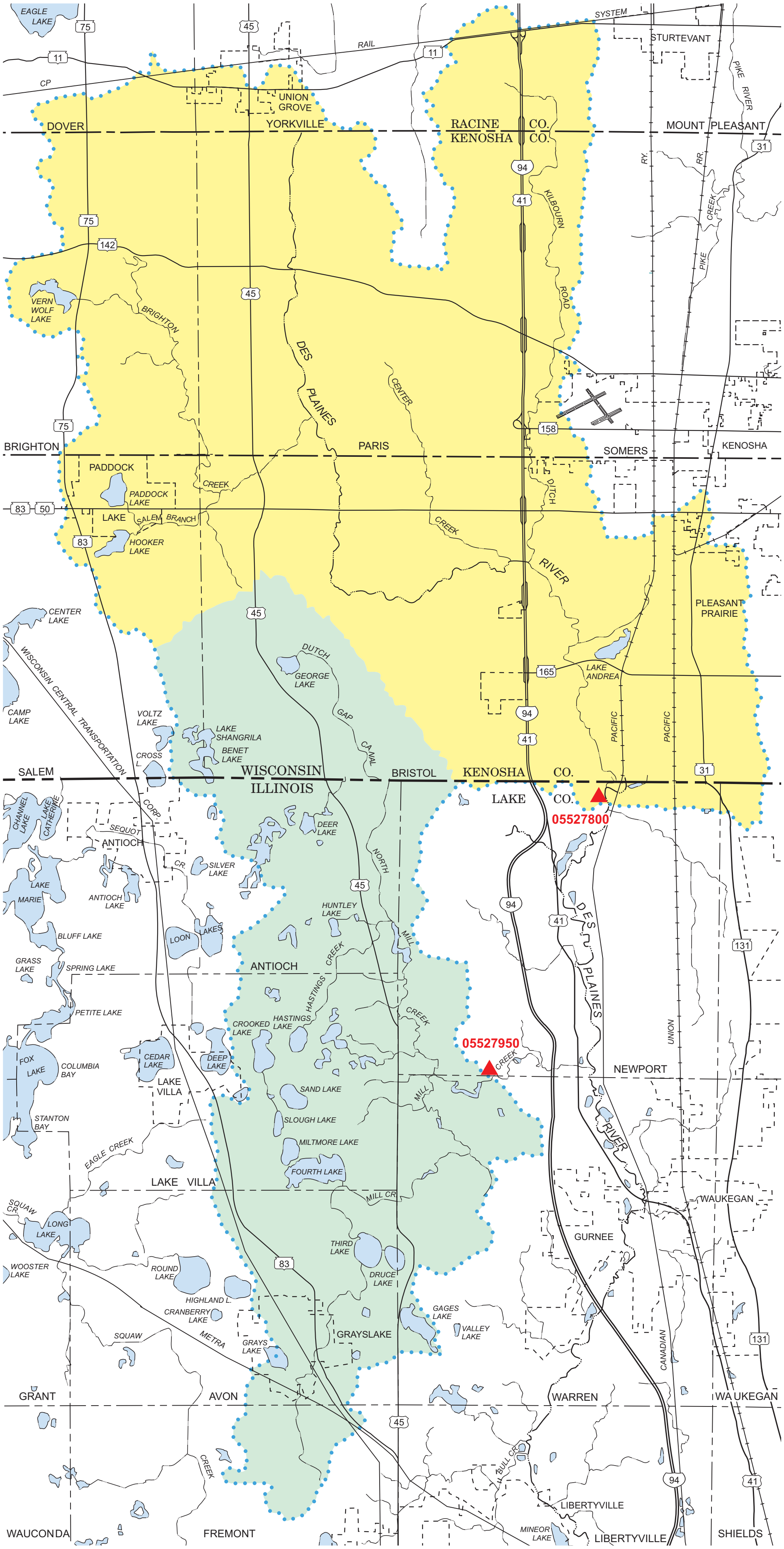
[2]*The Dutch Gap Canal is known as North Mill Creek and then Mill Creek farther downstream in Illinois. Mill Creek joins the Des Plaines River downstream of the Wisconsin-Illinois state line and downstream of the Russell gage.*

[3]*For a description, including photographs, of the various types of stage indicators, see SEWRPC Planning Report No. 26,* A Comprehensive Plan or the Menomonee River Watershed*, Volume One,* Inventory Findings and Forecasts*, October 1976, pp. 107-109.*

Map 30

STREAM STAGE AND DISCHARGE STATIONS IN THE DES PLAINES RIVER WATERSHED



WATERSHED BOUNDARY

DES PLAINES RIVER WATERSHED AREA TRIBUTARY TO THE MAIN STEM AT RUSSELL, ILLINOIS

DUTCH GAP CANAL/MILL CREEK SUBWATERSHED

CONTINUOUS STAGE RECORDING STATION

05527950 U.S. GEOLOGICAL SURVEY STATION NUMBER

NOTE: DUE TO MAP SCALE LIMITATIONS ONLY SELECTED CORPORATE LIMITS ARE SHOWN IN THE ILLINOIS PORTION OF THIS MAP.

Streamflow is unique among the various components of the hydrologic cycle in that it is the only component that is concentrated and confined so as to pass a limited number of identifiable locations and is, therefore, amenable to relatively accurate and precise measurement of the total quantities involved. As shown above, two continuous record stream stage and discharge monitoring stations were used in the hydrologic analysis conducted for the watershed study. The station on the Des Plaines River at Russell, Illinois measures runoff from 121.4 square miles, or 87 percent of the area for which detailed hydrologic and hydraulic modeling were performed. The remaining 18.0 square miles, or 13 percent of the detailed modeling area, contributes runoff to Dutch Gap Canal at the Wisconsin-Illinois state line. Downstream of the state line, an additional 41.6 square miles contributes runoff to Mill Creek at the Old Mill Creek station.

Source: U.S. Geological Survey; Lake County, Illinois; and SEWRPC.

Table 41

STREAMFLOW GAGING STATIONS IN THE DES PLAINES RIVER WATERSHED

USGS Station Number	Station Site	Period of Record	Continuous Recorder	Crest Stage Gage
05527800	Des Plaines River at Russell, Illinois	April 1960 – June 1967 June 1967 – continuing	- - X	X X
05527950	Mill Creek at Old Mill Creek, Illinois	October 1961 – September 1976 October 1989 - continuing	- - X	X X

Source: U.S. Geological Survey and SEWRPC.

been collected by the USGS, describes the type of data collected at each site, and defines the period of record. The USGS has operated both a continuous stage recorder gage and a crest stage gage on the Des Plaines River at Russell, Illinois since June 1967 (USGS Station No. 05527800). Occasional low-flow measurements were made at that gage site in 1962 and 1963 and annual maximum gage heights were measured in water years 1960 through 1966. The total drainage area tributary to the gage is approximately 121.4 square miles, including the entire 115.0-square-mile area tributary to the Des Plaines River in Wisconsin.

The USGS has operated both a continuous stage recorder gage and a crest stage gage on Mill Creek at Old Mill Creek, Illinois since October 1989 (USGS Station No. 05527950). In addition, annual maximum gage heights were measured for water years 1962 through 1976. The total drainage area of the Dutch Gap Canal at the state line is 18.0 square miles, including 11.5 square miles from Wisconsin and 6.5 square miles which drain from Illinois into Wisconsin. The total drainage area tributary to the Mill Creek gage is 59.6 square miles. Thus, the drainage area tributary to the Dutch Gap Canal at the Wisconsin-Illinois state line comprises approximately 30 percent of the drainage area of the Mill Creek gage.

Stage and Discharge Measurements Obtained by Other Agencies

Flood elevations along various streams in the watershed were field surveyed by Commission staff on April 16 and 20, 1993. As measured at the Russell gage, the instantaneous peak flow of 1,750 cfs during that flood was the largest on the Des Plaines River in 14 years, and the third largest in the 34 years of record of the gage. Flood elevations were determined at locations along the Des Plaines River, Brighton Creek, the Salem Branch of Brighton Creek, Unnamed Tributary No. 6 to Brighton Creek, Center Creek, Kilbourn Road Ditch, Jerome Creek, and Unnamed Tributary No. 5 to Jerome Creek.

Flood elevations along streams in the watershed were also field surveyed by Commission staff on June 13 and 14, 2000. At the Russell gage, the instantaneous peak flow of 2,130 cfs during that flood was the largest on the Des Plaines River in the 34 years of record of the gage. Flood elevations were determined at locations along the Des Plaines River, Unnamed Tributary No. 5 to the Des Plaines River, Brighton Creek, Center Creek, Kilbourn Road Ditch, Dutch Gap Canal, and Jerome Creek.

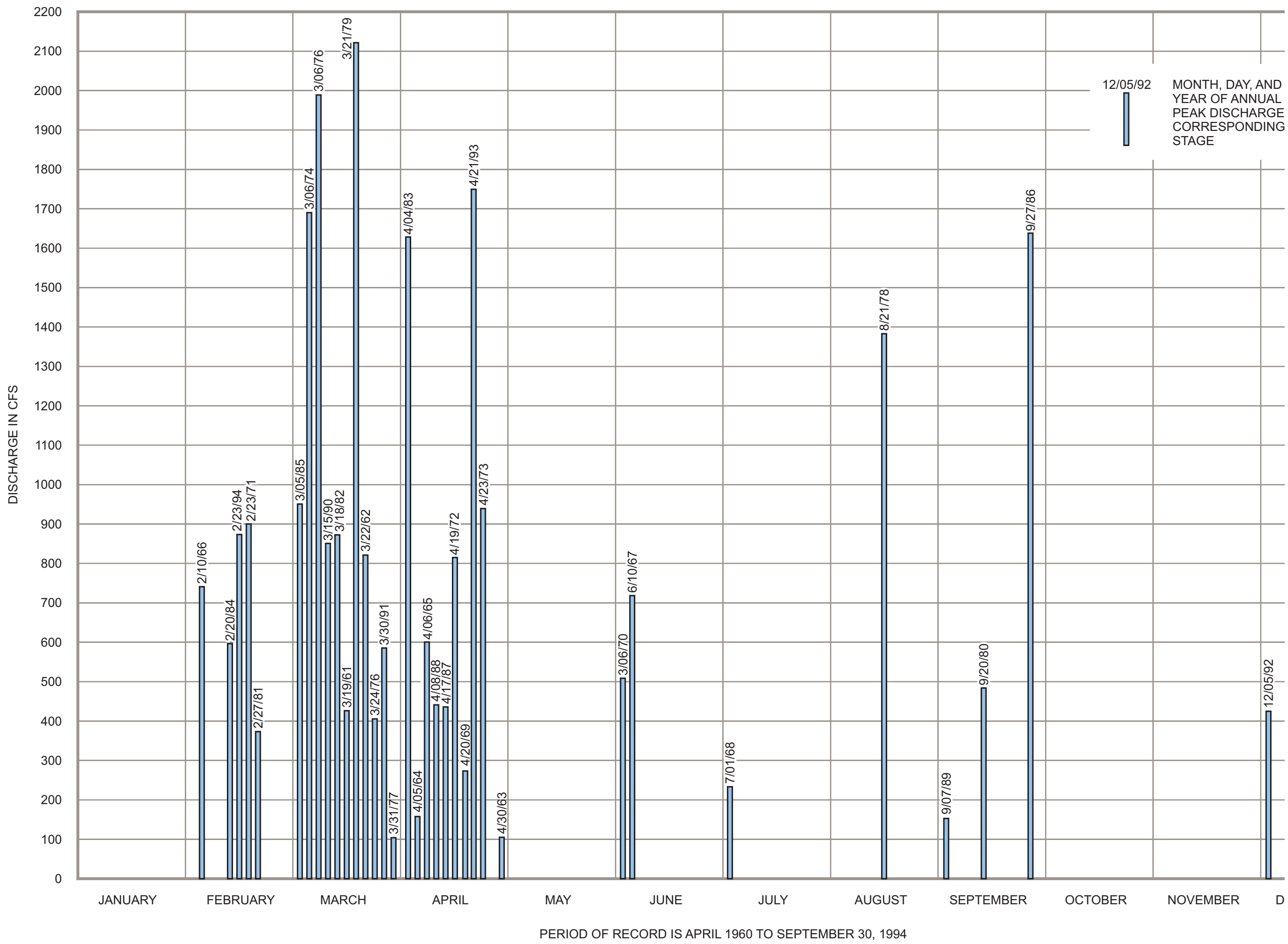
Aside from those operated by the USGS, there are no other streamflow gages in, or near, the Wisconsin portion of the Des Plaines River watershed. There are also no other agencies or organizations which regularly observe or measure high water marks along streams in the watershed.

Seasonal Distribution of Peak Stages

Flood stages recorded at the U.S. Geological Survey Russell, Illinois gaging station on the Des Plaines River were used to evaluate the seasonal distribution of annual flood peaks. The seasonal distribution of the recorded peak discharges are shown in Figure 15 which indicates that, over a 35-year record for the station as either a crest-stage or continuous recording gage, the occurrence of high water events was not limited to any one season. The lack of

Figure 15

SEASONAL DISTRIBUTION OF ANNUAL PEAK DISCHARGES FOR THE DES PLAINES RIVER AT RUSSELL, ILLINOIS (05527800)



Source: SEWRPC.

occurrence of annual peaks in the months of November, December and January is typical of watersheds in Southeastern Wisconsin. In the years from 1960 through 1994, the months of February, March, and April were the most active flood runoff periods in the Des Plaines River watershed, with 77 percent of the recorded annual peaks having occurred in these months.[4]

The period February through April is a high runoff period in the watershed because of the effects of snow accumulation and frozen ground in February and March, and the effects of snowmelt and rainfall on near-saturated soils in March and April when the drying effects of transpiration are still minimal and when air and surface temperatures still inhibit evaporation.

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[4]*In a 1995 memorandum which was prepared for the Commander of the North Central Division (NCD) of the U.S. Army Corps of Engineers and which describes the revision to the Des Plaines River portion of the Federal flood insurance studies for Cook and Lake Counties in Illinois, the Corps noted that 78 percent of the 32 largest flood events recorded at the Russell stream gage, including multiple floods in a given years, occurred in the months of February through April.*

Rainfall-Runoff Response
From the perspective of watershed hydrology and hydraulics, urbanization is the conversion of floodland and nonfloodland areas of a basin from rural to urban uses. The urbanization process, in the absence of compensatory detention storage or other similar structural flood control measures, may be expected to increase downstream flood discharges and stages.

The rainfall-runoff relationship is influenced by the degree of imperviousness of the surface in that the proportion of runoff resulting from a given amount of rainfall on ground that is not frozen may be expected to increase as the proportion of impervious surface increases. Since urbanization is normally accompanied by an increase in area covered by impervious surfaces, it follows that urbanization will result in larger volumes of runoff for given rainfall events, other factors being equal. An exception to this case is rainfall occurring on frozen ground which does not readily infiltrate, resulting in relatively large volumes of runoff even from normally pervious surfaces.

The response time of a watershed varies with the hydraulic resistance characteristics of its surfaces, which characteristics are, in turn determined largely by land use. The smooth surfaces, such as paved roadway and parking areas, paved gutters and channels, and storm sewers typical of many urban drainage systems, reduce runoff times, reduce baseflow, and increase the peaks of runoff hydrographs.

Thus, incremental urbanization can cause large increases in flood volumes, discharges, stages, and areas subject to inundation. Because of the impact of urbanization, small, intensely urbanized watersheds tend to show a rapid rise in runoff hydrographs in response to rainfall events compared to the rate of rise of runoff hydrographs in rural watersheds of similar size. The primary significance of that rapid response of hydrographs to rainfall events in highly urbanized watersheds is that very little time is available to warn riverine area residents of impending flood damage and disruption.

Significant urbanization may be expected to occur in parts of the Des Plaines River watershed in Wisconsin, although, even under the buildout land use condition used for the estimation of flood flows and stages under planned conditions, the proportion of urban land in the Wisconsin portion of the watershed is anticipated to only increase from the 1990 level of about 9 percent to about 25 percent. The impacts of urbanization on flood flows and stages were evaluated in the watershed planning effort and the findings described in Chapter XII of this report.

High-Flow Discharge-Frequency Relationships
The most important hydrologic characteristics of floods for watershed planning purposes are the frequency of occurrence, the peak rate of discharge, the volume of runoff, and the duration and timing of the flood events. The frequency, or "probability of occurrence," of a given flood flow may be defined as the chance of occurrence, in any year, of a flood flow equal to, or exceeding, a specified magnitude. The probability of occurrence may be expressed as a decimal, a fraction, or a percentage. The "recurrence interval" of a flood flow may be defined as the average time interval between flood flows of a given magnitude and is equal to the reciprocal of the probability. For example, a flood that would be equaled or exceeded on the average of once in 100 years would have a recurrence interval of 100 years and a 0.01 probability, or 1 percent chance, of occurring or being exceeded in any year.

A long and continuous record of river discharge is the best basis for determining flood discharge-frequency relationships. Discharge records for the gaging station on the Des Plaines River at Russell, Illinois were obtained for the period June 1967 through September 1994;[5] and for the gaging station on Mill Creek at Old Mill Creek, Illinois for the period October 1989 through September 1994. These records, in combination with historic flood stage data measured by Regional Planning Commission staff, were essential to the proper calibration of the hydrologic-hydraulic model of the watershed system as described in Chapter VIII of this report. Annual instantaneous peak discharges of the Des Plaines River at Russell, of Mill Creek at Old Mill Creek, and for other locations throughout the watershed, including streams tributary to the Des Plaines River and Dutch Gap Canal,

[5] *Annual peak discharges were also obtained for water years 1960 through 1966.*

were simulated for the 55-year period from 1940 through 1994. Those simulated discharges were used to determine one- through 500-year recurrence interval discharges for existing land use and channel-floodplain conditions. Statistical analyses required to compute the discharges corresponding to the desired recurrence intervals were conducted using the log Pearson Type III method of analysis. That method was used because, as noted in Chapter X, "Watershed Development Objectives, Principles, and Standards," its use is recommended by the U.S. Water Resources Council and is specified by the Wisconsin Department of Natural Resources for the conduct of analyses made for floodplain regulatory purposes. A graphical representation of discharge-frequency relationships under 1990 land use and channel conditions for the Des Plaines River at Russell, Illinois is shown in Figure 16.

Whereas Figure 16 presents the discharge-frequency relationship for instantaneous peak discharges under existing conditions in the watershed, Figure 17 shows high-flow discharge-frequency relationships under 1990 conditions in the watershed at Russell, Illinois for periods of one, seven, 30, and 120 days. These relationships also were developed using simulated streamflows and the log Pearson Type III method of statistical analysis. For a specified discharge, these curves facilitate estimation of the probability that a specified high streamflow will be maintained or exceeded for a given period of time during any water year. For example, the probability of maintaining an average flow of 200 cubic feet per second or more for a seven-day period in any water year is about 96 percent, while the probability of maintaining that average flow for 30 days is 80 percent, and for 120 days is 33 percent.

Low-Flow Discharge-Frequency Relationships

Figure 18 shows low-flow discharge-frequency relationships for the Des Plaines River at the Russell gage for periods of one, seven, 30, and 120 days under existing watershed conditions. Simulated discharges for the 55-year period from 1940 through September 1994 were used, in conjunction with the log Pearson Type III method of statistical analysis, to develop these relationships.

Low-flow discharge-frequency relationships are useful in water quality management studies. For example, the low-flow condition established by the Wisconsin Department of Natural Resources for evaluating compliance with water use objectives and supporting water quality standards is a streamflow equivalent to the minimum average seven-day flow expected to occur once on the average of every 10 years. The seven-day, 10-year low flow for the Des Plaines River at the Russell gage under existing watershed conditions as obtained from Figure 18 approximates 0 cfs.

Flow Duration Analysis

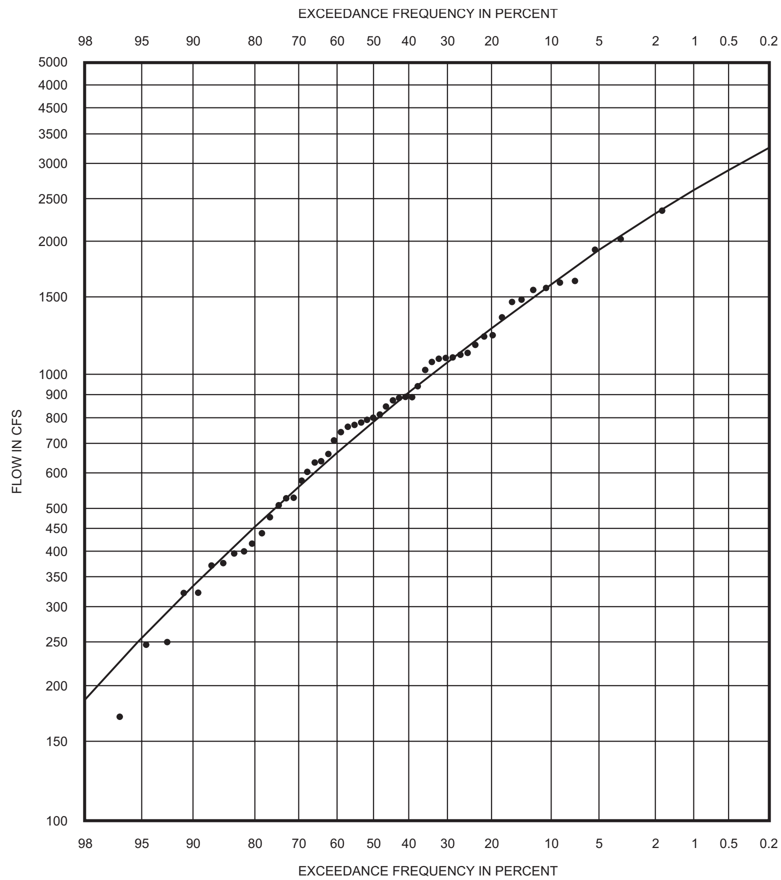
A flow duration curve is defined as a cumulative frequency curve that indicates the percentage of time that specified discharges may be expected to be equaled or exceeded. Figure 19 is a flow duration curve for existing 1990 land use and channel conditions based on 15-minute interval streamflows for the Des Plaines River at the Russell gage for the 55-years of simulated record. The simulated flows, on which the flow duration relationship is based, range from a low of 0 cfs on numerous occasions to a high of 2,120 cfs on March 21, 1979. Since the flow duration curve is based on all flows in the simulated period, it is an effective means of summarizing streamflow characteristics. Flow duration curves are most frequently used as an aid in forecasting the availability of specified rates of flow. For example, the flow duration curve indicates that a 15-minute flow of 5 cfs has been, and may be expected to be, exceeded 80 percent of the time under existing land use and floodland development conditions; whereas much higher 15-minute discharges of 235 cfs and 1,100 cfs have been, and may be expected to be, exceeded only 10 percent and 0.2 percent of the time, respectively.

Groundwater Phase of the Hydrologic Cycle

That part of precipitation that infiltrates into the ground and does not become evapotranspiration or part of the soil moisture percolates downward until it reaches the zone of saturation and becomes part of the groundwater reservoir. The inventory and analysis of the groundwater resources may be subdivided into two phases: groundwater hydrology and groundwater hydraulics. Groundwater hydrology, as described below, has to do with

Figure 16

DISCHARGE FREQUENCY RELATIONSHIP FOR DES PLAINES RIVER AT RUSSELL ROAD (05527800): 1990 LAND USE AND CHANNEL CONDITIONS



Source: SEWRPC.

the vertical and horizontal extent of the significant aquifers[6] underlying the watershed, their relative positions, and the quantities of water contained within them. In contrast, groundwater hydraulics relates to such factors as the flow resistance of the aquifers and the flow patterns associated with those aquifers. As stated in Chapter I of this report, the Des Plaines River watershed planning program is directed primarily at the resolution of existing and possible future surface water quantity and quality problems. However, an overview of groundwater hydrology is presented as an aid to understanding surface water quantity and quality conditions. Groundwater hydraulics are not discussed in this report with the exception of a brief treatment of the potentiometric surface of deep and shallow aquifers.

Principles of Occurrence

Groundwater in saturated rock occupies the pore spaces and other openings in the rock materials. Similarly, in loose, unconsolidated materials, groundwater occupies the spaces between individual grains of silt, clay, sand, or gravel. In rock, the openings that may be filled with water include those along bedding planes, fractures,

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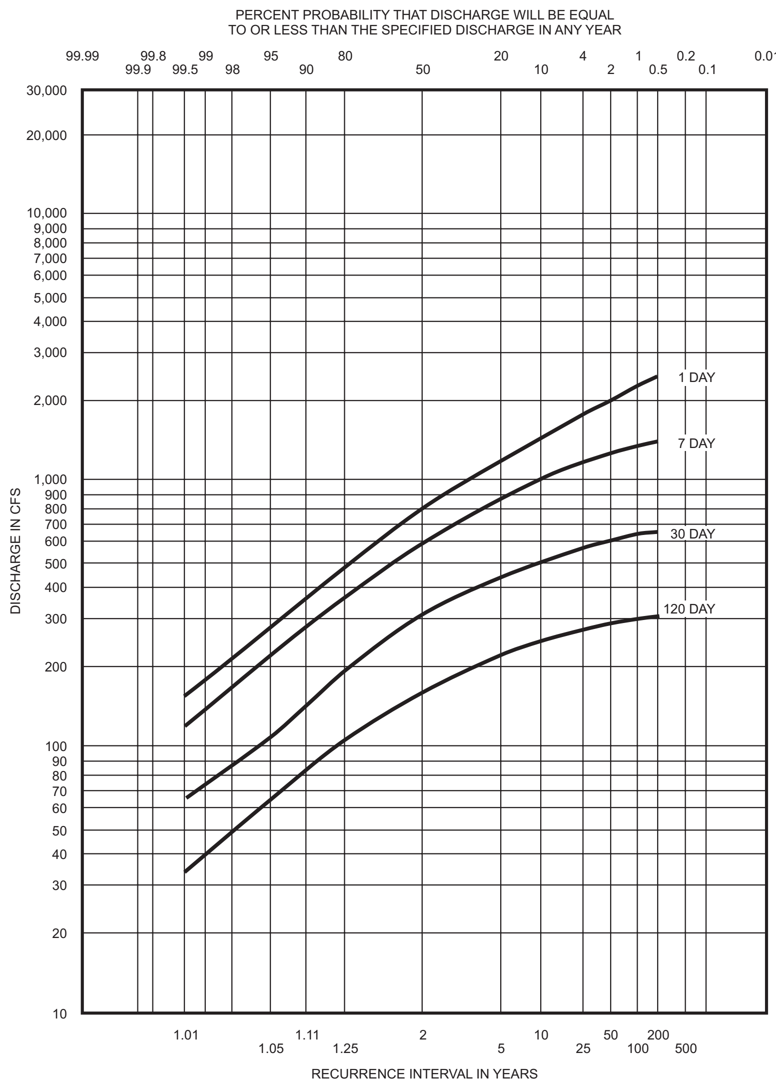
[6]*An aquifer is a porous water-bearing geologic formation. As used herein, it is a relative term designating geologic formations, or deposits, that contain significant amounts of groundwater which can be used as a principal source of water supply.*

Figure 17

HIGH-FLOW DISCHARGE FREQUENCY RELATIONS FOR DES PLAINES RIVER AT RUSSELL ROAD (05527800): 1990 LAND USE AND CHANNEL CONDITIONS



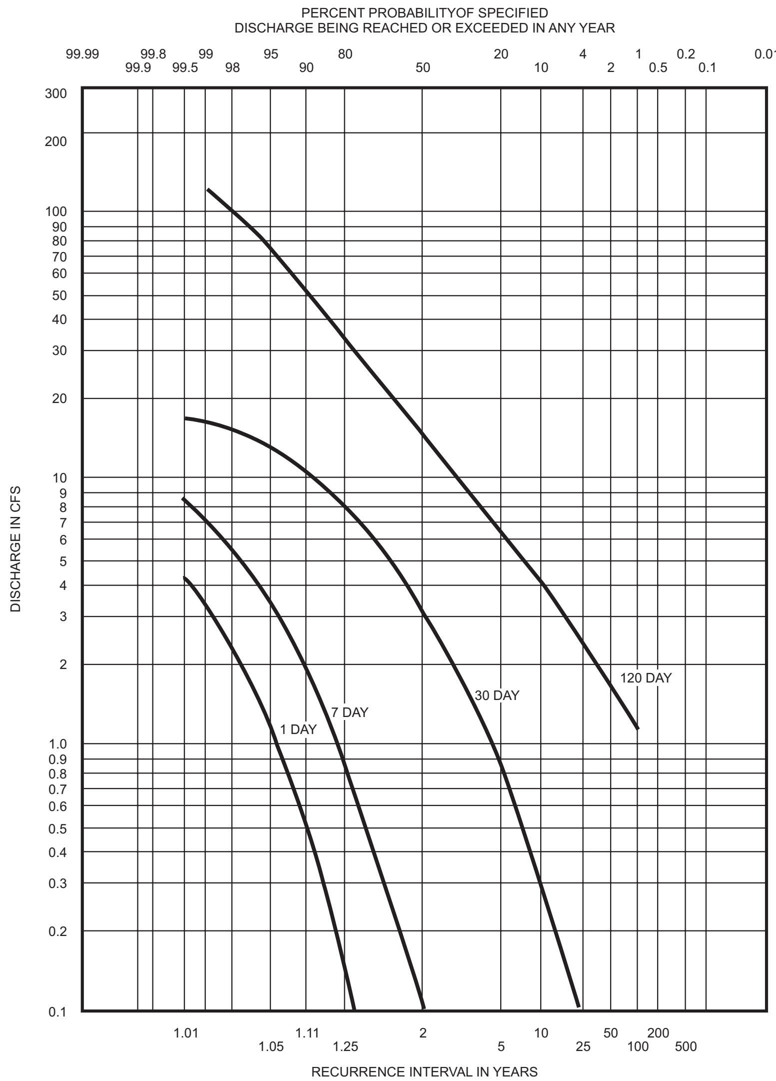
Source: SEWRPC.

faults, joints, and solution cavities. Solution cavities probably are important in the dolomite formations of the Des Plaines River watershed. Intergranular pore openings in rocks may be fewer and smaller than those in unconsolidated materials because they are often constricted by cementing material, such as calcite and silica. In rocks such as dolomite, which contain little or no intergranular pore space, the groundwater occupies primarily the fractures and crevices that pass through such rocks.

Groundwater occurs under water table conditions whenever the surface of the zone of saturation is at atmospheric pressure. Groundwater occurs under confined or artesian conditions wherever a saturated formation is directly overlain by a relatively impermeable formation which confines the water in the permeable unit under pressure greater than atmospheric pressure. Flow of groundwater from an artesian aquifer is similar to gravity flow from a

Figure 18

LOW-FLOW DISCHARGE FREQUENCY RELATIONS FOR DES PLAINES RIVER AT RUSSELL ROAD (05527800): 1990 LAND USE AND CHANNEL CONDITIONS



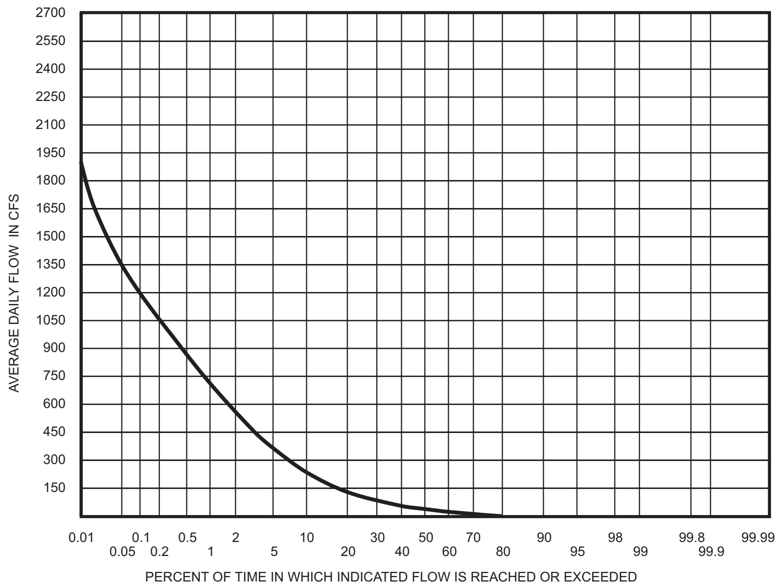
Source: SEWRPC.

high elevation reservoir through a pipe distribution system. The static water level in wells tapping artesian aquifers always rises above the top of the artesian aquifer. Discharge from artesian aquifers is controlled by the confining stratum, and most of the recharge of the artesian aquifer occurs where the confining stratum is missing. Uncased wells provide conduits for the movement of groundwater between aquifers in a multi-aquifer system, such as that present in the Des Plaines River watershed, both upward under artesian head and downward under gravity flow conditions. Flowing wells result if the static water level at the well is higher than the land surface. Flow continues until the water level is lowered below the land surface.

Groundwater is released from storage in water table and artesian aquifers as the result of different physical processes. In a water table aquifer, groundwater is released to wells by gravity drainage of the aquifer pore spaces.

Figure 19

**FLOW DURATION RELATIONSHIP FOR
DES PLAINES RIVER AT RUSSELL ROAD (05527800):
1990 LAND USE AND CHANNEL CONDITIONS**



Source: SEWRPC.

In an artesian aquifer, water is released to the well as the result of compression of the aquifer and expansion of groundwater. An aquifer consisting of tightly packed, well-sorted spherical particles of sand may contain up to 40 percent water by volume—about three gallons per cubic foot of aquifer. Given sufficient time, about one-half of this volume of water may be drained by gravity from a water table aquifer, with the other half adhering to the particles comprising the aquifer against the force of gravity. The quantity of groundwater released from a cubic foot of similar materials under artesian conditions is extremely small by comparison because, under artesian conditions, the aquifer is not drained but the released water is instead attributable solely to the expansion of the water and the compression of the solid material comprising the aquifer. This expansion of the water and contraction of the aquifer material is in response to the reduced water pressure caused by pumping the aquifer. The practical consequence of this difference in the origin of water taken from an unconfined aquifer and from a confined or artesian aquifer is that pumping from an artesian aquifer affects an immense area compared to the area affected by pumping at an equivalent rate from a water table aquifer of similar vertical and horizontal extent and materials.

Hydrologic Characteristics by Aquifer

There are three principal aquifers underlying the Des Plaines River watershed: the sandstone aquifer, the deepest of the three; the dolomite aquifer; and the sand and gravel aquifer, the shallowest of the three. The latter two are hydraulically interconnected and, therefore, are sometimes considered to comprise a single aquifer. The dolomite aquifer also is commonly, although incorrectly, called the “limestone” aquifer. The deep sandstone aquifer is separated from the shallower dolomite aquifer by a layer of relatively impermeable shale. The more important of the three aquifers are the sandstone and the dolomite aquifers, which underlie the entire watershed and are generally available for use in any locality. The sand and gravel aquifer is of lesser importance because, although it reaches a thickness of 340 feet in some areas of the watershed, it does not yield large quantities of water, and it is particularly susceptible to pollution from overlying land uses. The stratigraphic units comprising each of the three aquifers are summarized in Table 15 of Chapter III. Hydrologic characteristics of each of the three principal aquifers are discussed below.

The Sandstone Aquifer

In the Des Plaines River watershed, the sandstone aquifer includes all of the geologic units bounded above by the Maquoketa shale and bounded below by the Precambrian rocks. Although it is commonly referred to as the sandstone aquifer, some of the units contained within it, for example the Galena dolomite, are not sandstones. The Maquoketa shale confines water in the sandstone aquifer under artesian pressure and the shale is normally cased off in wells to prevent destruction of the well by caving of the formation.

The surface of the sandstone aquifer is located approximately 700 to 800 feet beneath the ground surface of the Des Plaines River watershed. The sandstone aquifer dips gently downward in an easterly direction and the natural hydraulic gradient of the aquifer parallels that dip. The thickness of the sandstone aquifer beneath the watershed is known to exceed 1,500 feet.

Recharge of the sandstone aquifer occurs in three ways. It occurs as infiltration of precipitation through glacial deposits in a recharge area located west of the watershed along the western edge of the seven-county Southeastern Wisconsin Region where the Maquoketa shale and younger formations are absent. Second, a small amount of recharge occurs as vertical leakage through the Maquoketa shale because of the hydraulic head difference existing between the top and the bottom of the shale. Third, and also because of that hydraulic head difference, deep wells uncased in both the dolomite and sandstone aquifers allow movement of water from a dolomite aquifer immediately above the Maquoketa shale to the sandstone aquifer beneath.

The direction of groundwater movement in the sandstone aquifer is defined by the potentiometric surface of the aquifer. The potentiometric surface of the sandstone aquifer sloped gently eastward throughout the watershed in 1880, when the sandstone aquifer was first tapped by wells. Wells in the aquifer in the area generally flowed at the surface as a result of the artesian pressure. Subsequent development of the aquifer in the Milwaukee and Chicago areas has resulted in a decline of the potentiometric surface within the Des Plaines River watershed of between about 300 and 400 feet and consequently wells no longer flow.

Comprehensive water level measurements of wells penetrating into the sandstone aquifer within the Southeastern Wisconsin Region were made in 1973-1974 and in 1980-1981.[7,8] Additional data through 1994 are also available from the U.S. Geological Survey Wisconsin Observation Well Network. The potentiometric surface for the sandstone aquifer as determined from the 1973-1974 data is shown on Map 31. Data through 1994 from two wells penetrating the sandstone aquifer are shown in Figures 20 and 21. The data from 1973 through 1994 show that, over that period, the elevation of the potentiometric surface has declined. The elevation based on the 1973-1974 data ranged from 500 to 550 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29). By 1994, the elevation range of the potentiometric surface had declined to between 420 and 470 feet above NGVD 29.[9]

As shown by Map 31, in 1973-74 the potentiometric divide demarcating flow towards the north and the Milwaukee area and flow towards the southeast and the greater Chicago area was oriented along an approximately

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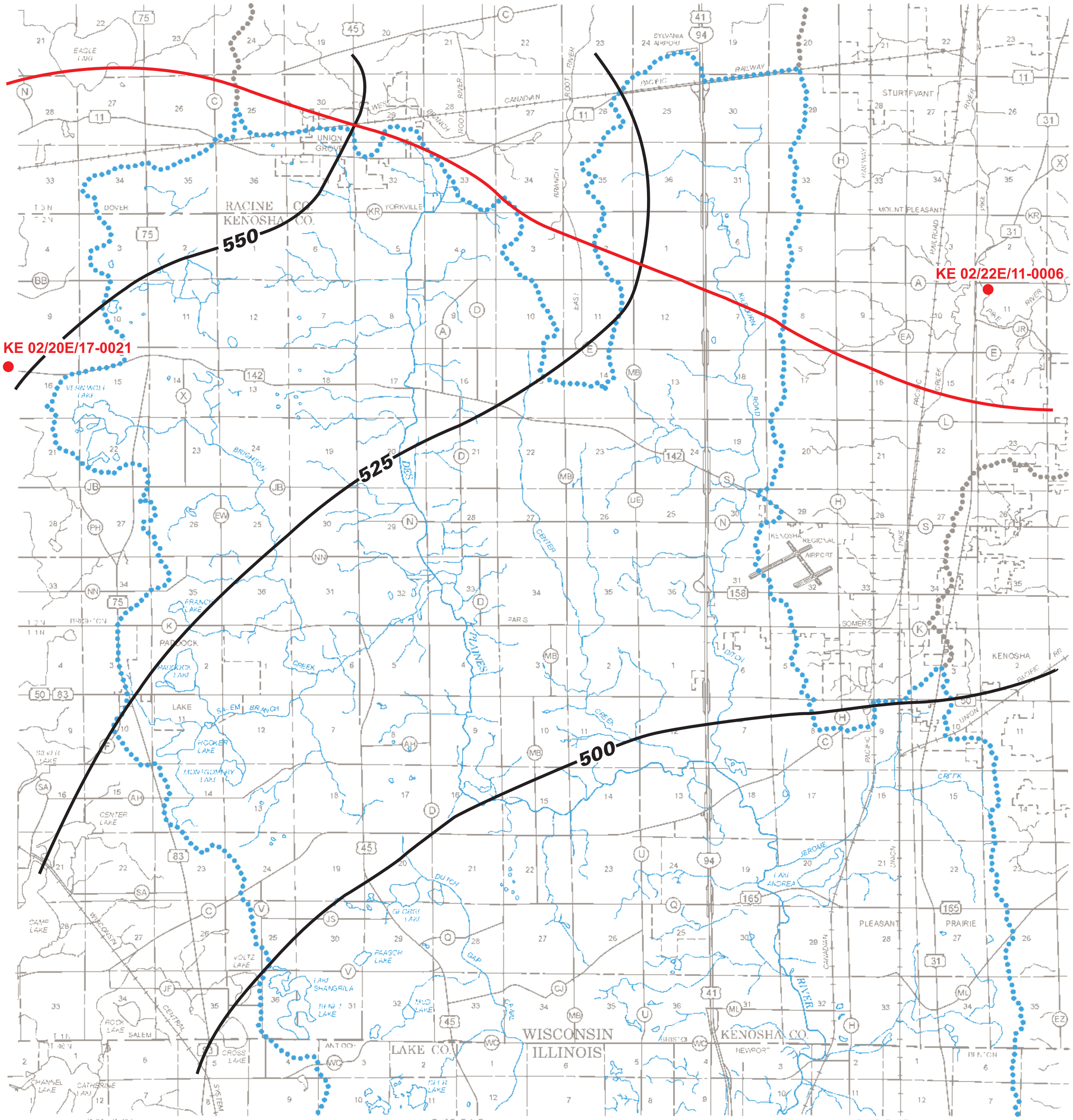
[7]*SEWRPC Technical Report No. 16,* Digital Computer Model of the Sandstone Aquifer in Southeastern Wisconsin*, U.S. Department of Interior, Geological Survey in cooperation with the University of Wisconsin-Extension Geological and Natural History Survey and the Southeastern Wisconsin Regional Planning Commission, April 1976.*

[8]Summary of Ground-Water Hydrology of the Cambrian-Ordovician Aquifer System in the Northern Midwest, United States*; U.S. Department of the Interior, Geological Survey; Professional Paper 1405-A; 1992.*

[9]*The ground elevation at well KE-02/20E/17-0021 (see Figure 20) is 802 feet above NGVD. The ground elevation at well KE-02/22E/11-0006 (see Figure 21) is 639 feet above NGVD.*

Map 31

GENERALIZED POTENTIOMETRIC SURFACE OF THE SANDSTONE AQUIFER: 1973-1974



-500- ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE SANDSTONE AQUIFER IN FEET ABOVE NATIONAL GEODETIC VERTICAL DATUM, 1929 ADJUSTMENT. CONTOUR INTERVAL: 25 FEET. DATA FROM MEASUREMENTS IN 1973 AND 1974.

POTENTIOMETRIC DIVIDE, 1973-1974

KE 02/20E/17-0021 U.S. GEOLOGICAL SURVEY SANDSTONE AQUIFER OBSERVATION WELL AND DESIGNATION (SEE FIGURES 20 AND 21)

GRAPHIC SCALE

0 1/2 1 2 MILES

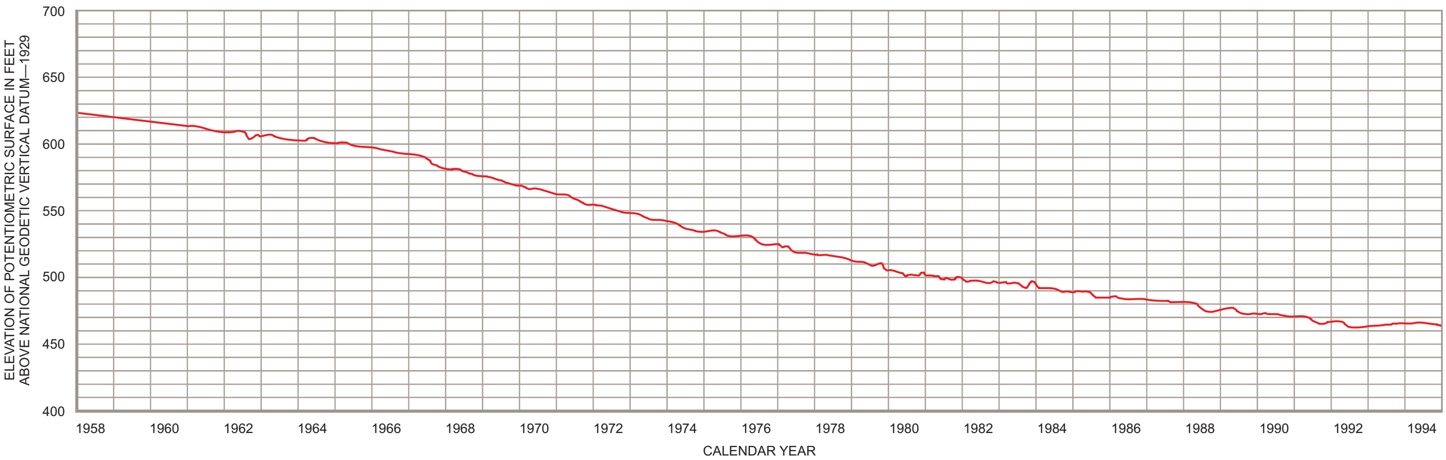
0 2,000 4,000 8,000 12,000 FEET

The approximate direction of groundwater movement in the sandstone aquifer in the watershed as of 1973-1974 is shown by the above map of the potentiometric surfacethe elevation to which water would rise in tightly cased wells tapping the aquifer. Movement is down the hydraulic gradient in a northwest to southeast direction toward northeastern Illinois. Additional data collected by the U.S. Geological Survey since 1974 (see Figures 20 and 21) indicate that the elevation of the potentiometric surface has further declined and that the potentiometric divide has moved to the north, out of the Des Plaines river watershed. The general direction of the hydraulic gradient is still toward northeastern Illinois.

Source: U.S. Geological Survey and SEWRPC.

Figure 20

POTENTIOMETRIC SURFACE OF THE SANDSTONE AQUIFER AT U.S. GEOLOGICAL SURVEY OBSERVATION WELL KE-O2/20E/17-0021

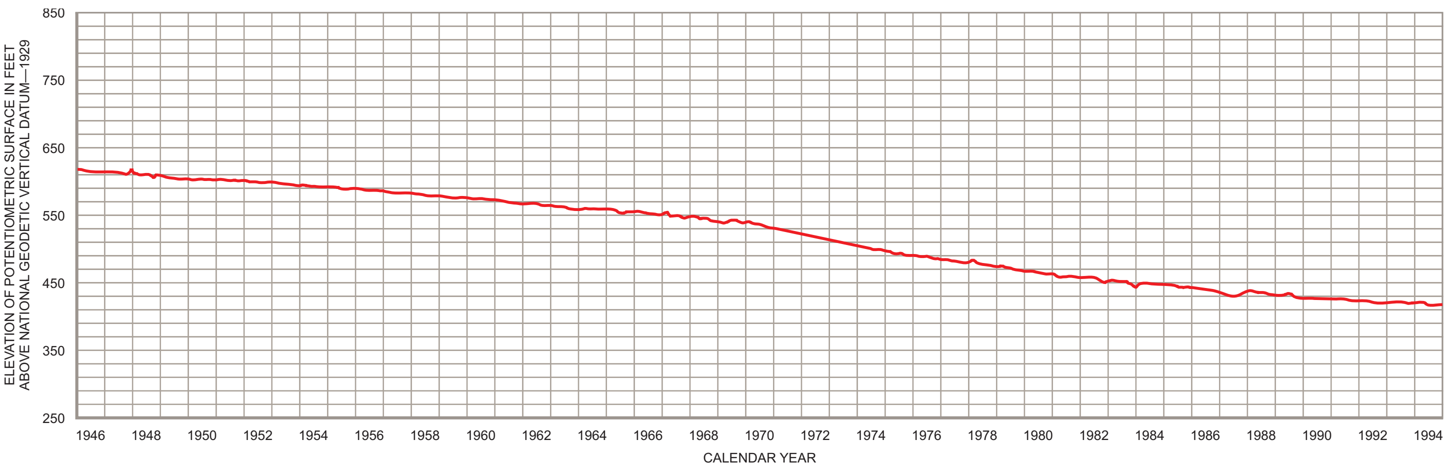


NOTE: THE ELEVATION OF THE GROUND SURFACE AT THIS OBSERVATION WELL IS 802 FEET ABOVE NATIONAL GEODETIC VERTICAL DATUM—1929. SEE MAP 31 FOR WELL LOCATION.

Source: SEWRPC.

Figure 21

POTENTIOMETRIC SURFACE OF THE SANDSTONE AQUIFER AT U.S. GEOLOGICAL SURVEY OBSERVATION WELL K3-02/22E/11-0006



NOTE: THE ELEVATION OF THE GROUND SURFACE AT THIS OBSERVATION WELL IS 639 FEET ABOVE NATIONAL GEODETIC VERTICAL DATUM—1929. SEE MAP 31 FOR WELL LOCATION.

Source: SEWRPC.

east-west line across the extreme northern portion of the watershed. The 1973-74 data show that concentrated pumpage in the Chicago area created a generally northwest to southeast gradient for groundwater flow in that portion of the aquifer underlying the Des Plaines River watershed. Since 1974, the potentiometric divide has moved to the north into central Racine County such that, as of 1980, the effects of pumpage in the Milwaukee area on the gradient beneath the Des Plaines River watershed was eliminated. The change in the location of the potentiometric divide is primarily attributable to the conversion of the source of some Milwaukee area water supplies from groundwater to Lake Michigan water. Although some similar water supply conversions occurred in northeastern Illinois, they did not have a large enough effect on the difference in total pumpage between the Chicago and Milwaukee areas to significantly alter the general northward movement of the potentiometric divide.

As noted earlier, a small amount of sandstone aquifer recharge occurs as downward flow through the Maquoketa shale from the overlying dolomite aquifer. Map 31 indicates the potentiometric surface for the sandstone aquifer. Map 32 indicates the potentiometric surface for the combined dolomite aquifer and glacial deposits. As shown by a comparison of the two maps, along with Figures 20 and 21, the elevation of the potentiometric surface of the combined dolomite aquifer and glacial deposits is greater than the elevation of the potentiometric surface of the sandstone aquifer throughout the watershed. Within the Des Plaines River watershed, the difference in hydraulic head for the two aquifers ranges from about 220 to 300 feet. Downward flow through the Maquoketa shale occurs because of that difference in hydraulic head. If the vertical permeability of the Maquoketa shale is assumed to be uniform, leakage will be greatest where the head differences are largest. Simulations of the aquifer system from 1864 to 1985 indicate that the vertical movement of groundwater across the Maquoketa shale layer and into the sandstone aquifer has increased due to the decline in the potentiometric surface of the sandstone aquifer.[10] Also because of the head difference between these aquifers, deep wells constructed in both the dolomite and sandstone aquifers allow movement of water from the dolomite aquifer into the sandstone aquifer.

The Dolomite Aquifer

The Silurian dolomite aquifer underlies most of the Des Plaines River watershed. Map 17 in Chapter III graphically represents the surface topography of the bedrock, which includes the dolomite aquifer and the Maquoketa shale. In most of the watershed, the relatively impermeable Maquoketa shale is positioned immediately below the dolomite aquifer, whereas unconsolidated glacial till, drift, and alluvial deposits, generally varying in thickness from 100 to 300 feet, lie immediately above.

The dolomite aquifer has a thickness, under the watershed, of approximately 0 to 345 feet and its surface generally slopes in the same direction as the present surface drainage pattern of the watershed. Recharge to the dolomite aquifer is primarily from infiltration of precipitation through overlying glacial deposits. The entire thickness of the dolomite aquifer lies beneath the water table and is, therefore, saturated with groundwater.

The water table surface for the combined dolomite aquifer and glacial deposits, as shown on Map 32, approximately defines the direction of the groundwater movement in these units in the watershed. The elevation of the water table ranges from a high of about 770 feet above NGVD 29 in the northwestern corner of the watershed to a low of about 650 feet above NGVD 29 along the eastern boundary of the watershed.

The Sand and Gravel Aquifer

The sand and gravel aquifer consists of stratified, unconsolidated glacial and alluvial sand and gravel deposits. As shown on Map 18 in Chapter III, the thickness of the unconsolidated deposits forming the sand and gravel aquifer generally varies from 100 to 300 feet within the watershed. The thickness of the zone of saturation, however, varies from about 100 to 190 feet, with an average value of about 120 feet.

Direct infiltration of precipitation is a major source of recharge to the sand and gravel aquifer. Recharge is greatest where the sand and gravel deposits and associated permeable soils occur at the surface, and it is smallest where fine-grained soils, such as clay, silt, or till form the surficial deposits. Water in the subsurface moves downward through the soils to the water table and then laterally toward streams and pumping areas. The water table surface for the combined dolomite aquifer and glacial deposits, as shown on Map 32, defines approximately the direction of movement of the groundwater in these units.

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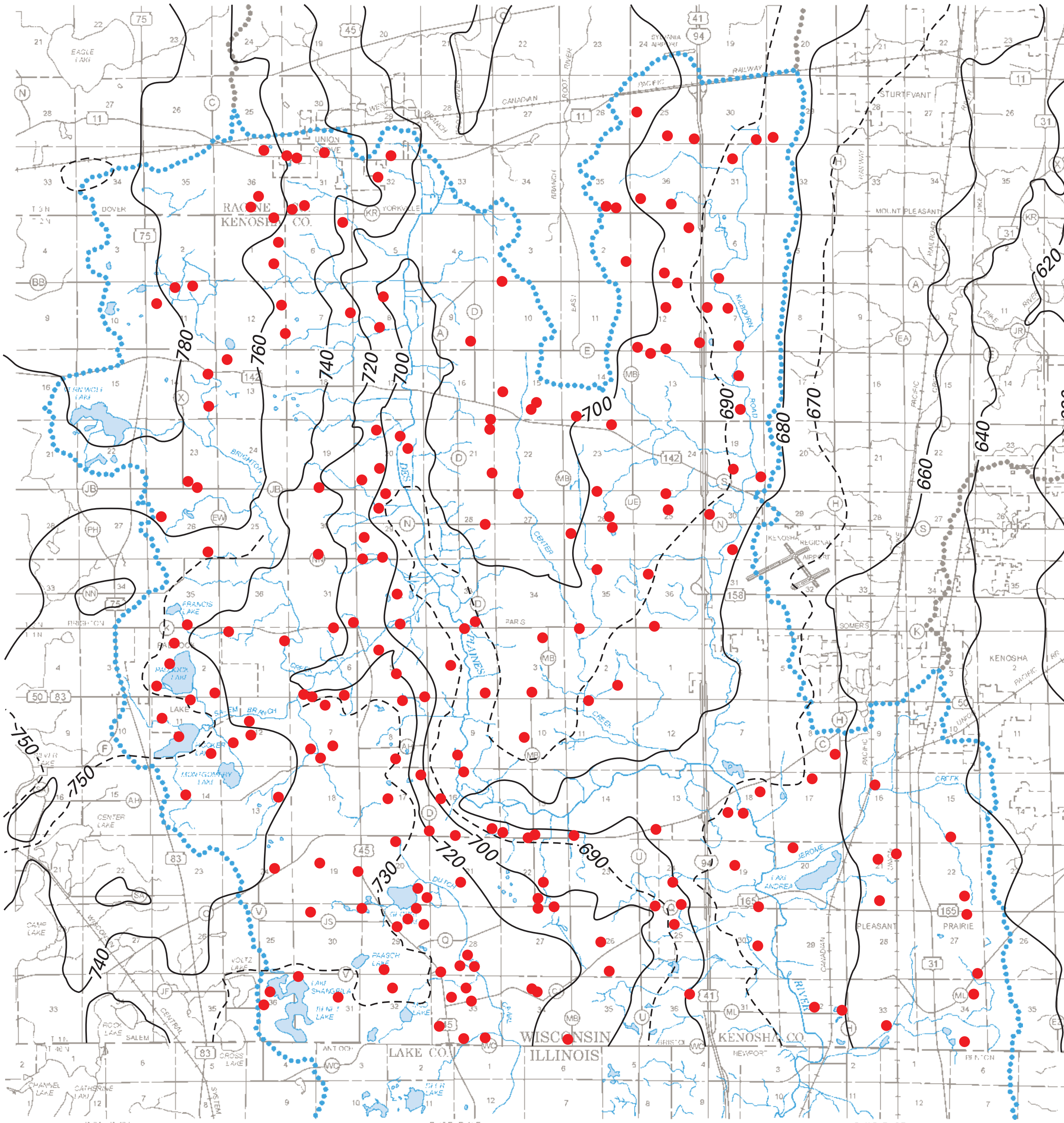
[10]Summary of Ground-Water Hydrology of the Cambrian-Ordovician Aquifer System in the Northern Midwest, United States*; U.S. Department of the Interior, Geological Survey; Professional Paper 1405-A; 1992.*

Map 32

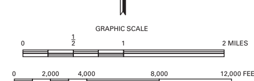
GENERALIZED WATER TABLE ELEVATION OF THE SHALLOW AQUIFER IN THE DES PLAINES RIVER WATERSHED



–700 – 20 FOOT CONTOUR INTERVAL AND ELEVATION OF THE POTENTIOMETRIC SURFACE OF THE SHALLOW AQUIFER IN FEET ABOVE NATIONAL GEODETIC VERTICAL DATUM, 1929 (DASHED LINES INDICATE 10-FOOT CONTOUR LINES)

● WELL OR BORING USED TO DETERMINE POTENTIOMETRIC SURFACE

NOTE: THIS MAP WAS DEVELOPED USING WELL WATER LEVEL RECORDS FROM DIFFERENT YEARS AND SEASONS.



The approximate direction of groundwater movement in the dolomite aquifer and glacial deposit in the watershed is shown by the above map of the water table surface in the shallow aquifer. Movement is down the hydraulic gradient toward Lake Michigan. Groundwater discharge sustains the dry-weather flow of the streams in the watershed. This mapping was prepared in the year 2000 under a groundwater inventory conducted by the Wisconsin Geologic and Natural History Survey and SEWRPC and represents an update of earlier water table mapping.

Source: Wisconsin Geological and Natural History Survey, U.S. Geological Survey and SEWRPC.

Natural discharge of groundwater from the glacial deposits occurs as seepage into the surface water system, by direct evaporation to the atmosphere where the water table is shallow, by plant transpiration during growing seasons, and by infiltration to the dolomite aquifer. The locations of known springs and other potential groundwater discharge sites in the Des Plaines River watershed are shown on Map 24 in Chapter III of this report. Estimated flows for springs where data are available are set forth in Table 23 in Chapter III. Groundwater seepage into the surface water system, primarily from glacial deposits, is estimated to be 2.79 inches annually under 1990 conditions.[11]

Map 33 shows the estimated depth to seasonal high water in the sand and gravel aquifer for the Des Plaines River watershed. Seasonal high water is the average of annual highest groundwater levels, most of which occur in the spring. Soils mapping and soils moisture information was used by the U.S. Geological Survey to determine the seasonal high water levels. Seasonal high water in this aquifer may be expected to be less than 10 feet beneath the land surface for about 48 percent of the watershed area. The seasonal high groundwater level in much of that area is actually less than three feet below the land surface, placing severe restrictions on urban development. The seasonal high water may be expected to be between 10 and 30 feet beneath the land surface for about 52 percent of the watershed area.

SUBWATERSHEDS AND SUBBASINS IN THE DES PLAINES RIVER WATERSHED

Data on subbasins, land use, channel slopes, hydraulic structures and channel modifications are essential to sound watershed planing. Pertinent hydraulic and hydrologic data by subwatershed are presented in Tables 42 and 43, respectively, and subwatershed and subbasin areas are set forth in Appendix E.

Subwatersheds

The Wisconsin portion of the Des Plaines River watershed may be considered to be a composite of eight subwatersheds, as shown on Map 34. Including the portion of the Dutch Gap Canal subwatershed which flows from Illinois into Wisconsin, the total area tributary to the Wisconsin portion of the watershed at the State line is 139.4 square miles. The total area in Wisconsin only is 132.9 square miles. The subwatersheds are: 1) the Upper Des Plaines River subwatershed, which encompasses 20.4 square miles, or 14.6 percent of the total watershed area and 15.3 percent of the area in Wisconsin; 2) the Lower Des Plaines River subwatershed, which encompasses 33.4 square miles, or 24.0 percent of the total watershed area and 23.6 percent of the area in Wisconsin; 3) the Brighton Creek subwatershed, which encompasses 20.7 square miles, or 14.9 percent of the total watershed area and 15.5 percent of the area in Wisconsin; 4) the Center Creek subwatershed, which encompasses 10.3 square miles, or 7.4 percent of the total watershed area and 7.8 percent of the area in Wisconsin; 5) the Dutch Gap Canal subwatershed, which encompasses 18.0 square miles, or 12.9 percent of the total watershed area and 10.2 percent of the area in Wisconsin; 6) the Jerome Creek subwatershed, which encompasses 5.9 square miles, or 4.2 percent of the total watershed area and 4.5 percent of the area in Wisconsin; 7) the Kilbourn Road Ditch subwatershed, which encompasses 23.7 square miles, or 17.0 percent of the total watershed area and 17.8 percent of the area in Wisconsin; and 8) the Salem Branch of Brighton Creek subwatershed, which encompasses 7.0 square miles, or 5.0 percent of the total watershed area and 5.3 percent of the area in Wisconsin.

It is estimated that channel modifications have been made along 39 percent of the stream reaches selected for development of flood hazard information in the Lower Des Plaines River subwatershed; 45 percent in the Brighton Creek subwatershed; 38 percent in the Center Creek subwatershed; 51 percent in the Salem Branch of Brighton Creek subwatershed; and along all of the stream reaches considered in the Upper Des Plaines River Dutch Gap Canal, Jerome Creek, and Kilbourn Road Ditch subwatersheds.

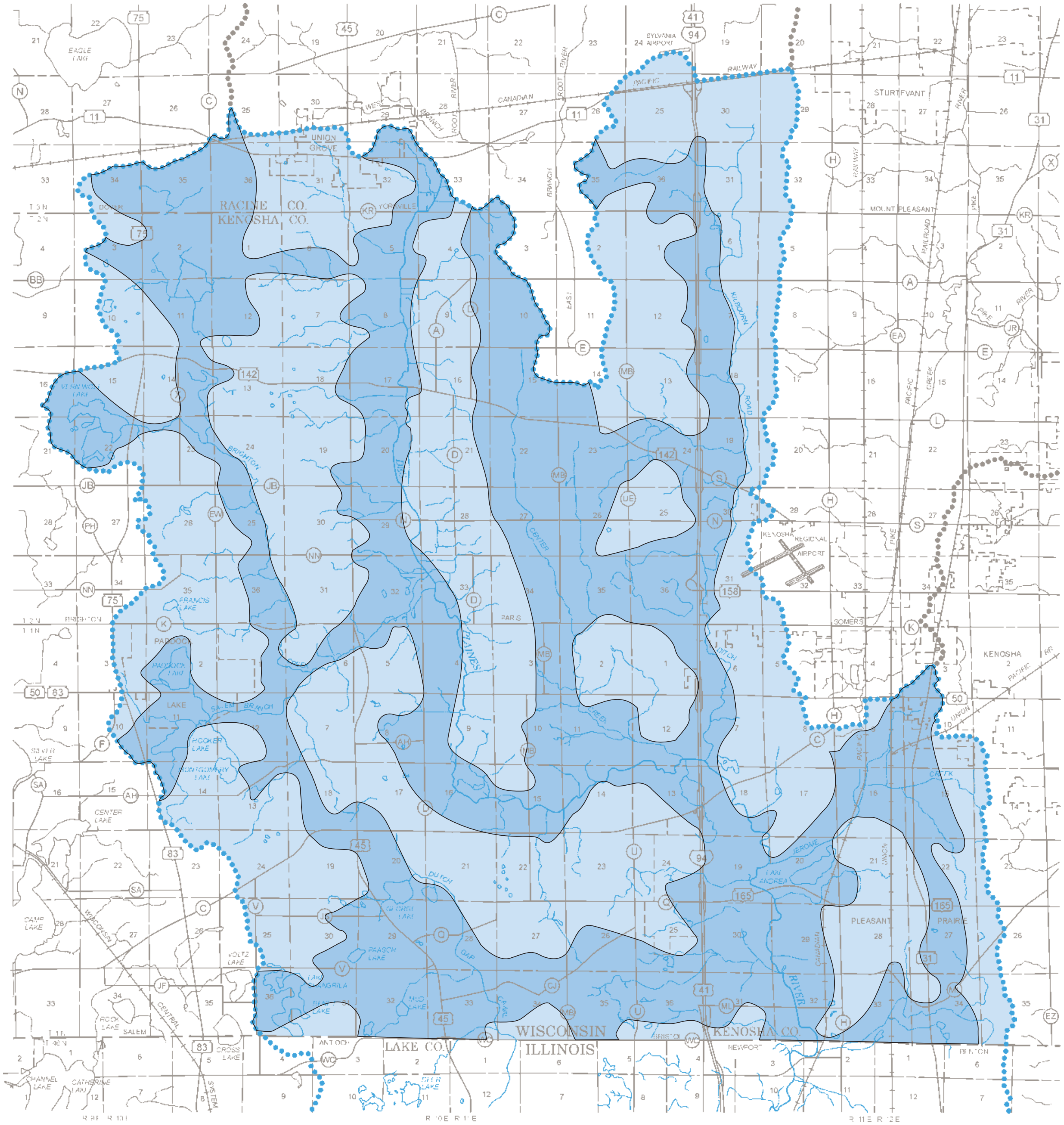
Subbasins

Hydrologic-hydraulic simulation modeling, the function of which is described in Chapter VIII, “Water Resource Simulation Model,” requires that the subwatersheds be further subdivided into hydrologic subbasins. Hydrologic subbasins are the basic “building blocks” for simulating the hydrologic-hydraulic response of the watershed land

[11]*Determined using the hydrologic-hydraulic model described in Chapter VIII.*

Map 33

DEPTH TO SEASONAL HIGH GROUNDWATER IN THE DES PLAINES RIVER WATERSHED



DEPTH OF WATER TABLE
IN FEET BELOW LAND SURFACE

LESS THAN 10

10 TO 30

GRAPHIC SCALE

0 ½ 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

The seasonal high groundwater in the watershed may be expected to be less than 10 feet beneath the land surface for about 48 percent of the watershed area. The seasonal high groundwater may be expected to be between 10 and 30 feet beneath the land surface for the remaining 52 percent of the watershed area. As would be expected, seasonal high groundwater is closest to the land surface in topographically low areas, such as those along the Des Plaines River and its major tributaries.

Source: U.S. Geological Survey and SEWRPC.

Table 42

SELECTED HYDRAULIC DATA FOR THE DES PLAINES RIVER WATERSHED: 1994

Stream Reach for Which Flood Stage Profiles Were Developed	Length	Elevation Difference in Feet from Mouth to Upstream End	Stream Slope (feet/mile)	Bridges and Culverts			Dams[b]			All Structures		Major Channel Modifications	
				Hydraulically Significant	Hydraulically Insignificant	Total	Hydraulically Significant	Hydraulically Insignificant	Total	Hydraulically Significant	Hydraulically Insignificant	Miles	Percent
Des Plaines River	21.81	46.5	2.10	17	5	22	- -	- -	- -	17	5	14.50	66
Unnamed Tributary No. 1 to Des Plaines River	2.26	35.0	15.50	5	1	6	- -	- -	- -	5	1	0.84	37
Unnamed Tributary No. 1a to Des Plaines River	1.24	37.2	30.00	4	- -	4	2	- -	2	6	0	1.24	100
Unnamed Tributary No. 1b to Des Plaines River	1.14	23.6	20.70	1	4	5	- -	- -	- -	1	4	1.14	100
Unnamed Tributary No. 1c to Des Plaines River	1.51	36.4	24.10	2	3	5	- -	- -	- -	2	3	1.51	100
Unnamed Tributary No. 1e to Des Plaines River	2.62	61.0	23.28	4	2	6	2	- -	2	6	2	0.69	26
Unnamed Tributary No. 1f to Des Plaines River	0.96	55.2	57.50	3	- -	3	- -	- -	- -	3	- -	0.32	33
Unnamed Tributary No. 2 to Des Plaines River	2.60	80.0	30.80	3	1	4	- -	- -	- -	3	1	0.80	31
Unnamed Tributary No. 2a to Des Plaines River	0.53	16.0	30.20	1	- -	1	- -	- -	- -	1	- -	0.00	0
Unnamed Tributary No. 5 to Des Plaines River	2.23	8.8	3.90	4	1	5	- -	- -	- -	4	1	2.23	100
Unnamed Tributary No. 5b to Des Plaines River	0.36	3.6	10.00	1	1	2	- -	- -	- -	1	1	0.36	100
Unnamed Tributary No. 7 to Des Plaines River	1.93	40.6	21.10	2	2	4	- -	- -	- -	2	2	1.93	100
Unnamed Tributary No. 37 to Des Plaines River	0.81	30.0	37.00	- -	- -	- -	- -	- -	- -	- -	- -	0.81	100
Unnamed Tributary No. 38 to Des Plaines River	1.23	54.0	43.90	1	- -	1	- -	- -	- -	1	- -	1.23	100
Unnamed Tributary No. 39 to Des Plaines River	0.70	38.0	54.30	- -	- -	- -	- -	- -	- -	- -	- -	0.07	100
Pleasant Prairie Tributary	1.38	13.6	9.90	- -	1	1	- -	- -	- -	- -	1	1.38	100
Union Grove Industrial Tributary	2.18	90.6	41.60	4	4	8	- -	- -	- -	4	4	2.18	100
Fonk's Tributary	0.66	37.4	56.70	- -	- -	- -	- -	- -	- -	- -	- -	0.66	100
Jerome Creek	4.60	46.0	10.00[a]	14	3	17	- -	- -	- -	14	3	4.60	100
Unnamed Tributary No. 1 to Jerome Creek	0.74	2.6	3.50	1	1	2	- -	- -	- -	1	1	0.74	100
Unnamed Tributary No. 2 to Jerome Creek	0.77	6.2	8.10	3	- -	3	- -	- -	- -	3	- -	0.77	100
Unnamed Tributary No. 3 to Jerome Creek	1.47	13.5	9.20	5	- -	5	- -	- -	- -	5	- -	1.47	100
Unnamed Tributary No. 4 to Jerome Creek	1.99	40.2	20.20	7	- -	7	- -	- -	- -	7	- -	1.99	100
Unnamed Tributary No. 5 to Jerome Creek	0.29	5.4	18.60	- -	2	2	- -	- -	- -	- -	2	0.29	100
Kilbourn Road Ditch	12.64	57.2	4.50	16	6	22	- -	- -	- -	16	6	12.64	100
Unnamed Tributary No. 1 to Kilbourn Road Ditch	0.67	9.2	13.70	5	- -	5	- -	- -	- -	5	- -	0.67	100
Unnamed Tributary No. 5 to Kilbourn Road Ditch	0.88	40.6	46.10	4	1	5	- -	- -	- -	4	1	0.88	100
Unnamed Tributary No. 8 to Kilbourn Road Ditch	0.83	14.3	17.22	2	- -	2	- -	- -	- -	2	- -	0.83	100
Unnamed Tributary No. 13 to Kilbourn Road Ditch	0.54	23.1	42.80	2	1	3	- -	- -	- -	2	1	0.54	100
Unnamed Tributary No. 15 to Kilbourn Road Ditch	0.44	7.0	15.90	2	- -	2	- -	- -	- -	2	- -	0.44	100
Unnamed Tributary No. 18 to Kilbourn Road Ditch	0.68	10.7	15.70	2	1	3	- -	- -	- -	2	1	0.68	100
Unnamed Tributary No. 19 to Kilbourn Road Ditch	0.14	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.14	100
Center Creek	3.73	51.3	13.80	7	1	8	- -	- -	- -	7	1	2.90	78
Unnamed Tributary No. 1 to Center Creek	2.16	76.0	35.20	2	3	5	- -	- -	- -	2	3	1.61	75
Unnamed Tributary No. 4 to Center Creek	0.96	56.7	59.10	2	5	7	- -	- -	- -	2	5	0.96	100
Unnamed Tributary No. 5 to Center Creek	0.76	30.3	39.87	3	- -	3	- -	- -	- -	3	- -	0.76	100
Brighton Creek	9.02	114.7	12.72	6	2	8	- -	- -	- -	6	2	3.51	39
Salem Branch of Brighton Creek	2.40	54.9	22.88	3	2	5	2	- -	2	5	2	1.25	52
Unnamed Tributary No. 1 to Salem Branch of Brighton Creek	2.10	58.2	27.70	3	2	5	- -	- -	- -	3	2	0.00	0
Unnamed Tributary No. 2 to Salem Branch of Brighton Creek	0.79	41.4	52.41	4	- -	4	1	- -	1	5	- -	0.53	67
Unnamed Tributary No. 3 to Salem Branch of Brighton Creek	0.70	40.0	57.14	2	1	3	- -	- -	- -	2	1	0.10	14
Unnamed Tributary No. 1 to Hooker Lake	1.91	59.3	31.05	3	6	9	- -	- -	- -	3	6	1.91	100
Unnamed Tributary No. 6 to Brighton Creek	2.46	41.4	16.83	8	2	10	- -	- -	- -	8	2	0.88	36
Unnamed Tributary No. 9 to Brighton Creek	1.35	13.8	10.22	4	1	5	1	- -	1	5	1	1.35	100
Dutch Gap Canal	4.07	5.3	1.30	4	5	9	- -	- -	- -	4	5	4.07	100
Mud Lake Outlet	1.40	10.0	7.14	2	- -	2	- -	- -	- -	2	- -	1.40	100
Unnamed Tributary No. 3 to Dutch Gap Canal	1.75	38.2	21.80	6	1	7	2	- -	2	8	1	1.75	100
Unnamed Tributary No. 4 to Dutch Gap Canal	0.37	7.4	20.00	2	- -	2	- -	- -	- -	2	- -	0.37	100
Total	108.76	- -	- -	176	71	247	10	- -	10	186	71	82.55	76

[a] *This is the overall average slope of the bed of Jerome Creek; however, the bed slope in the lower 3.25 miles of the stream is only 2.75 feet per mile.*

[b] *An additional dam for which data were collected under the watershed study is the Benet/Shangrila Lake dam. Although that dam is not located on a studied stream, it was represented in the hydrologic submodel in order to model the effect of Benet/Shangrila Lake on downstream flows.*

Source: SEWRPC.

Table 43

SELECTED HYDROLOGIC DATA FOR THE DES PLAINES RIVER WATERSHED: 1990

Subwatershed	Area[a]			Subbasins[b]				Rural Land Use[a]					
								Woodlands, Wetlands, and Surface Water		Agricultural and Other Open Lands		Total Rural	
	Acres	Square Miles	Percent of Watershed	Number	Largest (square miles)	Smallest (square miles)	Mean Area (square miles)	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed
Upper Des Plaines River	13,062.81	20.411	15.3	35	2.81	0.04	0.58	885.75	6.8	11,054.52	84.6	11,940.27	91.4
Lower Des Plaines river	20,095.28	31.399	23.6	61	2.25	0.04	0.55	3,918.01	19.5	13,781.14	68.6	17,699.15	88.1
Jerome Creek	3,798.31	5.935	4.5	15	0.93	0.02	0.40	390.82	10.3	2,351.93	61.9	2,742.75	72.2
Kilbourn Road Ditch	15,116.79	23.620	17.8	39	2.37	0.06	0.61	1,264.51	8.4	12,019.85	79.5	13,284.36	87.9
Center Creek	6,600.99	10.314	7.8	20	1.74	0.07	0.52	448.17	6.8	5,826.97	88.3	6,275.14	95.1
Brighton Creek	13,232.47	20.676	15.5	25	2.40	0.09	0.83	2,744.65	20.7	9,310.24	70.4	12,054.89	91.1
Salem Branch of Brighton Creek	4,475.29	6.993	5.3	15	1.38	0.10	0.47	1,177.53	26.3	2,225.42	49.7	3,402.95	76.0
Dutch Gap Canal	8,679.84	13.562	10.2	20	2.47	0.05	0.90	1,915.10	22.1	5,818.04	67.0	7,733.14	89.1
Total	85,061.78	132.909	100.0	230	2.81	0.02	0.61	12,744.54	15.0	62,388.11	73.3	75,132.65	88.3

Subwatershed	Urban Land Use[a]													
	Residential		Commercial		Industrial		Transportation, Communication, and Utility Facilities		Governmental and Institutional		Recreational		Total Urban	
	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed	Acres	Percent of Subwatershed
Upper Des Plaines River	504.35	3.9	22.77	0.2	32.61	0.2	379.14	2.9	54.93	0.4	128.74	1.0	1,122.54	8.6
Lower Des Plaines river	997.57	5.0	56.20	0.3	157.90	0.8	892.80	4.4	25.08	0.1	266.58	1.3	2,396.13	11.9
Jerome Creek	455.51	12.0	14.31	0.4	34.94	0.9	543.37	14.3	7.43	0.2	0.00	0.0	1,055.56	27.8
Kilbourn Road Ditch	655.47	4.3	57.57	0.4	70.11	0.5	980.68	6.5	12.56	0.1	56.04	0.4	1,832.43	12.1
Center Creek	141.18	2.1	0.00	0.0	12.95	0.2	161.96	2.5	4.95	0.1	4.81	0.1	325.85	4.9
Brighton Creek	543.56	4.1	6.73	0.1	0.09	0.0	335.78	2.5	20.80	0.2	270.71	2.0	1,177.58	8.9
Salem Branch of Brighton Creek	676.89	15.1	16.90	0.4	10.02	0.2	284.24	6.4	46.39	1.0	37.90	0.8	1,072.34	24.0
Dutch Gap Canal	587.50	6.8	10.02	0.1	11.50	0.1	299.23	3.4	30.03	0.3	8.42	0.1	946.70	10.9
Total	4,562.03	5.4	184.50	0.2	330.03	0.4	3,877.20	4.6	202.17	0.2	773.20	0.9	9,929.13	11.7

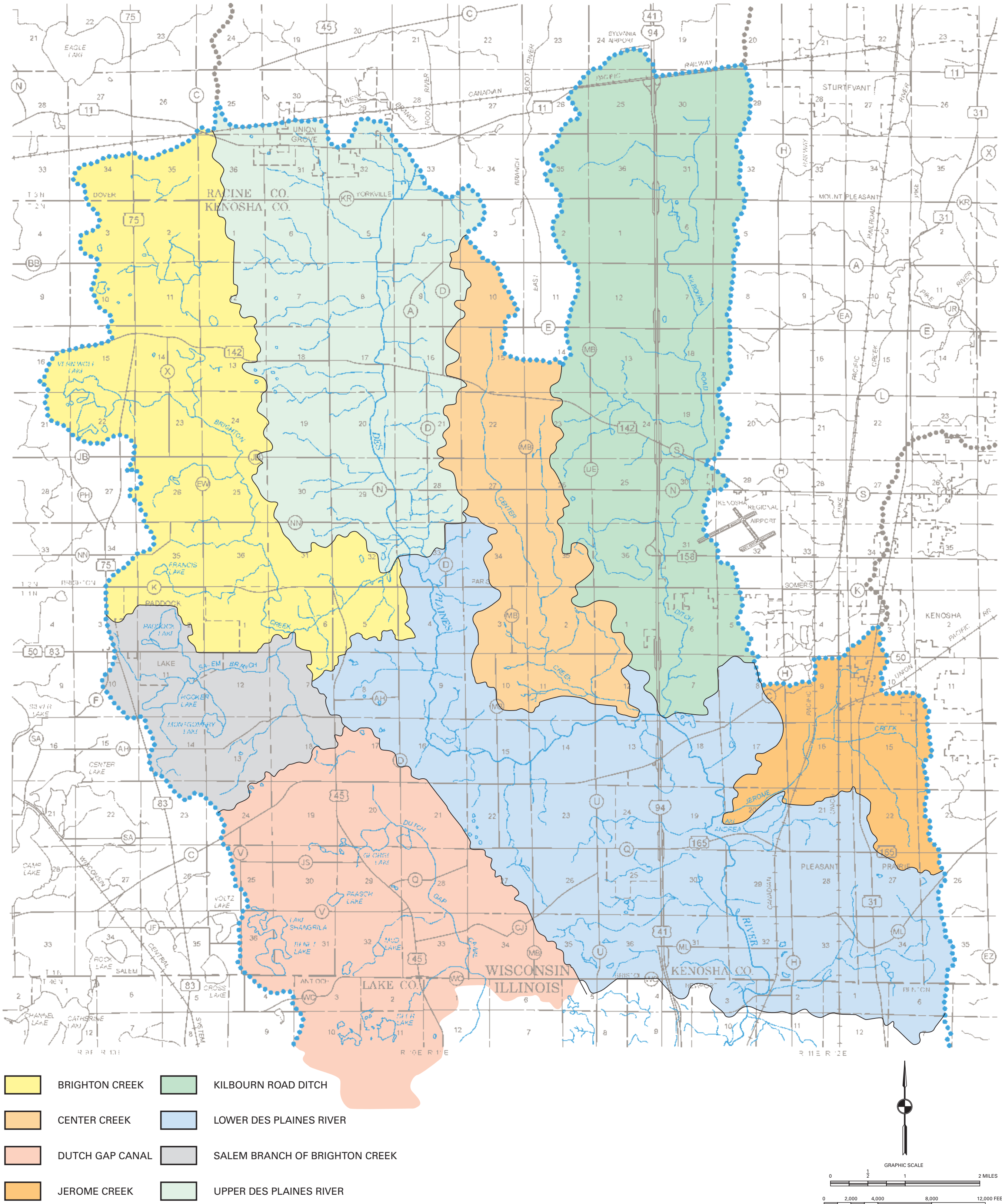
[a] *Includes only the portion of the watershed in Wisconsin.*

[b] *Includes all land area tributary to the U.S. Geological Survey stream gage on the Des Plaines River at Russell, Illinois, and all land area tributary to the Dutch Gap Canal at the Wisconsin-Illinois state line.*

Source: SEWRPC.

Map 34

SUBWATERSHEDS IN THE DES PLAINES RIVER WATERSHED

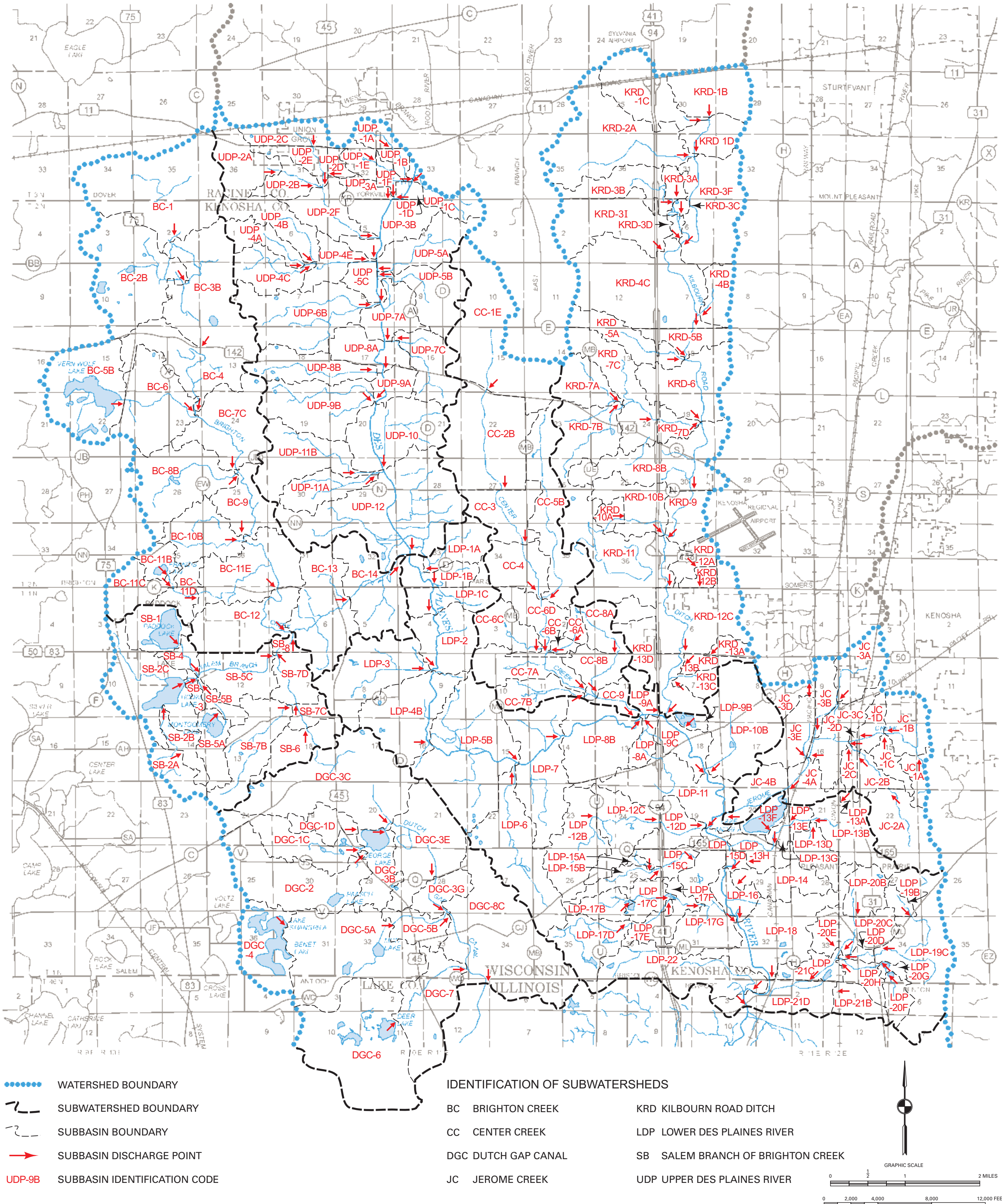


Eight subwatersheds were delineated within the Des Plaines River watershed with areas of 20.7, 10.3, 18.0, 5.9, 23.7,. 33.4, 7.0, and 20.4 square miles for the Brighton Creek, Center Creek, Dutch Gap Canal, Jerome Creek, Kilbourn Road Ditch, Lower Des Plaines River, Salem Branch of Brighton Creek, and Upper Des Plaines River subwatersheds, respectively. In addition to providing rational units for hydrologic analysis, the subwatersheds serve as geographic units that enable the watershed resident to readily identify the relationship of his or her local drainage area to the Des Plaines River watershed.

Source: SEWRPC.

Map 35

SUBBASINS IN THE DES PLAINES RIVER WATERSHED



A total of 230 subbasins were delineated with the Des Plaines River watershed for purposes of hydrologic-hydraulic simulation, ranging in size from 0.02 to 2.81 square miles and having an average area of 0.61 square miles. Subbasins were delineated to encompass areas tributary to intermittent and perennial streams, drainageways, storm sewers, and significant depression storage areas. The boundaries of subbasins were selected to reflect homogeneous hydrologic soil groups, land use, vegetal cover, and land slope, and thus permit characterization of hydrologic-hydraulic behavior of the land surface.

Source: SEWRPC.

surface. As shown on Map 35, 230 subbasins were delineated in the watershed, ranging in size from 0.02 to 2.81 square miles, and having an average area of 0.61 square mile. These subbasins were delineated using large-scale—one inch equals 200 feet scale, two foot contour interval—topographic maps, supplemented by field checks by Commission staff.

A number of factors were considered in the delineation of the subbasins. Some of these were hydrologic-hydraulic factors while others were related to plan preparation and implementation. Subbasins were delineated to encompass areas tributary to intermittent and perennial streams, drainageways, storm sewers, and significant depression storage areas. The boundaries of subbasins were selected to reflect land use, vegetative cover, and land slope. The existence of prominent natural features, such as potential sites for surface water impoundments, and prominent man-made features, such as dams, or long or high railway and roadway embankments, also entered into selection of the discharge point to be delineated for some subbasins. Subbasins were delineated to terminate at streamflow and water quality monitoring stations and at the upstream end of stream reaches for which flood hazard data were to be developed. Some subbasins were established to correspond to areas of special concern for watershed management, such as those areas subject to urbanization or to other significant land use changes.

HYDRAULICS OF THE WATERSHED

As defined earlier in this chapter, hydraulics—in the context of comprehensive watershed planning—involves the inventory and analysis of those factors that affect the physical behavior of water as it flows within stream channels and on attendant natural floodplains; under and over bridges, culverts and dams; through lakes and other impoundments; and within the watershed aquifer system. Previous sections of this chapter have concentrated on the hydrology of the Des Plaines River watershed under the broad categories of surface water and groundwater hydrology. This section of the chapter describes the results of the inventory and initial analysis of surface water hydraulics in the Des Plaines River watershed. The surface water system of the watershed consists of the streams and associated floodplains, including many wetlands, and lakes. An overview of the watershed surface water resources is presented in Chapter III, "Description of the Watershed Man-Made Features and Natural Resource Base."

Portion of the Stream System Selected for Development of Detailed Flood Hazard Data

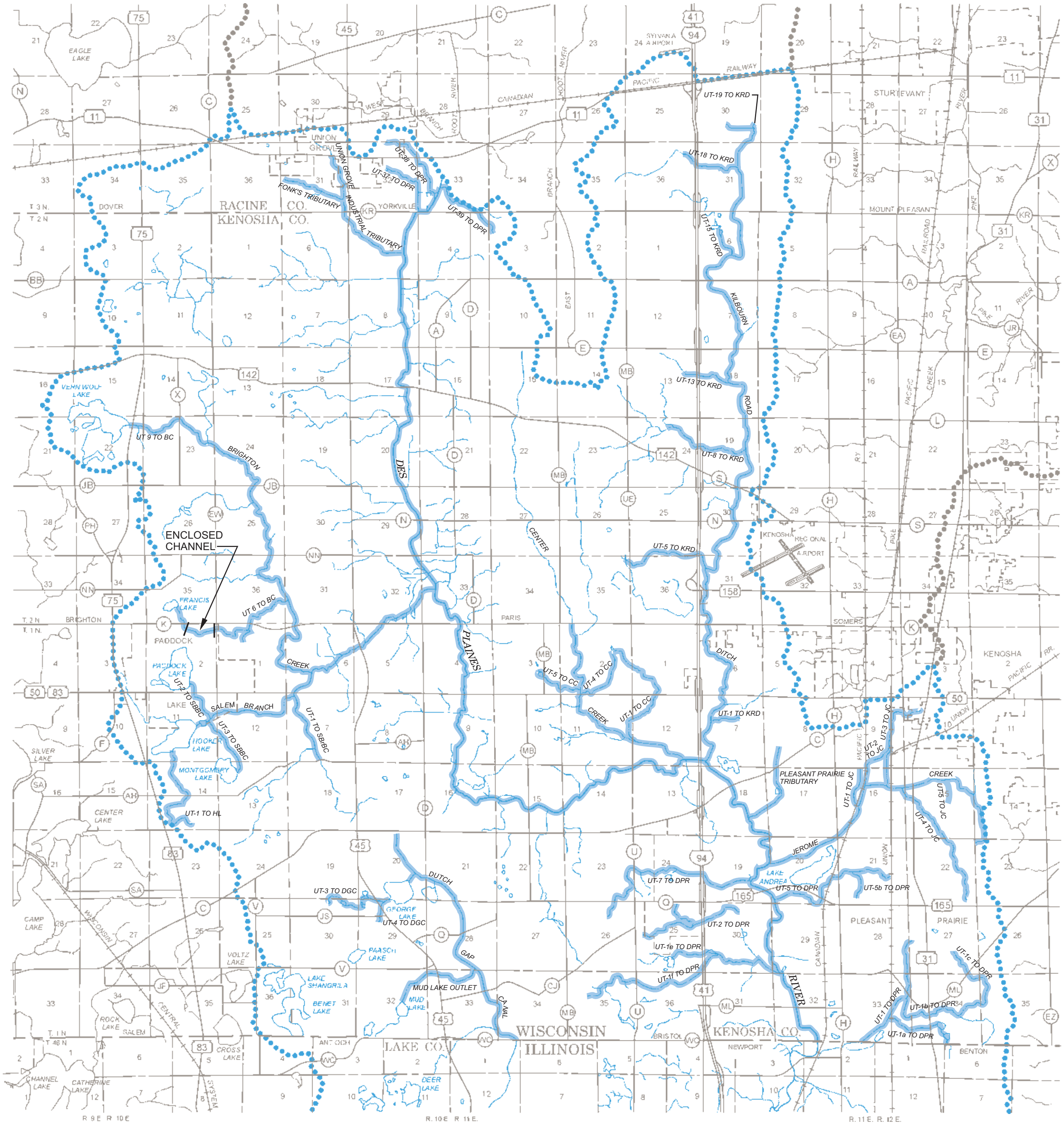
The lineal extent of the perennial and intermittent streams in the watershed is extensive if each tributary to the Des Plaines River is traced upstream to its origin. The cost of hydrologic-hydraulic simulation—which includes the cost of data collection, collation, and coding and the cost of analyzing model results—increases in proportion to the lineal miles of streams that are modeled. Therefore, practicality required that the portion of the watershed stream system for which detailed flood hazard information would be developed by hydrologic-hydraulic simulation studies be delineated prior to inventorying the hydraulic features of the stream system. Detailed flood hazard data are defined to include discharge-frequency relationships under existing and probable future land use conditions and corresponding flood stage profiles and areas subject to inundation by floods of selected recurrence intervals.

Selected Reaches

Stream reaches studied were selected by the Des Plaines River Watershed Committee on the basis of known historic and potential future flooding problems as determined by deliberations with local officials and citizens of the watershed, by available historic data, and by available funding. It should be noted that the stream reaches selected for study are independent of the perennial or intermittent nature of the streams as defined on U.S. Geological Survey quadrangle maps. The perennial or intermittent classification of a stream, particularly in an urban area, was considered to be of no consequence since it is not an index to the severity of either existing or potential future flooding problems in an urban area or an indication of the availability of data for analyzing those problems. As shown on Map 36, parts of 48 streams within the Des Plaines River watershed were selected for hydrologic-hydraulic simulation leading to the development of detailed flood hazard information. Information developed included discharge-frequency relationships under existing and probable future development conditions as well as corresponding flood stage profiles and areas of inundation.

Map 36

STREAM REACHES IN THE DES PLAINES RIVER WATERSHED SELECTED FOR PREPARATION OF FLOOD HAZARD INFORMATION



STREAM REACHES RECOMMENDED FOR DEVELOPMENT OF FLOOD HAZARD INFORMATION

A total of 108.8 miles of stream in the Des Plaines River watershed were selected for development of detailed flood hazard information. A detailed inventory was conducted of the 108.8 miles to determine the storage and conveyance characteristics of the floodlands and the hydraulic capacity of all bridges, culverts, and dams.

Source: SEWRPC.

The seven major streams incorporated in the hydrologic and hydraulic simulations include: 1) the main stem of the Des Plaines River in the Village of Pleasant Prairie and the Towns of Bristol, Paris, and Yorkville; 2) Brighton Creek in the Towns of Brighton, Bristol, Salem, and Paris; 3) the Salem Branch of Brighton Creek in the Village of Paddock Lake and the Towns of Bristol and Salem; 4) Center Creek in the Towns of Bristol and Paris; 5) Dutch Gap Canal in the Town of Bristol; 6) Jerome Creek in the Village of Pleasant Prairie; and 7) Kilbourn Road Ditch in the City of Kenosha, the Village of Pleasant Prairie, and the Towns of Mount Pleasant and Somers. Tables 42 and 43, and Map 37 present pertinent information on these stream reaches and the tributary drainage areas. As indicated in Table 42, detailed flood hazard information was developed for a total of 108.8 miles of streams in the Des Plaines River watershed. Subsequent to the identification of these 108.8 miles of stream, the Commission conducted a detailed engineering inventory of the selected reaches. This inventory included collection, collation, and preliminary analysis of floodland characteristics, as well as definitive data on bridges and culverts and physical information about dams.

Floodland Characteristics

Included in the category of floodland characteristics are the magnitude and variation of channel slope, floodplain shape, and roughness, and the extent and nature of channel improvements. For a given discharge, each of these floodland characteristics can be an important determinant of river stage.

Channel Profiles

Figure 22 shows channel profiles for the 58.3 miles of major streams selected for the development of detailed flood hazard information.[12] The sources of data for these channel bottom profiles were channel bottom elevations at bridges, culverts, dams, and weirs, determined from the field inventories of the structures, supplemented by stream channel contour crossings shown on the large-scale topographic maps of the watershed.[13] All of these data were collected and collated as part of the watershed hydraulic structure inventory.

Channel slopes are irregular, with the steepest slopes occurring on the small headwater tributary streams such as Unnamed Tributary No. 4 to Center Creek, Unnamed Tributary No. 1f to the Des Plaines River, Unnamed Tributary No. 3 to Salem Branch of Brighton Creek, and Fonks Tributary where bed slopes range from 56.7 to 59.1 feet per mile. Considerably flatter bed slopes, ranging from 1.3 to 4.5 feet per mile, occur on the Des Plaines River, Dutch Gap Canal, Kilbourn Road Ditch, and the lower reaches of Jerome Creek. All other hydraulic factors being equal or similar, steep channel slopes result in high streamflow velocities and shorter runoff times, whereas flat slopes produce lower velocities and longer runoff times.

The primary purpose of developing the channel bottom profiles was to provide a basis for estimating channel bottom elevations for channel-floodplain cross-sections located at points between the bridges, culverts, and dams. Channel bottom elevations for these intermediate locations—as obtained from the profiles were required for the development of floodland cross-sections as described below. This procedure was used on all the streams studied under the Des Plaines River watershed planning program.

Floodland Cross-Sections

The size and shape of the floodlands, that is, the channel and its natural floodplain, particularly the latter, are important floodland characteristics inasmuch as they influence flood stages and determine the extent of lateral inundation for a given flood discharge. Approximately 730 floodland cross-sections were prepared at an average spacing of 790 feet along the 108.8 miles of stream studied in the Des Plaines River watershed for the develop-

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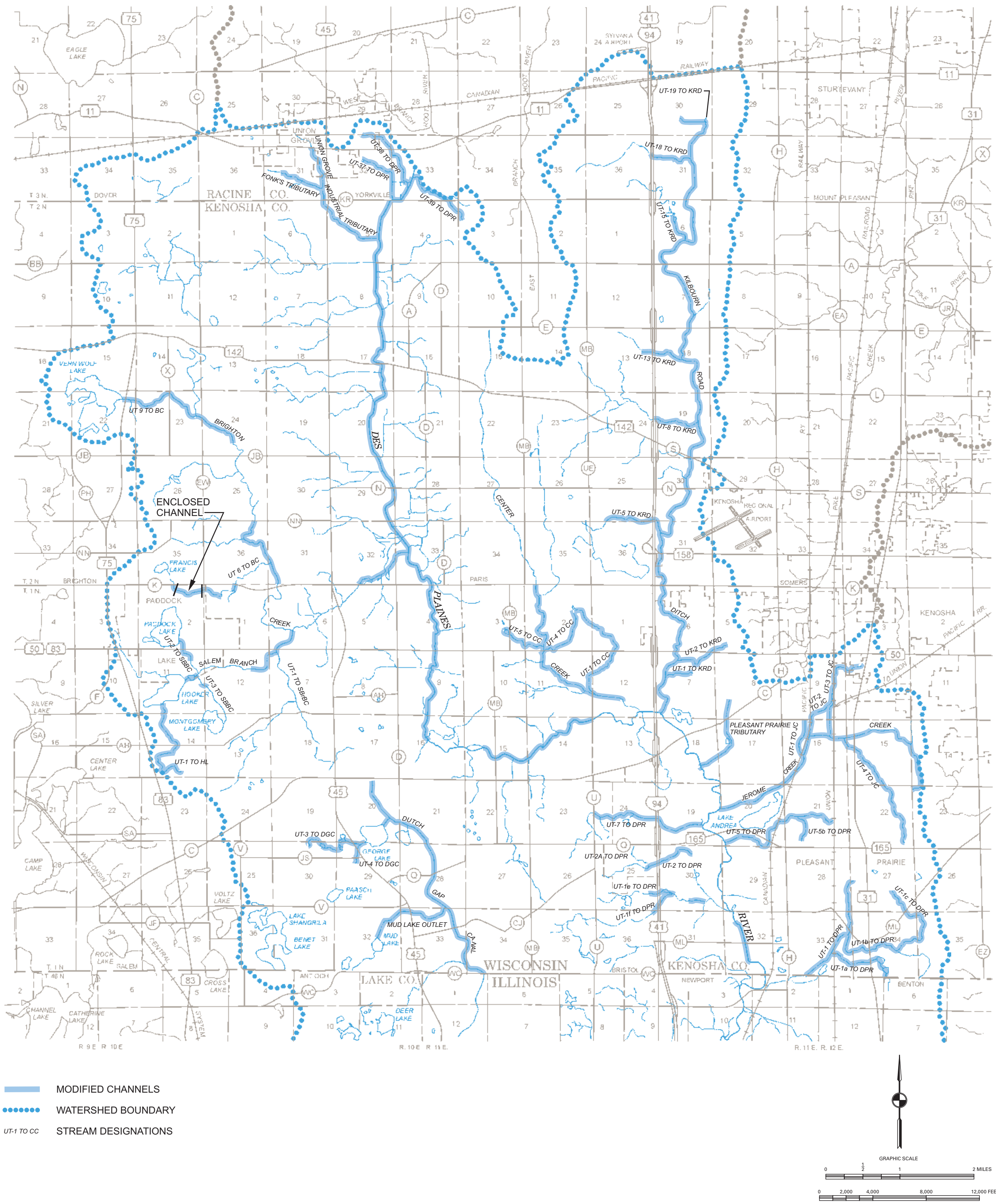
[12]*Flood hazard information was also developed for an additional 50.5 miles of minor tributaries.*

[13]*Stream channel contour crossings are indicators of the water surface elevation at the crossing and are useful in identifying changes in stream bed slope.*

Map 37

CHANNEL MODIFICATIONS IN THE DES PLAINES RIVER WATERSHED

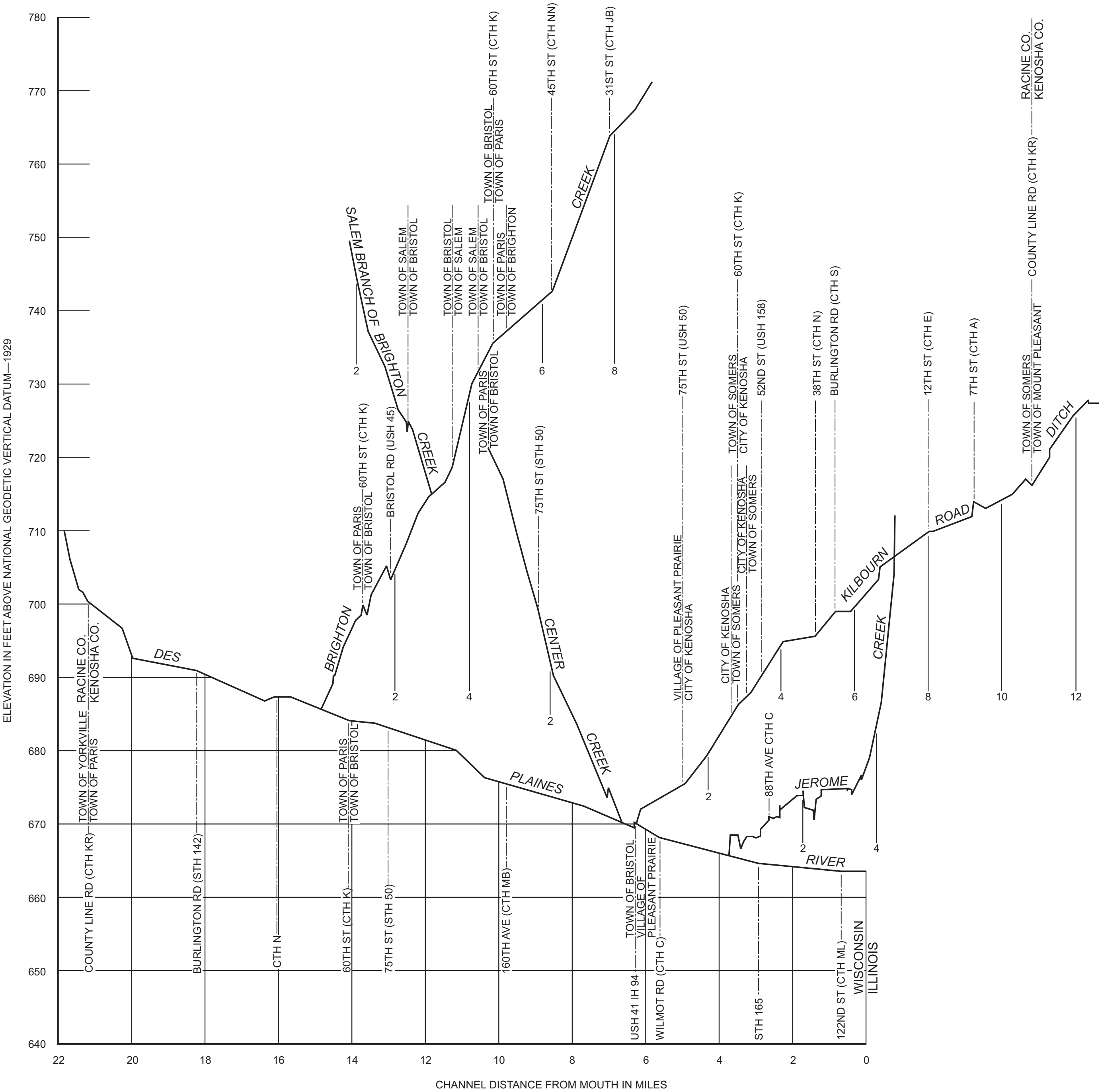


A large portion of the stream system of the Des Plaines watershed has been intentionally modified for flood control and agricultural drainage purposes. For example, of the 108.8 miles of stream system in the watershed selected for development of detailed flood hazard information, about 82.8 miles, or 76 percent, have undergone some type of man-made channel modification. Most of the streams selected for development of flood hazard data have experienced various degrees of channel modification.

Source: SEWRPC.

Figure 22

CHANNEL BOTTOM PROFILES FOR THE DES PLAINES RIVER AND SELECTED TRIBUTARIES



Source: SEWRPC.

ment of detailed flood hazard information.[14] After conversion to numeric form, these cross-sections were input to the hydraulic submodel of the hydrologic-hydraulic simulation model as described in Chapter VIII, "Water Resources Simulation Model."

Floodland cross-sections were developed from several sources, including the available large-scale topographic maps and field surveys of hydraulic structures. Channel bottom elevations were obtained from the channel profiles prepared under the study. A typical floodland cross-section is shown in Figure 23. Numerous factors were considered in the selection of the location, length, and orientation of the floodland cross-sections. These factors included nonhydraulic plan preparation and implementation considerations as well as strictly hydraulic considerations.

A principal hydraulic consideration was the selection of cross-section locations representative of the reach encompassed by the cross-section. Other hydraulic factors influencing cross-section location included abrupt changes in cross-sectional area or shape of the channel, or abrupt changes in natural floodplain roughness, and discontinuities in channel slope. The floodland cross-sections were oriented to be approximately perpendicular to the main flow of the stream and its floodplain during flood flow conditions. The terminal points of the cross-sections were established at sufficient distance laterally from the stream so as to be well outside of the anticipated 100-year recurrence interval floodland limits. Cross-sections were generally located at close, regular intervals so as to assure that computed flood stages would be of sufficient accuracy to be useful in all phases of floodland management, including the delineation of floodland regulatory zones. Furthermore, closely spaced cross-sections facilitate, subsequent to completion of the watershed plan, the hydraulic evaluation of proposed floodland developments or other riverine area changes.

One important nonhydraulic factor entering into the location of floodland cross-sections was the location of the civil division boundary intersections with streams. Cross-sections were located at civil division boundaries to permit the evaluation of the hydraulic effect of proposed riverine area developments in one community on upstream or downstream communities. Another important nonhydraulic factor entering into the location of floodland cross-sections was the location of U.S. Public Land Survey section and quarter section line intersections with the streams. Cross-sections were located at such intersections to facilitate the preparation of large-scale flood hazard maps showing the numerical value of the regulatory flood stages related to real property boundary lines.

Roughness Coefficients

Manning's roughness coefficients are relative measures of the resistances of a channel and its floodplain to flow. The discharge that can be conveyed in a given reach of channel at a specified channel slope and water stage is inversely proportional to the Manning roughness coefficient. Thus, the carrying capacity of the channel and its floodplain diminishes as the value of the roughness coefficient increases. Roughness coefficients are a function of several factors, including the kind of material—such as earth, gravel, and rock—forming the channel and attendant natural floodplain; the kind and density of vegetation—for example, rooted aquatic plants in the channel, and grass, agricultural crops, brush, and trees on the adjacent natural floodplains; and the sinuosity or degree of meandering of the channel.

Initial floodland Manning roughness coefficients were assigned on the basis of field examination of streams in the watershed and on interpretation of aerial photographs. Values were estimated assuming summer or growing season conditions. The roughness coefficients were input to the hydrologic-hydraulic model used in the watershed planning program. During the modeling process, coefficients were adjusted as appropriate to better represent hydraulic conditions such as the distribution of flow in the main channel and overbanks.

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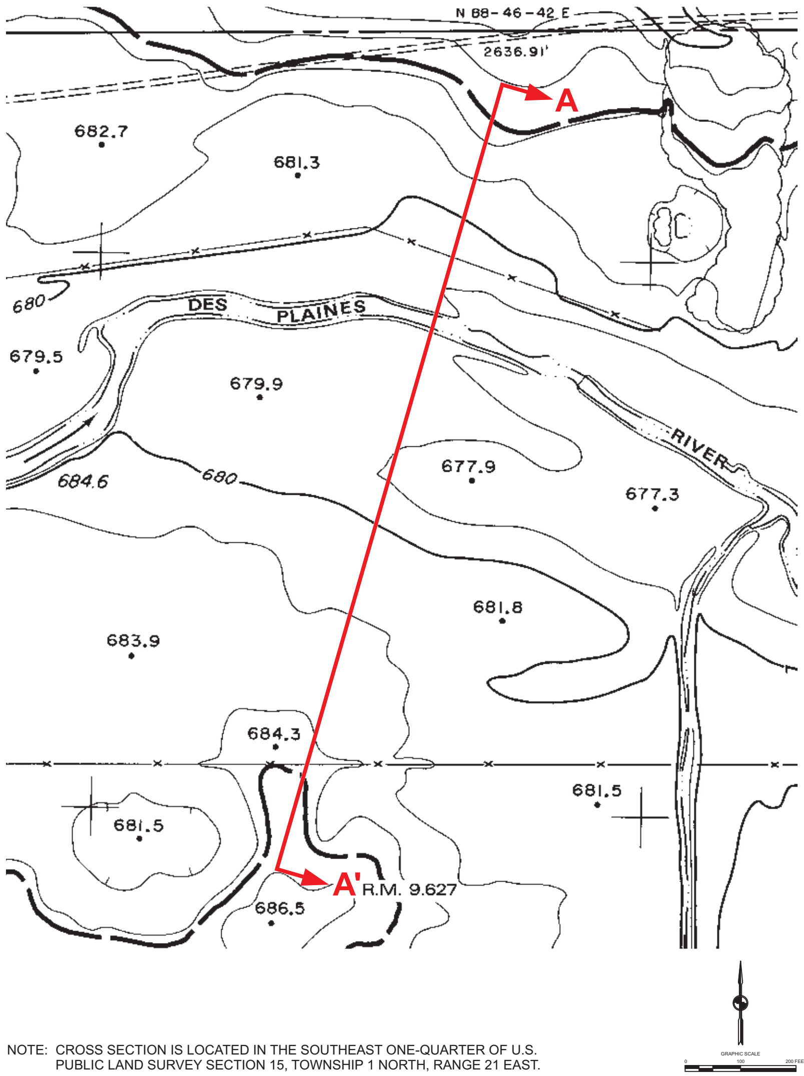
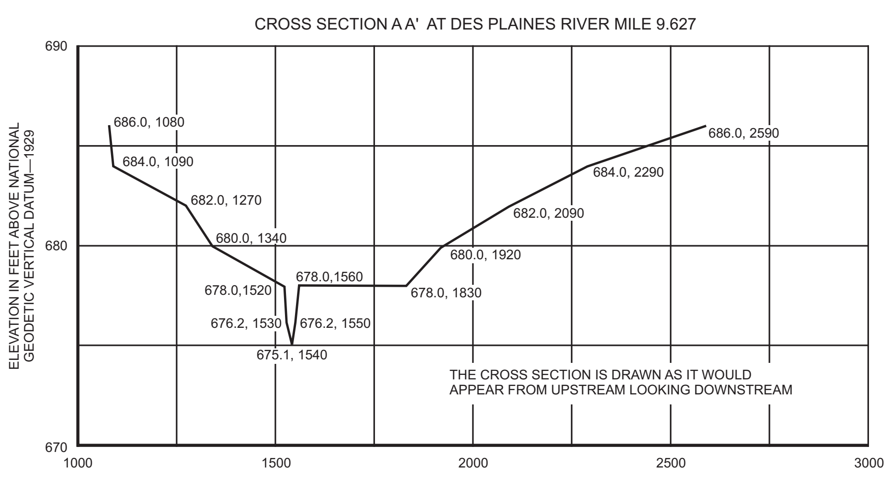
[14]*This number excludes cross-sections located immediately upstream and downstream of bridges and culverts. Those cross-sections were prepared primarily for the purpose of defining the bridge or culvert geometry and the associated roadway or railway profile.*

Figure 23

TYPICAL CROSS-SECTION OF CHANNEL AND FLOODPLAIN IN THE DES PLAINES RIVER WATERSHED



NOTE: CROSS SECTION IS LOCATED IN THE SOUTHEAST ONE-QUARTER OF U.S. PUBLIC LAND SURVEY SECTION 15, TOWNSHIP 1 NORTH, RANGE 21 EAST.



Source: SEWRPC.

Channel Modifications
Channel modification—or channelization—usually includes one or more of the following changes to the natural stream channel: channel straightening; channel deepening with ensuing lowering of the channel profile; channel widening; placement of a concrete invert and sidewalls; removal of dams, sills, or other obstructions to flow; and reconstruction of selected bridges and culverts. At times the natural channel may be relocated or completely enclosed in a conduit. These modifications to the natural channel generally yield a lower, hydraulically more efficient waterway, which results in lower flood stages within the channelized reach.

While channelization can be an effective means of reducing flood damages, it may entail high aesthetic and ecological costs. Furthermore, because of decreased floodplain storage and increased streamflow velocities resulting from channelization, channel modifications tend to increase downstream peak flood discharges and stages, and, therefore, may cause new flood problems or exacerbate existing ones. It is possible, however, depending on the relative position of the channelized reach or reaches in the watershed stream system, for channelization to result in reduced downstream discharges. Channelization in the lower reaches of a watershed or subwatershed may provide for the rapid removal of runoff from the lower reaches prior to the arrival of runoff from the middle and upper portions of the watershed or subwatershed, thereby reducing peak discharges and stages in the lower reaches.

It is apparent that haphazard and uncoordinated channel modification may cause adverse effects elsewhere in a watershed, resulting in little or no net overall improvement of the floodwater problems of a watershed. This possibility points to the need for proper water management practices based upon a comprehensive watershed plan. In recognition of the need to evaluate the potential downstream effect of channelization proposals within the Des Plaines River watershed, one of the standards supporting the adopted water control facility development objectives, as set forth in Chapter X, "Watershed Development Objectives, Principles, and Standards," requires the explicit determination of the downstream impact of any proposed channel modifications. Because of a lack of definitive historic data, it is not possible to make a meaningful quantitative evaluation of the overall effect which the existing channel modifications have had on the flow regimen of the stream system of the watershed.

Channelization is also employed with artificial subsurface drainage for agricultural drainage purposes to lower high groundwater tables beneath fields near streams to improve soil moisture conditions for crops and for the operation of farm machinery. Such channelization may also be beneficial for flood control purposes because of the increase in channel size attendant to channel deepening. However, channelization for agricultural drainage purposes, as for urban drainage purposes, can cause increased flood flows and stages in downstream reaches.

As shown graphically on Map 37, a large portion of the stream system of the Des Plaines River watershed has been historically intentionally modified for flood control and agricultural drainage purposes. Of the 108.8 miles of stream system in the watershed selected for development of detailed flood hazard data, it is estimated that about 82.6 miles, or 76 percent, have undergone some type of anthropomorphic channel modification.

The following two types of channelization were observed in the watershed:

1. Minor channelization: Localized clearing and widening with scattered straightening. These channel modifications have no concrete or masonry on either the channel bottom or side slopes. Channel modifications not readily apparent to the casual observer.

2. Major channelization: Continuous and extensive deepening, widening, and straightening. Channel modifications are readily apparent to the casual observer. These channel modifications have no lining on the channel bottom or side slopes.

It is difficult to identify with certainty all of those stream reaches in the minor channelization category since various degrees of channel modifications occur within the watershed. The channel modifications, for the most part, have been made over a long period of time, presumably by numerous public agencies and private parties, and adequate records are not available to identify all of the stream reaches so modified.

Artificial Subsurface Drainage
Artificial subsurface drainage is a factor primarily affecting the low-flow regimen of a watershed and is often closely associated with channel modification since straightening and deepening of natural channels is often required to provide adequate outlets for the agricultural drain tiles. Large portions of the Des Plaines River watershed have such poor surface drainage under natural conditions that it was deemed necessary to install tile drains to permit efficient agricultural operations. Because of the individual manner in which, and the long period of time over which, such drainage improvements have been installed, it is not possible to determine precisely the total tile-drained area. However, the boundaries of known existing or historic farm drainage districts within the watershed are shown on Map 4 in Chapter III and it is likely that agricultural drain tile systems are located in those districts. Additional, partial data were also collated on drain tile systems in other areas where such data were known to exist.

The effect of artificial agricultural drainage on the flow regimen of a watershed is particularly difficult to analyze, because the effect of the drainage is not to reduce the surface water storage, but rather to increase the capacity for temporary soil water storage during the growing season. The net result may generally be expected to increase the total volume of streamflow due to a reduction of evapotranspiration losses. In the spring, when ice and snow conditions cause blocking of the drainage courses, there is probably little overall effect on natural flow conditions. During the frost-free months, however, when tile underdrains are fully operable, it is probable that areas that have been tiled to eliminate poor surface drainage, or to lower a high groundwater table, will exhibit a decrease in peak surface runoff due to the increased storage made available in the dewatered soil profile, but will result in the ultimate release of a greater volume of flow. However, for the more infrequent, large rainfall events during which soil infiltration capacity is the limiting factor, it is doubtful that tiling in the Des Plaines River watershed has a significant influence on peak rates of runoff.

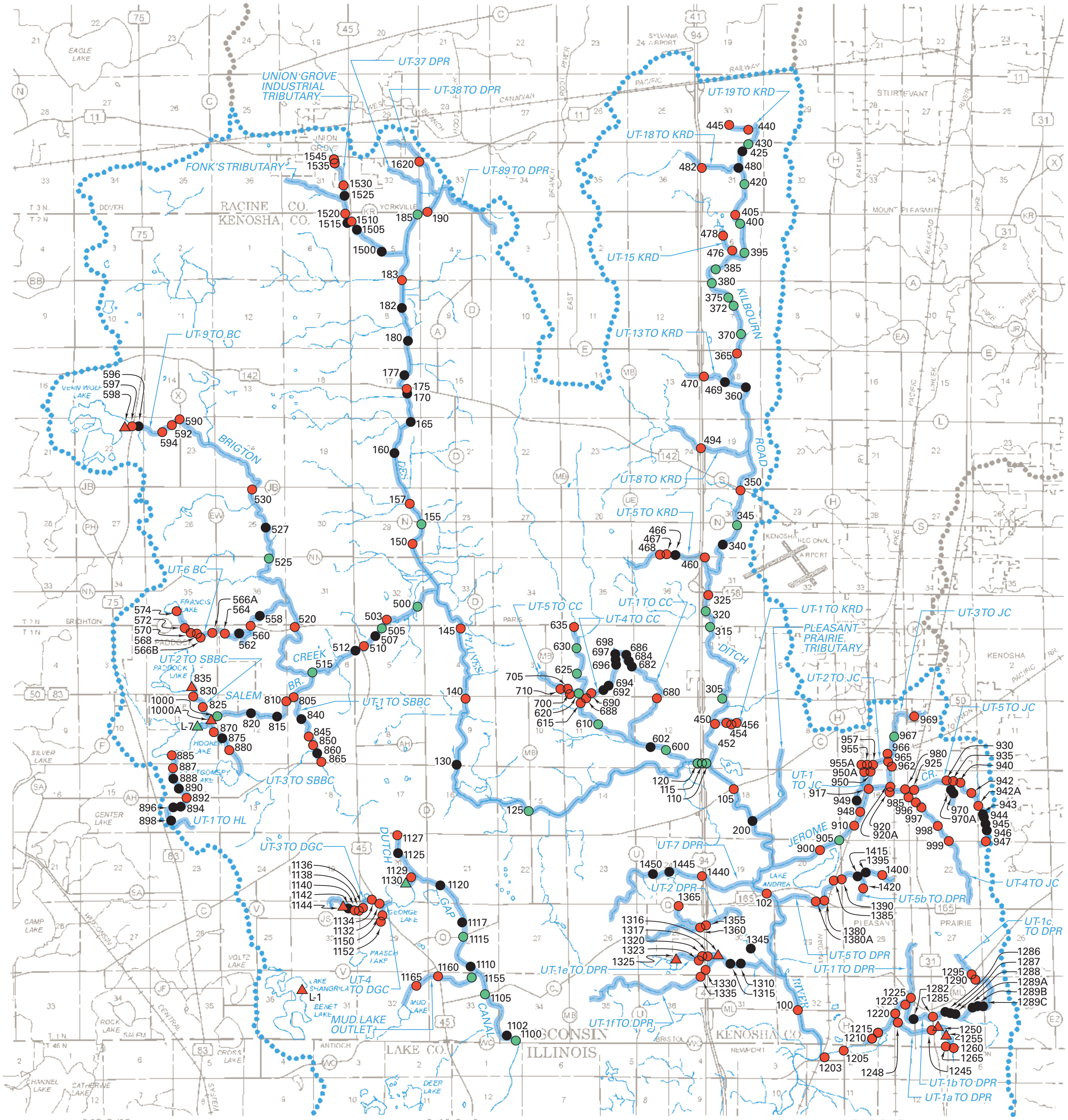
Bridges and Culverts
Depending on the size of the waterway opening and the characteristics of the approaches, bridges and culverts can be important elements in the hydraulics of a watershed, particularly with respect to localized effects. The constriction caused by a bridge or culvert under flood discharge conditions can result in a large backwater effect and thereby create upstream flood stages that are significantly higher, and an upstream floodland that is significantly larger, than would exist in the absence of the bridge or culvert. As of 1994, the 108.8 lineal miles of Des Plaines River watershed stream system selected for hydrologic-hydraulic modeling were crossed, as shown on Map 38, by 247 bridges and culverts having an average spacing of 0.44 mile. While the hydraulic submodel of the hydrologic-hydraulic simulation model, as described in Chapter VIII, has the capability of accommodating any number or type of bridges or culverts, the cost of the field surveys necessary to acquire the input data for the submodel required that a determination be made, based on a field reconnaissance, of the hydraulic significance of each bridge or culvert in order to reduce the number of structures for which complete physical descriptions would have to be obtained.

A bridge or culvert was defined as being hydraulically significant if field inspection suggested that the structure might increase flood stages for the 10- through 100-year recurrence interval flood discharges. In examining each bridge or culvert to evaluate its potential hydraulic significance, the structure was considered to consist of the roadway or railway approaches as well as the structural components, such as abutments, piers, and deck, in the immediate vicinity of the waterway opening. One category of hydraulically insignificant bridges and culverts consists of those having a relatively small superstructure compared to the combined width of the channel and its natural floodplain. Such structures typically have approaches that do not rise significantly above the floodplain while the portion of the structure in the immediate vicinity of the channel simply spans the channel. Pedestrian crossings and private roadway bridges and culverts comprise most of the bridges and culverts in this category of hydraulically insignificant structures. An example of this type of hydraulically insignificant structure is shown in Figure 24.

The second category of hydraulically insignificant bridges and culverts consists of those that are elevated on piers well above the channel and the floodplain. While being major or significant structures in the transportation sense, in that they carry railways and public streets and highways and particularly arterial streets and highways across

Map 38

HYDRAULIC STRUCTURE INDEX FOR THE DES PLAINES WATERSHED: 1994



INVENTORIED UNDER THE WATERSHED STUDY AND EXPLICITLY INCLUDED IN HYDROLOGIC-HYDRAULIC SIMULATION REACHES SELECTED FOR DEVELOPMENT OF FLOOD STAGE PROFILES

- BRIDGE OR CULVERT
- DAM

INVENTORIED UNDER PREVIOUS COMMISSION PLANNING EFFORTS AND EXPLICITLY INCLUDED IN HYDROLOGIC-HYDRAULIC SIMULATION

- BRIDGE OR CULVERT
- DAM

INVENTORIED UNDER THE WATERSHED STUDY BUT EXCLUDED FROM THE HYDROLOGIC-HYDRAULIC SIMULATION BECAUSE IT IS HYDRAULICALLY INSIGNIFICANT

- BRIDGE OR CULVERT

STREAM REACHES FOR WHICH FLOOD DISCHARGES AND PROFILES WERE DEVELOPED UNDER THE WATERSHED STUDY

WATERSHED BOUNDARY

UT-1 TO CC — STREAM DESIGNATIONS

1117 — STRUCTURE NUMBER

NOTE: WITH THE EXCEPTION OF STRUCTURE L-1, THIS MAP IS LIMITED TO HYDRAULIC STRUCTURES ON THOSE PORTIONS OF THE WATERSHED STREAM SYSTEM FOR WHICH FLOOD STAGE PROFILES WERE DEVELOPED. STRUCTURE NUMBERS ALONG A GIVEN STREAM INCREASE FROM DOWNSTREAM TO UPSTREAM.

GRAPHIC SCALE
0 ½ 1 2 MILES
0 2,000 4,000 8,000 12,000 FEET

Eleven dams, 247 bridges and culverts were inventoried during the course of the Des Plaines River Watershed Study. Data obtained from this inventory were used to identify those dams, bridges, and culverts that can be expected, by virtue of hydraulic capacity and location in the watershed, to significantly influence flood discharges and stages along the principal stream channels in the basin. As a result of this screening process, 176 bridges and culverts and 10 dams were identified for later incorporation into the water resources simulation model, as described in Chapter VIII.

Source: SEWRPC.

Figure 24

EXAMPLE OF A HYDRAULICALLY INSIGNIFICANT RIVER CROSSING IN THE DES PLAINES RIVER WATERSHED

Source: SEWRPC.

Figure 25

EXAMPLE OF A HYDRAULICALLY SIGNIFICANT RIVER CROSSING IN THE DES PLAINES RIVER WATERSHED

Source: SEWRPC.

the floodland, they are hydraulically insignificant in that they utilize little or no fill for the approaches and, therefore, offer little impedance to flow during even major flood events. No examples of this type of hydraulically insignificant structure were found in the Des Plaines River watershed.

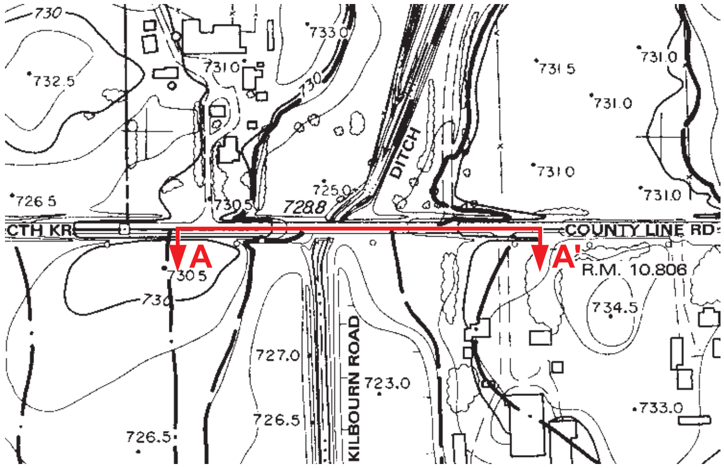
Hydraulically significant bridges and culverts generally are characterized by relatively small waterway openings in combination with approaches that are constructed well above the elevation of the floodplain. Such structures function as dams and have the potential for obstructing streamflow during major flood events. As shown in Figure 25, the CTH KR (County Line Road) crossing of the Kilbourn Road Ditch is an example of a hydraulically significant structure.

Based on field reconnaissance and review of available aerial photographs and large-scale topographic maps, 176, or 71 percent, of the 247 bridges or culverts on that portion of the Des Plaines River watershed stream system selected for development of detailed flood hazard data were determined to be hydraulically significant. The location of these hydraulically significant bridges and culverts is shown on Map 38 and the number of structures on each of the selected stream reaches is set forth in Table 42. The average spacing of these hydraulically significant structures is 0.62 mile.

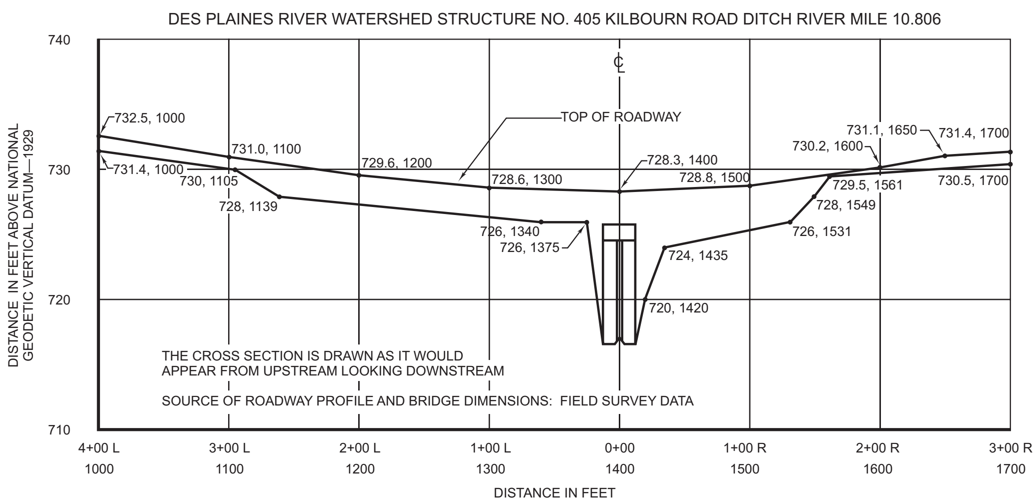
To meet the input data needs of the hydraulic submodel, it was necessary to obtain dimensional data on these 176 structures. Data needs included measurement of the waterway opening, determination of channel bottom elevations, and construction of a profile—from one side of the floodplain to the other—along the crown of the roadway or the top of rail of the railway concerned. The necessary information for each of the hydraulically significant bridges and culverts was obtained by field survey. A network of vertical survey control stations—bench marks—referenced to National Geodetic Vertical Datum of 1929 (NGVD-29) was established on all hydraulically significant bridges and culverts prior to the acquisition of detailed data on the structures. Closed differential level circuits were run to establish permanent bench marks on each structure. At least one reference bench mark was established for each permanent bench mark and a record of vertical survey control was prepared for each hydraulically significant bridge or culvert. As part of the field survey work needed to establish the vertical survey control network, the channel bottom elevation was determined at the upstream and downstream faces of each of the hydraulically significant bridges and culverts, which, in addition to providing information about the waterway opening, facilitated the drawing of channel bottom profiles.

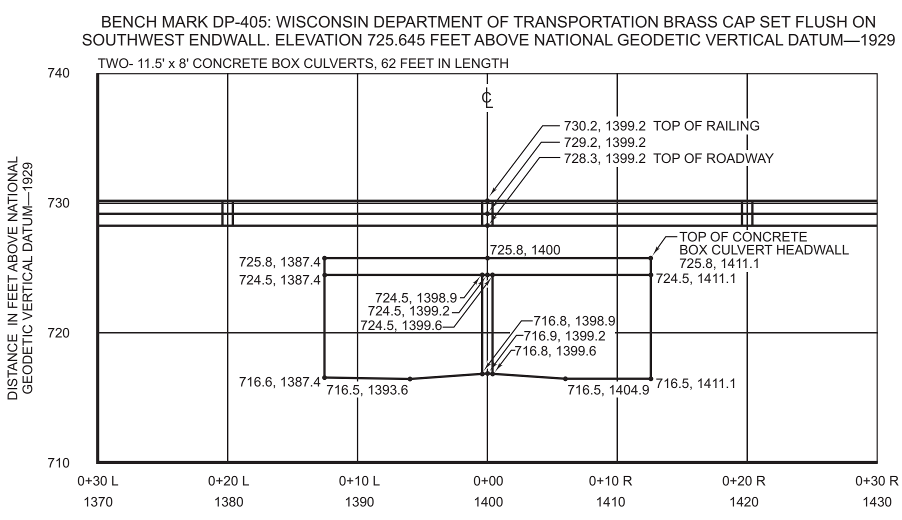
Figure 26

TYPICAL DRAWING OF A HYDRAULIC STRUCTURE IN THE DES PLAINES RIVER WATERSHED



SOURCE OF CHANNEL-FLOODPLAIN CROSS SECTION: SEWRPC TOPOGRAPHIC MAP
(2' CONTOUR INTERVAL 1"=200') OF SECTION 6, T2N, R22E, AND SECTION 31, T3N, R22E





Source: SEWRPC.

Prior to coding the bridge and culvert data for input to the hydraulic model, the structure information was used to draw a cross-section showing the physical configuration of the waterway opening and the approach roads. Figure 26 shows a structure drawing typical of those prepared for each of the hydraulically significant bridges and culverts in the Des Plaines River watershed.

Dams

In addition to the bridges and culverts located on that portion of the Des Plaines River watershed stream system selected for development of detailed flood hazard information, there are 10 dams on streams which were studied. The dams are generally on smaller tributaries at the outlets of lakes. The locations of the dams are shown on Map 38.

The vertical survey control network discussed above was extended to the hydraulically significant dams and channel bottom elevations were determined at each structure. Detailed information on the physical characteristics of the dams was obtained by field survey.

SUMMARY

This chapter describes those elements of the hydrologic-hydraulic system of the Des Plaines River watershed which constitute the framework within which all the water resource-related problems of the watershed must be analyzed and resolved. Included in the description of the hydrology of the watershed are: 1) data on precipitation, evapotranspiration, and other aspects of the hydrologic budget; 2) data on the volume and timing of runoff as revealed by stream gaging records; and 3) data on the location and quantity of water contained within the aquifers lying beneath the watershed. Included in the discussion of the hydraulics of the watershed are data on the length, slope, and flow resistance of the stream system and an evaluation of the hydraulic significance of the dams, bridges, culverts and other hydraulic structures in the watershed.

Knowledge of the complex hydrologic cycle as it affects the watershed is necessary to assess the availability of surface and groundwater for various uses and to improve the potential management of water during times of flooding or drought. The quantitative relationships between inflow and outflow—termed the hydrologic budget—were determined for the watershed. Precipitation is the primary source of water to the watershed and averages 32.6 inches annually. Surface water runoff and evapotranspiration losses constitute the primary outflow from the basin. The average annual runoff approximates 10.1 inches and the annual evapotranspiration loss total is about 22.5 inches. Historically, the period February through April has produced about 77 percent of the annual flood peaks in the Wisconsin portion of the Des Plaines River watershed based on flows measured from 1960 through 1994 at U.S. Geological Survey Stream gaging Station No. 05527800, located on the Des Plaines River at Russell, Illinois just south of the Wisconsin-Illinois state line. The largest instantaneous peak flood discharge recorded at that station were 2,120 cfs on March 21, 1979, and 2,130 cfs on June 14, 2000.

There are three main groundwater aquifers beneath the watershed: the deep sandstone, the shallow dolomite, and the unconsolidated sand and gravel aquifers. The confined or artesian sandstone aquifer is the deepest of the three systems and, except for minor leakage and a connection to the recharge area, is hydraulically separated from the remainder of the hydrologic-hydraulic system by the overlying semipermeable Maquoketa shale formation. The dolomite aquifer and the unconsolidated sand and gravel aquifers are, in contrast to the sandstone aquifer, recharged locally. Groundwater in the deep sandstone aquifer beneath the watershed moves in a generally southeasterly direction toward northern Illinois. Flow in the dolomite and sand and gravel aquifers tends to be more varied but exhibits an overall eastward movement toward Lake Michigan.

The Des Plaines River watershed may be considered as a composite of eight subwatersheds: 1) the Upper Des Plaines River subwatershed, which encompasses 20.4 square miles, or 14.6 percent of the total watershed area; 2) the Lower Des Plaines River subwatershed, which encompasses 33.4 square miles, or 24.0 percent of the total watershed area; 3) the Brighton Creek subwatershed, which encompasses 20.7 square miles, or 14.9 percent of the total watershed area; 4) the Center Creek subwatershed, which encompasses 10.3 square miles, or

7.4 percent of the total watershed area; 5) the Dutch Gap Canal subwatershed, which encompasses 18.0 square miles, or 12.9 percent of the total watershed area; 6) the Jerome Creek subwatershed, which encompasses 5.9 square miles, or 4.2 percent of the total watershed area; 7) the Kilbourn Road Ditch subwatershed, which encompasses 23.7 square miles, or 17.0 percent of the total watershed area; and 8) the Salem Branch of Brighton Creek subwatershed, which encompasses 7.0 square miles, or 5.0 percent of the total watershed area. For the hydrologic analyses performed the watershed was divided into approximately 230 subbasins, ranging in size from 0.02 to 2.81 square miles, and having an average area of 0.61 square mile.

Approximately 108.8 lineal miles of 48 streams in the watershed were selected for development of detailed flood hazard information, including discharge-frequency relationships, flood stage profiles, and mapped areas of inundation for selected flood recurrence intervals. Detailed data were obtained for 176 hydraulically significant dams, bridges, and culverts on that portion of the stream system, and for about 730 floodland cross-sections, all of these data being required as input to the hydrologic-hydraulic simulation model developed for the watershed.

Channel slopes are irregular, with the steepest slopes occurring on the small headwater tributary streams such as Unnamed Tributary No. 4 to Center Creek, Unnamed Tributary No. 1f to the Des Plaines River, Unnamed Tributary No. 3 to Salem Branch of Brighton Creek, and Fonks Tributary where bed slopes range from 56.7 to 59.1 feet per mile. Considerably flatter bed slopes, ranging from 1.3 to 4.5 feet per mile, occur on the Des Plaines River, Dutch Gap Canal, Kilbourn Road Ditch, and the lower reaches of Jerome Creek.

A large portion of the stream system of the Des Plaines River watershed has been historically intentionally modified for flood control and agricultural drainage purposes. Of the 108.8 miles of stream system in the watershed selected for development of detailed flood hazard data, it is estimated that about 82.6 miles, or 76 percent, have undergone some type of anthropomorphic channel modification.

Chapter VI

HISTORIC FLOOD CHARACTERISTICS AND PROBLEMS

INTRODUCTION

Flooding of the stream system of the Des Plaines River watershed has been, and may be expected to continue to be, a common and natural occurrence. In portions of the watershed the streams leave their channels and occupy parts of the adjacent natural floodplains almost annually as a result of late winter-early spring snowmelt or snowmelt-rainfall events or in response to spring, summer, and fall thunderstorms. Damage from this flooding has been partly a consequence of the failure to recognize and understand the relationships which should exist between the use of land—in both floodland and nonfloodland areas of the basin—and the hydrologic-hydraulic behavior of the stream system. Unnecessary occupancy of the natural floodlands by flood-vulnerable land uses, together with development-induced changes in the flow characteristics of the streams, has produced flood problems in some areas of the watershed. In some areas of the watershed flood problems have been caused by natural processess, such as excessive sedimentation and the overgrowth of vegetation which reduce the carrying capacity of the stream channels.

Comprehensive watershed planning is the first step in achieving or restoring a balance between the use of land and the hydrologic-hydraulic regimen of the watershed. To ensure that future flood damage will be held to a minimum, plans for the proper utilization of the riverine areas of the watershed must be developed so that control of land uses in flood hazard areas, public acquisition of flood lands, and river engineering can be used to properly direct new development into a pattern compatible with the demands of the river system on its natural floodlands and to achieve an adjustment or balance between land use development and floodwater flow and storage needs.

Because the Wisconsin portion of the Des Plaines River watershed is still predominantly rural, opportunity still exists for limiting flood damage risk through sound land use development in relation to the riverine areas of the watershed in Wisconsin and for limiting increases in flood damages along downstream reaches in Illinois through the preservation of natural floodwater storage areas. In the absence of sound land use development, flood damage potential and flood risk in the Wisconsin portion of the watershed could grow to significant proportions and existing flood problems in Illinois could be exacerbated as urban land use in Wisconsin increases. Some of the present flood risk in the Wisconsin portion of the watershed can be ascribed to the unnecessary location of flood damage-prone urban development in the natural floodlands—unnecessary since adequate alternative locations are available within the watershed and Region for such development—aggravated by increased flood flows attributable to urbanization. The existing flood risk in Illinois is far more significant than in Wisconsin and it can also be attributed to the unnecessary location of flood damage-prone urban development in the natural floodlands and increased flood flows resulting from urbanization.

This chapter presents historic flood characteristics and damages for the 108.8 miles of stream channels in the Des Plaines River watershed selected by the Watershed Committee for development of detailed flood hazard data and attendant floodland management plans. These stream channels are shown on Map 36 in Chapter V. Also included in this chapter are discussions of direct, indirect, and intangible flood losses and risks; the categorization of flood losses and risks by private and public ownership; the methodology used to quantify flood risks in monetary terms; and quantification of total and average annual damages which would be anticipated under 1990 land use and channel conditions.

The Des Plaines River watershed plan is intended to provide recommendations for resolution of existing flood problems along these selected stream channel reaches and for the prevention of future flood problems in the associated riverine areas. The watershed planning process is not intended to address the resolution of stormwater drainage problems not directly attributable to flooding of the watershed stream system, although both potential stormwater management alternatives which may be expected to have significant impacts on floodland management measures and the need to provide hydraulically adequate outlets for stormwater management facilities were considered in the process.

Basic Concepts and Related Definitions

Flooding is herein defined as inundation of the floodplains of the watershed—that is, of the relatively wide, low-lying, flat to gently sloping areas contiguous to and usually lying on both sides of the stream channels, as a direct result of stream water moving out of and away from the major stream channels. Flooding is a natural and certain process in hydrologic-hydraulic systems—one that is unpredictable only in the sense that the exact time of occurrence of a flood of a given magnitude cannot be predetermined, although the average recurrence interval of such a flood is amenable to engineering analyses. How much of a natural floodland will be flooded during a given event depends on the severity of the flood and, more particularly, on the peak elevation of the floodwaters. Thus, an infinite number of outer limits of natural floodlands may be delineated, each related to a specified recurrence interval as determined by engineering analyses. Based upon such analyses, floodlands may be delineated on large-scale topographic maps as continuous linear areas lying along the streams and water courses. Flooding is not necessarily synonymous with the presence of flood problems. Flood problems—and the demand for flood damage reduction measures—are created only when flood damage-prone land uses are allowed to intrude upon the natural floodlands of the watershed in such a fashion and to such an extent that the certain, although random, inundation of the floodlands results in disruption, monetary damages, and risks to human health and life.

Stormwater inundation is defined herein as the localized ponding of stormwater runoff which occurs when such runoff moving toward streams and other low-lying areas exceeds the conveyance and storage capacities of the stormwater management system and temporarily accumulates on the land surface. Stormwater runoff is conveyed and/or stored in networks consisting of overland or sheet flow, small intermittent channels, storm sewers, other drainageways, and detention storage facilities.

Stormwater inundation and riverine area flooding, as defined herein, differ in several significant ways. While stormwater inundation involves water moving downslope toward major rivers, flooding is caused by water moving in the opposite way, that is, out and away from major stream channels. In contrast to areas experiencing flooding, areas experiencing stormwater inundation tend to be a discontinuous, series of relatively small and scattered pockets not necessarily located in the lowest areas or near major streams or even near small intermittent channels or other well-defined drainageways. The definition of urban areas subject to stormwater inundation requires detailed analysis of local topography and local street and associated building grades and of local stormwater drainage and sanitary sewerage systems, whereas the definition of floodprone areas requires a broader, watershedwide analysis of the riverine areas of the major streams.

Stormwater problems are not necessarily synonymous with stormwater inundation. Stormwater problems, and the demand for works and measures to control stormwater runoff as it moves toward the natural and man-made drainageways, are created only when urban development occurs without proper regard for stormwater runoff conveyance and storage needs. Such local problems in urban design are to be differentiated from the areawide problems of flooding. Resolution of local stormwater drainage problems requires the preparation of detailed stormwater management plans which are beyond the scope of this systems level flood control stormwater management plan. Rather, the recommended plan will address the stormwater management needs of the area to the extent that stormwater management and flood control are interrelated. As such, the flood control plan will present a framework for preparing and carrying out local level stormwater management plans. In addition, the recommended plan will include the provision of specific guidelines to be used in addressing stormwater management problems including the best means of treating development proposals pending completion of detailed local stormwater management plans.

USES OF HISTORIC FLOOD INFORMATION

The collection, collation, and analysis of historic flood information comprises an important element of any comprehensive watershed study. Historic flood data have six primary applications in watershed planning and plan implementation, each of which is described below. Five of these applications occur during the planning process and one is directly related to plan implementation.

Identification and Delineation of Floodprone Areas
While the location and extent of some floodprone areas within the Des Plaines River watershed were known at the outset of the watershed study, the location and extent of all such areas within the watershed were not known for existing land use and channel conditions. Nor was such information available for probable future land use conditions and therefore adequate as a basis for the development of alternative flood control plans. One important use of historic flood information is the identification and delineation of all riverine areas in the watershed that not only are subject to flooding, but in which the flooding either causes, or has the potential to cause, significant monetary flood damages.

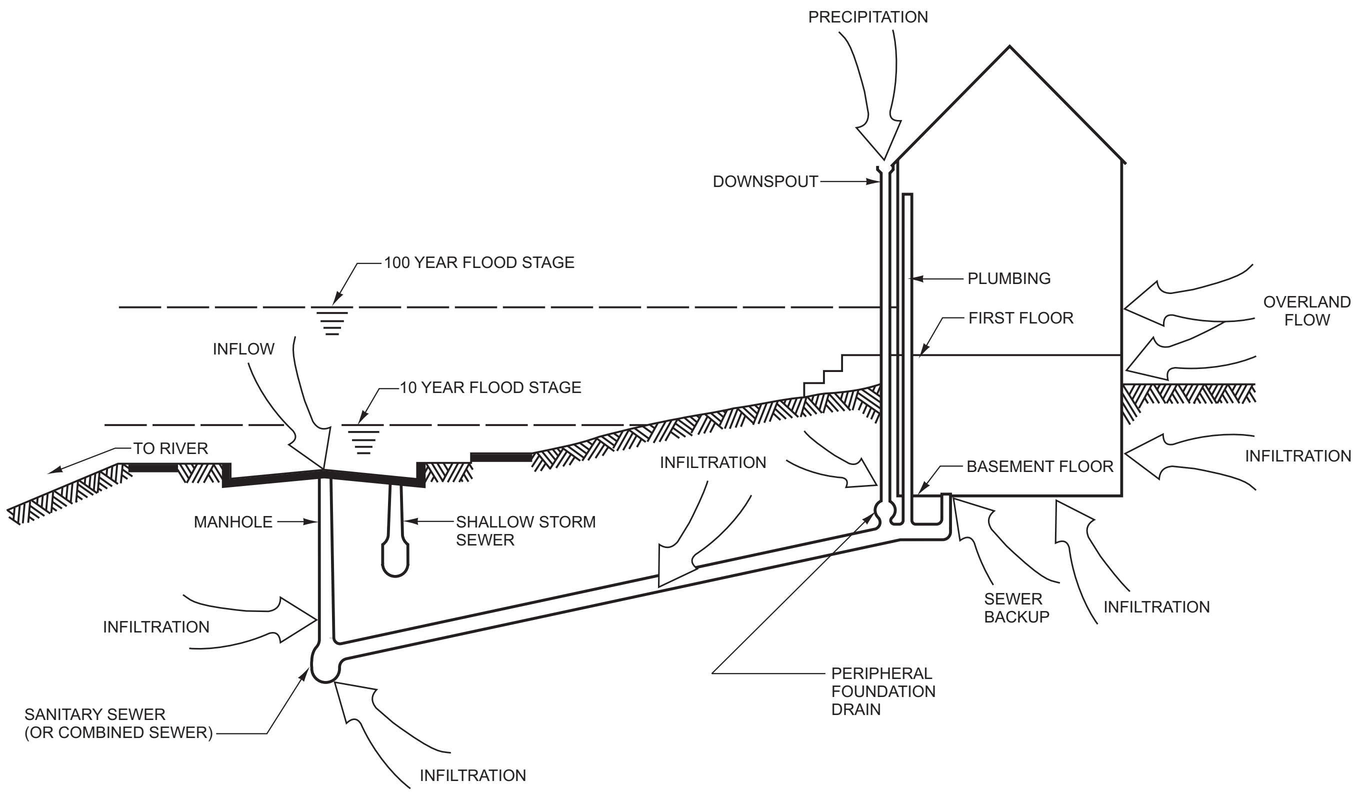
Determination of the Cause of Flood Damage
Flood damages in rural areas are caused primarily by the inundation of crops, and, to a lesser extent, by the inundation of roadways, agricultural buildings, and agricultural drainage systems. Historic floods have caused agricultural damage in the watershed, including damage to and destruction of crops. Crop damage and destruction are dependent upon the time of year of flood occurrence, the duration and depth of flooding, the floodwater velocity, and the type of crop. Early spring floods can delay planting, not only during the flooding periods but also afterwards, when field conditions may be too wet for the operation of farm machinery, resulting in an effectively shorter growing season and attendant reductions in agricultural production and farm income.

Flood damages in urban areas are caused primarily by the inundation of buildings and, to a lesser extent, by the inundation of roadways and utilities. Residential, commercial, and industrial buildings are particularly vulnerable to flood damage partly because of the many ways in which floodwaters can enter such structures. As illustrated in Figure 27, an unprotected floodland structure is vulnerable to the entry of floodwaters in a number of ways. Rising floodwaters may surcharge the sanitary or storm sewers in an urban area, thereby reversing the flow in these sewers and forcing water into the structures through basement floor drains, plumbing fixtures, and other openings connected to the sewer system. As a result of saturated soil conditions around structure foundations, water may enter through cracks or structural openings in basement walls or floors. If overland flooding occurs—that is, flood stages rise above the elevation of the ground near a particular residential, commercial, or industrial structure—floodwater may enter the basement of the structure through basement doors, windows, and other structural openings. If flood stages rise high enough, floodwaters similarly may gain access to the first or main floor of a structure. In addition to the inundation damage to the structure and its contents, external hydrostatic pressures may cause the uplift and buckling of basement floors and the collapse of basement walls. Finally, floodwaters may exert hydrostatic or dynamic forces of sufficient magnitude to lift or otherwise move a structure from its foundation.

It should be noted that flood damage can occur to the basements of structures located outside of the geographic limits of the overland flooding when floodwaters gain access via the hydraulic connections between the inundated area—the area of primary flooding—and basements that are provided sanitary, storm, or combined sewer systems. Such flooding of basements outside of, but adjacent to, the area of primary flooding is herein defined as

Figure 27

MEANS BY WHICH FLOODWATER MAY ENTER A STRUCTURE



NOTE: TYPICAL AND GENERALLY PREFERABLE VARIATIONS INCLUDE DOWNSPOUTS DISCHARGING TO THE GROUND SURFACE AND FOUNDATION DRAINS CONNECTED TO STORM SEWERS OR CONNECTED TO A SUMP FROM WHICH WATER IS PUMPED TO THE GROUND SURFACE AT SOME POINT AWAY FROM THE STRUCTURE

Source: SEWRPC.

secondary flooding. With the exception of selected areas in the Village of Paddock Lake, secondary flooding adjacent to streams in the watershed has not been reported as a widespread problem. Therefore, damages attributed to secondary flooding were not included in the flood damage estimates determined under this study, except in the Village of Paddock Lake where documented occurrences of secondary flooding were used in the computation of damages. Primary and secondary flooding zones are illustrated in Figure 28.

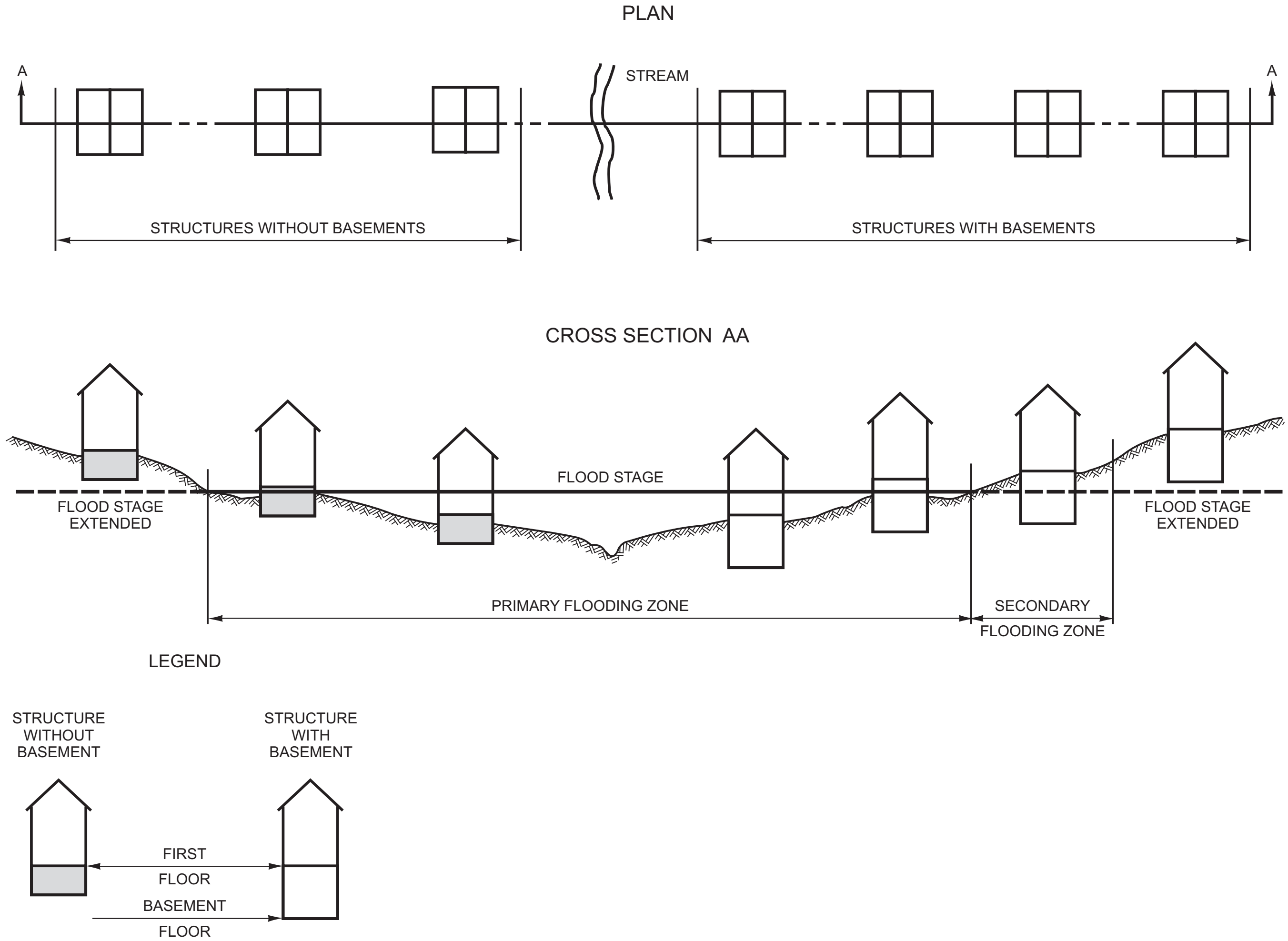
Calibration of the Hydrologic-Hydraulic Model

Flood flows, stages, and areas of inundation throughout the watershed were developed for floods with recurrence intervals ranging from two through 100 years by application of a mathematical simulation model assembled by the Commission. Such simulation modeling is necessary to properly describe flood-related stream flows and stages for a range of conditions which have not occurred and, thus, have not been measured on a uniform basis in the watershed, but which are necessary to an analysis based upon sound engineering practice and regulatory considerations. For example, stormwater drainage facilities are commonly designed using flows based upon a five- to 10-year recurrence interval level based upon engineering judgement, costs of protection, and levels of acceptable frequency of inundation. However, based upon sound engineering practice, floodplain management regulations and comprehensive watershed planning consider a 100-year recurrence interval design flood.

Sound engineering practice requires calibration of such a model through careful comparisons between the model results and reliable observations of the actual hydrologic-hydraulic behavior of the stream system. Such comparisons permit adjustments to and refinements in the model and thereby result in a more accurate

Figure 28

PRIMARY AND SECONDARY FLOOD ZONES



Source: SEWRPC.

representation of watershed hydrology and hydraulics. As described in Chapter VIII, "Water Resource Simulation Model," use was made of historic flood information in the model calibration process.

The flood stages and flood inundation maps generated by application of the Commission hydrologic-hydraulic simulation submodel were compared to similar data presented in the Federal flood insurance studies for Kenosha and Racine Counties.[1] Table 44 provides a comparison of peak flood discharges and stages. A graphic summary of the comparison with respect to areas of inundation is provided on Map 39.

Differences between these data from the two sources may be attributed to actual changes in the channels, bridges, or culverts; to the availability of additional and more current hydraulic structure data for the Commission

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[1]*Federal Emergency Management Agency, Federal Insurance Administration,* Flood Insurance Study, Kenosha County, Wisconsin*, August 17, 1981; Federal Emergency Management Agency, Federal Insurance Administration,* Flood Insurance Study, Racine County, Wisconsin*, October 1981.*

Table 44

COMPARISON OF PEAK FLOOD DISCHARGES AND STAGES DEVELOPED FROM THE COMMISSION'S HYDROLOGIC-HYDRAULIC SIMULATION SUBMODEL TO THOSE PRESENTED IN THE FEDERAL FLOOD INSURANCE STUDIES FOR KENOSHA AND RACINE COUNTIES: EXISTING LAND USE AND CHANNEL-FLOODPLAIN CONDITIONS

River Mile	Location	100-Year Recurrence Interval Discharge (cfs)		100-Year Recurrence Interval Stage (feet above NGVD-29)	
		Commission[a]	Federal Flood Insurance Study	Commission[a]	Federal Flood Insurance Study
	Des Plaines River				
0.00	Wisconsin-Illinois state line	2,560	2,870	675.7[b]	674.4
5.64	Downstream CTH C	2,750	3,905	678.1	679.8
6.34	Downstream IH 94/USH 41	1,870	2,645	679.2	680.2
7.26	Upstream confluence with Center Creek	1,880	2,555	679.6	681.2
16.08	Downstream CTH N	820	1,320	695.5	696.5
21.20	Downstream CTH KR	290	365	706.5	706.0
21.35	Downstream private drive	290	310	707.1	707.0
	Union Grove Industrial Tributary				
1.26	Upstream CTH KR	670	260	742.9	737.6
	Unnamed Tributary No. 37 to Des Plaines River				
0.04	About 240 feet upstream of mouth	165	130	707.3	707.6
	Kilbourn Road Ditch				
1.33	Downstream STH 50	1,400	2,256	682.4	681.4
5.47	Downstream CTH S	1,370	1,550	705.8	705.9
9.24	Upstream CTH A	770	845	721.9	722.6
	Unnamed Tributary No. 15 to Kilbourn Road Ditch				
0.26	Downstream private drive	220	210	723.5	724.0
	Unnamed Tributary No. 18 to Kilbourn Road Ditch				
0.34	About 1,800 feet upstream of mouth	300	230	730.6	730.8
	Brighton Creek				
1.14	Downstream CTH K	1,230	1,570	707.4	707.2
	Mud Lake Outlet				
0.70	Downstream USH 45	130	150	761.7	761.8

[a]*Flood discharges and stages which were developed for all of the stream reaches studied are listed in Appendix F for existing land use and channel conditions, and in Appendix G for buildout land use and existing channel conditions.*

[b]*This elevation is based upon a 1995 study of the Des Plaines River watershed which was conducted by the Chicago District of the U.S. Army Corps of Engineers, in cooperation with the State of Illinois Division of Water Resources. Revised Federal Emergency Management Agency Flood Insurance Rate Maps for the Des Plaines River in Lake County, Illinois became effective in September 2000.*

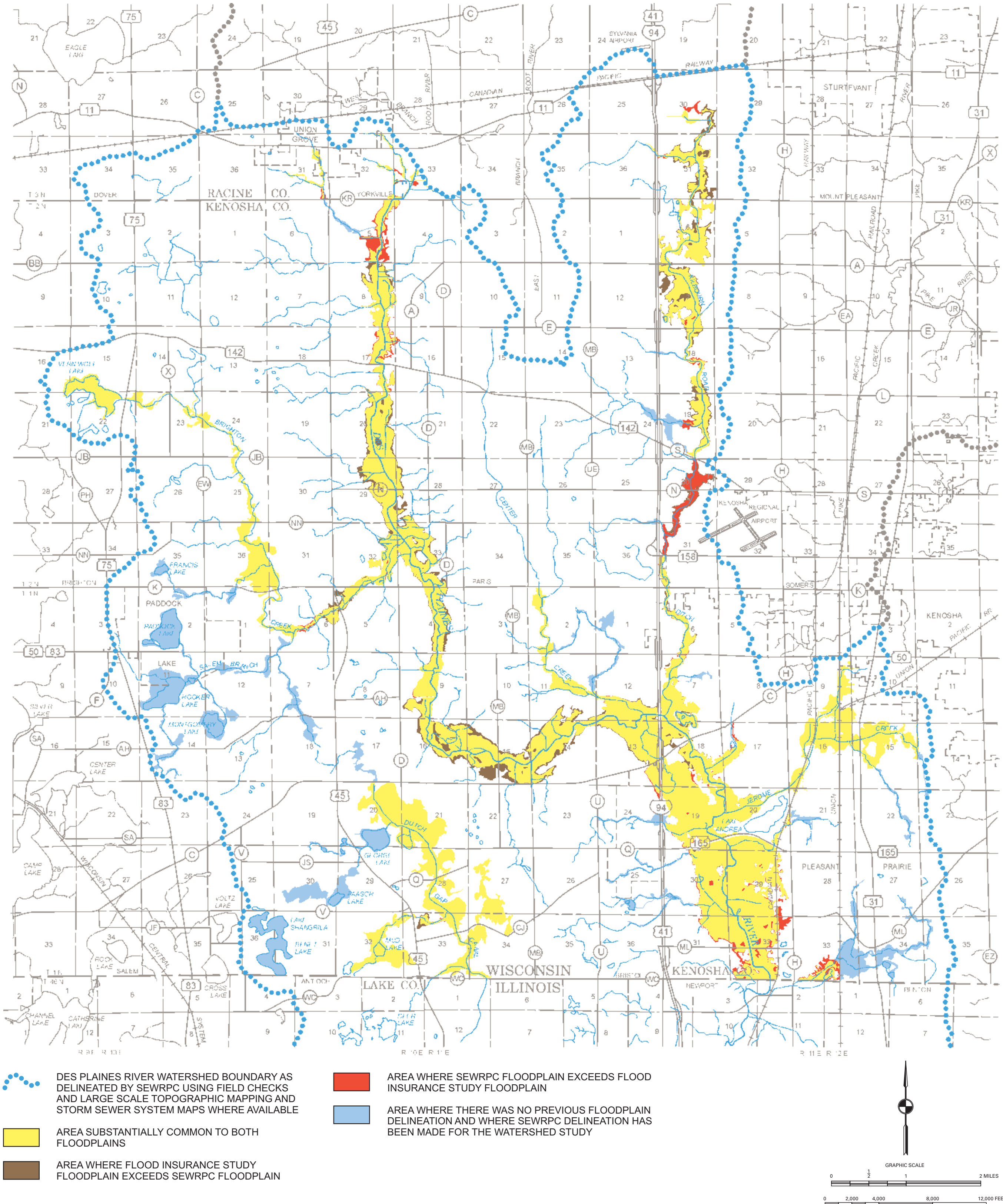
Source: SEWRPC.

hydrologic-hydraulic simulation modeling; and to the differences in techniques used to determine peak flood discharges for the watershed. Also, significant lengths of stream along tributaries to the main streams in the watershed, which were not included under the Federal flood insurance studies, were analyzed under the watershed study.

Flood flows used in the Federal flood insurance studies were based upon several computational methods. Some flows were developed for the land use conditions existing at the times that the studies were conducted and others were developed for estimated year 2000 land use conditions. For the Des Plaines River, the U.S. Soil

Map 39

COMPARISON OF THE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN AS DELINEATED UNDER THE DES PLAINES RIVER WATERSHED STUDY TO THOSE PRESENTED IN THE FEDERAL FLOOD INSURANCE STUDIES FOR KENOSHA AND RACINE COUNTIES



The data provided by the flood inundation maps generated from the SEWRPC hydrologic-hydraulic simulation submodel under 1990 land use and existing channel conditions were compared to similar data presented in the Federal flood insurance studies for Kenosha and Racine Counties. Observed differences between these data from the two sources may be attributed to actual changes in the channels, bridges, or culverts; to the availability of additional and more current hydraulic structure data for the SEWRPC hydrologic-hydraulic simulation modeling; and to differences in techniques used to determine peak flood discharges for the watershed. Also, significant additional lengths of stream along tributaries to the main streams in the watershed were analyzed under the watershed study.

Source: SEWRPC.

Conservation Service (now the U.S. Natural Resource Conservation Service) Technical Release No. 20 (TR-20), *Computer Program for Project Formulation-Hydrology*, computer program was used for the development of flood flows for planned year 2000 land use conditions. The flood flows for Brighton Creek and Kilbourn Road Ditch at their confluences with the Des Plaines River were estimated using the TR-20 results for the Des Plaines River. Flood flows at locations on those two streams upstream of their confluences with the Des Plaines River were estimated by applying exponential drainage area relationships to the flows at the confluences. Flood flows for the Mud Lake Outlet, Unnamed Tributaries No. 15 and No. 18 to Kilbourn Road Ditch, the Union Grove Industrial Tributary to the Des Plaines River, and Unnamed Tributary No. 37 to the Des Plaines River were developed using U.S. Geological Survey (USGS) regional flood frequency equations, U.S. Natural Resource Conservation Service (NRCS) unit hydrograph methods, and Cook's empirical method.

In contrast to the use of various computational methods at various times, the Commission modeling utilized a common methodology applied throughout the watershed for a specified base year. Accordingly, the Commission data represent the best and most current available within the watershed at this time.

Computation of Monetary Flood Damages

Monetary flood damages for flood events of specified recurrence intervals, as well as average annual damages under existing and probable future land uses, must be determined for selected stream reaches in order to permit economic evaluation to be made of alternative flood control measures. The information required to compute monetary flood damages includes data: 1) on the types of agricultural land flooded, including specific crops potentially inundated; 2) on typical flood-free yields for crops which could be damaged by flooding; and 3) on crop prices; 4) on the types of structures affected; 5) on the elevation of the ground at the structure and on the elevation of the first floor; 6) on the existence or absence of a basement; 7) on the fair market value of potentially flooded structures; and 8) on the value of the contents of affected structures. Indirect flood damages, and the method of determination of those damages are described later in this chapter.

Formulation of Alternative Flood Control Measures

Alternative flood control measures include acquisition and removal of floodprone structures, structure floodproofing, the provision of detention storage of runoff, channel modification, construction of dikes or floodwalls, and floodwater diversion. In the formulation of alternative flood control measures for a particular reach the nature and causes of the existing and possible future flood problems in that reach as determined from historic flood information and from simulation of the flood potential under planned conditions in the absence of control measures must be carefully considered.

Post-Plan Adoption, Information, and Education

The aforedescribed uses of historic flood information all relate to the preparation of comprehensive watershed plans. The sixth and last use of such information occurs during the plan implementation process after the plan is completed. Experience indicates that affected segments of the public become very concerned about flood problems immediately after a severe flood event, but that such concern diminishes with the passage of time after a significant flood event. Yet other segments of the public may exaggerate the severity of flood problems in an area, and of specific flood events.

Documented historic flood information is an effective way to bring the severity of flood problems into proper focus and perspective for rational, objective consideration. Such information provides a common basis for understanding the nature of the problem in a particular area and, thus, promotes implementation of flood control measures contained in adopted watershed plans. Historic flood information—in contrast with flood hazard information produced by mathematical modeling—is particularly effective in improving public understanding of the need for plan implementation, since laymen can more readily understand and relate to such graphic data as a photograph of an inundated area, a peak flood stage measured from and related to a bridge or major building, or the delineation of the lateral extent of flooding based on the deposit of debris as observed in the field. The available historic flood information, accordingly, has been documented in this chapter so that it will be readily and widely available over time to both public officials and interested citizens and thereby contribute to plan implementation.

INVENTORY PROCEDURE AND INFORMATION SOURCES

A research effort employing a variety of procedures and information sources was required to develop an accurate account of historic flooding in the Des Plaines River watershed. The inventory of historic flooding was initiated by reviewing engineering and planning reports previously prepared by governmental agencies and private consulting firms and addressed to flood problems in all, or parts of, the watershed. Records for the streamflow gaging stations located on the Des Plaines River at Russell, Illinois, and on Mill Creek at Old Mill Creek, Illinois, were obtained and analyzed to identify flood dates since 1960.[2] These dates were supplemented by dates of major historic flood events in the Des Plaines River watershed as documented in reports prepared by various governmental agencies, including the U.S. Army Corps of Engineers and the U.S. Natural Resource Conservation Service. In addition, synthetic streamflows generated for the Des Plaines River watershed by application of the Commission continuous process hydrologic-hydraulic simulation model were used for identification of major flood events since 1940.

This initial review of published reports and data was followed by a Commission staff review of newspapers and newspaper files. Although a long period of history was considered in this review, information could be assembled on each of only a few historic floods. The principal sources of information for this review were past issues of *The Kenosha News* (formerly the *The Kenosha Evening News*) and the *Westosha Report*. The Commission staff also contacted officials of various organizations—including officials of the Kenosha and Racine County Planning and Development Offices, the Kenosha County Department of Public Works, the City of Kenosha Water Utility, and local officials in each of the Villages and Towns in the watershed—for information on historic floods. Also, at the eighth meeting of the watershed Advisory Committee on September 18, 1996, local units of government in the watershed were encouraged by Commission staff to hold public informational meetings at which Commission staff would review floodplain maps, answer questions, and interview those in attendance regarding drainage and flooding problems. The results of local meetings are set forth later in this chapter.

ACCOUNTS OF HISTORICAL FLOODS

Method of Presentation

The historical flood information for the Des Plaines River watershed, as obtained by means of the inventory efforts described above, is presented in this study by major flood events. Major flood events are defined herein as those known to have caused flooding in the Wisconsin portion of the watershed with attendant disruption of normal community activities. Large floods which were recorded at the U.S. Geological Survey, Russell, Illinois, stream gaging station are listed in Table 45,[3] and shown graphically in Figure 15 in Chapter V. In addition to the

[2]*The Dutch Gap Canal flows into Lake County, Illinois, where it is known as North Mill Creek and, farther downstream, Mill Creek. The confluence of Mill Creek and the Des Plaines River is near the U.S. Geological Survey streamflow gaging station and crest stage gage at Old Mill Creek, Illinois. That gage was operated as a crest stage gage during water years 1962 through 1976 and it has been operated as both a crest stage gage and a continuous recording gage from 1989 through the present time. The Des Plaines River gage at Russell was operated as a crest stage gage during water years 1960 through 1966 and it has been operated as both a crest stage gage and a continuous recording gage from 1967 through the present time.*

[3]*Although the disruption associated with each major flood may have been of several days' duration, the flood event is herein generally identified by the date on which the highest, or peak, flood flow occurred when that date is known.*

Table 45

LARGE FLOODS RECORDED AT THE U.S. GEOLOGICAL SURVEY GAGE 05527800 ON THE DES PLAINES RIVER AT RUSSELL, ILLINOIS

Date	Instantaneous Peak Discharge (cfs)
April 2, 1960	1,320
April 23, 1973	1,100
March 5, 1974	1,690
March 6, 1976	1,990
August 21, 1978	1,380
March 21, 1979	2,120
April 4, 1983	1,630
September 27, 1986	1,640
April 21, 1993	1,750
June 14, 2000	2,130

Source: U.S. Geological Survey and SEWRPC.

floods in Table 45 for which discharges were measured, floods which occurred on the Des Plaines River outside of the time period that the gaging station was in operation are described below.[4]

The flood problems discussed herein were selected to be representative of the kind of damage or disruption that occurred and of the locations in which it occurred. Almost no data on monetary flood losses were available from historic accounts of the floods. When such loss data are reported in the descriptions of historic flooding, the amounts reflect those reported during or shortly after each flood event and, and if used in a current context, must be adjusted to current economic levels.

High Water Mark Data

Historical high water marks for major floods are among the best means of documenting in a detailed and definitive manner the severity of historic flooding by graphically presenting peak stages relative to the channel bottom and relative to various hydraulic structures located along a stream system. No definitive data on such marks could be discovered in the historic flood inventory conducted by the Commission staff of the Des Plaines River watershed. Flood stages were surveyed by the Commission staff during the flood of April 1993. Those surveyed flood stages, along with photographs and reports concerning the extent of flooding for particular events within the Des Plaines River watershed were compared to flood stages and flood inundation maps generated by application of the Commission hydrologic-hydraulic simulation submodel for similar recurrence interval floods, and relatively good agreement was found, thereby verifying the validity of the simulated flood data.

Flood of March 1943

On March 15, 1943, a total of 1.60 inches of rain occurring on frozen ground was recorded in an eight-hour period at the National Weather Service station at the City of Kenosha and 2.00 inches of rain fell at the National Weather Service station at the Village of Union Grove. According to the Kenosha Evening News, the rainfall was preceded by a period of snowmelt. Based on simulated streamflow data, the recurrence interval of the resulting flood on the Des Plaines River at Russell, Illinois, just south of the Wisconsin-Illinois state line is estimated to be about 25 years; however, simulated flows indicate that the flood frequency ranged from 100 to 200 years along the upper reaches of the Des Plaines River in the Towns of Paris and Bristol, along the upper reaches of Brighton Creek in the Town of Brighton, along a portion of Center Creek in the Town of Bristol, and along Kilbourn Road Ditch in the Towns of Somers and Pleasant Prairie. Newspaper accounts reported submergence of numerous roads, including USH 45 and STH 43 (now STH 142) and washouts of culverts along, or under, secondary roads. The reported areas which experienced the heaviest flooding were rural with no significant urban development or potential for flood damage to structures reported.

[4]*A review of the historic record indicates that, during periods of flooding along the Des Plaines river when there may have been substantive damage and disruption in northeastern Illinois, there often was little damage or disruption in the Wisconsin portion of the watershed. Thus, there was no information relative to flooding in the Wisconsin portion of the watershed for the floods on the Des Plaines River which resulted in flooding problems in Illinois during the spring of 1938, April 1950, September 1965, or June 1967. On September 21 and 22, 1967, 3.70 inches of rain were recorded in the City of Kenosha, but no flooding problems were reported in the* Kenosha Evening News*. Similar storms with considerable rainfall, but no reports of flooding occurred from June 13 through 15 when 4.69 inches were recorded at Kenosha and on June 13, 1950 when 2.57 inches of rain was measured at Kenosha.*

Flood of March 1948

On March 19 and March 20, 1948, a total of 2.48 inches of rain occurring on frozen ground was recorded at the National Weather Service station at the City of Kenosha. Of that total, 1.99 inches, or 80 percent, occurred on March 19. Based on simulated streamflow data, the recurrence interval of the resulting flood on the Des Plaines River at Russell, Illinois is estimated to be about four years. Newspaper accounts indicate that 60th Street (CTH K) and several unidentified town roads were overtopped, farmlands were flooded throughout Kenosha County, and basement flooding from an unknown source was reported at an implement sales building in the Town of Bristol. The Kenosha County Highway Commissioner estimated the damage to public and private roads at several thousand dollars.

Flood of June 1954

From May 31 to June 4, 1954, a total of 5.83 inches of rain was recorded at Kenosha. Of this total, 3.78 inches, or 65 percent, fell on June 3. Based on simulated streamflow data the recurrence interval of the resulting flood on the Des Plaines River at Russell, Illinois, is estimated to be about seven years. The flood reportedly caused damage to truck farm crops and washed out some newly seeded crops.

Flood of April 2, 1960

The snow cover at Kenosha, which was 10 inches on March 16, 1960, melted rapidly at the end of March. That snowmelt coupled with 1.01 inches of rain on March 30, created flooding conditions in the watershed. The recurrence interval of the flood on the Des Plaines River is estimated to be about six years, based on the recorded peak flow of 1,320 cubic feet per second (cfs) at the U.S. Geological Survey gaging station at Russell, Illinois. The Des Plaines River overtopped STH 43 (now STH 142) in the Town of Paris and an ice jam at the STH 43 bridge over the Kilbourn Road Ditch in the Town of Somers resulted in overtopping of the roadway. Roads which were closed due to flooding included CTH H south of STH 50 and CTH ML at the Des Plaines River, both in the former Town of Pleasant Prairie; STH 158 at Kilbourn Road Ditch in the Town of Somers; and CTH U just north of the Wisconsin-Illinois state line in the Town of Paris. By April 2, floodwaters had receded to the point where all roads in Kenosha County were passable, although some were still flooded to shallow depths.

Flood of March 22, 1962

On February 21, 1962, the total snow depth on the ground at Kenosha was 11 inches. By March 19 the snow cover had completely melted. From March 8 through March 19, 1.59 inches of rain fell, which coupled with the runoff from snowmelt, resulted in flooding of farmland along the Des Plaines River. The recurrence interval of the flood on the Des Plaines River is estimated to be about two years, based on the recorded peak flow of 820 cfs at the USGS stream gaging station at Russell, Illinois. The flood stage at the STH 50 bridge, which was being constructed over the Kilbourn Road Ditch, rose to within about 0.5 foot of the roadway.

Flood of April 21, 1973

From April 12 through April 21, 1973, 4.87 inches of rain were recorded at Kenosha. There was relatively little snow cover and, consequently, little snowmelt preceding the rain. The flood on the Des Plaines River resulting from the rain storm had an estimated recurrence interval of only about three years, based on the recorded peak flow of 940 cfs at the USGS stream gaging station at Russell, Illinois. No damages were reported in the Des Plaines River watershed. Field observations by the Commission staff made at the time of the flood indicated some flooding of cropland along the Des Plaines River in the vicinity of CTH N and STH 50.

Flood of March 6, 1976

From February 5 to March 1, 1976 the snow depth on the ground at Kenosha decreased from six inches to a trace. On March 2 a total of 0.89 inch of rain occurring on frozen ground was recorded at the National Weather Service station at Kenosha. An additional 2.11 inches of rain was recorded on March 4. The recurrence interval of the resultant flood on the Des Plaines River is estimated to be about 22 years, based on the recorded peak flow of 1,990 cfs at the USGS stream gaging station at Russell, Illinois. The Des Plaines River was reported to be at flood stage in the former Town of Pleasant Prairie and low-lying roads and fields were flooded.

Flood of August 21, 1978

On August 18 and 19, 1978, a total of 3.27 inches of rain was recorded at Kenosha. Of that total 2.04 inches, or 62 percent, occurred on August 19. The storm was locally variable, with *The Kenosha News* reporting a total of up to 5.5 inches of rain over the two-day period elsewhere in the Kenosha area. The recurrence interval of the resultant flood on the Des Plaines River is estimated to be about six years, based on the recorded peak flow of 1,380 cfs at the USGS stream gaging station at Russell, Illinois. The Des Plaines River overtopped CTH K (60th Street) on the boundary between the Towns of Bristol and Paris. Newspaper accounts reported that CTH V (now CTH Q) west of IH 94 was flooded, but the source of the flooding was not mentioned. Damage to cabbage, potato, soybean, and alfalfa crops was reported. The Pleasant Prairie town clerk told *The Kenosha News* that the flood stage had risen to within six inches of the sanitary sewerage system lift station at the north end of the River Oaks subdivision near the confluence of the Des Plaines River and Kilbourn Road Ditch.

The fire chief of the Village of Union Grove told *The Kenosha News* that pumper units were mobilized to alleviate local flooding, but the article did not indicate the location of the flooding. Because the Village is located at the divide between the Des Plaines and Root River watersheds, it is unknown whether the local flooding occurred in the Des Plaines River watershed.

Stormwater drainage-related problems included the washout of about 500 feet of the shoulder of USH 45 about one mile south of the Kenosha-Racine County line and the accumulation of runoff on IH 94/USH 41 which hindered efforts to fight a fire.

Flood of March 21, 1979

The depth of snow on the ground at Kenosha was reduced from 26 inches on February 17, 1979 to 14 inches on March 2, 1979 and to only a trace on March 19, 1979. On March 19, 1979, a total of 0.28 inch of rain occurring on frozen ground was recorded at Kenosha. The flood peak resulting from the heavy snowmelt combined with the rain on frozen ground was the largest recorded in the 35 years of record of the USGS stream gaging station on the Des Plaines River at Russell, Illinois. The recurrence interval of the flood is estimated to be about 30 years, based on the recorded peak flow of 2,120 cfs. Despite the magnitude of the flood, local newspapers did not have extensive coverage of the resultant flooding in the watershed. *The Kenosha News* reported that CTH JS was under water and closed to traffic between CTH V (now CTH Q) and USH 45. Unnamed Tributary No. 4 to Dutch Gap Canal crosses that part of CTH JS, but the newspaper account did not specify the source of the flooding.

Flood of April 4, 1983

From April 1 through April 3, 1983, a total of 2.29 inches of rain was recorded at Kenosha, with 1.72 inches, or 75 percent of that total, occurring between midnight and 8:00 p.m. on April 2. The recurrence interval of the resultant flood on the Des Plaines River is estimated to be about 11 years, based on the recorded peak flow of 1,630 cfs at the USGS stream gaging station at Russell, Illinois. The Des Plaines River overflowed its banks, but no specific accounts of flood damage to structures or cropland were reported in *The Kenosha News*.

As during the March 21, 1979 flood, CTH JS was under water and closed to traffic between CTH V (now CTH Q) and USH 45. The maximum depth of flooding of the road was reported as several feet by the County highway commissioner. Sections of STH 142 were also reported to be at least partially blocked due to high water. Flooding of 120th Avenue, the east frontage road along IH 94/USH 41, was reported at the intersection of IH 94/USH 41 and STH 158. That road is adjacent to Kilbourn Road Ditch; however, the newspaper report did not indicate whether the flooding occurred as a result of overflow from Kilbourn Road Ditch or due to inadequate local drainage. Stormwater drainage-related problems were reported along some portions of IH 94/USH 41.

Flood of March 13, 1986

From March 10 through March 13, 1986, a total of 0.53 inch of rain occurring on frozen ground was recorded at the National Weather Service station at Kenosha. The runoff from that rainfall, along with that from a four-inch snowmelt from February 28 through March 8, resulted in a flood on the Des Plaines River with an estimated recurrence interval of about three years, based on the recorded peak flow of 995 cfs at the USGS stream gaging station at Russell, Illinois. As during the March 21, 1979 and the April 4, 1983 floods, CTH JS was under water and closed to traffic between CTH V (now CTH Q) and USH 45. The parking lot of the Pleasant Prairie Mobile Home Court south of CTH K (60th Street) and east of IH 94/USH 41 along the Kilbourn Road Ditch was flooded, but a photograph in the Kenosha News indicated that the flood stage rose to a level near, but below, the ground elevation at some of the mobile homes. About 100 feet of pavement of CTH NN was destroyed at a location about one-half mile west of USH 45 in the Town of Paris near a minor tributary to the Des Plaines River.

Flood of September 27, 1986

From September 9 to September 11, 1986, a total of 3.71 inches of rain was recorded at the National Weather Service station at Kenosha. That storm was followed by 3.78 inches of rain from September 21 through 26. The unofficial total rainfall for the period from September 22 through September 25 was more than 10 inches in parts of Bristol. The recurrence interval of the resultant flood on the Des Plaines River is estimated to be about 11 years, based on the recorded peak flow of 1,640 cfs at the USGS stream gaging station at Russell, Illinois.

Although the recorded flood at the Russell gage was not indicative of an extremely rare event, flood flows with recurrence intervals of from about 100 to 200 years were simulated in parts of the Brighton Creek subwatershed, particularly along Salem Branch and some of its tributaries. First-floor flooding to a depth of about one foot was reported at one residence on 62nd Street in the Village of Paddock Lake in the floodplain of Unnamed Tributary No. 6 to Brighton Creek. The simulated flood at that location had a recurrence interval of about 100 years. The level of Paddock Lake was reported to have risen more than nine inches, which is consistent with the simulated Lake stage. Also, according to the staff of the Kenosha County Office of Planning and Development and Town of Salem officials and staff, 84th Street was overtopped at its crossing of Unnamed Tributary No. 1 to Hooker Lake (hydraulic structure No. 885). *The Kenosha News* reported that one residence along Hooker Lake incurred damages of $4,000.

In the Dutch Gap Canal subwatershed, flows with recurrence intervals greater than 100 years were simulated. The Bristol town clerk reported that Dutch Gap Canal was overflowing its banks at the Wisconsin-Illinois state line. As during the March 21, 1979; the April 4, 1983; and March 13, 1986 floods, CTH JS was under water and closed to traffic between CTH V (now CTH Q) and USH 45.

Flood of April 21, 1993

The early spring of 1993 was characterized by the National Weather Service as the wettest since official record keeping began in Southeastern Wisconsin in 1871. In the period from March 31 through April 16, 1993, 6.1 inches of precipitation fell at Kenosha. On April 19 and 20 a total of 2.51 inches of rain was recorded, with 2.38 inches, or 95 percent of that rain, occurring on April 19. The recurrence interval of the resultant flood is estimated to be about 13 years, based on the recorded peak flow of 1,750 cfs at the USGS stream gaging station on the Des Plaines River at Russell, Illinois.

The Kenosha News reported that high water warning signs were placed on CTH K east of USH 45 in the vicinity of Brighton Creek and at CTH MB and CTH C.

Flood stages along the Des Plaines River and several tributaries were field surveyed by Commission staff on April 16 and 20. The surveyed elevations are set forth in Table 46. In general, elevations were surveyed at each location on both April 16 and 20. In all such cases it was found that flood stages were higher on April 20, thus, only those stages are reported except for Kilbourn Road Ditch at CTH N where measurements were only made on April 16. The April 20 stage measurements give a reasonable approximation of the peak stages on the Des Plaines River and its tributaries upstream of the gage since those streams, or reaches of streams, would be expected to peak earlier than would the Des Plaines River at Russell.

Commission staff observed extensive flooding of agricultural land, but no flooding of roads or houses. Significant flooding of cropland was observed 1) along the Des Plaines River both upstream and downstream of CTH N in the Town of Paris (see Figure 29), 2) along the Des Plaines River upstream of STH 50 in the Town of Bristol (see Figure 30), and 3) along Brighton Creek upstream of CTH K in the Town of Bristol (see Figure 31). Flooding of

Table 46

MEASURED FLOOD STAGE ELEVATIONS ALONG THE DES PLAINES RIVER AND SELECTED TRIBUTARIES: APRIL 16 AND 20, 1993 (ESTIMATED 13-YEAR RECURRENCE INTERVAL FLOOD EVENT)

Stream	Date	Time	Road Crossing	River Mile[a]	Structure Number	Upstream Water Level (feet above NGVD-29)
Des Plaines River	April 20, 1993	10:10 a.m.	CTH N	16.08	155	694.8
	April 20, 1993	10:45 a.m.	CTH K	14.13	145	692.4
	April 20, 1993	3:20 p.m.	STH 50	13.04	140	689.8
	April 20, 1993	2:00 p.m.	STH 165	2.92	102	673.0
Unnamed Tributary No. 5 to the Des Plaines River	April 20, 1993	2:15 p.m.	CTH H	1.41	1390	673.5
Brighton Creek	April 20, 1993	9:55 a.m.	CTH NN	6.21	525	741.8
	April 20, 1993	11:00 a.m.	CTH K	1.145	505	705.2
	April 20, 1993	11:15 a.m.	CTH K	4.65	520	740.4
Unnamed Tributary No. 6 to Brighton Creek	April 20, 1993	11:30 a.m.	62nd Street and 236th Avenue	1.89	566A	768.7
Center Creek	April 20, 1993	10:30 a.m.	CTH MB	- -	640	740.4
	April 20, 1993	3:05 p.m.	STH 50	2.31	615	702.6
Dutch Gap Canal	April 20, 1993	1:15 p.m.	CTH Q	2.14	1115	755.8
	April 20, 1993	1:35 p.m.	CTH CJ	1.07	1105	756.1
Jerome Creek	April 20, 1993	2:35 p.m.	CTH H	1.12	905	674.3
Kilbourn Road Ditch	April 20, 1993	2:50 p.m.	STH 50	1.33	305	681.9
	April 16, 1993	3:50 p.m.	CTH N	4.92	345	701.2

[a]*Measured from the Wisconsin-Illinois state line for the Des Plaines River. Measured from the mouth of the stream for all other streams.*

Source: SEWRPC.

open lands in the primary environmental corridor along Kilbourn Road Ditch upstream of STH 50 is shown in Figure 32.

Flood of August 16, 1995

Reported flooding on this date was limited to the Village of Paddock Lake in the vicinity of Unnamed Tributary No. 6 to Brighton Creek. The Village of Paddock Lake recorded 4.5 inches of rain in the 45-minute period from 3:30 p.m. to 4:15 p.m. The intense storm was limited in areal extent and flooding was not experienced elsewhere in the watershed. Hydrologic simulation of that storm indicates that the peak flood flow on Unnamed Tributary No. 6 to Brighton Creek had an estimated recurrence interval of greater than 100 years.

The storm created significant flooding problems in the vicinity of Unnamed Tributary No. 6 to Brighton Creek in the extreme northeast corner of the Village. According to data provided by the Village and as verified through the hydrologic and hydraulic simulations conducted under the watershed study, in the area bounded by 234th Avenue on the east, 239th Avenue on the west, CTH K on the north, and 63rd Street extended on the south, about 13 houses were affected by overland flooding; an additional six houses were affected by a combination of overland flooding and sanitary sewer backups; and one property was affected by sanitary sewer backup alone. Basements were flooded with up to four feet of water and the level of Paddock Lake rose seven inches. The first level of the Village sewage treatment plant was flooded, affecting electrical equipment. County Trunk Highway K was overtopped at a low spot west of its intersection with 248th Avenue. Overtopping of the roadway occurs frequently in that location, which is over one-half mile west of Unnamed Tributary No. 6 and is not influenced by

Figure 29

FLOODING UPSTREAM OF THE CTH N
CROSSING OF THE DES PLAINES RIVER: APRIL 16, 1993

This photograph, which was taken at about 1:30 p.m. on April 16, shows significant flooding of open land on the upstream (north) side of CTH N in the Town of Paris.

Source: SEWRPC.

stages in the unnamed tributary. Additional damage in the Village included washouts of road shoulders, driveways, and culverts.

Flood of May 23, 1996

This flood was produced by heavy rains occurring on saturated ground. On May 20, rainfall totals of 2.57 inches, 2.40 inches, and 1.90 inches were recorded at the City of Kenosha, the Village of Union Grove, and the City of Antioch, Illinois, respectively. The recurrence interval of the resultant flood is estimated to be about four years, based on the recorded peak flow of 1,180 cfs on May 23 at the USGS stream gaging station on the Des Plaines River at Russell, Illinois.

The rainfall resulted in widespread flooding of cropland, both along the Des Plaines River and at off-stream sites which collect local runoff. The most extensive flooding of agricultural land along the Des Plaines River occurred at CTH N and at STH 50. Flooding of cropland also occurred along Center Creek at 144th Avenue and Dutch Gap Canal at CTH Q. Stormwater drainage-related damage included erosion of the shoulder of the roadway along CTH D south of CTH N and the washout of a culvert along CTH E between IH 94/USH 41 and CTH MB.

The stage of Kilbourn Road Ditch rose to elevations of the pads of mobile homes located just south of CTH K, but no flooding of the mobile homes was reported. Considerable flooding occurred along Unnamed Tributary No. 6 to Brighton Creek in the Village of Paddock Lake where nine homes were evacuated.

Flood of June 14, 2000

Precipitation totals in and near the watershed for the months of May and June 2000 were well above normal, with the May total at the City of Kenosha being about nine inches, or three times the 58-year monthly average of 3.02

Figure 30

FLOODING AT THE STH 50 CROSSING OF THE DES PLAINES RIVER: APRIL 16, 1993

This photograph, which was taken at about 3:00 p.m. on April 16, shows flooding of cropland upstream (north) of STH 50 in the Town of Bristol. The main river channel is located along the treeline near the center of the photo.

This photograph, which shows flooding conditions downstream of STH 50, was also taken about 3:00 p.m. on April 16. The bridge is located beyond the lower right corner of the photograph. None of the buildings shown were affected by overland flooding.

Source: SEWRPC.

inches, and the June total being 7.51 inches, or 2.2 times the average of 3.44 inches. Thus, the soil moisture content was relatively high prior to the occurrence of heavy rains over the watershed on June 12 and 13, 2000. The Kenosha Regional Airport, which is located in the eastern part of the watershed, recorded a total of 4.48 inches of rain from 7:00 a.m. on June 12 through 7:00 a.m. on June 14. About 85 percent of that amount, or 3.79 inches, fell on June 12. The Village of Pleasant Prairie sewage treatment plant, which is located in the southeastern part of the watershed recorded a total rainfall of 4.65 inches from 7:00 a.m. on June 12 through 7:00 a.m. on June 14. About 90 percent of that amount, or 4.16 inches, fell on June 12. The Village of Paddock Lake sewage treatment plant, which is located in the western part of the watershed recorded a total rainfall of 4.22 inches from 7:30 a.m. on June 12 through 7:30 a.m. on June 14. About 90 percent of that amount, or 3.83 inches, fell on June 12. The Village of Union Grove sewage treatment plant, which is located near the northern part of the watershed, recorded a total rainfall of 1.47 inches from 7:00 a.m. on June 12 through 7:00 a.m. on June 14. About 85 percent of that amount, or 1.25 inches, fell on June 12. At the U.S. Geological Survey (USGS) stream gage on the Des Plaines River at Russell, Illinois, which is located just south of the Wisconsin-Illinois State line, a total rainfall of about 4.00 inches was recorded on June 12 through June 13. About 88 percent of that amount, or 3.50 inches, fell on June 12. The recording rain gage at the USGS Russell gage indicated that about 3.20 inches, or 90 percent of the total rainfall on June 12 occurred in about a 7.5-hour period from 6:00 a.m. through 1:30 p.m. Thus, from three to four inches of rain fell over much of the watershed on June 12. The recurrence interval of the resultant flood peak on the Des Plaines River is estimated to be about 30 years, based on the recorded peak flow of about 2,130 cfs at the USGS stream gaging station at Russell, Illinois. The peak flow at the Russell gage occurred near midnight on June 14.

Significant areas of reported riverine or lacustrine flooding or stormwater drainage problems[5] in the Des Plaines River watershed included:

[5]*This watershed study primarily addresses flooding problems due to overflow of streams, rather than stormwater drainage problems at locations that are separated from streams. Stormwater drainage problems would appropriately be addressed under detailed stormwater management plans that would be prepared after the watershed plan.*

Figure 31

FLOODING UPSTREAM OF THE CTH K CROSSING OF BRIGHTON CREEK: APRIL 16, 1993

This photograph, which was taken at about 2:40 p.m. on April 16, shows flooding of cropland upstream of CTH K in the Town of Bristol.

Source: SEWRPC.

Figure 32

FLOODING UPSTREAM OF THE STH 50 CROSSING OF KILBOURN ROAD DITCH: APRIL 16, 1993

This photograph, which was taken at about 3:30 p.m. on April 16, shows flooding of open lands in the primary environmental corridor upstream (north) of STH 50 in the City of Kenosha. Note the new residential development in the background, beyond the limits of flooding.

Source: SEWRPC.

1. Flooding of mobile homes in the Pleasant Prairie Mobile Home Court due to overflow from Kilbourn Road Ditch south of CTH K (60th Street) and east of IH 94/USH 41.[6] About two dozen people were evacuated at this location.

2. Flooding of houses in the Village of Paddock Lake in the vicinity of Unnamed Tributary No. 6 to Brighton Creek.

3. Flooding of the intersection of 78th Street and 243rd Avenue in the Village of Paddock Lake north of Hooker Lake as a result of elevated lake levels.

4. Street and basement flooding and sanitary sewer backup into basements along 57th Avenue between 81st and 85th Streets in the City of Kenosha and the Village of Pleasant Prairie in the Jerome Creek subwatershed. That flooding was apparently caused by rates and volumes of runoff exceeding the capacity of the stormwater drainage system, rather than direct flooding due to overflow from Jerome Creek.

5. Flooding and sanitary sewer backups into basements near and along Unnamed Tributary No. 1 to Kilbourn Road Ditch in the Chateau Eau Pleines subdivision and along Lake Russo near the Des Plaines River in the River Oaks subdivision. Both of those subdivisions are located in the Village of Pleasant Prairie.

6. Flooding at several houses in the Jerome Creek floodplain near the intersection of 85th Street and STH 31 and of one house on 89th Street in the floodplain along the upper reach of Jerome Creek.

7. Flooding around houses in the Town of Bristol in the area north of George Lake in the Dutch Gap Canal floodplain between 191st and 192nd Avenues.

[6] *The mobile home court is located in the Town of Somers, Kenosha County.*

8. Basement flooding to a depth of about six feet at one house in the Village of Pleasant Prairie on the west side of IH 94/USH 41 near Unnamed Tributary No. 2 to the Des Plaines River.

9. Scattered areas of stormwater drainage problems in the Village of Pleasant Prairie.

10. Flooding of low-lying agricultural land throughout the watershed.

11. Flooding of the southbound lane of IH 94/USH 41, south of CTH C and north of STH 165; CTH C along the Des Plaines River near CTH MB; and CTH K at 248th Avenue and at a location about 0.25 mile east of Brighton Creek.

Flood stages along the Des Plaines River and several tributaries were measured by the Commission staff on June 13 and 14, 2000. The elevations are set forth in Table 47. The data generally indicate that, following the heavy rainfall on June 12, flood stages along the Des Plaines River tributaries peaked prior to the time of measurement on June 13. By the afternoon of June 14, when the Des Plaines River flood stage at the Russell gage was nearing its peak, flood stages along the Des Plaines River at, and upstream from, IH 94/USH 41 were beginning to fall. The stages at CTH C, which is the farthest downstream location along the Des Plaines where comparative measurements were made, indicate that the river stage was almost the same on June 13 and 14. This illustrates the significant effect that the very large wetland/floodplain storage complex downstream of IH 94/USH 41 has in storing floodwater and reducing the flood peak while, at the same time, prolonging the reduced peak. Based on the relatively close proximity of CTH C, CTH ML, and the Russell gage, it is estimated that the measured water surface elevations at the highways are close to the absolute peak stages reached during the flood. The flood stage observations are consistent with the expectation that flood stages would rise and fall much more rapidly along the tributaries than along the main stem of the Des Plaines River.

Additional General Flood Observations Not Related to a Single Flood Event

During interviews with local officials and the staffs of the Kenosha County Office of Planning and Development and the Racine County Division of Planning and Development, several other general historical flood and drainage problems which were not directly related to specific runoff events were identified. A summary of those observations follows:

Town of Bristol

Significant overbank flooding of agricultural lands along the Dutch Gap Canal has occurred periodically. According to Mr. Randall Kerkman, the Town Public Works Foreman, flooding has been observed in the vicinity of the 82nd Street crossing of Unnamed Tributary No. 1 to the Salem Branch of Brighton Creek and the shoulder of the road washed out in 1986. The 208th Avenue crossing of an unnamed tributary to the Mud Lake outlet has been overtopped about once every two years on average. That stream, which is located in a sparsely populated area downstream of the Benet/Shangrila Lake dam, was not selected for the preparation of flood hazard information under the watershed study.

Town of Mt. Pleasant

There are no records of flooding complaints in the portion of the Town within the Des Plaines River watershed. According to the Town director of public works, there have been no problems with overbank flooding of agricultural lands and isolated ponded water is adequately drained by the existing drain tile/ditch system.

Table 47

MEASURED FLOOD STAGE ELEVATIONS ALONG THE DES PLAINES RIVER AND SELECTED TRIBUTARIES
JUNE 13 AND 14, 2000 (ESTIMATED 30-YEAR RECURRENCE INTERVAL FLOOD EVENT AT RUSSELL, ILLINOIS)

Stream	Date	Time	Street/Highway	River Mile[a]	Structure Number	Location of Measurement	Water Surface Elevation (feet, NGVD29)	100-Year Flood Elevation Buildout, Land Use, Existing Channel (feet, NGVD29)[b]
Brighton Creek	June 13, 2000	10 a.m.-12 p.m.	CTH K (E. of USH 45)	1.145	505	Upstream	706.3[c]	707.8
Brighton Creek	June 13, 2000	3:00 p.m.	CTH K (E. of USH 45)	1.145	505	Upstream	705.8	707.8
Brighton Creek	June 13, 2000	10 a.m.-12 p.m.	CTH K (W. of USH 45)	4.65	520	Downstream	740.9	740.3
Brighton Creek	June 13, 2000	3:15 p.m.	CTH K (W. of USH 45)	4.65	520	Upstream	740.7[d]	740.9
Brighton Creek	June 13, 2000	3:45 p.m.	CTH NN	6.21	525	Upstream	747.2	749.8
Center Creek	June 13, 2000	2:20 p.m.	STH 50	2.31	615	Upstream	702.1	706.4
Center Creek	June 13, 2000	10 a.m.-12 p.m.	STH 50	2.31	615	Upstream	701.9	706.4
Center Creek	June 13, 2000	2:30 p.m.	CTH K	3.72	635	Upstream	731.0	733.1
Dutch Gap Canal	June 13, 2000	1:45 p.m.	CTH CJ	1.07	1105	Upstream	756.6	758.6
Dutch Gap Canal	June 13, 2000	1:35 p.m.	CTH Q	2.14	1115	Upstream	757.3	758.8
Des Plaines River	June 14, 2000	2:10 p.m.	CTH ML	0.69	100	Upstream	673.1	675.9
Des Plaines River	June 13, 2000	1:20 p.m.	CTH C	5.64	105	Upstream	676.9	678.2
Des Plaines River	June 14, 2000	2:00 p.m.	CTH C	5.64	105	Upstream	676.8	678.2
Des Plaines River	June 14, 2000	1:45 p.m.	W. IH 94 Frontage Road (120th Avenue)	6.39	120	Upstream	677.7[e]	679.3
Des Plaines River	June 13, 2000	10 a.m.-12 p.m.	CTH MB	9.82	125	Upstream	682.2	682.8
Des Plaines River	June 14, 2000	1:30 p.m.	CTH MB	9.82	125	Upstream	683.0[f]	682.8
Des Plaines River	June 13, 2000	2:10 p.m.	STH 50	13.04	140	Upstream	691.2	690.8
Des Plaines River	June 14, 2000	1:20 p.m.	STH 50	13.04	140	Upstream	690.8	690.8
Des Plaines River	June 13, 2000	2:45 p.m.	CTH N	16.08	155	Upstream	695.1	695.6
UT5 to Des Plaines	June 13, 2000	1:00 p.m.	CTH H	1.41	1390	Upstream	674.2	679.6
Jerome Creek	June 13, 2000	12:55 p.m.	CTH H	1.12	905	Upstream	675.5	678.5
Kilbourn Road Ditch	June 13, 2000	12:35 p.m.	STH 50	1.33	305	Upstream	681.7	683.3
Kilbourn Road Ditch	June 13, 2000	10 a.m.-12 p.m.	CTH K	2.81	315	Upstream	692.6	695.1
Kilbourn Road Ditch	June 13, 2000	12:25 p.m.	CTH K	2.81	315	Upstream	692.4	695.1
Kilbourn Road Ditch	June 13, 2000	12:15 p.m.	CTH N	4.92	345	Upstream	702.0	703.9

[a]*Measured from the Wisconsin-Illinois state line for the Des Plaines River. Measured from the mouth of the stream for all other streams.*

[b]*The 100-year recurrence interval flood stage elevations that were determined under this watershed study are included in the table to provide a quantitative context in which to evaluate the measured flood stages. The relationship between the 100-year stages and the measured stages may not necessarily be an indication of the recurrence interval of the flood that occurred on each stream because the water surface elevation measurements were not necessarily made at the time of the peak flood stage. In some cases, indirect measurement of possible high water marks, as indicated in the footnotes to this table, provide an estimate of the absolute peak flood stage.*

[c]*Debris line high water mark at elevation 706.3 feet above NGVD29 measured on June 13.*

[d]*Concrete wet stain high water mark at elevation 741.1 feet above NGVD29 measured on June 13.*

[e]*Concrete wet stain high water mark at elevation 678.4 feet above NGVD29 measured on June 14.*

[f]*Debris line high water mark at elevation 683.5 feet above NGVD29 measured on June 14.*

Source: SEWRPC.

Town of Paris

According to Mr. August Zirbel, Jr., the former Town chairman, and a former member of the Des Plaines River watershed study advisory committee, some local flooding problems have occurred along the Des Plaines River in the vicinity of STH 142. The installation in the 1960s of a farm crossing with two small 36-inch-diameter corrugated metal pipe culverts in the River just downstream of STH 142 has been cited by nearby property owners as contributing to the problems. Additional flooding has occurred northwest of the CTH N crossing of the Des Plaines River as observed by Commission staff in April of 1993.

Problems have been reported with beaver dams in the Des Plaines River, resulting in water backing up into the agricultural drain tile system that discharges into the River.

Overbank flooding, and the attendant disruption of farming activities, has occurred along the Des Plaines River in the 0.6-mile-long reach from CTH KR at the Kenosha-Racine County line to the confluence with the Union Grove Industrial Tributary.

Village of Pleasant Prairie
River Road (114th Avenue) is located in the floodplain of the Des Plaines River and floods annually. Reported flooding problems at houses along 104th Avenue north of CTH C appear to be due to localized stormwater drainage problems.

Town of Somers
Periodic spring and fall flooding of undeveloped land has occurred.

Town of Yorkville
Problems with drainage of agricultural lands served by drain tiles that discharge into the Des Plaines River have occurred during spring and fall periods of elevated stages in the River.

Results of Public Informational Meetings
Following the eighth watershed advisory committee meeting on September 18, 1996, the Commission staff contacted local officials in the watershed regarding holding public informational meetings at which interested parties could review floodplain maps and provide comments and observations regarding stormwater and agricultural drainage and riverine flooding problems. As a result of those contacts, meetings were sponsored by the Town of Paris and by Racine County.

Meeting Regarding Drainage and Flooding Problems in the Town of Paris
This meeting, which was held at the Town Safety Building on October 10, 1996, was attended by about 20 local residents, landowners, farmers, and representatives of local businesses. Those in attendance primarily provided observations regarding agricultural drainage and flooding problems along the main stem of the Des Plaines River. In general, the attendees verified the limits of the two-, 10-, and 100-year recurrence interval floodplains under existing land use and channel conditions as digitally delineated by Commission staff on 1995 aerial photographs.

The most common problems cited were impaired agricultural drain tile systems and slow recession of floods. Reasons cited for agricultural drainage problems included submergence of tile outlets by standing water and obstruction of tile outlets due to accumulation of sediment in the Des Plaines River channel. It was noted that in some cases the effects of obstructed drain tile systems extend beyond the limits of the floodplain. Beaver dams were cited as a major cause of standing water in the Des Plaines River channel and of elevated river stages which submerge tile outlets. Based on accounts from attendees, significant amounts of sediment have not been removed from the Des Plaines River main stem since the 1950s and 1960s.

A perceived increase in flows in the Union Grove Industrial Tributary over time was cited as a problem in the 1.0-mile-long reach of the main stem of the Des Plaines River from the confluence with the Industrial Tributary upstream to CTH KR (County Line Road). The increased flows were perceived as creating a backwater condition in that reach, resulting in higher river stages at the Great Lakes Dragaway and on agricultural land.

No significant drainage or flooding problems were identified by the attendees along the other studied streams in the Town which include Brighton Creek, and Unnamed Tributaries No. 5 and 13 to Kilbourn Road Ditch.

Meeting Regarding Drainage and Flooding Problems
in the Racine County Portion of the Watershed[7]
This meeting, which was held at the Racine County Ives Grove Office Complex on October 29, 1996, was open to the public and meeting notices were posted by the Racine County Division of Planning and Development. The

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[7]*The civil divisions in Racine County in which studied streams are located are the Villages of Union Grove, the Town of Mt. Pleasant, and the Town of Yorkville.*

meeting was attended by Mr. James E. Moyer, the Chairman of the Town of Yorkville, Mr. Alvin R. Wilks, the Chairman of the Racine County Drainage Board, and Mr. Arnold L. Clement, the Racine County Planning and Development Director. A brief presentation of the watershed study and its purpose was made by Commission staff and those in attendance provided observations regarding agricultural drainage and flooding problems along the main stem of the Des Plaines River and along Unnamed Tributary Nos. 37, 38, and 39 to the Des Plaines River. The attendees generally verified the limits of the two-, 10-, and 100-year recurrence interval floodplains under existing land use and channel conditions as digitally delineated by Commission staff on 1995 aerial photographs. Concerns were expressed regarding the potential for increased runoff from developing areas in the Village of Union Grove. Sediment accumulation in the stream channels was also cited as a factor which hinders drainage of agricultural land.

Field Investigations Following Public Informational Meetings

In order to verify and quantify the extent of the problems and concerns raised during the public informational meetings, the Commission staff made field investigations along the 17.5-mile-long reach of the Des Plaines River from STH 142 in the Town of Paris to CTH ML in the Village of Pleasant Prairie on October 16 and November 8, 1996. Data were collected in the following categories:

1. Sediment depths were obtained at 18 locations along the River.

2. Photographs and observations were made of significant obstructions in the channel, including beaver dams, trees, and brush.

Those data, along with similar additional data collected in 1999, are presented in Chapter VII, “Surface Water Quality Characteristics and Problems.”

Historical Flooding: Summary

Characteristics of Floods in the Watershed

As shown by Figure 15 in Chapter V of this report, major floods in the Des Plaines River watershed generally occur in the late winter and early spring as the result of runoff from rainfall on frozen ground or from snowmelt or rainfall-snowmelt combinations. However, the occurrence of major floods in August 1978, September 1986, June 2000, and the localized flooding on August 16, 1995 caused by an intense thunderstorm indicate that, with the exception of the winter season, major floods can occur at any time of the year in the watershed. As indicated by Figure 33, along the main stem of the Des Plaines River, flood stages have generally risen relatively gradually and peak, or near peak, flows have typically been sustained for from three to 12 days.

Extent and Nature of Reported Flooding

Because land use in the Des Plaines River watershed is still primarily rural, the most common types of problems reported in the Des Plaines River watershed have been damage to croplands and flooding of roadways. Historically, damage to structures and to their contents as a result of overland and/or secondary flooding within the watershed has not been widely reported, except in the Villages of Paddock Lake and Pleasant Prairie and the mobile home court at CTH K in the Town of Somers. Bridges and culverts and sections of roadways have been damaged by the erosive action of rapidly moving floodwaters to an extent requiring repair, and roadways have been temporarily closed due to overtopping at low places. In the public sector, routine operations of governmental units have been disrupted on some occasions during flood events as public officials attempt to provide immediate relief to affected areas.

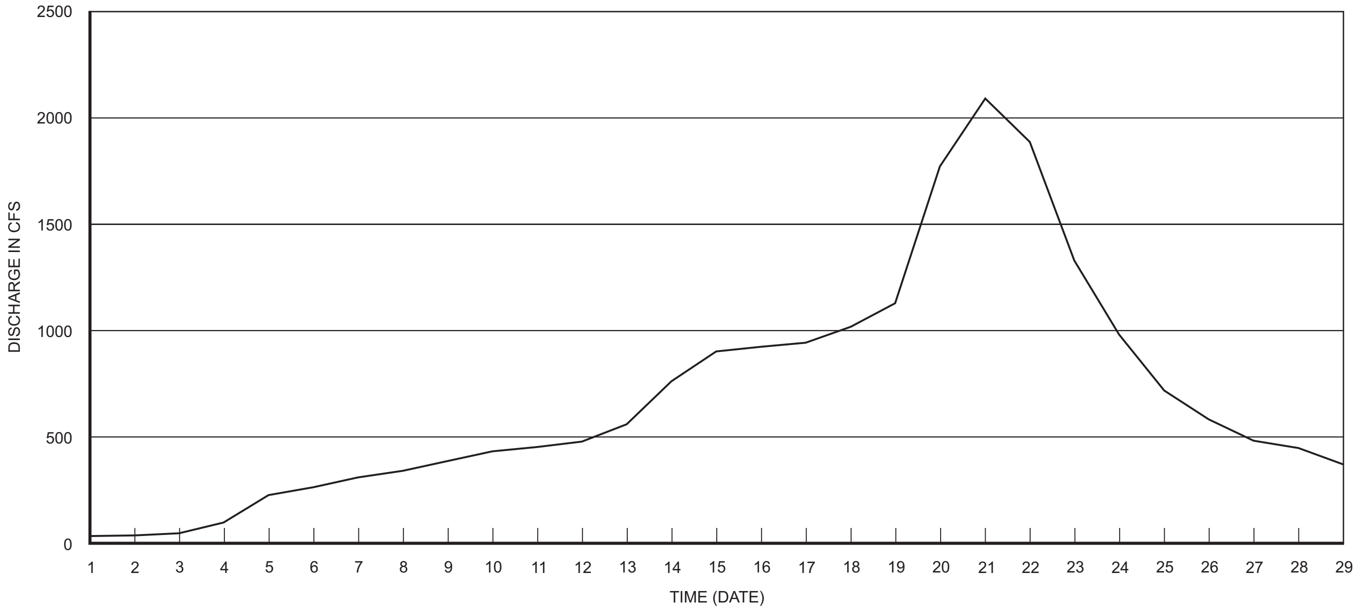
Relationship of Historical Floods to the Design Flood Adopted for the Watershed Plan

On a watershed-wide basis, the largest known flood occurred in June 2000.[8] In general, the flooding problems observed during that event occurred in areas where the hydrologic/hydraulic model developed under the

[8] *The June 2000 flood peak of 2,130 cfs was only slightly greater than the March 1979 peak of 2,120 cfs.*

Figure 33

**HYDROGRAPH OF THE MARCH 1979 FLOOD
DES PLAINES RIVER AT RUSSELL ROAD**



Source: U.S. Geological Survey and SEWRPC.

watershed study predicts flooding of land or buildings due to overflow from streams. As noted above, the peak flood discharge recorded for the Des Plaines River at the Russell, Illinois stream gage during the June 2000 flood is estimated to have a recurrence interval of about 30 years. At several undeveloped locations along the Upper Des Plaines River and Brighton Creek, correlation of observed flood stages and flood inundation areas with hydrologic/hydraulic model results indicate that the magnitude of the June 2000 flood approximated the 100-year flood.

The design flood selected for the Des Plaines River watershed planning program is the 100-year recurrence interval event as it would occur under full development, or buildout, of the planned year 2010 sewer service areas within the watershed.[9] As discussed in Chapter X, the selection of an event with a 100-year recurrence interval, and the need to consider a full range of flood events from the two-year recurrence interval up through the 100-year recurrence event is dictated by sound engineering practice, regulatory considerations, and public policy. Because of the limitations of the measured flood flow data, it was necessary to use simulation modeling to adequately evaluate conditions under the full range of runoff events to be considered. During a 100-year recurrence interval design flood, it may be expected that, on a watershed-wide basis, the estimated monetary flood damages, the number of buildings flooded, and the number of acres of agricultural land flooded would be somewhat greater than the observations of damages and building and agricultural flooding during the March 1979 and June 2000 floods.

Hydrologic-hydraulic flood risk analyses were performed to quantify flood problems likely to occur in the watershed, and to identify floodprone areas, under both the 1990 land use and channel conditions and under

[9]*An explanation of the rationale for selection of the design flood is set forth in Chapters IV and X of this report.*

buildout land use conditions. The resultant quantification of flood damages under 1990 conditions is presented in this chapter and the resultant quantification of damages under buildout conditions is presented in Chapter XII of this report. This estimation of amount of the damages under 1990 conditions enables determination of the incremental amount of the damages which may be expected under buildout conditions within the watershed as described in Chapter XII of this report.

It is estimated that under 1990 land use and existing channel conditions, 95 structures located on 83 properties, and about 4,000 acres of agricultural land may be expected to experience direct flooding during a 100-year recurrence interval flood event. As shown on Map 40, almost all of the 4,000 acres of agricultural land are located on hydric soils characteristic of wetland conditions. It is likely that much of the cropland on hydric soils subject to damage originally consisted of wetlands which have since been drained. The average amount of agricultural land which may be expected to be flooded annually over the long term may be expected to approximate 2,160 acres, including about 2,080 acres of cropland and 80 acres of pasture.[10]

These estimated flooding problems appear more severe than might be expected by review of the historic reports herein presented. Comparison of simulated flood flows, stages, and areas of inundation with recorded flows, stages, and areas of inundation for events which have occurred over the past 60 years indicate that the results are consistent. That is, for the watershed as a whole, the damages under events which have occurred are reasonably consistent with the damages expected under simulated conditions under 1990 land use and existing channel conditions.

MONETARY FLOOD LOSSES AND RISKS

Flood damage is defined herein as the physical deterioration or destruction caused by floodwaters. The term flood loss refers to the net effect of flood damage on the regional economy and well being, with the components of the loss being expressed in monetary units. Flood risk is the probable damage, expressed either on a per flood event basis or on an average annual basis, that will be incurred as a result of future flooding with the tangible portion of the risk expressed in monetary terms. All losses resulting from historic flooding or the risk attendant to future flooding can be classified into one of three types of damage categories—direct, indirect, and intangible. Such damages can also be classified according to whether the private or the public sector incurs the losses or risks. This two-way classification of flood losses and risks is set forth in Table 48.

Flood Losses and Risks Categorized by Type

In order to promote compatibility with the policies and practices of Federal agencies, such as the U.S. Army Corps of Engineers, which may be asked to assist in the implementation of the recommended watershed plan, the following three categories of flood losses and risks were defined for the purpose of the study:

1. Direct flood losses or risks were defined as monetary expenditures required, or which would be required, to restore flood-damaged property to its pre-flood condition. This includes the cost of cleaning, repairing, and replacing residential, commercial, industrial, and agricultural buildings and contents, and other objects and materials located outside of the buildings on the property. Direct losses and risks also encompass the cost of cleaning, repairing, and replacing roads and bridges, stormwater systems, sanitary sewer systems, and other utilities; the cost of restoring damaged park and recreational lands; and the cost of replanting as well as the cost of losing all or part of the first crop.

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[10]*These estimates of agricultural flooding account for the extreme flood events as well as the more common events, thus, they cannot be considered to represent a "typical" annual flood condition. During 1996, the Natural Resource Conservation Service—former U.S. Soil Conservation Service—staff updated information regarding the amount of agricultural land flooded as set forth in the* Preliminary Investigation Report—Des Plaines River Watershed—Kenosha and Racine Counties, Wisconsin*, August 1974. The updated information indicates that about 450 acres of agricultural land in the watershed upstream of IH 94/USH 41 would be flooded in a typical year.*

2. Indirect flood losses and risks were defined as the net monetary cost of evacuation, relocation, lost wages, lost production, and lost sales; the increased cost of highway and railway transportation because of flood-caused detours; the costs of flood-fighting and emergency services provided by governmental units; the cost of post-flood flood-proofing of individual structures. The costs of post-flood engineering and planning studies also are categorized as indirect losses and risks. Although often difficult to determine with accuracy, indirect losses and risks nevertheless constitute a real monetary burden on the economy of the Region.

3. Intangible flood losses and risks were defined as flood effects which cannot be readily measured in monetary terms. Such losses and risks include health hazards, property value depreciation as a result of flooding, and the general disruption of normal community activities. Intangible losses and risks also include the psychological stress experienced by owners or occupants of riverine area structures.

Flood Losses and Risks Categorized by Ownership

As already noted, flood losses and risks may also be classified on the basis of ownership into public-sector and private-sector losses and risks. Each of the three categories of flood loss—direct, indirect, and intangible—may, therefore, be further subdivided into public-sector losses as shown in Table 48. Within the direct loss category, for example, the cost of cleaning, repairing, and replacing residential buildings and their contents is a private-sector flood loss, whereas the cost of repairing or replacing damaged bridges and culverts is a public-sector loss.

Role of Monetary Flood Risks

Previous sections of this chapter identified the major historical flood events known to have occurred within the watershed and the relative magnitude of simulated or recorded peak flood discharges. Those sections also described the severity of each flood event and, in some cases, the reaches of the stream affected, and the types of damage and disruption that occurred. In most cases, though, little such historical information was available. While such a qualitative description of flooding is an effective means of communicating the characteristics of flooding, it is not adequate for sound economic analyses of alternative solutions to flood problems. Such analyses require that flood damages for the various upstream reaches be quantified in monetary terms on a uniform basis throughout the watershed.

The quantitative, uniform means of expressing flood damages selected for use in the Des Plaines River watershed study was the average annual flood damage risk expressed in 1999 dollars. Expected annual flood risk was computed for floodprone reaches to provide a monetary value that could be used, wholly or in part, as an annual quantity for comparison to annual costs of technically feasible alternative flood control measures.

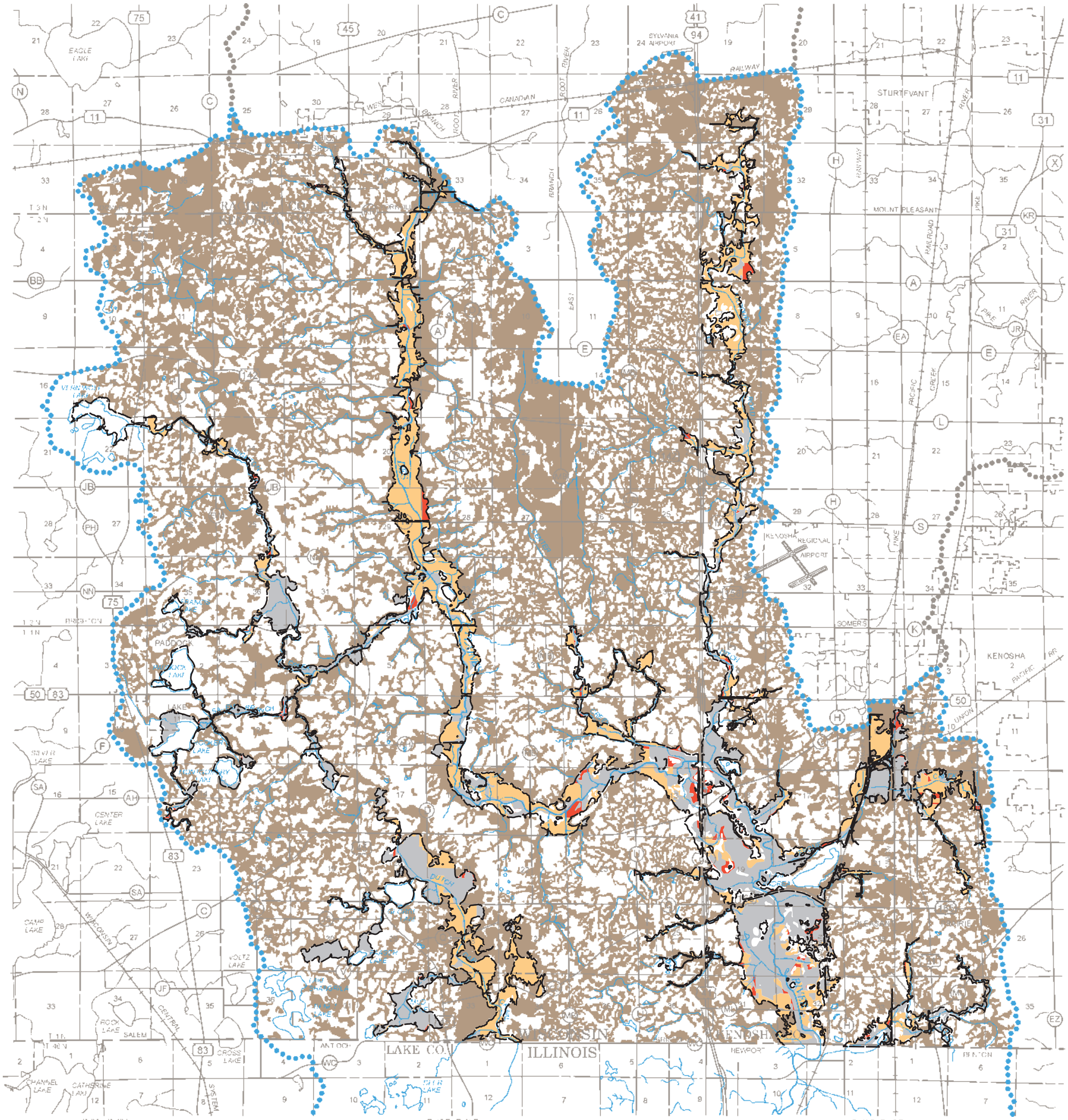
Methodology Used to Determine Expected Annual Flood Risks

The expected annual flood damage risk for a stream reach is defined as the sum of the direct and indirect monetary flood losses resulting from floods of all probabilities, each weighted by its probability of occurrence or exceedance in any year. If a damage-probability curve is constructed, such as the graph of dollar damage versus flood probability illustrated in Figure 34, the expected annual damage is represented by the area beneath the curve. The damage-probability curve for each floodprone reach is developed by combining the reach stage-probability relationship with the reach stage-damage curve as illustrated in Figure 34. The determination of expected annual flood risk for a particular floodprone reach, therefore, depends upon construction of the stage-probability and stage-damage relationships for the reach.

The two required relationships for a particular reach would be ideally developed from a long series of stage observations which could be analyzed statistically to yield the stage-probability curve and from a similar long series of recorded direct and indirect damages actually experienced by riverine area occupants for a full range of flood stages. Inasmuch as neither the long-term river stage information nor the damage information were available for the Des Plaines River watershed, it was necessary to develop the stage-probability and stage-damage relationships by analytical means and then to combine them to form the damage-probability relationship.

Map 40

HYDRIC SOILS WITHIN THE DES PLAINES RIVER WATERSHED



DES PLAINES RIVER WATERSHED BOUNDARY AS DELINEATED BY SEWRPC USING FIELD CHECKS AND LARGE SCALE TOPOGRAPHIC MAPPING AND STORM SEWER SYSTEM MAPS WHERE AVAILABLE

100-YEAR FLOODPLAIN BOUNDARY

HYDRIC SOILS IN CROPLAND WITHIN THE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN

HYDRIC SOILS IN PASTURE WITHIN THE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN

HYDRIC SOILS IN LAND OTHER THAN CROPLAND OR PASTURE WITHIN THE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN

HYDRIC SOILS IN LAND OUTSIDE THE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN

NOTE: 100-YEAR RECURRENCE INTERVAL FLOODPLAIN DELINEATED FOR EXISTING (1990) LAND USE AND EXISTING CHANNEL CONDITIONS.

GRAPHIC SCALE

0 1/2 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

Almost all of the 4,000 acres of agricultural land which is subject to damage during the 100-year recurrence interval flood is on hydric soils. It is likely that the land originally consisted of wetlands which have since been drained.

Source: SEWRPC.

Table 48

CATEGORIES OF FLOOD LOSSES AND RISKS

Type of Damage	Ownership	
	Private Sector	Public Sector
Direct	Cost of cleaning, repairing, or replacing residential, commercial, and industrial buildings, contents, and land Cost of cleaning, repairing, or replacing agricultural buildings and contents and cost of lost crops and livestock	Cost of repairing or replacing road segments, bridges, culverts, and dams Cost of repairing damage to stormwater systems, sanitary sewerage systems, and other utilities Cost of restoring parks and other public recreational lands
Indirect	Cost of temporary evacuation and relocation Lost wages Lost production and sales Incremental cost of transportation Cost of post-flood floodproofing	Incremental costs to governmental units as a result of flood fighting measures Cost of post-flood engineering and planning studies
Intangible	Loss of life Health hazards Psychological stress Reluctance by individuals to inhabit flood-prone areas thereby depreciating riverine area property values	Disruption of normal community activities Reluctance by business interest to continue development of flood-prone commercial-industrial areas thereby adversely affecting the community tax base

Source: SEWRPC.

Synthesis of Reach Stage-Probability Relationships

The stage-probability relationship for a particular reach is determined by the hydraulic characteristics of the reach, such as the shape of the floodland cross-sections, the value of the Manning roughness coefficients, and the presence of bridges, culverts, and other structures—all of which are to some extent determined by human activities—plus the magnitude of flood flows expected in the reach. These flood flows are, in turn, a function of upstream hydraulics and hydrology which are also, because of human activities, continuously undergoing change or have the potential to do so. It follows that each reach does not have a unique stage-probability curve but instead has many possible stage-probability curves, each of which is associated with a given combination of hydrologic-hydraulic conditions in and upstream of the reach in question.

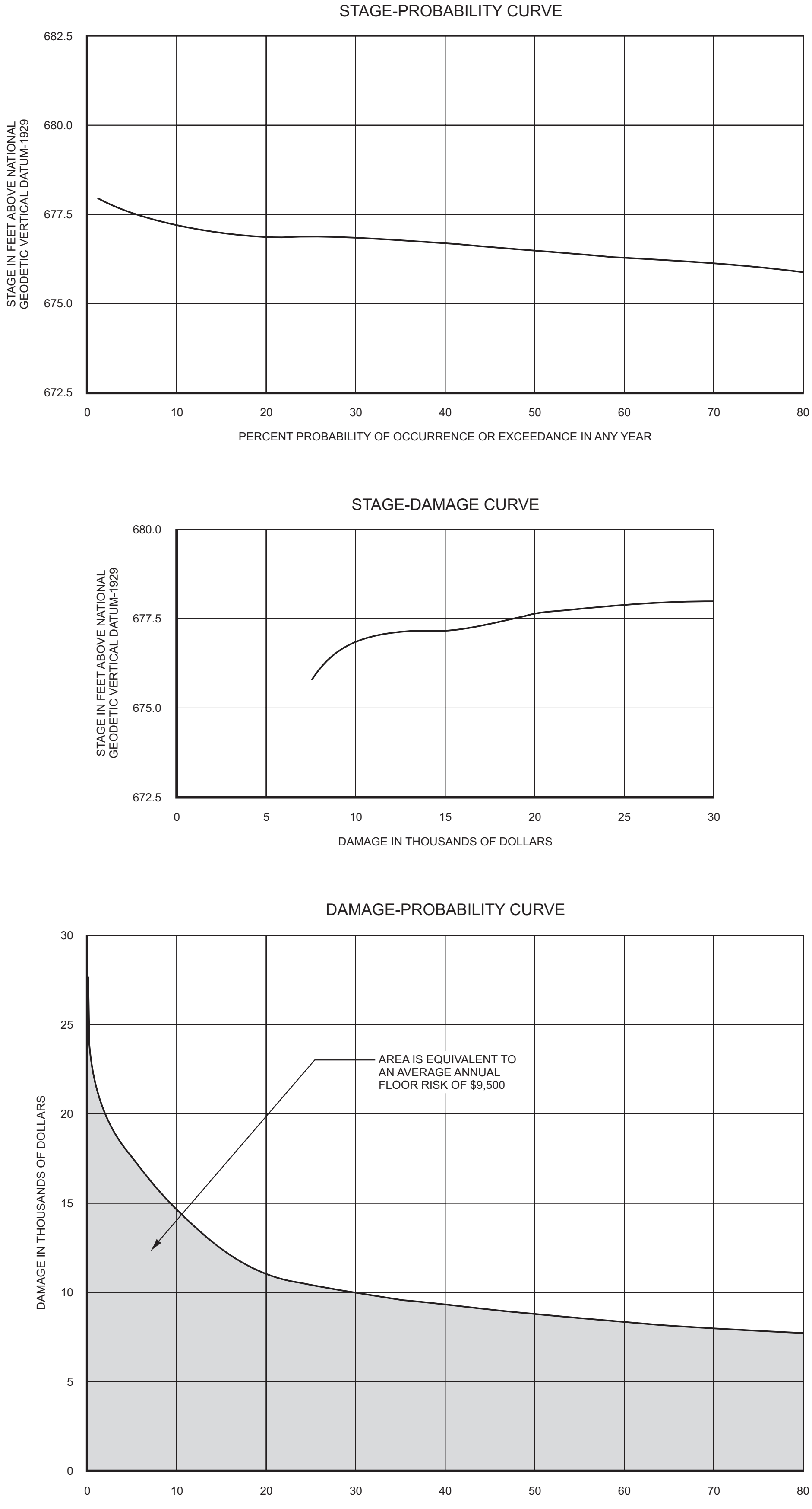
Synthesis of Reach Stage-Damage Relationships

The stage-damage curve for a reach is determined by the nature and extent of floodprone structures and other property, including agricultural lands, contained within the reach. It follows that there is a separate stage-damage curve for each combination of riverine area land uses. Development of the stage-damage relationship for a particular combination of riverine area land uses in a reach begins with computation of the flood losses that may be expected for an arbitrarily selected flood stage slightly above the elevation of the river channel. These flood losses consist of estimates of the direct and indirect monetary flood losses. Upon completion of the summation of flood losses at the initial flood stage, a higher stage is considered. This process is repeated so as to consider the full spectrum of flood stages from just above the river bank up to the 100-year recurrence interval flow stage. Figure 34 presents an example of a synthesized stage-damage curve.

Synthesis of reach stage-damage relationships requires the use of depth-damage relationships for the various type structures, facilities, croplands, and activities likely to be present in or to occur in floodlands. A depth-damage relationship for a particular type of structure is a graph of depth of inundation in feet relative to the first floor versus dollar damage to the structure expressed as a percent of the total dollar value of the structure. A similar,

Figure 34

EXAMPLE OF DETERMINATION OF AVERAGE ANNUAL FLOOD RISK FOR A HYPOTHETICAL REACH



Source: SEWRPC.

separate relationship can be developed for the contents of a structure. The depth-damage relationships for seven types of structures used in the Des Plaines River watershed study area are shown in Figure 35. These depth-damage relationships were developed by the Commission staff using Federal Insurance Administration tables first published in 1970 and periodically revised as more damage data became available, with the most recent revision occurring in 1994. The depth-damage relationships for croplands were provided by the U.S. Natural Resource Conservation Service and have been used by the NRCS in cost-benefit studies of proposed flood control measures in agricultural areas in Wisconsin. The NRCS damage data enable consideration of the time of year when flooding may be expected to occur. Depth-damage data for corn, hay, oats, pasture, soybeans, and wheat, are shown in Table 49. The yield component of the gross crop value was verified by the Kenosha County Land Conservationist.

The depth-damage curves do not take into account the duration of flooding, assuming, in effect, that if inundation occurs, damages will be incurred. This is a realistic assumption for the urban structure damages where inundation for even very short periods of time will damage such costly components as electrical motors, controls, and equipment; furnishings; and interior decorating. In agricultural areas this assumption may be expected to provide a good approximation of actual damages, since many crops may be damaged by very short periods of inundation, although some crops must be inundated for some length of time to be totally destroyed.

Determination of Indirect Damages
The above depth-damage relationships reflect the direct damage to each of the various types of structures or croplands as the function of the depth of inundation. Indirect damages, which can be a significant portion of the total monetary losses incurred during a flood event, were computed as a percentage of the direct damages to the various types of structures. The direct damages to commercial and industrial structures were increased by 40 percent to account for indirect damages, whereas the direct damages to residential and all other noncommercial and nonindustrial structures were increased by 15 percent to reflect indirect damages.

Expected Annual Flood Risks
The above methodology was used to compute expected annual flood risks for selected reaches in the Des Plaines River watershed under existing and probable future floodland development-land use conditions. The resulting per event and expected annual flood risks for selected reaches under buildout development conditions are presented in Chapter XII of this report. For 1990 land use and existing channel conditions, the average annual flood damage for the Des Plaines River watershed was determined to be $149,000. Of that total, about $91,000, or 61 percent, would be damages to structures and $58,000, or 39 percent, would be agricultural damages. Total damages expected to be caused by the two-, 10-, 50-, and 100-year recurrence interval flood events were determined to be $48,000, $336,000, $867,000, and $1,107,000, respectively.

SUMMARY

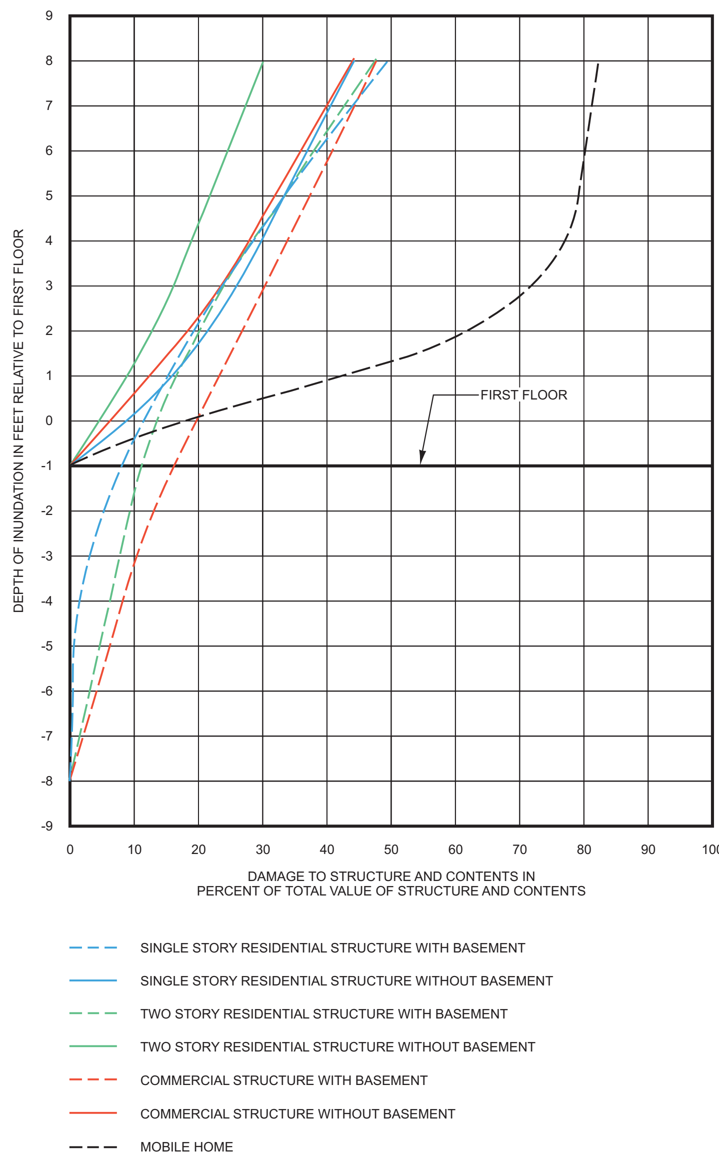
An understanding of the interrelationships that exist between the flood characteristics of the watershed stream system and the uses to which the floodland and nonfloodland areas of the watershed are put is fundamental to any comprehensive watershed study. This understanding is a prerequisite to the abatement of existing flood problems and the prevention of future flood problems. Flood damage and disruption in the Des Plaines River watershed have been largely a consequence of the failure to recognize and account for the relationships which exist between the use of land, both within and outside the natural floodlands of the watershed, and the flow behavior of the stream system of the watershed.

Historical flood information has several key applications during both the plan preparation and plan implementation processes including: 1) identification of problem areas; 2) determination of the causes of flooding; 3) calibration of the hydrologic-hydraulic model; 4) computation of monetary flood damages; 5) formulation of alternative flood control plan elements; and 6) post-plan information and education purposes. Synthesized monetary flood damages are utilized during the watershed planning process to conduct cost-benefit analyses of alternative flood control measures such as acquisition and removal of floodprone structures, structure floodproofing, channel modification, and construction of dikes, floodwalls, and flood control storage facilities.

A distinction is made in this report between flooding problems, which are the primary concern of the watershed study and stormwater inundation problems which are beyond the scope of the watershed planning program. Flood problems are defined, for purposes of this report, as damaging inundation which occurs along well-defined rivers and streams as the direct result of water moving out of and away from those rivers and streams, and includes both overland and secondary flooding. In contrast, stormwater inundation problems are defined as damaging inundation which occurs when stormwater runoff en route to rivers and streams and other low-lying areas encounters inadequate conveyance or storage facilities and, as a result, causes localized ponding, overflow of roadside swales, and surcharging of storm and sanitary sewers.

Figure 35

DEPTH-DAMAGE CURVES FOR SELECTED STRUCTURES



Source: SEWRPC.

Research of the available historical records indicates the occurrence from 1943 through 2000 of 15 major areawide floods in the Des Plaines River watershed. In addition, one localized, severe event, occurred during this period. The major floods which occurred generally throughout the watershed and which caused damage to property and crops due to flooding and/or inadequate stormwater drainage, as well as disruption of normal social and economic activities, were the floods of March 1943; March 1948; June 1954; April 2, 1960; March 22, 1962; April 21, 1973; March 6, 1976; August 21, 1978; March 21, 1979; April 4, 1983; March 13, 1986; September 27, 1986; April 21, 1993; May 23, 1996; and June 14, 2000. The single localized, severe event occurred in the Village of Paddock Lake on August 16, 1995.[11]

Information about the cause and effect of each of these floods was derived by a process consisting of the following steps: initial review of published reports and data; review of newspaper accounts and files; and personal interviews with community and agency officials, local residents, landowners, farmers, and representatives of local businesses. In addition, streamflow and crest gaging records collected from 1960 through 2000, supplemented by synthetic streamflow records generated by the application of the Commission simulation model, were utilized to identify the occurrence and magnitude of major floods and the causes thereof.

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[11]*Although the 1995 event was the most severe event known to have occurred within the Paddock Lake area, flooding and stormwater drainage problems also occurred in the same general area of the Village at other times when flooding was also more widespread throughout the watershed.*

Table 49

DEPTH-DAMAGE DATA FOR CROPS IN THE DES PLAINES RIVER WATERSHED

Crop	Gross Value per Acre	Flood Depth (feet)	Percent Damage per Month											
			January	February	March	April	May	June	July	August	September	October	November	December
Corn[a]	$340	0-1	1	1	1	4	29	38	18	18	13	9	4	1
		1-3	2	2	2	5	42	58	44	35	26	13	9	2
		>3	3	3	3	7	52	64	70	61	53	26	13	3
Hay[b]	$270	0-1	4	4	4	11	14	18	14	11	7	4	4	4
		1-3	4	7	7	14	22	29	25	22	11	4	4	4
		>3	7	7	11	18	29	36	32	29	14	7	7	7
Oats[c]	$100	0-1	3	3	3	18	36	46	23	3	3	3	3	3
		1-3	6	6	6	27	64	73	36	6	6	6	6	6
		>3	10	10	10	36	80	80	46	10	10	10	10	10
Pasture[d]	$ 40	0-1	0	0	0	0	6	8	3	2	1	1	0	0
		1-3	0	0	0	6	8	11	8	5	2	1	0	0
		>3	0	0	0	12	13	15	10	6	3	1	0	0
Soybeans[e]	$240	0-1	1	1	1	1	20	55	49	49	39	15	1	1
		1-3	2	2	2	2	25	55	78	78	63	24	2	2
		>3	4	4	4	4	31	55	93	93	78	29	4	4
Wheat[f]	$120	0-1	5	5	10	24	33	43	14	3	3	14	10	5
		1-3	10	10	14	38	62	76	24	5	5	24	14	10
		>3	10	10	19	47	76	86	29	8	8	29	19	10

[a]*Gross value of corn based on yield of 150 bushels per acre at a value of $2.29 per bushel.*

[b]*Gross value of hay based on yield of five tons per acre at a value of $53.71 per ton.*

[c]*Gross value of oats based on yield of 70 bushels per acre at a value of $1.42 per bushel.*

[d]*Gross value of pasture as feed based on 120 cow-pasture days at $0.33 per cow per acre per day.*

[e]*Gross value of soybeans based on yield of 40 bushels per acre at a value of $5.97 per bushel.*

[f]*Gross value of wheat based on yield of 50 bushel per acre at a value of $2.48 per bushel.*

Source: Natural Resource Conservation Service, Kenosha County Land Conservationist, and SEWRPC.

Based upon the quantitative data derived from the inventory of historical flooding, several observations can be made regarding the characteristics of flooding in the Des Plaines River watershed. First, the historical record indicates that significant damage to structures and their contents as a result of overland and/or secondary flooding has not been reported throughout the watershed, with the only concentrated area of such damage being reported in the Villages of Paddock Lake and Pleasant Prairie and the mobile home court at CTH K in the Town of Somers. Second, due to flooding of roadways and the resultant road closures, the disruption attendant to major floods is also experienced by the general public, and by watershed residents other than those who actually occupy the floodlands. Third, the analysis of historical flooding indicates that major floods in the Des Plaines River watershed generally occur in the late winter or early spring as the result of runoff from rainfall on frozen ground or from snowmelt or rainfall-snowmelt combinations. However, the occurrence of major floods in August 1978, September 1986, June 2000, and the localized flooding on August 16, 1995 caused by an intense thunderstorm indicate that, with the exception of the winter season, major floods can occur at any time of the year in the watershed. Along the main stem of the Des Plaines River, flood stages have risen relatively gradually and peak, or near peak, flows have typically been sustained for from three to 12 days.

The most common type of damage reported in the Des Plaines River watershed has been damage to croplands and the flooding of roadways. Bridges and culverts and sections of roadways have been damaged by the erosive action of rapidly moving floodwaters and roadways have been temporarily closed due to overtopping. In the public sector, routine operations of governmental units have, on some occasions, been disrupted during flood events as public officials attempt to provide immediate relief to affected areas.

On a watershed-wide basis, the largest known flood occurred in June 2000. In general, the flooding problems observed during that event occurred in areas where the hydrologic/hydraulic model developed under the watershed study predicts flooding of land or buildings due to overflow from streams. As noted above, the peak flood discharge recorded for the Des Plaines River at the Russell, Illinois stream gage during the June 2000 flood is estimated to have a recurrence interval of about 30 years. At several undeveloped locations along the Upper Des Plaines River and Brighton Creek, correlation of observed flood stages and flood inundation areas with hydrologic/hydraulic model results indicate that the magnitude of the June 2000 flood approximated the 100-year flood.

The design flood selected for the Des Plaines River watershed planning program is the 100-year recurrence interval event as it would occur under complete development, or buildout, of the planned year 2010 sewer service areas within the watershed. During a 100-year recurrence interval design flood, it may be expected that, on a watershed-wide basis, the estimated monetary flood damages, the number of buildings flooded, and the number of acres of agricultural land flooded would be somewhat greater than the observations of damages and building and agricultural flooding during the March 1979 and June 2000 floods. Comparison of simulated flood flows, stages, and areas of inundation with recorded flows, stages, and areas of inundation for events which have occurred over the past 60 years indicates that the modeling results are consistent with observations.

Flood loss refers to the net effect of historical flooding on the regional economy and well-being, with the tangible portions of the loss being expressed in monetary terms. Flood risk is the probable damage, expressed either on a per flood event basis or on an expected annual basis, that may be expected to be incurred as a result of future flooding, with the tangible portion expressed in monetary terms. All flood losses and risks may be classified into one of three categories—direct, indirect, and intangible—and they may be classified by whether the private or public sector is affected.

The quantification of flood damages during a range of floods up to, and including, a 100-year recurrence interval flood occurring under 1990 land use and existing channel conditions, based on hydrologic-hydraulic flood risk analyses, is presented in this chapter. This estimation of the amount of the damages under existing conditions enables determination of the incremental amount of the damage which may be expected under buildout conditions within the watershed as described in Chapter XII of this report. It is estimated that under 1990 land use and existing channel conditions, 95 structures located on 83 properties and about 4,000 acres of agricultural land may be expected to experience direct flooding during a 100-year recurrence interval flood. The average amount of agricultural land which may be expected to be flooded annually over the long term may be expected to approximate 2,160 acres, or about 2,080 acres of cropland and 80 acres of pasture.

Expected annual flood damage expressed in monetary terms was selected as the quantitative, means of uniformly expressing flood severity in the Des Plaines River watershed. These values were derived from damage-probability curves developed for selected reaches under existing, planned, and other floodland and nonfloodland development conditions. The expected average annual flood damage in the watershed is estimated to be $149,000 for 1990 land use conditions. Of this total, $58,000 represents agricultural damages and $91,000 represents structure and contents damage. Flood damages resulting from the occurrence of a major flood with a recurrence interval of 100 years may be expected to result in flood damages within the watershed totaling about $1,107,000.

Chapter VII

SURFACE WATER QUALITY CHARACTERISTICS AND PROBLEMS

INTRODUCTION

A basic premise of the Commission watershed studies is that the human activities within a watershed affect, and are affected by, surface and groundwater quality conditions. This is especially true in the urbanizing areas of the Des Plaines River watershed, where the effects of human activities on water quality tend to overshadow natural influences. The hydrologic cycle provides the principal linkage between human activities and the quality of surface and ground waters in that the cycle transports potential pollutants from human activities to the environment and from the environment into the sphere of human activities.

Comprehensive water resources planning efforts in general, and the Des Plaines River watershed planning program in particular, should include an evaluation of historic, present, and anticipated water quality conditions and the relationship of those conditions to existing and probable future land and water uses. The purpose of this chapter is to determine the extent to which surface waters in the Des Plaines River watershed have been and are polluted, and to identify the probable causes for, or sources of, that pollution. More specifically, this chapter discusses the concepts of water quality and pollution; summarizes the Commission-recommended water use objectives and supporting water quality standards for the surface water system of the watershed as a benchmark against which historic and recent water quality may be measured; documents current surface water pollution problems in the watershed utilizing field data from a variety of water quality studies, most of which were conducted during the past three decades; explores the differences between wet and dry weather water quality phenomena; and indicates the location and type of the numerous and varied sources of wastewater and other potential pollutants discharged to the surface water system of the watershed, describes the characteristics of the discharges from those sources and, to the extent feasible, quantifies the pollutant contribution of each source. The information presented herein provides an important basis for the development and testing of the alternative water quality control plan elements under the watershed study.

The focus of this chapter is on surface water quality characteristics and problems. The topics of groundwater quality and water supply are treated in this report only to the extent that they provide information about the development potential of the watershed, or relate to surface water quality problems. This minimal emphasis on groundwater quality and on surface water and groundwater supply is in accordance with the objectives of the Des Plaines River watershed planning program which are set forth in Chapter I. The *Des Plaines River Watershed Planning Program Prospectus* identified five water resource-related problems in the watershed: flooding and stormwater management, pollution of surface waters, soil erosion, deterioration of the natural resource base, and changing land use. The inventory and analysis phases of the watershed planning program did not identify any serious problems in the areas of groundwater quality and water supply within the Des Plaines River watershed.

Even if groundwater problems—particularly ground water quantity problems—do develop in the Des Plaines River watershed, it is highly unlikely that the watershed study or an extension of the study would be a sound basis for investigating and resolving those problems. Regardless of whether the groundwater moves in the shallow or deep aquifers, that movement is essentially independent of watershed processes and watershed boundaries, being instead influenced by regional and even extraregional aquifer characteristics, recharge patterns, and groundwater pumpage. Groundwater supply problems beginning to appear in the Southeastern Wisconsin area can best be resolved through a comprehensive regional water supply planning program.

WATER QUALITY AND POLLUTION: BACKGROUND

The term water quality refers to the physical, chemical, and biological characteristics of surface water and groundwater. Water quality is determined both by the natural environment and by human activities. The uses which can be made of the surface water resource are significantly affected by its quality, and, similarly, each potential use requires a certain level of water quality. Surface water uses may also be affected by the physical characteristics of the channels and by modifications in those characteristics.

Definition of Pollution

Pure water, in a chemical sense, is not known to exist in nature in that foreign substances, originating from the natural environment or human activities, will always be present. Water is said to be polluted when those foreign substances are in such a form and so concentrated as to render the water unsuitable for any desired beneficial uses such as the following: preservation and enhancement of fish and other aquatic life, water-based recreation, public water supply, industrial water and cooling water supply, wastewater disposal, and aesthetic enjoyment.

This definition of pollution does not explicitly consider the source of the polluting substance, which may significantly affect the meaning and use of the term. For the purpose of this report, the causes of pollution are considered to be exclusively related to human activities—anthropogenic pollution—and, therefore, the sources are potentially subject to control through alteration of human activities. Examples of potentially polluting discharges to the surface waters that are related to human activities include discharges of treated effluent from municipal and private sewage treatment facilities, discharges from commercial and industrial establishments, and runoff from urban areas and agricultural lands. Substances derived from natural sources that are present in such quantities as to adversely affect certain beneficial water uses—natural pollution—would not be herein defined as pollution, but would constitute a natural condition that impairs the usefulness of the water.

Types of Pollution

As defined above, water pollution is the direct result of human activities in the tributary watershed. Water pollution may be classified into one or more of the following eight categories in accordance with the nature of the substance that causes the pollution:

1. Toxic pollution, such as that caused by heavy metals and other inorganic and organic elements or compounds in industrial wastes, domestic sewage, or runoff, some of which may be toxic to humans and to other life.

2. Organic pollution, such as that caused by oxygen-demanding organic compounds—carbonaceous and nitrogenous—in domestic sewage and industrial wastes, which has a high oxygen demand and may deplete the dissolved oxygen content of the water, severely affecting fish and other aquatic life.

3. Nutrient pollution, or eutrophication, such as that caused by an overabundance of plant nutrient elements such as nitrogen and phosphorus in urban or agricultural runoff and in domestic sewage; this type of pollution may cause unsightly, excessive plant growths which can, alternately, supersaturate the dissolved oxygen supply in the river during the day due to photosynthesis and deplete the oxygen supply in water through respiration at night, and as a result of decay processes.

4. Pathogen or disease-related pollution, such as that caused by the presence of bacteria and viruses in domestic sewage or in runoff, which may transmit water-borne, infectious diseases from one person to another.

5. Thermal pollution, such as that caused by heated discharges, which may adversely affect aquatic flora and fauna.

6. Sediment pollution, such as that caused by erosion resulting from a lack of adequate soil conservation practices in rural areas and a lack of adequate runoff control from construction sites in urban areas. Such pollution results in instream sediment accumulations that have the potential to inhibit aquatic life, interfere with navigation, impede agricultural drainage, and increase flood stages.

7. Radiological pollution, such as that caused by the presence of radioactive substances in sewage or cooling water discharges, which may adversely affect human and animal life.

8. Aesthetic pollution, which may be associated in combination with any of the other forms of pollution, along with floating debris and unsightly accumulations of trash along streambanks and lakeshores.

All of the above eight types of water pollution may occur in surface waters. Groundwater pollution is normally limited to toxic, nutrient, pathogen, and radiological pollution. With the exception of thermal and radiological pollution—the high concentrations of radon in the groundwater of the Region being from natural and not anthropogenic sources and, hence, not defined as pollution in this chapter—all of the above types of pollution are known to occur, or to have occurred, in the Des Plaines River watershed as documented in this chapter.

The Relative Nature of Pollution

The determination of whether or not a particular surface water or groundwater resource is polluted is a function of the intended use of the water resource, in that the water may be considered to be polluted for some uses and not polluted for others. For example, a stream that contains a low dissolved oxygen level would be classified as polluted from the perspective of its use for sport fishing, since the survival and propagation of fishes depends upon an ample supply of dissolved oxygen. That same stream, however, may not be considered polluted when its water is used for industrial cooling. Water pollution, therefore, is a relative term, depending on the uses that the water is to satisfy and the quality of the water relative to the minimum requirements established for those uses or needs.

Water Quality Indicators

There are literally hundreds of parameters, or indicators, available for measuring and describing water quality; that is, the physical, chemical, and biological characteristics of water. A list of these indicators would include all of the physical and chemical substances in solution or suspension in water, all of the macroscopic and microscopic organisms in water, and the physical characteristics of the water itself. Only a few of these hundreds of indicators, however, are normally useful in evaluating wastewater quality and natural surface water quality and in indicating pollution. Selected indicators were employed in the Des Plaines River watershed planning program to evaluate surface water quality by comparing it to supporting adopted water use standards, which in turn relate to specific water use objectives. These same indicators were also used to describe the quality of point discharges and diffuse source runoff and to determine the effect of those discharges on receiving streams. These indicators were: temperature; specific conductance; turbidity; hydrogen ion concentration (pH); and total dissolved solids (TDS), total suspended solids (TSS), chloride, dissolved oxygen, biochemical oxygen demand (BOD, or BOD_5 when referring to the five-day BOD test), total and fecal coliform bacteria, heavy metal, pesticide, and polychlorinated biphenyl (PCB), phosphorus, and nitrogen concentrations; and aquatic flora and fauna species distributions.[1] These latter are generally described in terms of biological or biotic indices, two of which are in general use within Wisconsin—namely, the Hilsenhoff Biotic Index (HBI)[2] and the Index of Biotic Integrity (IBI).[3] These indices are applied to stream systems as a means of assessing the quality of the habitat, and its associated fauna. The HBI is used primarily to assess the diversity and quality of benthic invertebrates, or the organisms that generally provide the food resources that support a fishery, while the IBI is typically applied to an assessment of the quality of the fishery and fish habitat.

Wet and Dry Weather Conditions: An Important Distinction

A distinction is drawn in this chapter between instream water quality during dry weather (base flow) conditions and during wet weather (flood) conditions. In general, a water quality sample was assumed to represent dry weather conditions if 0.10 inch or less of rainfall was recorded in the 24 hours prior to the time of sampling, assuming that the precise time of sampling was known, or if such rainfall was recorded on the day of sampling in those cases where the precise time of sampling was not known. Dry weather instream water quality is assumed to reflect the quality of groundwater discharge to the stream plus the continuous or intermittent discharge of various point sources; for example, industrial cooling or process waters, and leakage and discharge from sanitary sewers. While instream water quality during wet weather conditions includes the above discharges, the dominant influence, particularly during major rainfall or snowmelt runoff events, is likely to be the soluble and insoluble substances carried into the streams by direct land surface runoff. That direct runoff moves from the land surface to the surface waters by overland routes, such as drainage swales, street and highway ditches, and gutters, or by underground storm sewer systems.

Until recently, water quality sampling and monitoring were most often conducted in dry weather, low-flow periods such as might be expected in July, August, and September. This practice reflects a period in the development of the state-of-the-art of water quality control when continuous and relatively uniform discharges from point sources—primarily municipal sewage treatment plant and industrial wastewater outfalls—were the dominant sources of pollution addressed in pollution abatement efforts. The impact of these kinds of point sources of pollutants on stream water quality was most critical when stream flows were lowest. Accordingly, most of the available water quality monitoring studies for the Des Plaines River watershed and, therefore, most of the data presented in this chapter pertain to dry weather, low-flow conditions.

Significant progress has been made in the understanding and control of major point sources of pollution. Consequently, substances carried into the streams by land surface runoff during wet weather conditions are becoming increasingly important in terms of their impacts on water quality—in some situations over half of the total contaminant load to a system can be transported into the surface water system by two or three major storms. Thus, wet weather conditions are likely to be as critical in terms of adverse water quality conditions as dry weather conditions. This is of importance in the Des Plaines River watershed because of the absence of major point sources of pollution. Therefore, every effort was made to obtain and report wet weather instream water quality conditions in the Des Plaines River watershed in order to present a balanced account of all factors influencing instream water quality.

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[1]*For a more complete discussion of most of the cited indicators, including their significance in evaluating water quality, see Chapter V of SEWRPC Technical Report No. 17,* Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975*, June 1978.*

[2]*Wisconsin Department of Natural Resources Technical Bulletin No. 132,* Using a Biotic Index to Evaluate Water Quality in Streams*, 1982.*

[3]*U.S. Department of Agriculture, National Forest Service General Technical Report No. NC-149,* Using the Index of Biotic Integrity (IBI) to Measure Environmental Quality in Warmwater Streams of Wisconsin*, April 1982.*

The frequency of wet weather conditions is defined, for purposes of this chapter, as being equal to the average number of days in a year on which 0.10 inch or more of precipitation occurs. An examination of daily rainfall data for the watershed for the 54-year period of record, from 1940 through 1994, at Union Grove, Wisconsin, indicates that, in the northern portions of the Des Plaines River watershed, there are an average of 66 days per year during which 0.10 inch or more of precipitation may be expected. In the southern portions of the watershed, an examination of daily rainfall data for the watershed for the 52-year period of record, from 1940 through 1992, at Antioch, Illinois, indicates that there are an average of 69 days per year during which 0.10 inch or more of precipitation may be expected. Therefore, wet weather conditions may be expected to occur on about 20 percent of the days in any given year.

WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS

This chapter includes an evaluation, based on field studies, of historic water quality conditions in the Des Plaines River watershed. Chapter VIII of this report uses simulation modeling to evaluate existing and hypothetical future water quality conditions in the surface waters of the watershed. Water use objectives and supporting water quality standards are particularly relevant to these two chapters since they provide a scale against which the historic, existing, and probable future water quality of the surface water system of the Des Plaines River watershed can be evaluated.

For purposes of the comparative water quality analyses set forth in this chapter and in Chapter VIII, the following recommended water use objectives, as shown on Map 59 in Chapter X of this report, have been established under the adopted areawide water quality planning program for the Des Plaines River watershed and refined based upon subsequent Wisconsin Department of Natural Resources (WDNR) and Commission planning programs:[4]

1. For the Mud Lake Tributary, Fonks Tributary, the Union Grove Industrial Tributary upstream of its confluence with Fonks Tributary, and the upstream reach of the Unnamed Tributary to Center Creek (Kenosha Beef International), limited recreational use and maintenance of limited aquatic life;

2. For the Union Grove Industrial Tributary downstream of its confluence with Fonks Tributary and the downstream reach of the Unnamed Tributary to Center Creek (Kenosha Beef International), limited recreational use and maintenance of a limited forage fish community; and

3. For the main stem and remaining tributary streams of the Des Plaines River watershed not specified above, full recreational use and maintenance of warmwater sport fish communities.

The relevant water quality standards established for planning purposes pursuant to these surface water use objectives are set forth in Table 96. The standards are intended to permit use of the majority of the surface waters of the Des Plaines River watershed for full body contact recreational uses, and to support warmwater sport fish communities and aquatic life. The water use objectives and supporting water quality standards, as summarized in Table 96 specify a minimum dissolved oxygen level, a maximum temperature, a fecal coliform count level, a total residual chlorine level, an ammonia-nitrogen level, a total phosphorus level, and a pH range. Acute and chronic toxicity standards for selected metals are set forth in Table 97 in Chapter X of this report. In addition, by explicit and implicit reference to Federal and other reports,[5,6,7] the water use objectives and standards incorporate recommended maximum or minimum levels for other water quality parameters.

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[4]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume One,* Inventory Findings*, September 1978; SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.*

[5]*U.S. Environmental Protection Agency,* Quality Criteria for Water*, Report No. EPA-440/5-86-001, Washington, D.C., 1986.*

Although it was recognized that the final watershed plan could recommend stream water use objectives different from the federally mandated fishable-swimmable stream water use objectives in the Des Plaines River watershed, it was deemed appropriate to use the Federal objectives and corresponding standards as a point of departure and a basis for evaluating the surface water quality conditions in the Des Plaines River watershed. The comparative analyses set forth herein and in Chapter VIII are intended to provide the information needed to determine if the fishable-swimmable water use objectives are, as a practical matter, achievable and, if not, to recommend the establishment of a reasonable lesser set of water use objectives and supporting standards.

The currently adopted standards were developed for planning purposes based upon consideration of those set forth in the initial areawide water quality management plan and the *Wisconsin Administrative Code*—Chapters NR 102, NR 104, and NR 105—as well as from additional sources.

Historically, water quality standards were applied based upon the belief that water pollution was essentially a dry-weather, low-streamflow problem. This practice was based upon analyses of stream water quality conditions affected by sewage treatment plant discharges. Such plants normally discharge sewage effluent at a relatively constant rate and quality, thereby causing the most severe water quality problems when receiving streamflows—and, hence, dilution—are low. The Wisconsin Department of Natural Resources currently requires that all instream water quality standards be met during all but the very lowest flow conditions, such conditions being defined as flows less than the seven-day average, one-in-10-year recurrence interval low flow.

Under the Commission's regional water quality management planning programs, however, it was determined that a probabilistic approach to the application of certain water quality standards, whereby the percent of time a given standard should be allowed to be violated would be specified, would allow the assessment and resolution of water quality problems during high-flow as well as low-flow conditions. This approach is considered appropriate for planning, as opposed to regulatory, purposes as it allows the use of standards as criteria to measure the relative merits of alternative plans. Accordingly, analyses were conducted, under the initial regional water quality management plan, to determine the percentage of time certain standards should be allowed to be violated except under specified conditions. A 95 percent compliance level was selected as the criterion for meeting the water quality standards for some parameters which directly affect desirable forms of aquatic life; namely, dissolved oxygen, temperature, un-ionized ammonia nitrogen, and pH. A 90 percent compliance level was selected as a criterion for parameters which do not directly affect desirable forms of aquatic life; namely, phosphorus, fecal coliform organism, and chloride concentrations. The analyses indicated that if these compliance levels were always met other than during periods of extreme low-flow conditions, the duration of the violation could be expected to be relatively short and the intensity of the violation relatively low, so that desirable uses and forms of aquatic life should not be adversely affected. Furthermore, the analyses indicated that even those surface waters which currently support full recreational uses and healthy fish and aquatic life communities often did not meet applicable water quality standards at all times. Thus, some level of violation of the standards was considered acceptable.

This probabilistic approach to water quality standards application was also used where applicable as a supplement to the current exemption in the standards for flow conditions lower than the seven-day average, one-in-10-year recurrence interval low flow. This approach was generally used in considering the achievement of the water use objectives based upon modeling data developed in the initial regional water quality management plan for conditions arising from pollutant control levels which approximate current conditions. The probabilistic compliance level approach was not applied to those parameters for which seasonal standards—or standards based

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[6]*Frits van der Leeden, Fred L. Troise and David Keith Todd,* The Water Encyclopedia*, 2nd Edition, Lewis Publishers, 1990. p. 417 ff.*

[7]*U.S. Environmental Protection Agency,* Water Quality Standards Handbook*, 2nd Edition, U.S. EPA Report No. EPA-823/B-93-002, September 1993.*

upon acute and chronic toxicity criteria—were developed. For dissolved oxygen concentrations, an absolute minimum standard is also considered. For metals concentrations, values based upon acute toxicity are presented and the application of such standards and criteria is specific and no probabilistic compliance level procedure is used. Chronic toxicity levels are also presented for metals concentrations and were considered based upon the 90 percent compliance level noted above.

Criteria have been recommended by the U.S. Environmental Protection Agency (EPA) for metals, polychlorinated biphenyls (PCBs), and pesticides, and those recommended criteria are used by the Wisconsin Department of Natural Resources in administering the Wisconsin Pollutant Discharge Elimination System. These recommended criteria are summarized in part in Table 97 in Chapter X of this report and are presented later in this chapter in conjunction with the data available from the Des Plaines River watershed regarding metals, PCBs, and pesticides.[8]

SURFACE WATER QUALITY STUDIES: PRESENTATION AND INTERPRETATION OF DATA

A variety of data sources, based primarily on field studies, were available for use in assessing the historic and existing water quality in the surface waters of the Des Plaines River watershed. Each of the sources used in the watershed study is cited and briefly described below in chronological order according to the initiation date of the investigation. Information about each of the water quality studies used as a basis for this chapter, along with selected water quality data from these sources, is set forth in Table 50, and sampling station locations are shown on Map 41. From these water quality data, conclusions are drawn as to the nature and, to the extent possible, the cause of surface water pollution in the Des Plaines River watershed. An understanding of the nature and probable causes of surface water pollution is basic to developing achievable water quality objectives and alternative pollution abatement plan elements. Some of the data and information presented herein are based on studies conducted over 35 years ago. These data are presented to demonstrate changes in water quality conditions where the data permit.

Southeastern Wisconsin Regional Planning Commission Benchmark Surveys: 1964-1965 and 1965-1975

SEWRPC Water Quality Study: 1964-1965

During the 14-month period from January 1964 through February 1965, the Regional Planning Commission conducted an extensive stream water quality sampling program during which almost 4,000 water samples were collected at 87 sampling stations established in 43 streams in the Region. Under this program, samples were taken at three stations in the Des Plaines River watershed—on the Des Plaines River at STH 50 and on the Des Plaines River at CTH ML—the sampling stations being identified as Dp-2 and Dp-3 on Map 41, respectively, and on Brighton Creek at USH 45—the sampling station being identified as Dp-1 on Map 41. The samples were taken under dry weather conditions on a monthly basis from April 1964 to February 1965. The samples were analyzed for selected chemical, physical, and biological characteristics to determine the then-existing condition of stream water quality in relation to pollution sources, land use, and population distribution and concentration. The study procedure and results are presented in SEWRPC Technical Report No. 4, *Water Quality and Flow of Streams in Southeastern Wisconsin*, published in November 1966. For purposes of this analysis, comparisons were made assuming that similar low flows occurred during the months of August and September, and that the streams were likely to exhibit similar dry weather, low-flow water quality conditions.

Findings of the Study

Tables 51 and 52 present a synopsis of dry weather water quality conditions in the Des Plaines River and Brighton Creek as determined by the Regional Planning Commission in the 1964-1965 sampling. Water quality conditions, based on dissolved oxygen, total dissolved solids, and chloride concentrations; biochemical oxygen demand; temperature; total coliform bacteria counts; pH; and specific conductance are set forth below.

[8]Ibid.

Table 50

SOURCES OF WATER QUALITY DATA ON THE DES PLAINES RIVER WATERSHED USED IN THIS PLAN

Data Source	Documentation	Streams and Lakes Sampled	Stations Sampled	Study Period	Parameters Measured
SEWRPC	Technical Report No. 4, *Water Quality and Flow of Streams in Southeastern Wisconsin*	Des Plaines River Brighton Creek	Dp-2 Dp-3 Dp-1	1964-1965	Si, Fe, Mn, Cr, Ca, Mg, Na, CO_3, HCO_3, SO_4, Cl, F, NO_2, NO_3, P, CN, oils, detergents, TDS, hardness, alkalinity, specific conductance, pH, color, turbidity, BOD, DO, FC, and temperature
SEWRPC and DNR	Technical Report No. 17, *Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975*	Des Plaines River Brighton Creek Benet/Shangrila Lake George Lake Hooker Lake Paddock Lake	Dp-2 Dp-2a Dp-3 Dp-1	1968-1975	Temperature, DO, pH, specific conductance, P, NO_3, NO_2, Cl, and TC
SEWRPC	Planning Report No. 30, *A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volumes One through Three	Des Plaines River	Dp-2 Dp-2a	1976	Temperature, DO, pH, specific conductance, P, N, Cl, BOD, and Pb
USGS	Water Data Reports No. IL-75-1 through IL-91-2, *Water Resources Data: Illinois: Water Years 1975 through 1991*	Des Plaines River	Dp-4	1977-1991	Temperature, pH, specific conductance, turbidity, DO, COD, FC, hardness, alkalinity, Ca, Mg, Na, K, TSS, N, P, Al, Ba, Be, Bo, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Ag, Sr, Va, Zn, and CN
DNR	Self-Help Monitoring Program[a]	Benet/Shangrila Lake George Lake Hooker Lake	- -	1988-1992	Secchi-disk transparency
DNR	Baseline Monitoring Effort	Des Plaines River, Brighton Creek, Jerome Cree, Kilbourn Road Ditch	Dp-1 Dp-2 Dp-2a	1999-2001	Temperature, DO, pH, TDS, specific conductance

[a]*Data sources also include the 1977 Statewide Lake Survey conducted by the Wisconsin Department of Natural Resources.*

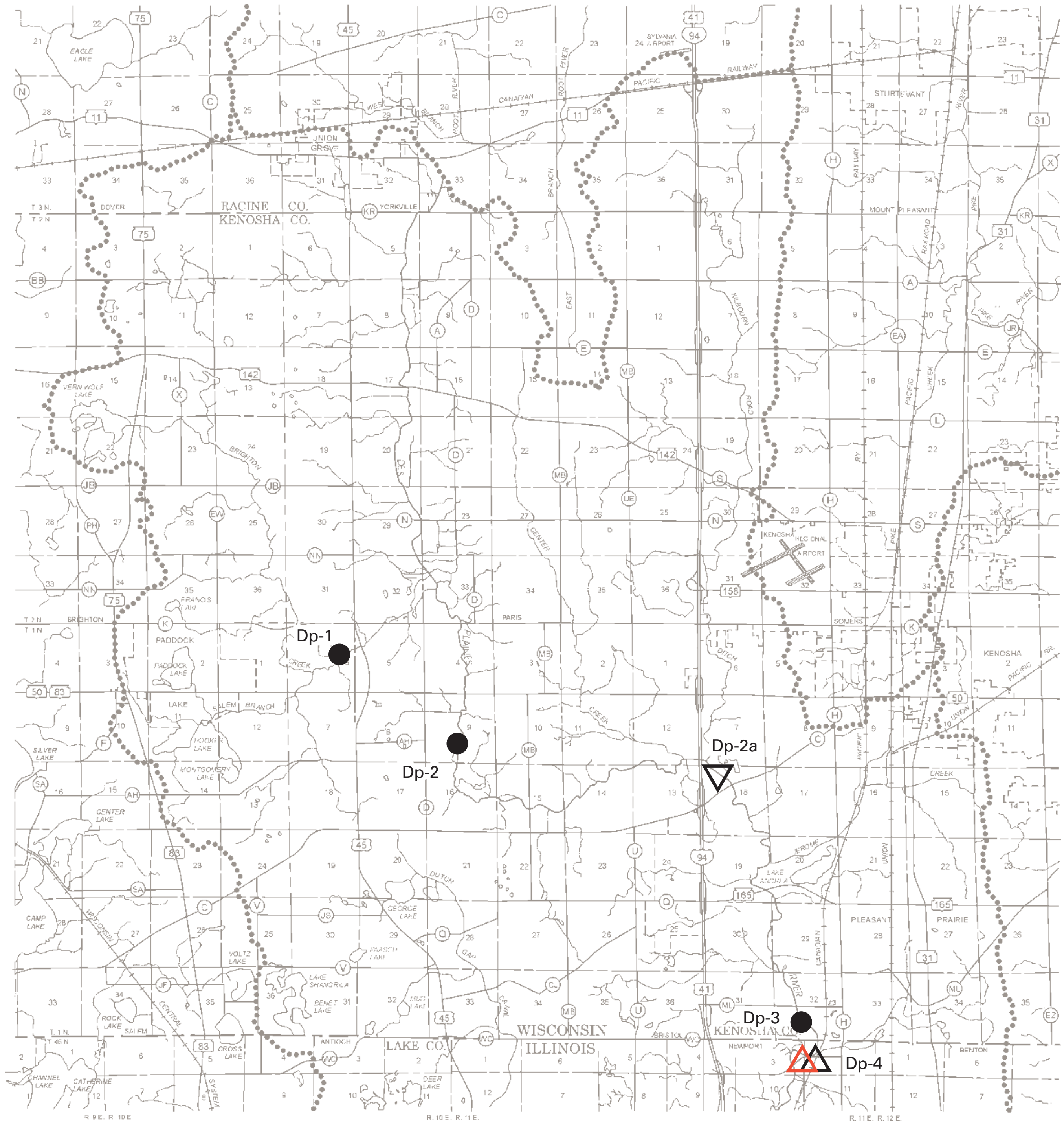
Source: SEWRPC.

Dissolved Oxygen

During the 1964-1965 sampling period, the dissolved oxygen levels in the watershed were found to range from 2.1 milligrams per liter (mg/l) to 13.9 mg/l, with an average of 8.6 mg/l, at stations Dp-2 and Dp-3, and from about 5.5 mg/l to about 13.0 mg/l at station Dp-1. Samples taken at station Dp-3 regularly exhibited an oxygen concentration of below 5.0 mg/l, especially during the summer months, dropping below 5.0 mg/l in mid-June and remaining below 5.0 mg/l until early-September 1964. Critical concentrations of less than 3.0 mg/l were recorded at station Dp-3 during July 1964. Dissolved oxygen concentrations of less than 5.0 mg/l were also recorded during January 1965. Substandard levels were also recorded from station Dp-2 in late-August/early-September 1964.

Map 41

LOCATION OF WATER QUALITY SAMPLING STATIONS IN THE DES PLAINES RIVER WATERSHED



SAMPLING STATIONS USED IN PREPARATION OF INITIAL REGIONAL WATER QUALITY MANAGEMENT PLAN

SEWRPC

DNR

USGS

POST-1976 SAMPLING STATIONS USED IN THE PREPARATION OF PLAN UPDATE

USGS-LONG TERM

GRAPHIC SCALE
0 1/2 1 MILE
0 2,000 4,000 6,000 FEET

A variety of data sources are available for use in assessing the historic and existing water quality in the Des Plaines River watershed and its tributaries and for identifying the causes of surface water pollution. The data are derived from long-term monitoring studies such as the cooperative effort carried out since 1964 by SEWRPC and the Wisconsin Department of Natural Resources, from special-purpose studies such as the SEWRPC monitoring for the areawide water quality management plan, and monitoring at the U.S. Geological Survey gage at Russell, Illinois (Dp-4) from 1977 through 1991.

Source: SEWRPC.

Table 51

WATER QUALITY IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATIONS DP-2 AND DP-3: 1964-1965

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	105	50	20	16	- -
Dissolved Oxygen	5.0	13.9	8.6	2.1	25	4
Specific Conductance (:S/cm)	- -	1,110	- -	796	2	- -
Nitrate-N	0.3	3.2	- -	0.6	- -	- -
Total Phosphorus	0.1	- -	0.3	- -	1[a]	1
Fecal Coliform (MFFCC/100ml)	400	32,000	8,100	<100	25	11
Temperature (°F)	89	81	51	32	25	0
Hydrogen Ion Concentration	6-9	- -	8.0	- -	2	0
Biological Oxygen Demand	- -	2.4	- -	1.8	2[b]	- -
Total Dissolved Solids	- -	825	700	430	16	- -
Calcium	- -	131	- -	64	2	- -
Magnesium Hardness	- -	66	- -	46	2	- -
Sodium (and potassium)	- -	65	- -	15	2	- -
Carbonate	- -	365	- -	195	2	- -
Sulfate	- -	336	274	125	- -	- -
Silica	- -	5	- -	2	2	- -
Lead	- -	0.05	- -	0.04	2	- -
Chromium	- -	- -	<0.005	- -	1	- -
Fluoride	- -	- -	<0.7	- -	1	- -
Cyanide	- -	- -	<0.01	- -	1[c]	- -

NOTE: Units are in mg/l, unless otherwise specified.

[a]*October 20, 1964.*

[b]*April 9, 1964 and October 20, 1964.*

[c]*November 11, 1964.*

Source: SEWRPC.

Dissolved oxygen concentrations at station Dp-1 were always above 5.0 mg/l during the study period. Dissolved oxygen concentrations at all three stations demonstrated similar seasonal variations.

Diurnal variations in dissolved oxygen concentrations were also assessed during this study. It was determined that dissolved oxygen concentrations of less than 5.0 mg/l prevailed in an approximately 13-mile reach of the Des Plaines River around station Dp-3 during daylight hours of the summer and early fall of the study period. Nocturnal concentrations were presumed to be even lower. While this oxygen sag was not well-correlated with temperature or BOD, the presence of coincidentally high fecal coliform bacteria counts suggested that the source of the oxygen demand might speculatively be sewage wastes. The degree of the oxygen demand was sufficiently high to off-set daily oxygen production by the aquatic plants and algae observed in this river reach.

Biochemical Oxygen Demand

During the 1964-1965 sampling period, the five-day biochemical oxygen demand (BOD_5) in the Des Plaines River was found to range from 1.8 mg/l to 2.4 mg/l at station Dp-3, and from less than 0.5 mg/l to 2.0 mg/l at station Dp-1. The lowest values were recorded at both stations in October 1964 and the highest values in April 1964.

Table 52

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-1: 1964-1965

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	30	25	15	2	- -
Dissolved Oxygen	5.0	13.3	9.7	5.5	11	0
Specific Conductance ((:S/cm)	- -	724	- -	586	2	- -
Fecal Coliform	400	56,000	5,900	100	11	4
Temperature (°F)	89	84	55	32	10	0
Hydrogen Ion Concentration	6-9	8.3	- -	7.8	2	0
Biological Oxygen Demand	- -	2.0	- -	<0.5	2[a]	- -
Total Dissolved Solids	- -	615	540	460	2	- -
Calcium	- -	85	- -	56	2	- -
Magnesium	- -	41	- -	40	2	- -
Sodium (and potassium)	- -	- -	60	- -	2	- -
Carbonate	- -	380	- -	195	2	- -
Sulfate	- -	300	- -	58	2	- -
Silica	- -	16	- -	6	2	- -
Lead	- -	0.14	- -	0.01	2	- -

NOTE: Units are in mg/l, unless otherwise specified.

[a] *April 9, 1964 and October 20, 1964.*

Source: SEWRPC.

Temperature

During the 1964-1965 sampling period, the temperature of the Des Plaines River was found to range from 32ºF to 84ºF. For the period June through September 1964, the temperatures ranged from about 60ºF to about 82ºF at station Dp-3, and from about 65ºF to about 84ºF at station Dp-1. Such temperature variations were attributed primarily to seasonal changes.

Total Coliform Bacteria

During the 1964-1965 sampling period, coliform levels in the Des Plaines River were found to vary from the level of detection—less than 100 membrane filter coliform counts (MFCC) per 100 ml—up to 56,000 MFCC/l00 ml. The highest counts—56,000 MFCC/100 ml at station Dp-1 and 32,000 MFCC/100 ml at station Dp-3—occurred in September 1964 and, again, in January 1965. The highest counts were observed in summer and winter, with lower counts being recorded during spring and autumn. The average coliform bacteria count at station Dp-3 during the study period was 8,100 MFCC/100 ml, and at station Dp-1, 5,900 MFCC/100 ml.

Hydrogen Ion Concentration (pH)

During the 1964-1965 sampling period, the pH values at stations Dp-3 and Dp-1 averaged about 8.0 standard units; in Brighton Creek—station Dp-1—the pH ranged from 7.8 standard units in October 1964 to 8.3 standard units in April 1964, while the pH did not vary at station Dp-3 on the Des Plaines River, remaining constant at 8.0 standard units. The recommended maximum of 9.0 standard units is prescribed by the Wisconsin Department of Natural Resources for the maintenance of fish and aquatic life.

Specific Conductance and Total Dissolved Solids

During the 1964-1965 sampling period, the specific conductance of the surface waters of the Des Plaines River watershed was found to range from 796 microSiemens per centimeter (µS/cm) to 1,110 µS/cm at 25ºC at station Dp-3 and from 586 µS/cm to 724 µS/cm at 25ºC at station Dp-1. Specific conductance is an approximate measure of the dissolved ions present in water, the increased specific conductance normally due to the presence of increased amounts of such substances as sulfates, bicarbonates, and chlorides. As anticipated, higher specific conductance levels were evident during the spring runoff because of the greater concentrations of dissolved solids from the residue of winter street and highway salting operations. Total dissolved solids concentrations at station Dp-3 varied from 430 mg/l to 825 mg/l with a mean value during the study period of 700 mg/l. At station Dp-1, TDS concentrations varied from 460 mg/l to 615 mg/l with a mean of 540 mg/l. During the late-spring, mid-summer, and early-fall months, specific conductance levels returned to normal—about 500 mg/l—at station Dp-3. This latter value was about 100 mg/l higher than the presumed TDS concentration of the Niagara aquifer and was considered to reflect in part anthropogenic waste inputs and in part natural processes such as the concentration of dissolved solids in the river water due to evapotranspiration effects and in-channel dissolution of rocks and minerals from the land surface and soils in the watershed. The principle source of TDS in Brighton Creek was thought to be from wetland areas with a minor contribution from anthropogenic sources.

Chloride

During the 1964-1965 sampling period, the observed chloride concentrations for the Des Plaines River watershed ranged from 20 mg/l to 105 mg/l at station Dp-3, with the average value for the Des Plaines River being 50 mg/l, and from 15 mg/l to 30 mg/l, with the average value for Brighton Creek being 25 mg/l. The levels of chloride concentration were typically elevated during the winter months as a result of runoff contaminated with road salt.

Concluding Statement

The 1964-1965 dry weather survey indicated that water quality conditions consistently satisfied the temperature standards established for the surface waters of the Des Plaines River watershed. The sample data, however, indicated that the dissolved oxygen, pH, and fecal coliform standards were occasionally to frequently violated. The violation of these standards was primarily attributed to excessive nonpoint source pollution loading to the streams and to the discharge of sanitary sewage from sewer overflows.

Water Quality—1964

For all stations on the Des Plaines River main stem, intended for full recreational use and maintenance of a warmwater sportfish community, the water quality conditions during the survey satisfied the temperature and pH standards. Substandard dissolved oxygen levels were found at Dp-3, located 0.7 mile upstream from the state line. For Brighton Creek, which has the same water use objectives as the Des Plaines River, the water quality conditions during the August 1964 survey satisfied the temperature, pH, and dissolved oxygen concentration standards. Since no fecal coliform counts, or nitrate, total phosphorus, or ammonia analyses were made in the 1964 samples, no assessment could be made as to the nutrient concentrations and bacteriological safety of the Des Plaines River and Brighton Creek waters for 1964. However, since the total coliform counts in the Des Plaines River and Brighton Creek were in the range of 600 MFCC/100 ml to 6,000 MFCC/100 ml with an average of 2,200 MFCC/100 ml for 12 months, it was considered probable that the fecal coliform counts were higher than the permissible limits.

SEWRPC-WDNR Cooperative Water Quality Study: 1965-1975

In 1965, the Commission entered into a cooperative agreement with the Wisconsin Department of Natural Resources for the execution of a continuing stream water quality monitoring program within the Region. The objective of the program was to provide, on a continuing basis, the water quality information necessary to assess the long-term trends in water quality within the rapidly urbanizing seven-county Region. The continuing monitoring program was designed to build upon the benchmark stream water quality data base established by the Commission in the initial 1964-1965 stream water quality study.

During the eight-year period from 1968 to 1975, the Regional Planning Commission continued the extensive stream water quality sampling program initiated during 1964-1965. Under this program, samples were taken at the same three stations in the Des Plaines River watershed—two on the Des Plaines River main stem, identified as Dp-2 and Dp-3, and one on Brighton Creek, identified as Dp-1—as used in the benchmark water quality study. In addition, data were collected by the Wisconsin Department of Natural Resources at an additional station, designated as station Dp-2a on Map 41, on the mainstem of the Des Plaines River. Water quality data from the

1965 to 1975 study included eight summer sampling programs, three spring sampling programs, and one fall sampling program.

The summer sampling surveys began in August 1968 and involved collection of samples on one day in August every year during low-flow conditions. An analysis of the flow data from *Water Resources Data for Wisconsin*, published annually by the U.S. Geological Survey indicated that, for the streams in Southeastern Wisconsin, low flow generally occurred during the months of August and September. Although the collection and analysis of one sample per station per year could not represent water quality conditions for the whole year, it was assumed to reasonably represent the water quality conditions of the stream at that location during the low-flow period, which was generally considered the most critical period for the maintenance of sufficient dissolved oxygen to support fish and other aquatic life. The study procedure and the results are presented in SEWRPC Technical Report No. 17, *Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975*, published in June 1978.

During 1968 and 1969, the SEWRPC stream water quality monitoring program involved twice-yearly sampling at all stations during periods of both high and low flow, with the samples being analyzed for dissolved oxygen, chloride, nitrate nitrogen, nitrite nitrogen, dissolved phosphorus concentrations; fecal and total coliform counts; pH; temperature; and specific conductance.

To provide additional information on the diurnal fluctuations of stream water quality, the monitoring program was revised in 1970 to provide for the collection of six stream water samples over a 24-hour period once yearly during the period of low stream flow at each sampling station, with each sample being analyzed for the following five parameters: dissolved oxygen and chloride concentrations; temperature; pH; and specific conductance. In addition, one sample obtained during the 24-hour period was analyzed for the following four parameters: fecal coliform counts, and nitrate-nitrogen, nitrite-nitrogen, and dissolved phosphorus concentrations.

In order to obtain regional information on additional water quality indicators, the Commission and the Wisconsin Department of Natural Resources agreed to a further revision of the program beginning with the 1972 survey. The overall continuity of the sampling program was maintained by continuing to monitor those parameters included in previous surveys with the following changes: a decrease from six to four per day in the frequency of dissolved oxygen concentration, temperature, and specific conductance measurements; a decrease from six to two per day in the frequency of chloride concentration determinations; an increase from one to two per day in the frequency of fecal coliform counts, and nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, and dissolved phosphorus concentration measurements; and the addition of two determinations per day of organic nitrogen, ammonia-nitrogen, and total phosphorus concentrations. The addition of these latter three parameters was prompted by the need for more regional information on nutrients, and an increased interest in both the oxygen demand exerted by ammonia nitrogen and the toxic effect of ammonia nitrogen.

Thus, the stream water quality monitoring program, as revised in 1972, provided for four measurements over a 24-hour period once yearly. Four measurements were made during the period of low flow at each of the 87 stations in the Region for each of the following three parameters: dissolved oxygen concentration, temperature, and specific conductance. Two determinations were made at each station over the same 24-hour period for each of the following nine parameters: pH, fecal coliform counts, and chloride, nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, organic nitrogen, dissolved phosphorus, and total phosphorus concentrations.

Findings of the Study

The summary of the results for specific conductance; hydrogen ion concentration (pH); dissolved oxygen; nitrate-, nitrite-, ammonia-, and organic-nitrogen; soluble and total phosphorus; chloride; and fecal coliform counts for each of the three stations sampled in the Des Plaines Des Plaines River watershed by the Commission since 1968 is set forth in Tables 53 through 55, and the summary of water quality data obtained from DNR Dp-2a by the Wisconsin Department of Natural Resources on the Des Plaines River is set forth in Table 56. Stream flow data for the Des Plaines River near Russell, Illinois, located 0.8 mile downstream from the state line and 1.5 miles downstream from Dp-3, were available from the U.S. Geological Survey records, and stream flow data at this location for the years 1968 through 1975 on the days the water samples were collected is presented in Figure 36.

Table 53

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-1: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	38.0	17.5	6.0	22	- -
Dissolved Oxygen	5.0	13.7	6.7	2.5	30	10[a]
Ammonia-N	2.5	0.44	0.14	0.03	8	0
Organic-N	- -	2.27	1.01	0.08	8	- -
Total-N	- -	2.68	1.36	0.12	8	- -
Specific Conductance (:S/cm)	- -	875.0	671.0	553.0	29	- -
Nitrite-N	- -	0.19	0.03	0.00	11	- -
Nitrate-N	0.30	0.34	0.18	0.04	12	1
Soluble Orthophosphate-P	- -	0.36	0.22	0.03	12	- -
Total Phosphorus	0.10	0.50	0.25	0.05	8	7
Fecal Coliform (MFFCC/100 ml)	400	7,600	1,185	30	12	8
Temperature (°F)	89.0	80.0	64.2	51.0	29	0
Hydrogen Ion Concentration	6-9	8.5	8.0	7.6	16	0

NOTE: Units of measure are in mg/l, unless otherwise specified.

[a]*The concentration were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 54

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-2: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	168.0	65.7	7.0	22	- -
Dissolved Oxygen	5.0	13.7	6.7	3.1	30	8[a]
Ammonia-N	2.5	0.24	0.09	0.03	8	0
Organic-N	- -	2.98	1.52	0.72	8	- -
Total-N	- -	4.61	2.32	0.95	8	- -
Specific Conductance (:S/cm)	- -	1,300	981.7	686.0	29	- -
Nitrite-N	- -	0.118	0.045	0.012	12	- -
Nitrate-N	0.30	1.340	0.525	0.110	12	7
Soluble Orthophosphate-P	- -	0.461	0.25	0.137	12	- -
Total Phosphorus	0.10	0.59	0.33	0.17	8	8
Fecal Coliform (MFFCC/100ml)	400	2,300	774	200	12	8
Temperature (°F)	89.0	86.0	71.7	60.0	30	0
Hydrogen Ion Concentration	6-9	8.4	8.0	7.7	16	0

NOTE: Units of measure are in mg/l, unless otherwise specified.

[a]*The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 55

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-3: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	85.0	55.0	30.0	22	- -
Dissolved Oxygen	5.0	12.6	5.9	1.9	30	13[a]
Ammonia-N	2.5	0.26	0.09	0.03	8	0
Organic-N	- -	2.42	1.52	0.99	8	- -
Total-N	- -	4.17	2.40	1.34	8	- -
Specific Conductance (:S/cm)	- -	1,100	920	708	29	- -
Nitrite-N	- -	0.13	0.06	0.03	12	- -
Nitrate-N	0.30	2.0	0.72	0.23	12	10
Soluble Orthophosphate-P	- -	0.61	0.38	0.09	12	- -
Total Phosphorus	0.10	0.62	0.41	0.15	8	8
Fecal Coliform (MFFCC/100ml)	400	880	391	70	12	7
Temperature (°F)	89.0	90.0	74.4	62.0	30	2
Hydrogen Ion Concentration	6-9	8.6	8.1	7.6	16	0

NOTE: Units of measure are in mg/l, unless otherwise specified.

[a]*The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Table 56

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-2A: 1968-1975

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	114	53	26	8	- -
Dissolved Oxygen	5.0	9.5	6.1	4.3	8	2[a]
Ammonia-N	2.5	1.11	0.29	0.03	7	0
Organic-N	- -	1.50	1.00	0.15	7	- -
Total-N	- -	- -	- -	- -	- -	- -
Specific Conductance (:S/cm)	- -	- -	- -	- -	- -	- -
Nitrite-N	- -	- -	- -	- -	- -	- -
Nitrate-N	0.30	0.26	0.11	0.01	5	0
Soluble Orthophosphate-P	- -	- -	- -	- -	- -	- -
Total Phosphorus	0.10	0.44	0.26	0.12	7	7
Fecal Coliform (MFFCC/100ml)	400	2,300	520	50	8	2
Temperature (°F)	89.0	82.4	73.4	60.8	8	0
Hydrogen Ion Concentration	6-9	8.2	7.9	7.7	8	0

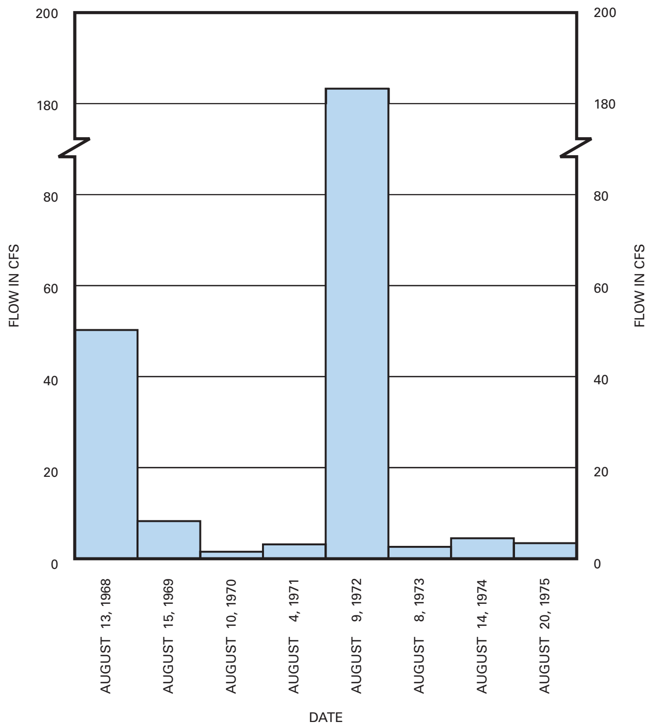
NOTE: Units of measure are in mg/l, unless otherwise specified.

[a]*The concentrations were below the water quality standard of 5.0 mg/l for dissolved oxygen.*

Source: SEWRPC.

Figure 36

FLOW MEASUREMENT IN THE DES PLAINES RIVER WATERSHED AT USGS STATION DP-4b ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: U.S. Geological Survey.

Dissolved Oxygen

During the 1968-1975 sampling period, for the watershed as a whole, the dissolved oxygen concentrations in the Des Plaines River stream system in August were 2.6 mg/l to 13.2 mg/l. The average dissolved oxygen concentrations for the eight-year period were 7.1 mg/l and 6.9 mg/l for the Des Plaines River stations Dp-2 and Dp-3; the average dissolved oxygen concentration for Brighton Creek was 7.1 mg/l. Although the eight-year summer average dissolved oxygen concentrations were above 5.0 mg/l for all three locations, the dissolved oxygen concentrations were lower than 5.0 mg/l at Dp-1, Dp-2, and Dp-3 on several occasions during 1968-1975. Substandard levels of dissolved oxygen concentrations occurred in 10, eight, and 13 of the 30 samples collected at each sampling station Dp-1, Dp-2, and Dp-3, respectively.

The 11-year (1965-1975) monthly sample data provided by the Wisconsin Department of Natural Resources from station Dp-2a, located between Commission stations Dp-2 and Dp-3, indicated that the dissolved oxygen concentrations were generally lower during the months of June and July than during August. Similar results, i.e., lower dissolved oxygen concentrations in the months of June and July than in August, were observed in the samples collected by the Commission during the 1964-1965 bench mark study. These results from the Wisconsin Department of Natural Resources and the Commission benchmark study indicated that, for the years 1968 through 1975, the concentrations of dissolved oxygen at stations Dp-1 through Dp-3 could have been lower in June or July than those measured in August.

Temperature

During the 1968-1975 sampling period, as indicated in Tables 53 through 56, the temperature of the stream water of the watershed remained below the 89ºF standard established for fish and aquatic life, except during one sampling date, that of August 10, 1970. No trend in temperature variation was observed from August 1964 through 1975, although seasonal fluctuations were noted.

Fecal Coliform Bacteria

During the 1968-1975 sampling period, the fecal coliform counts were found to be in the range of 70 Membrane Filter Fecal Coliform Counts per 100 milliliters (MFFCC/100 ml) to 2,300 MFFCC/100 ml for the two stations of the Des Plaines River. The water samples collected by the Wisconsin Department of Natural Resources at DNR Dp-2a had fecal coliform counts in the range of 50 MFFCC/100 ml to 2,300 MFFCC/100 ml. The fecal coliform counts at the sampling station Dp-1, located on Brighton Creek, were found to be in the range of 30 MFFCC/100 ml to 7,600 MFFCC/100 ml. The average fecal coliform counts at sampling stations Dp-1, Dp-2, Dp-3, and DNR Dp-2a were 1,185 MFFCC/100 ml, 774 MFFCC/100 ml, 391 MFFCC/100 ml, and 520 MFFCC/100 ml, respectively. The water samples collected in August 1968 showed fecal coliform counts of 1,200 MFFCC/100 ml and 700 MFFCC/100 ml at sampling stations Dp-2 and Dp-3, respectively, on the Des Plaines River and 7,000 MFFCC/100 ml at sampling station Dp-1 on Brighton Creek. On the other hand, the water samples collected in 1975 had fecal coliform counts in the range of 465 MFFCC/100 ml to 835 MFFCC/100 ml at all three sampling locations. At the sampling station DNR Dp-2a, the fecal coliform counts were 2,300 MFFCC/100 ml on

August 27, 1968, and decreased to 480 MFFCC/100 ml in the sample collected on August 27, 1975. When 1968 and 1975 samples were compared, a decrease in the fecal coliform counts was observed at sampling stations Dp-l, Dp-2 and DNR Dp-2 and the water quality remained the same at Dp-3. No significant change in the fecal coliform counts was noted at sampling station Dp-3 over the eight years of the study period. The decrease in the fecal coliform counts at sampling station Dp-1 was most probably associated with the improvement of the sewage treatment plant at the Village of Paddock Lake and the installation of sewage collection and treatment facilities of the Town of Salem Sewer Utility District No. 1 in 1966.

Hydrogen Ion Concentrations (pH)

During the 1968-1975 sampling period, as indicated in Tables 53 to 56, the pH values of the watershed surface water system were generally within the range of 6.0 and 9.0 standard units prescribed for recreational use and maintenance of fish and aquatic life. No trend in pH variation of the samples collected in August 1964 through 1975 was observed.

Specific Conductance

During the 1968-1975 sampling period, specific conductance, a measure of total dissolved ions in water, was in the range of 553 µS/cm to 1,250 µS/cm at 25ºC for the three locations on the Des Plaines River on the days sampled between 1968 and 1975 in August. The highest specific conductance value was found at sampling station Dp-2 in August 1974. No specific pattern of change in the conductance values was seen at sampling stations Dp-2 and Dp-3 over the years 1968 through 1975, although the variation with time generally followed a similar pattern for sampling stations Dp-2 and Dp-3. At the Brighton Creek sampling station Dp-1, a decreasing trend was observed in the specific conductance levels. This, in association with the corresponding decrease over time in total phosphorus and total nitrogen values at sampling station Dp-1, indicated a favorable effect on water quality of the increased capacity of the Paddock Lake Sewage Treatment Plant and the 1966 installation of the sewage treatment plant for the Town of Salem Sewer Utility District No. 1.

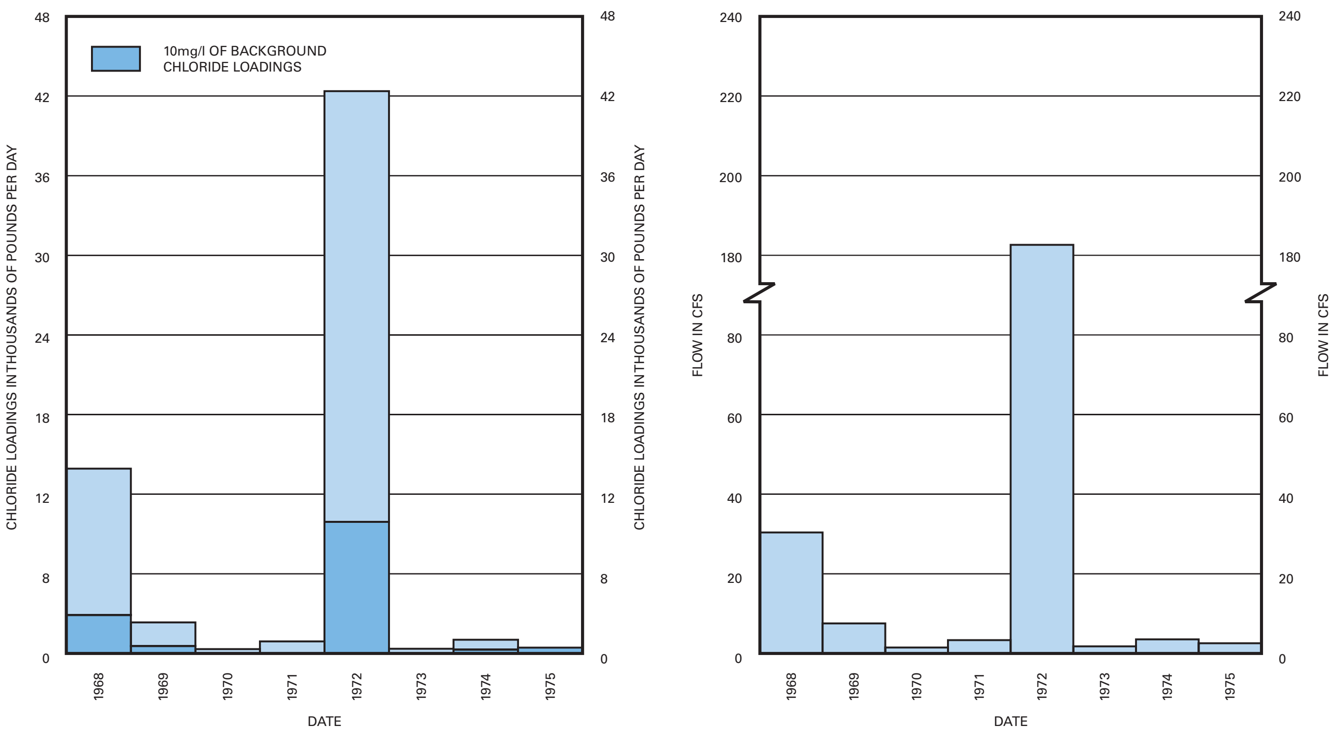
Chloride

During the 1968-1975 sampling period, chloride concentrations were found to range from 7 mg/l to 168 mg/l in the samples collected at the stations on the Des Plaines River. During those years, the water samples collected by the Wisconsin Department of Natural Resources at DNR Dp-2a had chloride concentrations in the range of 32 mg/l to 114 mg/l. The chloride concentrations at the sampling station located on Brighton Creek, Dp-1, were found to range from 6 mg/l to 38 mg/l. The average chloride concentrations of the samples collected over the eight years of the study period at sampling stations Dp-2, DNR Dp-2a, and Dp-3 were 62, 53, and 51 mg/l, respectively, significantly higher than the area groundwater chloride concentrations of approximately 10 mg/l. The high chloride concentrations at sampling station Dp-2 indicated that the source of chloride was located upstream from the sampling location. Brighton Creek, which meets the Des Plaines River upstream of sampling station Dp-2, was found to have an average chloride concentration of 18 mg/l and therefore accounted for only a third of the chloride levels found in the Des Plaines River at station Dp-2. The other possible sources of chloride located upstream of sampling station Dp-2 were the four industries: Culligan Water Conditioning Company, discharging backwash water; Bardon Rubber Products Company; Wisconsin Rubber Products Company; and Plastic Parts, Inc., discharging cooling waters; and the de-icing road salt which percolated and was discharged into the stream water through tile drainage from the agricultural land.

A comparison of the chloride concentrations in April 1968 with August 1968, and in April 1969 with August 1969, indicated higher chloride concentrations in the August samples of the Des Plaines River and Brighton Creek. Although the chloride concentrations were higher in the August samples in 1968 and 1969 at Dp-3, the chloride loadings were significantly higher in the April samples. The higher chloride loadings during high flow in April at Dp-3 were related to the spring runoff from the pasture land and from de-icing salt from the highways located near the sampling station. No change in chloride concentrations was seen when the August 1968 and 1975 data were compared for the samples collected from stations Dp-1 and Dp-3, but a decrease in chloride concentrations was observed at Dp-2. At sampling station Dp-1 on Brighton Creek and Dp-3 on the Des Plaines River, the chloride concentrations generally remained constant over the study period. At sampling stations Dp2 and DNR Dp-2a, no specific trend was observed. If, as it was assumed, the chloride contribution from the sewage treatment plants remained constant, the chloride loadings in the stream would not have been expected to vary with

Figure 37

COMPARISON OF FLOW MEASUREMENTS AND CHLORIDE LOADINGS IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

the flow of the River. The fact that the chloride loading did vary with the flow at Dp-3 indicated that chloride had significant sources other than sewage effluent and it was determined that these sources probably lay in the area tributary to Dp-2. As shown on Figure 37, the occurrence of relatively high chloride concentrations, along with high stream flows in 1972, raised the possibility of the origin of chloride being associated with stormwater runoff. The background chloride loadings, assuming a maximum background chloride concentration of 10 mg/l, are included in Figure 37 and illustrate the fact that the increased chloride loadings in all the samples at Dp-3 were three to 10 times higher than the background loadings assumed.

Soluble and Total Phosphorus

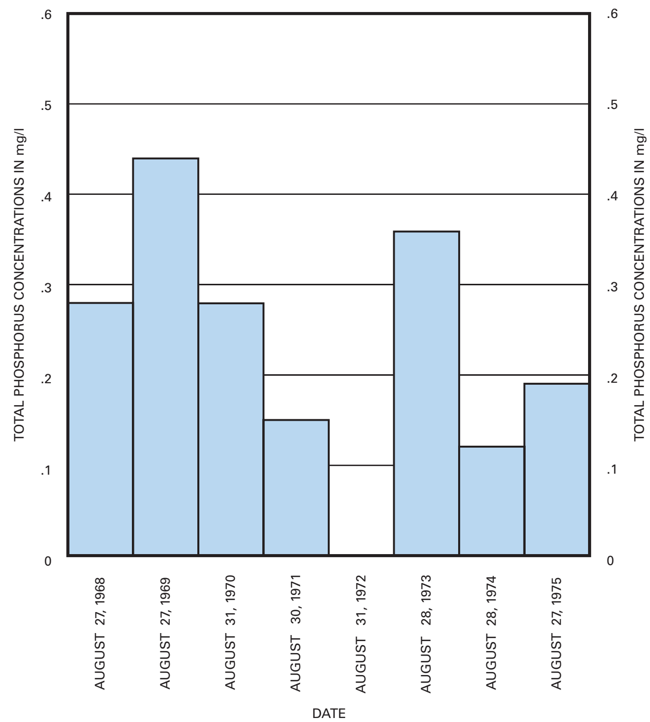
During the 1968-1975 sampling period, water samples collected from the two Des Plaines River sampling locations and one sampling station on Brighton Creek during August were analyzed for soluble orthophosphate concentrations. A range of 0.02 mg/l to 0.23 mg/l of soluble phosphorus was obtained for the eight samples at the three locations. During the years 1972 through 1975, the water samples also were analyzed for total phosphorus and a range of phosphorus concentrations of 0.05 mg/l to 0.52 mg/l was obtained. The high ratio of soluble phosphorus—ranging from 0.5 to 1.0—to total phosphorus in the water samples indicated that most of the phosphorus was in a form readily available for the growth of aquatic plants in the Des Plaines River and Brighton Creek. Although not enough samples were available in the four years of data to characterize the trends in the total phosphorus concentrations with time, especially with the 1972 sample having been taken soon after a heavy rain, it was evident from the data that the concentrations were many times higher than those required for excessive algal growth. A level of total phosphorus of 0.10 mg/l generally is held to be sufficiently high to cause the nuisance growth of algae and other aquatic plants in flowing waters. All water samples from the Des Plaines

River had total phosphorus levels higher than 0.10 mg/l. In Brighton Creek seven or eight samples had total phosphorus levels higher than 0.10 mg/l. The August 1968 through 1975 data from the Des Plaines River water samples at DNR Dp-2a also had total phosphorus values higher than 0.10 mg/l as P, with a range of 0.12 mg/l to 0.44 mg/l. As indicated in Figure 38, no specific trend in the total phosphorus data obtained in August for the years 1968 through 1975 at DNR Dp-2a was observed.

Since the total phosphorus loadings followed the flow pattern—in that the high flow of 1972 had increased total phosphorus loadings in the River—and since additional data are only available for three years, no attempt was made to characterize the trend in the total phosphorus loadings in the River. However, the soluble phosphorus data which were available for the years 1968-1975, and which are presented in Figure 39, indicated soluble phosphorus loadings of less than 10 pounds per day except for the year 1972 during a period of high flow. Since the soluble phosphorus concentrations accounted for 50 to 100 percent of the total phosphorus concentrations, it was likely that the total phosphorus loadings also remained low over the eight years of the study. The increase in phosphorus in conjunction with the increase in flow indicated that the increased phosphorus load was probably due to agricultural runoff.

Figure 38

TOTAL PHOSPHORUS CONCENTRATIONS AT SAMPLING STATION DNR DP-2a IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

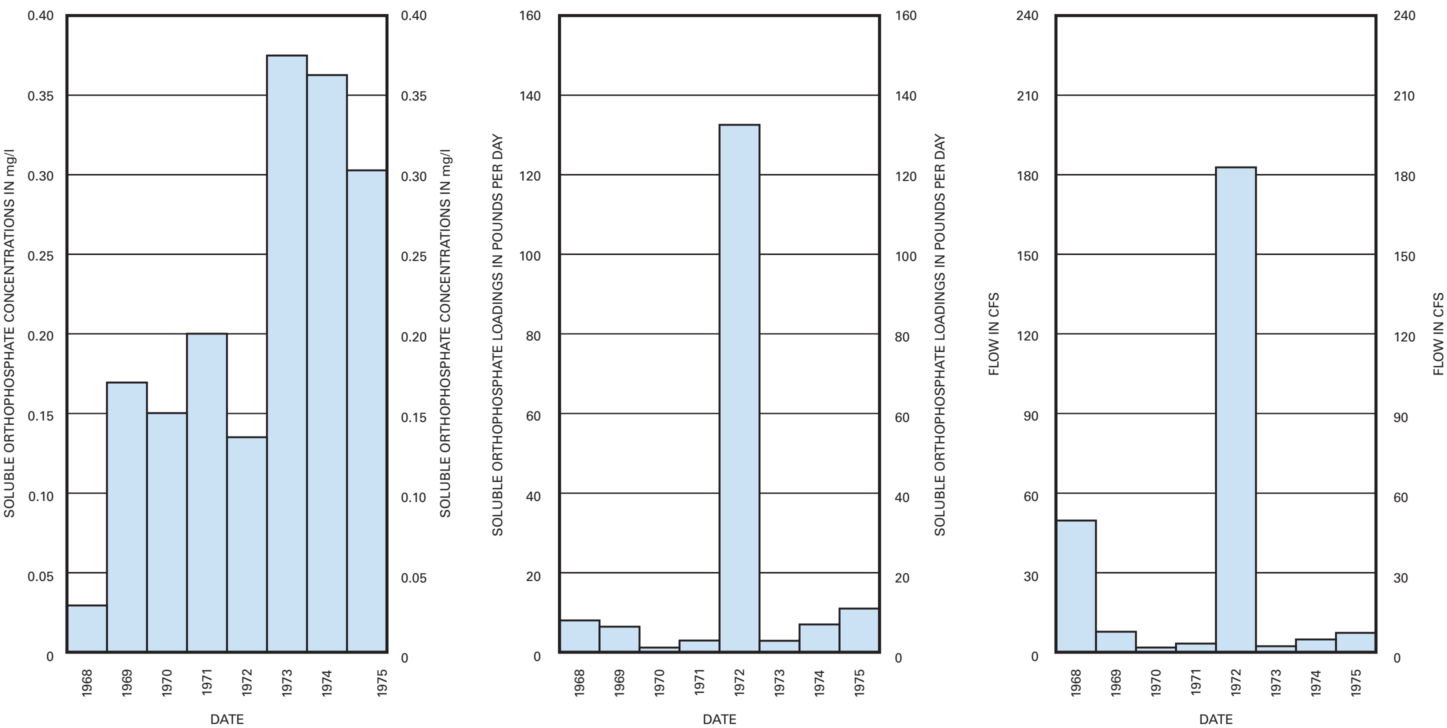
Nitrogen

During the 1968-1975 sampling period, total nitrogen concentrations in the Des Plaines River water samples collected during August were in the range of 0.11 mg/l to 3.70 mg/l as N, and, of these, 1 to 9 percent was in the form of nitrite-nitrogen, 0 to 25 percent as ammonia-nitrogen, 6 to 50 percent as nitrate-nitrogen, and 48 to 85 percent as organic nitrogen, with 18 to 45 percent of the total nitrogen present in the readily available form of nitrate- and ammonia-nitrogen. Nitrates are obtained as the end product of aerobic degradation of proteinaceous materials (organic nitrogen), nitrites are the byproducts of bacteriological action upon ammonia and nitrogenous substances, and ammonia is the chief decomposition product from plant and animal proteins. The presence of ammonia-nitrogen in the stream water is chemical evidence of pollution of recent origin. In the presence of oxygen, ammonia is transformed into nitrite and ultimately into nitrate. The concentrations of ammonia-nitrogen in the Des Plaines River and Brighton Creek sampling sites ranged from 0.03 mg/l to 0.44 mg/l, well below the known toxic level of 2.5 mg/l for ammonia-nitrogen. Similarly, the ammonia-nitrogen at DNR Dp-2a was low and in the range of 0.03 mg/l to 0.57 mg/l. On five of the 24 sampling dates the ammonia-nitrogen levels exceeded the 0.2 mg/l, generally held to be indicative of lakes and streams affected by pollution.

Nitrate-nitrogen concentrations in the Des Plaines River watershed ranged from 0.03 mg/l to 2.20 mg/l as N. Surface runoff from fields where there has been excessive or improper applications of natural or artificial fertilizers can contribute significant quantities of nitrate to streams. Nitrates are also present in treated municipal wastes and enter the receiving streams with the discharged effluent. For the samples collected at station Dp-1 in Brighton Creek during the years 1968-1975, all but one had a nitrate concentration of less than the recommended level of 0.30 mg/l of nitrate-nitrogen. On the other hand, at sampling stations Dp-2 and Dp-3, the concentration of nitrate-nitrogen remained higher than 0.30 mg/l during more than 50 percent of the sampling events. The major

Figure 39

COMPARISON OF SOLUBLE ORTHOPHOSPHATE CONCENTRATIONS, LOADINGS, AND FLOW AT SAMPLING STATION DP-3 IN THE DES PLAINES RIVER WATERSHED ON THE DATES OF WATER SAMPLE COLLECTION: 1968-1975



Source: SEWRPC.

land use upstream from sampling station Dp-2 was agricultural and, therefore, the major source of nitrate-nitrogen in the Des Plaines River watershed was considered to be fertilizers and wastes from domestic animals and wildlife.

Organic-nitrogen accounted for 48 to 85 percent of the total nitrogen in the samples collected in the Des Plaines River watershed and is contributed by amino acids, proteins, and polypeptides, all products of biological processes. The presence of organic-nitrogen is directly related to the discharge of organic wastes such as sewage or plant and animal decay products. The organic-nitrogen content was in the range of 0.08 mg/l to 2.98 mg/l with the higher concentrations being found at sampling stations Dp-2 or Dp-3. At sampling station DNR Dp-2a the organic-nitrogen concentrations were in the range of 0.15 mg/l to 1.43 mg/l. The relatively high organic-nitrogen concentrations probably contributed to the reduction of dissolved oxygen concentrations at sampling station Dp-3, since the oxidation step in the decomposition of organic-nitrogen compounds utilizes the oxygen present in the water.

The total nitrogen loadings followed the flow pattern, in that the high flow of 1972 was associated with increased total nitrogen loadings in the Des Plaines River and Brighton Creek. The four years of data that are available are insufficient to characterize a trend in the total nitrogen loading in the River. However, the increase in total nitrogen along with the increase in total phosphorus and flow in the River reaches draining rural areas probably resulted from agricultural runoff and runoff from other rural lands such as woodlands, wetlands, and unused lands. Accordingly, it was assumed that intensification of agricultural practices during the study period probably increased the effects of these sources.

Diurnal Water Quality Changes
Figures 40 through 43 illustrate diurnal changes in temperature, chloride and dissolved oxygen concentrations, and pH that occurred during low flow conditions on August 10, 1970, at the Des Plaines River sampling stations. The rate of flow on August 10, 1970, was 1.1 cubic feet per second (cfs) in the Des Plaines River, or about 11 times the seven-day, 10-year low flow (0.1 cfs).

Water temperature ranged from a low of 51ºF and 68ºF during the early morning hours on August 10 to a high of 65ºF and 90ºF during the early evening hours of that day, for Brighton Creek and the Des Plaines River, respectively. The difference in the temperature between Brighton Creek and the Des Plaines River, measured at approximately the same time of the day, was significant. The water in Brighton Creek had its source in densely vegetated marshes, and sampling station Dp-1 was located in a wooded and consequently shaded area. These factors combined to keep the water temperature significantly lower at sampling station Dp-1 than at sampling stations Dp-2 or Dp-3 which were located on the Des Plaines River on agricultural lands downstream from the confluence of Brighton Creek with the Des Plaines River. The recorded diurnal water temperature fluctuations at all three stations were probably due to corresponding diurnal variations in air temperature and solar radiation.

Chloride concentrations ranged from a high of 9 mg/l and 92 mg/l during the early morning hours to a low of 6 mg/l and 89 mg/l during the evening of August 10, 1970, in Brighton Creek and the Des Plaines River, respectively. The significant difference in the chloride concentrations between the samples taken at Brighton Creek and the samples taken on the Des Plaines River, indicated that the predominant source of chloride for Brighton Creek was probably the groundwater, while some external sources were the cause of significantly increased concentrations in the main stem of the Des Plaines River.

The concentrations of dissolved oxygen varied from a low of 3.8 mg/l during the early morning hours to a high of 12.5 mg/l in the late evening hours at sampling station Dp-1 in Brighton Creek. In view of the extreme diurnal variations, the low early morning dissolved oxygen concentrations were attributed to respiration by algae and other aquatic plants and animals as well as to the biochemical oxygen demand from organic sources entering Brighton Creek. The early morning hour dissolved oxygen concentrations at sampling stations Dp-1, Dp-2, and Dp-3 sampled within half an hour were 3.8 mg/l, 3.5 mg/l, and 2.0 mg/l, respectively. The lower dissolved oxygen concentrations at sampling stations Dp-2 and Dp-3 compared to sampling station Dp-1 indicated a source of oxygen-demanding substances between sampling stations Dp-1 and Dp-2. The dissolved oxygen content at all three stations increased considerably during the daytime and were attributed to the net photosynthetic production of oxygen by algae and other aquatic plants as well as to the atmospheric reaeration of the stream water.

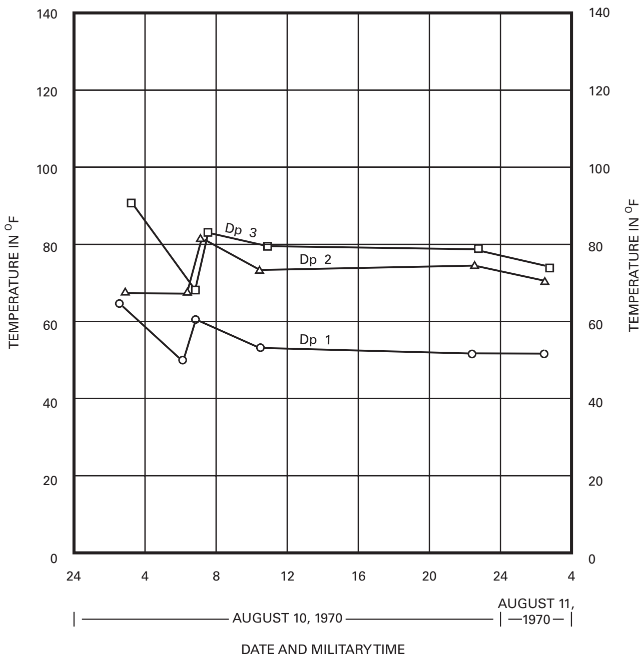
The hydrogen ion concentration (pH) varied from a low of 7.8 standard units during the early morning hours of August 10 to a high of 8.6 standard units in the late evening. The uptake of carbon dioxide during photosynthesis and the release of carbon dioxide during respiration by algae and aquatic plants probably accounted for the higher pH in the late evening samples and for the lower pH during the early morning hours.

A practical consequence of diurnal water quality fluctuations was that, while the average level of concentration of key parameters may have met the established water quality standards for recreational use and for preservation of fish and aquatic life, the lower levels during the daily cycle may not have met the standards. For example, the averages of six dissolved oxygen concentration values on August 10, 1970, were 5.6 mg/l and 6.7 mg/l for Dp-1 and Dp-2, and well above the minimum standard of 5.0 mg/l for recreational use and the preservation of fish and aquatic life. However, substandard oxygen levels of less than 4.0 mg/l were measured in the early morning and late evening samples taken.

Spatial Water Quality Changes
The water quality surveys clearly indicated that the water quality conditions changed from one location to another in the watershed stream system in response to a combination of human activities and natural phenomena. A comparison of the average data for the sampling stations Dp-2 and Dp-3 indicated lower specific conductance, chloride concentrations, and fecal coliform counts at Dp-3 than at Dp-2, reflecting an improvement in water

Figure 40

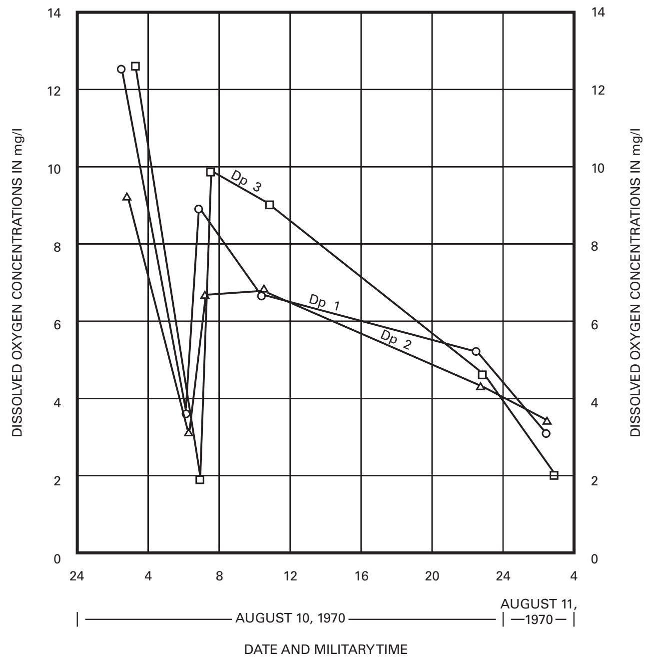
DIURNAL VARIATIONS IN TEMPERATURES RECORDED AT SAMPLING STATIONS DP-1, DP-2, AND DP-3 IN THE DES PLAINES RIVER WATERSHED: AUGUST 10 AND 11, 1970



Source: SEWRPC.

Figure 41

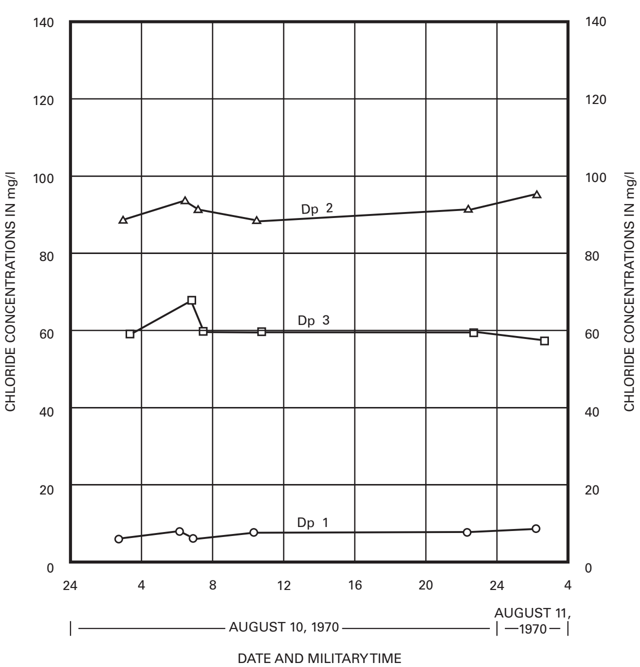
DIURNAL VARIATIONS IN DISSOLVED OXYGEN CONCENTRATIONS AT SAMPLING STATIONS DP-1, DP-2, AND DP-3 IN THE DES PLAINES RIVER WATERSHED: AUGUST 10 AND 11, 1970



Source: SEWRPC.

Figure 42

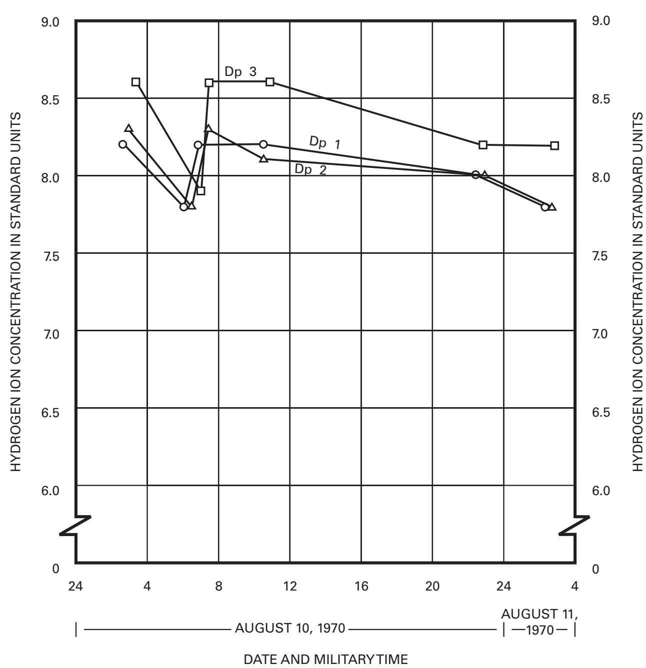
DIURNAL VARIATIONS IN CHLORIDE CONCENTRATIONS AT SAMPLING STATIONS DP-1, DP-2, AND DP-3 IN THE DES PLAINES RIVER WATERSHED: AUGUST 10 AND 11, 1970



Source: SEWRPC.

Figure 43

DIURNAL VARIATIONS IN HYDROGEN ION CONCENTRATIONS (pH) RECORDED AT SAMPLING STATIONS DP-1, DP-2, AND DP-3 IN THE DES PLAINES RIVER WATERSHED: AUGUST 10 AND 11, 1970



Source: SEWRPC.

quality from sampling station Dp-2 to Dp-3 on the main stem of the Des Plaines River. However, the averages for total phosphorus and dissolved oxygen indicated an increase from sampling station Dp-2 to sampling station Dp-3 and a decrease from sampling station Dp-2 to sampling station Dp-3, respectively. Thus, the overall water quality improvement for some indicators at sampling station Dp-3 over Dp-2 was offset by the changes in total phosphorus and dissolved oxygen, resulting in no overall improvement in water quality between stations. A comparison of the water quality data at sampling station Dp-1 on Brighton Creek and at sampling station Dp-2 on the Des Plaines River located downstream from the confluence point of Brighton Creek with the Des Plaines River indicated lower average specific conductance, and chloride and total nitrogen concentrations at Dp-1. The decreasing trend in water quality from Dp-1 in Brighton Creek to Dp-2 in the Des Plaines River in an area of low population density and with predominantly agricultural land use indicated that the pollution sources tributary to Dp-2 were probably agricultural, including runoff from crop and pasture lands and animal feedlots, wastes from domestic animals, decay of leaf and plant residues, and nutrients, herbicides, and pesticides applied to the land. Since much of the soil in the Des Plaines River watershed is poorly drained, subsurface tile drainage systems are used extensively to speed the flow of water from the cultivated fields; the runoff from these systems may carry relatively high loads of soluble compounds such as chlorides and nitrogen compounds.

Concluding Statement

The comprehensive water quality data obtained from the summer low flow samples between 1964 and 1975 were used to assess the quality of the Des Plaines River stream network. This provided an assessment of water quality as it existed on the days sampled between 1964 and 1975, and allowed for an evaluation of the water quality changes compared to the water quality standards that support the recreational use objectives, as well as the fish and aquatic life use objectives established for the streams of the Des Plaines River watershed. The comparative analysis considered the concurrent hydrologic conditions since the water quality standards are not intended to be satisfied under all stream flow conditions. The data for the daily stream flow at Russell, Illinois, on the Des Plaines River indicated that watershed stream flows during all surveys were in excess of the seven-day, 10-year low flow, and, therefore, the water quality standards were to have been met.

The comparison of observed water quality and the adopted water quality standards was based on seven parameters: temperature; pH; fecal coliform bacteria counts; and dissolved oxygen, total phosphorus, ammonia, and nitrate concentrations. Critical limits on the first four parameters are explicitly set forth in the standards adopted by the State of Wisconsin, whereas critical values of the last three parameters are recommended levels which were adopted by the Commission. In the analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, did not fall within the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. A precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated.[9]

WATER QUALITY—1975

Water quality conditions during August 1975 were such that the ammonia concentration, temperature, and pH standards were satisfied throughout the watershed while substandard levels of dissolved oxygen, nitrate, total phosphorus, and fecal coliform observations were recorded. Substandard dissolved oxygen concentrations—less

[9]*The fecal coliform bacteria standard for the recreational water use objective states that the fecal coliform count shall not exceed a monthly geometric mean of 200 colonies per 100 ml, based on not less than five samples per month, nor shall the count exceed a monthly geometric mean of 400 colonies per 100 ml in more than 10 percent of all samples during a month. Inasmuch as the surveys did not include the requisite large number of samples taken over a one-month period, the fecal coliform bacteria standards associated with the recreational use objective were assumed to be violated during a particular survey at a location if any of the fecal coliform counts obtained at that location exceeded 400 colonies per 100 ml.*

than 5.0 mg/l at sampling station Dp-2 and less than 2.0 mg/l at sampling station Dp-3—occurred on the Des Plaines River. The fecal coliform limit of 400 colonies per 100 ml was exceeded at the two sampling locations on the main stem. For Brighton Creek, substandard dissolved oxygen and fecal coliform counts greater than 400 MFFCC/100 ml were observed. Total phosphorus concentrations were in excess of the level recommended by the Commission—0.10 mg/l—applicable throughout the entire length of the Des Plaines River and Brighton Creek. Total phosphorus levels in excess of 0.10 mg/l on the Des Plaines River were attributed in part to the agricultural runoff and in part to the discharges from the municipal sewage treatment plants located between the sampling stations Dp-2 and Dp-3. Nitrate-nitrogen in excess of 0.30 mg/l existed at Dp-3. The high nitrate-nitrogen and high total phosphorus concentrations at Dp-2 and Dp-3 generally could be attributed to the runoff from agricultural land uses.

Southeastern Wisconsin Regional Planning Commission
Regional Water Quality Management Plan: 1976

During the preparation of the adopted regional water quality management plan, the Regional Planning Commission conducted additional stream water quality sampling at sampling stations Dp-2 and Dp-2a during September and October 1976. Under this program, daily or multiple-daily samples were taken at the two stations. The samples were analyzed for selected chemical, physical, and biological characteristics to determine the then-existing condition of stream water quality in relation to pollution sources, land use, and population distribution and concentration. The study procedure and results are presented in SEWRPC Planning Report No. 30, *A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, Volumes One and Two*, published in September 1978 and February 1979, respectively.

Findings of the Study

Tables 57 and 58 present a synopsis of dry weather water quality conditions in the Des Plaines River as determined by the Regional Planning Commission in the 1976 sampling. Water quality conditions, based on dissolved oxygen, total and dissolved phosphorus, total organic and inorganic nitrogen, and chloride concentrations; biochemical oxygen demand; temperature; total coliform bacteria counts; and specific conductance are set forth below.

Dissolved Oxygen

During the 1976 sampling period, the dissolved oxygen levels in the watershed were found to range from 4.1 mg/l to 13.1 mg/l, with an average of 6.8 mg/l at stations Dp-2 and Dp-2a. These concentrations are within the range of concentrations observed during the previous water quality surveys. Samples regularly exhibited an oxygen concentration of below 5.0 mg/l. In general, the adopted regional water quality management plan recommended only minimum diffuse source controls to satisfy the warmwater fishery and aquatic life dissolved oxygen standard of 5.0 mg/l within the Des Plaines River watershed despite the severe dissolved oxygen problems which were indicated in all analysis areas except the upper Brighton Creek and the upper Salem Branch subwatersheds. These problems were caused by high oxygen demand from bottom deposits and benthic organisms, and were estimated to be primarily attributable to historical and existing contributions from both point and diffuse sources. It was concluded that control of the point sources and the implementation of minimum diffuse source controls as provided for in the plan would be likely to either stabilize these bottom deposits or facilitate their assimilation within the stream system. A 50 percent reduction in the oxygen demand from the bottom deposits was determined as necessary to achieve the desired level of dissolved oxygen throughout the Des Plaines River watershed.

Biochemical Oxygen Demand

During the 1976 sampling period, the biochemical oxygen demand (BOD) in the Des Plaines River at stations Dp-2 and Dp-2a was found to range from 0.0 mg/l to 9.0 mg/l. These values exceeded the range of concentrations observed during the 1964-1965 water quality surveys, wherein BOD values, based on four samples, ranged from less than 0.5 mg/l to 2.4 mg/l. No comparable data were available for the 1968-1975 sampling period. As the range of values observed during the 1976 sampling program included the ranges of values measured during the 1964-1965 sampling period, these values were perhaps a better index of the range of BOD concentrations that could have been expected in the Des Plaines River.

Table 57

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-2: 1976[a]

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	273	104	25	34	- -
Dissolved Oxygen	5.0	13.1	6.9	4.2	34	7
Ammonia	2.5	0.25	0.11	0.03	34	0
Organic-N	- -	2.0	1.1	0.5	34	- -
Total-N	- -	2.6	1.4	0.6	34	- -
Specific Conductance (:S/cm)	- -	1,478	911	347	34	- -
Nitrite-N	- -	0.20	0.03	0.003	34	- -
Nitrate-N	0.30	0.46	0.76	0.04	34	4
Soluble Orthophosphate-P	- -	0.18	0.05	0.01	34	- -
Total Phosphorus	0.10	1.29	0.18	0.07	34	29
Temperature (°F)	89.0	80.0	62.0	53.0	34	0
Biological Oxygen Demand	- -	9.0	3.4	0.0	34	- -
Lead	400	4,300	570	10	34	16

NOTE: Units of measure are in mg/l, unless otherwise specified.

[a]*Samples taken from September 7 through October 6, 1976.*

Source: SEWRPC.

Table 58

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-2A: 1976[a]

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	72	37	26	34	- -
Dissolved Oxygen	5.0	8.9	6.7	4.1	34	3
Ammonia-N	2.5	0.28	0.09	0.03	34	0
Organic-N	- -	1.8	0.9	0.1	34	- -
Total-N	- -	2.5	1.3	0.7	34	- -
Specific Conductance (:S/cm)	- -	1,197	987	790	34	- -
Nitrite-N	- -	0.08	0.03	0.01	34	- -
Nitrate-N	0.30	0.57	0.23	0.04	34	9
Soluble Orthophosphate-P	- -	0.19	0.06	0.02	34	- -
Total Phosphorus	0.10	0.44	0.17	0.09	31[b]	29
Temperature (°F)	89.0	94.0	64.0	54.0	34	0
Biological Oxygen Demand	- -	7.2	3.9	1.0	34	- -
Lead	400	3,600	670	40	34	13

NOTE: Units of measure are in mg/l, unless otherwise specified.

[a]*Samples taken from September 7 through October 6, 1976.*

[b]*No data reported on September 9, 21, and 29, 1976.*

Source: SEWRPC.

Temperature

During the 1976 sampling period, the temperature of the Des Plaines River was found to range from 53ºF to 84ºF, consistent with the temperature ranges observed during the previous studies in the autumnal months. The temperature standard of 89ºF was satisfied within the Des Plaines River watershed; the temperature standard was not expected to be exceeded more than one percent of the time.

Fecal Coliform Bacteria

During the 1976 sampling period, fecal coliform levels in the Des Plaines River were found to vary from 10 MFFCC/100 ml to 4,300 MFFCC/100 ml. These levels are within the range of concentrations observed during the previous water quality surveys, although the minimum value of 10 MFFCC/100 ml observed in 1976 was lower than the minimum values reported in the previous studies. Nevertheless, all water quality analysis areas within the Des Plaines River watershed were expected to satisfy a fecal coliform standard of 200/400 MFFCC/100 ml under a diffuse source pollutant loading reduction of 50 percent.

Specific Conductance

During the 1976 sampling period, the specific conductance of the surface waters of the Des Plaines River watershed was found to range from 347 μS/cm to 1,478 μS/cm at stations Dp-2 and Dp-2a. These values exceeded the range of concentrations observed during the previous water quality surveys. The range of values reported during the 1976 survey exceeded that reported in 1964-1965—which ranged from 586 μS/cm to 1,110 μS/cm—and in 1968-1975—which ranged from 553 μS/cm to 1,300 μS/cm. Notwithstanding, the observed mean values of specific conductance at sampling stations Dp-2 and Dp-2a during 1976 were similar to those reported during the earlier surveys, which suggested little overall change in dissolved mineral composition of the waters of the Des Plaines River.

Chloride

During the 1976 sampling period, the chloride concentrations in the Des Plaines River ranged from 25 mg/l to 273 mg/l, with the average value being 70 mg/l for stations Dp-2 and Dp-2a. These concentrations exceeded the range of concentrations observed during the previous water quality surveys, although, consistent with the specific conductance data reported above, the mean chloride concentrations observed during 1976 were similar to those reported during the earlier studies.

Soluble and Total Phosphorus

During the 1976 sampling period, soluble phosphorus concentrations at sampling stations Dp-2 and Dp-2a were found to range from 0.01 mg/l to 0.19 mg/l. Total phosphorus concentrations during the same period ranged from 0.07 mg/l to 1.29 mg/l at the two stations. Both the concentrations and ratio of soluble phosphorus to total phosphorus observed during the 1976 sampling period were similar to those concentrations and values determined during the 1968-1975 sampling period discussed above, although the maximum total phosphorus concentration measured during 1976 exceeded those measured in the previous studies. Generally, the soluble phosphorus concentrations were lower than those measured previously, and the range in phosphorus concentrations during the recent study was at the lower end of the historic observed range, suggesting a reduced influence of point source discharges.

Nitrogen

During the 1976 sampling period, water samples from stations Dp-2 and Dp-2a were analyzed for nitrate-, nitrite-, ammonia-, organic and total nitrogen. Analyses of seasonal variations in un-ionized ammonia nitrogen concentrations in the Des Plaines River watershed indicated that the standard of 0.02 mg/l should seldom be exceeded, and that diffuse source controls would not be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed. Ammonia-nitrogen concentrations during the 1976 sampling period ranged from 0.03 mg/l to 0.28 mg/l. These concentrations are within the range of concentrations observed during the 1968-1975 sampling survey.

Nitrate-nitrogen concentrations ranged from 0.04 mg/l to 0.57 mg/l during the 1976 sampling period. Nitrite concentrations ranged from 0.003 mg/l to 0.20 mg/l. These ranges of concentrations are within the ranges of concentrations observed during the 1968-1975 sampling survey.

Total nitrogen and organic nitrogen concentrations at station Dp-2 and Dp-2a in the Des Plaines River watershed ranged from 0.6 mg/l to 2.6 mg/l, and from 0.1 mg/l to 2.0 mg/l, respectively. These ranges of concentrations are within the ranges of concentration observed during previous sampling surveys of the Des Plaines River.

Concluding Statement

The water quality data obtained from the fall samples collected in 1976 were used to assess the quality of the Des Plaines River. This provided an affirmation of the water quality trends as they existed during the comprehensive water quality sampling programs conducted by the Regional Planning Commission between 1964-1965 and 1968-1975, and allowed for an evaluation of the water quality changes compared to the water quality standards that support the recreational use objectives, as well as the fish and aquatic life use objectives established for the streams of the Des Plaines River watershed.

The comparison of observed water quality and the adopted water quality standards was based on nine parameters: temperature; specific conductance; biochemical oxygen demand; fecal coliform bacteria counts; and dissolved oxygen, total phosphorus, ammonia, nitrate and nitrite concentrations. Critical limits on these parameters either have been explicitly set forth in the standards adopted by the State of Wisconsin or they have been adopted by the Commission. In the analysis for a given survey, the water quality at a sampling site was considered substandard for a given parameter if any of the water quality analyses for that parameter, as obtained over the approximately 24-hour sampling period, did not fall within the specified limits. That is, water quality was assessed on the basis of individual determinations made for each parameter as opposed to using values averaged over the day of the survey. As for the 1965-1975 cooperative study, a precise comparison of observed fecal coliform bacteria concentrations to the specified standards could not be made because of the manner in which the standards are stated.

WATER QUALITY—1976

Water quality conditions during September and October 1976 were such that the ammonia concentration and temperature standards were satisfied throughout the watershed while substandard levels of dissolved oxygen, nitrate, total phosphorus, and fecal coliform observations were recorded. Substandard dissolved oxygen concentrations—less than 5.0 mg/l at sampling stations Dp-2 and Dp-2a—primarily occurred on the Des Plaines River during the nighttime or early morning hours when the respiratory demands of aquatic organisms commonly exceed their oxygen production. The fecal coliform limit of 400 colonies per 100 ml was also exceeded at the two sampling locations. Total phosphorus concentrations were regularly in excess of the level recommended by the Commission—0.10 mg/l—applicable throughout the entire length of the Des Plaines River watershed. Nitrate-nitrogen in excess of 0.30 mg/l existed at both stations. The high nitrate-nitrogen and high total phosphorus concentrations at Dp-2 and Dp-2a generally could be traced to the runoff from agricultural and urban land uses. These findings were consistent with those reported from the 1964-1965 and 1968-1975 studies carried out by the Commission and described above.

U.S. Geological Survey Water Resources Survey: 1977-1991

USGS Water Quality Study: 1977-1991

The majority of the post-1975 water quality data available were collected at the U.S. Geological Survey sampling station No. 05527800 located at Russell Road, Russell, Illinois, and designated as station Dp-4 (see Map 41). That station is located about one-quarter mile south of the Wisconsin-Illinois state line. Water quality data were collected at this station during a 14-year period from November 1977 through September 1991 (water year 1978 through water year 1991).

Findings of the Study

Table 59 presents a synopsis of water quality conditions in the Des Plaines River as determined by the U.S. Geological Survey in the water year 1979 through 1991 sampling. Water quality conditions, based on dissolved oxygen, chemical oxygen demand, temperature, fecal coliform bacteria counts, pH, specific conductance, soluble and total phosphorus concentrations, nitrogen concentrations, and metals are set forth below. Review of these data

Table 59

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATION DP-4: 1977-1991

Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Chloride	- -	175.0	77.3	30.0	16	- -
Dissolved Oxygen	5	22.0	8.6	0.0	124	11
Ammonia	2.5	1.4	0.2	0.0	131	0
Unionized Ammonia	- -	0.0480	0.0025	0.0	128	- -
Total Nitrogen	- -	11.0	2.7	0.0	130	- -
Specific Conductivity (:S/cm)	- -	2,220	934	44	130	- -
Total Phosphorus	0.10	0.70	0.20	0.05	79	65
Fecal Coliform (MFFCC/100 ml)	400	33,500	869	9	120	32
Temperature (°F)	89	82.6	52.6	26.6	131	0
pH	6-9	8.8	7.6	6.2	128	0
Calcium	- -	168.0	93.3	43.0	72	- -
Sulfate	- -	235.0	153.6	52.0	19	- -
Total Lead (:g/l)	1,050/62[a]	100.0	33.5	0.0	111	0[b]
Lead (:g/l)	- -	100.0	37.6	5.0	72	- -
Chromium (:g/l)	14	13.0	5.6	5.0	71	0
Total Chromium (:g/l)	6,061/175[a]	17.0	4.8	0.0	108	0
Cyanide	46	0.020	0.004	0.0	93	0
Chemical Oxygen Demand	- -	105	29.4	9.0	131	- -
Arsenic (:g/l)	364	1.0	0.8	0.0	19	0
Barium (:g/l)	- -	70.0	39.5	19.0	72	- -
Beryllium (:g/l)	- -	2.0	0.7	0.5	72	- -
Boron (:g/l)	- -	231.0	106.0	36.0	71	- -
Total Cadmium (:g/l)	146/2.4[a]	10.0	2.7	0.0	104	0
Cadmium (:g/l)	- -	8.0	3.1	3.0	72	- -
Cobalt (:g/l)	- -	10.0	5.1	5.0	72	- -
Total Copper (:g/l)	64/44[a]	51.0	7.2	0.0	114	0
Copper (:g/l)	- -	48.0	6.4	0.0	72	- -
Iron (:g/l)	- -	305.0	64.7	35.0	72	- -
Manganese (:g/l)	- -	320.0	74.3	5.0	71	- -
Mercury (:g/l)	1.5	0.1	0.0	0.0	8	0
Total Nickel (:g/l)	3,628/222[a]	25.0	6.8	0.0	90	0
Nickel (:g/l)	- -	25.0	6.6	5.0	69	- -
Potassium	- -	9.0	3.8	1.3	72	- -
Silver (:g/l)	- -	5.0	3.1	3.0	71	- -
Strontium (:g/l)	- -	1,728.0	639.0	115.0	69	- -
Sulfate	- -	235.0	153.6	52.0	19	- -
Vanadium (:g/l)	- -	20.0	5.4	5.0	72	- -
Total Zinc (:g/l)	248/167[a]	439.0	73.2	0.0	102	0
Zinc (:g/l)	- -	395.0	75.3	0.0	71	- -

NOTE: Units are in mg/l, unless otherwise specified.

[a]*Acute Toxicity Criteria and Chronic Toxicity Criteria respectively calculated using the method set forth in Chapter NR 105,* Wisconsin Administrative Code*, using an estimated hardness value of 420 mg/l.*

[b]*Based on Acute Toxicity Criterion; Chronic Toxicity Criterion was violated.*

Source: SEWRPC.

indicates that there were no apparent significant changes in water quality conditions from 1979 through 1988, with a possible improvement following 1988 as evidenced by reduced suspended solids, total phosphorus, and ammonia-nitrogen levels and less variability in dissolved oxygen levels. This modest improvement was attributed, in part, to the improvements which were made between 1985 and 1988 to the Paddock Lake, Bristol, and Pleasant Prairie Utility District D sewage treatment plants.

Dissolved Oxygen

During the 1977 to 1991 sampling period, the dissolved oxygen levels in the watershed as measured at station Dp-4 ranged from a minimum of 2.0 mg/l in 1978 and 1986 to a maximum of 22.0 mg/l in 1979. Average concentrations were generally above the minimum dissolved oxygen standard of 5.0 mg/l, although mean dissolved oxygen concentrations of 4.0 mg/l and 4.3 mg/l were recorded in 1987 and 1990, respectively. Minimum dissolved oxygen concentrations exceeded the recommended minimum dissolved oxygen concentration for the maintenance of fish and aquatic life during four of the 13 years. As observed during previous investigations, the lowest concentrations of dissolved oxygen were observed during the summer months of July and August, when concentrations were generally less than 7.0 mg/l. The highest dissolved oxygen concentrations were observed during the fall and winter months, November to March, when concentrations often equaled or exceeded 10.0 mg/l.

Chemical Oxygen Demand

During the 1977-1991 sampling period, values of chemical oxygen demand (COD), or the total amount of chemically oxidizable matter present in the water, ranged from 3.7 mg/l to 100 mg/l. No clear seasonal or inter-annual trends were observed in the data set.

Temperature

During the 1977-1991 sampling period, the temperature of the Des Plaines River at sampling station Dp-4 was found to range from about 26.5ºF to about 85ºF. At no time during the study period did the water temperature exceed the maximum standard of 89ºF. As expected, the highest water temperatures occurred during the summer months, and the lowest during the winter months. The observed low values were recorded during January and February of each year, with the highest value of 85ºF being recorded in July 1991 at station Dp-4. Mean annual temperature appeared to follow an approximate five-year cyclical variation, with mean annual temperatures exceeding 77ºF once every five years.

Fecal Coliform Bacteria

During the 1977-1991 sampling period, fecal coliform bacteria levels in the Des Plaines River ranged from less than 10 MFFCC/100 ml to over 30,000 MFFCC/100 ml. Extreme values were recorded during 1986, when fecal coliform counts of 34,000 MFFCC/100 ml were recorded, and in 1991 when the value of less than 10 MFFCC/100 ml was recorded. Highest fecal coliform bacterial levels were generally observed, as during previous surveys, in late-fall and early-winter, and lowest fecal coliform levels were observed in early-spring. Fecal coliform counts generally exceeded the recommended standard during the period from 1977 to 1987, after which the counts were generally within the recommended standard of 400 MFFCC/100 ml; however, the maximum standard of 200/400 MFFCC/100 ml was exceeded on at least one occasion each year during the study period.

Hydrogen Ion Concentrations (pH)

During the 1977-1991 sampling period, the pH value at station Dp-4 ranged between 6.3 and 8.8 standard units, with the exception of 1978, 1981 and 1985, when the annual average pH values exceeded 8.0 standard units. At no time during the study period did the pH values exceed either the recommended minimum or recommended maximum standards of 6.0 standard units and 9.0 standard units, respectively. The average annual range in pH was usually less than 1 standard pH unit.

Specific Conductance

During the 1977-1991 sampling period, specific conductance of the surface waters of the Des Plaines River was found to range from 44 µS/cm to 1,740 µS/cm at sampling station Dp-4. The lowest values were recorded during spring, April and May, and increased steadily thereafter, reaching their highest values in late summer and fall, August to November. The average conductivity value during this sampling period was 979 µS/cm at sampling station Dp-4, which was higher than, but consistent with, those measured during previous monitoring programs, which indicated that conductivity increased with distance downstream.

Soluble and Total Phosphorus

During the 1977-1991 sampling period, total phosphorus concentrations ranged from 0.07 mg/l to 0.75 mg/l, with average annual total phosphorus concentrations of 0.20 mg/l, 0.37 mg/l, 0.20 mg/l, 0.24 mg/l and 0.10 mg/l being recorded during 1984, 1985, 1989, 1990, and 1991, respectively. With the exception of the minimum total phosphorus concentration of 0.09 mg/l recorded in 1991, total phosphorus concentrations observed during the sampling period at sampling station Dp-4 met or exceeded the recommended maximum phosphorus standard.

Soluble phosphorus concentrations generally ranged from 0.02 mg/l to 0.70 mg/l, or from 40 percent to 80 percent of the total phosphorus concentration, although, during June 1991, this proportion decreased to about 20 percent of the total phosphorus concentration. These observations implied that a major portion of the phosphorus being transported in the Des Plaines River was in the particulate form, or absorbed onto sediments or incorporated into plant material transported by the River waters. Soluble to total phosphorus concentration ratios greater than 50 percent, and approaching 90 percent, suggest that point sources or wastewater discharges may be a significant contributor to the nutrient pool. Ratios below 50 percent imply that the source of phosphorus is from more natural or nonpoint sources. The data obtained at sampling station Dp-4 would suggest that both point and nonpoint sources contributed to the phosphorus pool of the Des Plaines River. This finding was consistent with previous surveys of water quality in the Des Plaines River.

The relatively high total and soluble phosphorus concentrations observed during the water year 1979 through water year 1991 sampling period, which generally met or exceeded the recommended standard of 0.10 mg/l, were sufficiently high to cause the nuisance growth of algae and/or aquatic plants in the flowing waters of the system. Further, the relatively high proportion of soluble phosphorus indicated that the phosphorus pool in the flowing water system was readily available for use by algae and aquatic plants. These data were not dissimilar to the data recorded during the 1965 through 1975 study period, and were consistent with the generally-observed trend of increasing phosphorus concentrations with downstream distance observed during the previous sampling study. As previously stated, no consistent annual trends were observed in the data, although there was a tendency for the concentrations to be lowest during spring and early summer—during peak runoff periods—and higher thereafter, and for the ratios of soluble to total phosphorus to be highest during spring and early summer. Likewise, no consistent inter-annual trends were observed in these data.

Nitrogen

During the 1977-1991 sampling period, samples obtained at sampling station Dp-4 were analyzed for nitrogen fractions by the U.S. Geological Survey; results were reported for nitrate- and nitrite-nitrogen,[10] ammonia-nitrogen (un-ionized ammonia, NH_3), and ammonium-nitrogen (NH_4^+). Ammonia-nitrogen, at concentrations above 0.04 mg/l may be toxic to fishes, and is generally held to be indicative of organic pollution of rivers and streams.

Nitrate- plus nitrite-nitrogen concentrations in the Des Plaines River at sampling station Dp-4 ranged from less than 0.10 mg/l—the limit of detection—to 11.00 mg/l. The lowest concentrations were measured during the summer months of 1991, while the highest values were observed during spring; the peak concentration of 11.00 mg/l was recorded during March 1978. Nitrate- plus nitrite-nitrogen concentrations were generally higher than the recommended standard of 0.30 mg/l of nitrate.

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[10]*Inorganic nitrogen concentrations in freshwaters are generally measured as nitrate (NO_3) plus nitrite (NO_2) concentrations. Nitrite is a transitional product in the denitrification process during which nitrate is converted to nitrogen gas (N_2) by bacterial action, and in the nitrification process wherein ammonia is transformed into nitrate. Because of its transitional nature, it is generally not present in any measurable quantities. Hence, measurement of nitrate plus nitrite concentrations is assumed to adequately reflect to concentration of biologically-available nitrogen—nitrate—in freshwaters (R.G. Wetzel,* Limnology*, Saunders, Philadelphia, 1975).*

Ammonium- and ammonia-nitrogen concentrations ranged from less than 0.001 mg/l—the limit of detection—to 0.032 mg/l, and from 0.02 mg/l to 1.40 mg/l, respectively. The highest concentrations of ammonium were recorded during the winter months, with the lowest values being observed during summer; the highest concentrations of ammonia were generally recorded during summer. At no time during the sampling period was the recommended ammonium standard of 0.04 mg/l violated.

Metals and Other Contaminants

During the 1977-1991 sampling period, the U.S. Geological Survey measured the heavy metal and metallic salt concentrations present in the Des Plaines River at sampling station Dp-4. Concentrations of dissolved aluminum, barium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, strontium, vanadium, zinc and cyanide were measured. For the most part, concentrations of most metals and metal salts were below the limits of detection for the metals analyzed. Exceptions included barium, boron, chromium, copper, iron, manganese, nickel, strontium, vanadium and zinc, which were present in detectable quantities during all or part of the years studied. Because of its greater bioavailability, the concentrations of the dissolved phase of these metals are reported here; values of the total recoverable concentrations for the heavy metals regulated in terms of Chapter NR 105 of the *Wisconsin Administrative Code* are also reported where appropriate and set forth in Table 59, although the total recoverable concentrations of the metals includes the (dominant) particulate phase that is generally less biologically available.[11] Where standards have not been established under Chapter NR 105 of the *Wisconsin Administrative Code*, guidelines are provided based upon accepted ranges in metal concentrations gleaned from the scientific literature;[12] where both standards and guidelines were available, both values have been reported for purposes of comparison. Generally, the literature-based guidelines provided an adequate approximation of the Chapter NR 105 standards. These latter standards are legally enforceable by the Wisconsin Department of Natural Resources, whereas the guidelines are provided for information only.

The recommended acute toxicity standards, set forth in Table 97, for the metals which were present in detectable quantities were not violated, although the recommended standards for chronic toxicity, also set forth in Table 97, were violated on occasion during the study period. Values of these standards were calculated using a typical hardness value measured in the Des Plaines River of 420 mg/l.

Dissolved aluminum concentrations ranged from 0.05 mg/l to 0.48 mg/l, with the highest value being recorded in May 1989. No clear annual trends were observed, with aluminum concentrations generally being less than the limit of detection of 0.05 mg/l in at least half of the samples obtained during any given year. Aluminum concentrations of less than 0.20 mg/l are considered as posing minimal risk of deleterious effects on fish and aquatic life.[13]

Dissolved barium concentrations during the sampling period ranged from 0.021 mg/l to 0.070 mg/l. No clear seasonal trends were observed in the data. Concentrations of barium in freshwaters of less than 0.50 mg/l are considered as posing minimal risk of deleterious effects.[14]

Dissolved boron concentrations ranged from 0.05 mg/l to 0.24 mg/l during the sampling period. Concentrations of dissolved boron were generally highest during fall and winter, and declined during spring and summer, dropping

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[11]*Werner Stumm and James J. Morgan,* Aquatic Chemistry. An Introduction Emphasizing Chemical Equilibria in Natural Waters*, Wiley-Interscience, New York, 1970. pp. 287-288.*

[12]*Frits van der Leeden, Fred L. Troise, and David Keith Todd,* The Water Encyclopedia*, 2nd Edition, Lewis Publishers, 1990, Table 6-50, pp. 467-471.*

[13]Ibid.

[14]Ibid.

below the limits of detection—0.05 mg/l—in about 20 percent of the samples analyzed. Concentrations of dissolved boron of less than 5.0 mg/l are considered as posing minimal risk of deleterious effects.[15]

Dissolved cadmium concentrations exceeded the limit of detection—0.003 mg/l—on one occasion during the sampling period, when a concentration of 0.004 mg/l was recorded at sampling station Dp-4 in November 1990. Although the recommended standard for chronic toxicity is 0.001 mg/l—well below the limit of detection—the applicable guideline for freshwater management purposes is better described by the equation [1.16 (ln hardness in mg/l) - 3.841], which, when solved for sampling station Dp-4 in November 1990, when the hardness was reported as 420 mg/l, results in a recommended guideline of 0.003 mg/l.[16] This is consistent with the State methodology—acute toxicity is determined by the equation $e^{[1.147 (\ln \text{hardness}) - 2.3912]}$ and chronic toxicity by $e^{[0.7852 (\ln \text{hardness}) - 2.9109]}$—and values for total recoverable cadmium set forth in Chapter NR 105 of the *Wisconsin Administrative Code*, which establishes an acute toxicity criterion of 0.093 mg/l and a chronic toxicity criterion of 0.006 mg/l. This would suggest that, during this single sampling period, there was some potential for deleterious impacts to occur, although the likelihood of contamination problems was minimal due to the general compliance of the Des Plaines River water with the guidelines for dissolved cadmium.

Dissolved chromium concentrations at sampling station Dp-4 ranged from 0.005 mg/l to 0.013 mg/l, with about half of the samples being less than the limit of detection—0.005 mg/l. Chromium concentrations were generally below the limits of detection during late-winter and spring, and late-summer. At no time did the dissolved chromium concentration exceed the recommended maximum concentration of 0.011 mg/l.[17] This is consistent with the values—acute toxicity is determined by the equation $e^{[0.819 (\ln \text{hardness}) + 3.7627]}$ and chronic toxicity by $e^{[0.819 (\ln \text{hardness}) + 0.2184]}$—and values for total recoverable chromium set forth in Chapter NR 105 of the *Wisconsin Administrative Code*, which establishes an acute toxicity criterion of 6.061 mg/l and a chronic toxicity criterion of 0.175 mg/l.

Dissolved cobalt concentrations exceeded the limit of detection—0.005 mg/l—on two occasions during the sampling period, when concentrations of 0.009 mg/l and 0.008 mg/l were recorded at sampling station Dp-4 in August 1986 and November 1990.

Dissolved copper concentrations exceeded the limit of detection—0.005 mg/l—on 11 occasions during the sampling period, when concentrations of 0.015 mg/l; 0.009 mg/l; 0.006 mg/l; 0.006 mg/l, 0.006 mg/l, 0.007 mg/l and 0.008 mg/l; 0.008 mg/l and 0.009 mg/l; 0.018 mg/l; and 0.006 mg/l were recorded at sampling station Dp-4 in August 1981; October 1983; October 1985; January, March, August and October 1986; February and July 1988; October 1989; and November 1990, respectively. During 1984 to 1985, the dissolved copper concentrations measured at station Dp-4 regularly exceeded the limits of detection, ranging from 0.006 mg/l to 0.048 mg/l on five occasions during that hydrologic year. These concentrations did not exceed the recommended acute or chronic toxicity criteria of 0.064 and 0.044, respectively—determined by the equations $e^{[0.9422 (\ln \text{hardness}) - 1.531]}$ for acute toxicity and $e^{[0.9422 (\ln \text{hardness}) - 1.8956]}$ for chronic toxicity—set forth in Chapter NR 105 for total recoverable copper, but did violate the recommended guideline concentration for dissolved copper derived from the solution of the equation [0.905 (ln hardness in mg/l) + 3.568], which, when solved for the sampling dates noted above, resulted in a concentration of 0.009 mg/l, in October 1989.[18] Nevertheless, the likelihood of contamination problems would appear to be minimal due to the general compliance of the Des Plaines River water with the guidelines for dissolved copper.

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[15]Ibid.

[16]Ibid.

[17]Ibid.

[18]Ibid.

Dissolved iron concentrations exceeded the limits of detection—0.05 mg/l—on 17 occasions during the sampling period at sampling station Dp-4. Concentrations of dissolved iron were observed at this station in October 1980; August 1981; December 1983; May, July and October 1984; July, October and November 1985; March, August and October 1986; February, April, September and November 1987; January and February 1988; and January and August 1990, when concentrations of 0.60 mg/l; 0.61 mg/l; 0.11 mg/l; 0.09 mg/l, 0.09 mg/l and 0.28 mg/l; 0.31 mg/l, 0.06 mg/l and 0.052 mg/l; 0.068 mg/l, 0.098 mg/l, 0.61 mg/l and 0.051 mg/l; 0.17 mg/l and 0.065 mg/l; 0.08 mg/l, 0.068 mg/l and 0.055 mg/l; and 0.10 mg/l, and 0.09 mg/l were recorded, respectively. Concentrations of iron of less than 0.30 mg/l are not considered as constituting a hazard to aquatic life, with concentrations of less than 0.05 mg/l being considered as posing minimal risk of deleterious effects.[19]

Dissolved manganese concentrations were generally present in concentrations above the limits of detection—0.005 mg/l—and ranged from 0.008 mg/l to 0.380 mg/l during the sampling period. No apparent seasonal trends were observed in the data. Levels of less than 0.02 mg/l are considered to pose minimal risk of deleterious effects.[20] This level was exceeded in all but three samples obtained at sampling station Dp-4, two of which were samples with dissolved manganese concentrations below the limit of detection. The high levels of manganese in the waters of the Des Plaines River are likely to arise from geologic sources within the watershed, although there is a possibility that these high concentrations could indicate organic contamination of groundwaters that results in chemical processes that release this metal.

Dissolved nickel concentrations ranged from 0.006 mg/l to 0.022 mg/l during the study period. About half of the samples analyzed had dissolved nickel concentrations that were below the limits of detection—0.005 mg/l. No seasonal trends could be discerned in the data. Chapter NR 105 sets forth criteria for acute and chronic toxicity for total recoverable nickel derived from the solution of the equations $e^{[0.846 (\ln \text{hardness}) + 3.0865]}$ and $e^{[0.846 (\ln \text{hardness}) + 0.2956]}$, respectively, or 3.628 mg/l and 0.222 mg/l.

Dissolved strontium concentrations ranged from 0.120 mg/l to 1.70 mg/l, with the lowest values being recorded during spring. Strontium concentrations were generally highest during winter.

Dissolved vanadium concentrations exceeded the limit of detection—0.005 mg/l—on four occasions during the sampling period, when concentrations of 0.007 mg/l, 0.020 mg/l, 0.007 mg/l, and 0.006 mg/l were recorded at sampling station Dp-4 in October 1987, July and October 1988, and November 1990, respectively.

Dissolved zinc concentrations exceeded the limits of detection—variously 0.10 and 0.05 mg/l depending on the methodology used by the U.S. Geological Survey—on four occasions during the sampling period, when concentrations of 0.12 mg/l were recorded at sampling station Dp-4 in December 1984, March 1985, and February 1991, and a concentration of 0.15 mg/l was recorded in August 1986. The 0.10 mg/l limit of detection exceeded the recommended guideline of 0.0892 mg/l for chronic toxicity, as did the concentration of zinc measured in February 1991 at sampling station Dp-4.[21] At no time, however, did the concentrations of zinc exceed the recommended guideline for acute toxicity of 0.0892 mg/l; further, concentrations of total zinc of less than 0.18 mg/l are considered as posing minimal risk of deleterious impacts on freshwater organisms.[22] Chapter NR 105 sets forth the acute and chronic toxicity criteria for total recoverable zinc as the solutions to the equations $e^{[0.8473 (\ln \text{hardness}) + 0.7352]}$ and $e^{[0.8473 (\ln \text{hardness}) + 0.0019]}$, or 0.348 mg/l and 0.167 mg/l, respectively.

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[19]Ibid.

[20]Ibid.

[21]Ibid.

[22]Ibid.

Wisconsin Department of Natural Resources Survey: 1999-2001

WDNR Baseline Monitoring Program: 1999-2001

The Wisconsin Department of Natural Resources implemented their baseline monitoring program during the period beginning in 1999. While including a number of sampling locations within the Des Plaines River Basin and its tributary stream system, the Baseline Monitoring Program included the collection of data from stations Dp-1 on Brighton Creek, Dp-2 and Dp-2a, both on the main stem of the Des Plaines River (see Map 41). Water quality data were collected at these stations during an initial three-year period from July 1999 through November 2001.

Findings of the Study

Table 60 presents a synopsis of water quality conditions in the Des Plaines River as determined by the Wisconsin Department of Natural Resources in the 1999 through 2001 baseline monitoring sampling effort. Water quality conditions, based on dissolved oxygen, temperature, pH, specific conductance, and total dissolved solids, are set forth below. Review of these data indicates that there were no apparent significant changes in water quality conditions from those observed in the period 1979 through 1991, although the data are too few to make a definitive determination of a change in water quality.

Dissolved Oxygen

During the 1999-2001 sampling period, the dissolved oxygen levels in the watershed as measured at station Dp-1 ranged from a minimum of 6.2 mg/l in 1999 to a maximum of 17.6 mg/l also recorded in 1999. Average concentrations were always above the minimum dissolved oxygen standard of 5.0 mg/l. As observed during previous investigations, the lowest concentrations of dissolved oxygen were observed during the summer, in July, when concentrations were generally less than 7.0 mg/l. The highest dissolved oxygen concentrations were observed during the fall, in November to March, when concentrations often approached or exceeded 10.0 mg/l.

On the main stem Des Plaines River stations, Dp-2 and Dp-2a, the dissolved oxygen levels ranged from a minimum of 4.1 mg/l at station Dp-2 in 1999 to a maximum of 14.2 mg/l recorded in 1999 at station Dp-2 and in 2000 at station Dp-2a. Average concentrations were always above the minimum dissolved oxygen standard of 5.0 mg/l at both stations. As observed during previous investigations, the lowest concentrations of dissolved oxygen were observed during the summer, in July, when concentrations were generally less than 5.0 mg/l at station Dp-2. The highest dissolved oxygen concentrations were observed during the fall, in November to March, when concentrations exceeded 10.0 mg/l at both stations.

Temperature

During the 1999-2001 sampling period, the water temperature at the Des Plaines River and Brighton Creek sampling stations was found to range from about 50ºF to about 78ºF. At no time during the study period did the water temperature exceed the maximum standard of 89ºF. As expected, the highest water temperatures occurred during the summer months, and the lowest during the winter months. The observed low values were recorded during November of each year, with the highest values being recorded in July.

Hydrogen Ion Concentrations (pH)

During the 1999-2001 sampling period, the pH values at stations Dp-1, Dp-2, and Dp-2a ranged between 7.4 and 8.1 standard units. At no time during the study period did the pH values exceed either the recommended minimum or recommended maximum standards of 6.0 standard units and 9.0 standard units, respectively. The average annual range in pH was usually less than 1 standard pH unit.

Specific Conductance and Total Dissolved Solids

During the 1999-2001 sampling period, specific conductance of the surface waters of the Des Plaines River was found to range from about 670 µS/cm to about 1,000 µS/cm at sampling stations Dp-1, Dp-2, and Dp-2a. Total dissolved solids measurements mirrored those of specific conductance, ranging from 0.42 mg/l to 0.64 mg/l at the three sampling stations.

Table 60

WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED AT SAMPLING STATIONS DP-1, DP-2, AND DP-2A: 1999-2001

Sampling Station/Parameter	Recommended Level/Standard	Numerical Value			Number of Analyses	Number of Times Recommended Standard Not Met
		Maximum	Average	Minimum		
Dp-1						
Dissolved Oxygen	5.0	17.6	10.2	6.1	4	0
Specific Conductance (µS/cm)	- -	930	826	668	3	- -
Temperature (°F)	89.0	78.0	64.0	49.5	4	0
Total Dissolved Solids	- -	594	528	427	3	- -
pH	6 - 9	8.1	7.7	7.5	3	0
Dp-2						
Dissolved Oxygen	5.0	16.5	10.3	4.2	2	1
Specific Conductance (µS/cm)	- -	- -	996	- -	1	- -
Temperature (°F)	89.0	78.0	68.0	58.0	2	0
Total Dissolved Solids	- -	- -	638	- -	1	- -
pH	6 - 9	- -	8.0	- -	1	0
Dp-2a						
Dissolved Oxygen	5.0	- -	13.3	- -	1	0
Specific Conductance (µS/cm)	- -	- -	800	- -	1	- -
Temperature (°F)	89.0	- -	33.5	- -	1	0
Total Dissolved Solids	- -	- -	537	- -	1	- -
pH	6 - 9	- -	7.4	- -	1	0

NOTE: Units of measure are in mg/l, unless otherwise specified.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Concluding Statement

The major stream reaches in the Des Plaines River watershed are recommended to meet the warmwater sportfish-full recreational use objective. Based upon the available data for sampling stations in the watershed, the main stem of the Des Plaines River downstream of STH 50 did not fully meet water quality standards associated with the recommended water use objectives during and prior to 1975. More recent data available for the period of 1979 through 2001 indicated that the standards associated with the recommended water use objective were also not fully achieved during that period. Violations of the dissolved oxygen, total phosphorus, and fecal coliform levels occurred at station Dp-4 on the main stem of the Des Plaines River just south of the Wisconsin-Illinois border. However, based upon review of the water quality sampling and water quality simulation data developed under the regional water quality management plan and the state of implementation of that plan, it is likely that violations of the dissolved oxygen, fecal coliform, and phosphorus standards also occurred at upstream stations. This finding is consistent with the presence of pollution-tolerant fish species in the Des Plaines River watershed reported in Chapter III and Appendix B of this report.

Wisconsin Department of Natural Resources

Surveys of Toxic and Hazardous Substances: 1973-1977

The available data on the levels of toxic and hazardous substances in the streams and lakes of the Region as obtained under the Wisconsin Department of Natural Resources drainage basin study programs were assembled by the Commission under the areawide water quality management planning program. Such data applicable to the Des Plaines River watershed are presented below.

Toxic and Hazardous Substances—Background
The general category of toxic and hazardous materials consists of the three subcategories: metals, pesticides, and synthetic organic chemicals such as polychlorinated biphenyls. All of these materials tend to accumulate in the environment as a result of human activities. Metals such as cadmium, chromium, cobalt, copper, lead, mercury, nickel, and zinc have a specific gravity greater than four. Such metals have several oxidation states, and readily form complex ions. Pesticides are organic chemicals utilized by man to control or destroy undesirable forms of plant and animal life. Pesticides encompass all forms of insecticides, herbicides, fungicides, fumigants, nematocides, algicides, and rodenticides. Synthetic organic chemicals are a class of compounds that do not exist naturally but are produced by the combination of elements having specific properties and generally used for industrial applications. PCBs—polychlorinated biphenyls—and PAHs—polyaromatic hydrocarbons—are probably the best known of chemicals in this category.

Metals, pesticides, PCBs, and other toxic and hazardous substances generally do not present the gross aesthetic or olfactory offense of some other water pollutants, but may present a serious and insidious health hazard to animal and human populations. Reported adverse effects of metals, pesticides, and PCBs on humans include liver and kidney disorders, carcinogenic effects, nervous system damage, skin lesions, and disruption of reproductive processes. PCBs can also affect reproduction in animals and can cause physical and mental disabilities which impede survival. Not only are these toxic and hazardous materials taken up by rooted plants, but certain of these materials have the innate ability to bioaccumulate—or enter the food chain at the lowest levels of vegetative growth and then gradually move up the food chain and accumulate in the fleshy tissue of fish, which in turn are available for human consumption.

Metals, pesticides, and PCBs may be potentially transported into the surface waters of the Des Plaines River watershed directly via stormwater runoff as well as through industrial and municipal wastewater outfalls or by groundwater discharge if groundwater were to become contaminated with these materials. Potential diffuse sources of heavy metals, pesticides, and PCBs in the Des Plaines River watershed include, or have included, atmospheric fallout and washout; washoff from streets, highways, parking lots, rooftops, lawns, and other pervious and impervious surfaces; organic and inorganic fertilizers for agricultural and lawn and garden purposes; pesticides that have been sprayed or spread; and discharges of sanitary sewerage system flow relief devices.

Findings of the Study
The Wisconsin Department of Natural Resources collected samples for dry weather metal, PCB, and pesticide concentration analyses from selected surface water sampling stations located on the Des Plaines River from 1973 through 1977. In the three instream water quality samples analyzed for toxic and hazardous substances, levels of heptachlor epoxide, a persistent pesticide, were exceeded only once. Sample analyses for cadmium, chromium, copper, lead, mercury, nickel, zinc, PCBs, and DDT, DDE, DDD, aldrin, heptachlor, lindane, dieldrin, methoxychlor, and phthalate uncovered no violations of U.S. Environmental Protection Agency recommended levels. No stream or lake bottom sediment analyses were conducted for any of the toxic and hazardous substances. No updated data on toxic and hazardous substances are available for the three sites sampled in the Wisconsin Department of Natural Resources study. However, toxic and hazardous substances data were obtained in the vicinity of the Pheasant Run Landfill on Brighton Creek during 2001 by the Wisconsin Department of Natural Resources. Sample analyses for arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, and PAHs indicated no violations of the U.S. Environmental Protection Agency recommended levels.

As previously described, the results of recent samplings of metals in the watershed at the U.S. Geological Survey station on the Des Plaines River at Russell Road (designated as Dp-4) are set forth in Table 59. Lead and copper concentrations at this station generally were, over the period 1979 through 1991, below the standards established for toxicity by the Wisconsin Department of Natural Resources, but zinc concentrations exceeded the established level in 1986. Concentrations of dissolved barium, boron, chromium, iron, manganese, nickel, strontium, and vanadium also exceeded recommended water quality guidelines on at least one occasion during this period. However, these data indicated few violations of recommended standards.

Water Quality of Lakes in the Des Plaines River Watershed: 1965-2000

There are six major lakes in the watershed of the Des Plaines River having a surface area of 50-acres or more: Lake Andrea, Benet/Shangrila Lakes, George Lake, Hooker Lake, Paddock Lake, and Vern Wolf Lake. The physical characteristics of these lakes are set forth in Table 21 in Chapter III of this report. These data indicate that the major lakes in the watershed have a combined surface area of about 667 acres, or less than one percent of the total area of the watershed.

The data sources that were used for the analysis of the lake water quality in the Des Plaines River watershed included data provided by the Wisconsin Department of Natural Resources Self-Help Lake Monitoring program, and data acquired through other data collection programs such as the Chapter NR 190 Lake Management Planning Grant program administered by the Wisconsin Department of Natural Resources. Table 61 presents available data used in calculation of trophic state indices on five of the six lakes. Table 62 presents the Wisconsin Trophic State Index values for these lakes for those parameters for which data were available. The available trophic state index values under current and historic conditions are provided in Table 63. These data are presented using the Carlson Trophic State Index in order to present the newer data on a comparable basis to the historic data which used that index.

The variation of water quality in a lake depends on a number of factors, both within and without the lake basin. Within the lake basin, the depth of the lake, as well as the season of the year, play a role in determining water quality conditions and the propensity of a lake to experience perceived water quality problems. In shallow lakes, the water is generally well-mixed, with water quality being fairly uniform throughout the entire depth profile. In lakes deeper than about 15 to 25 feet, however, thermal and chemical stratification tends to occur during summer and winter. In chemically-stratified lakes, the water quality of the lakes varies with the depth as shown in Figure 44. Two of the major lakes in the Des Plaines River watershed, Paddock Lake and Lake Andrea, have a maximum depth of greater than 25 feet. Benet/Shangrila, George, and Hooker Lakes have a maximum depth of between 15 and 25 feet.

Chemical data were available for Hooker and Paddock Lakes, both of which are greater than 15 feet in depth and, therefore, subject to stratification during the summer months. The data indicated that the concentration of dissolved oxygen in the epilimnion, or surface waters, of these lakes generally remained higher than 7.0 mg/l. However, in the hypolimnion, or bottom waters, of these lakes, dissolved oxygen concentrations typically were between zero and less than 1.0 mg/l of dissolved oxygen, indicating anoxic, and possibly anaerobic, conditions during summer. Low dissolved oxygen concentrations adversely affect the fish and other aquatic life in these lakes.

Temperature and dissolved oxygen levels in the shallow lakes of the Des Plaines River watershed were generally similar to the conditions existing in the epilimnion of the stratified lakes during the summer months, with oxygen levels near or above saturation. Of the six major lakes, two have been classified using the Uttormark and Wall trophic status classification.[23] Benet/Shangrila Lake was defined as very eutrophic, and Paddock Lake was classified as a mesotrophic lake. Complete data were not available for the other lakes for the classification of their trophic status. These general categorizations and assessments of lake water quality conditions relied on the interpretation of detailed physical, chemical, and biological data for inland lakes of the Region. Water quality samples collected during specific conditions must be interpreted with regard to the general lake characteristics, seasonal cycles, and shorter-term meteorological phenomena.

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[23] *Paul D. Uttormark and J. Peter Wall,* Lake Classification—A Trophic Characterization of Wisconsin Lakes*, U.S. EPA Report No. EPA-660/3-75-033, June 1975.*

Table 61

WATER QUALITY OF THE MAJOR LAKES IN THE DES PLAINES RIVER WATERSHED

Lake Name	Area (acres)	Total Phosphorus (mg/l)					Chlorophyll-*a* (:g/l)				
		Maximum	Minimum	Average[a]	Date of Data	Source[b]	Maximum	Minimum	Average[a]	Date of Data	Source[b]
Benet/Shangrila Lake	186	0.54	0.01	0.17(16)	1977-78	LSF	- -	- -	- -	- -	- -
Vern Wolf Lake	123	0.24	0.10	0.15(3)	1977	LSF	- -	- -	- -	- -	- -
George Lake	59	0.22	0.03	0.08(38)	1976-80	LSF	- -	- -	- -	- -	- -
Hooker Lake	87	0.18	0.02	0.05(17)	1977-92	LSF/USGS	19.00	9.00	13.00(4)	1992	USGS
Paddock Lake	112	- -	- -	- -	- -	- -	8.37	0.54	2.2(15)	1977	ERA
Lake Andrea[c]	100	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Lake Name	Area (scres)	Secchi-Disk (feet)				
		Maximum	Minimum	Average[a]	Date of Data	Source[b]
Benet/Shangrila Lake	186	3.0	1.5	2.25(2)	1991	Self-Help
Vern Wolf Lake	123	1.0	1.0	1.0(1)	1977	LSF
George Lake	59	7.0	1.25	2.7(35)	1988-92	Self-Help
Hooker Lake	87	7.2	2.6	5.4(10)	1991-92	Self-Help
Paddock Lake	112	6.25	- -	- -	- -	- -
Lake Andrea[c]	100	- -	- -	- -	- -	- -

[a]*Number in parentheses refers to number of samples taken.*

[b]*The following sources were cited:*
- *LSF • Wisconsin Department of Natural Resources, Lake Survey Forms*
- *SELF-HELP • Wisconsin Self-Help Lake Monitoring Program Data, 1986-1988*
- *ERA • Environmental Resource Assessment Report*
- *USGS • U.S. Geological Survey, Water Resources Data-Wisconsin (annual)*

[c]*Man-made lake constructed after data were collected.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Lake Andrea

Lake Andrea, referred to as an unnamed quarry lake in SEWRPC Memorandum Report No. 93, *A Regional Water Quality Management Plan: An Update and Status Report*, is a 100-acre lake, situated in a former quarry and presently serving as public parkland, located in the Village of Pleasant Prairie in Kenosha County. Map 42 presents a graphic summary of the proposed year 2010 land use in the lake watershed. The Lake is intended to remain in largely open space recreational use.

As indicated in Table 64, it was estimated that, at the time the Lake was created in 1990, all sources contributed about 45 pounds of phosphorus annually to the Lake. The major source of phosphorus in the lake watershed is rural (parkland) land runoff. Some institutional development in the vicinity of the parkland is anticipated under year 2010 conditions. As a result, total phosphorus loads are expected to increase to about 48 pounds of phosphorus per year.

The total phosphorus concentrations during spring overturn under existing and anticipated year 2010 and buildout conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.025 mg/l and 0.027 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Therefore, existing and anticipated year 2010 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Andrea which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery. Thus, the long-term maintenance of water quality in Lake Andrea requires that nutrient input reductions be achieved.

Table 62

COMPARISON OF TROPHIC STATE INDEX VALUES FOR MAJOR LAKES IN THE DES PLAINES RIVER WATERSHED[a]

Lake Name	Carlson Trophic State Index Values[b]		
	Satellite Information 1979-1981	Water Chemistry Pre-1981	Water Chemistry 1981-1991
Benet/Shangrila	51	70	67
Vern Wolf Lake	- -	77	- -
George Lake	57	62	64
Hooker Lake	51	58	54
Paddock Lake	49	57	- -
Lake Andrea[c]	- -	- -	- -

[a]*Carlson TSI values were calculated from available data from spring measurements for phosphorus and from summer measurements for chlorophyll-*a *and water clarity. Water Chemistry Values were calculated from data shown in Table 61. Satellite information values were determined from* Wisconsin's Lakes–A Trophic Assessment Using Landsat Digital Data, 1983.

[b]*Carlson Trophic State Index ranges:*

Below 40 = oligotrophic
40 - 50 = mesotrophic
50 - 60 = eutrophic
Above 60 = hypertrophic

[c]*Man-made lake constructed after data were collected.*

Source: Wisconsin Department of Natural Resources, U.S. Environmental Protection Agency, and SEWRPC.

Table 63

TROPHIC STATE INDEX VALUES FOR MAJOR LAKES WITHIN THE DES PLAINES RIVER WATERSHED[a]

Lake Name	Wisconsin Trophic State Index Values[b]			
	Total-P	Chlorophyll-*a*	Secchi	Mean
Benet/Shangrila	68.0	- -	65.6	66.8
Vern Wolf Lake	67.0	- -	67.0	67.0
George Lake	62.1	- -	57.1	59.6
Hooker Lake	58.9	54.1	51.7	54.9
Paddock Lake	72.8	40.7	56.2	56.6
Lake Andrea[c]	- -	- -	- -	- -

[a]*Wisconsin Trophic State Index values were calculated using water chemistry data shown in Table 61.*

[b]*Wisconsin Trophic State Index ranges:*

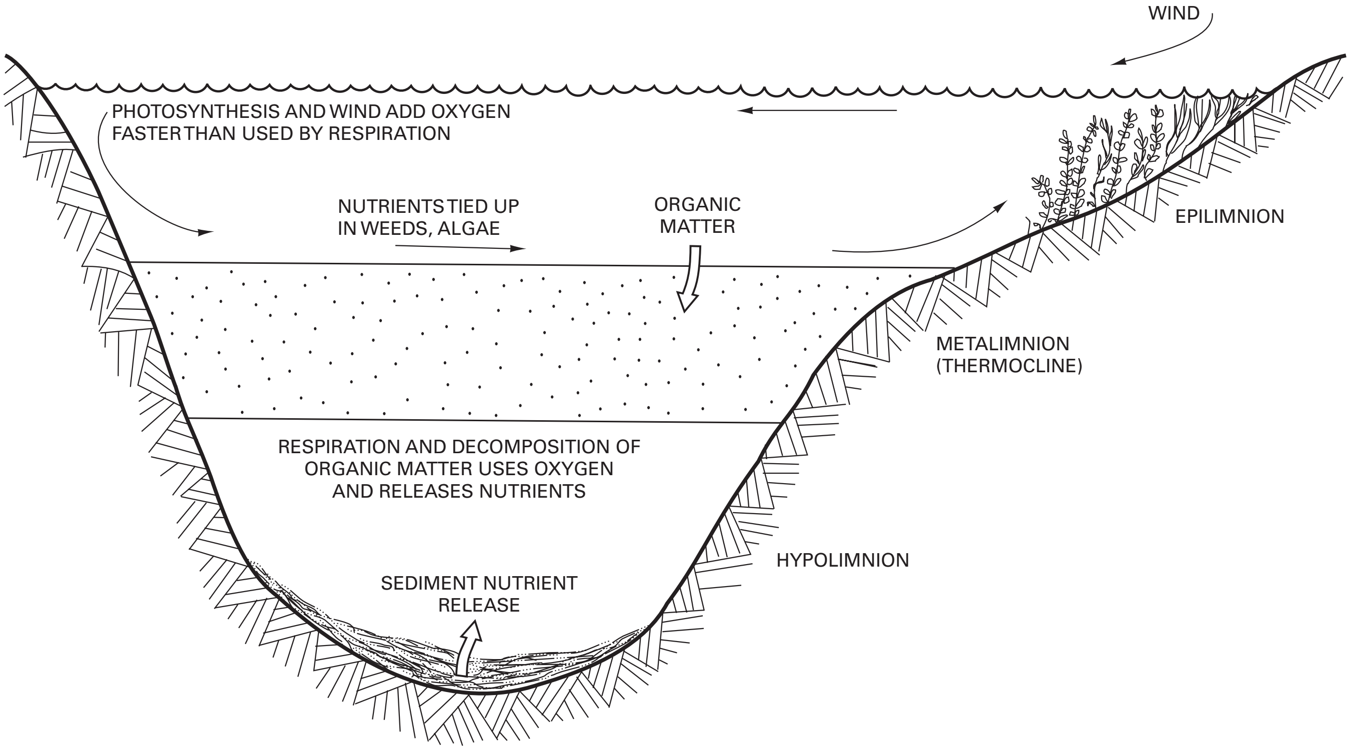
Below 44 = oligotrophic
45 - 53 = mesotrophic
54 - 75 = eutrophic
Above 75 = hypertrophic

[c]*Man-made lake constructed after data were collected.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 44

LAKE PROCESSES DURING SUMMER STRATIFICATION



Source: University of Wisconsin Extension and SEWRPC.

Benet/Shangrila Lake

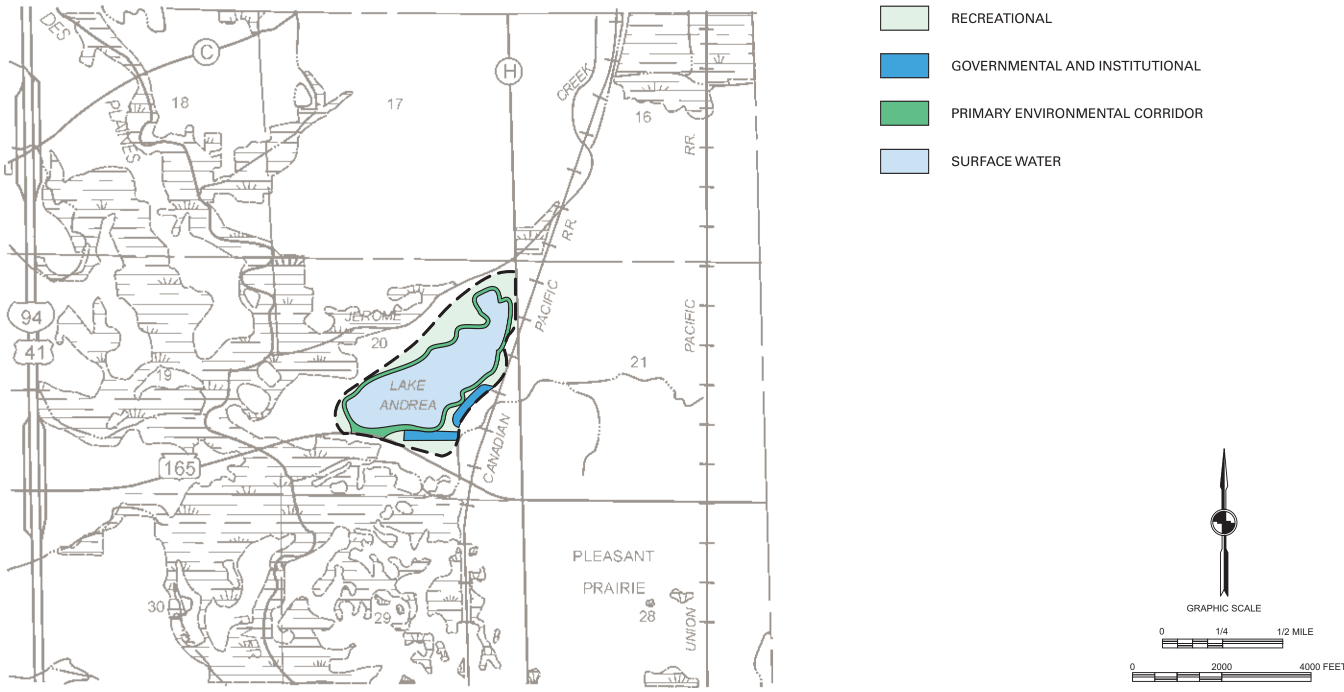
Benet/Shangrila Lake is a 186-acre lake located in the Towns of Bristol and Salem in Kenosha County. The Lake drains to a wetland area directly east of the Lake and eventually to the Dutch Gap Canal. Map 43 presents a graphic summary of the proposed year 2010 land use in the lake watershed.

All of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers under buildout conditions.[24] In 1975, however, an estimated 203 privately owned onsite sewage disposal systems—all of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. Subsequently, in 1983, the area was included in the Town of Salem Utility District No. 2 and the urban development surrounding the Lake has been provided with a public sanitary sewer system, as recommended in the adopted regional water quality management plan.

[24]*A land use development scenario providing for complete development, or buildout, of the approved planned sewer service areas within the watershed, as described in Chapter IV of this report was adopted for the hydrologic, hydraulic, and water quality modeling undertaken for the watershed study.*

Map 42

PLANNED LAND USE IN THE DRAINAGE AREA TRIBUTARY TO LAKE ANDREA: 2010 AND BUILDOUT CONDITIONS



Lake Andrea has a tributary drainage area of about 66 acres. About 21 acres, or 32 percent of the drainage area, are planned to be in rural land uses, and 45 acres, or 68 percent, to be in urban land uses.

Source: SEWRPC.

Table 64

ESTIMATED TRIBUTARY PHOSPHORUS LOADS TO LAKE ANDREA

Source of Phosphorus	1990			2010			Buildout		
	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution
Urban Land (acres)	- -	- -	- -	18	8	17	18	8	17
Rural Land (acres)	66	18	40	48	13	27	48	13	27
Atmosphere Contributions (acres)[b]	100	27	60	100	27	56	100	27	56
Total	- -	45	100	- -	48	100	- -	48	100

[a]*Measured in pounds per year.*

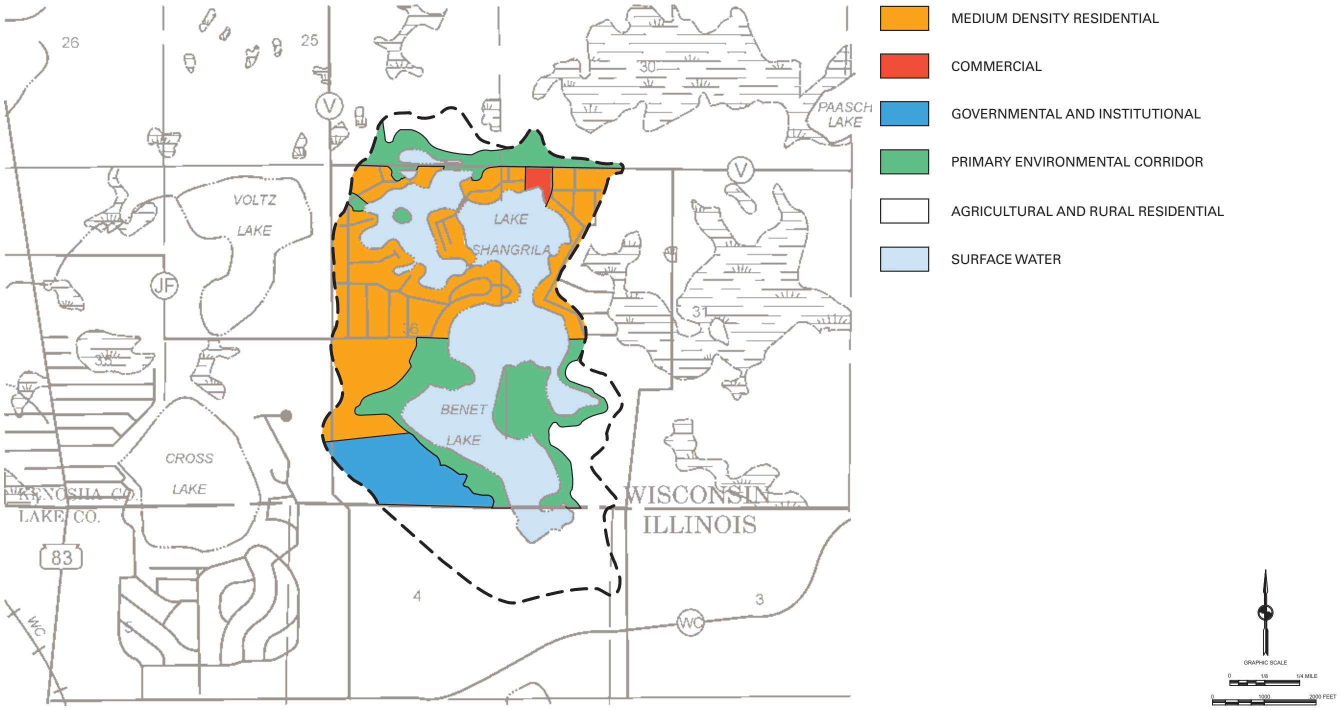
[b]*Due to direct deposition onto the Lake.*

Source: SEWRPC.

As indicated in Table 65, it was estimated that, in 1975, all sources contributed about 779 pounds of phosphorus annually to Benet/Shangrila Lake. The major source of phosphorus in the lake watershed at that time was the septic tank systems which have been eliminated. Thus, it was estimated that all sources contributed only 240 pounds of phosphorus annually to the Lake under 1990 land use conditions. As indicated in Table 65, under planned year 2010 land use conditions, urban land uses in the watershed are expected to increase by about 40 percent in comparison to 1990 conditions. Annual total phosphorus loadings to the Lake are expected to increase to about 188 pounds by the year 2010, under buildout conditions. Although the provision of sanitary

Map 43

PLANNED LAND USE IN THE DRAINAGE AREA TRIBUTARY TO BENET AND SHANGRILA LAKES: 2010 AND BUILDOUT CONDITIONS



Benet and Shangrila Lakes have a tributary drainage area of about 336 acres. About 120 acres, or 36 percent of the drainage area, are planned to be in rural land uses, and 216 acres, or 64 percent, to be in urban land uses.

Source: SEWRPC.

Table 65

ESTIMATED TRIBUTARY PHOSPHORUS LOAD TO BENET/SHANGRILA LAKE

Source of Phosphorus	1975			1990			2010			Buildout		
	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution
Urban Land (acres)	168	79	10	154	69	29	216	97	52	216	97	52
Onsite Sewage Disposal Systems[b]	203	588	76	- -	- -	- -	- -	- -	- -	- -	- -	- -
Rural Land (acres)	160	35	4	207	129	54	145	49	26	145	49	26
Atmosphere Contributions	154	77	10	154	42	17	154	42	22	154	42	22
Total	- -	779	100	- -	240	100	- -	188	100	- -	188	100

[a]*Measured in pounds per year.*

[b]*Includes those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

Source: SEWRPC.

sewers within the watershed eliminated all septic tank systems, loadings from urban land use activities are expected to remain the primary source of phosphorus to the Lake under anticipated year 2010 conditions.

The total phosphorus concentrations during spring overturn under existing conditions and anticipated year 2010 and buildout conditions, as estimated from the phosphorus loading and lake and drainage basin characteristics, are

0.06 mg/l and 0.05 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of warmwater fishery and recreational use classification. Existing and anticipated year 2010 pollutant loadings may be expected to result in total phosphorus concentrations in Benet/Shangrila Lake which meet or exceed the recommended level for recreational use and for the maintenance of a warmwater fishery. Thus, the long-term maintenance of water quality in Benet/Shangrila Lake requires that nutrient input reductions be achieved.

George Lake

George Lake is a 59-acre lake located in the Town of Bristol in Kenosha County. The Lake drains to the Dutch Gap Canal. Map 44 presents a graphic summary of the proposed year 2010 land use in the lake watershed.

Most of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2010. In 1975, an estimated 56 privately owned onsite sewage disposal systems—15 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. Subsequently, in 1986, the area was included in the Town of Bristol Utility District No. 1 and the urban development surrounding the Lake has been provided with a public sanitary sewer system, as recommended in the adopted regional water quality management plan. Further, extensive pest, nutrient, and soil conservation management practices have been put into place in the western portions of the watershed.

As indicated in Table 66, it was estimated that, in 1975 and 1990, the annual contributions of phosphorus to George Lake were about 1,130 pounds and 1,436 pounds, respectively. As indicated in Table 66, under planned year 2010 and buildout conditions, urban land uses in the watershed are expected to increase by about 30 percent, in comparison to 1990 conditions. The annual total phosphorus load to the Lake under 1990 conditions is estimated to be 1,436 pounds, and, under anticipated year 2010 conditions, the load is expected to be about 1,080 pounds. Implementation of nonpoint source control measures has resulted in the reduction of sediment and nutrient loads to the Lake. However, livestock, rural land, and construction activities may be expected to remain the primary sources of phosphorus to the Lake under anticipated year 2010 conditions.

The total phosphorus concentrations during spring overturn under existing conditions, and anticipated year 2010 and buildout conditions, as estimated from the water quality simulation model, are 0.15 mg/l and 0.12 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2010 pollutant loadings may be expected to result in total phosphorus concentrations in George Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery. Thus, the long-term maintenance of water quality in George Lake requires that nutrient input reductions be achieved.

Hooker Lake

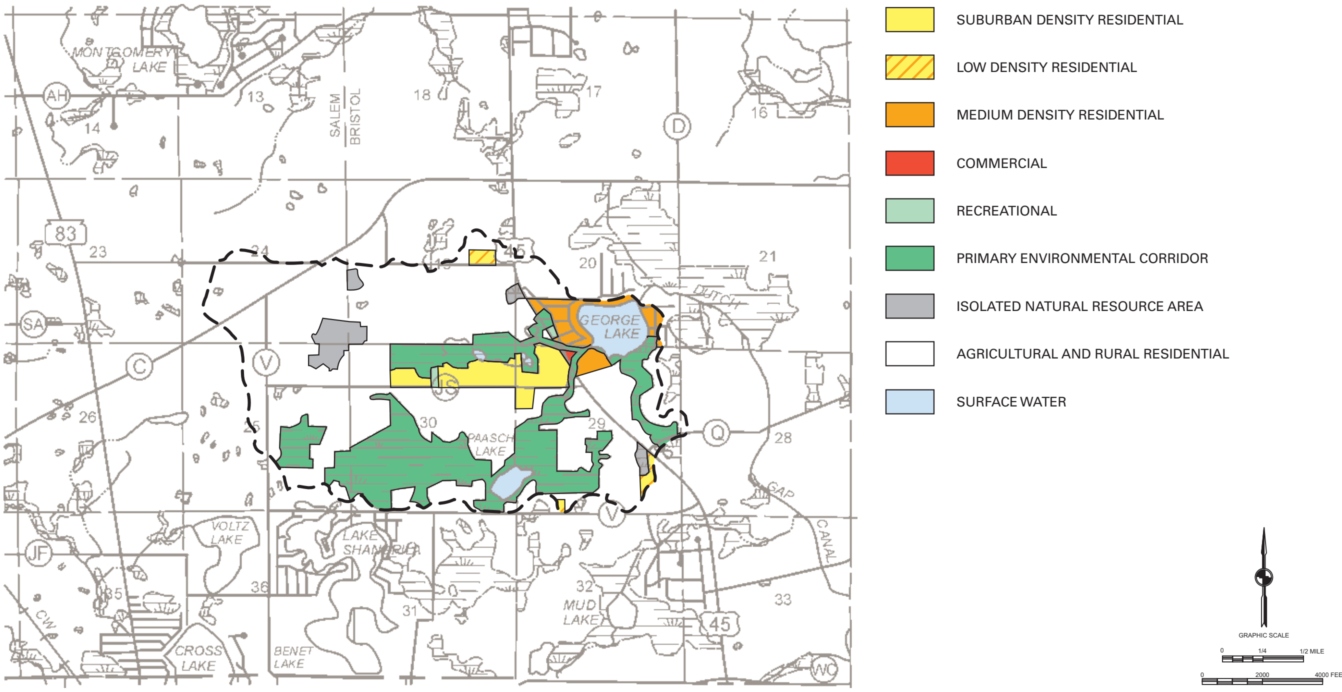
Hooker Lake is an 87-acre lake located in the Town of Salem in Kenosha County. The Lake drains to the Salem Branch of Brighton Creek. Map 45 presents a graphic summary of the proposed year 2010 land use in the lake watershed.

Most of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2010. In 1975, an estimated 23 privately owned onsite sewage disposal systems—14 of which were located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area. Subsequently, in 1983, the area was included in the Town of Salem Utility District No. 1 and the urban development surrounding the Lake has been provided with a public sanitary sewer system, as recommended in the adopted regional water quality management plan.

As indicated in Table 67, it is estimated that in 1975 and 1990, the annual contributions of phosphorus to Hooker Lake were about 970 pounds and 860 pounds, respectively. The major sources of phosphorus in the lake watershed were livestock operations, runoff from construction activities, and runoff from rural land. As indicated

Map 44

PLANNED LAND USE IN THE DRAINAGE AREA TRIBUTARY TO GEORGE LAKE: 2010 AND BUILDOUT CONDITIONS



George Lake has a tributary drainage area of about 2,158 acres. About 1,998 acres, or 92 percent of the drainage area, are planned to be in rural land uses, and 188 acres, or 8 percent, to be in urban land uses.

Source: SEWRPC.

Table 66

ESTIMATED TRIBUTARY PHOSPHORUS LOAD TO GEORGE LAKE

Source of Phosphorus	1975			1990			2010			Buildout		
	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution
Urban Land (acres)	120	32	3	137	36	2	177	42	4	177	42	4
Construction Activity	9	198	17	- -	- -	- -	- -	- -	- -	- -	- -	- -
Onsite Sewage Disposal Systems[b]	15	32	3	- -	- -	- -	- -	- -	- -	- -	- -	- -
Rural Land (acres)	1,782	348	31	1,634	1,384	97	1,595	1,025	94	1,590	1,025	94
Livestock Operations	186	491	43	- -	- -	- -	- -	- -	- -	- -	- -	- -
Atmosphere Contributions	59	29	3	59	16	1	59	16	2	59	16	2
Total	- -	1,130	100	- -	1,436	100	- -	1,083	100	- -	1,083	100

[a]*Measured in pounds per year.*

[b]*Includes those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

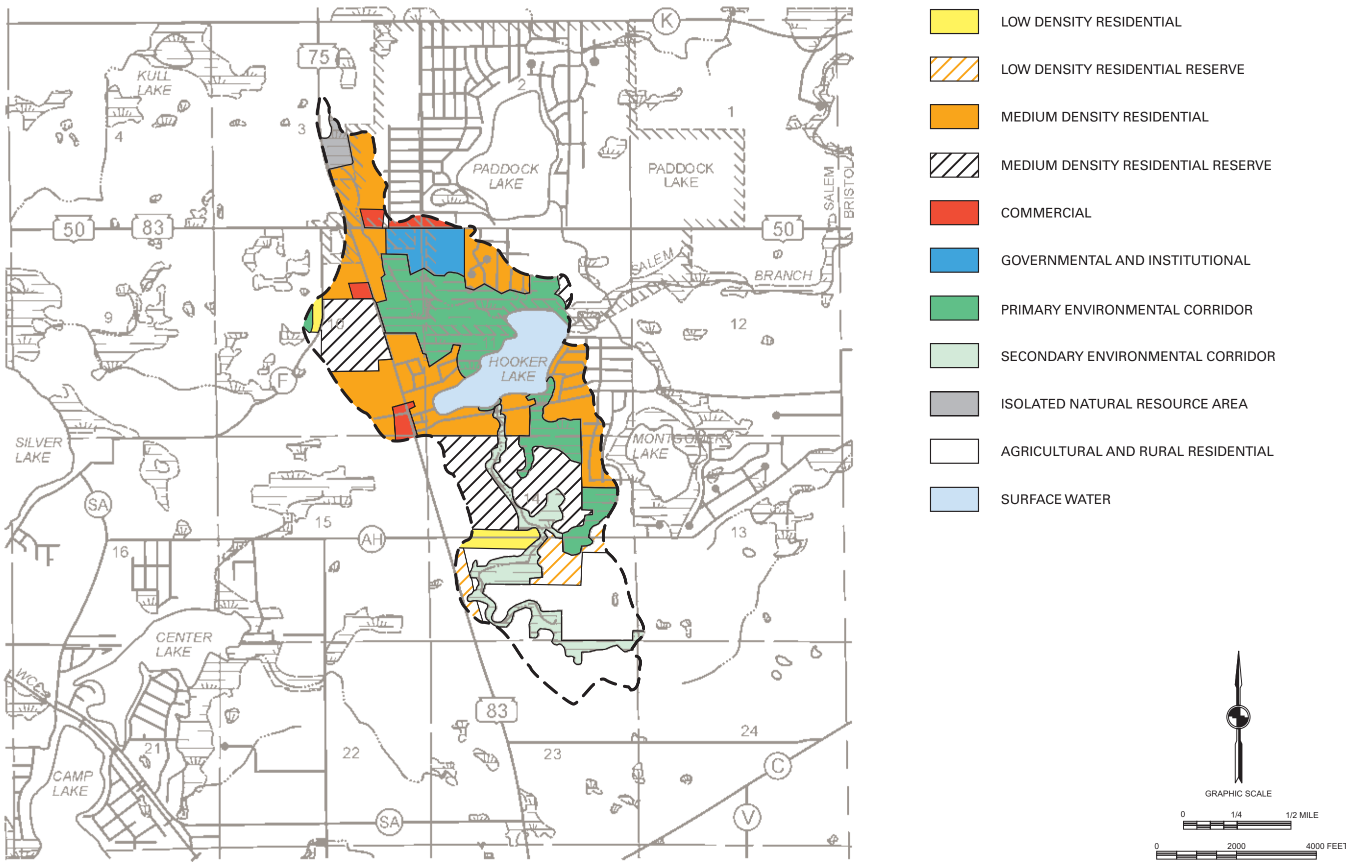
Source: SEWRPC.

in Table 67, under planned year 2010 conditions, urban land uses in the watershed are expected to increase by up to 125 percent, respectively, in comparison to 1990 conditions.

The benefits of any proposed extension of the sewer service area may be offset by increased urban runoff, with the annual total phosphorus load under year 2010 conditions estimated at about 600 pounds. Unless phosphorus

Map 45

PLANNED LAND USE IN THE DRAINAGE AREA TRIBUTARY TO HOOKER LAKE: 2010 AND BUILDOUT CONDITIONS



Hooker Lake has a tributary drainage area of about 1,241 acres. About 562 acres, or 45 percent of the drainage area, are planned to be in rural land uses, and 680 acres, or 55 percent, to be in urban land uses. The areas indicated as reserve would be expected to develop latest in the planning period.

Source: SEWRPC.

Table 67

ESTIMATED TRIBUTARY PHOSPHORUS LOAD TO HOOKER LAKE

Source of Phosphorus	1975			1990			2010			Buildout		
	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution
Urban Land (acres)	242	106	11	302	122	14	437	188	28	680	282	52
Construction Activity	5	236	24	- -	- -	- -	- -	- -	- -	- -	- -	- -
Onsite Sewage Disposal Systems[b]	14	40	4	- -	- -	- -	- -	- -	- -	- -	- -	- -
Rural Land (acres)	886	224	23	942	711	84	807	445	68	564	228	44
Livestock Operations	49	323	33	- -	- -	- -	- -	- -	- -	- -	- -	- -
Atmosphere Contributions	87	44	5	87	24	2	87	24	4	87	24	4
Total	- -	973	100	- -	857	100	- -	657	100	- -	534	100

[a]*Measured in pounds per year.*

[b]*Includes those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

Source: SEWRPC.

loadings are reduced by the implementation of nonpoint source control measures, livestock operations and construction activities may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2010 conditions. The total phosphorus concentration during spring overturn under existing conditions and anticipated year 2010 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.11 mg/l and 0.08 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2010 pollutant loadings may be expected to result in total phosphorus concentrations in Hooker Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery. Thus, the long-term maintenance of water quality in Hooker Lake requires that nutrient input reductions be achieved.

Paddock Lake

Paddock Lake is a 112-acre lake located in the Village of Paddock Lake in Kenosha County. The Lake drains to the Salem Branch of Brighton Creek. Map 46 presents a graphic summary of the proposed year 2010 land use in the lake watershed.

Most of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2010. In 1975, fewer than five privately owned onsite sewage disposal systems—two located in areas covered by soils having severe and very severe limitations for the use of such systems—were estimated to be in operation in the lake watershed area. Subsequently, the urban development surrounding the Lake has been provided with a public sanitary sewer system serviced by the Village of Paddock Lake, as recommended in the adopted regional water quality management plan.

As indicated in Table 68, it was estimated that, in 1975 and 1990, the annual contributions of phosphorus to Paddock Lake were 197 pounds and 190 pounds, respectively. The major source of phosphorus in the lake watershed was urban land runoff. As indicated in Table 68, under planned 2010 and buildout land use conditions, urban land uses in the watershed are expected to increase by 19 percent in comparison to 1990 conditions. Unless phosphorus loadings are reduced by the implementation of nonpoint source control measures, urban runoff is expected to continue to be the primary source of phosphorus to the Lake under anticipated year 2010 conditions.

The estimated total phosphorus concentrations during spring overturn under existing conditions, and anticipated year 2010 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.05 mg/l and 0.04 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Therefore, existing and anticipated year 2010 land use conditions pollutant loadings may be expected to result in total phosphorus concentrations in Paddock Lake which exceeds the recommended level for recreational use and for the maintenance of a warmwater fishery. Thus, the long-term maintenance of water quality in Paddock Lake requires that nutrient input reductions be achieved.

Vern Wolf Lake

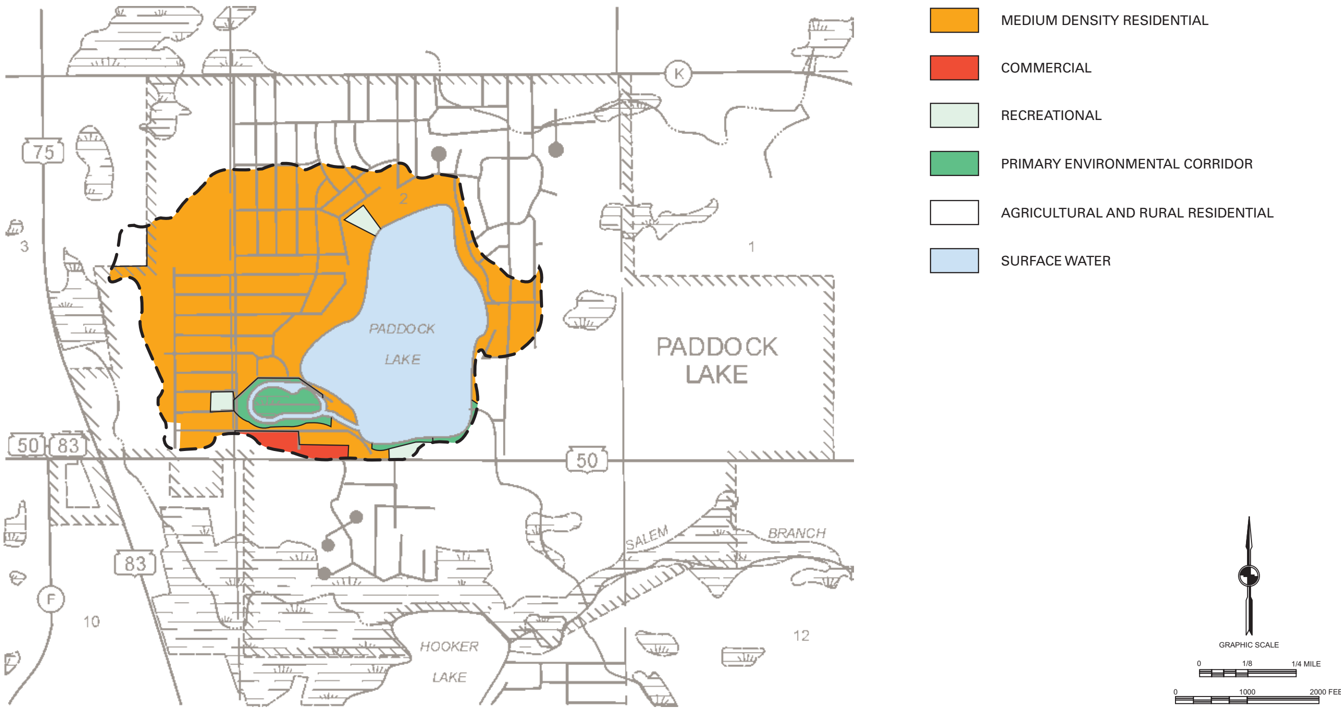
Vern Wolf Lake, formerly known as East Lake Flowage, is a 123-acre lake located within the Bong State Recreational Area in the Town of Brighton in Kenosha County. The Lake drains to Brighton Creek. Map 47 presents a graphic summary of the proposed year 2010 land use in the lake watershed. The drainage area to the Lake is intended to remain in largely open space use, served by onsite sewage disposal systems.

As indicated in Table 69, it was estimated that, in 1990, all sources contributed about 244 pounds of phosphorus annually to Vern Wolf Lake. The major source of phosphorus in the lake watershed was rural land runoff from the State natural area surrounding the Lake. No changes in land uses in the watershed are expected under planned year 2010 land use conditions, although it is anticipated that existing urban lands surrounding the parkland will be subsumed into the park development.

It is estimated that the total phosphorus concentration during spring overturn would be 0.04 mg/l under existing and anticipated year 2010 conditions. The Commission recommends a level of 0.02 mg/l or less of total

Map 46

PLANNED LAND USE IN THE DRAINAGE AREA TRIBUTARY TO PADDOCK LAKE: 2010 AND BUILDOUT CONDITIONS



Paddock Lake has a tributary drainage area of about 273 acres. About 13 acres, or 5 percent of the drainage area, are planned to be in rural land uses, and 260 acres, or 95 percent, to be in urban land uses.

Source: SEWRPC.

Table 68

ESTIMATED TRIBUTARY PHOSPHORUS LOAD TO PADDOCK LAKE

Source of Phosphorus	1975			1990			2010			Buildout		
	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution
Urban Land (acres)	250	98	50	217	99	52	259	116	76	259	116	76
Construction Activity	<1	11	6	- -	- -	- -	- -	- -	- -	- -	- -	- -
Onsite Sewage Disposal Systems[b]	<5	3	1	- -	- -	- -	- -	- -	- -	- -	- -	- -
Rural Land (acres)	112	29	15	74	61	33	32	8	4	32	8	4
Atmosphere Contributions	112	56	28	112	30	15	112	30	20	112	30	20
Total	- -	197	100	- -	190	100	- -	154	100	- -	154	100

[a]*Measured in pounds per year.*

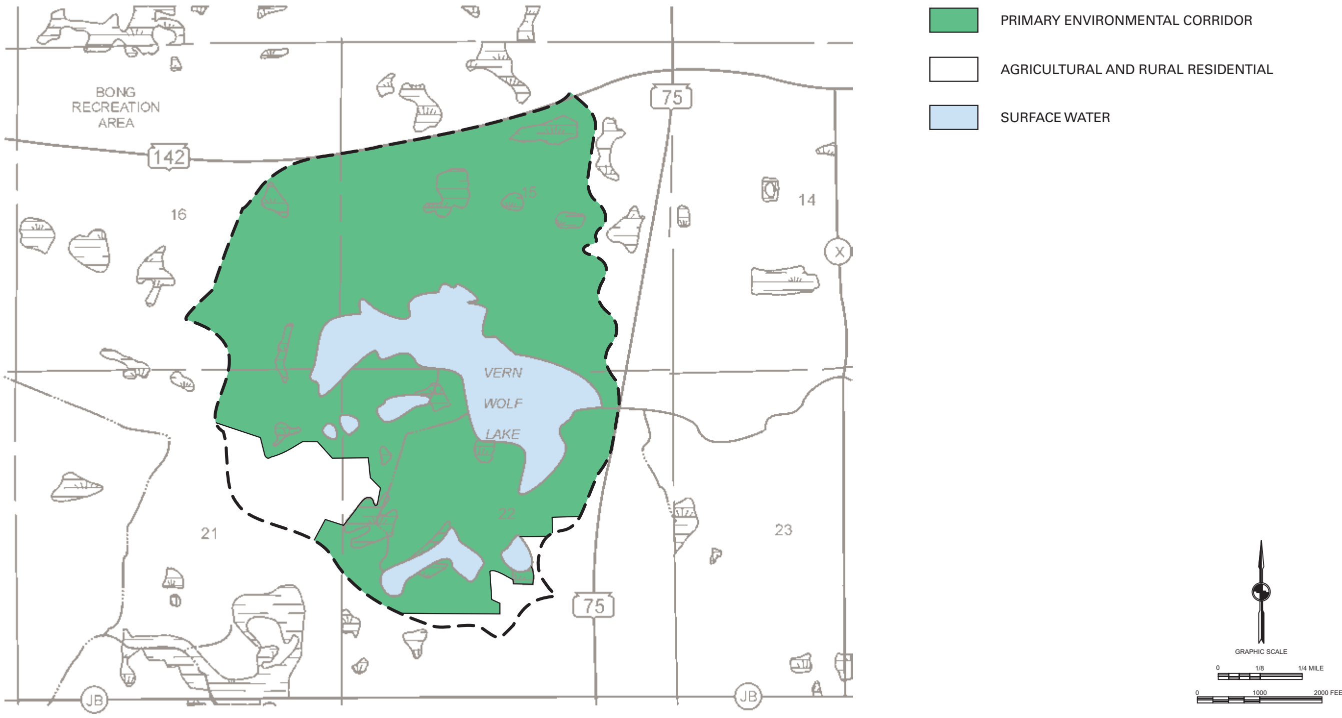
[b]*Includes those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

Source: SEWRPC.

phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Therefore, existing and anticipated year 2010 pollutant loadings may be expected to result in total phosphorus concentrations in Vern Wolf Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery. Thus, the long-term maintenance of water quality in Vern Wolf Lake requires that nutrient input reductions be achieved.

Map 47

PLANNED LAND USE IN THE DRAINAGE AREA TRIBUTARY TO VERN WOLF LAKE: 2010 AND BUILDOUT CONDITIONS



Vern Wolf Lake has a tributary drainage area of about 856 acres. All of the drainage area is planned to remain in rural land uses.

Source: SEWRPC.

Table 69

ESTIMATED TRIBUTARY PHOSPHORUS LOAD TO VERN WOLF LAKE

Source of Phosphorus	1990			2010			Buildout		
	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution	Number	Total Loading[a]	Percent Distribution
Urban Land (acres)	<1	<1	0	- -	- -	- -	- -	- -	- -
Rural Land (acres)	802	213	87	802	219	88	802	219	88
Atmosphere Contributions	115	31	13	115	31	12	115	31	12
Total	- -	244	100	- -	250	100	- -	250	100

[a]*Measured in pounds per year.*

Source: SEWRPC.

A carp and bullhead eradication program for Vern Wolf Lake was completed in October 2001. The lake was drawn down three feet and treated with rotenone. The drawdown was maintained through the winter of 2001-2002. Following treatment of Eurasian water milfoil with a herbicide in the spring of 2002, the water level will be allowed to rise back to normal and the Lake will be restocked with northern pike, largemouth bass, and bluegills.

Concluding Statement
The six major lakes in the watershed having a surface area of 50 acres or more, are Benet/Shangrila Lake, Vern Wolf Lake, George Lake, Hooker Lake, Paddock Lake, and Lake Andrea. The waters of all of the six lakes are recommended for the maintenance of a warmwater sport fishery and full recreational use, or a mesotrophic status.

The data available indicate all of the lakes may be classified as in the eutrophic range, except for Paddock Lake which is a drained lake currently classified in the mesotrophic range. Benet/Shangrila Lake is a drained lake which continues to remain in the eutrophic water quality classification range. Vern Wolf Lake is a eutrophic drainage lake which is part of the Wisconsin Department of Natural Resources Bong Recreation Area and is managed by the Department for a variety of wildlife and recreational uses. George Lake is a drained lake situated down-gradient of Benet/Shangrila Lake and remains in the eutrophic classification range. Hooker Lake is a drained lake which remains in the eutrophic classification range. There are no water quality data available for Lake Andrea which was created in the early 1990s at a now-abandoned quarry site. No conclusions regarding changes in water quality conditions can be drawn based upon the limited data available.

George Lake and Paddock Lake, for which complete water quality data were available between 1965 and 1975, violated the standards for total phosphorus of 0.02 mg/l recommended by the Commission. In addition, George Lake and Benet/Shangrila Lake violated the dissolved oxygen standard on at least one occasion between 1965 and 1975. Modeling data indicate that all six major lakes probably would not meet the phosphorus standard. No current water quality sampling data were available to assess the current compliance with water quality standards for the major lakes in the Des Plaines River watershed. Based upon review of the previous modeling data and the status of implementation of the regional water quality management plan recommendations, it may be expected that all of the lakes would have total phosphorus levels exceeding the 0.02 mg/l standard. However, based upon lake use observations and a review of water quality conditions, all of the lakes have water quality conditions which support the desired water uses to be carried out much of the time. Though those uses may be impaired somewhat, the lakes serve as a valuable resource under current conditions.

Concluding Remarks—Surface Water Quality Studies
Certain observations may be made and conclusions drawn from the available water quality data. Dry and wet weather water quality conditions in the watershed may be identified and an overall assessment made as to the degree to which established water quality standards are satisfied (see Table 70). More particularly, the following observations and conclusions are based on the historic monitoring studies in the Des Plaines River watershed, supplemented with analyses of data drawn from studies of other watersheds.

- Of the eight potential types of surface water pollution—toxic, organic, nutrient, pathogenic, thermal, sediment, radiological, and aesthetic—all but thermal and radiological pollution were observed to some degree in the Des Plaines River watershed.

- Substandard water quality conditions, associated with high concentrations of pollutants, were more likely to occur during wet weather conditions than during dry weather conditions and were attributable to: 1) the accumulation of pollutants on the land surface between rainfall and snowmelt events, and the subsequent transport of pollutants from the land surface to the stream system by rainfall and snowmelt runoff; and 2) the resuspension of polluted streambed sediments by the high stream velocities which occurred during runoff periods.

- The substantial increase in available dilution water during a rainfall or snowmelt runoff event was usually more than offset by the increased quantity (mass) of potential pollutants carried into the surface land flow, through storm sewer and channel systems, or from shallow subsurface groundwater inflow. The known exceptions were the concentrations of nitrogen and chloride, which did not exhibit a marked increase during the rainfall events which were recorded in October 1976.

Table 70

SUMMARY OF WATER QUALITY CONDITIONS IN THE DES PLAINES RIVER WATERSHED: 1964-2001

Parameter	Standard	Standard or Guideline Never Exceeded[a]	Standard or Guideline Rarely Exceeded[a]	Standard or Guideline Frequently Exceeded[a]	Standard or Guideline Very Frequently Exceeded[a]
Dissolved Oxygen	5.0	Dp-1:1964-65 Dp-1:1999-2001 Dp-2a:1999-2001	Dp-2:1964-65 Dp-2:1976 Dp-2a:1976 Dp-4:1977-91	Dp-1:1968-75 Dp-2:1968-75 Dp-2:1999-2001 Dp-2a:1968-75 Dp-3:1968-75	- -
Ammonia Nitrogen	2.5	Dp-1:1968-75 Dp-2:1968-75 Dp-2:1976 Dp-2a:1968-75 Dp-2a:1976 Dp-3:1968-75 Dp-4:1977-91	- -	- -	- -
Nitrate Nitrogen	0.3	Dp-2a:1968-75	Dp-1:1968-75 Dp-2:1976	Dp-2:1968-75 Dp-2a:1976	Dp-3:1968-75
Total Phosphorus	0.1	- -	- -	- -	Dp-1:1968-75 Dp-2:1964-65 Dp-2:1968-75 Dp-2: 1976 Dp-2a:1968-75 Dp-2a:1976 Dp-3:1968-75 Dp-4:1977-91
Fecal Coliform (MFFCC/100 ml)	400	- -	- -	Dp-1:1964-65 Dp-1:1968-75 Dp-2:1964-65 Dp-2:1968-75 Dp-2a:1968-75 Dp-3:1968-75 Dp-4:1977-91	- -
Temperature (°F)	89	Dp-1:1964-65 Dp-1:1968-75 Dp-1:1999-2001 Dp-2:1964-65 Dp-2:1968-75 Dp-2:1976 Dp-2:1999-2001 Dp-2a:1968-75 Dp-2a:1976 Dp-2a:1999-2001 Dp-4:1977-91	Dp-3:1968-75	- -	- -
pH	6-9	Dp-1:1964-65 Dp-1:1964-75 Dp-1:1999-2001 Dp-2:1964-65 Dp-2:1968-75 Dp-2:1999-2001 Dp-2a:1968-75 DP-2a:1999-2001 Dp-3:1968-75 Dp-4:1977-91	- -	- -	- -
Total Lead (µg/l)	1,050/62[b]	Dp-4:1977-91[c]	- -	Dp-2:1976 Dp-2a: 1976	- -
Chromium (µg/l)	14	Dp-4:1977-91	- -	- -	- -
Total Chromium (µg/l)	6,061/175[b]	Dp-4:1977-91	- -	- -	- -

Table 70 (continued)

Parameter	Standard	Standard or Guideline Never Exceeded[a]	Standard or Guideline Rarely Exceeded[a]	Standard or Guideline Frequently Exceeded[a]	Standard or Guideline Very Frequently Exceeded[a]
Cyanide	46	Dp-4:1977-91	- -	- -	- -
Arsenic (µg/l)	364	Dp-4:1977-91	- -	- -	- -
Total Cadmium (µg/l)	146/2.4[b]	Dp-4:1977-91	- -	- -	- -
Total Copper (µg/l)	64/44[b]	Dp-4:1977-91	- -	- -	- -
Mercury (µg/l)	1.5	Dp-4:1977-91	- -	- -	- -
Total Nickel (µg/l)	3,628/222[b]	Dp-4:1977-91	- -	- -	- -
Total Zinc (µg/l)	248/167[b]	Dp-4:1977-91	- -	- -	- -

NOTE: Units are in mg/l, unless otherwise specified.

[a]*Frequency of violation of standards or guidelines was determined based upon the following breakdown: Standard or Guideline Never Exceeded = no reported parameter values exceed the specified standard; Standard or Guideline Rarely Exceeded = reported parameters values exceed the specified standard in less than 25 percent of cases reported; Standard or Guideline Frequently Exceeded = reported parameter values exceed the specified standard in 25 to 75 percent of cases reported; and Standard or Guideline Very Frequently Exceeded = reported parameters values exceed the specified standard in more than 75 percent of cases reported.*

[b]*Acute Toxicity Criteria and Chronic Toxicity Criteria respectively calculated using the method set forth in Chapter NR 105,* Wisconsin Administrative Code*, using an estimated hardness value of 420 mg/l.*

[c]*Based upon Acute Toxicity Criterion; Chronic Toxicity criterion was exceeded.*

Source: SEWRPC.

- Based upon data collected during September and October 1976, wet weather conditions generally had a much greater impact on the mass of pollutants transported from the watershed to the river system than on the concentration of pollutants being transported within the river system, as indicated by the ratio of wet weather to dry weather mass transport being significantly greater than the ratio of wet weather to dry weather concentrations.

- The temperature standard, which specifies that surface water temperatures be less than or equal to 89ºF, appeared to have been met virtually all of the time in the Des Plaines River watershed under both dry weather and wet weather conditions.

- The pH standard, which specifies that pH be within a range of 6.0 to 9.0 standard units, appeared to have been met virtually all of the time in the watershed during both dry and wet weather conditions.

- The dissolved oxygen standard, which specifies a concentration greater than or equal to 5 mg/l, appeared to have been met about 85 percent of the time during both dry and wet weather conditions in the downstream reaches of the Des Plaines River watershed. However, in the past, there was an apparent adverse impact of infrequent discharges of sanitary sewage from sanitary sewer overflows in the watershed on dissolved oxygen levels in the downstream portions of the Des Plaines River. Those overflows have now been abated. As of 1990, there were no known points of sanitary sewage flow relief in the Des Plaines River watershed—although there have been structural pipe failures in the local sewer system in the Town of Bristol Utility District No. 1. Those failures, which resulted in infrequent overflows from the tributary sanitary sewer system, were corrected in 1993.

- The fecal coliform standard, which specifies a fecal coliform count not exceeding 400 MFCC/100 ml, appeared to have been exceeded about 46 percent of the time in the watershed.

- The total phosphorus standard of 0.1 mg/l appeared to have been exceeded about 83 percent of the time within the watershed.

- Sampling data collected in the Des Plaines River indicated no violations of the ammonia-nitrogen standard.

- Nitrogen concentrations increased or decreased during wet weather conditions, depending on the magnitude of the base flow nitrogen concentration. If the base flow nitrogen concentration was higher than the nitrogen concentration of the surface runoff, the nitrogen concentration generally decreased during wet weather conditions. Likewise, if the base flow nitrogen concentration was lower than the nitrogen concentration of the surface runoff, the nitrogen concentration generally increased during wet weather conditions.

- Chloride concentrations in the surface waters of the Des Plaines River watershed were relatively high compared to the mean value of 7 mg/l reported from Wisconsin lakes by the WDNR,[25] but were generally similar to those found in more rural watersheds of Southeastern Wisconsin. Chloride in the surface waters was attributable to the use of chloride compounds for street de-icing during the winter. The highest instream chloride concentrations probably occurred during snowmelt conditions. The effect of street de-icing salt was felt throughout the year in that dry weather condition chloride concentrations continuously declined from the end of the winter de-icing period to the beginning of the subsequent winter de-icing period. At all other times, instream chloride concentrations decreased significantly during wet weather conditions as the result of the dilution effect of the runoff waters. Occasional, unusually high specific conductance and chloride levels, particularly when they occurred long after the winter de-icing period, were indicative of accidental spills or intentional discharges of soluble substances.

- The concentrations of metals in the Des Plaines River watershed were found to be generally within the limits of the recommended standards or guidelines based on the limited data available. However, several samples did suggest that some metals—barium, boron, chromium, copper, iron, manganese, nickel, strontium, vanadium and zinc—might have exceeded the recommended standards on occasion, although such exceedences were not a regular feature of the data set.

- The concentrations of biocides and synthetic organic chemicals in the Des Plaines River watershed were found to be generally within the limits of the recommended standards, based on the limited data available.

- The surface waters of the Des Plaines River watershed generally did not meet the established water use objectives. Although the levels of some critical parameters such as pH and temperature were met essentially all of the time, levels of other parameters such as dissolved oxygen, phosphorus, and fecal coliform were in excess of recommended standards at least some of the time.

- Violations of the water quality standards for the warmwater fishery water use objective were documented in the surface waters of the Des Plaines River watershed. These violations were related to low dissolved oxygen levels.

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[25]*Richard A. Lillie and John W. Mason,* Limnological Characteristics of Wisconsin Lakes*, Wisconsin Department of Natural Resources Technical Bulletin No. 138, 1983.*

- The recreational water use objective was not met in the Des Plaines River watershed primarily because of the fecal coliform bacteria present in the surface waters, and the excessive nutrient concentrations, in excess of the recommended standards, which provided the potential for aquatic plant and algal growth.

POLLUTION SOURCES

An evaluation of water quality conditions in the Des Plaines River watershed must include an identification, characterization and, where feasible, quantification of known pollution sources. This identification, characterization, and quantification is intended to aid in determining the probable causes of the water pollution problems discussed earlier in this chapter.

The schematic representation of the average annual volume of water passing through various paths in the hydrologic cycle of the Des Plaines River watershed is shown in Figure 45. The hydrologic budget was prepared using the hydrologic simulation model that is described in Chapter VIII of this report, supplemented with municipal, private, and industrial point source discharge data collated from the Wisconsin Pollutant Discharge Elimination System (WPDES). The flows associated with each of the above pollution sources reach the surface waters of the watershed by one or more of the flow paths shown in Figure 45. For example, pollutants discharged from storm sewer outfall points will be transported as wet weather flow and surface runoff to the stream system. Nonpoint source pollutants will move along both the wet weather and dry weather routes from their point of origin to the stream system.

Point Source Pollution

Point source pollution is defined as pollutants that are discharged to surface waters at discrete locations. Examples of such discrete discharge points include sanitary sewerage system flow relief devices, sewage treatment plant discharges, and industrial discharges.

Sanitary Sewerage System Flow Relief Points

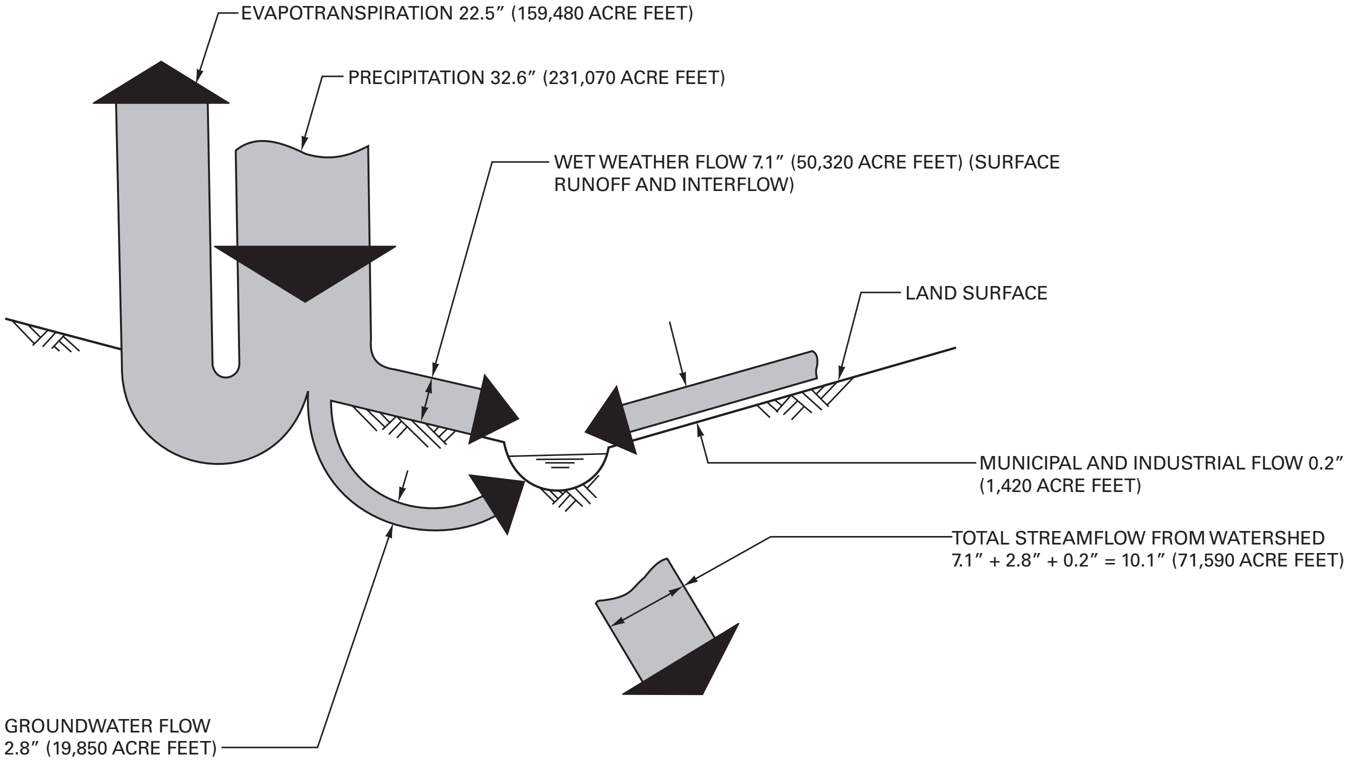
Raw sanitary sewage can enter the surface water system of a watershed either directly from sanitary sewer overflows or indirectly via flow relief devices to separate storm sewer systems. This direct or indirect conveyance of sanitary sewage to the surface water system of a watershed occurs through various types of flow relief devices as a result of one or more of the following conditions: inadequate sanitary sewage conveyance facilities, excessive infiltration and inflow of clear water during wet weather conditions, and mechanical and/or power failures at sanitary sewage pumping facilities. In order to prevent damage to residential dwellings or the mechanical elements of the conveyance system as a result of the aforementioned system failures, a sanitary sewerage flow relief device may be provided. Since the promulgation of the regional water quality management plan and State and Federal clean water initiatives in the 1970s, it has been the policy within the Region to phase out such devices as part of a general sewerage system upgrade.

Number and Location of Flow Relief Devices in the Watershed

As of early 2001, there were no sanitary sewerage system relief devices—or overflows—located in the watershed. The three known separate sewer system flow relief devices known to exist in the Des Plaines River watershed in 1975, at the time the regional water quality management plan was prepared—one bypass to Brighton Creek from the Village of Paddock Lake and two bypasses to the Des Plaines River, one each from the Town of Bristol and Village of Pleasant Prairie—were eliminated as the plants were upgraded, as recommended in the plan. The infrequent discharges of untreated sewage from the Town of Bristol Utility District No. 1 sewerage system, resulting from structural pipe failures in the system between pumping station No. 1 and the sewage treatment plant, were corrected in 1993 as part of the sewer system improvements which included upgrading the pumping station, replacing the force main and constructing a new trunk sewer.

Figure 45

AVERAGE ANNUAL HYDROLOGIC BUDGET FOR THE DES PLAINES WATERSHED 1990 LAND USE



Source: SEWRPC.

Municipal Sewage Treatment Facilities

In 2002, there were four public sewage treatment facilities located in the Des Plaines River watershed, as shown on Map 48. Two plants served the Village of Pleasant Prairie—the Village of Pleasant Prairie Utility District D and the Village of Pleasant Prairie Sanitary District No. 73-1[26]—and discharged treated effluent indirectly to the main stem of the Des Plaines River via small tributaries; one plant served the Village of Paddock Lake and discharged indirectly to Brighton Creek below the Harris Tract Marsh through Unnamed Tributary No. 6 to Brighton Creek; and one plant served the Town of Bristol—the Town of Bristol Utility District No. 1—and discharged treated effluent directly to a tributary of the Des Plaines River. One public sewage treatment plant has been abandoned since 1975, that being the Town of Salem Utility District No. 1 plant which service area was connected to the Town of Salem Utility District No. 2 plant for sewage treatment purposes. The status of implementation in regard to the abandonment, upgrading and expansion of the public and private sewage treatment plants in the Des Plaines River watershed, as recommended in the regional water quality management plan, is shown in Table 71. Selected characteristics of the public sewage treatment plants currently existing in the watershed are given in Table 7 in Chapter III, and Table 72.

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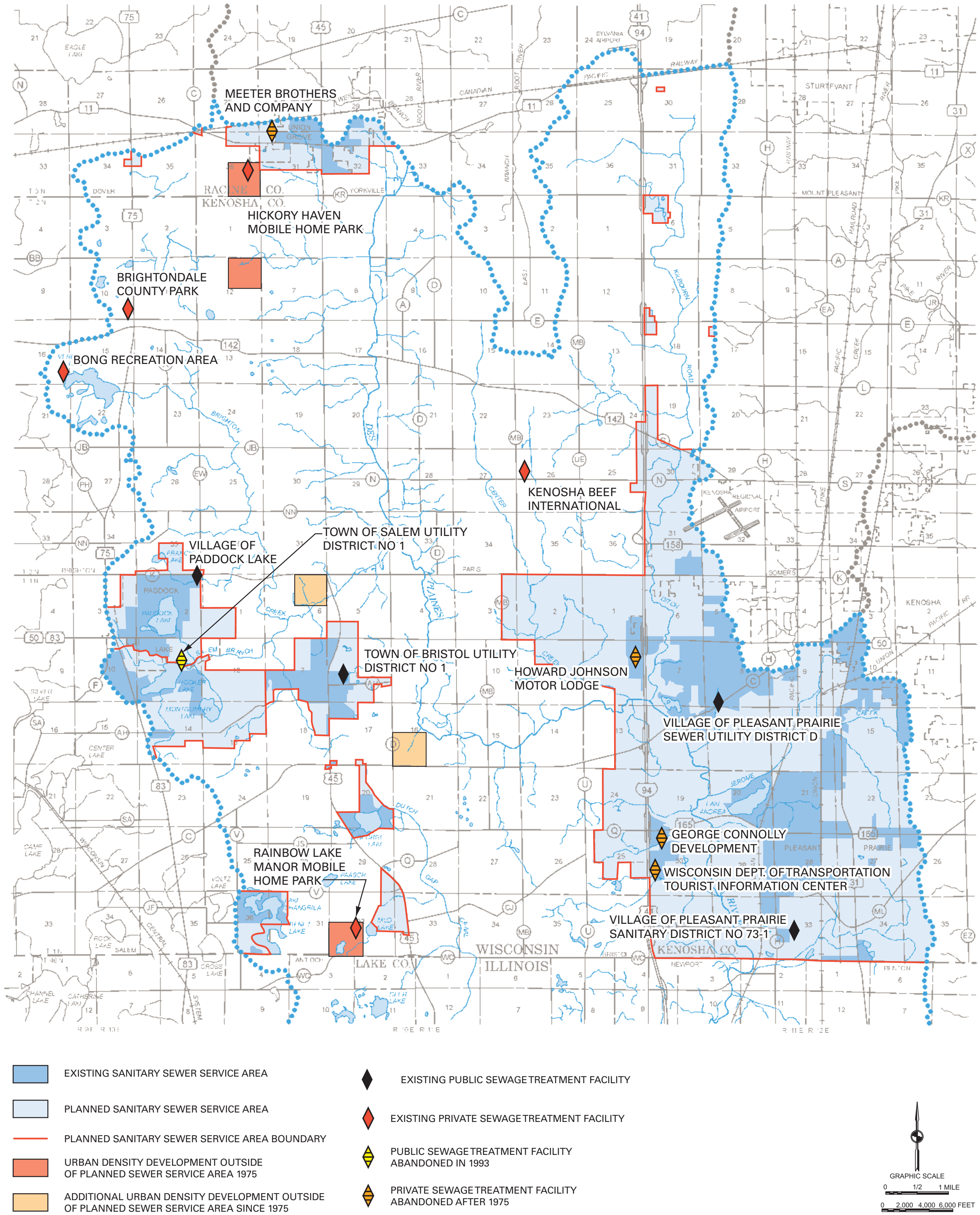
[26]*In 1989, the Town of Pleasant Prairie was incorporated as a Village and the name of these special-purpose units of government were changed to the Village of Pleasant Prairie Utility District "D" and the Village of Pleasant Prairie Sanitary District No. 73-1, respectively.*

Map 48

SANITARY SEWER SERVICE AREAS AND SEWAGE TREATMENT FACILITIES WITHIN THE DES PLAINES RIVER WATERSHED: 2002



Of the four public sewage treatment facilities located in the watershed in 2000, two plants served the Village of Pleasant Prairie and discharged treated effluent indirectly to the main stem of the Des Plaines River via small tributaries; one plant served the Village of Paddock Lake and discharged indirectly to Brighton Creek below the Harris Tract Marsh through Unnamed Tributary No. 6 to Brighton Creek; and one plant served the Town of Bristolthe Town of Bristol Utility District No. 1and discharged treated effluent directly to a tributary of the Des Plaines River. The eventual abandonment of the two treatment plants operated by the Village of Pleasant Prairie is recommended. Five private sewage treatment plants are currently in operation within the watershed, generally serving isolated enclaves of urban land uses beyond the current limits of the planned sanitary public sewer service areas.

Source: SEWRPC.

Table 71

IMPLEMENTATION STATUS OF THE INITIAL REGIONAL WATER QUALITY MANAGEMENT PLAN FOR PUBLIC AND PRIVATE SEWAGE TREATMENT PLANTS IN THE DES PLAINES RIVER WATERSHED: 2002

Public Sewage Treatment Plants	Disposal of Effluent	Plan Recommendation	Implementation Status
Town of Bristol Utility District No. 1	Bristol Creek tributary of Des Plaines River	Upgrade and expand	Completed (1988), with subsequent facility planning (1999) and phosphorus removal facilities added (2000)
Village of Paddock Lake	Brighton Creek below Harris Tract Marsh	Upgrade and expand	Completed[a] (1989), with subsequent facility planning (1997) and phosphorus removal facilities (2001)
Village of Pleasant Prairie Sanitary District No. 73-1	Tributary of Des Plaines River	Abandon plant[b]	Plant is being phased out
Village of Pleasant Prairie Sewer Utility District "D"	Tributary of Des Plaines River	Abandon plant[b]	Completed[a] (1985); plant is being phased out
Town of Salem Utility District No. 1	Salem Branch of Brighton Creek	Abandon plant[c]	Completed (1993)

Private Sewage Treatment Plant	Disposal of Effluent	Plan Recommendation	Implementation Status
Bong Recreation Area	Peterson Creek (Fox River watershed) via outfall sewer[d]		
Brightondale County Park	Soil absorption	Maintain and upgrade as needed	Facility maintained
Hickory Haven Mobile Home Park[e]	Tributary to the Des Plaines River	Maintain and upgrade as needed	Facility maintained and upgraded (1988)
Kenosha Beef International Company[f]	Soil absorption	Maintain and upgrade as needed	Facility maintained
Meeter Brothers Company	Tributary to the Des Plaines River	Maintain and upgrade as needed	Plant abandoned due to industry change (1987)
Rainbow Lake Manor Mobile Home Park[g]	Soil absorption	Maintain and upgrade as needed	Facility maintained
George Connolly Development[h]	Tributary to the Des Plaines River	Abandon plant[i]	Plant abandoned[h]
Howard Johnson Motor Lodge	Des Plaines River	Abandon plant	Plant abandoned (1989)
Wisconsin Tourist Information Center	Tributary to the Des Plaines River	Abandon plant[i]	Plant abandoned (1991)

[a]*Plant upgrading and expansion was completed representing implementation of the plan recommendations, except for the provision of phosphorus removal facilities which have not yet been provided.*

[b]*The Village of Pleasant Prairie Sanitary District No. 73 and Sewer Utility "D" sewage treatment plants were recommended to be retained in the initial regional water quality management plan. A 1996 amendment to the regional water quality management plan for the greater Kenosha area recommends the abandonment of the Village of Pleasant Prairie Sanitary District No. 73-1 and of the Village of Pleasant Prairie Sewer Utility District "D" sewage treatment plants and for sanitary sewer needs to be provided for by the Kenosha Water Utility's sewage treatment plant.*

[c]*The Town of Salem Utility District No. 1 sewage treatment plant was recommended to be retained in the initial regional water quality management plan. A 1991 amendment to the regional water quality management plan for the Town of Salem recommended the plant to be abandoned and for the Town of Salem Utility District No. 1 sewer service area to be served by the Town of Salem Utility District No. 2 sewage treatment plant. The plant was abandoned in 1993.*

[d]*The private plant serving the Bong Recreation Area is physically located in the Des Plaines River watershed, but discharges via an outfall sewer to Peterson Creek in the Fox River watershed.*

[e]*Formerly Fonk's Mobile Home Park No. 2.*

[f]*Formerly Kenosha Packing Company.*

[g]*Formerly Paramski Mobile Home Park.*

[h]*The George Connolly Development and Wisconsin Tourist Information Center sewage treatment plants were recommended to be retained in the initial regional water quality management plan. 1987 and 1996 amendments to the regional water quality management plan for the City of Kenosha and environs recommended the plants be abandoned and that sewer service be provided for by the Village of Pleasant Prairie Sanitary District No. 73-1 initially and the Kenosha Water Utility sewage treatment plant ultimately.*

[i]*The private treatment plant serving the George Connolly Development was never placed into operation.*

Source: SEWRPC.

Table 72

SELECTED DESIGN DATA FOR PUBLIC SEWAGE TREATMENT PLANTS IN THE DES PLAINES RIVER WATERSHED: 1995 AND 2020

Name of Public Sewage Treatment Plant	Sewer Service Areas	Design Capacity-Average Annual Hydraulic (mgd)	Existing 1995			Planned Year 2020				
			Average Hydraulic Loading (mgd)	Total Area Served (square miles)	Resident Population Served	Planned Sewer Service Area (square miles)	Intermediate-Growth Centralized Land Use Plan		High-Growth Decentralized Land Use Plan	
							Resident Population Served	Average Hydraulic Loading (mgd)	Resident Population Served	Average Hydraulic Loading (mgd)
Town of Bristol Utility District No. 1	Bristol	0.48	0.50	1.2	1,450	2.5	2,600	0.75	6,000	1.40
Village of Paddock Lake	Paddock Lake	0.49	0.45	1.1	2,700	2.2	4,100	0.70	6,600	1.00

Source: SEWRPC.

As can be seen by review of Table 71, full implementation of the regional water quality management plan would provide for the upgrading and expansion of the Village of Paddock Lake and Town of Bristol Utility District No. 1 sewage treatment plants, and the abandonment of the Town of Salem Utility District No. 1 sewage treatment plant and the connection of that service area to the Town of Salem Utility District No. 2 sewerage system and the abandonment of the two sewage treatment plants operated by the Village of Pleasant Prairie, the Village of Pleasant Prairie Utility District No. D and the Village of Pleasant Prairie Sanitary District No. 73-1 facilities and connection of the associated sewer service areas to the City of Kenosha sewerage system for treatment purposes. Implementation of these recommendations has been largely completed, with the exception that the two Village of Pleasant Prairie sewage treatment plants have not yet been abandoned. However, those plants are being phased out and agreements are in place for abandonment before the year 2010. As of November 2001, the portion of the service area west of IH 94 and much of the area located east of the Canadian Pacific Railway system had been connected to the Kenosha sewerage system. Thus, the amount of water currently being diverted has been substantially reduced from that which was previously approved on an interim basis.

With regard to the two treatment plants operated by the Village of Pleasant Prairie, the eventual abandonment of these facilities was proposed in a 1992 sanitary sewerage and water supply system plan[27] which was completed for the greater Kenosha area, and adopted as an amendment to the adopted regional water quality management plan in March 1996. That plan, which includes portions of the Des Plaines River watershed in the vicinity of the IH 94 corridor, identified the sanitary sewer and water supply needs of that planning area, and evaluated alternative means of meeting those needs; recommended a coordinated set of design year 2010 sewerage and water supply system plans for the area; identified the intergovernmental, administrative, legal, and fiscal issues inherent in the implementation of the system plans; and recommended an institutional structure for implementation of those plans, as follows:

1. The sewer service areas as set forth in the adopted regional water quality management plan are to be revised to conform with those set forth under the recommended Kenosha area sewerage system plan.

[27]*Ruekert & Mielke, Inc.,* A Coordinated Sanitary Sewer and Water Supply System Plan for the Greater Kenosha Area*, 1992.*

2. The Kenosha Water Utility sewage treatment plant is designated as the sole public sewage treatment plant to serve the area considered, as shown on Map 48; and the two public sewage treatment plants operated by the Village of Pleasant Prairie Sewer Utility District D and the Village of Pleasant Prairie Sanitary District No. 73-1 are recommended to be abandoned during the planning period.

3. The intercommunity trunk sewers needed to provide service are recommended to be added to the regional plan recommendations.

With regard to the two public sewage treatment plants which are recommended to be maintained in the Des Plaines River watershed, it is noted that both plants currently have recorded monthly average flows which approach or exceed the average design capacity of the plant as shown on Table 72. Thus, facility planning programs have been initiated to explore plant expansion alternatives for both the Village of Paddock Lake and the Town of Bristol Utility District No. 1 sewage treatment plants.

There are six sewer service areas identified in, or partially in, the Des Plaines River watershed—Bristol, Salem South, Salem North, Kenosha, Paddock Lake, and Union Grove. All of these areas have undergone refinement as recommended in the regional water quality management plan. The boundaries of the sewer service areas, as currently refined, are shown on Map 48. Table 73 lists the plan amendment prepared for each refinement and the date the Commission adopted the document as an amendment to the regional water quality management plan. As shown in Table 73, the planned sewer service areas in the Des Plaines River watershed, as refined through 2001, total about 37.3 square miles, or about 28 percent of the total watershed area.

Private Sewage Treatment Facilities

As indicated in Table 71, three of the nine private sewage treatment plants in the watershed were, as of 1975, recommended to be abandoned. As of 2001, each of these three plants had ceased operation. In addition, the Meeter Brothers private plant had also ceased operation because the industry the plant supported is no longer in business at this location. The remaining four private plants were recommended to be maintained and upgraded to provide effluent quality which would be determined on a case-by-case basis as part of the Wisconsin Pollution Discharge Elimination Permit system. These four plants are continuing to operate in this manner. In addition, a new private treatment plant was constructed in 1980 to serve the Bong Recreation Area in accordance with the recommendations set forth in the regional water quality management plan. However, despite the physical location of this plant within the Des Plaines River watershed, treated effluent from this facility is discharged to the Fox River basin via the Peterson Creek.

Five private sewage treatment plants are currently in operation within the Des Plaines River watershed, generally serving isolated enclaves of urban land uses as shown on Map 48, including two mobile home parks and one industry: Hickory Haven Mobile Home, Rainbow Lake Manor Mobile Home Park, the Bong Recreational Area, the Brightondale County Park, and the Kenosha Beef International Company. These facilities, which serve isolated land uses are located beyond the current limits of the planned sanitary public sewer service areas and are recommended to be retained, with the exceptions of the Hickory Haven Mobile Home Park—located in close proximity to the planned Union Grove Sewer Service Area—and the Rainbow Lake Manor Mobile Home Park—located in close proximity to the planned Bristol service area, which have the potential to be consolidated with public treatment facilities. Thus, it is recommended that at the time each of these two private plants require significant upgrading or modification that detailed facility planning be conducted to evaluate the alternative of connecting these two land uses to the adjacent public sanitary sewer systems. For the remaining three private sewage treatment plants, the need for upgrading and level of treatment should be formulated on a case-by-case basis during plan implementation as part of the Wisconsin Pollution Discharge Elimination System permitting process.

Management of Solids from Public and Private Sewage Treatment Plants

The regional water quality management plan included a set of specific options to be considered in facilities planning for management of solids generated at the public and private sewage treatment plants in the Des Plaines River watershed. These options included methods for processing, transportation, and utilization or disposal of

Table 73

PLANNED SANITARY SEWER SERVICE AREAS IN THE DES PLAINES RIVER WATERSHED: 2001

Name of Sanitary Sewer Service Area(s)	Planned Sewer Service Area (square miles)	Date of SEWRPC Adoption: Initial Plan/Most Recent Amendment	Plan Amendment Document
Bristol	2.5	December 1, 1986/ September 10, 1997	SEWRPC CAPR No. 145, *Sanitary Sewer Service Area for the Town of Salem Utility District No. 1, Village of Paddock Lake, and Town of Bristol Utility District Nos. 1 and 1B, Kenosha County, Wisconsin*, as amended
Salem South	0.6	March 3, 1986/ March 7, 2001	SEWRPC CAPR No. 143, *Sanitary Sewer Service Area for the Town of Salem Utility District No. 2, Kenosha County, Wisconsin*, as amended
Salem North	2.8		
Kenosha	27.5	December 2, 1985/ March 6, 1996	SEWRPC CAPR No. 106, *Sanitary Sewer Service Areas for the City of Kenosha and Environs, Kenosha County, Wisconsin*, as amended
Paddock Lake	2.2	December 1, 1986/ March 1, 2000	SEWRPC CAPR No. 145, *Sanitary Sewer Service Area for the Town of Salem Utility District No. 1, Village of Paddock Lake, and Town of Bristol Utility District Nos. 1 and 1B, Kenosha County, Wisconsin*, as amended
Union Grove	1.7	September 12, 1990/ - -	SEWRPC CAPR No. 180, *Sanitary Sewer Service Area for the Village of Union Grove and Environs, Racine County, Wisconsin*
- -	37.3	- -	- -

NOTE: CAPR indicates Community Assistance Planning Report.

Source: SEWRPC.

treatment plant solids. As facility plans are prepared, they are reviewed for conformance with the plan recommendations. Since sludge management planning is generally carried out as part of the sewage treatment plant facility planning, implementation of this element of the regional plan generally parallels the municipal and private treatment plant implementation described above. One of the principal recommendations under that plan element concerned the preparation of a plant-specific sludge management plan. Since 1977, the Department of Natural Resources has included, as a part of the discharge permitting process, the requirement that the designated management agencies develop and submit a sludge management report. In addition, the permit requires that, upon approval and implementation of the sludge management plan, records be maintained of sludge application sites and quantities, and that the sites be monitored for adverse environmental, health, or social effects that may be experienced due to sludge disposal. At the present time, such reports have been prepared and submitted to the Department, or are under preparation, for all of the public and private sewage treatment plants currently within the watershed.

Intercommunity Trunk Sewers
The construction of two intercommunity trunk sewers in the Des Plaines River watershed was proposed in the regional water quality management plan: one trunk sewer would connect the urban development in the Town of Bristol in the vicinity of IH 94 and STH 50 to the Pleasant Prairie Sewer Utility District D sewerage system, and the second trunk sewer would connect the Town of Salem Utility District No. 1 to the Town of Salem Utility District No. 2 sewerage system. These trunk sewers were constructed in 1987 and 1993, respectively.

Based upon the aforementioned 1992 sanitary sewer and water supply system plan for the greater Kenosha area, the regional water quality management plan recommended that three new trunk sewers be constructed to convey wastewater from the Pleasant Prairie-Bristol portion of the service area to Pleasant Prairie and ultimately to the City of Kenosha sewerage system.

Industrial Discharges

In 1975, there were a total of six known point sources of pollution identified in the Des Plaines River watershed other than public and private sewage treatment plants. These other point sources consisted primarily of six outfalls through which industrial cooling, process, rinse, wash waters, and filter backwash waters were discharged directly or indirectly to the surface water system. Of these, three were identified as discharging only cooling water. The remaining three were discharging other types of wastewater. The adopted regional plan recommended that these industrial sources of wastewater be monitored and discharges limited to levels which must be determined on a case-by-case basis under the Wisconsin Pollutant Discharge Elimination System permit process.

It was also recognized in the regional water quality management plan that there would be changes in the number of such wastewater sources as the industries and other facilities change location or processes and as decisions are made with regard to the connection of such sources to public sanitary sewer systems. As of 1993, there were ten such point sources of wastewater discharging to the Des Plaines River and its tributaries directly through industrial waste outfalls or indirectly through drainage ditches and storm sewers. Table 94 in Chapter IX of this report summarizes selected characteristics of these other point sources and Map 58 in Chapter IX shows their locations.

Nonpoint Source Pollution

Nonpoint source pollution, also referred to as diffuse source pollution, consists of various discharges of pollutants to the surface waters which cannot be readily identified as point sources. Nonpoint source pollution is transported from the rural and urban land areas of a watershed to the surface waters by means of direct runoff from the land via overland routes, via storm sewers and channels, and by interflow during and shortly after rainfall or rainfall-snowmelt events. Nonpoint source pollution also includes pollutants conveyed to the surface waters via groundwater discharge—base flows—which is a major source of stream flow between runoff events.

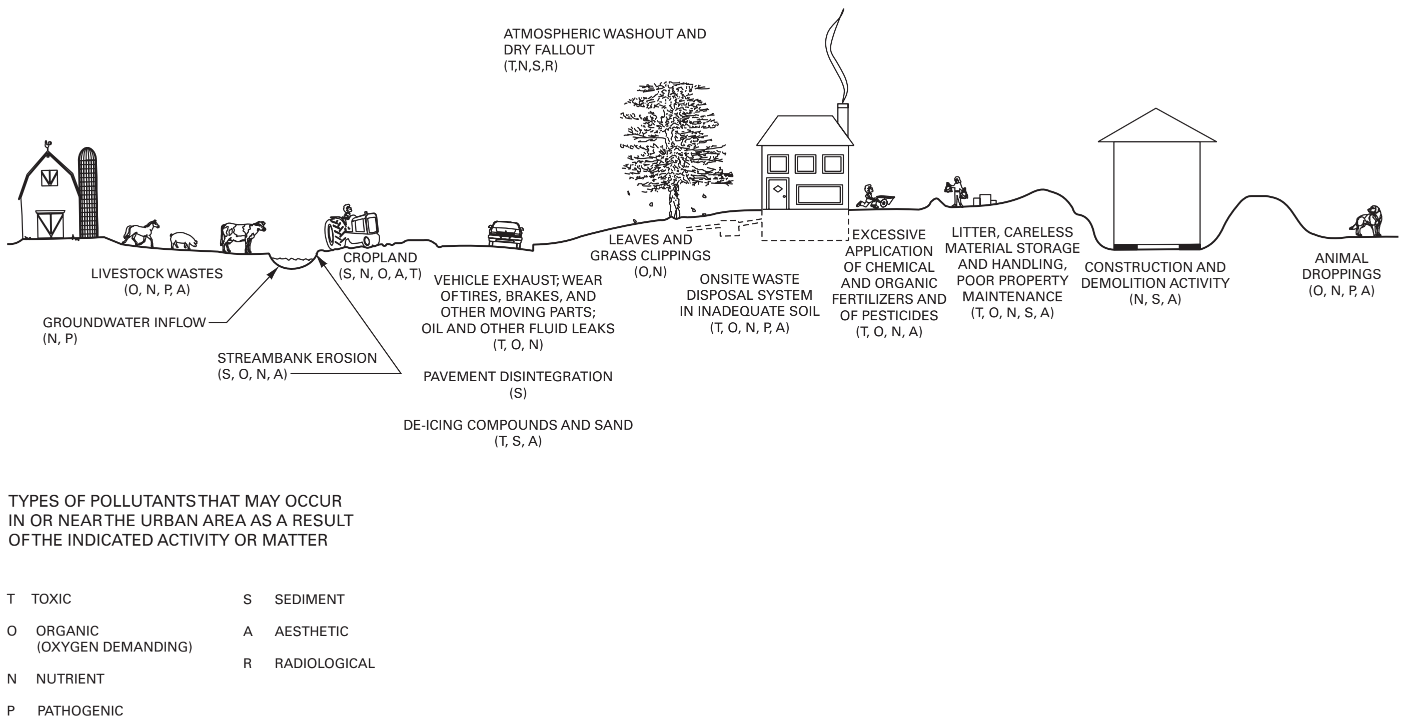
The distinction between point and nonpoint sources of pollution is somewhat arbitrary since a nonpoint source pollutant, such as sediment being transported in overland rainfall runoff, can be collected in open channels or in storm sewers and conveyed to points of discharge, such as a storm sewer outfall. Thus, for purposes of this report, nonpoint source pollution includes substances washed from the land surface or subsurface by rainfall and snowmelt runoff and then conveyed to the surface waters by that runoff, even though the entry into the surface waters may be through a discrete location such as a storm sewer outfall.

Nonpoint source pollution is similar in composition to point source pollution in that it can cause toxic, organic, nutrient, pathogenic, sediment, radiological, and aesthetic pollution problems. Nonpoint source pollution is becoming of increasing concern in water resources planning and engineering as efforts to abate point source pollution become increasingly successful. The control of nonpoint source pollution is a necessary step in the process of improving surface waters to render such waters suitable for full recreational use and a healthy fishery.

Nonpoint source pollution generally differs from point source pollution in one important respect: nonpoint source pollution is transported to the surface water at a highly irregular rate in that large portions of the overall transport occur during rainfall or snowmelt events. In the dry period after washoff events, potential nonpoint source pollutants gradually accumulate on the land surface as a result of human activities, becoming available for transport to the surface waters during the next runoff event. The following activities, or effects of human activities, result in nonpoint source pollution: 1) dry fallout and washout of atmospheric pollution; 2) vehicle exhaust and lubricating oil and fuel leakage; 3) the gradual wear and disintegration of tires, pavements, structures, and facilities; 4) improper disposal of grass clippings and leaves; 5) improperly located and maintained onsite wastewater disposal systems; 6) poor soil and water conservation practices; 7) improper management of livestock wastes; 8) excessive use of fertilizers and pesticides; 9) debris, careless material storage and handling, and poor property maintenance; 10) construction and demolition activity; 11) application of de-icing salts and sand; 12) streambank erosion; and 13) domestic and wild animal litter, as illustrated diagrammatically in Figure 46.

Figure 46

NONPOINT SOURCES OF WATER POLLUTION



Source: SEWRPC.

With respect to spatial distribution, the entire 132.9-square-mile surface of the Des Plaines River watershed is a potential source of nonpoint source pollution. The following discussion addresses the types of nonpoint sources of water pollution in the Des Plaines River watershed and presents the inventory findings.

Urban Land Use

Urban land uses within the Des Plaines River watershed include residential, commercial, and industrial land uses as set forth in Chapter III. Each of these land uses contributes nonpoint source pollutants to the surface and ground waters of the Des Plaines River.

Residential Land Use

The concentration of people, domestic structures, and activities in residential areas and the alteration of the natural drainage and infiltration characteristics results in the production and release of nonpoint source water pollutants. Runoff from lawns, rooftops, driveways, sidewalks, and unused land is channeled through drainageways and streets and is transported directly, as overland flow, or indirectly, through storm sewerage systems, to surface waters. Pollutant sources associated with residential land uses include street debris, fertilizers, pesticides, pet wastes, garbage and litter, vegetation, degraded surface coatings such as paint particles, and detergent. Surface runoff from precipitation events and from urban activities within residential areas, such as lawn sprinkling or automobile washing, release pollutants to the environment.

Commercial Land Use

The high percentage of impervious area and attendant high runoff rates, together with the accumulation of litter and debris, make commercial land a significant contributor of nonpoint source pollutants. Rainfall and snowmelt runoff from rooftops, parking lots, buildings, alleys, streets, loading docks and work areas, and adjacent sidewalks and open areas contribute sediment, oxygen-demanding substances, dissolved substances, nutrients, toxic and hazardous substances, oil, grease, bacteria, and viruses to the streets and storm sewers which drain the commercial areas and discharge into the streams of the Des Plaines River watershed. Another source of runoff is the washing of debris from work areas, sidewalks, and areas adjacent to storage areas.

Industrial Land Use

Runoff from industrial spills, production and distribution sites, automobile salvage yards, loading docks and work areas, material storage sites, industrial buildings and adjacent streets, parking lots, rooftops, lawns, sidewalks, and open areas transports fuels, oil, grease, wood, metals, paper, plastic, salt, sand and gravel, organic substances, fly ash, petroleum and chemical products, corrosives, waste chemicals, brush, garbage, rubber, acids, glass, ceramics, paint particles, glue, and solvents to streets, storm sewers, and large collector sewers. Many industrial operations do not have the indoor or covered storage capacity to house raw materials awaiting processing and, therefore, store the materials in outdoor bins or designated areas exposed to natural weathering processes, breakage, leakage, erosion, oxidation, heat, cold, and moisture which increase the degradation of the material and the potential for its removal and transport to surface waters by storm runoff or snowmelt.

Underground Storage Tanks

Storage and transmission of a wide variety of fuels and chemicals are inherent in many industrial, commercial, agricultural, and individual activities. Petroleum and petroleum products are the most common potential contaminants. Underground storage tanks for gasoline, oil, and other liquids that were installed during the 1950s and 1960s have now exceeded their expected 20- to 30-year life. The large volume and high concentration of hazardous materials that can leak or can be released from a storage tank in a small area creates an onsite, and sometimes offsite, contamination risk. Leaks in petroleum-product conveyance and transmission lines also are a potential source of groundwater contamination. The Wisconsin Department of Natural Resources keeps an inventory of leaking underground storage tanks (LUST) that they have identified and categorized according to risk. LUST sites are identified as high priority when it is known that the site is causing contamination to groundwater, or where there is a high potential for such contamination. LUST sites that are ranked as medium priority, have known soil contamination problems or a potential for groundwater contamination.

As of 1993, there were 11 leaking underground storage tanks in the Des Plaines River watershed identified by the Wisconsin Department of Natural Resources. None of these sites were permitted to discharge remediation wastewater directly to surface or ground waters. While there is little evidence to document the impact of these individual sources on water quality within the watershed, it can be reasonably assumed that the cumulative effect of multiple leaking underground storage tanks has the potential to result in detrimental effects on water quality over time.

Hazardous Spills

Industrial spills are an additional source of pollution to surface waters. Common to nearly all industrial activities is the storage of petroleum and chemical substances. Heavy loadings of nutrients, oxygen-demanding substances, suspended and dissolved solids, toxic substances, and fecal coliform bacteria may be contributed to surface waters by leaking oil drums; overflowing hoppers and bins of scrap metal saturated with cutting oils; punctured industrial waste hoppers; and spilled greases, fuels, process wastes, metals, synthetic organic chemicals such as polychlorinated biphenyls, and other organic materials. The resulting pollution of the surface water resources by careless or improper handling of industrial substances can be catastrophic depending on the nature of those substances and the quantity and location of the spill.

Transportation Activities

Transportation activities contribute significant amounts of pollutants to surface waters in the Des Plaines River watershed as goods and people are moved by rail, air, bus, truck, or car. The terminals, transportation routes, and service and maintenance areas are all sites of pollutant buildup and potential release. Motor vehicle pollutants accumulate on freeways and expressways, highways, streets, and parking lots. Motor vehicles deposit fuel, oil and grease, hydraulic fluids, coolants, exhaust emissions—particulates and gases, tire rubber, litter, metals, asbestos, and nutrients on streets. De-icing salts, pavement debris, vegetation debris, animal wastes, litter, fertilizers, pesticides, chemicals, and material from adjacent land also accumulate on streets. Because the transportation-related urban surfaces are impervious and designed to drain very quickly, they play a particularly important role in the transport of pollutants.

De-icing Salt Usage

Initially, salts were used in conjunction with abrasives such as sand or ashes to facilitate travel on snowy and icy highways. In the winter of 1956-1957, the Wisconsin Highway Commission initiated a bare pavement winter maintenance program, which required liberal and frequent applications of straight salt in order to provide, wherever possible, consistently dry and, therefore, safer driving surfaces. Sodium chloride is the most commonly used de-icing salt. The de-icing salts dissolve to form solutions with lower freezing points than the freezing point for water. The application of de-icing salts on highways during the winter may significantly affect the quality of runoff water. The salt applied to the highway must either be carried by surface runoff or must infiltrate the ground surface. Improper or excessive salt application may lead to groundwater or surface water contamination, soil contamination, damage to plants, damage to wildlife, increased corrosion, and possible human toxicity in extreme circumstances.

Recreational Activities

Certain outdoor recreational activities, which utilize large areas of the land and water, may constitute nonpoint sources of pollution by contributing pollutants to stormwater runoff and snowmelt that are then carried to surface waters. Normally, outdoor recreational sites include large areas of land which are relatively well stabilized and act either as relatively modest sources of pollutants or as pollutant-trapping mechanisms. For example, grass buffer strips along streams serve to remove pollutants from stormwater runoff and snowmelt through the sedimentation, filtration, and nutrient uptake effects of the vegetative cover. However, outdoor recreational sites may also include space and impervious areas for the conduct of such recreational pursuits as tennis, swimming, and boating. Consequently, recreational areas may be sources of nonpoint pollution. The amount of pollutants contributed will depend upon such factors as the types of recreational facilities provided, the location and size of vegetated buffer areas and zones, the amount of fertilizers and pesticides used, the land management methods applied, the drainage efficiency of the site, and the location of the site with respect to adjacent lakes or streams. However, well-designed and managed recreational lands may serve as a means of resolving other nonpoint source pollution problems.

Construction Activities

The development and redevelopment of residential, commercial, industrial, transportation, and recreational areas within the Des Plaines River watershed can cause significant quantities of pollutants to be contributed to streams. Construction activities generally involve soil disturbance and destruction of stable vegetative cover; changes in the physical, chemical, and biological properties of the land surface; and attendant changes in the hydrologic and water quality characteristics of the site as an element of the natural system of surface and groundwater movement. The clearing and grading of construction sites subjects the soil to high erosion rates. Potential pollutants from construction activities include soil particles; pesticides; petroleum products, such as oils, grease, gasoline, and asphalt; solid waste materials, such as paper, wood, metal, rubber, garbage, and plastic; construction chemicals such as paints, glues, solvents, sealants, acid, and concrete; and soil additives such as lime, fly ash, and salt. The transportation of pollutants from construction sites to natural waters is by direct runoff of stormwater and snowmelt, leaching and groundwater infiltration, wind, soil slippage or landslide, and mechanical transfer on vehicles. In the Des Plaines River watershed, the City of Kenosha, the Villages of Pleasant Prairie and Paddock Lake, and the Towns of Salem and Somers, have construction site erosion control ordinances based upon the *Wisconsin Construction Site Erosion Control Model Ordinance*, developed by the Wisconsin Department of Natural Resources and Wisconsin League of Municipalities, and published by the League of Wisconsin Municipalities in 1989. In addition, the Village of Union Grove and the Towns of Bristol, Dover, and Mt. Pleasant have ordinance requirements which are related to the control of construction site erosion, but are not based on the model ordinance.

Through the year 2010, it is estimated that, on average, approximately 280 acres of land, or about 0.3 percent of the watershed area in Wisconsin, would be under construction each year. From 1995 through October 2001, the State of Wisconsin issued 44 construction site permits covering a total area of 1,423 acres.

Onsite Sewage Disposal Systems
An onsite sewage disposal system may be a conventional septic tank system; a mound system; an alternative system, such as an aerobic treatment unit or a sand filter; or a holding tank. Failure of an onsite sewage disposal system occurs when the soils surrounding the seepage area will no longer accept or properly stabilize the effluent, when the groundwater rises to levels which will no longer allow for uptake of liquid effluent by the soils, or when age or lack of proper maintenance cause the system to malfunction. Hence, onsite sewage disposal system failure may result from installation in soils with severe limitations for system use, improper design or installation of the system, or inadequate maintenance.

During the year 2000, the Wisconsin Legislature amended Chapter Comm 83 and adopted new rules governing onsite sewage disposal systems. These rules, which had an effective date of July 1, 2000, increased the number of types of onsite sewage disposal systems that legally could be used from four to nine. The Wisconsin Department of Commerce envisions that other systems also will be approved in the future. These new rules significantly alter the existing regulatory framework and will increase the area in which onsite sewage disposal systems may be utilized. The new rules included a provision that allows counties the option of waiting three years before implementing the new onsite sewage disposal system rules and permitting the use of the new types of systems. Both Kenosha and Racine Counties have chosen to defer the use of the new technologies for new development for three years.

Enclaves of urban development located outside the planned sewer service areas are shown on Map 48. The corresponding urban enclave population and the distance to the nearest planned year 2020 sewer service area are listed in Table 74. Each of these areas is covered by soils, and has lot sizes, which have a high probability of not meeting the criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* covering conventional onsite sewage disposal systems as it existed early in the year 2000. Thus, for the identified urban enclaves in the Des Plaines River watershed, the regional water quality management plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. These areas should consider alternative methods of waste disposal and an intensive inspection and maintenance program for conventional systems, as well as the possibility of connection to the public sanitary sewer service areas. About 72 percent of the Des Plaines River watershed area is served by private onsite sewage disposal facilities.

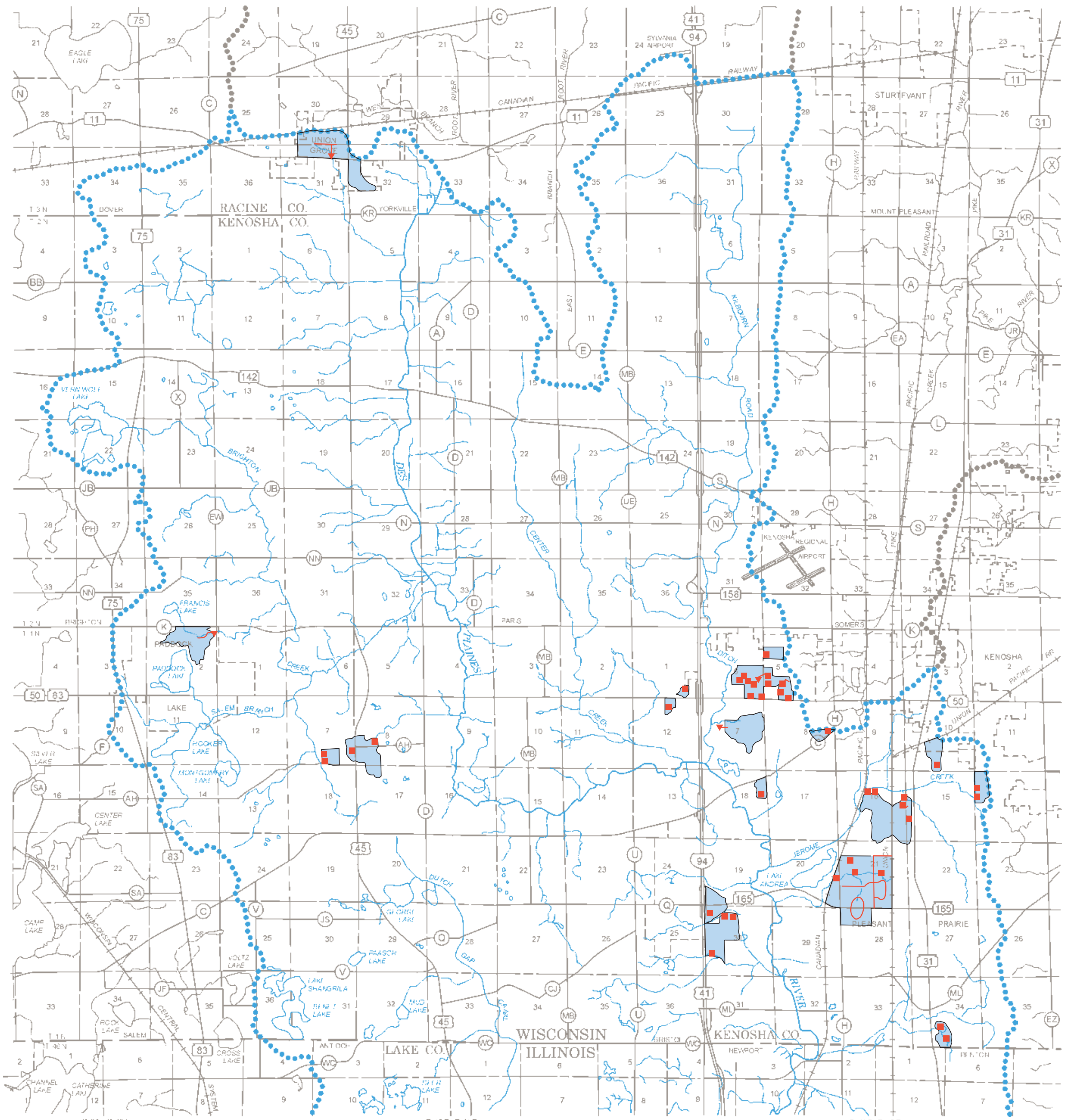
Stormwater Drainage Systems
Stormwater drainage facilities are defined, for purposes of this report, as conveyances or storage facilities—including, but not limited to, subsurface pipes and conduits, ditches, channels, and appurtenant inlet, outlet, detention and retention basins, and pumping facilities—located in urbanized areas and constructed or improved and operated for purposes of collecting stormwater runoff from tributary drainage areas and conveying or storing such runoff prior to discharge to natural watercourses. In the larger and more intensively developed urban communities, these facilities consist either of complete, largely piped, stormwater drainage systems which have been planned, designed, and constructed as systems in a manner similar to sanitary sewer and water utility systems, or of fragmented or partially piped systems incorporating open surface channels to as great a degree as possible.

In the Des Plaines River watershed, the stormwater drainage systems provide the means by which a portion of the nonpoint source pollutants reach the surface water system. However, including nonpoint source pollution control and treatment features, such as wet detention basins, vegetated filter strips, or infiltration devices, as part of an overall stormwater management system will reduce the loads of pollutants that are transported to streams.

The known existing stormwater drainage systems which serve portions of the Des Plaines River watershed are shown on Map 49. These include the systems operated by the City of Kenosha; Villages of Paddock Lake, Pleasant Prairie, and Union Grove; and Town of Bristol. Together these systems have a combined tributary drainage area within the watershed of about 3.5 square miles, or about 3 percent of the total area of the watershed. Included within this stormwater drainage area are 38 known stormwater detention basins. The detention basins are a mix of dual-purpose basins with permanent ponds that would provide water quantity control as well as nonpoint source pollution control and dry detention basins without permanent ponds that would provide water quantity

Map 49

URBAN STORM SEWER SYSTEMS IN THE DES PLAINES RIVER WATERSHED: 1995



WATERSHED BOUNDARY

EXISTING STORM SEWER (30-INCH DIAMETER OR LARGER)

EXISTING STORM SEWER OUTFALL

EXISTING STORM WATER DETENTION BASIN

EXISTING STORM SEWER OR DETENTION BASIN SERVICE AREA

NOTE: DOES NOT INCLUDE STORM SEWERS PRIMARILY INTENDED TO PROVIDE DRAINAGE ALONG STATE TRUNK HIGHWAYS AND INTERSTATE HIGHWAYS.

GRAPHIC SCALE
0 1/2 1 MILE
0 2,000 4,000 6,000 FEET

As of 1995, the known existing stormwater drainage systems in the watershed were operated by the City of Kenosha; the Villages of Paddock Lake, Pleasant Prairie and Union Grove; and the Town of Bristol. Together these systems have a combined tributary drainage area within the watershed of about 3.5 square miles, or about 3 percent of the total area of the watershed. Included within this stormwater drainage area are 38 known stormwater detention basins which are a mix of dual-purpose basins with permanent ponds that would provide water quantity control as well as nonpoint source pollution control and dry detention basins without permanent ponds that would provide water quantity control, but would not significantly control nonpoint source pollution.

Source: SEWRPC.

Table 74

EXISTING URBAN DEVELOPMENT OUTSIDE THE PLANNED PUBLIC SANITARY SEWER SERVICE AREA IN THE DES PLAINES RIVER WATERSHED

Major Urban Concentration[a]	1995 Estimated Resident Population	Distance from Year 2020 Sewer Service Area (miles)
Kenosha County		
Town of Brighton-Section 12[b]	95	1.50
Town of Bristol-Section 6[b]	103	0.25
Town of Bristol-Section 16[b]	109	0.60
Mud Lake[c]	261	0.20
Racine County		
Town of Dover-Section 36[c]	301	0.00
Total	869	- -

[a]*Urban development is defined in this context as concentrations of urban land uses within any given U.S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

[b]*Based upon consideration of soils, lot sizes, and density, further site-specific planning should be conducted during the planning period to determine the best means of providing for wastewater management.*

[c]*Served by a private sewage treatment plant.*

Source: SEWRPC.

control, but would not significantly control nonpoint source pollution. The locations and configurations of the major storm sewers, detention basins and estimated system tributary drainage areas are shown on Map 49.

Solid Waste Disposal Sites

Solid waste disposal sites are a potential source of surface water, as well as groundwater, pollution. It is important to recognize, however, the distinction between a properly designed and constructed sanitary landfill and the variety of operations that are referred to as refuse dumps—especially with respect to potential effects on water quality. A solid waste disposal site may be defined as any land area used for the deposit of solid wastes regardless of the method of operation, or whether a subsurface excavation is involved. A sanitary landfill may be defined as a solid waste disposal site which is carefully located, designed, and operated to avoid hazards to public health or safety, or contamination of groundwaters or surface waters. The proper design of sanitary landfills requires careful engineering to confine the refuse to the smallest practicable area, to reduce the refuse mass to the smallest practicable volume, to avoid surface water runoff, to minimize leachate production and percolation into the groundwater and surface waters, and to seal the surface with a layer of earth at the conclusion of each day's operation or at more frequent intervals as necessary.

In order for a landfill to produce leachate, there must be some source of water moving through the fill material. Possible sources include precipitation, the moisture content of the refuse itself, surface water infiltration, groundwater migrating into the fill from adjacent land areas, or groundwater rising from below to come in contact with the fill. In any event, leachate is not released from a landfill until a significant portion of the fill material exceeds its saturation capacity. If external sources of water are excluded from the sanitary landfill, the production of leachates in a well-designed and -managed landfill can be effectively minimized if not entirely avoided. The quantity of leachate produced will depend upon the quantity of water that enters the solid waste fill site minus the quantity that is removed by evapotranspiration. Studies have estimated that for a typical landfill, from 20 to 50 percent of the rainfall infiltrated into the solid waste may be expected to become leachate. Accordingly, a total annual rainfall of about 33 inches, which is typical of the Des Plaines River watershed, could produce from 180,000 to 450,000 gallons of leachate per year per acre of landfill if the facility is not properly located, designed, and operated.

As of the year 2000, there were two active landfills and four known abandoned landfills located in the Des Plaines River watershed. None of these landfills are known to be negatively affecting surface waters.

Rural Land Use

Rural land uses within the Des Plaines River watershed include agricultural—both livestock operations and crop production—and woodlands, as set forth in Chapter III. Each of these land uses contributes nonpoint source pollutants to surface and ground waters of the Des Plaines River.

Livestock Operations

The presence of livestock and poultry manure in the environment is an inevitable result of animal husbandry and is a major potential source of water pollutants. Animal manure, composed of feces, urine, and sometimes bedding materials, contributes suspended solids, nutrients, oxygen-demanding substances, bacteria, and viruses to surface waters. Presently in the watershed, there are still several small dairies with less than 100 animals, one large dairy with over 400 animals, and several horse-boarding facilities. Additionally, there are other forms of animal agriculture including hogs, poultry, a swan farm with over 200 birds, and a large herd of beef cattle that has over 400 steers. The largest dairy is located just west of USH 45 and south of STH 142 in the Town of Brighton. The beef cattle herd is located along CTH K, about one mile west of IH 94. In the vicinity of that farm, also on CTH K, in the Kilbourn Road Ditch drainage area, is a stable, as well as a small feedlot operation that has a mixed variety of livestock. The swan farm is located along STH 50, just west of USH 45 in the Town of Bristol. Aside from traditional farm animals, this watershed has seen a rapid expansion in the horse industry. There are several horse-boarding facilities located throughout the watershed, and many of those facilities board about 40 horses. Animal waste constituents of pastureland and barnyard runoff, and animal wastes deposited on pastureland and cropland and in barnyards, feedlots, and manure piles, can potentially contaminate water by surface runoff, infiltration to the groundwater, and volatilization to the atmosphere. During the warmer seasons of the year the manure is often scattered on cropland and pastureland where the waste material is likely to be taken up by the vegetative growth composing the land cover. However, when the animal manure is applied to the land surface during the winter, the animal wastes are subject to excessive runoff and transport, especially during the spring snowmelt period.

Crop Production

Runoff from cropland can have an adverse effect upon water quality within the Des Plaines River watershed, by contributing excessive sediments, nutrients, and organic matter, including pesticides to streams. Negative effects associated with soil erosion and transport to waterbodies include reduced water clarity, sedimentation on streambeds, and contamination of the water from various agricultural chemicals and nutrients that are attached to the individual soil particles. Some of these nutrients, in particular phosphorus, and to some extent nitrogen, are directly associated with eutrophication of water resources. The extent of water pollution from cropping practices varies considerably as a result of the soils, slopes, and crops, as well as in the numerous methods of tillage, planting, fertilization, chemical treatment, and conservation practices. Conventional tillage practices, or moldboard plowing, involve turning over the soil completely, leaving the soil surface bare of most cover or residue from the previous year's crop, and making it highly susceptible to erosion due to wind and rain. The use of conservation tillage practices has become common in the watershed in recent years within areas most susceptible to erosion and surface water impacts.

Crops grown in the Des Plaines River watershed include row crops, such as corn and soybeans; small grains, such as wheat and oats; hay, such as clover, alfalfa, timothy, and canary grass; vegetables, such as potatoes, peas, and sweet corn; and specialty crops, such as strawberries. Row and vegetable crops, which have a relatively higher level of exposed soil surface, tend to contribute higher pollutant loads than do hay and pastureland, which support greater levels of vegetative cover. Crop rotations typically follow a two- or three-year sequence of corn and soybeans and occasionally winter wheat in the third year. However, hay is periodically included as part of a long-term rotation of corn, oats, and alfalfa.

Since the early 1930s, it has been a national objective to preserve and protect agricultural soil from wind and water erosion. Federal programs have been developed to achieve this objective, with the primary emphasis being on sound land management and cropping practices for soil conservation. An incidental benefit of these programs has been a reduction in the amount of eroded organic and inorganic material entering surface waters as sediment or attached to sediment. Some practices are effective in both regards, while others may enhance the soil conditions with little benefit to surface water quality. Despite the implementation of certain practices aimed at controlling erosion of soil from agricultural land, and development of soil erosion control plans for the portions of the Des Plaines River basin in Kenosha and Racine Counties,[28] such erosion and the resultant deposition of sediment in the streams of the Des Plaines River watershed remains a significant water resource problem. Soil erosion from agricultural lands is one of the major sources of sediment and nutrients in the Des Plaines River and its tributaries. Analyses conducted for the regional water quality management plan and under this watershed study identified cropland runoff as the primary source of sediment loading to streams in the watershed.

One of the most important characteristics of a soil with regards to the potential for soil erosion, is the degree of slope or relief. Soils which have slopes greater than 6 percent are at the highest risk of soil loss from erosion. As illustrated by Map 50 and Table 75, within the Des Plaines River watershed, there are about 6,600 acres of highly erodible soils (HES), or about 7.4 percent of the watershed area. Approximately four percent of those acres are zoned for agricultural use and the remaining 3.3 percent are zoned for other uses, which predominately include residential areas. Aside from the steeper slopes, these soils have other characteristics, which make them susceptible to erosion. The majority of soils in the watershed were formed from parent material that contains a dense clay layer. This has the effect of slowing the infiltration of water into the soil, thereby increasing the amount of runoff from a rain event. Additionally, many of the soils in the watershed contain silt in the surface horizon. Silts are highly susceptible to transport and movement by water. Because of their small particle size, silts tend to remain suspended in the water column for a relatively long period of time.

Nutrients such as phosphorus and agri-chemicals, including certain herbicides and pesticides, are electrostatically attracted to silt sized particles and are transported to surface waters through soil erosion. As previously mentioned, phosphorus is one of the primary nutrients associated with eutrophication of water resources, and agri-chemicals can negatively impact the life cycle of aquatic organisms. In the eutrophication process, phosphorus enhances growth of aquatic vegetation and algae, which has the effect of accelerating the aging process of a water resource. Phosphorus is usually not susceptible to downward movement through the soil profile; instead, the majority of phosphorus reaches water resources by overland flow, or erosion. Nitrogen also is a nutrient that contributes to eutrophication, however, it is most often associated with subsurface water quality contamination. Nitrogen in the form of nitrate can be associated with respiration problems in newborn infants. Nitrogen is susceptible to downward movement through the soil profile; however, due to the nature of soils in the watershed, nitrogen is not as significant a threat due to various chemical reactions that occur within the soil.[29]

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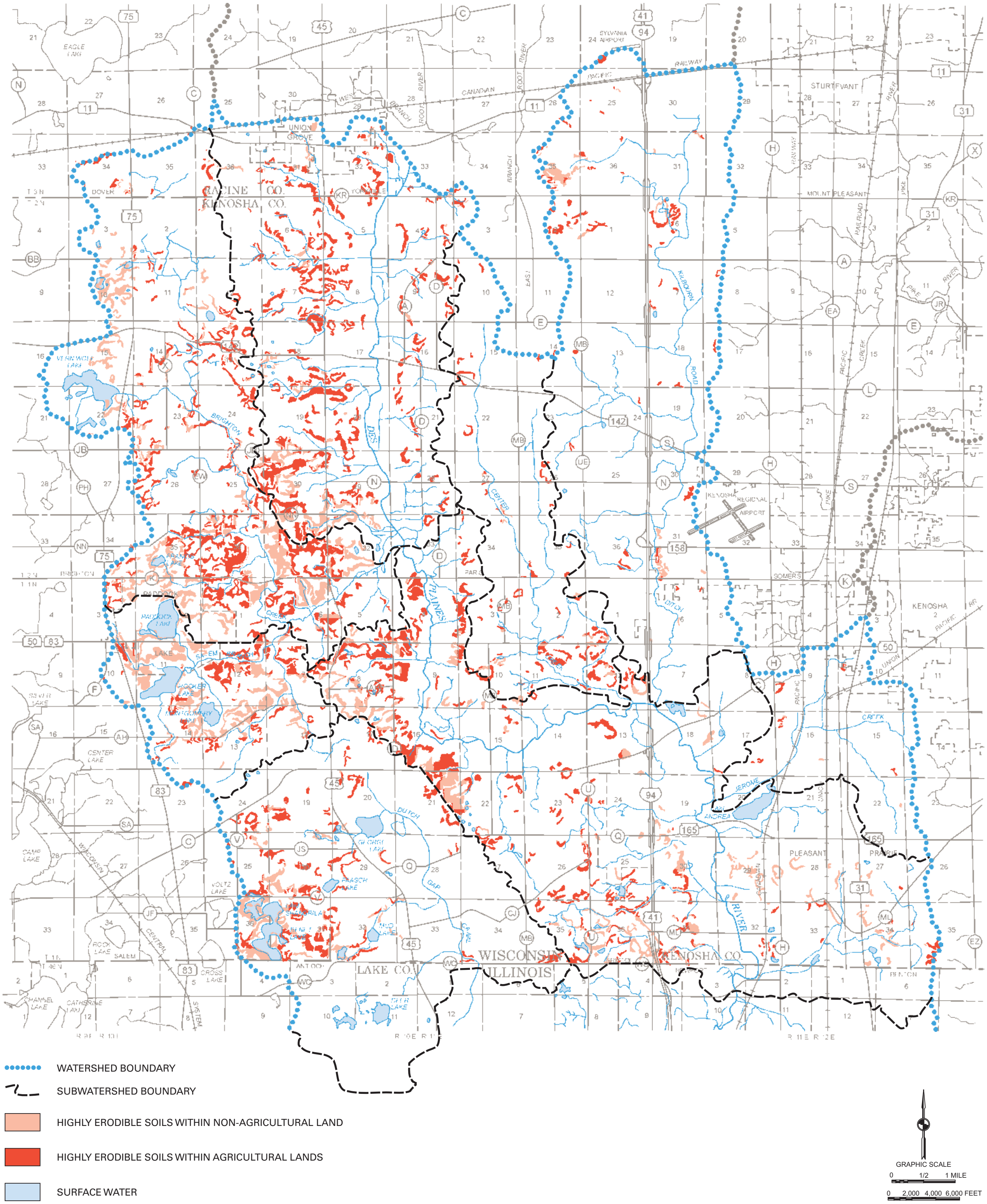
[28]*SEWRPC Community Assistance Planning Report No. 164,* Kenosha County Agricultural Soil Erosion Control Plan*, April 1989; and SEWRPC Community Assistance Planning Report No. 160,* Racine County Agricultural Soil Erosion Control Plan*, July 1988.*

[29]*Soils that have a high clay content and stay wet for long periods of time, or even well-drained soils after a rainfall event are susceptible to nitrogen losses to the atmosphere through a chemical reaction known as denitrification. This reaction converts nitrate,* NO_3^- *to gaseous nitrogen,* N_2*, which is lost to the atmosphere.*

Map 50

HIGHLY ERODIBLE SOILS IN THE DES PLAINES RIVER WATERSHED: 1999



Within the Des Plaines River watershed, there are about 6,560 acres of highly erodible soils, covering about 7.4 percent of the watershed area. Approximately 3,650 acres, or 56 percent, of those lands are zoned for agricultural use and the remaining 2, 910 acres, or 44 percent, are zoned for other uses, which are predominately residential uses.

Source: SEWRPC.

Table 75

HIGHLY ERODIBLE SOILS WITHIN THE DES PLAINES RIVER WATERSHED

Parameter	Acres	Percent of Watershed
Highly Erodible Soils		
Highly Erodible Soils in Agriculture	3,652	4.1
Highly Erodible Soils Not in Agriculture	2,907	3.3
Other Soils	82,627	92.6
Total	89,186	100.0

Source: U.S. Natural Resources Conservation Service, Kenosha County Planning and Development, and SEWRPC.

Since the data presented in the Kenosha and Racine County Agriculture Soil Erosion Control Plans is nearly 12 years old, in 1999 both counties initiated a soil erosion transect system in response to the Department of Agriculture, Trade, and Consumer Protection's "T by 2000" program. This program was initiated by the State with the objective that all counties in Wisconsin would reduce their average annual erosion to less than or equal to the average "T Value" for each County. The survey was used as a means to estimate the amount of agricultural erosion taking place from numerous, random survey points. According to the results in 1999 for both Racine and Kenosha Counties, the average annual soil loss rate was 1.7 and 3.2 tons per acre per year, respectively. Additionally, the Kenosha County survey indicated that approximately 74 percent of the fields that were surveyed within the watershed were at or below the tolerable soil loss rate. However, caution should be exercised regarding the watershed-specific erosion rates, as there are not enough sample points for that data to be considered statistically accurate.

Woodlands

A well-managed woodland contributes few pollutants to surface waters. Under poor management, however, woodlands may have detrimental water quality effects through the release of sediments, nutrients, organic matter, and pesticides into nearby surface waters. If trees along streams are cut, thermal pollution may occur as the direct rays of the sun strike the water. Disturbances caused by tree harvesting, livestock grazing, tree growth promotion, tree disease prevention, fire prevention, and road and trail construction are a major source of pollution from silvicultural activities. Most of these activities are seldom practiced in the Des Plaines River watershed.

Atmospheric Sources

Streams are subjected directly to the deposition of pollutants from the atmosphere via dry fallout and precipitation washout. Human activities and the physical environment influence air pollutant concentrations, dispersal, and fallout rates. Air pollutants in the form of smoke, dust, soot, fly ash, fumes, mist, odors, seeds, pollen, spores, and contaminated precipitation fall directly on surface waters and are direct sources of nutrients, sediments, oxygen-demanding substances, metals, and chemicals. Some air pollutants present no threat to water quality, but others are significant contributors to water quality degradation. Oxides of nitrogen may react with sodium, potassium, and other metals to form soluble nitrates which, when washed out of the atmosphere by rain, may contribute to the fertility of surface waters. Phosphorus adsorbed on fine clay and silt-sized particles may be transported by wind erosion and deposited in surface waters. In cases where ice covers a body of water, the various deposits still occur, but are stored until spring thaw. Direct contribution to surface water systems is of special concern because there is no intervening filtration by the land surface. The deposit of contaminants from the air to the water environment may be indirect, resulting from the transport, transformation, and storage of contaminants on land. This may introduce a substantial time delay between the time when a contaminant reaches the land and the time when the contaminant shows up in the water. The storage of air contaminants deposited on land also provides opportunity for the transformation of the contaminants into other chemical forms prior to their reaching the waterways. The indirect transfer of air pollutants to streets and through drainageways, storm sewers, and surface runoff is considered to be an element of the pollutant loadings from the sources discussed above.

Stream Processes

General Description

Instream processes also affect the pollution transport loading of a stream. The tremendous amount of energy possessed by flowing water in a stream channel is dissipated along the stream length by turbulence, streambank and streambed erosion, and sediment resuspension. Sediments and associated substances delivered to a stream may be stored, at least temporarily, on the streambed, particularly where obstructions or irregularities in the channel decrease the flow velocity or act as a particle trap or filter. On an annual basis or on a long-term basis, streams may exhibit a net deposition, a net erosion, or no net change in internal sediment transport, depending on the tributary land uses, watershed hydrology, precipitation, and geology. It was reported in SEWRPC Technical Report No. 21, *Sources of Water Pollution in Southeastern Wisconsin: 1975*, that from 3 to 11 percent of the annual sediment yield in a watershed in Southeastern Wisconsin may be contributed by streambank erosion. In general, increased stream urbanization may be expected to result in increased stream flow rates and volumes, with potential increases in streambank erosion and bottom scour, and flooding problems. These effects may be mitigated by utilization of proper stormwater management practices. In the Des Plaines River watershed, streambank erosion in rural areas is also a significant source of sediment that is delivered to streams.

Sedimentation in Streams

As shown on Map 51, in 1996 and 1999, the Commission staff collected measurements of unconsolidated sediment depths at numerous locations along the Des Plaines River and its tributaries. Significant accumulations of sediment ranging from one to 3.5 feet deep were observed along the main stem of the Des Plaines River upstream of STH 50, primarily in the Town of Paris. In general, measured unconsolidated sediment depths along the tributaries and the Des Plaines River main stem downstream from STH 50 were one foot or less. A localized reach of the Des Plaines River with sediments depths from 1.5 to two feet was identified between IH 94/USH 45 and CTH C in the Village of Pleasant Prairie, downstream of the confluence of the Des Plaines River and Kilbourn Road Ditch.

The main negative effects of sedimentation that have been identified along the main stem of the Des Plaines River are 1) damage to the aquatic habitat of the stream due to covering of the natural bottom sediments and 2) impairment of agricultural drain tile systems.

During an October 10, 1996, public meeting at the Paris Town Hall, the Commission staff solicited comments from 18 farmers and landowners along the Des Plaines River regarding sedimentation and obstructions in the stream and the possible effects of those factors on agricultural drain tile systems and flooding of low-lying lands. Numerous complaints were recorded regarding malfunctioning drain tiles as a result of high water levels in the River. In some cases, it was reported that drain tile outlets were covered with accumulated sediment, but the primary concern was impairment of drain tile systems that was attributed to increases in water levels in the River during periods of normal flows and annual floods. The accumulation of sediment in the stream, along with beaver dams and other obstructions, such as downed trees, are all factors that contribute to the impairment of agricultural drain tile systems.[30]

Streambank Erosion

Bank erosion along the streams in the watershed is a significant source of sediment that is delivered directly to the streams. Bank erosion degrades habitat for fish and other aquatic life through the reduction in cover plants and overhangs along a stream and through covering of the natural bottom sediments. Bank erosion also contributes to impaired functioning of drain tiles when outfalls become partially or wholly blocked by eroded sediment.

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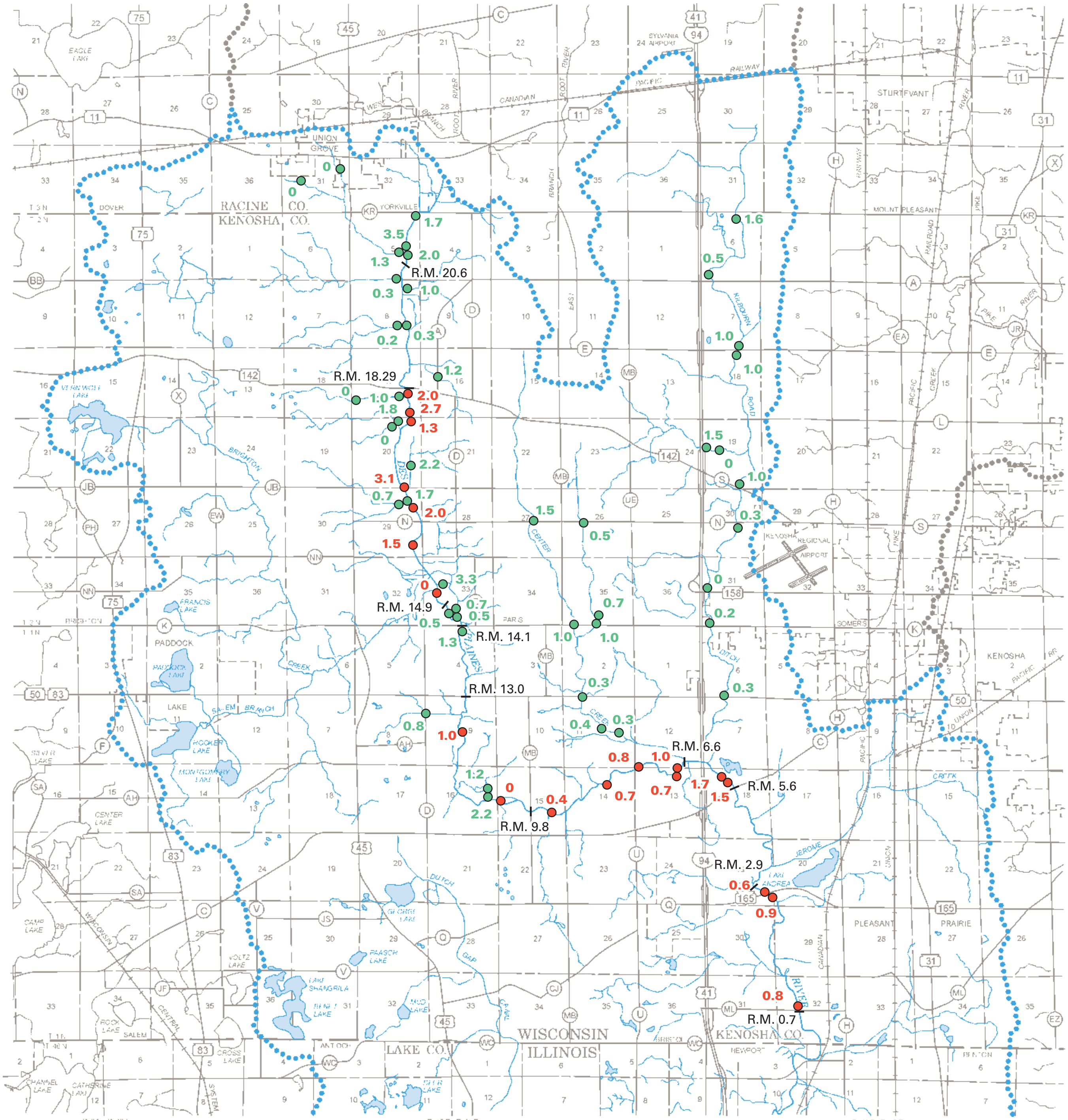
[30]*During the 1999 streambank inventories by the Commission staff many plugged and/or failed drain tile outfalls were observed.*

Map 51

SEDIMENT DEPTH MEASUREMENTS IN THE DES PLAINES RIVER WATERSHED: 1996 AND 1999



LOCATION OF SEDIMENT DEPTH MEASUREMENT OCTOBER AND NOVEMBER OF 1999

1.0 UNCONSOLIDATED SEDIMENT DEPTH OCTOBER AND NOVEMBER OF 1999 (IN FEET)

LOCATION OF SEDIMENT DEPTH MEASUREMENT OCTOBER AND NOVEMBER OF 1996

0.7 UNCONSOLIDATED SEDIMENT DEPTH OCTOBER AND NOVEMBER OF 1996 (IN FEET)

R.M. 13.0 LOCATION OF RIVER MILE AND RIVER MILE STATION IDENTIFICATION

GRAPHIC SCALE
0 1/2 1 MILE
0 2,000 4,000 6,000 FEET

The main negative effects of sedimentation that have been identified along the main stem of the Des Plaines River are 1) damage to the aquatic habitat of the stream due to covering of the natural bottom sediments and 2) impairment of agricultural drain tile systems. Some drain tile outlets have been covered with accumulated sediment, but the primary concern of riparian land owners is impairment of drain tile systems that is attributed to increases in water levels in the River during periods of normal flows and annual floods. The accumulation of sediment in the stream, along with beaver dams and other obstructions, such as downed trees, are all factors that contribute to the impairment of agricultural drain tile systems.

Source: SEWRPC.

In general, sediment accumulation on the bed of the main stem of the Des Plaines River was found to be the greatest in reaches that receive runoff from primarily rural lands. Thus, the inventory and analysis of streambank erosion characteristics were concentrated in the rural portions of the watershed that are tributary to the main stem.

From April through October 1999, the Commission staff, with assistance from the Natural Resources Conservation Service (NRCS), conducted an inventory of streambank erosion conditions along the Des Plaines River and its tributaries at the locations shown on Map 52. For the approximately 11 miles of streambanks indicated on Map 52, eroding bank lengths and heights and bankfull channel widths and depths were field measured and lateral bank recession rates in feet per year were estimated using NRCS procedures. The Kenosha and Racine County large-scale topographic maps were used to determine the tributary area, stream slope, stream length, and sinuousity (channel length between two points divided by valley length between those points) for the 11 miles of streambanks that were field checked, plus an additional 62 miles of streambanks in the watershed.

A multiple linear regression analysis was completed on the data for the sites that were field inventoried, using the percent reach failure (expressed relative to the total sampled streambank length as determined from large-scale topographic maps) as the dependent variable. The independent variables were field measurements of bank height, bankfull width, and bankfull depth, and calculated, total area tributary to the stream discharge point, stream slope in percent, reach length, and sinuosity. Based on this analysis, it was found that stream slope and total area tributary to the stream discharge point were the two parameters that explain the greatest amount of variation in streambank failure. Ranges in total tributary area were established and assigned integer point values from zero through five, with a rating of zero indicating a stream reach with the lowest potential for bank erosion, based on total tributary area, and five indicating a reach with the highest potential. Similarly, ranges in longitudinal stream slope were assigned integer point values from zero through five. A total point value for each stream reach was calculated as the sum of the area and slope ratings. Through correlation with the point totals established for the 11 miles of field-inventoried reaches, each of the stream reaches comprising the additional 62 miles of banks for which erosion potential was to be evaluated were characterized as having low, medium, or high bank erosion potential. The results of that characterization are shown on Map 52. It was found that about 19 miles of streambank, or 26 percent of the total considered, would be expected to have a low erosion potential; about 52 miles of streambank, or 71 percent of the total considered, would be expected to have a medium erosion potential; and about two miles of streambank, or 3 percent of the total considered, would be expected to have a high erosion potential.

Nonpoint Source Pollutant Loads

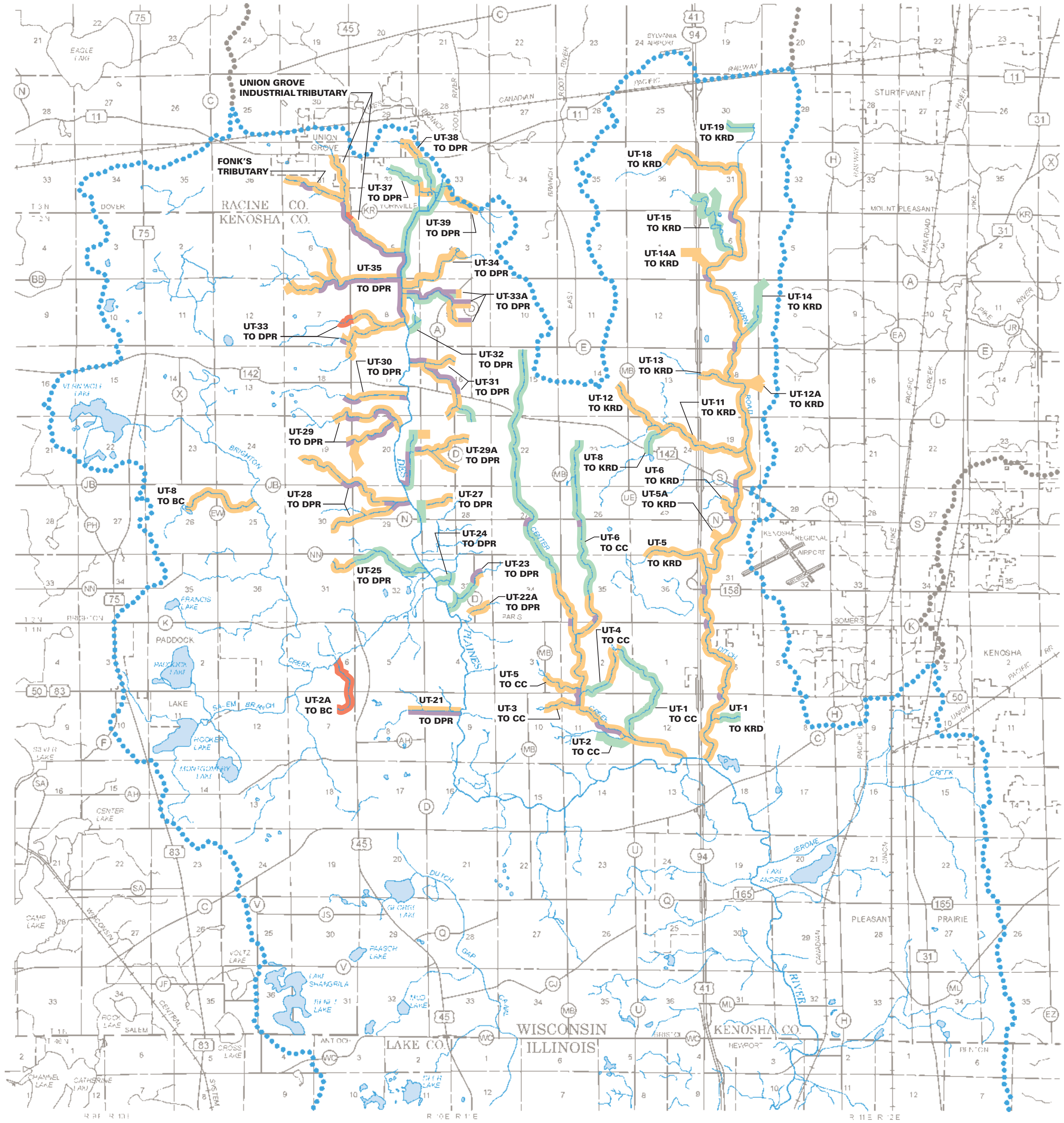
Nonpoint source pollutant loads delivered to streams in the Des Plaines River watershed were estimated by the unit load analysis method and by using 1) measured pollutant concentrations observed at the U.S. Geological Survey station on the Des Plaines River at Russell, Illinois, designated as station Dp-4, and 2) a water quality simulation model for estimating the load of pollutants transported to the mouth of the Des Plaines River.

Unit Load Analysis

A preliminary analysis of the relative magnitude of nonpoint source pollutant loadings from the various land use-land cover combinations comprising the Des Plaines River watershed was conducted under the Regional Planning Commission's regional water quality management planning program. That analysis was based on unit loading rates for various pollutants and land use-land cover combinations. To the maximum extent possible, these unit area loads were based upon data collected from within the Region. The unit loading rates used in the regional water quality management plan, revised where necessary to reflect more recent study results, are set forth in Table 76. The present analysis provides an estimate of gross pollutant loads from nonpoint sources delivered to the perennial and intermittent streams in the Des Plaines River watershed, as well as a means of identifying the most important sources of each pollutant. The results of this analysis for 1990 and planned land use conditions assuming buildout of the approved sewer service areas, are summarized in Tables 77 and 78. Estimated pollutant loads from point sources were considered insignificant in the Des Plaines River watershed. Annual pollutant loadings are estimated for sediment, total phosphorus, and selected heavy metals.

Map 52

INVENTORY OF STREAMBANK EROSION CONDITIONS IN THE DES PLAINES RIVER WATERSHED: 1999



STREAMBANK EROSION POTENTIAL

- HIGH
- MEDIUM
- LOW

UT	UNNAMED TRIBUTARY
DPR	DES PLAINES RIVER
KRD	KILBOURN ROAD DITCH
BC	BRIGHTON CREEK
CC	CENTER CREEK
	FIELD CHECKED STREAM

GRAPHIC SCALE
0 1/2 1 MILE
0 2,000 4,000 6,000 FEET

The Commission staff, with assistance from the Natural Resources Conservation Service (NRCS), conducted a detailed inventory of streambank erosion conditions along 11 miles of streambanks of the Des Plaines River and its tributaries. Eroding bank lengths and heights and bankfull channel widths and depths were field measured and lateral bank recession rates in feet per year were estimated using NRCS procedures. Through correlation with the analysis of the 11 miles of field-inventoried reaches, an additional 62 miles of banks were characterized as having low, medium, or high bank erosion potential. About 19 miles of streambank, or 26 percent of the total considered, would be expected to have a low erosion potential; about 52 miles of streambank, or 71 percent of the total considered, would be expected to have a medium erosion potential, and about two miles of streambank, or 3 percent of the total considered, would be expected to have a high erosion potential.

Source: SEWRPC.

Table 76

UNIT AREA LOADS USED IN THE DES PLAINES RIVER WATERSHED POLLUTANT LOADING ANALYSIS

Land Use Category	River (pounds per acre per year)						Lakes[a] (pounds per acre per year)		
							Total Phosphorus		
	Total Suspended Solids	Total Phosphorus	Lead	Copper	Zinc	Chromium	Low	Likely	High
Urban							0.45	0.89	1.34
Residential									
Low-Density	19.5	0.20	0.040	0.00	0.01	0.00	- -	- -	- -
Medium-Density	100.0	0.27	0.120	0.02	0.14	0.00	- -	- -	- -
High-Density	240.0	0.85	0.460	0.12	0.81	0.01	- -	- -	- -
High-Density with Alleys	318.0	0.85	0.610	0.12	0.81	0.01	- -	- -	- -
Multi-Family	240.0	0.85	0.610	0.12	0.81	0.01	- -	- -	- -
Commercial	784.0	1.20	2.070	0.22	1.49	0.01	- -	- -	- -
Industrial	752.0	1.17	1.810	0.22	1.49	0.01	- -	- -	- -
Governmental and Institutional	511.0	1.35	0.960	0.07	0.80	0.00	- -	- -	- -
Freeway[b]	980.0	1.04	0.540	0.75	2.72	0.02	- -	- -	- -
Recreational	24.0	0.27	0.050	0.00	0.00	0.00	- -	- -	- -
Land Under Development	20,000.0	13.00	0.070	- -	- -	- -	- -	- -	- -
Rural									
Agricultural	- -	- -	- -	- -	- -	- -	0.27	0.45	1.78
Cropland	450.0	0.86	0.010	0.00	0.00	0.00	- -	- -	- -
Pasture	450.0	0.86	0.010	0.00	0.00	0.00	0.09	0.27	0.45
Open lands	9.5	0.11	0.030	0.00	0.00	0.00	- -	- -	- -
Woodlands	3.0	0.03	0.004	0.00	0.00	0.00	0.04	0.09	0.18
Wetlands	3.0	0.03	0.004	0.00	0.00	0.00	0.09	0.09	0.09
Water	188.0	0.13	0.130	0.00	0.00	0.00	0.09	0.27	0.89

[a]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-94 REV,* Wisconsin Lake Model Spreadsheet User's Manual, *June 1994.*

[b]*Assumes 160-foot right-of-way width, 68-foot pavement and shoulder width, and grassed swale drainage.*

Source: SEWRPC.

Table 77

RESULTS OF THE UNIT AREA LOAD-BASED POLLUTANT LOADING ANALYSIS IN THE DES PLAINES RIVER WATERSHED: 1990 LAND USE CONDITIONS

Source	Total Suspended Solids		Total Phosphorus		Total Lead		Total Copper		Total Zinc		Total Cadmium	
	Load (tons)	Percent of Total Load	Load (pounds)	Percent of Total Load	Load (pounds)	Percent of Total Load	Load (pounds)	Percent of Total Load	Load (pounds)	Percent of Total Load	Load (pounds)	Percent of Total Load
Urban												
Residential[a]	108	0.8	1,033	2.0	312	10.4	32	5.7	245	7.9	0.1	0.6
Commercial	109	0.8	328	0.6	523	17.5	69	12.4	603	19.4	2.0	11.4
Industrial	151	1.1	467	0.9	729	24.4	57	10.2	384	12.4	3.0	15.8
Governmental and Institutional	71	0.5	376	0.7	267	8.9	30	5.4	314	10.1	0.0	0.0
Freeway	280	2.1	595	1.1	266	8.9	369	66.2	1,556	50.2	11.0	72.2
Communication and Utilities	2	0.0	36	0.1	9	0.3	0	0.0	0	0.0	0.0	0.0
Recreation	9	0.1	202	0.4	41	1.4	0	0.0	0	0.0	0.0	0.0
Subtotal	730	5.4	3,037	5.8	2,147	71.8	557	100.0	3,102	100.0	16.0	100.0
Rural												
Agricultural and Open Lands	12,696	93.6	48,913	93.3	636	21.3	0	0.0	0	0.0	0.0	0.0
Woodlands	7	0.1	137	0.3	19	0.6	0	0.0	0	0.0	0.0	0.0
Wetlands	10	0.1	196	0.4	27	0.9	0	0.0	0	0.0	0.0	0.0
Atmospheric	116	0.9	155	0.3	161	5.4	0	0.0	0	0.0	0.0	0.0
Subtotal	12,829	94.6	49,401	94.2	843	28.2	0	0.0	0	0.0	0.0	0.0
Total	13,559	100.0	52,438	100.0	2,990	100.0	557	100.0	3,102	100.0	16.0	100.0

[a]*Includes the contribution from onsite sewage disposal systems.*

Source: SEWRPC.

Table 78

RESULTS OF THE UNIT AREA LOAD-BASED POLLUTANT LOADING ANALYSIS IN THE DES PLAINES RIVER WATERSHED: PLANNED LAND USE CONDITIONS[a]

Source	Total Suspended Solids		Total Phosphorus		Total Lead		Total Copper		Total Zinc		Total Cadmium	
	Load (tons)	Percent of Total Load	Load (pounds)	Percent of Total Load	Load (pounds)	Percent of Total Load	Load (pounds)	Percent of Total Load	Load (pounds)	Percent of Total Load	Load (pounds)	Percent of Total Load
Urban												
Residential[b]	361	2.7	2,615	5.1	926	6.1	130	6.5	942	7.4	0	0.0
Commercial	1,217	9.0	3,725	7.2	5,976	39.2	658	33.0	4,457	34.9	30	38.4
Industrial	1,411	10.4	4,390	8.5	6,791	44.5	804	40.3	5,442	42.6	37	46.9
Governmental and Institutional	128	0.9	675	1.3	480	3.1	35	1.7	374	2.9	0	0.0
Freeway	280	2.1	595	1.2	266	1.7	369	18.5	1,556	12.2	11	14.6
Communication and Utilities	3	0.0	80	0.2	19	0.1	0	0.0	0	0.0	0	0.0
Recreation	13	0.1	295	0.6	57	0.4	0	0.0	0	0.0	0	0.0
Subtotal	3,413	25.2	12,375	24.0	14,516	95.1	1,995	100.0	12,770	100.0	78	100.0
Rural												
Agricultural and Open Lands	10,012	73.9	38,656	75.0	555	3.6	0	0.0	0	0.0	0	0.0
Woodlands	7	0.1	136	0.3	18	0.1	0	0.0	0	0.0	0	0.0
Wetlands	10	0.1	186	0.4	26	0.2	0	0.0	0	0.0	0	0.0
Atmospheric	107	0.8	156	0.3	148	1.0	0	0.0	0	0.0	0	0.0
Subtotal	10,135	74.8	39,133	76.0	746	4.9	0	0.0	0	0.0	0	0.0
Total	13,547	100.0	51,509	100.0	15,262	100.0	1,995	100.0	12,770	100.0	78	100.0

[a]Planned land use conditions are based upon buildout of the approved sewer service areas.

[b]Includes the contributions from onsite sewage disposal systems.

Source: SEWRPC.

The stream channel pollutant loads may be expected to be different from the actual transport from the watershed, because physical, chemical, and/or biological processes may retain or remove pollutants or change their form during transport over the land surface or within the stream system. These processes include particle deposition or entrapment on the land surface or in floodplains, stream channel deposition or aggradation, biological uptake, and chemical transformation and precipitation. The stream channel pollutant loading rates and, therefore, the total stream channel pollutant loads set forth in Table 76 are representative of the annual quantities of potential pollutants moved from small areas of the Des Plaines River watershed into localized drainage swales and stream channels, but are not intended to reflect the total amount of the pollutants moving from those sources through the entire hydrologic-hydraulic system to the watershed outlet.

In order to assess the degree to which materials are retained within the Des Plaines River watershed, the data presented in Table 77 were compared to the actual pollutant loads measured by the U.S. Geological Survey at their Russell Road station. The suspended solids, total phosphorus and selected heavy metal loads for the 1990 hydrologic year were calculated using the U.S. Geological Survey data. These data, together with those generated from the 1990 land use condition and originally used in the regional water quality management plan, are set forth in Table79.

The measured 1990 total phosphorus load of about 40,000 pounds was similar to the estimated total phosphorus load of about 52,000 pounds calculated using the unit area load model. The measured 1990 suspended solids load of 705 tons was a fraction of the approximately 13,600 tons forecast on the basis of land uses. Similarly, the lead load of about 900 pounds was significantly less than the approximately 3,000 pounds predicted by the unit area load model. In contrast, cadmium, copper, and zinc loads during 1990 at Russell Road determined using the level of detection in cases where the actual concentration is less than the level of detection exceeded the forecast loads.

Table 79

FORECAST AND OBSERVED POLLUTANT LOADS AT THE U.S. GEOLOGICAL SURVEY RUSSELL ROAD GAGING STATION: 1990

Pollutant	Mass Unit	Predicted[a] Delivery from Land Surface	Observed Instream Loads[b]	Forecast in Regional Water Quality Management Plan[c]
Sediment	Tons per year	13,560	705	- -
Total Phosphorus	Pounds per year	52,435	39,815	38,195
Cadmium	Pounds per year	16	544[d]	- -
Copper	Pounds per year	560	895[d]	- -
Lead	Pounds per year	2,990	878	- -
Zinc	Pounds per year	3,100	11,254[d]	- -

[a]*Predicted using unit area load analysis based on 1990 land uses.*

[b]*Observed values reflect net result of watershed and instream processes and should be less than predicted deliveries from the land surface.*

[c]*Data abstracted from Hydrocomp Water Quality Submodel simulation, and adjusted to reflect total phosphorus loading rates at Russell Road.*

[d]*Observed concentrations were less than the level of analytical detection; use of the detection limit as the ambient concentration results in an unrealistically high loading estimate.*

Source: SEWRPC.

Because the level of detection was assumed where concentrations were less than that level, about 540 pounds of cadmium passed the Russell Road gage during 1990, compared to the 16 pounds forecast on the basis of unit area load modeling; an upper limit of about 900 pounds of copper passed the gage, compared to about 560 pounds forecast by the modeling; and, about 11,250 pounds of zinc passed the gage, compared to about 3,100 pounds modeled. Because the level of detection was assumed where concentrations were less than that level, the cadmium, copper, and zinc loads shown in Table 79 represent an upper limit on the actual loads. The differences between delivery from the land surface and measured loads of sediment and lead are likely to reflect watershed and instream processes, which would be consistent with the lesser amount of particulate materials measured at Russell Road and observations of sediment accumulation in streams in the watershed.

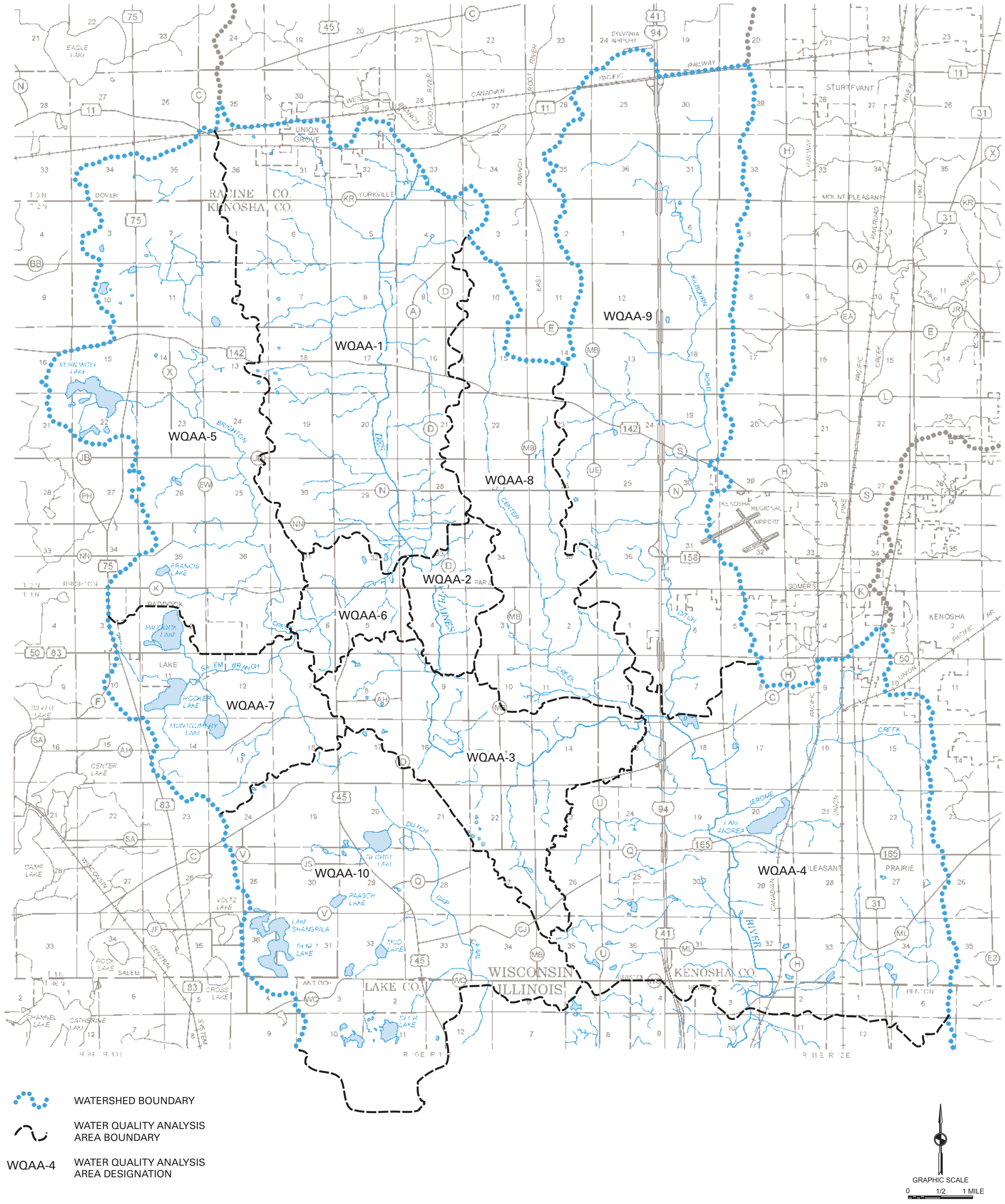
Likewise, the forecast total phosphorus load used in the adopted regional water quality management plan, of 38,000 pounds, is similar to the measured 1990 total phosphorus load of about 40,000 pounds. Sediment loads and metals were not modeled in the regional water quality management planning program.

In order to refine the watershed-scale pollutant loading estimates, the Des Plaines River watershed was divided into 10 water quality analysis areas, as shown graphically on Map 53. Within those analysis areas transmission coefficients[31] were applied to the data derived from unit area load-based calculations to better account for watershed and instream processes. These transmission coefficients were estimated from the predicted and

[31]*See discussion in Sven-Olof Ryding and Walter Rast,* The Control of Eutrophication of Lakes and Reservoirs*, Unesco Man and the Biosphere Series Volume 1, Parthenon Press, Carnforth, pp. 141-143.*

Map 53

WATER QUALITY ANALYSIS AREAS IN THE DES PLAINES RIVER WATERSHED



In order to refine watershed-scale pollutant loading estimates, the Des Plaines River watershed was divided into 10 water quality analysis areas. Within those analysis areas transmission coefficients were applied to the data derived from unit area load-based calculations to better account for watershed and instream processes. Use of the water quality analysis areas also allowed estimation of the mean annual concentrations of suspended sediment, total phosphorus, and heavy metals at various points along the Des Plaines River system.

Source: SEWRPC.

observed data shown in Table 79, and were determined to be 0.20 for suspended sediments, 0.95 for total phosphorus, 0.60 for lead.[32] Use of the subbasins also allowed estimation of the mean annual concentrations of suspended sediment, total phosphorus, and heavy metals at various points along the Des Plaines River system. These refined data are set forth in Tables 80 through 85, and are shown schematically in Figures 47 and 48 for the 1990 and planned land use scenarios. Under these scenarios, suspended sediment and total phosphorus loads are expected to remain relatively stable, while loads of heavy metals are anticipated to increase, primarily in the eastern portions of the watershed.

Based on the 1990 data set forth in Table 77, urban sources of pollution are estimated to contribute about 6 percent of the phosphorus, 5 percent of the sediments, and between 72 and 100 percent of the metals, depending on the specific pollutant. Consistent with the findings of the regional water quality management plan, the contribution from urban point sources is relatively insignificant—less than 0.3 percent of total pollutants. Of the pollutant loads from all sources within the watershed, rural pollution sources contribute an estimated 94 percent of the phosphorus and 95 percent of the sediments.

Based on the estimated planned land use data set forth in Table 78, in the absence of additional controls, urban sources of pollution would be expected to contribute about 24 percent of the phosphorus, 25 percent of the sediments, and between 95 and 100 percent of the metals, depending on the specific pollutant. Of the pollutant loads from all sources within the watershed, in the absence of additional controls, rural pollution sources would be expected to contribute an estimated 76 percent of the phosphorus and 75 percent of the sediments.

Pollution Sources: Overview

Figures 47 and 48 provide a graphic summary of the average annual loads of selected pollutants to the stream network of the Des Plaines River watershed from nonpoint sources, as determined in the unit load analysis. The following observations may be made, and conclusions drawn, based on the identification, characterization, and quantification of pollution sources:

- No untreated sanitary sewage enters the surface water system of the watershed through flow relief devices or overflows.

- There are currently four municipal sewage treatment plants discharging to the surface waters of the Des Plaines River watershed: one facility—the Village of Paddock Lake plant—discharges to Brighton Creek, while three facilities—the Village of Pleasant Prairie Sewer Utility District D, the Village of Pleasant Prairie Sanitary District No. 73-1, and the Town of Bristol Utility District No. 1—discharge to the Des Plaines River via tributary streams.

- Ten industrial establishments which discharge wastewater are known to exist in the watershed and constitute a minor component of the hydraulic budget of the basin, accounting for only 2 percent of the total average annual flow from the basin. Nine industrial outfalls all normally discharge spent cooling waters, a combination of cooling and boiler blowdown water, stormwater, and process water. There is also one permitted sludge landspreading operation. The average annual pollutant contribution from these sources is insignificant, accounting for less than 0.3 percent of the total load of all pollutants evaluated.

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[32]*Lead was used in this analysis as an indicator of metals and other pollutants contributed primarily from urban sources. It should be noted that lead loadings will probably decline in the future as the use of leaded engine fuels decline and is discontinued and as the use of lead in solder for domestic water supply piping and in paint products is also discontinued. Thus, future lead loadings presented in this section may overestimate the actual loadings of that metal. However, the loadings of other metals from urban sources will not be affected by these changes.*

Table 80

PREDICTED AND OBSERVED SEDIMENT CONCENTRATIONS FOR THE DES PLAINES RIVER WATERSHED: 1990 AND PLANNED LAND USE CONDITIONS[a]

Water Quality Analysis Area[b]	Sediment Load		Simulated Mean Annual Flow (cfs)		Standard (mg/l)	1990		Planned	
	1990 (tons)	Planned (tons)	1990	Planned		Predicted Concentrations (mg/l)	Observed Concentrations (mg/l)	Predicted Concentrations (mg/l)	Observed Concentrations (mg/l)
5	306	299	11.30	11.80	- -	27.5	- -	25.8	- -
7	120	81	5.97	6.71	- -	20.4	- -	12.3	- -
6	134	134	19.90	20.60	- -	6.9	- -	7.0	- -
1	490	500	13.30	14.80	- -	37.3	- -	34.4	- -
2	125	127	34.90	36.20	- -	3.7	- -	3.7	- -
3	220	218	42.50	43.90	- -	5.2	- -	5.0	- -
8	234	242	6.53	6.92	- -	36.4	- -	35.4	- -
9	555	618	16.80	20.00	- -	33.6	- -	31.3	- -
4	667	639	85.10	97.70	10-50[c]	8.0	7.5 (3-11)[d]	6.6	- -
10	234	232	15.50	18.90	- -	15.4	- -	12.5	- -

[a]*Planned land use conditions are based upon buildout of the approved sewer service areas.*

[b]*As shown on Map 53. Ordered from upstream to downstream.*

[c]*Optimum value of suspended solids for wildlife propagation and recreation.*

[d]*Range observed during the 1990 water year at station Dp-4.*

Source: *U.S. Geological Survey; Frits van der Leeden, Fred L. Troise, and David Keith Todd, The Water Encyclopedia, 2nd Edition, Lewis Publishers, 1990. p. 417 ff.; and SEWRPC.*

- Nonpoint source pollution includes materials washed from the atmosphere, land surface, or subsurface by rainfall, snowmelt, or seepage waters and conveyed to surface waters. The majority of potential pollutants accumulated on or near the land surface may be traced to a variety of human activities or to the effects of human activities. Nonpoint sources account for essentially all of the total annual pollutant load to the surface waters of the Des Plaines River watershed.

- Of the total nonpoint source pollutant load to the watershed, as estimated using the unit load analysis, urban nonpoint sources are estimated to contribute about 5.8 percent of the phosphorus, about 5.4 percent of the sediment, and about 71.8 to 100 percent of the heavy metal load. Rural nonpoint sources account for the remaining 94.2 percent of the phosphorus, 94.6 percent of the sediment, and 0.0 to 28.2 percent of the heavy metals.

- Analysis of data collected during field inventories conducted in the watershed in 1999 indicates that about 19 miles of streambank, or 26 percent of the total considered would be expected to have a low erosion potential; about 52 miles of streambank, or 71 percent of the total considered would be expected to have a medium erosion potential, and about two miles of streambank, or 3 percent of the total considered would be expected to have a high erosion potential.

- The recommended temperature, pH, and ammonia-nitrogen standards are met virtually all of the time. The dissolved oxygen, phosphorus and fecal coliform standards recommended for Des Plaines River are violated about 15 percent, 83 percent and 46 percent of the time, respectively.

- Pollutant sources identified in the Des Plaines River watershed can be categorized into point sources, urban nonpoint sources, and rural nonpoint sources. Known point sources of pollution include four public and five private wastewater treatment facilities. Nonpoint sources of pollution include materials washed from the atmosphere, and the land surface or subsurface, by rainfall, snowmelt, or

Table 81

PREDICTED AND OBSERVED PHOSPHORUS CONCENTRATIONS FOR THE DES PLAINES RIVER WATERSHED: 1990 AND PLANNED LAND USE CONDITIONS[a]

Water Quality Analysis Area[b]	Phosphorus Load		Simulated Mean Annual Flow (cfs)		Standard (:g/l)	1990		Planned	
	1990 (pounds)	Planned (pounds)	1990	Planned		Predicted Concentrations (:g/l)	Observed Concentrations (:g/l)	Predicted Concentrations (:g/l)	Observed Concentrations (:g/l)
5	5,771	5,652	11.30	11.80	100	259	- -	243	- -
7	2,236	1,619	5.97	6.71	100	191	- -	122	- -
6	8,526	7,963	19.90	20.60	100	216	250[c] (50-500)[d]	196	- -
1	9,075	9,128	13.30	14.80	100	346	- -	313	- -
2	16,721	16,236	34.90	36.20	100	242	330[e] (170-590)[d]	227	- -
3	19,506	19,138	42.50	43.90	100	233	260[f] (120-440)[d]	221	- -
8	4,286	4,369	06.53	6.92	100	333	- -	319	- -
9	9,898	10,507	16.80	20.00	100	299	- -	266	- -
4	40,552	39,746	85.10	97.70	100	244	204[g,h] (130-310)[d]	206	- -
10	4,298	4,293	15.50	18.90	100	141	- -	115	- -

[a] *Planned land use conditions are based upon buildout of the approved sewer service areas.*

[b] *As shown on Map 53. Ordered from upstream to downstream.*

[c] *Observed concentrations during water years 1968 through 1975 at station Dp-1.*

[d] *Range of observed concentrations.*

[e] *Observed concentrations during water years 1968 through 1975 at station Dp-2.*

[f] *Observed concentrations during water years 1968 through 1975 at station Dp-2a.*

[g] *Observed concentrations during water year 1990 station Dp-4.*

[h] *Concentrations observed during water years 1968 through 1975 were a mean of 410 :g/l and a range of 150 :g/l to 620 :g/l at station Dp-3, located slightly upstream of station Dp-4.*

Source: U.S. Geological Survey and SEWRPC.

seepage waters. In urban areas, these pollutants are conveyed to the surface waters directly or via the storm sewer systems located in the watershed. As of 1990, urban land uses comprised about 9 percent of the Des Plaines River watershed, with the approximately 7.3 square miles of residential land use accounting for about 46 percent of the total urban land. Other major sources of urban nonpoint pollutants in the watershed were the approximately 0.9 square mile of freeway, 0.3 square mile of commercial land use, and 0.4 square mile of industrial land use, and onsite sewage disposal systems which serve about 14,000 persons. The approximately seven square miles of land under construction, used for extractive activities or for landfills, is also a major source of nonpoint source pollutants. Rural lands comprised about 91 percent of the watershed, with pollutant loadings from the 94 square miles of agricultural and open land being the most significant rural pollutant sources.

SUMMARY

Human activities and the occurrences of nature affect and are affected by the quality of surface water. In a watershed such as the Des Plaines River watershed, the effects of human activities on water quality tend to overshadow the natural influences. A comprehensive watershed planning program should assess water quality conditions and, if pollution problems exist or are likely to develop, must address the abatement of such problems in the plan preparation phase of the work. This chapter determines the extent to which surface waters in the Des Plaines River watershed have been and are polluted, and identifies the sources of that pollution.

Table 82

PREDICTED AND OBSERVED LEAD CONCENTRATIONS FOR THE DES PLAINES RIVER WATERSHED: 1990 AND PLANNED LAND USE CONDITIONS[a]

Water Quality Analysis Area[b]	Lead Load		Simulated Mean Annual Flow (cfs)		Standard[c] (:g/l)	1990		Planned	
	1990 (pounds)	Planned (pounds)	1990	Planned		Predicted Concentrations (:g/l)	Observed Concentrations (:g/l)	Predicted Concentrations (:g/l)	Observed Concentrations (:g/l)
5	132	142	11.30	11.80	- -	5.9	- -	6.1	- -
7	167	221	5.97	6.71	- -	14.1	- -	16.7	- -
6	204	406	19.90	20.60	- -	5.3	- -	10.0	- -
1	220	676	13.30	14.80	- -	8.3	- -	23.1	- -
2	254	649	34.90	36.20	- -	3.7	- -	9.3	- -
3	240	545	42.50	43.90	- -	2.9	- -	6.3	- -
8	68	353	6.53	6.92	- -	5.4	- -	26.8	- -
9	461	3,116	16.80	20.00	- -	6.3	- -	78.6	- -
4	989	6,522	85.10	97.70	1050/62	5.9	5.4[d] (<5-9)[e]	34.0	- -
10	132	181	15.50	18.90	- -	4.3	- -	4.9	- -

[a]*Planned land use conditions are based upon buildout of the approved sewer service areas.*

[b]*As shown on Map 53. Ordered from upstream to downstream.*

[c]*Acute Toxicity Criteria and Chronic Toxicity Criteria respectively calculated using the method set forth in Chapter NR 105,* Wisconsin Administrative Code*, using an estimated hardness value of 420 mg/l.*

[d]*Observed concentrations during water year 1990 at station Dp-4.*

[e]*Range of observed concentrations.*

Source: U.S. Geological Survey; Frits van der Leeden, Fred L. Troise, and David Keith Todd, The Water Encyclopedia*, 2nd Edition, Lewis Publishers, 1990. p. 417 ff.; and SEWRPC.*

The term water quality encompasses the physical, chemical, and biological characteristics of water. Water is deemed to be polluted when foreign substances caused by, or related to, human activities are in such form and concentration as to render the water unsuitable for desired beneficial uses. Water pollution may be classified as one or more of the following eight types, depending on the nature of the substance causing the pollution: toxic pollution, organic pollution, nutrient pollution, pathogenic or disease-carrying pollution, thermal pollution, sediment pollution, radiological pollution, and aesthetic pollution. Water pollution is relative in the sense that determination of whether or not a particular water resource is polluted is a function of the intended use of that water resource; that is, water may be polluted with respect to some uses and, at the same time, not polluted with respect to others.

Many parameters or indicators are available for measuring and describing water quality. The parameters used in analyzing water quality conditions in the Des Plaines River watershed include temperature, specific conductance, turbidity, biochemical oxygen demand, and total and fecal coliform bacteria counts; total dissolved solids (TDS), total suspended solids (TSS), hydrogen ion (pH), chloride, dissolved oxygen, phosphorus, and nitrogen concentrations; aquatic flora and fauna; and metal, pesticide, and polychlorinated biphenyl (PCBs) concentrations. Aquatic flora and fauna were assessed using the Hilsenhoff Biotic Index (HBI) and the Index of Biotic Integrity (IBI).

Water quality standards corresponding to the water use objectives for the watershed surface water system provide a scale against which historic and existing water quality can be judged. For purposes of the comparative water quality analysis set forth in this chapter, water quality standards associated with a water use objective of full recreational use and the maintenance of warmwater sportfish communities were used. That objective was established under the regional water quality management plan, in conformance with the national water quality objectives cited in Public Law 92-500, have been used. Lesser water use objectives have been established for

Table 83

PREDICTED AND OBSERVED COPPER CONCENTRATIONS FOR THE DES PLAINES RIVER WATERSHED: 1990 AND PLANNED LAND USE CONDITIONS[a]

Water Quality Analysis Area[b]	Copper Load		Simulated Mean Annual Flow (cfs)		Standard[c] (:g/l)	1990		Planned	
	1990 (pounds)	Planned (pounds)	1990	Planned		Predicted Concentrations[d] (:g/l)	Observed Concentrations (:g/l)	Predicted Concentrations (:g/l)	Observed Concentrations (:g/l)
5	13	7	11.30	11.80	- -	0.7	- -	0.3	- -
7	13	21	5.97	6.71	- -	1.0	- -	1.6	- -
6	18	38	19.90	20.60	- -	0.4	- -	1.0	- -
1	16	72	13.30	14.80	- -	0.5	- -	2.5	- -
2	20	66	34.90	36.20	- -	0.3	- -	0.9	- -
3	19	53	42.50	43.90	- -	0.2	- -	0.6	- -
8	4	33	6.53	6.92	- -	0.3	- -	2.5	- -
9	178	465	16.80	20.00	- -	4.2	- -	11.8	- -
4	214	882	85.10	97.70	64/44	1.2	7.0[e] (<5-21)[f]	4.8	- -
10	8	13	15.50	18.90	- -	0.2	- -	0.4	- -

[a]*Planned land use conditions are based upon buildout of the approved sewer service areas.*

[b]*As shown on Map 53. Ordered from upstream to downstream.*

[c]*Acute Toxicity Criteria and Chronic Toxicity Criteria respectively calculated using the method set forth in Chapter NR 105,* Wisconsin Administrative Code, *using an estimated hardness value of 420 mg/l.*

[d]*Computed assuming the same transmission coefficient that was calculated for lead. Transmission coefficient could not be computed for copper, zinc, and cadmium because observed concentrations were generally below the limit of detection.*

[e]*Observed concentrations during water year 1990 at station Dp-4.*

[f]*Range of observed concentrations.*

Source: U.S. Geological Survey; Frits van der Leeden, Fred L. Troise, and David Keith Todd, The Water Encyclopedia, *2nd Edition, Lewis Publishers, 1990. p. 417 ff.; and SEWRPC.*

certain tributaries to the Des Plaines River; however, no observed water quality data are available for use in evaluating whether the objectives are being met.

A distinction must be drawn between instream water quality during dry weather conditions and during wet weather conditions. Dry weather instream quality reflects the quality of groundwater discharged to the stream plus the continuous or intermittent discharge of various point sources, such as industrial cooling or process waters. While instream water quality during wet weather conditions includes the above discharges, the dominant influence—particularly during major rainfall or snowmelt events—is the load from soluble and insoluble substances washed into the streams by stormwater runoff. This runoff moves from the land surface to the stream waters via overland routes, such as drainage ditches and streets and highway ditches and gutters, or via the underground storm sewer system. Wet weather conditions—defined as being days on which 0.10 inch or more of precipitation occurs—may be expected to occur on an average of about 20 percent of the days in a given year in the Des Plaines River watershed.

A variety of data sources, based primarily on field studies conducted from 1964 through 2001, were used to assess the historic and existing water quality of surface water in the Des Plaines River watershed. Most of the historic water quality monitoring information available for the watershed represents dry weather conditions, with some information being available on wet weather conditions and relatively little information being available on either dry or wet-weather condition concentrations of such more exotic pollutants as metals, pesticides, and polychlorinated biphenyls. The past studies have shown that high concentrations of pollutants are more likely to occur during wet weather conditions in the Des Plaines River watershed than during dry weather conditions.

Table 84

PREDICTED AND OBSERVED ZINC CONCENTRATIONS FOR THE DES PLAINES RIVER WATERSHED: 1990 AND PLANNED LAND USE CONDITIONS[a]

Water Quality Analysis Area[b]	Zinc Load		Simulated Mean Annual Flow (cfs)		Standard[c] (:g/l)	1990		Planned	
	1990 (pounds)	Planned (pounds)	1990	Planned		Predicted Concentrations[d] (:g/l)	Observed Concentrations (:g/l)	Predicted Concentrations (:g/l)	Observed Concentrations (:g/l)
5	98	43	11.30	11.80	- -	4.3	- -	1.8	- -
7	128	162	5.97	6.71	- -	9.7	- -	12.3	- -
6	170	267	19.90	20.60	- -	4.2	- -	6.7	- -
1	140	501	13.30	14.80	- -	4.8	- -	17.2	- -
2	186	461	34.90	36.20	- -	2.6	- -	6.5	- -
3	173	371	42.50	43.90	- -	2.0	- -	4.3	- -
8	12	230	6.53	6.92	- -	0.9	- -	17.4	- -
9	839	2,783	16.80	20.00	- -	21.2	- -	0.7	- -
4	1,105	5,631	85.10	97.70	248/167	5.8	<61.1[e](<100)[f]	29.4	- -
10	55	103	15.50	18.90	- -	1.5	- -	2.8	- -

[a]*Planned land use conditions are based upon buildout of the approved sewer service areas.*

[b]*As shown on Map 53. Ordered from upstream to downstream.*

[c]*Acute Toxicity Criteria and Chronic Toxicity Criteria respectively calculated using the method set forth in Chapter NR 105,* Wisconsin Administrative Code, *using an estimated hardness value of 420 mg/l.*

[d]*Computed assuming the same transmission coefficient that was calculated for lead. Transmission coefficient could not be computed for copper, zinc, and cadmium because observed concentrations were generally below the limit of detection.*

[e]*Observed concentrations during water year 1990 at station Dp-4.*

[f]*Range of observed concentrations.*

Source: U.S. Geological Survey; Frits van der Leeden, Fred L. Troise, and David Keith Todd, The Water Encyclopedia, *2nd Edition, Lewis Publishers, 1990. p. 417 ff.; and SEWRPC.*

The recommended temperature, pH, and ammonia-nitrogen standards appear to be satisfied in the Des Plaines River system virtually all of the time. In contrast, the dissolved oxygen, phosphorus and fecal coliform standards are violated 15 percent, 83 percent and 46 percent of the time, respectively. These findings are consistent with the presence of pollution-tolerant fishes in the Des Plaines River watershed.

The magnitude and extent of toxic and hazardous substance contamination of the Des Plaines River watershed cannot be determined from the limited data available.

Of the eight potential types of surface water pollution, all but thermal and radiologic pollution are known to exist, at least to some degree, in the Des Plaines River watershed. As a result, the quality of the surface waters of the Des Plaines River watershed does not fully support the maintenance of warmwater sportfish communities objective, nor does it fully support the full recreational use objective.

Commission inventories indicate that as of 2002, point source contributions of pollutants were relatively insignificant, and both urban and rural nonpoint sources were major contributors of pollutants.

Point source pollutant loads in the Des Plaines River watershed were estimated by utilizing measured data obtained under the Wisconsin Pollution Discharge Elimination System. Pollutant loads from nonpoint sources were estimated using a unit load analysis. Based on the unit load analysis, urban nonpoint sources of pollution are estimated to contribute 4.7 percent of the phosphorus, 3.3 percent of the sediment, and 70.7 percent of the heavy metals which are discharged to drainage channels in the Des Plaines River watershed. Of the total pollutant loads, rural nonpoint pollutant sources contribute the remaining 95.3 percent of the phosphorus, 96.6 percent of the sediment, and 29.3 percent of the metals.

Table 85

PREDICTED AND OBSERVED CADMIUM CONCENTRATIONS FOR THE DES PLAINES RIVER WATERSHED: 1990 AND PLANNED LAND USE CONDITIONS[a]

Water Quality Analysis Area[b]	Cadmium Load		Simulated Mean Annual Flow (cfs)		Standard[c] (Φg/l)	1990		Planned	
	1990 (pounds)	Planned (pounds)	1990	Planned		Predicted Concentrations[d] (Φg/l)	Observed Concentrations (Φg/l)	Predicted Concentrations (Φg/l)	Observed Concentrations (Φg/l)
5	0.2	0.0	11.30	11.80	- -	0.009	- -	0.000	- -
7	0.1	0.3	5.97	6.71	- -	0.009	- -	0.152	- -
6	0.2	1.2	19.90	20.60	- -	0.005	- -	0.030	- -
1	0.3	2.8	13.30	14.80	- -	0.012	- -	0.096	- -
2	0.3	2.4	34.90	36.20	- -	0.004	- -	0.034	- -
3	0.4	1.9	42.50	43.90	- -	0.005	- -	0.022	- -
8	0.0	1.5	6.53	6.92	- -	0.000	- -	0.110	- -
9	5.5	18.5	16.80	20.00	- -	0.166	- -	0.470	- -
4	6.4	35.1	85.10	97.70	146/2.4	0.038	<3.0[e] (<3.0)[f]	0.183	- -
10	0.1	0.3	15.50	18.90	- -	0.003	- -	0.008	- -

[a]*Planned land use conditions are based upon buildout of the approved sewer service areas.*

[b]*As shown on Map 53. Ordered from upstream to downstream.*

[c]*Acute Toxicity Criteria and Chronic Toxicity Criteria respectively calculated using the method set forth in Chapter NR 105,* Wisconsin Administrative Code, *using an estimated hardness value of 420 mg/l.*

[d]*Computed assuming the same transmission coefficient that was calculated for lead. Transmission coefficient could not be computed for copper, zinc, and cadmium because observed concentrations were generally below the limit of detection.*

[e]*Observed concentrations during water year 1990 at station Dp-4.*

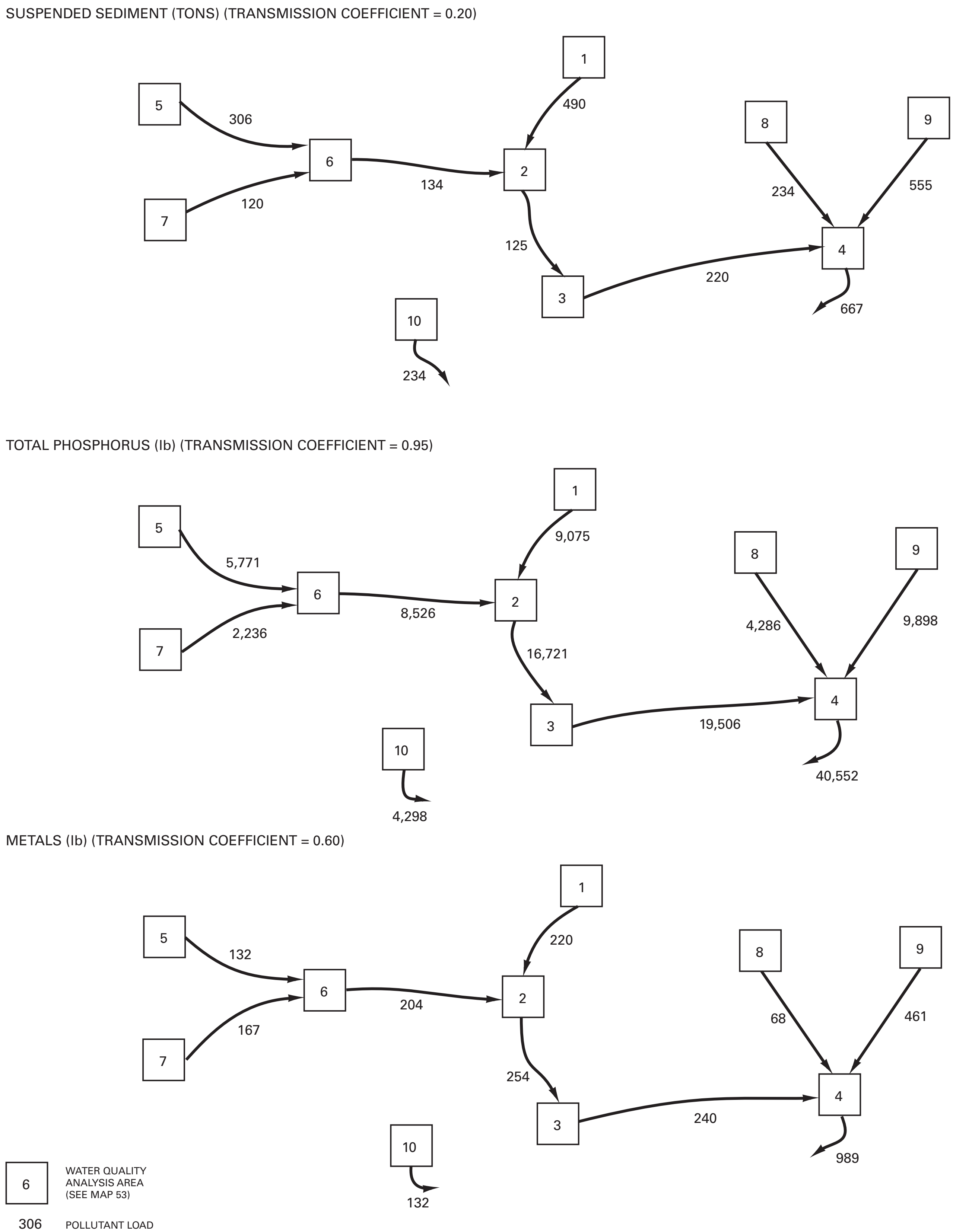
[f]*Range of observed concentrations.*

Source: U.S. Geological Survey; Frits van der Leeden, Fred L. Troise, and David Keith Todd, The Water Encyclopedia, *2nd Edition, Lewis Publishers, 1990. p. 417 ff.; and SEWRPC.*

Analysis of data collected during field inventories conducted in the watershed in 1999 indicates that about 19 miles of streambank, or 26 percent of the total considered would be expected to have a low erosion potential; about 52 miles of streambank, or 71 percent of the total considered would be expected to have a medium erosion potential, and about two miles of streambank, or 3 percent of the total considered would be expected to have a high erosion potential.

Figure 47

NONPOINT SOURCE POLLUTANT LOADING IN THE DES PLAINES RIVER WATERSHED: 1990

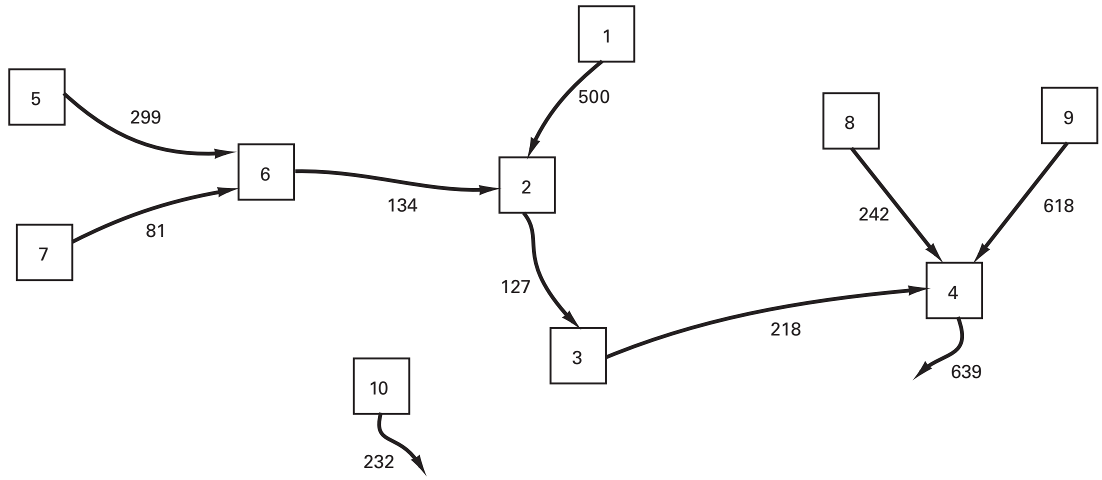


Source: SEWRPC.

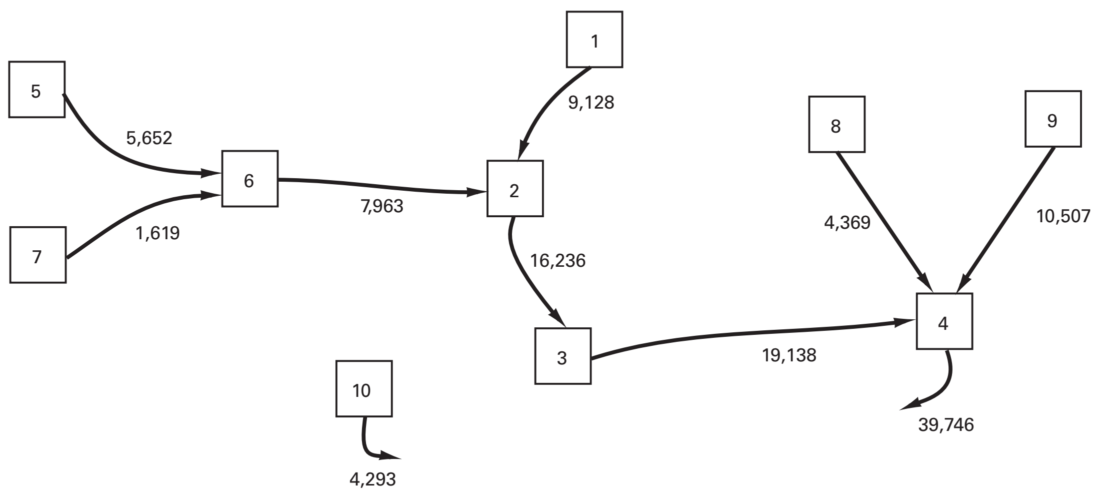
Figure 48

NONPOINT SOURCE POLLUTANT LOADING IN THE DES PLAINES RIVER WATERSHED: PLANNED

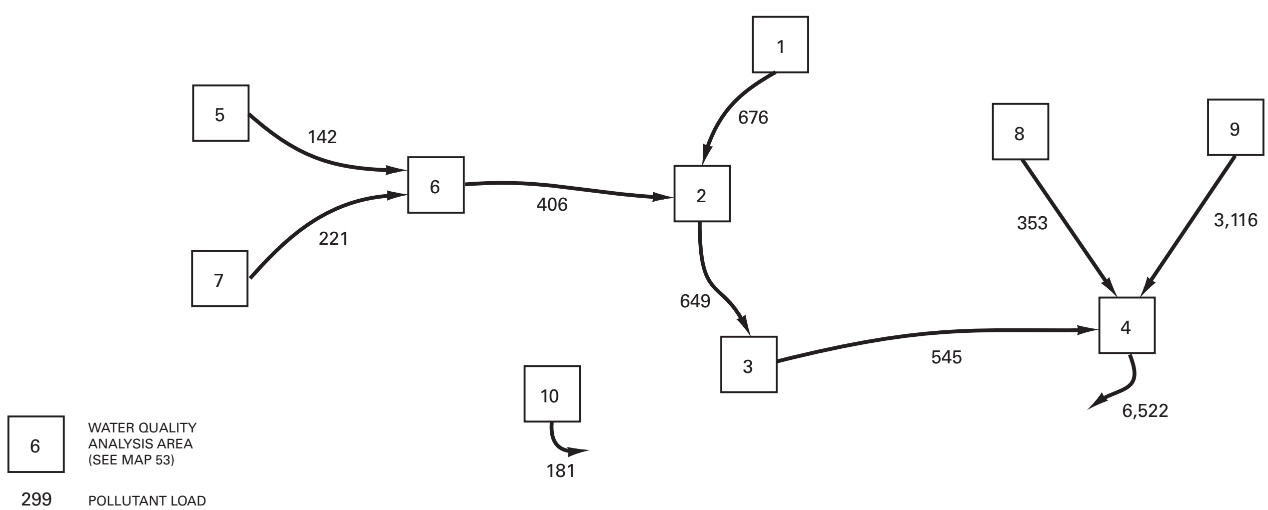
SUSPENDED SEDIMENT (TONS) (TRANSMISSION COEFFICIENT = 0.20)



TOTAL PHOSPHORUS (lb) (TRANSMISSION COEFFICIENT = 0.95)



METALS (lb) (TRANSMISSION COEFFICIENT = 0.60)



Source: SEWRPC.

Chapter VIII

WATER RESOURCE SIMULATION MODELING

INTRODUCTION

Quantitative analyses of the hydrology, hydraulics, and water quality of a watershed under existing and alternative future conditions are a fundamental requirement of any sound, comprehensive watershed planning effort. Of particular interest in watershed planning are: those aspects of the hydrology and hydraulics of the watershed which affect peak flood discharges and stages and which are, therefore, of concern in floodland and stormwater management; and those aspects of the hydrology and hydraulics of the watershed which affect water quality conditions, including periods of critically low streamflows and periods of pollutant washoff from the land surface, and which are, therefore, of concern in water quality management.

Planning and engineering techniques are available that make it possible to calculate existing and future hydrologic, hydraulic, and water quality conditions in a watershed. These techniques involve the formulation and application of mathematical models that simulate[1] the behavior of the surface water system. These models, which are usually programmed for computer application, permit the quantitative analyses of the hydrology, hydraulics, and water quality characteristics of a watershed under existing and alternative future conditions.

The purpose of this chapter is to describe the water resource simulation model—actually a combined hydrologic, hydraulic, and water quality model—used in the Des Plaines River watershed planning program. More specifically, this chapter discusses model selection, the submodels comprising the water resources simulation model, input data requirements and data base development, and model calibration.

Another important element of the comprehensive planning effort is the accurate estimation of potential flood damages within the watershed. These damage estimates provide the basis for determining the need for analysis and implementation of selected flood control and drainage measures. As with the water resource simulation model, specific techniques have been developed for the estimation of flood damages for both structures and agricultural lands. A discussion of these techniques and their application to the Des Plaines River watershed is also presented in this chapter.

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[1]*Simulation is defined as reproduction of the important behavioral aspects of a system. It should be emphasized that simulation, as used in comprehensive watershed planning, does not normally achieve, or need to achieve, exact duplication of all aspects of system behavior.*

MODEL USED IN THE DES PLAINES RIVER WATERSHED PLANNING PROGRAM

Model Selection Criteria

For comprehensive watershed planning, the needed mathematical simulation model should be able to:

1. Simulate hydrologic, hydraulic, and water quality conditions in both rural and urban areas;
2. Compute flood discharges and stages for a wide range of recurrence intervals, including the 100-year recurrence interval, with sufficient accuracy for use in delineating floodland regulatory districts and areas and for designing and evaluating alternative flood control measures and works and floodland management options;
3. Incorporate the effects of hydraulic structures such as bridges, culverts, and dams and of localized floodland encroachments on upstream and downstream flood discharges and stages;
4. Incorporate the hydrologic, hydraulic, and water quality effects of land use changes—particularly the effects of the conversion of land from rural to urban uses—within the entire tributary watershed;
5. Incorporate the hydrologic and hydraulic effects of floodland management options and alternative structural flood control works, such as wetland and prairie restoration, channelization, dikes and floodwalls, and storage impoundments;
6. Permit assessment of the impact on surface water quality of discharges from point sources of pollution such as municipal and industrial discharges;
7. Permit assessment of the impact on surface water quality of diffuse, or nonpoint, sources of pollution, such as organic materials and plant nutrients washed from the land surface or leached out of soil profiles; and
8. Allow for calibration to reflect hydrologic, hydraulic, and water quality concerns represented in the Des Plaines River watershed.

Model Selection

Figure 49 graphically illustrates the overall structure of the water resources simulation model selected by the Commission for use in the Des Plaines River watershed study; identifies four submodels within the overall model; shows the relationships between these submodels; indicates the input and output of each submodel; and indicates the uses of the simulation model results.

The hydrologic submodel, the first of two hydraulic submodels, and the water quality submodel consist of three computer programs originally contained within a program package known as "Hydrocomp simulation programming."[2] These submodels, which were available on a proprietary basis through the consulting firm, Hydrocomp, Inc., had been under development since the early 1960s, when pioneering work in hydrologic-hydraulic modeling was initiated at Stanford University. The Hydrocomp program submodels—that is, the hydrologic submodel, the first hydraulic submodel, and the water quality submodel—are all continuous process models which were used in, among other applications, the Commission Menomonee River, Kinnickinnic River, Pike River, and Oak Creek watershed studies and in the Commission areawide water quality management planning program, including under the latter the simulation of water quality conditions in the Des Plaines River watershed.[3]

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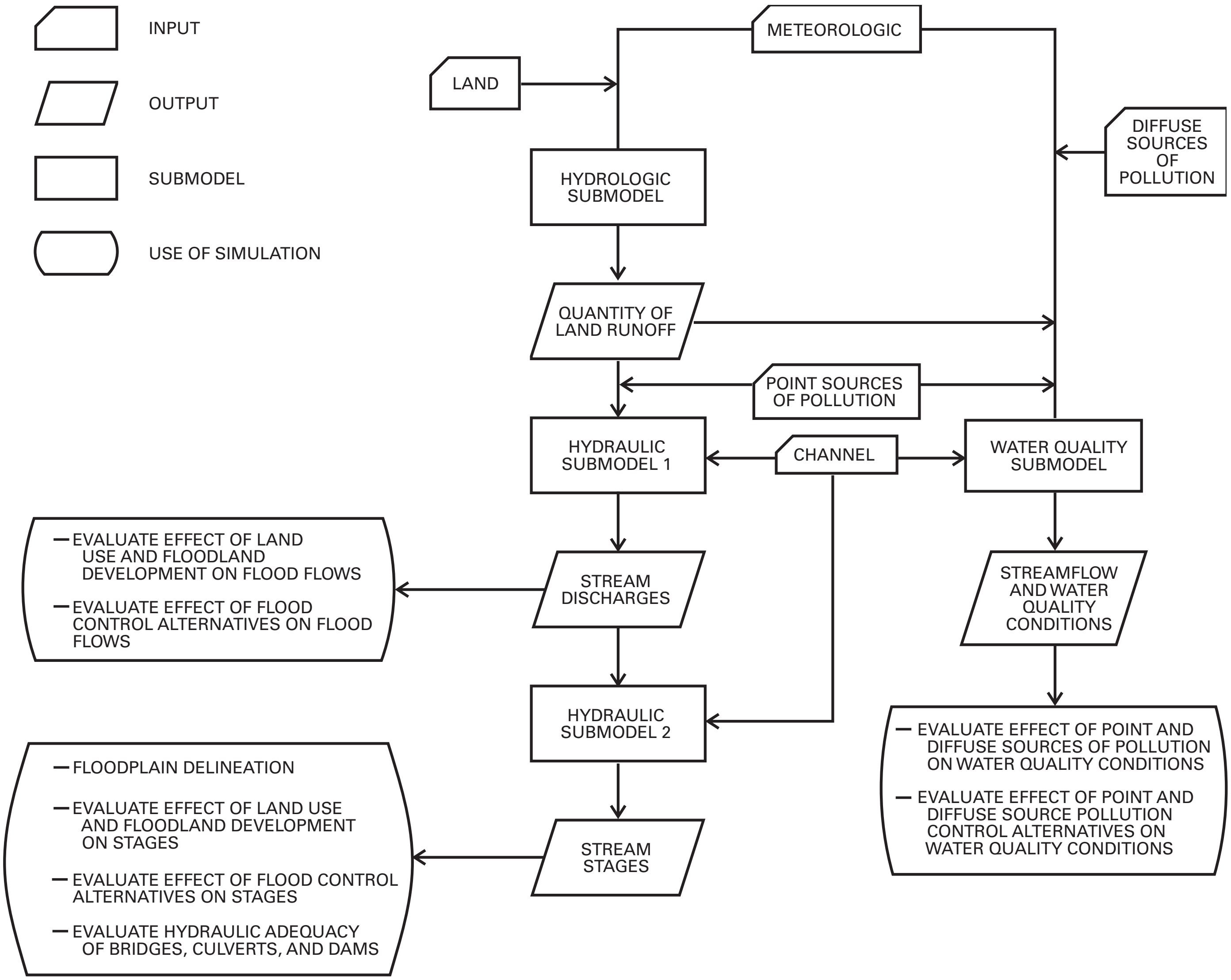
[2]*See Hydrocomp, Inc.,* Hydrocomp Simulation Programming Operations Manual*, 4th Edition, January 1976; and Hydrocomp, Inc.,* Hydrocomp Water Quality Operations Manual*, April 1977.*

[3]*See SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume Two,* Alternative Plans*, February 1979.*

Figure 49

HYDROLOGIC-HYDRAULIC-WATER QUALITY MODEL USED IN THE DES PLAINES RIVER WATERSHED PLANNING PROGRAM



Source: SEWRPC.

The continuous simulation program which was used for the Des Plaines River watershed study, called "Hydrological Simulation Program-Fortran" (HSPF), was obtained from the U.S. Environmental Protection Agency and represents a refined version of the original Hydrocomp program package.[4] The HSPF program was used for flood control related analyses conducted under the Des Plaines River watershed study. This program had previously been used for the flood control related analysis conducted for the Commission Oak Creek watershed study.

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[4]*U.S. Environmental Protection Agency, Environmental Research Laboratory,* Hydrological Simulation Program—Fortran, User's Manual for Release 10*, Athens, Georgia, September 1993.*

The second hydraulic submodel is the U.S. Army Corps of Engineers HEC-2 “Water Surface Profiles” computer program.[5] This discrete event, steady state model has been used extensively by the Commission in its floodland management planning and plan implementation activities since mid-1972.

Each of the four submodels is described briefly below. These separate descriptions emphasize the function of each submodel within the overall modeling scheme, the types of algorithms that are contained within each submodel, data needs, and the kinds of output that are provided.

Hydrologic Submodel

The principal function of the hydrologic submodel is to determine the volume and temporal distribution of flow from the land to the stream system. As used herein, the concept of runoff from the land is broadly interpreted to include surface runoff, interflow, and groundwater flow to the streams. The amount and rate of runoff from the land to the watershed stream system are largely a function of two factors. The first is the meteorological events which determine the quantity of water available on or beneath the land surface and the second factor is the nature and use of the land.

The basic conceptual unit on which the hydrologic submodel operates is called the hydrologic land segment type. A hydrologic land segment type is defined as a unique combination of meteorological characteristics, such as precipitation and temperature; land characteristics, such as pervious or impervious surfaces; soil type; and slope. A strict interpretation of this definition results in a virtually infinite number of unique hydrologic land segment types within even a small watershed because of the large number of possible combinations of meteorological characteristics, land characteristics, and soils which exhibit a continuous, as opposed to discrete, spatial variation throughout the watershed. To apply the concept, the study area is divided into hydrologic land segments. A hydrologic land segment is defined as a surface drainage unit which exhibits a runoff pattern characteristic of a particular combination of hydrologic land segment types. Thus, the practical, operational definition of a hydrologic land segment is a surface drainage unit consisting of a subbasin or a combination of subbasins that are represented by a particular grouping of hydrologic land segment types. The hydrologic land segments were defined so that simulated output data could be obtained at sites where historic stream flow and water quality data were available, or at points located upstream or downstream of known sources of pollution. As described later in this chapter, 12 hydrologic land segment types, and 192 hydrologic land segments were identified within the Des Plaines River watershed for modeling existing conditions.

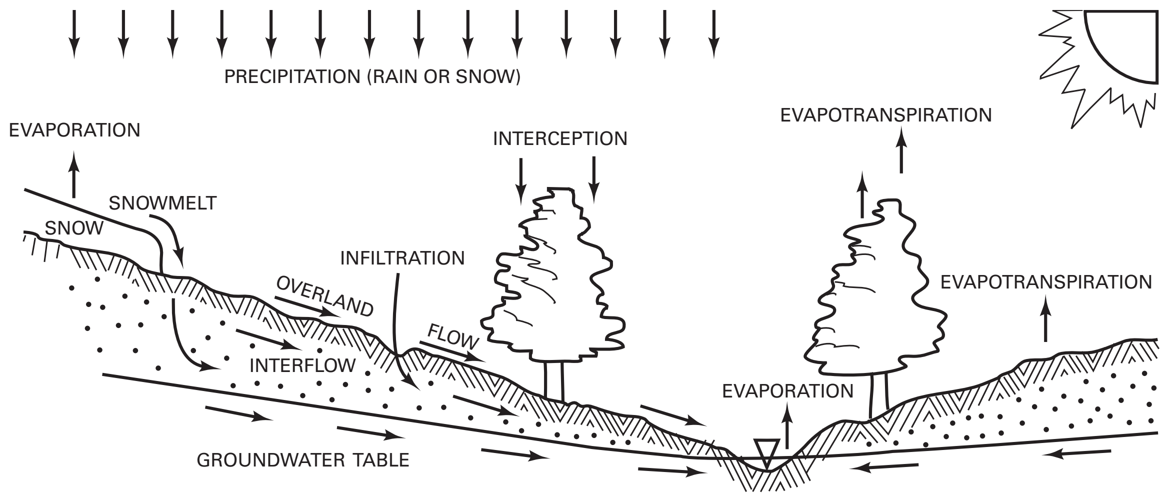
The hydrologic processes explicitly simulated within the hydrologic submodel are shown in Figure 50. The submodel, operating on a time interval of 15 minutes, continuously and sequentially maintains a water balance within and between various hydrologic processes. Because of the tendency for some of the smaller streams studied to experience a rapid rise and fall of floodwaters, a 15-minute simulation time interval was chosen in order to correctly simulate the instantaneous peak discharges along those streams. The water balance accounting procedure is based on the interdependence between the various hydrologic processes shown schematically in Figure 51. The hydrologic submodel maintains a running account of the quantity of water that enters, leaves, and remains within each phase of the hydrologic cycle during each successive time interval.

As already noted, the volume and rate of runoff from the land is determined by meteorological phenomena and the nature and use of the land. Therefore, meteorological data and land data constitute the two principal types of input data for each land segment type in the hydrologic submodel. Table 86 identifies eight categories of historic meteorological data sets, seven of which are input directly or indirectly to the hydrologic submodel for each land segment type, and indicates the use of each data set. The procedures used to acquire or develop the eight different types of meteorological data sets used in simulating the hydrologic response of the Des Plaines River watershed land surface are described later in this chapter.

[5]*U.S. Army Corps of Engineers, Hydrologic Engineering Center,* HEC-2, Water Surface Profiles*, Version 4.6.2, Davis, California, May 1991.*

Figure 50

PROCESSES SIMULATED IN THE HYDROLOGIC SUBMODEL



Source: Hydrocomp Inc. and SEWRPC.

Table 87 identifies the parameters that are input to the hydrologic submodel for each hydrologic land segment type and indicates the primary source of numerical values for each parameter. The numerical values assigned to each of these land parameters for a given land segment have the effect of adapting the hydrologic submodel to the land segment type. The procedures used to assign values to the land parameters for each hydrologic land segment type are described later in this chapter.[6]

Hydraulic Submodels

The primary function of the first hydraulic submodel (HSPF) is to accept as input the runoff from the land surface, along with point and groundwater discharges as produced by the hydrologic submodel, to combine the two, and to route[7] them through the stream system, thereby producing a continuous series of discharge values at predetermined locations along the rivers and streams of the watershed. Computations proceed at a time interval of 15 minutes. Statistical analyses performed on the resulting continuous series of discharges yield the various recurrence interval flood discharges that are then input to the second hydraulic submodel for calculation of stage.

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[6]*Appendix J provides information relative to the assignment of hydrologic parameters that represent wetland and prairie conditions modeled for the analysis of floodland management alternatives.*

[7]*Routing refers to the mathematical technique used to represent the process in which a streamflow hydrograph for a point at the entrance to a river reach or an impoundment, such as a lake or reservoir, is attenuated—that is, in the absence of additional inflowing runoff volume, the peak flow is reduced and the time base lengthened—through the reach or impoundment as a result of either temporary channel-floodplain storage or temporary impoundment storage.*

Figure 51

INTERDEPENDENCE BETWEEN PROCESSES IN THE HYDROLOGIC AND WATER QUALITY SUBMODELS

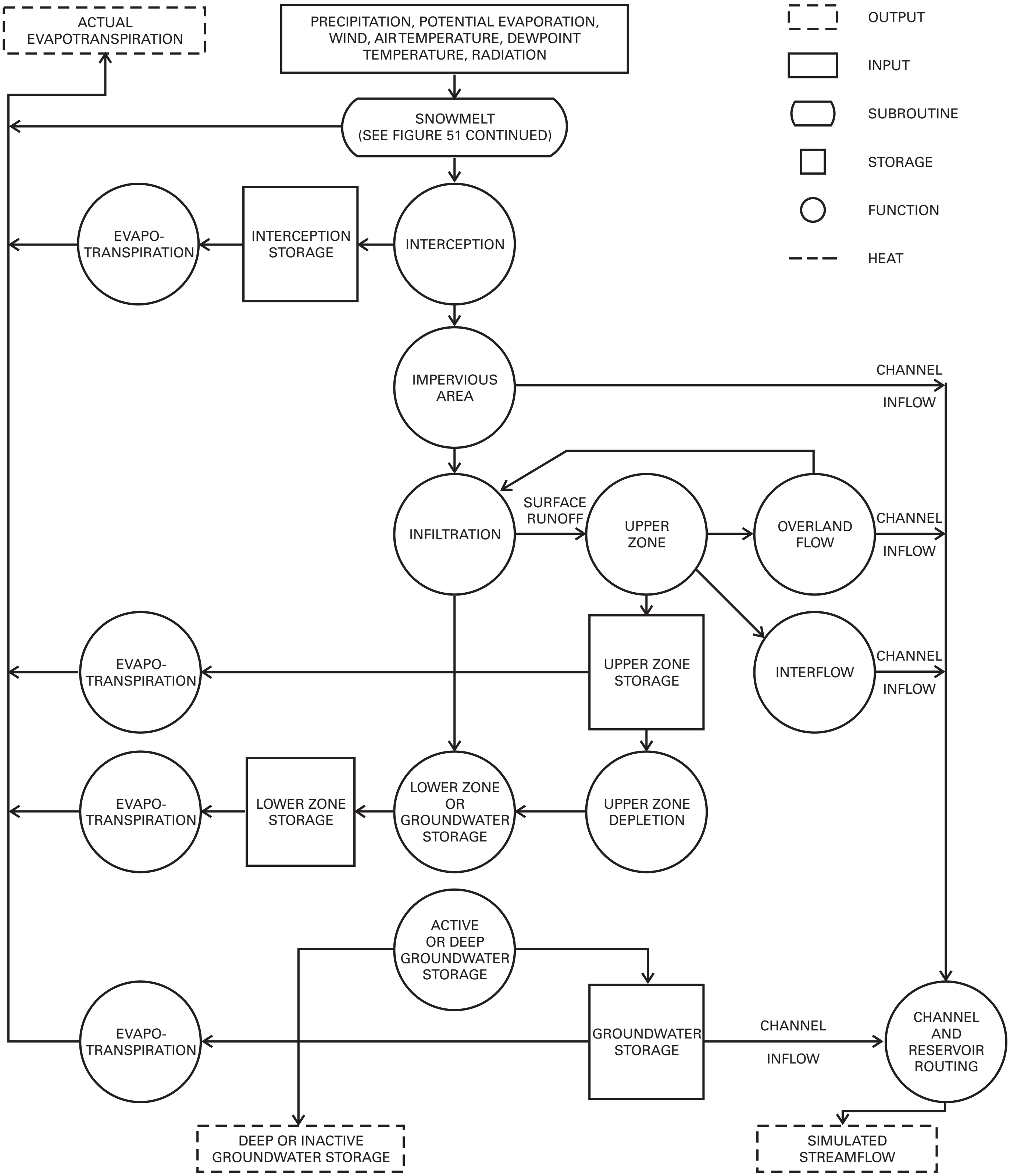
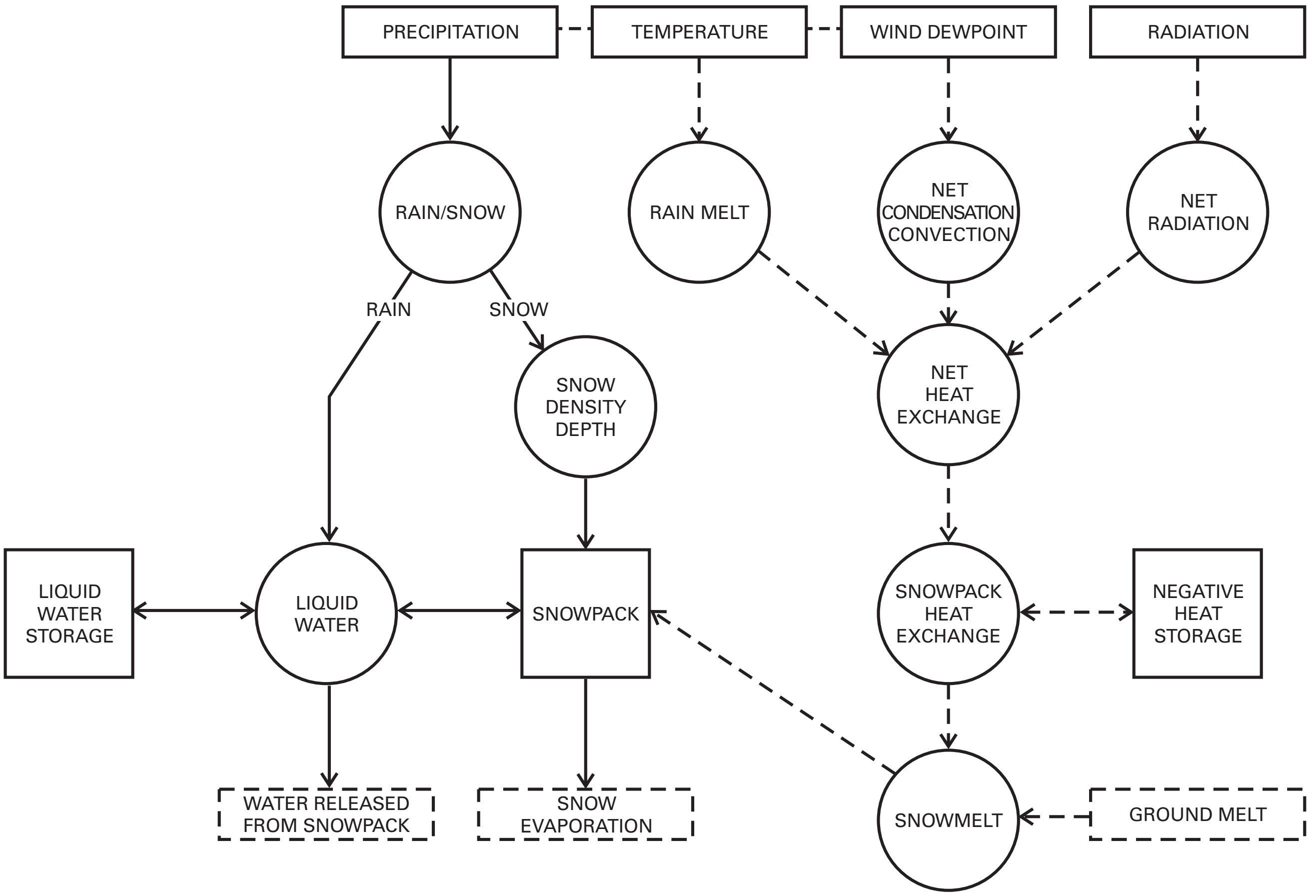


Figure 51 (continued)

FLOWCHART FOR SNOWMELT SUBROUTINE



Source: Hydrocomp Inc. and SEWRPC.

In addition to maintaining a continuous accounting of inflow to the stream system, the first hydraulic submodel performs routing calculations for land segments—a land segment being either a channel reach and its tributary drainage area, or an impoundment and its tributary drainage area—by employing the conservation of mass principle and basic hydraulic laws.

Reach routing is accomplished on a continuous basis using a storage, or reservoir, routing technique. Use of this analytic procedure requires that a stage-discharge-cumulative storage table be prepared for each reach with the values selected so as to encompass the entire range of physically possible water surface elevations. As simulated by the routing algorithm, a volume of flow enters the reach during a particular time increment with the origin of the flow being discharge from a reach immediately upstream combined with runoff from the additional drainage area directly tributary to the reach. The incremental volume of flow is added to that already in the reach at the beginning of the time interval, and the stage-discharge-cumulative volume relationship is then used to estimate the rate of discharge from the reach during the time increment. The volume of water stored in the reach at the end of the time increment is calculated as the initial volume plus the inflow volume minus the outflow volume. This computational process is then repeated for subsequent time increments, with the result of each such computation being the stage of, and the discharge rate from, the reach at the end of each time increment. Any number of stage-discharge relationships may be utilized for a given reach, facilitating the simulation of a variety of potential outlet works and operating procedures.

Table 86

METEOROLOGICAL DATA SETS AND THEIR USE IN THE HYDROLOGIC AND WATER QUALITY SUBMODELS

Data Set	Units	Frequency: Desirable	Frequency: Allowable	Origin of Data: Historic	Origin of Data: Computed	Use in Hydrologic Submodel	Use in Water Quality Submodel	Use in Synthesizing Other Meteorological Input Data for the Submodels
Precipitation	10^{-2} inches	Hourly or more frequent	Daily	X	- -	Rain or snowfall applied to the land Data from hourly stations used to disaggregate data from daily stations	- -	- -
Radiation	Langleys/day[a]	Hourly	Daily	- -	X	Snowmelt	Water temperature-heat flux to water by short wave solar radiation	Compute potential evaporation
Potential Evaporation	10^{-3} inches	Hourly	Daily	- -	X	Evaporation from lakes, reservoirs, wetlands, depression storage, and interception storage Evapotranspiration from upper zone storage, lower zone storage, and groundwater storage Evaporation from snow	- -	- -
Temperature	°F	Hourly	- -	X	- -	Snowmelt Density of new snow Occurrence of precipitation as snow	Water temperature-heat flux to water surface by long wave solar radiation Water temperature-heat flux from water by conduction-convection	Average daily temperature used to compute evaporation
Wind Movement	Miles/day	Hourly	Daily	X	- -	Snowmelt by condensation-convection Evaporation from snow	Water temperature-heat loss from water surface by evaporation Lake reaeration	Compute evaporation
Dewpoint Temperature[b]	°F	Daily	- -	X	- -	Snowmelt by condensation-convection Evaporation from snow	Water temperature-heat loss from water surface by evaporation	Compute evaporation
Cloud Cover	Decimal fraction	Daily	- -	X	- -	Used indirectly	Water temperature-heat flux to water surface by long wave solar radiation	Compute solar radiation which was in turn used to compute evaporation
Sunshine	Percent possible	Daily	- -	X	- -	Used indirectly	Used indirectly	Compute solar radiation which was in turn used to compute evaporation

[a]*Solar energy flux, that is, the rate at which solar energy is delivered to a surface—such as the earth's surface—is expressed in terms of energy per unit area per unit time. The Langley expresses energy per unit area and is equivalent to 1.0 calories/cm^2 or 3.97 x 10^{-3} BTU/cm^2. Therefore, a Langley/day, which expresses solar energy flux in terms of energy per unit area per unit time, is equivalent to 1.0 calories/cm^2/day or 3.97 x 10^{-3} BTU/cm^2/day. The solar energy flux above the earth's atmosphere and normal to the radiation path is about 2,880 Langleys/day.*

[b]*Dewpoint temperature is the temperature at which air becomes saturated when cooled under conditions of constant pressure and constant water vapor content.*

Source: Hydrocomp, Inc. and SEWRPC.

Table 87

PARAMETERS REQUIRED BY THE HYDROLOGIC SUBMODEL

Parameter		Definition or Meaning	Unit	Primary Source of Numerical Values[a]
Number	Symbol			
1	LAT	Latitude of segment	Degrees	U.S. Geological Survey quadrangle map
2	MELEV	Mean elevation of segment	Feet sea level datum	Topographic map
3	SHADE	Decimal fraction of segment shaded from solar radiation	None	Aerial photograph
4	SNOWCF	Adjust snowfall measurements to account for typical catch deficiency	None	- -[b]
5	COVIND	Water equivalent of snowpack when segment is completely covered by snow	Inches	- -[c]
6	RDCSN	Density of new snow at 0°F	None	- -[c]
7	TSNOW	Air temperature below which precipitation occurs as snow	°F	- -[c]
8	SNOEVP	Adjust theoretical snow evaporation equations to field conditions	None	- -[c]
9	CCFACT	Adjust theoretical snowmelt equations to field conditions	None	- -[c]
10	MWATER	Maximum water content of the snowpack expressed as a fraction of the water equivalent of the pack; that is, the maximum amount of liquid water that can be accumulated in the snowpack	None	- -[b]
11	MGMELT	Groundmelt rate attributable to conduction of heat from underlying soil to snow	Inches per day	- -[c]
12	FOREST[d]	Decimal fraction of segment covered by forest which will continue to transpire in winter	None	Aerial photographs
13	LZSN[d]	Nominal transient groundwater storage in the lower soil zones	Inches	Related to precipitation, but determined primarily by calibration
14	INFILT[d]	Nominal infiltration rate	Inches per hour	Calibration
15	LSUR	Average length of overland flow	Feet	Topographic maps
16	KVARY[d]	Allows groundwater recession flow to be nonexponential in its decay with time	1/inches	Hydrograph analysis
17	AGWRC[d]	Groundwater recession rate	None	Hydrograph analysis
18	PETMAX	Air temperature below which input evapotranspiration will be arbitrarily reduced	°F	- -[c]
19	PETMIN	Air temperature below which evapotranspiration will be set to zero	°F	- -[c]

Table 87 (continued)

Parameter		Definition or Meaning	Unit	Primary Source of Numerical Values[a]
Number	Symbol			
20	DEEPFR[d]	Decimal fraction of the groundwater recharge that percolates to deep or inactive groundwater storage	None	- -[c]
21	BASETP[d]	Fraction of potential evapotranspiration which can be satisfied from groundwater outflow—relates to amount of riparian vegetation	None	Calibration
22	AGWETP[d]	Fraction of potential evapotranspiration which can be satisfied from active groundwater storage—relates to amount of deep-rooted vegetation	None	Calibration
23	CEPSC[d]	Maximum interception storage	Inches	Extent and type of vegetation as determined from aerial photographs and field examination
24	UZSN[d]	Nominal transient groundwater storage in the upper soils zones	Inches	A function of LZSN and, therefore, determined primarily by calibration
25	NSUR	Manning roughness coefficient for overland flow	None	Field reconnaissance
26	INTFW[d]	Index of interflow	None	Calibration
27	IRC[d]	Interflow recession rate	None	Hydrograph analysis
28	LZETP[d]	Decimal fraction of segment with shallow groundwater subject to direct evapotranspiration	None	Soils and topographic data
29	SLSUR	Average slope of overland flow	None	Topographic maps
30	RETSC[e]	Retention storage capacity of surface	Inches	Field examination

[a]*Regardless of the primary source of parameter values, all land parameters were subject to adjustment during the calibration process.*

[b]*Initial values were assigned based on information and data reported in hydrology textbooks. See R. K. Linsley, M.A. Kohler, and J. L. H. Paulhus,* Hydrology for Engineers*, Second Edition, (New York: McGraw-Hill, 1975).*

[c]*Initial values were assigned based on experience with the Hydrologic Submodel on watersheds having similar geographic or climatological characteristics. See Chapter VIII of SEWRPC Planning Report No. 26,* A Comprehensive Plan for the Menomonee River Watershed*, Volume One,* Inventory Findings and Forecasts*, October 1976.*

[d]*Required for pervious land segment types only.*

[e]*Required for impervious land segment types only.*

Source: U.S. Environmental Protection Agency.

As already noted, the primary function of the second hydraulic submodel (HEC-2) is to determine the flood stages attendant to the flood flows of specified recurrence intervals produced by the first hydraulic submodel. Given a starting discharge and stage, this "backwater" computer program employs the conservation principles of mass and energy to calculate river stages at successive, preselected upstream locations.

A computational procedure known as the "standard step method" is used in floodland reaches between hydraulic structures such as bridges, culverts, and dams. Given a discharge and stage at a starting floodland cross-section, a trial stage is selected for the next upstream cross-section. The Manning equation for open channel flow is used to calculate the mechanical energy loss between the two cross-sections, and then a check is made to determine if the conservation of energy principle is satisfied. If not, another upstream stage is selected and tested, and the process repeated until the unique upstream stage is found at which the conservation of energy principle is satisfied. The above iterative computational process is then repeated for successive upstream floodland reaches. The result is a calculated flood stage at each of the cross-section locations.

The second hydraulic submodel also determines the hydraulic effect of a bridge or culvert and the associated approach roadways by computing the upstream stage as a function of the downstream stage, flood discharge, and the physical characteristics of the hydraulic structure. Starting downstream of the structure, the mechanical energy loss due to the expansion of the flow leaving the structure is computed, then the energy losses directly attributable to flow through or over the structure are calculated, and finally the energy loss due to contraction of the flow approaching and entering the structure is computed. Flow through or over a bridge or culvert may consist of various combinations of open channel flow, pressure flow, and weir flow depending on the position of the upstream stage relative to the low chord of the waterway opening and the profile of the roadway surface.

Input data for that portion of the second hydraulic submodel that performs backwater computations through floodland reaches between hydraulic structures include flood discharges, channel-floodplain cross-sections including distances between such sections, and Manning roughness coefficients for the channel and each floodplain. Data requirements for that portion of the second hydraulic submodel that calculates the hydraulic effect of bridges, culverts, and other hydraulic structures include channel bottom elevations, waterway opening measurements, pier position and shape, culvert entrance conditions, profiles along the approach roads and across the structure from one side of the floodland to the other, and dam or weir crest shape.

The backwater computations assume proper waterway opening design and maintenance so the full waterway opening of each bridge or culvert, as it existed at the time of the hydraulic structure inventory, is available for the conveyance of flood flow. In recognition of the fact that waterway openings can be temporarily blocked as result of ice and buoyant debris being carried on floodwaters, floodplain regulations applicable to areas adjacent to or on the fringes of flood prone areas normally require protection to an elevation equal to the 100-year recurrence interval flood stage plus a freeboard of two feet. A freeboard of three feet or more during a 100-year flood is required by Chapter NR 116 of the Wisconsin Administrative Code in the design of structural flood control works, such as dikes and floodwalls, when such works are intended to protect human life.

Water Quality Submodel

The water quality submodel is one of three water quality analyses models applied under the watershed planning program. The other two models are described in the subsequent section of this chapter. The principal function of the water quality submodel as used in the Des Plaines River watershed planning program is to simulate the time-varying concentration, or levels, of the following nine water quality indicators at selected points throughout the surface water system of the watershed: temperature, dissolved oxygen, fecal coliform, phosphate phosphorus, biochemical oxygen demand, total nitrogen, organic nitrogen, ammonia nitrogen, and nitrate plus nitrite nitrogen. These indicators were selected because they are directly related to the water quality standards that support the adopted water use objectives set forth in Chapter X of this report. This submodel was calibrated and applied for both the then current conditions and future conditions based upon planned year 2000 land use and point source conditions as part of the regional water quality management planning program completed in 1979. This submodel was further verified for use in the Des Plaines River watershed planning program by comparing the model outputs to measured water quality data available at the U.S. Geological Survey (USGS) monitoring station at Russell

Road. The model results were utilized along with another water quality model discussed in the subsequent section of this report, to develop existing and future water quality conditions for the streams in the watershed.

The concentration of a particular water quality constituent in the surface waters of the watershed at a particular point and time is a function of three factors. The first is the temporal and spatial distribution of runoff—surface or overland runoff, interflow, and baseflow—which determines the amount of water available to transport a potential pollutant to and through the surface water system. The second factor is the nature and use of the land, with emphasis on those features that affect the quantity and quality of point and nonpoint sources of pollutants. For example, a portion of a watershed that supports agricultural activity is a nutrient source for the surface waters. The third factor is the characteristics of the stream system which determine the rate and manner in which a potential pollutant is either assimilated in, or transported from, the watershed.

Simulation of the above three factors that influence instream water quality requires a large and diverse data base. As shown in Figure 49, operation of the water quality submodel requires the input of six data sets—meteorological, land, channel, diffuse sources of pollution, point sources of pollution, and output from the hydrologic submodel or the quantity of runoff. Table 86 identifies the six categories of historic meteorological sets that are input directly or indirectly to the water quality submodel and notes the use of each data set. The channel data required for the hydraulic portion of the water quality submodel are similar to the data required for the first hydraulic submodel. In addition, nonhydraulic channel data must be provided, consisting primarily of water quality parameters and such coefficients as the maximum benthic algae concentration and the deoxygenation coefficient for each reach.

The basic conceptual unit upon which the water quality submodel operates is called the water quality land segment type. A water quality segment type is defined as an area of land which exhibits a unique combination of meteorological characteristics such as precipitation and temperature, land characteristics such as the proportion of land surface covered by impervious surfaces, soil type slope, vegetative cover, and land management practices such as contour plowing on agricultural land and street sweeping in urban areas. A strict interpretation of this definition results in a virtually infinite number of unique water quality land segment types even within a small watershed because of the large number of possible combinations of the abovementioned characteristics within a watershed that exhibit continuous, as opposed to discrete, spatial variations throughout the watershed. To apply the concept, the study area is divided into water quality land segments. A water quality land segment is defined as a surface drainage unit which exhibits the pollutant runoff characteristic of a unique water quality land segment type. Thus, the practical, operational definition of a water quality land segment is a surface drainage unit consisting of a subbasin, or a combination of subbasins, which can be considered to be represented by a particular water quality land segment type.

Water quality land segment types and water quality land segments are refinements of the hydrologic land segment types and hydrologic land segments in that they incorporate the pollutant runoff characteristics of the land. For a given hydrologic land segment, the different types of land management practices that affect pollutant runoff may produce different water quality response but the same hydrologic response. Thus, several water quality land segments may have to be identified within a single hydrologic land segment.

A set of nonpoint pollution source data is required for each constituent that is to be modeled on each hydrologic-water quality land segment type. Each set of data contains monthly land loading rates of the pervious and impervious portions, expressed as a weight per unit area, and a loading limit for the pervious and impervious areas, expressed in weight per unit area of land surface. The nonpoint source data set for each land segment also contains the concentration of the constituent in the groundwater flow from the segment to the stream system. Each point source of pollution similarly requires a data set consisting of identification of the river reach to which the source discharges, a series of monthly volumetric flow rates, and a series of corresponding concentrations for each of the constituents to be modeled. The final category of input to the water quality submodel is output from the hydrologic submodel which consists of runoff volumes from the pervious and impervious portion of each hydrologic land segment as well as daily groundwater discharges to the stream system.

For the purpose of describing the operation of the water quality submodel, the simulation process may be viewed as being composed of a land phase and a channel phase, each of which is simulated continuously. In the land phase, the quantity of a given constituent that is available for washoff from the land at the beginning of a runoff event is equal to the amount of material remaining on the land surface after the last runoff event plus the net amount of material that has accumulated on the land surface since the last runoff event. The quantity of washoff from the land to the stream system during a runoff event is proportional to the amount of material on the land surface at the beginning of the computational time interval and is also dependent on the runoff rate over the time interval. The above process is not used to simulate the temperature and dissolved oxygen of land runoff. The model assumes that the temperature of the runoff is equal to atmospheric temperature and that the runoff is fully saturated with dissolved oxygen. Pervious surface runoff and impervious surface runoff during and immediately after rainfall or rainfall-snowmelt events are the two mechanisms for transporting accumulated nonpoint source constituents from the land surface to the stream system. Groundwater flow is the mechanism for continuously transporting potential pollutants to the stream system from the subsurface of the watershed.

Operating on a reach-by-reach basis, the channel phase of the water quality submodel uses kinematic routing to determine the inflow to, outflow from, and net accumulation of flow within each reach during the simulation time step. This is followed by a summation over the time step of all mass inflows and outflows of each water quality constituent for the end of the period. The above channel phase computations are then repeated within the reach for subsequent time intervals and also are repeated for all other reaches. Water quality processes explicitly simulated within the Water Quality Submodel are indicated in Figure 52.

Additional Water Quality Models Utilized

In addition to the Hydrocomp water quality submodel, two other water quality models were employed in the analysis of present and forecast future water quality conditions in the Des Plaines River watershed. These models were the Unit Area Load model (UAL)[8] which was used to provide additional information on stream water quality and the Wisconsin Lake Model Spreadsheet (WILMS) promulgated by the Wisconsin Department of Natural Resources[9] which was used to provide information on lake water quality. Both of these models make use of land use data as the input data base, and, like the Hydrocomp model, apply appropriate numerical values of pollutant export to each of the land segment types to generate a delivered pollutant load to a stream system or lake. The WILMS model was used to estimate total phosphorus, as an index of lake water quality, while the UAL model was used to estimate the annual loads of total suspended solids; total phosphorus; and selected heavy metals loads, including cadmium, copper, lead, and zinc, as an index of stream water quality.

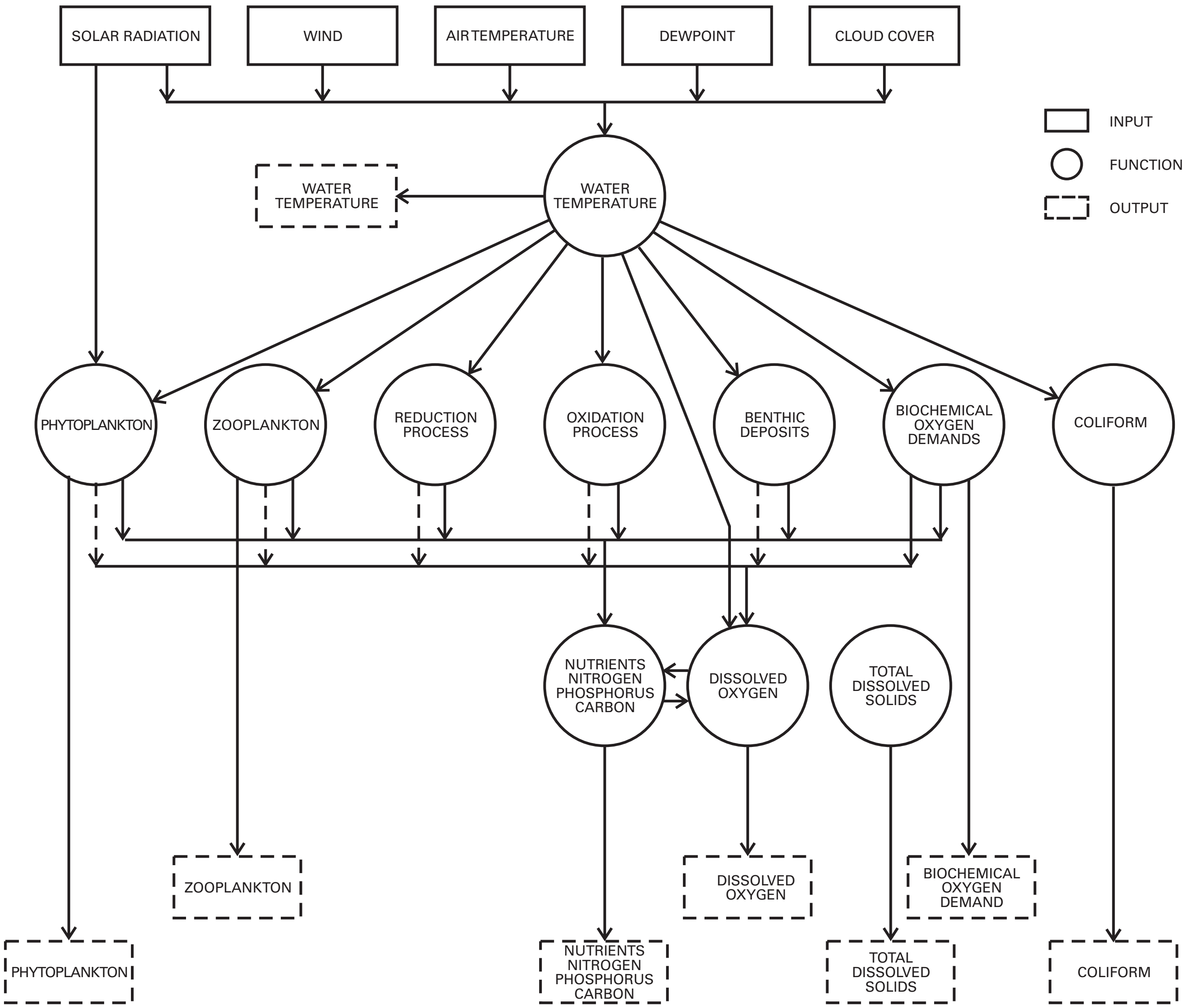
The UAL and WILMS models are both lumped-parameter models which treat the drainage basin as a unit, assessing the influence of the watershed components in a uniform and homogeneous manner. Based on the total land surface area of a particular land use category within the defined basin, an annual average pollutant load is estimated as a function of the unit area load coefficient or export coefficient. This load is then summed with the product of each additional land use type and its related export coefficient to define the total average annual load for each pollutant. The export coefficients used in this study are set forth in Table 76. For the UAL model, the export coefficients were derived largely from studies conducted within the Southeastern Wisconsin Region, while the coefficients used in WILMS were established for the State of Wisconsin as a whole. Thus, while the models may be considered to be calibrated for Wisconsin conditions, they were not specifically calibrated to conditions pertaining in the Des Plaines River as was the Hydrocomp model. For this reason, the results of the UAL modeling were compared to the results of the Hydrocomp modeling to test the similarity of the modeling results, as described in the subsequent section of this chapter regarding model calibration. On this basis, it was judged to

[8]*S.-O. Ryding, and W. Rast,* The Control of Eutrophication of Lakes and Reservoirs*, Unesco Man and the Biosphere Series, Volume 1, Parthenon Publishing, London, 1989.*

[9]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-96 REV,* Wisconsin Lake Model Spreadsheet, Version 2.00, User's Manual*, June 1994.*

Figure 52

INTERDEPENDENCE OF PROCESSES IN THE WATER QUALITY SUBMODEL



Source: Hydrocomp Inc. and SEWRPC.

be appropriate to use the UAL model to extrapolate the detailed instream water quality simulation modeling results of the Hydrocomp model as developed under the regional water quality management plan. The UAL model was selected for this purpose because of its utility and common usage.

The UAL and WILMS models' outputs were used to calculate water quality conditions based upon existing 1990 land use conditions, as well as forecast 2010 land use conditions and forecast buildout land use conditions. Calculation of water quality conditions based upon existing 1990 land use conditions allowed an assessment to be made of the ability of the models to predict known conditions as measured at the U.S. Geological Survey station at Russell, Illinois.

The initial output of the UAL model was refined by dividing the Des Plaines River watershed into 10 water quality analysis areas (WQAAs). These WQAAs were identified on the basis of defined stream segments used in the Hydrocomp analysis conducted under the regional water quality management planning program, and were designed to permit the assessment of the relative pollutant contributions from these stream segments. Factors, or transmission coefficients, were applied to adjust the contaminant loads forecast by the UAL model to account for instream processes and overland retention within these WQAAs, allowing a progressive refinement of the pollutant loads as the pollutants progressed downstream. By segmenting the Des Plaines River watershed into 10 water quality analysis areas, it was possible to modify the lumped-parameter approach of the UAL model into a transitional model that had the simplicity of the lumped-parameter model but the improved resolution of a distributed-parameter model like the Hydrocomp water quality submodel.[10] As noted above, the refined UAL model was then used to refine and extend the year 2000 forecast set forth in SEWRPC Planning Report No. 30 to the buildout planned land cover conditions.

DATA BASE DEVELOPMENT

The largest single work element in the preparation and application of the hydrologic-hydraulic-water quality simulation model is data base development. This consists of the acquisition, verification, and coding of data needed to develop, calibrate, test, verify, and apply the model. The data base for the water resource simulation model used in the Des Plaines River watershed study consists of a file of information that quantitatively depicts the characteristics of the surface water system of the watershed.

As shown schematically in Figure 49, application of the model requires the development of a data base composed of the following five distinct categories of information: meteorology conditions, land use and related conditions, channel conditions, diffuse sources of pollution, and point sources of pollution. Each of these five data categories provides input to at least one of the submodels comprising the simulation model. Of the five input data sets, the meteorological data set is the largest, consisting of 55 years of daily and hourly information for each of the eight historic meteorological data types. The meteorological data set is also the most critical since experience with the model indicates that simulated stream discharges, stages, and water quality levels are very sensitive to how well the meteorological data set—particularly precipitation—represents historical meteorological conditions.

With respect to origin, the data in the base are largely historic; being based on existing records of past observations and measurements. For example, the bulk of the meteorological data in the base are assembled from National Weather Service (NWS) records. Some of the data in the base are original, having been obtained by field measurements made during the watershed planning program. The channel and related hydraulic structure data, for example, were obtained from field surveys conducted during the course of the study and from large-scale topographic maps. A small fraction of the data in the data base are synthetic, being calculated from other available historic data. Such calculated data sets were used when historic data were not available and it was impossible or impractical to obtain original data. The solar radiation data used, for example, are synthetic because of the absence of long-term historic radiation observations in or near the watershed, and because of the impracticality of developing long-term original solar radiation data. Solar radiation data were computed from available historic daily cloud cover index values.

A distinction should be drawn between model input data and model calibration data. The five categories of data identified above constitute the input data for the model and constitute the data base needed to operate the various submodels in the model. Calibration data, which are described in a subsequent section of this chapter, are not required to operate the model, but are important to the calibration of the model, that is to the adjustment of the model parameters so that the model performance fits real world and real time data. The principal types of calibration data are streamflow, flood stage, and water quality.

Each of the five types of input data, as well as the calibration and verification data, are described in the following sections. The origin of each data set is described, as are the procedures used to verify and code the information. In

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[10]*W. Rast, S.-O. Ryding, M.M. Holland, G. Jolankai, and J.A. Thornton,* Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems*, Unesco Man and the Biosphere Series, Volume 19, Parthenon Publishing, London, 1997.*

the case of some of the data types, the means of acquisition have been described in earlier chapters of this report or other Commission reports, and, with the exception of a brief reference, are not repeated in this chapter.

Meteorologic Data
As shown in Table 86, the following seven of the eight types of meteorological data are required as direct input to the hydrologic and water quality submodels: 15-minute precipitation, hourly temperature, hourly wind movement, hourly solar radiation, daily dewpoint temperature, hourly potential evaporation, and daily cloud cover. Map 13 in Chapter III of this report shows the location of the three National Weather Service meteorologic observation stations operated in or near the watershed and the Thiessen polygon network which was constructed for the purpose of delineating the geographic area to be represented by each station. Because each of the three stations collect daily, rather than hourly, precipitation data, records of the National Weather Service stations at General Mitchell International Airport, located in southeastern Milwaukee County, and Stratton Dam (formerly McHenry Lock and Dam), located at the outlet of the Fox River Chain of Lakes in McHenry County, Illinois, were used to distribute the daily precipitation totals from the three stations located near the Des Plaines River watershed into hourly values. In addition, the General Mitchell International Airport station was used as the source for necessary meteorological data other than the precipitation and temperature data recorded at the three gages near the watershed. The hourly precipitation data, as well as daily maximum and minimum temperatures, wind movement, solar radiation, and potential evapotranspiration, were distributed into 15-minute or hourly values using a utility computer program (METCMP) developed by the U.S. Geological Survey. That program distributes weather-related time series data based upon empirical relationships.

The process used to develop the meteorological data sets for the model is schematically depicted in Figure 53. Much of the meteorological data base development was completed under other Regional Planning Commission work programs. The principal work element completed under the Des Plaines River watershed planning program was an extension of the termination date of the meteorologic data base. Meteorological data sets were developed for the 55-year period from 1940 through September 1994. January 1, 1940, was selected as the starting date for the data sets since it marks the beginning of hourly observations at the Milwaukee station.

Land Data
As shown in Figure 49, land data are needed to operate the hydrologic submodel, the output of which influences the four other submodels. Table 87 identifies the land-related parameters that are required for each land segment type that is to be simulated. Four land characteristics—meteorology, soil type, slope, and land use-cover—are the major determinants of the magnitude and timing of surface runoff, interflow, and groundwater flow from the land to the watershed stream system and therefore are the basis for hydrologic land segment identification and delineation. There are other land characteristics that may influence the hydrologic response of the land surface; for example, depth to bedrock, type of vegetation, and density of the stormwater drainage system. However, the four characteristics indicated were selected for use as both the most basic and the most representative.

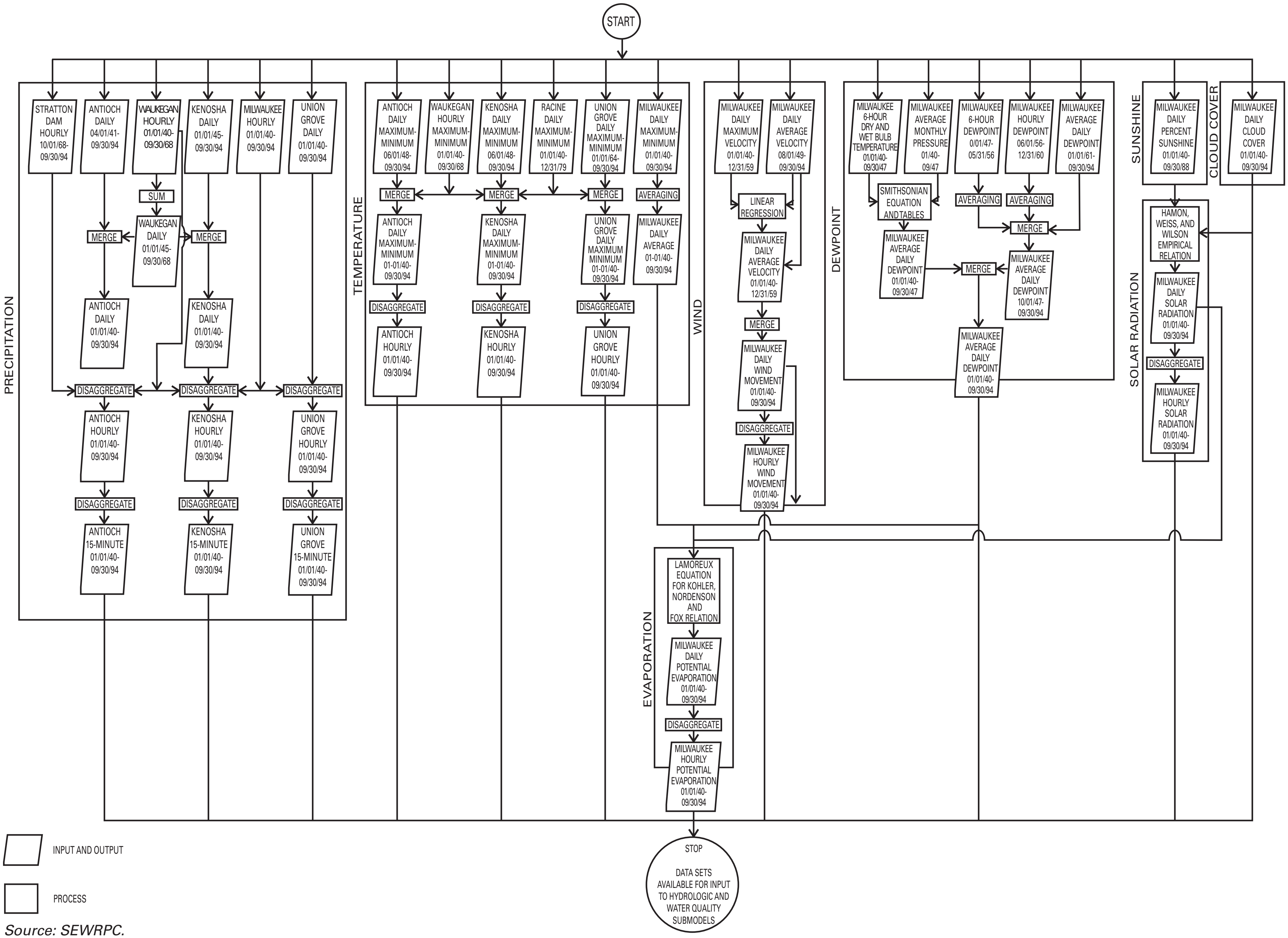
Identification of Hydrologic Land Segment Types
The process used to identify hydrologic land segment types in the watershed began with the subdivision of the watershed into subbasins using the procedure described in Chapter V of this report. As shown on Map 35 in Chapter V, a total of 230 subbasins were delineated ranging in size from 0.02 to 2.81 square miles.[11] These subbasins provided the basic "building blocks" for the identification of hydrologic land segment types.

Influence of Meteorological Stations
As already noted, a Thiessen polygon network was constructed for the watershed and surrounding areas in order to facilitate subdivision of the watershed into areas lying closest to each of the meteorological stations concerned.

[11]*Thirty-nine of the 230 total subbasins, with a total area of 8.1 square miles were determined to be internally drained and were assumed to contribute only to subsurface flow.*

Figure 53

PROCESS USED TO DEVELOP METEOROLOGICAL DATA SETS FOR THE MODEL



Source: SEWRPC.

Hydrologic Soil Group
The regional soil survey conducted by the U.S. Natural Resources Conservation Service (NCRS), formerly the U.S. Soil Conservation Service, for the Regional Planning Commission, classified the soils of the Region into four hydrologic soil groups, designated A, B, C, and D, based upon those properties affecting runoff. In terms of runoff characteristics, these four soil groups range from Group A soils, which exhibit very little runoff because of high infiltration capacity, high permeability, and good drainage, to Group D soils, which generate large amounts of runoff because of low infiltration capacity, low permeability, and poor drainage. The Des Plaines River watershed was determined to be covered primarily by Hydrologic Group C soils. Significant areas of A/D and B/D soils, which exhibit infiltration characteristics of Hydrologic Group A or B soils if artificially drained and Group D soils if not drained, were also identified. In cases where such soils were located on agricultural lands it was assumed that those soils were drained and the areas covered by those soils were, therefore, assigned to the Group A or B category as appropriate.

Slope
As shown on Map 15 in Chapter III of this report, approximately 91 percent of the land in the watershed has slopes of 6 percent or less. Based on the analysis of slopes throughout the watershed and previous slope sensitivity studies, it was determined that the use of slopes in the determination of required land segment types was not warranted.

Land Use and Cover
The combination of land use and cover often reflects human influences on the hydrologic processes of a watershed. Land cover differs from land use in that land cover describes the types of surface—for example, paved, grassed, and wooded—whereas land use describes the purpose served by the land—for example, residential, commercial, and recreational. The combination of land use and cover is quantified and represented in the model for hydrologic modeling purposes through use of percent imperviousness. The hydrologic submodel uses separate subroutines for simulation of runoff from pervious and impervious surfaces. For each hydrologic land segment, the percentage of pervious and impervious drainage area may be specified in the model.

Resulting Hydrologic Land Segment Types and Hydrologic Land Segments
Application of the above process yielded a total of 12 different hydrologic land segment types in the Des Plaines River watershed. The 12 hydrologic land segment types used to represent the land surface of the watershed for hydrologic-hydraulic simulation are defined in Table 88 in terms of their hydrologic soil group, land cover type, and proximity to a meteorological station.

The impervious land segment type, coupled with urban drainage efficiency as characterized in the hydrologic submodel, serves to distinguish between the effects on stormwater runoff of lands having various types and densities of urban development. The drainage efficiency of a particular hydrologic land segment type can be represented in the hydrologic submodel by specifying the length of overland flow. In an urban area provided with an engineered storm sewer system, the length of overland flow is the average distance which storm water runoff must travel before reaching a street gutter, storm sewer inlet, or drainage channel. In a rural area, it is the acreage distance which stormwater runoff must travel before reaching a defined drainage channel or watercourse. This length is much shorter in urban than in rural areas, and serves to increase the peak rate of runoff.

Thus, the simulation model has the capability of differentiating between the rate of runoff from various densities of urban use, as well as between the rate of runoff from urban as opposed to rural land. This capability is particularly important in the preparation of a watershed plan which is to serve as a basis for integrating land use and flood control planning and development. The integrated plans can identify those areas of the watershed which are in urban use and those which are recommended to be converted from rural to urban use over the plan design period; and can calculate peak flood flows to be used in delineating flood hazard areas and in determining the hydraulic capacity of flood control works, recognizing the increases in flood flows that will accompany the planned land use conversion.

Table 88

HYDROLOGIC LAND SEGMENT TYPES REPRESENTATIVE OF THE DES PLAINES RIVER WATERSHED

Identification Number of Hydrologic Land Segment Type	Most Influential Meteorological Station			Hydrologic Soil Group		Land Cover Description			
	Antioch	Kenosha	Union Grove	A-D or B-D Soil	C Soil	Drained Agricultural	Woodland	Other Pervious Land	Impervious Land
1	X	- -	- -	X	- -	X	- -	- -	- -
2	X	- -	- -	- -	X	- -	X	- -	- -
3	X	- -	- -	- -	X	- -	- -	X	- -
4	X	- -	- -	- -	X	- -	- -	- -	X
5	- -	X	- -	X	- -	X	- -	- -	- -
6	- -	X	- -	- -	X	- -	X	- -	- -
7	- -	X	- -	- -	X	- -	- -	X	- -
8	- -	X	- -	- -	X	- -	- -	- -	X
9	- -	- -	X	X	- -	X	- -	- -	- -
10	- -	- -	X	- -	X	- -	X	- -	- -
11	- -	- -	X	- -	X	- -	- -	X	- -
12	- -	- -	X	- -	X	- -	- -	- -	X

Source: SEWRPC.

Assignment of Parameters to Hydrologic Land Segment Types

Subsequent to identification of the hydrologic land segment types and delineation of the hydrologic land segments present in the watershed, numerical values were selected for each of the land-related parameters required for each of the land segment types. Table 87 indicates that the numerical values were established in a number of ways, including state-of-the-art engineering practice, direct measurement of watershed characteristics, experience gained through previous application of the hydrologic submodel to watersheds having geographic and climatologic characteristics similar to those of the Des Plaines River watershed, and calibration—under the Des Plaines River watershed planning program—of the hydrologic and hydraulic submodels against historic streamflow records. The calibration process, which is the principal means of assigning numerical values to factors and terms comprising the models is described later in this chapter.

Channel Data

Channel conditions, including slope, channel roughness, and cross-section, are important determinants of the hydraulic behavior of a stream system. As indicated in Figure 49, channel data are needed to operate the hydraulic submodels and the water quality submodel.

Channel Data for the Second Hydraulic Submodel

The following four types of channel data are required as input to the second hydraulic submodel: discharge; channel-floodplain cross-sections, including the distance between cross-sections; Manning roughness coefficients for the channel and each floodplain; and hydraulic structure—bridge, culvert, and dam—data. Hydraulic structure data include channel bottom elevations, waterway opening dimensions, pier position and shape, culvert material and entrance conditions, profiles along the approach roads and across the structure from one side of the floodland to the other, and dam or weir crest shape and elevation.

The required discharges for water quantity purposes were obtained by operating the hydrologic submodel and first hydraulic submodel at a 15-minute computational time interval over the 55-year simulation period for which recorded meteorological data were available—January 1, 1940 through September 30, 1994—and performing discharge frequency analyses on the 55 simulated annual instantaneous peak discharges using the log Pearson Type III technique. The frequency analyses yield flood discharges of a known recurrence interval at various points throughout the watershed stream system. The procedures used to obtain the other three types of data required by the second hydraulic submodel are described in greater detail in Chapter V. As indicated in Chapter V, the necessary information, including floodland cross-sections with an average spacing of about 800 feet and physical descriptions of 176 hydraulically significant structures, was obtained for about 109 miles of stream selected for flow simulation.

Channel Data for the First Hydraulic Submodel

As noted earlier in this chapter, a stage-discharge-cumulative storage table must be provided along with the surface area for each hydrologic land segment. The process used to develop the stage-discharge-cumulative storage tables was initiated by subdividing the approximately 109 miles of stream system selected for water quantity simulation into reaches and assigning tributary areas to the reaches, thus creating hydrologic land segments. As shown on Map 54, the stream system was partitioned into 192 hydrologic land segments. Each has an average reach length of about 1.14 miles, considered appropriate for operation of the first hydraulic submodel at a 15-minute computational time interval.

After subdivision of the stream system into hydrologic land segments, one of the following two procedures were applied to develop stage-discharge-cumulative storage data to be used for routing with the hydraulic submodel:

1. For approximately 98 miles of stream for which flood profiles were developed under the watershed study, the second hydraulic submodel was used to develop stage-discharge-cumulative storage data. The streams for which that approach was taken include the main stem of the Des Plaines River and most of its minor tributaries, Brighton Creek and its tributaries, Center Creek, Dutch Gap Canal and its tributaries, Jerome Creek and two of its tributaries, Kilbourn Road Ditch and two of its tributaries, and the Salem Branch of Brighton Creek and several of its tributaries. The use of the second hydraulic submodel enabled consideration of such factors as the backwater effects of hydraulic structures.

2. For the remaining 11 miles of studied streams, and also for minor tributaries and drainageways in headwater reaches with steeper bed slopes where the backwater effects of hydraulic structures are not significant, a generalized channel cross-section representative of each hydrologic land segment was identified. A stage-discharge-cumulative storage table was then developed using this cross-section.

In cases where channel modifications or the provision of detention storage were considered under the alternatives analysis, new stage-discharge-cumulative storage tables were prepared which were representative of those changes relative to existing stream conditions.

Channel Data for Water Quality Submodel

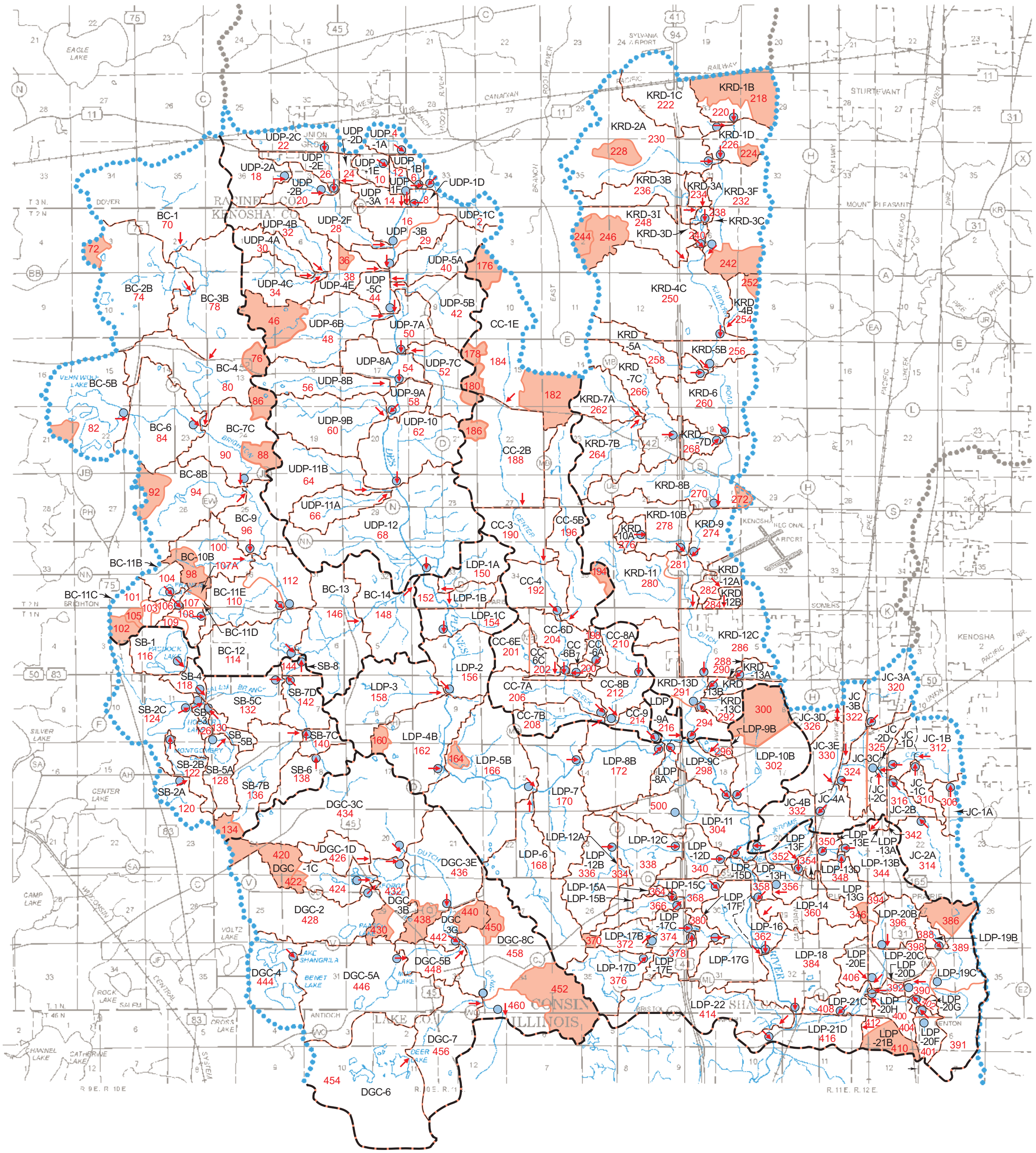
Hydraulic channel data required for the Water Quality Submodel are almost identical to the data required for the first hydraulic submodel. Stage-discharge-cumulative storage data were developed using composite cross-sections characteristic of each hydrologic land segment. Nonhydraulic channel data, however, must also be provided for the stream reach within each hydrologic water quality land segment. These data consist of water quality parameters and coefficients, such as the biochemical oxygen demand reaction rate coefficient, maximum benthic algae concentration, total coliform die-away coefficient, and the benthal release rates for nutrients. The principal sources of numerical values for these parameters and coefficients were state-of-the-art engineering practice and previous experiences with application of the water quality submodel.

Point Source Data

Figure 49 illustrates how point source data were input to the first hydraulic submodel and to the water quality submodel. Point source input data for the water quality submodel consisted of monthly effluent discharge values together with monthly water quality values for 22 point sources in the watershed as of 1975. Those point sources included five municipal and eight private sewage treatment plants; three sanitary sewer flow relief devices; and six industrial outfalls discharging industrial cooling, process, rinse, and wash waters and filter backwash waters. As shown on Map IX-3 in Chapter IX of this report, as of 1993, there were 18 point sources in the watershed. Those point sources included four municipal and four private sewage treatment plants and ten industrial outfalls.

Map 54

REPRESENTATIONS OF THE DES PLAINES RIVER WATERSHED FOR HYDROLOGIC-HYDRAULIC SIMULATION



DES PLAINES RIVER WATERSHED BOUNDARY AS DELINEATED BY SEWRPC USING FIELD CHECKED DATA AND LARGE SCALE MAPPING, SUPPLEMENTED WITH STORM SEWER MAPS WHERE AVAILABLE.

SUBWATERSHED BOUNDARY

SUBBASIN BOUNDARY

SUBBASIN DISCHARGE POINT

UDP-9B SUBBASIN IDENTIFICATION CODE

HYDROLOGIC LAND SEGMENT BOUNDARY

192 HYDROLOGIC LAND SEGMENT IDENTIFICATION

SIMULATED STREAMFLOW OUTPUT LOCATION

INTERNALLY DRAINED SUBBASIN — FOR SIMULATION PURPOSES THESE AREAS CONTRIBUTE TO SUBSURFACE FLOW ONLY

IDENTIFICATION OF SUBWATERSHEDS

BC	BRIGHTON CREEK	KRD	KILBOURN ROAD DITCH
CC	CENTER CREEK	LDP	LOWER DES PLAINES RIVER
DGC	DUTCH GAP CANAL	SB	SALEM BRANCH OF BRIGHTON CREEK
JC	JEROME CREEK	UDP	UPPER DES PLAINES RIVER

GRAPHIC SCALE
0 1/2 1 MILE
0 2,000 4,000 6,000 FEET

For purposes of hydrologic-hydraulic modeling, the watershed land surface was partitioned into 192 hydrologic land segments and consisted of 12 hydrologic land segment types. Each hydrologic land segment type has a particular combination of soil type, land cover, and proximity to a meteorologic station and is used within the hydrologic-hydraulic model to simulate the conversion of rainfall and snowmelt to streamflow. Each hydrologic land segment has unique hydrologic-hydraulic characteristics in the model and is used to simulate the accumulation of runoff from land surface in the stream system and the transport of that flow through the watershed.

Source: SEWRPC.

As documented in the regional water quality management plan, in 1975 point sources of pollution accounted for only between 0 and 5 percent of the total annual point and nonpoint source pollution loadings in the Des Plaines River watershed. A review of the current pollutant loadings generated from the 18 now existing point sources compared to the future loadings estimated to be contributed from the 22 sources in existence in 1975 indicates that the relative magnitude importance of the current point source loadings is similar to that expected based upon the regional water quality management plan modeling results with respect to the relative magnitude of point and nonpoint source pollutant loadings. Point source discharge data were not input to the hydraulic submodels since these values were found to be insignificant with respect to peak flood discharges.

Nonpoint Source Data
Figure 49 illustrates how nonpoint source data were input to the water quality submodel, along with meteorologic, point source, channel data, and output from the hydrologic submodel. The choice of initial numerical values for some nonpoint source pollution parameters, such as land surface loading rates, was based on values reported in the literature for urban and rural areas similar to the Des Plaines River watershed [12] and on previous Commission staff experience. Some of these values were subsequently adjusted during the calibration process to improve the correlation between observed and simulated water quality. Map 55 indicates the subdivision of the Des Plaines River watershed into hydrologic water quality land segments for water quality simulation.

Calibration Data
The six categories of data—meteorological, land, channel, riverine area structure, point pollution source, and nonpoint pollution source—constitute the total input data required to operate the water resource simulation model. Of equal importance are calibration data. Although not needed to operate the model, these data are necessary for calibration of the model. These data, which are derived entirely from actual field measurements, included recorded streamflows, river stages, and water quality conditions. Since calibration data represent the actual historic response of the stream system of the watershed to a variety of hydro-meteorological events and conditions, such data may be compared to the simulated response of the watershed, and the model calibrated as necessary to provide an accurate simulation.

Streamflow Data
The principal source of historic streamflow information in the watershed is the streamflow measurements made by the U.S. Geological Survey from April 1960 to the present at a continuous streamflow recording station located on the Des Plaines at Russell, Illinois.[13] Streamflow data are also available for the USGS gaging station on Mill Creek near Old Mill Creek, Illinois.[14] However, because the 18.0-square-mile area tributary to the Dutch Gap Canal at the Wisconsin-Illinois state line comprises only about 30 percent of the 59.6-square-mile area tributary to the Mill Creek gaging station; and data required for modeling of the intervening 41.6-square-mile area in Illinois were not available, it was determined not to calibrate the hydrologic model for the Dutch Gap Canal watershed using data from the Mill Creek gage. Because of the similarity in watershed characteristics of the portion of the Des Plaines River watershed tributary to the Russell, Illinois, gage and the Dutch Gap Canal subwatershed, it was

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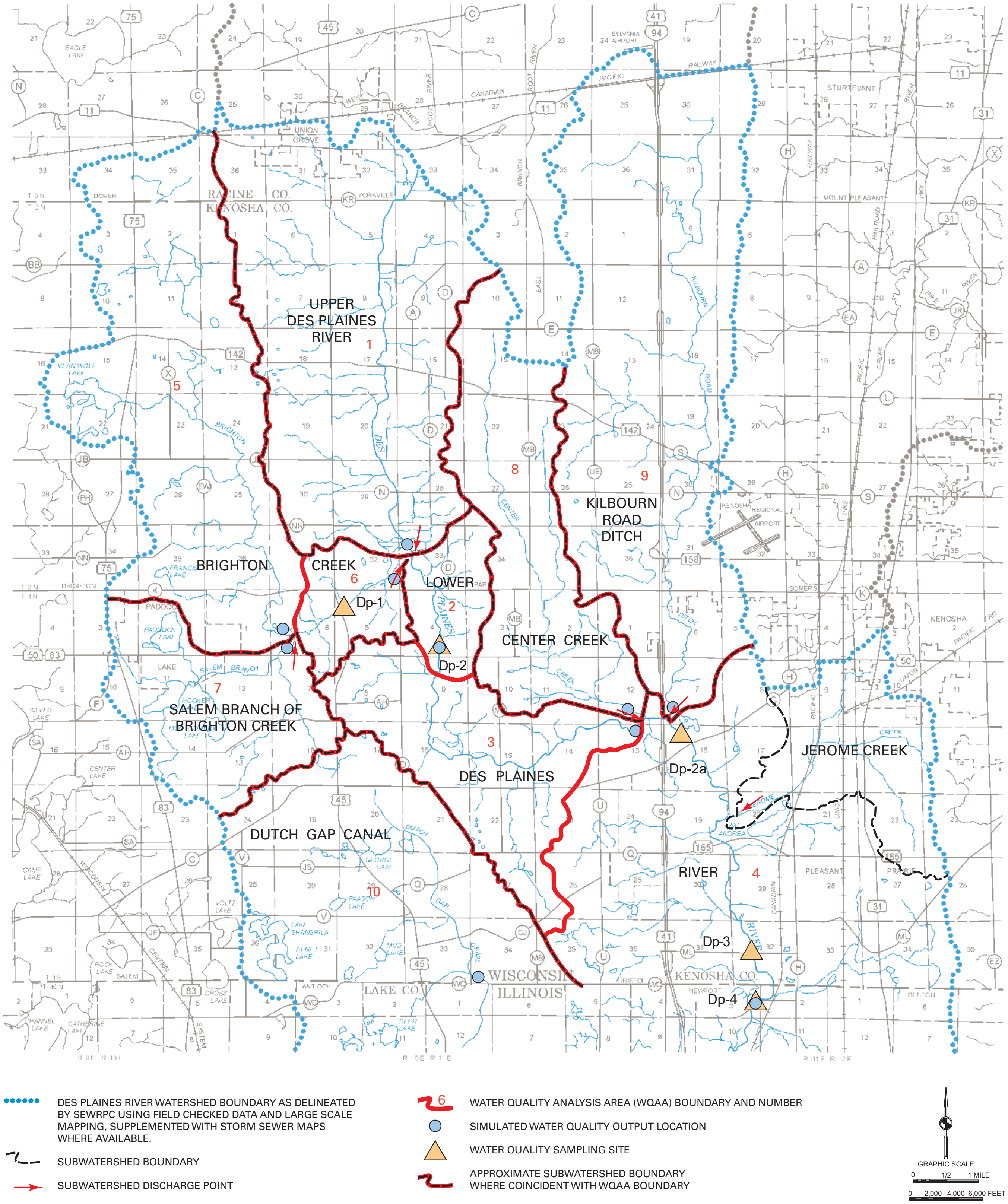
[12]*See Chapter IV of SEWRPC Technical Report No. 18,* State of the Art of Water Pollution Control in Southeastern Wisconsin*, Volume Three,* Urban Storm Water Runoff*, July 1977; Hydrocomp, Inc.,* Hydrocomp Water Quality Operations Manual*, Fourth Edition, April 1977; and U.S. Army Corps of Engineers-Seattle District,* Environmental Management of the Metropolitan Area Cedar-Green River Basins, Washington, Part II: Urban Drainage*, December 1974, p. 86.*

[13]*From April 1960 to June 1967, the Russell stream gaging station consisted of a crest stage gage which recorded annual peak flood data only. From June 1967 through 1997, the station consisted of a continuous water stage recorder and a crest stage gage.*

[14]*The stream known as Dutch Gap Canal in Wisconsin is known as the North Branch of Mill Creek in Illinois. The North Branch of Mill Creek flows into Mill Creek upstream of the Old Mill Creek gaging station.*

Map 55

REPRESENTATION OF THE DES PLAINES RIVER WATERSHED FOR WATER QUALITY SIMULATION



For purposes of water quality modeling, the watershed stream system was partitioned into hydrologic-water quality land segments. The hydrologic-water quality land segments were the basis for simulating the transport of potential pollutants from the land to the stream system via surface runoff, groundwater flow, or point sources. Each hydrologic-water quality land segment, as represented by a set of parameters, was used to simulate the accumulation of potential pollutants in the channel system and the resulting instream biochemical and advection processes.

Source: SEWRPC.

determined to apply modeling parameters developed from the Des Plaines River calibration to the hydrologic modeling of Dutch Gap Canal subwatershed.

Flood Stage Data
Information on historic flooding, including flood stages, was provided by public officials, consulting engineers, private citizens, and the staff of the Regional Planning Commission. This information was used to check the validity of simulated flood stage profiles. Additional information on the source and characteristics of historic flood stage information is presented in Chapter VI.

Water Quality Data
The principal source of stream water quality data used in the calibration of the water quality submodel was the stream water index site sampling program conducted by the Commission in cooperation with the Wisconsin Department of Natural Resources and the U.S. Geological Survey under the areawide water quality management planning program, as described in Chapter VII. Under this program, stream water quality measurements were made at daily intervals from September 7, 1976 through October 6, 1976, on the Des Plaines River at stations Dp-2 and Dp-2a situated on the Des Plaines River mainstem at STH 50 in the Town of Bristol and CTH C in the Village of Pleasant Prairie, respectively. These data were used in the initial calibration of the water quality submodel as described in SEWRPC Planning Report No. 30 and summarized below. The results from application of the Hydrocomp model, as well as from the UAL model, were verified using data obtained from the Des Plaines River mainstem station Dp-4 at the U.S. Geological Survey gaging station at Russell, Illinois. As described in Chapter VII, these data were obtained at monthly intervals, between November 17, 1977 and August 23, 1991.

Data on lake water quality were taken from the Wisconsin Department of Natural Resources lake survey and environmental resource assessment programs, conducted between 1976 and 1980, for Benet/Shangrila Lake, George Lake, Hooker Lake, Paddock Lake, and Vern Wolf Lake. Secchi-disk transparency data were also available for Benet/Shangrila Lake, George Lake, and Hooker Lake for the period 1988 through 1992.

MODEL CALIBRATION

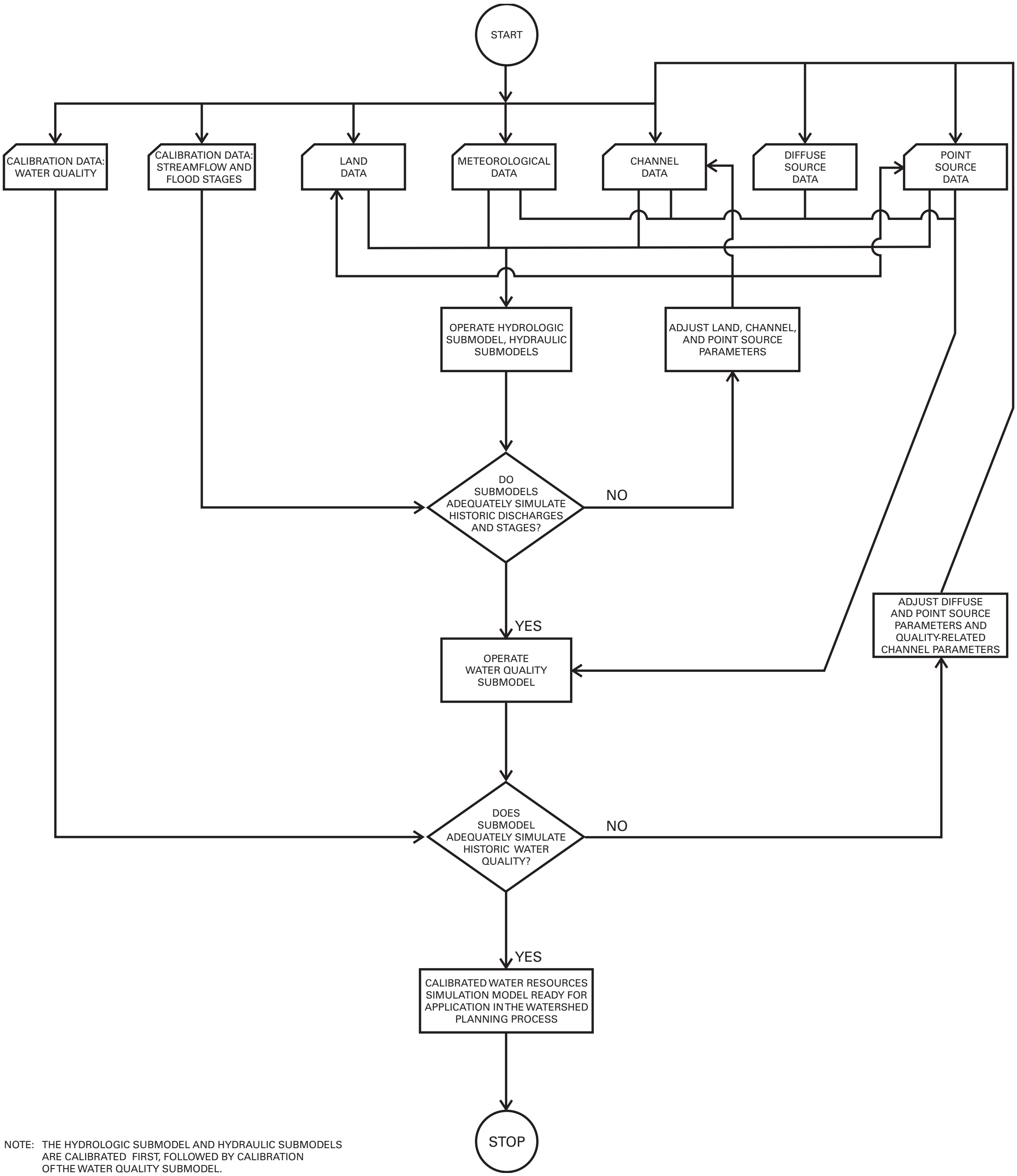
Need for Model Calibration
Many of the algorithms comprising the water resource simulation model are mathematical approximations of complex natural phenomena. Therefore, before the model can be reliably used to simulate streamflow behavior and water quality conditions under alternative watershed development conditions, it was necessary to calibrate the model—that is, to compare simulation model results with actual historic data—and, if significant differences were found, to make adjustments in the model parameters to better adjust the model to the specific natural and man-made features of the watershed. A schematic representation of the calibration process used for the water resource simulation model of the Des Plaines River watershed is shown in Figure 54. Once the water resource simulation model is calibrated for a particular watershed, the basic premise of subsequent simulation is that the model will respond accurately to a variety of model inputs representing hypothetical watershed conditions, such as land use changes, channel modifications, and construction of detention storage and thereby provide a powerful analytic tool in the watershed planning process.

Careful calibration of the first three submodels comprising the overall model is of particular importance because output from these submodels has direct bearing on the testing and evaluation of the floodland management elements of the watershed plan. Furthermore, the validity of the results obtained from application of the water quality submodel is determined, in part, by the quality of the output of the hydrologic submodel and the second hydraulic submodel.

Hydrologic-Hydraulic Calibration of the Hydrologic and First Hydraulic Submodels (HSPF)
Meteorological, hydrologic land segment type, and channel data sets were prepared using the procedures described in this chapter. The choice of numerical values to be assigned to the parameters for each of the hydrologic segment types was influenced by parameter values established under previous Commission water resources-related planning efforts. This was possible since the combinations of soil type, slope and land use-cover

Figure 54

CALIBRATION PROCESS USED FOR HYDROLOGIC-HYDRAULIC AND WATER QUALITY MODELING



NOTE: THE HYDROLOGIC SUBMODEL AND HYDRAULIC SUBMODELS ARE CALIBRATED FIRST, FOLLOWED BY CALIBRATION OF THE WATER QUALITY SUBMODEL.

The water quality submodel developed for the regional water quality management plan was reviewed and applied under the watershed planning effort. New hydrologic and hydraulic submodels for water quality modeling were developed to 1) account for additional stream flow data collected since the regional water quality management plan was prepared, and 2) to provide the greater level of detail necessary for modeling of the extensive stream system chosen for study by the Des Plaines River watershed advisory committee.

Source: SEWRPC.

present in the Des Plaines River watershed were similar to those found in other watersheds of Southeastern Wisconsin for which water resource models had been previously developed by the Commission staff.

For model calibration purposes, the hydrologic submodel and first hydraulic submodel were operated during the 26-year period from October 1968 through September 1994 for the 121.4-square-mile area tributary to the continuous streamflow recording gage located on the Des Plaines River at Russell, Illinois. Approximately 115 square miles of that area, or 95 percent, drains directly to the main stem of the Des Plaines River within Wisconsin. An additional 4.6 square miles, or about 3 percent, is located within Wisconsin but drains to the Des Plaines River downstream of the state line.

The results obtained in the calibration process for the Des Plaines River gaging station are presented below through a comparison of recorded and simulated annual and monthly runoff volumes, recorded and simulated flow-duration curves, and recorded and simulated hydrographs for major runoff events:

- Figure 55 presents a graphic comparison of recorded and simulated annual runoff volumes for the 26-year calibration period. Simulated annual runoff volumes range from 25 percent below to 111 percent above recorded values. Simulated volumes were within 20 percent of the recorded values for 20 of the 26 years used in the calibration, and within 10 percent for 15 of those years. The simulated cumulative annual runoff volume for the 26-year period is 286.3 inches, or about 3 percent below the 294.4-inch cumulative recorded annual runoff volume for that same period.

- Recorded and simulated monthly runoff volumes are compared in Figure 56. The monthly runoff data points are seen to be grouped about a 45-degree line, indicating the desired tendency to exhibit a one-to-one correlation between the recorded and simulated monthly runoff volumes.

- Recorded and simulated flow duration curves based on average daily flows for the 26-year period for which recorded discharge data were available are shown in Figure 57. Each of the two flow duration curves indicates the percentage of time that specified average daily discharges may be expected to be equaled or exceeded. The flow duration curves based on simulated and recorded discharges exhibit adequate agreement.

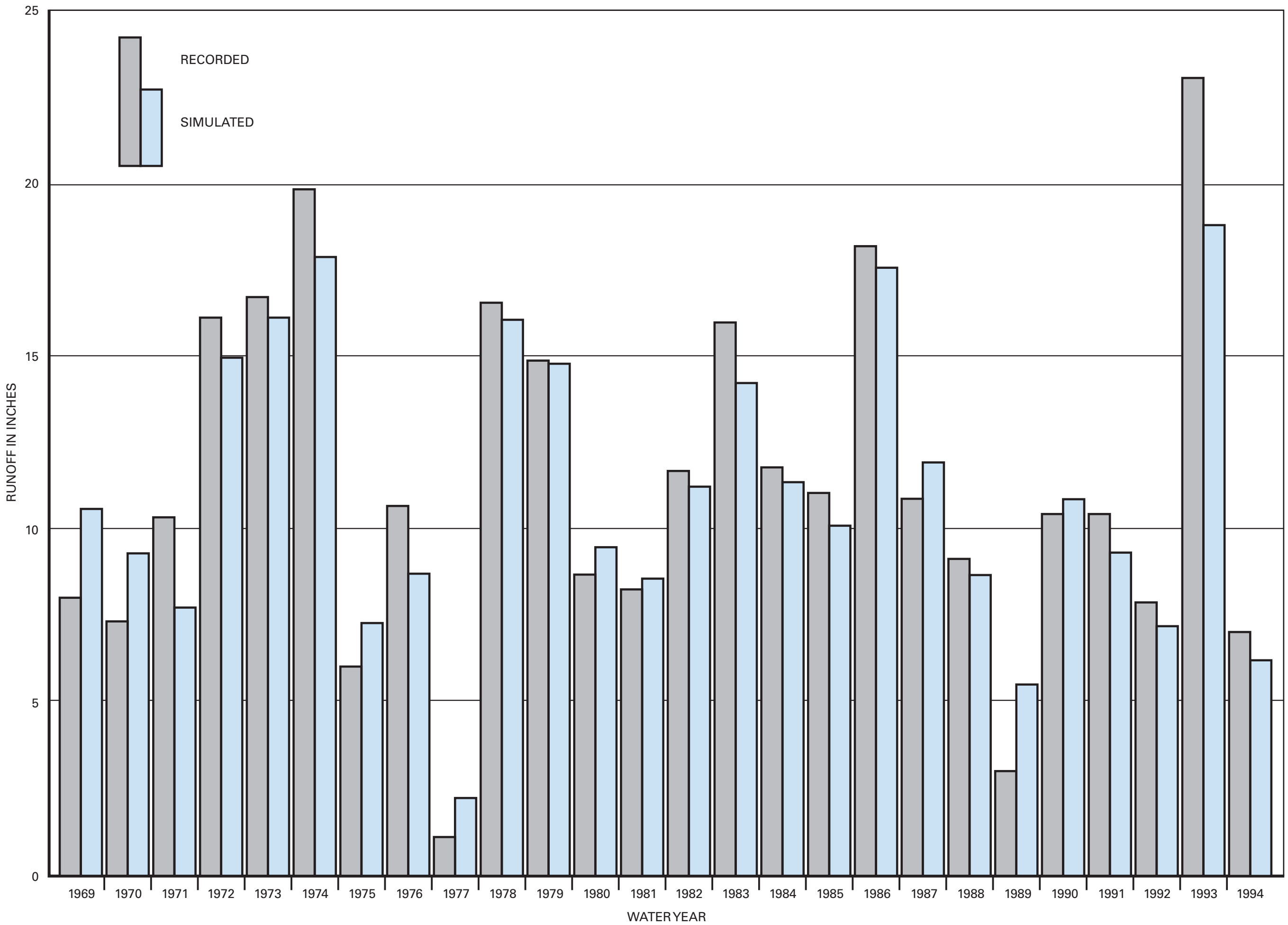
- Recorded and simulated hydrographs for six runoff events drawn from various times of the year are shown in Figure 58. These six events were selected so as to illustrate the full range of correlations between recorded and simulated flows. The recorded and simulated hydrographs for rainfall and rainfall-snowmelt events occurring during the calibration period exhibited acceptable agreement.

- Recorded and simulated peak flow values from the highest runoff events occurring each water year since October 1959 are compared in Figure 59. These data are also seen to be grouped about a 45-degree line, indicating a tendency to exhibit the desired one-to-one correlation between the recorded and simulated peak flow values. An additional line shown in Figure 59 represents the line of best fit through the points plotted for all the selected runoff events. The line closely approximates a 45-degree line, which suggests that the hydraulic submodel, in conjunction with the hydrologic submodel, simulates peak discharges without significant bias.

Over-simulation or under-simulation of flood discharge may be attributable to spatial variations in the amount of rainfall occurring over the watershed. That is, it is possible for portions of a watershed to receive precipitation amounts, especially during brief events such as thunderstorms, that are significantly different from those recorded at observation stations. Over-simulation or under-simulation may also be attributable to variations in the time at which a particular runoff event begins. It is unlikely that precipitation will begin throughout a watershed at exactly the same time at which it begins at the observation stations.

Figure 55

RECORDED AND SIMULATED ANNUAL RUNOFF VOLUMES FOR THE DES PLAINES RIVER AT THE RUSSELL ROAD, ILLINOIS GAGE: OCTOBER 1, 1968 – SEPTEMBER 30, 1994



Source: SEWRPC.

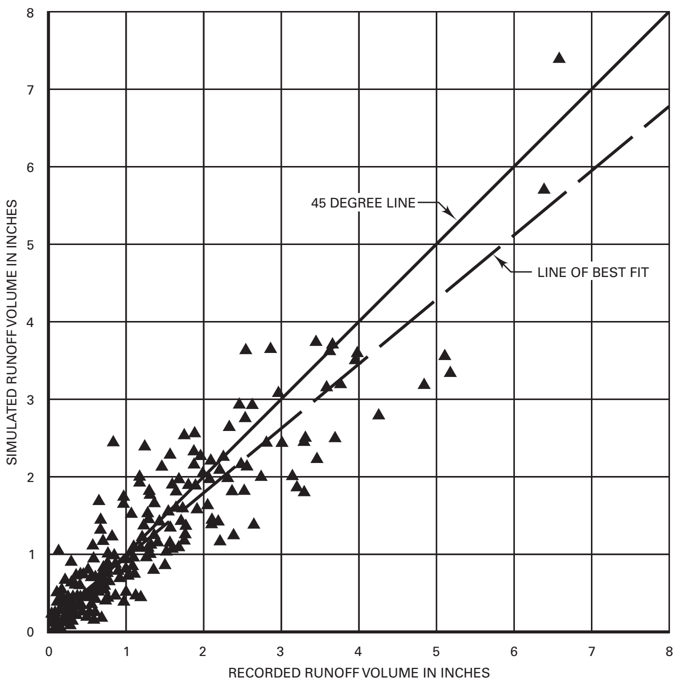
Over-simulation of flood discharges during early spring months may be attributable to the structure of the hydrologic submodel itself. The model, in simulating certain kinds of winter runoff events, may compute too much infiltration, thus somewhat under-simulating the actual runoff. The model may also, in simulating certain kinds of early spring runoff events, compute too little infiltration, thus somewhat over-simulating the actual runoff. However, such differences between simulated and actual runoff events for a limited number of particular events should not adversely affect overall hydrologic-hydraulic modeling results. This is so because over the relatively long 55-year simulation period used in the Des Plaines River watershed study, positive and negative simulation errors tend to compensate, thus resulting in a relatively uniform frequency distribution of simulated annual peak discharges. This simulated frequency distribution should closely approximate the actual distribution for the 55-year period. Therefore, the simulated flood frequency curves may be expected to closely approximate actual flood frequency relationships even though simulation error for some individual flood events may exist.

Second Hydraulic Submodel (HEC-2)

After successful calibration of the hydrologic submodel and first hydraulic submodel on the Des Plaines River watershed, and subsequent development of flood discharges, the second hydraulic submodel was calibrated against historic flood stage information utilizing the developed flood discharges. The historic flood inventory described in Chapter VI provided limited historic high water data for streams in the Des Plaines River watershed.

Figure 56

LINEAR CORRELATION BETWEEN RECORDED AND SIMULATED MONTHLY RUNOFF VOLUMES FOR THE DES PLAINES RIVER AT THE RUSSELL ROAD, ILLINOIS GAGE: OCTOBER 1, 1968 – SEPTEMBER 30, 1994



Source: SEWRPC.

The calibration process involved comparing flood stage elevations computed at various locations in the watershed for the simulated flood of April 1993 to high water mark elevations surveyed by Commission staff. The recorded and simulated flood stages were compared and reasonable agreement was found.

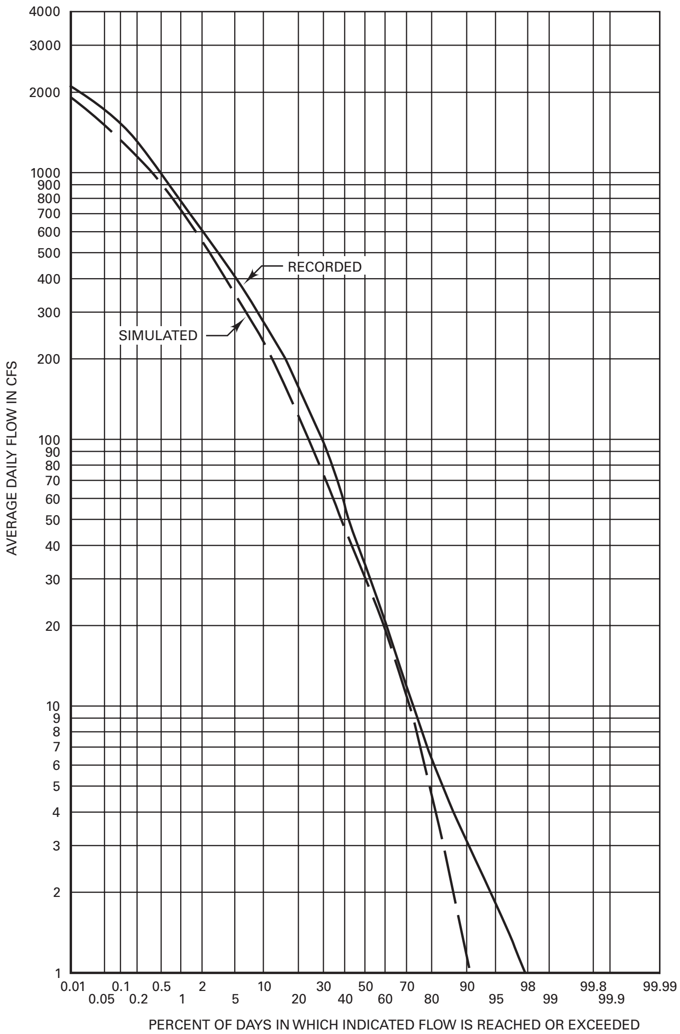
Water Quality Calibrations on the Des Plaines River Watershed

As already noted, water quality simulation modeling for the Des Plaines River watershed was initially completed under the Commission areawide water quality management planning program. Under that program, the Hydrocomp water quality submodel was calibrated, using the results of the stream water quality index sampling program conducted under the areawide water quality management planning program. The fall calibration period, September 7, 1976, to October 6, 1976, provided the primary data for calibration of the water quality submodel at the sampling station. The calibration process consisted of comparison of the observed water quality and the model results for the sampling location. After achieving successful calibration with emphasis on six parameters—water temperature, dissolved oxygen, phosphate phosphorus, the nitrogen forms, fecal coliform counts, and biochemical oxygen demand—the remaining simulated parameters were examined for reasonableness. After minor adjustments were made in some nonpoint loading rates, the model produced acceptable results for the calibration period. The refined model results were subsequently verified using measured water quality data collected during the 1965-1975 Commission stream water quality monitoring effort from three Commission and one Wisconsin Department of Natural Resources water quality sampling stations established in the Des Plaines River watershed.

A somewhat different procedure was employed in the development of the UAL model data. As previously noted, this model was applied using coefficients which were developed largely from studies conducted in the Southeastern Wisconsin Region. Thus, the model is considered calibrated to some extent for Wisconsin conditions, but not necessarily for the specific conditions in the Des Plaines River watershed. A transmission coefficient was determined for, and applied within, each of the water quality assessment areas for total suspended solids, total phosphorus and total metals in order to account for the reduction in loads due to instream processes and overland retention within the watershed. These transmission coefficients were determined to be 0.20, 0.95 and 0.60, respectively, reflecting the relatively high retention of sediments in the system; the relatively high percentage of dissolved phosphorus in the system, as measured at station Dp-4; and the intermediate reactivity of metals. The results of the UAL model were then compared to the results of the Hydrocomp water quality submodel. That comparison showed a similarity in modeling results which was considered an indication of the validity of both models. The resultant estimates of water quality conditions within the Des Plaines River generated using this refined UAL modeling approach were then verified using observed data acquired at sampling station Dp-4 by the U.S. Geological Survey during the period November 17, 1977 through August 23, 1991.

Figure 57

RECORDED AND SIMULATED FLOW DURATION CURVES FOR THE DES PLAINES RIVER AT RUSSELL ROAD, ILLINOIS GAGE



Source: SEWRPC.

It should be noted that, as is the case with lumped-parameter models, both the UAL and WILMS models provide a single-value numerical output for each parameter modeled. This output is considered to be an annual average value that equates to the estimated long-term mean annual concentration of the parameter of concern. In this case, the parameters considered specifically were total suspended sediment, total phosphorus, and total metal concentrations. For the UAL and WILMS models, the forecast values calculated are assumed to represent the centroid of a normal distribution, with the range of concentrations and their frequency of occurrence being evenly distributed about the mean value. In other words, at any given time within a specific year or between years within a time series, the actual observed concentration of a parameter of concern measured within the Des Plaines River may be expected to fall within two standard deviations of the forecast mean value at least 95 percent of the time. Such an output is in contrast to the output of a distributed-parameter continuous simulation model such as the Hydrocomp model, which calculates a range of water quality conditions for a given time period, based upon a range of hydrological and other conditions existing within the watershed, and provides an estimate of the anticipated distribution of concentrations around the mean in a time-linked linear manner. Notwithstanding these different modeling approaches, both the lumped-parameter models such as the UAL and WILMS models, and the distributed-parameter continuous simulation models such as the Hydrocomp model, tend to forecast conditions equating to long-term average conditions, especially when used in a predictive sense. Thus, both types of models should produce statistically comparable results insofar as the estimated annual average concentrations of the parameters of concern are concerned. This latter assumption was tested as part of the water quality modeling element of the watershed planning program.

Annual average surface water phosphorus concentrations in the six major lakes in the Des Plaines River watershed were determined using contaminant loads generated using the Wisconsin Lake Model Spreadsheet (WILMS). WILMS uses unit area loads to generate the nutrient loading input data for use in a number of empirical lake models, including the Dillon and Rigler model used to generate lake phosphorus concentration data in the regional water quality management plan.[15] As noted above, the phosphorus export coefficients used to

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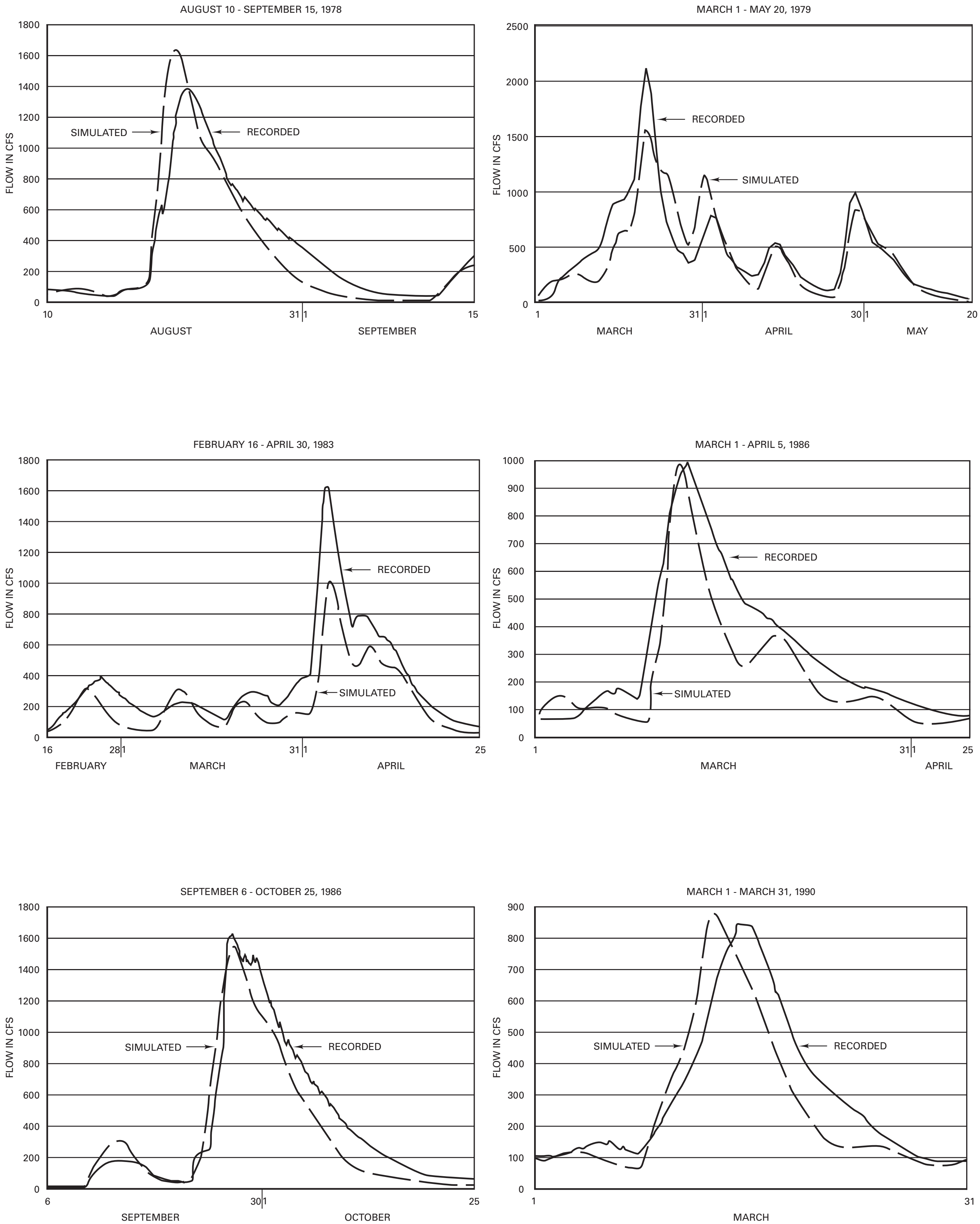
[15] *P.J. Dillon and F.H. Rigler, "A Test of a Simple Nutrient Budget Model Predicting the Phosphorus Concentration in Lake Water,"* Journal of the Fisheries Research Board of Canada*, Volume 31, pp. 1,771-1,778, 1974; see also SEWRPC Planning Report No. 30, Volume Two,* op. cit*.*

Figure 58

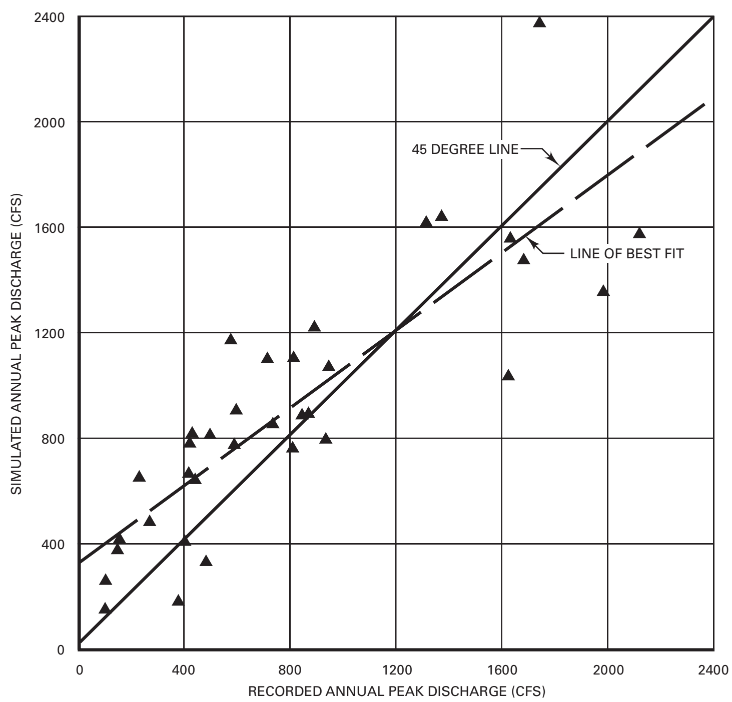
RECORDED AND SIMULATED HYDROGRAPHS FOR THE DES PLAINES RIVER AT THE RUSSELL ROAD, ILLINOIS GAGE FOR SELECTED EVENTS: OCTOBER 1967 – SEPTEMBER 1994



Source: SEWRPC.

Figure 59

LINEAR CORRELATION BETWEEN RECORDED AND SIMULATED ANNUAL PEAK DISCHARGES FOR THE DES PLAINES RIVER AT RUSSELL ROAD, ILLINOIS GAGE: WATER YEARS 1960-1993[a]



[a]*Peak discharge for water year 1994 was not recorded due to an ice jam at the gage.*

Source: SEWRPC.

generate the phosphorus loading rates for lakes in the Des Plaines River watershed are derived for Wisconsin conditions, primarily conditions in southeastern Wisconsin, but not specifically calibrated to conditions in the Des Plaines River watershed. Nevertheless, the specific values of the nutrient export coefficients used within WILMS are similar to those used in the UAL model described further below (see Chapter VII). The lack of current data from the major lakes within the watershed precluded a statistical evaluation of the model forecasts. However, the few current data available, summarized in Table 89, and the similarity of the approach which was previously verified under the regional water quality management planning program indicated the validity of this model.

Annual average contaminant concentrations were determined for sampling station Dp-4 using contaminant loads generated using the UAL model and flow data generated using the Hydrological Simulation Program-Fortran water quantity model. These data were compared with the Hydrocomp model output, and both data sets were verified using the observed data reported for the period 1977 through 1991 by the U.S. Geological Survey for sampling station Dp-4 at Russell, Illinois, as shown in Table 90. Based on a chi-squared analysis of the means, it was concluded that the mean concentrations of the contaminants of concern estimated using the UAL model and based upon 1990 land use conditions were not statistically different from the mean concentrations of the contaminants of concern estimated using the Hydrocomp model and based upon 1975 land use conditions. Further, it was concluded that, with the exception of the fecal coliform concentrations, the mean concentrations of the contaminants of concern estimated using the Hydrocomp model were not significantly different from the mean concentrations of the contaminants of concern reported in the observed data during the period from 1977 through 1991. Similarly, the concentrations of the contaminants of concern estimated using the UAL model were not significantly different from the mean concentrations of the contaminants of concern reported in the observed data for this same period.

Conducting the same statistical analysis on the forecast and observed ranges in water quality conditions yields a similar outcome. Based on a chi-squared analysis of the ranges, the range in concentrations of the contaminants of concern estimated using the Hydrocomp model and based upon 1975 land use conditions, in general, do not differ significantly from the observed range in concentrations of the contaminants of concern reported by the U.S. Geological Survey at sampling station Dp-4 during the period 1977 through 1991, with the exception of the fecal coliform concentrations, nitrate concentrations, and flow data. Some differences in the range of flow conditions would be expected when comparing a single year to a longer period of time, and can attributed to inter-annual variability. Similarly, some differences in the ranges of fecal coliform and nitrate concentrations can be attributed to such inter-annual variability, while a further measure of difference in the range of nitrate concentrations may be

Table 89

FORECAST 1990 AND 2000 LAKE DATA COMPARED TO OBSERVED DATA

Lake	Hydrocomp Simulation 2000 P Concentration (Φg/l)	WILMS[a] 1990 P Concentration (Φg/l)	Observed Phosphorus Concentrations (Φg/l) Maximum	Average	Minimum
Andrea	- -	17	- -	- -	- -
Benet/Shangrila	60	33	540	170[b]	10
George	100	101	220	80[c]	30
Hooker	90	60	180	50[d]	20
Paddock	20	34	- -	- -	- -
Vern Wolf	- -	21	240	150[e]	100

[a]*Based upon the Dillon and Rigler model.*

[b]*Based upon 1977-1978 Wisconsin Department of Natural Resources Lake Survey Form.*

[c]*Based upon 1976-1980 Wisconsin Department of Natural Resources Lake Survey Form.*

[d]*Based upon 1977-1992 Wisconsin Department of Natural Resources Lake Survey Form and U.S. Geological Survey water resources data.*

[e]*Based upon 1977-1978 Wisconsin Department of Natural Resources Lake Survey Form.*

Source: SEWRPC.

attributed to shifts in the distribution of total nitrogen between its various chemical forms, including ammonia and gaseous nitrogen, that exist in freshwater environments.[16]

Thus, with the aforementioned exceptions, it was concluded that the maximum, minimum, and mean data simulated using the Hydrocomp model and based upon 1975 land use conditions, as set forth in the regional water quality management plan, were indeed generally statistically similar to the observed data reported by the U.S. Geological Survey for sampling station Dp-4 for the period from 1977 through 1991. It was further concluded that the mean data simulated using the Hydrocomp model and based upon 1975 land use conditions were statistically similar to the mean data calculated using the UAL model and based upon 1990 land use conditions.

Given that much of the available data collected from station Dp-4 is closer to the forecast year 2000 conditions than to the initial 1975 conditions, the Hydrocomp model output for the planned year 2000 conditions was also tested for statistical similarity to the observed data. Based upon a chi-squared analysis of the median concentrations of the contaminants of concern estimated using the Hydrocomp model and the average observed concentrations of these contaminants reported from station Dp-4 for the period from 1977 through 1991, it can be concluded that the forecast concentrations, with the exception of the fecal coliform concentrations, were not significantly different from the mean concentrations reported in the observed data, shown in Table 90. Further, because mean concentration data were not available for the forecast year 2000 conditions, the mean and median

[16]*See W. Stumm and J.J. Morgan,* Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters*, Wiley-Interscience, New York, 1970.*

Table 90

FORECAST 1975 AND 1990 DATA COMPARED TO OBSERVED 1977-1991 DATA: STATION DP-4

Parameter	1975 Numerical Values[a]			2000 Numerical Values[a]	1990 Numerical Values[c]	1977-1991 Numerical Values[d]		
	Maximum	Average	Minimum	Median[b]	Average	Maximum	Average	Minimum
Flow (cfs)	1,860	102	2	125	85	2,100[e]	97[e]	0[e]
Temperature (°F)	88.0	52.0	32.0	50.5	- -	82.6	52.6	26.6
Nitrate/Nitrite (mg/l)	10.0	5.1	0	4.9	- -	130.0	3.7	0
Ammonia (mg/l)	1.5	0.23	0	0.26	- -	1.4	0.2	0
Dissolved Oxygen	13.5	6.8	0	8.1	- -	22	8.6	0
Biological Oxygen Demand (mg/l)	54	4.9	0	3.9	- -	- -	- -	- -
Fecal Coliform (MFFCC/100 ml)	2,031	363	113	310	- -	33,500	869	9
Phosphate (mg/l)	1.4	0.13	0	0.07	0.20	0.8	0.1	0.0
Organic Nitrogen (mg/l)	608	1.18	0.23	1.30	- -	- -	- -	- -
Total Nitrogen (mg/l)	12.1	7.3	0	6.8	- -	11.0	2.7	0
Lead (Φg/l)	- -	- -	- -	- -	5.3	100	<33.5[f]	0
Copper (Φg/l)	- -	- -	- -	- -	0.3	51	<7.2[f]	0
Zinc (Φg/l)	- -	- -	- -	- -	6.1	439	<73.2[f]	0
Cadmium (Φ/l)	- -	- -	- -	- -	0.05	10	<2.7[f]	0

[a]*From SEWRPC Planning Report No. 30, based upon Hydrocomp computations.*

[b]*Median value used due to availability of data.*

[c]*From this study based on UAL computations; flow computed using HPSF.*

[d]*From U.S. Geological Survey publication Water Resources Data for Wisconsin. Based on observations.*

Water Year	*Number of Observations*	*Comments*
1978	*10*	*Some data missing*
1979	*- -*	*- -*
1980	*23, 14*	*Phosphorus and metals, 2-7; Temperature, 23; Other parameters, 14*
1981	*10*	*Phosphorus, 1; Metals, 5; Dissolved oxygen, 8; Fecal coliform, 9*
1982	*18*	*Ten observations for all, except water temperature*
1983	*Temperature 18*	*Both nitrogens, fecal coliform, and dissolved oxygen, 9; Phosphorus, 3; Metals, 8*
1984	*10*	*- -*
1985	*9*	*- -*
1986	*10*	*Eight observations for dissolved oxygen*
1987	*10*	*- -*
1988	*9*	*Eight observations for dissolved oxygen*
1989	*10*	*Eight observations for all, except water temperature*
1990	*10*	*Nine observations for most, except water temperature; One observation for* NO_2/NO_3
1991	*9*	*- -*

[e]*From U.S. Geological Survey based on flow observations between 1967 and 1991.*

[f]*Concentrations generally below the limits of analytical detection; average calculated assuming the limit of detection is the observed concentration as set forth in Chapter VII.*

Source: SEWRPC.

Table 91

COMPARISON OF MEAN AND MEDIAN VALUES DERIVED FROM THE HYDROCOMP MODEL SIMULATIONS

Parameter	Hydrocomp Simulation: 1975 Average Numerical Value	Hydrocomp Simulation: 1975 Median Numerical Value
Flow (cfs)	102	122
Temperature (°F)	52.0	52.1
Fecal Coliform (MFFCC/100 ml)	363	310
Nitrate/Nitrite (mg/l)	5.1	5.1
Ammonia (mg/l)	0.23	0.17
Phosphate (mg/l)	0.13	0.05
Dissolved Oxygen (mg/l)	6.8	7.1
Biological Oxygen Demand (mg/l)	4.9	4.0
Organic Nitrogen (mg/l)	1.18	1.18
Total Nitrogen (mg/l)	7.3	7.3

Source: SEWRPC.

values of the contaminants of concern, set forth in Table 91, were further analyzed for similarity using the chi-squared test, and were found to be similar.

A further basis from which to assess the validity of the foregoing analyses may be found in the similarity of the streamflow-duration relationships for the Des Plaines River at Russell, Illinois, which evinced little variation in the forecast flows based upon 1975 land use and channel conditions, 1990 land use and channel conditions, forecast 2000 land use conditions as set forth in the regional water quality management plan, and forecast planned conditions as simulated under the watershed planning effort. Such similarity indicates consistency in the range of rates and volumes of runoff from the watershed under the range of land use conditions from 1975 through planned conditions. Such a consistency is usually reflected in a similar consistency in the magnitude of the contaminant loads delivered to a stream from the land surface within a watershed and in the ability of a stream to transport contaminants.[17]

Given the statistical similarity of the contaminant concentrations estimated based upon 1975 and 1990 land use conditions, the consistent distribution of the water quality data around the mean as shown by a comparison of the 1975 and planned year 2000 pollutant concentration-frequency relationships developed under the regional water quality management plan using the Hydrocomp water quality submodel,[18] and the similarity in the Des Plaines River flow-duration relationships over the range of existing and planned land use conditions, it was concluded that the distribution of the data around the mean under planned conditions would be similar to that under 1990 conditions. Thus, it was further concluded that the UAL model as verified for 1990 conditions could be used to validly estimate future nonpoint source pollutant loadings under planned land use conditions. The statistical similarity of the results of the UAL and Hydrocomp models further suggests that a given stream water quality standard, as set forth in Chapter NR 102 of the Wisconsin Administrative Code, would be met if the average annual concentration determined using the UAL model is less than or equal to the average annual concentration determined using the Hydrocomp model for the recommended pollution control conditions established under the regional water quality management plan.

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[17]*Rast et al., Unesco Man and Biosphere Series Volume 19,* op. cit.

[18]*SEWRPC unpublished data from regional water quality management plan 208 study Volume No. 6315, Exhibit H-1b.*

COMPUTATION OF FLOOD DAMAGES

The procedures used for flood damage estimation enable the calculation of both total flood damages for individual floods of specified recurrence intervals and of average annual damages. The procedures compute damages using flood frequency relationships developed with the hydrologic and first hydraulic submodel; flood stage-discharge relationships developed using the second hydraulic submodel; and flood-depth percent damage relationships for specific structure types and specific crops. In addition, the procedure used to calculate agricultural damages also uses monthly flood distribution data; "flood stage-area flooded" relationships derived from the flood profiles computed with the second hydraulic submodel; and crop distribution, yield, and value data. The procedure used to calculate structure damages also uses structure value data.

Agricultural Damages

Flood damages to crops and pasture were computed using a model developed by the U.S. Natural Resources Conservation Service—formerly the U.S. Soil Conservation Service—called "ECON2-Floodwater Damage Economic Evaluation."[19] Each stream in the watershed where the potential exists for agricultural flooding was defined as a damage reach. Those reaches were then divided into cross-sections representing stream segments with uniform hydraulic properties and flooding characteristics. An elevation-discharge-area flooded relationship characteristic of each cross-section was used by the model, along with depth-damage and flood frequency relationships[20] and crop distribution, yield, and value data to determine the total flood damages during floods with recurrence intervals ranging up to, and including, 100 years. Damages were weighted according to a monthly flood distribution relationship. Those damage amounts were then correlated with the flood frequency relationship to determine average annual agricultural flood damages.

A monthly distribution relationship characteristic of the Des Plaines River watershed was developed through analysis of the four largest flood peaks in each year of record at the U.S. Geological Survey Russell, Illinois, stream gage on the Des Plaines River. Average flood-free unit crop yields were provided by the Natural Resource Conservation Service and the Kenosha County Land Conservationist. Crop values were provided by the NCRS based on the Wisconsin five-year average for the time period from 1990 through 1994. A typical distribution of crops within the watershed was determined using annual data on acres harvested in Kenosha and Racine Counties as compiled by the Wisconsin Agricultural Statistics Service for the years from 1991 through 1994. The crops for which damages were computed included corn, soybeans, hay, wheat, and oats.

The potential areal extent of cropland or pasture flooded during the two-, 10-, and 100-year recurrence interval floods was determined using flood stage elevation-discharge data developed with the second hydraulic submodel along with data developed using the Commission geographic information system (GIS). Floodplain boundaries for those three floods were delineated on one inch equals 200 feet scale topographic maps of the watershed. Cross-sections coinciding with selected channel and floodplain cross-sections used in development and application of the second hydraulic submodel were identified on the maps. The floodplain boundaries and cross-section alignments were digitized and the areas in cropland and pasture within each segment of the three floodplains as defined by upstream and downstream cross-sections were quantified. Those areas were then used to

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[19]*U.S. Soil Conservation Service,* ECON2-Floodwater Damage Economic Evaluation*, Version 1.01, revised November 5, 1991.*

[20]*Because the magnitude of agricultural flood damages is dependent on the time of year in which flooding occurs, the submodel utilizes flood frequency data based on a partial duration series which is developed considering the largest flood peaks above a given threshold, including multiple flood peaks in a given year where appropriate. Consistent with accepted engineering practice, the flood frequency data developed with the Hydrologic Submodel and Hydraulic Submodel 1 for the floodland management aspects of the watershed study is based on an annual flood series which utilizes the greatest peak flood discharge in each year of the simulation period. Thus, prior to use in the agricultural flood damage model, the annual series flood frequency relationship was converted to a partial duration series relationship using standard statistical procedures.*

calculate agricultural flood damages along with the corresponding flood elevation-discharge relationships developed using the hydraulic submodel.

Structure Flood Damages

As with the agricultural lands, calculation of structure flood damages made use of the discharge-frequency and stage-discharge relationships developed using the hydrologic and hydraulic submodels. Those relationships, along with depth-damage relationships as described in Chapter VI and structure type, elevation, and value, were used to compute total structure damages during floods with recurrence intervals ranging up to, and including, 100 years. Those damage amounts were then correlated with the flood frequency relationship to determine average annual structure flood damages.

Flood stage elevation-discharge data developed with the second hydraulic submodel were used to delineate the two-, 10-, and 100-year recurrence interval floodplain boundaries on one inch equals 200 feet scale topographic maps of the watershed. These maps, supplemented with Commission aerial photographs, were used to identify all structures located within or adjacent to the 100-year recurrence interval floodplain. County tax records were used to obtain structure value, type, and presence of a basement. Building grade elevations were obtained from the large-scale topographic maps used for floodplain delineation, supplemented with as-built surveyed elevations where available. The height of the first floor relative to the building grade was estimated based on structure type and field inspection, and was used to determine first floor elevation.

Determination of a structure's susceptibility to flooding was based on comparison of the flood stage elevation to the lowest adjacent grade elevation in the case of structures with basements or crawl spaces, and to the first floor elevation for structures constructed without a basement or crawl space. Estimation of direct damages was made using the depth-damage relationships and structure values. Indirect damages were computed as a percent of the direct damage as described in Chapter VI. Total damages were computed for the two-, 10-, 25-, 50-, and 100-year recurrence interval flood events.

SUMMARY

Quantitative analyses of streamflow and water quality conditions under existing and possible alternative future conditions is a fundamental requirement of any sound comprehensive watershed planning effort. Discharge, stage, and water quality at any point and time within the stream system of a watershed are a function of three factors: meteorological conditions and events; the nature and use of the land; and the characteristics of the stream system.

Hydrologic-hydraulic-water quality simulation, accomplished with a set of interrelated computer programs, is an effective way to conduct the quantitative analysis required for watershed planning. Such a water resource model was developed for and used in the Des Plaines River watershed planning program. The various submodels comprising the model were selected from available computer programs so that the composite model would meet the watershed study needs as specified by eight criteria. The Water Resource Simulation Model used in the Des Plaines River watershed planning program consists of the following five submodels: the Hydrologic Submodel; Hydraulic Submodel 1; Hydraulic Submodel 2; the Agricultural Flood Damages and Benefits Submodel; and the Water Quality Submodel.

The principal function of the Hydrologic Submodel was to determine the volume and temporal distribution of runoff from the land to the stream system. The basic conceptual unit on which this submodel operates is the hydrologic land segment type. A hydrologic land segment type is defined as a land drainage unit exhibiting a unique combination of meteorological characteristics, such as precipitation and temperature; land characteristics, such as pervious or impervious surfaces; soil types; and slopes. The submodel, which was operated on a time interval of 15 minutes for water quantity simulation and one hour for water quality simulation, continuously and sequentially maintains a water balance within and between the various interrelated hydrological processes as they occur with respect to the land segment type. Meteorologic and land data constitute the two principal types of input for operation of the Hydrologic Submodel. The key output from the submodel consists of a continuous series of runoff quantities for each hydrologic land segment type in the watershed.

The first hydraulic submodel accepts as input the runoff—or discharge—from the land surface and groundwater sources as produced by the hydrologic submodel, aggregates these discharges, and routes the aggregate discharges through the stream system, to produce a continuous series of discharge values at predetermined locations along the rivers and streams of the watershed. Application of this submodel requires that the stream system be divided into land segments, a land segment being either a channel reach and its tributary drainage area, or an impoundment and its tributary drainage area. Input for the first hydraulic submodel consisted of a stage-discharge-cumulative storage table for each land segment, as well as the output from the hydrologic submodel.

The second hydraulic submodel computes flood stage attendant to flood flows of specified recurrence intervals as produced by the first hydraulic submodel. Use of this submodel requires, in addition to the output of the first hydraulic submodel, a detailed description of the watershed stream system, including channel-floodplain cross-sections, Manning roughness coefficients, and complete physical descriptions of all hydraulically significant culverts, bridges, and dams. The principal output from the second hydraulic submodel consists of flood stage profiles, which can then be used to delineate flood hazard areas for flood events with various recurrence intervals up to, and including, 100 years.

The water quality submodel simulates the time-varying concentration, or levels, of the following water quality indicators at selected points throughout the surface water system: temperature, dissolved oxygen, fecal coliform bacteria, phosphate phosphorus, total dissolved solids, carbonaceous biochemical oxygen demand, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, and organic nitrogen. Operating on a reach-by-reach basis, the submodel continuously determines instream water quality conditions as a function of reach inflow and outflow, dilution, and biochemical processes. Input to the water quality submodel consists of output from the hydrologic submodel, channel data, meteorologic data, and nonpoint and point pollution source data. Output from the submodel consists of a continuous series of water quality conditions at selected locations on the watershed stream system. Additional water quality modeling was undertaken using a Unit Area Load-based model and the Wisconsin Lake Model in order to refine and update the results of the Hydrocomp water quality submodel.

Model data base development included the acquisition, verification, and coding of the data needed to operate, calibrate, test, and apply the model. The model data base for the watershed consisted of a large, primarily computer-based file divided into six categories: meteorological data, land data, channel data, riverine area structure data, diffuse or nonpoint source data, and point source data. The meteorological data comprised the largest set because it contains 55 years of daily and hourly information for eight types of meteorological data. The data base was assembled using data collected under other Commission planning programs, inventory data collected under the Commission areawide water quality management planning program, and data from other sources such as the National Weather Service, as well as data collected under the watershed study itself.

The algorithms incorporated into the water resource simulation model are approximations of complex natural phenomena. Therefore, before the model could be used to simulate watershed conditions, it was necessary to calibrate the model. Calibration consists of comparing model results with actual measured historic data and, if significant differences are found, making parameter adjustments to better adapt the model to the specific effects of the natural and man-made features of the planning region and the watershed. The three types of data available for calibration of the simulation model were streamflow data, flood stage data, and water quality data.

The hydrologic submodel and the two hydraulic submodels were successfully calibrated by comparing the simulated discharges to daily streamflows at the U.S. Geological Survey stream gaging station located on the Des Plaines River at Russell, Illinois; and by comparing simulated stage data to available historic stage data.

The water quality submodel and other water quality models used in the watershed planning effort were calibrated using data obtained from stream and lake sampling programs conducted by the U.S. Geological Survey, the Wisconsin Department of Natural Resources, and the Commission. These data represented a range of meteorologic, hydrologic, and hydraulic conditions.

In order to assess the need for evaluation of flood control and drainage measures within the Des Plaines River watershed, it was necessary to first estimate potential flood damages. Both structure and agricultural flood damages were estimated for the watershed. The techniques used enable the calculation of both total flood damages to structures, crops, and pasture for individual floods of specified recurrence intervals and of average annual damages. The techniques make use of flood frequency relationships developed with the hydrologic and first hydraulic submodels; flood stage-discharge relationships developed using the second hydraulic submodel; flood depth-damage relationships for specific building types and crops; and structure value and crop price data. In addition, agricultural damage calculations also made use of monthly flood distribution data; "flood stage-area flooded" relationships developed from the second hydraulic submodel; and crop distribution and yield data.

Chapter IX

WATER LAW AND FEDERAL, STATE, AND LOCAL REGULATIONS RELATED TO WATER RESOURCE PLANNING

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 problems under consideration. In comprehensive watershed planning, the law can be as important as the hydrology of the basin or the benefits and costs of proposed water quantity and quality 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.

Water constitutes one of the most important natural resources. It is essential not only to many of the primary economic activities of man but also to life itself. The available quantity and quality of this important resource are of concern to agricultural, commercial, manufacturing, conservation, and government interests. The rights to the availability and use of water are, accordingly, of vital concern to a host of public-interest and private-interest groups; the body of law regulating these rights is far from simple or static. Moreover, changes in this complex, dynamic body of law may be expected to take place even more rapidly as pressure on regional, State, and National water resources becomes more intense. For example, the Wisconsin Supreme Court has expressly overruled the historic common law doctrine on both groundwater[1] and diffuse surface water law,[2] finding the historic doctrines in these areas not to be applicable to modern water resource problems and conflicts. To provide the basis for a careful analysis of existing water law in Southeastern Wisconsin, a survey was undertaken of the legal framework of public and private water rights affecting water resources management, planning, and engineering. The findings of this legal study were set forth in SEWRPC Technical Report No. 2, 2nd Edition, *Water Law in Southeastern Wisconsin*, published in April 1977. This study includes a detailed exposition of water law concepts and principles, including legal classifications of water, principal divisions of water law, riparian and public rights law, groundwater law, and diffuse surface water law; an inventory of existing powers and responsibilities of the various levels and agencies of government involved in water resource management; and an exposition on interbasin water diversion, all of which must necessarily be considered in the formulation of a comprehensive watershed plan.

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[1]State v. Michels Pipeline Construction, Inc., *63 Wis. 2d 278 (1974).*

[2]State v. Deetz*, 66 Wis. 2d 1, 224 N.W. 2d 407 (1974).*

This chapter summarizes applicable portions of the technical report, provides updated information where applicable, draws on information developed under subsequent Commission planning efforts related to wetland and shoreland regulations, and includes a review of local and county regulations with respect to wetlands, floodlands, and stormwater management. The major purpose of this chapter is to summarize the salient legal factors bearing on the water-related problems of the Des Plaines River watershed and on plans for their solution, thereby laying the basis for intelligent future action. This chapter does not, however, dispense with the need for continuing legal study with respect to water law, since this aspect of the overall planning effort becomes increasingly important as plan proposals reach the implementation stage.

In this chapter attention is focused first on those aspects of water law generally pertinent to the planning and management of the water resources of any watershed in Southeastern Wisconsin. Included in this section are a discussion of the machinery for water quality management of the Federal, State, and local levels of government. Finally, more detailed consideration is given to those aspects of water law that relate more specifically to the problems of the Des Plaines River watershed, including inventory findings on State water regulatory permits and State water pollution abatement orders and permits.

WATER QUALITY MANAGEMENT

Because the Des Plaines River watershed study is intended to deal with problems of both water quality and water quantity and to recommend water use objectives and water quality standards for the Des Plaines 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 government and through private action.

Federal Water Quality Management

The Federal government has long been involved in water quality management efforts, although it is only in recent years that the U.S. Congress has acted to secure the establishment of water use objectives and supporting standards for navigable waters. The 1899 Refuse Act prohibited the discharge of refuse matter of any kind, other than that flowing from streets and sewers, into any navigable waters of the United States or tributaries thereto without first obtaining a permit from the Secretary of the Army. The Secretary was directed to make a specific finding that the discharge of any refuse matter would not adversely affect anchorage and navigation; no finding on water quality was, however, required. This Act and the permits issued thereunder were largely ignored until enactment of the National Environmental Policy Act of 1969 (NEPA), which required all Federal agencies to consider the environmental impact in the administration of all public laws, and the Water Quality Improvement Act of 1970, which required applicants for Federal permits to file a certification from the appropriate state that the proposed discharge would not violate any applicable state-adopted water quality standard.

A broader Federal approach to water quality management began with the passage of the Federal Water Pollution Control Act on June 30, 1948. With the passage of this Act, the Federal government began to take effective steps toward controlling and preventing pollution of the navigable waters of the United States. Initially, the Act was primarily directed at establishing a Federal grant-in-aid program for the construction of publicly owned waste treatment facilities. In the mid-1960s, requirements were added relating to the establishment of interstate water quality standards. The Act was substantially revised by the amendments of 1972, 1977, and 1987. The name of the statute was changed from the Federal Water Pollution Control Act to the Federal Clean Water Act at the time of the 1977 amendment. In general, the Act, as amended in 1972 and 1977, called for: 1) an increased emphasis on enhancing the quality of all of the navigable waters of the United States, whether interstate or intrastate, 2) an increased emphasis on planning and on examining alternative courses of action to meet stated water use objectives and supporting water quality standards, 3) waters of the United States to be made to the extent practicable “fishable and swimmable,” 4) the provision of substantial Federal financial assistance to construct publicly owned waste treatment works, and 5) the development and implementation of areawide waste treatment management planning processes to assure adequate control of sources of pollutants within each state. The requirements of the Act, as amended in 1972 and 1977, may be categorized under the following headings: water quality standards and effluent limitations, pollutant discharge permit system, continuing statewide water quality management planning processes, areawide waste treatment planning and management, and waste treatment works construction. The 1987 amendment to the Act called for 1) the development of control strategies for waters polluted by toxic substances, 2) a permitting program for stormwater discharges from municipalities of a certain size, certain industries, and construction sites, and 3) the establishment of a program ultimately to replace the Federal program of construction grants for sewage treatment facilities with revolving funds run by the states. In the following sections, attention is focused on the most relevant portions of the Federal Clean Water Act, as well as on the requirements of the NEPA of 1969.

Water Quality Standards and Effluent Limitations

Since 1965, the Federal Water Pollution Control Act, and, later, the Clean Water Act, have required states to adopt water use objectives and supporting water quality standards for all interstate waters. The Act, as amended in 1972, incorporates by reference all existing interstate water quality standards and requires for the first time the adoption and submittal to the U.S. Environmental Protection Agency (EPA) for approval of all intrastate water use objectives and supporting water quality standards. Wisconsin, through the Natural Resources Board and the Wisconsin Department of Natural Resources (WDNR), has adopted the required interstate and intrastate water use objectives and supporting water quality standards. These objectives and standards as related to streams and watercourses in the Des Plaines River watershed are discussed in a subsequent section of this chapter.

In addition to water use objectives and standards, the Act requires the establishment of specific effluent limitations for all point sources of water pollution. Such limitations require the application of the best practicable water pollution control technology currently available, as defined by the EPA Administrator. Also, any waste source which discharges into a publicly owned treatment works must comply with applicable pretreatment requirements, also to be established by the EPA Administrator. The Act established a requirement that publicly owned treatment works meet effluent limitations based upon a secondary level of treatment and through application of the best applicable waste treatment technology. In addition to these uniform or National effluent limitations, the Act provides that any waste source must meet any more stringent effluent limitations as required to implement any applicable water use objective and supporting standard established pursuant to any State law or regulation or any other Federal law or regulation.

Pollutant Discharge Permit System

The Clean Water Act establishes the National Pollutant Discharge Elimination System (NPDES). Under this system the EPA Administrator or a state, upon approval of the EPA Administrator, may issue permits for the discharge of any pollutant or combination of pollutants upon the condition that the discharge will meet all applicable effluent limitations or upon such additional conditions as are necessary to carry out the provision of the Act. All such permits must contain conditions to assure compliance with all of the requirements of the Act, including conditions relating to data collection and reporting. In essence, the Act stipulates that all discharges to navigable waters must obtain a Federal permit or, where a state is authorized to issue permits, a state permit. The intent of the permit system is to include in the permit, where appropriate, a schedule of compliance which will set forth the dates by which various stages of the requirements imposed in the permit shall be achieved. As set forth below, Wisconsin has an approved permit system operating under the NPDES.

The 1987 amendments to the Clean Water Act established a Federal program for permitting of stormwater discharges from municipalities and specific industries. The Phase I program applies to the specified industries and to municipalities with populations of 100,000 or more. Ultimately, every separate municipal stormwater management system will be required to obtain a permit, regardless of the size of the municipality. The program is administered by the U.S. EPA and calls for the issuance of NPDES permits. Pollution from stormwater runoff is commonly characterized as diffuse, or nonpoint source, pollution. The Clean Water Act specifically exempts such pollution sources from the requirements of the NPDES program. However, because most urban stormwater runoff is discharged to receiving streams through storm sewers or other facilities which concentrate flows, the 1987 amendments designated urban stormwater pollution as a point source which could be regulated under the NPDES program. The Federal stormwater discharge permitting program requires: 1) control of industrial discharges utilizing the best available technology economically achievable, 2) control of construction site discharges using best management practices, and 3) municipal system controls to reduce the discharge of pollutants to the maximum extent practicable. As described in a later section of this report, the EPA has delegated the administration of the Phase I stormwater discharge permitting program in the State of Wisconsin to the WDNR.

In October of 1999, the EPA expanded the coverage of the stormwater discharge permitting regulations when it issued Phase II stormwater rules that apply to urbanized areas with populations between 50,000 and 100,000 persons and to construction sites that disturb from one to five acres. The Phase II program requires that regulated municipalities reduce nonpoint source pollution to the "maximum extent practicable" through implementations of a set of minimum control measures, including:

- Public education and outreach
- Public involvement and participation
- Illicit discharge detection and limitation
- Construction site stormwater runoff control
- Post-construction stormwater management for new development and redevelopment
- Pollution prevention and good housekeeping for municipal operations.

Continuing Statewide Water Quality Management Planning Processes

The Clean Water Act stipulates that each state must have a continuing planning process consistent with the objectives of the Act. States are required to submit a proposed continuing planning process to the EPA Administrator for approval. The Administrator is prohibited from approving any state discharge permit program under the pollutant discharge elimination system if that state does not have an approved continuing planning program. The state continuing planning process must result in water quality management plans for the navigable waters within the state. Such plans must include at least the following items: effluent limitations and schedules of compliance to meet water use objectives and supporting water quality standards; the elements of any areawide wastewater management plan prepared for metropolitan areas; the total maximum daily pollutant load to all waters identified by the state for which the uniform or national effluent limitations are not stringent enough to implement the water use objectives and supporting water quality standards; adequate procedures for the revision of plans; adequate authority for intergovernmental cooperation; adequate steps for implementation, including schedules of compliance with any water use objectives and supporting water quality standards; adequate control over the disposition of all residual waste from any water treatment processing; and an inventory and ranking in order of priority needs for the construction of waste treatment works within the state.

In effect, a state's planning process is designed to result in the preparation of comprehensive water quality management plans for natural drainage basins or watersheds. Such basin plans, however, are likely to be less comprehensive in scope than the comprehensive watershed plans prepared by the Regional Planning Commission.

Areawide Waste Treatment Planning and Management

Section 208 of the Clean Water Act provides for the development and implementation of areawide waste treatment management plans. Such plans are intended to become the basis upon which the EPA approves grants to local units of government for the construction of waste treatment works. The Act envisions that the Section 208 planning process would be most appropriately applied in the nation's metropolitan areas which, as a result of urban and industrial concentrations and other development factors, have substantial water quality control problems. Accordingly, the Act envisions the formal designation of a Section 208 planning agency for substate areas that are largely metropolitan in nature and the preparation of the required areawide water quality management plan by that agency.

Any areawide plan prepared under the Section 208 planning process must include the identification of both point and nonpoint sources of water pollution and the identification of cost-effective measures which will abate the pollution from those sources. The plans must also identify the appropriate management agency responsibilities for implementation.

On September 27, 1974, the seven-county Southeastern Wisconsin Region and the Southeastern Wisconsin Regional Planning Commission were formally designated as a Section 208 planning area and planning agency pursuant to the terms of the Clean Water Act. Following preparation of a detailed study design and after receiving a planning grant from the U.S. Environmental Protection Agency, the Commission started the planning program in July 1975. The program was continued through July 12, 1979, the date of formal adoption of the plan by the Commission. The plan adoption followed a series of public meetings and hearings and is fully documented in SEWRPC Planning Report No. 30, *A Regional Water Quality Management for Southeastern Wisconsin*, Volume One, *Inventory Findings*, Volume Two, *Alternative Plans*, and Volume Three, *Recommended Plan*. The plan was approved by the Wisconsin Natural Resources Board on July 25, 1979; by the Governor on December 3, 1979; and by the U.S. Environmental Protection Agency on April 30, 1980.

The original regional water quality management plan has been updated over time through an amendment and revision process. A status report on the plan as amended through 1993 is presented in SEWRPC Memorandum Report No. 93, *A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995. That report also identifies issues which remain to be addressed in the continuing planning process.

Waste Treatment Works Construction

Prior to the 1987 amendments, one of the basic goals of the Clean Water Act was to provide for Federal funding of publicly owned waste treatment works. Such funding was based upon an approved areawide water quality management plan designed to provide for control of both point and nonpoint sources of pollution in a cost-effective manner. As noted above, the 1987 amendments to the Act revised this funding program by establishing the current program, which provides for revolving loan funds operated by the states.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 broadly declares that it is national policy to encourage a productive and enjoyable relationship between man and his environment, to promote efforts which will prevent or eliminate damage to the environment, and to enrich the understanding of the ecological systems and natural resources important to the nation. This Act has broad application to all projects in any way related to Federal action. The mechanism for carrying out the intent of the NEPA of 1969 is the preparation of an environmental assessment for each project. This document must include an exposition of the potential environmental impacts of the proposed project, any adverse environmental effects which cannot be avoided should the project be constructed, any alternative to the proposed project, the relationship between the local short-term uses of man’s environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments or resources which would be involved in the proposed action if it is implemented. As described below, Wisconsin has a similar environmental policy accompanying State governmental action of all kinds within the State, whether or not such action is federally aided.

State Water Quality Management

Responsibility for water quality management in Wisconsin in centered in the WDNR. Pursuant to the State Water Resources Act of 1965, the WDNR acts as the central unit of State government to protect, maintain, and improve the quality and management of the groundwater and surface waters of the State. The only substantive areas of water quality management authority not located in the WDNR, or shared with other agencies, are: 1) the authority to regulate private sanitary sewer systems, private septic tank sewage disposal systems, and construction site erosion control for single- and two-family residential building sites and commercial sites, which are the responsibility of the Wisconsin Department of Commerce, 2) the establishment of groundwater standards under Chapter NR 140 of the *Administrative Code*, which is shared with the Wisconsin Department of Health and Social Services, 3) the development by the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) of a model shoreland management ordinance and of regulations for drainage districts and county land and water resource management plans, and 4) the authority to regulate highway construction site erosion control for projects administered by the Wisconsin Department of Transportation (WisDOT), which is the responsibility of WisDOT. Attention in this section of the chapter will be focused on those specific functions of the WDNR which bear directly upon water quality management and, hence, upon the preparation of those elements of the Des Plaines River watershed plan pertaining to water pollution control.

Water Resources Planning
Section 281.12(1) of the *Wisconsin Statutes* requires that the WDNR formulate a long-range comprehensive State water resources plan for each region in the State. The seven-county Southeastern Wisconsin Planning Region lies entirely within the eight-county Southeast Region of the Department. This section of the Statutes also stipulates that the Department should formulate plans and programs for the prevention and abatement of water pollution and for the maintenance and improvement of water quality. In addition, Section 281.13 of the *Wisconsin Statutes* authorizes the Department to conduct drainage basin surveys. This statutory authority enables the Department to conduct the continuing State water quality management planning process required by the Clean Water Act.

Water Use Objectives and Water Quality Standards
Section 281.15(1) of the *Wisconsin Statutes* requires that the WDNR prepare and adopt water use objectives and supporting water quality standards that apply to all surface waters of the State. Such authority is essential if the State is to meet the requirements of the Clean Water Act. Water use objectives and supporting water quality standards were initially adopted for interstate waters in Wisconsin on June 1, 1967, and for intrastate waters on September 1, 1968. Administrative Code Chapters NR 102 through NR 105 comprise the water quality standards for the surface waters of the State. On October 1, 1973, the Wisconsin Natural Resources Board adopted revised water use objectives and supporting water quality standards which were set forth in *Wisconsin Administrative Code* Chapters NR 102 and 104. On October 1, 1976, Administrative Code Chapter NR 104 was repealed and a new chapter was created. Code Chapter NR 105, which establishes surface water quality criteria for toxic substances, took effect on March 1, 1989. Code Chapter NR 106, which also took effect on March 1, 1989, establishes procedures for calculating water quality-based effluent limitations for toxic and organoleptic substances discharged to surface waters. Such effluent limitations are essential to assure that the water quality standards set forth in Chapters NR 102 through NR 105 are attained. Chapter NR 103, which establishes water quality standards for wetlands, took effect on August 1, 1991.

Water quality standards have been promulgated by the Department for the following major water uses in Southeastern Wisconsin:

1. <u>Great Lakes Communities</u>: Streams classified under this category are those waters which drain to Lake Michigan and its bays, arms, and inlets, which serve as spawning areas for anadromous fishes.

2. <u>Coldwater Biological Communities</u>: Streams classified under this category are capable of supporting a community of coldwater fish and other aquatic life or serve as spawning areas for coldwater sport fish species. This category includes, but is not restricted to, surface waters identified as trout waters by the WDNR. Also included in this classification are coldwater streams which, although too small to support sport fish, are capable of supporting an abundant and diverse population of forage fish and macroinvertebrates which are intolerant of pollution.

3. <u>Warmwater Sport Fish Communities</u>: Streams placed under this classification are capable of supporting a warmwater sport fishery or they serve as spawning areas for warmwater sport fish species such as walleyed pike, bluegill, largemouth bass, and smallmouth bass. Also present are aquatic macroinvertebrates which are relatively intolerant of pollution.

4. <u>Warmwater Forage Fish Communities</u>: This category includes surface waters with natural water quality and habitat capable of supporting an abundant, usually diverse, community of forage fish (shiners, minnows) or aquatic macroinvertebrates (insects, clams, crayfish) which are relatively intolerant of pollution. These streams are generally too small to support sport fish species. Streams capable of supporting valuable populations of pollution-tolerant forage fish are also included in this classification.

5. Limited Forage Fish Communities (Intermediate Surface Waters): Streams within this classification are of limited capacity, naturally poor water quality, and deficient habitat. These intermediate surface waters are capable of supporting only a limited community of pollution-tolerant forage fish and aquatic macroinvertebrates.

6. Limited Aquatic Life (Marginal Surface Waters): Streams with this classification have a severely limited capacity, naturally poor water quality, and deficient habitat. These marginal surface waters are only capable of supporting a limited community of aquatic life.

As set forth in the following section, there are also minimum standards which apply to all waters. The existing water use objectives for all stream channels studied within the Des Plaines River watershed, as adopted by the WDNR, are shown on Map 56, and applicable water quality standards for all water uses designated in Southeastern Wisconsin are set forth in Table 92.[3] Map 56 shows that water uses 3, 5, and 6 in the above list are assigned by the Department to streams in the watershed.

The water quality standards are statements of the physical, chemical, and biological characteristics of the water that must be maintained if the water is to be suitable for the specified uses. Chapter 281 of the *Wisconsin Statutes* recognizes that different standards may be required for different waters or portions thereof. According to the Chapter, in all cases the "standards of quality shall be such as to protect the public interest, which includes the protection of the public health and welfare and the present and prospective future use of such waters for public and private water supplies; propagation of fish and aquatic life and wildlife; domestic and recreational purposes; and agricultural, commercial, industrial and other legitimate uses."[4]

Minimum Standards
All surface waters must meet certain conditions at all times and under all flow conditions. Chapter NR 102 of the *Wisconsin Administrative Code* states that:

> "Practices attributable to municipal, industrial, commercial, domestic, agricultural, land development or other activities shall be controlled so that all waters including the mixing zone and the effluent channel meet the following conditions at all times and under all flow conditions:
>
> "(a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in the waters of the State.
>
> "(b) Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to interfere with public rights in the waters of the State.
>
> "(c) Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in the waters of the State.

[3]*The water quality standards adopted by the Wisconsin Department of Natural Resources are used for regulatory purposes. The standards adopted by the Regional Planning Commission for planning purposes are set forth in Chapter X. The Commission standards differ somewhat from the Department standards because of their application for planning, rather than regulatory, purposes.*

[4]Wisconsin Statute *Section 281.15(1).*

"(d) Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life."[5]

Recreational Use
Waters to be used for recreational purposes should be aesthetically attractive, free of substances that are toxic upon ingestion or irritating to the skin upon contact, and void of pathogenic organisms. The first two conditions are satisfied if the water meets the minimum standards for all waters as previously described, whereas the third condition requires that a standard be set to ensure the safety of water from the standpoint of health. The concentration of fecal bacteria is the indicator now used by the Wisconsin Department of Natural Resources for this purpose. Since the fecal coliform count is only an indicator of a potential public health hazard, the Wisconsin standards specify that a thorough sanitary survey to assure protection from fecal contamination be the chief criterion for determining recreational suitability.

Fish and Aquatic Life
The limited forage fish and aquatic life categories apply to streams for restricted use downstream from an area of intense urban development or where wastewater has a predominant influence. These categories are used to signify conditions which may be hazardous to health upon whole or partial body contact.

Application of the Water Use Objectives to the Des Plaines River Watershed
The application of the basic categories of water use objectives require specification of a design low flow at, or above, which the water quality standards commensurate with each water use objective are to be met. The water use objectives state that compliance with the supporting standards is to be evaluated on the basis of streamflow as low as the seven-day, 10-year low flow, which is defined as the minimum seven-day mean low flow expected to occur once on the average of every 10 years. That is, for a given water use objective, the stream water quality is to be such as to satisfy the supporting standards for all streamflow conditions at or above the seven-day, 10-year low flow. The biological water use objectives established as of 2002 by the WDNR for the surface waters of the Des Plaines River watershed are warmwater sport fish community, limited forage fish community, and limited aquatic life. The State-adopted water use objectives are identical to the Regional Planning Commission-recommended objectives, except as noted in Table 98 in Chapter X of this report. Based on changes in the quality of discharges to streams in the watershed, either from the addition or subtraction of point discharges (through the construction or abandonment of sewage treatment plants), the WDNR has proposed revisions to the State-adopted water use objectives. Those revisions are listed in Table 93. The water use objectives that are recommended under this watershed study are consistent with the revisions proposed by the WDNR.

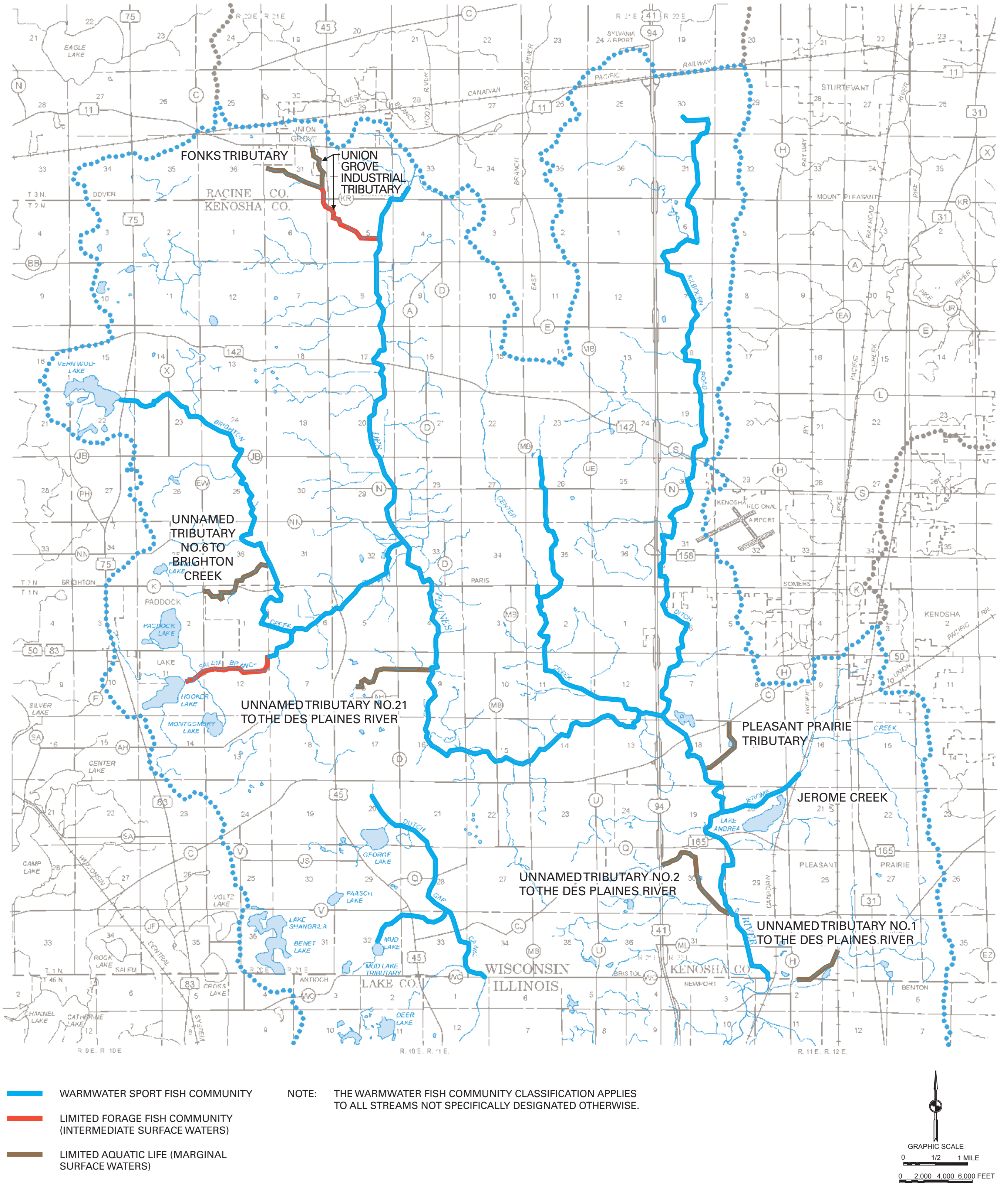
Water Pollution Abatement Programs
Section 281.58 of the *Wisconsin Statutes* authorizes the WDNR to provide financial assistance through the Clean Water Fund Loan Program for the construction of point source pollution abatement facilities necessary for the protection of State waters. The rules governing the Clean Water Fund small loan interest rate subsidy program are set forth in Chapter NR 165 of the *Wisconsin Administrative Code*. Under this program, communities proposing eligible projects may receive loans at or below market interest rates. The program establishes three tiers of projects which may be eligible for loan interest rates ranging from 55 to 100 percent of the market rate.

Chapter Comm 87, which was created on February 1, 1999, pursuant to Section 145.245 of the *Wisconsin Statutes*, sets forth rules for the implementation and administration of the State financial assistance program for

[5]Wisconsin Administrative Code *Chapter NR 102.04.*

Map 56

WATER USE OBJECTIVES FOR SURFACE WATERS IN THE DES PLAINES RIVER WATERSHED ADOPTED BY THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES: 2002



Water use objectives and supporting water quality standards for all surface waters in the Des Plaines River watershed are established by the Wisconsin Department of Natural Resources and are reviewed and revised, as appropriate, at least every three years under the provision of the Federal Clean Water Act. The existing DNR water use objectives shown above served as a point of departure for the development of the water use objectives and supporting water quality standards recommended in the Commission's areawide water quality management planning program. The results of which constitute the basic water quality management elements of the Des Plaines River watershed plan. The recommended water use objectives and supporting standards which were used in the development of the comprehensive plan for the Des Plaines River watershed are set forth on Map 59 and in Tables 96 and 97 in Chapter X of this report.

Source: SEWRPC.

Table 92

EXISTING DEPARTMENT OF NATURAL RESOURCES WATER USE OBJECTIVES AND WATER QUALITY STANDARDS FOR SURFACE WATERS IN THE SOUTHEASTERN WISCONSIN REGION: 2002

Water Quality Parameter	Individual Water Use Objectives Applicable to Surface Waters[a]				
	Warmwater Sport Fish Communities	Warmwater Forage Fish and Aquatic Life	Coldwater Communities	Limited Forage Fish Communities (Intermediate Surface Waters)[b]	Limited Aquatic Life (marginal surface waters)[c]
Maximum Temperature (°F)	89	89[d,e]	- -[d,e,f]	89[d,e]	89[d,e]
pH Range (S.U.)	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]
Minimum Dissolved Oxygen (mg/l)	5.0	5.0[e]	6.0[e]	3.0[e]	1.0[e]
Total Ammonia Nitrogen (mg/l)	- -	- -	- -	3/6[h]	- -
Other	- -[i]	- -[i]	- -[i,j]	- -[i,k]	- -[i,l]

[a]*All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the State. Materials producing color, odor, taste, or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life.*

[b]*Includes selected continuous and noncontinuous streams as specified by the DNR on the basis of field surveys and identified as "surface waters not supporting a balanced aquatic community (intermediate aquatic life)." (See* Wisconsin Administrative Code*, Chapter NR 104.02(3)(a).)*

[c]*Includes all effluent channels used predominantly for waste carriage and assimilation, wetlands, and diffuse surface waters, and includes selected continuous and noncontinuous streams as specified by the DNR on the basis of field surveys and identified as "marginal surface waters" (See* Wisconsin Administrative Code*, Chapter NR 104.02(3)(b).)*

[d]*There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the existing natural temperature shall not exceed 5°F for streams and 3°F for lakes.*

[e]*Dissolved oxygen and temperature standards apply to streams and the epilimnion of stratified lakes and to unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. Trends in the period of anaerobic conditions in the hypolimnion of deep inland lakes should be considered important to the maintenance of their natural water quality, however.*

[f]*There shall be no significant artificial increases in temperature where natural trout or salmon reproduction is to be protected. Dissolved oxygen shall not be lowered to less than 7.0 mg/l during the trout spawning season. The dissolved oxygen in the Great Lakes tributaries used by salmonids for spawning runs shall not be lowered below natural background levels during the period of habitation.*

[g]*The pH shall be within the range of 6.0 to 9.0 standard units, with no change greater than 0.5 unit outside the estimated natural seasonal maximum and minimum.*

[h]*Ammonia nitrogen (as N) at all points in the receiving water shall not be greater than 3 mg/l during warm temperature conditions, nor greater than 6 mg/l during cold temperatures to minimize the zone of toxicity and to reduce dissolved oxygen depletion caused by oxidation of the ammonia.*

[i]*Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life. Surface waters shall meet the acute and chronic criteria as set forth in, or developed pursuant to, Sections NR 105.05 and 105.06 of the* Wisconsin Administrative Code.

[j]*Streams classified as trout waters by the DNR (Wisconsin Trout Streams, publication 6-3600) or as Great Lakes or coldwater communities shall not be altered from natural background temperature and dissolved oxygen levels to such an extent that trout populations are adversely affected.*

[k]*All other substances shall meet the acute and chronic toxicity criteria for limited forage fish communities specified in or developed pursuant to Sections NR 105.05 and 105.06 of the* Wisconsin Administrative Code.

[l]*All other substances shall meet the acute and chronic toxicity criteria for the limited aquatic life subcategory communities specified in, or developed pursuant to, Sections NR 105.05 and 105.06 of the* Wisconsin Administrative Code.

Source: Wisconsin Department of Natural Resources.

Table 93

PROPOSED REVISIONS TO WATER USE OBJECTIVES SET FORTH IN CHAPTERS NR 102 AND NR 104 OF THE WISCONSIN ADMINISTRATIVE CODE

Number in Table 4, Section NR 104.06	Stream Reach	Water Use Objective per S. NR 104.06	Proposed Water Use Objective	Notes
19	Unnamed Tributary No. 1 to the Des Plaines River	Limited aquatic life	Warmwater sport fish	Point source discharge recommended to be eliminated
31	Des Plaines River tributary to WisDOT Kenosha Rest Area 26 (Unnamed Tributary No. 2 to the Des Plaines River)	Limited aquatic life	Warmwater sport fish	Point source discharge eliminated
- -	Des Plaines River tributary to Kenosha Beef International (Unnamed Tributary to Center Creek)	Warmwater sport fish Warmwater sport fish	Limited aquatic life Limited forage fish	New point source
18	Pleasant Prairie Tributary	Limited aquatic life	Warmwater sport fish	Point source discharge recommended to be eliminated
22	Salem Branch of Brighton Creek from Hooker Lake to 216th Avenue	Limited forage fish	Warmwater sport fish	Point source discharge eliminated
2	Unnamed Tributary No. 21 to the Des Plaines River (Town of Bristol)	Limited aquatic life	Warmwater sport fish	Effluent limits set to be protective of the Des Plaines River
15	Unnamed Tributary No. 6 to Brighton Creek (Village of Paddock Lake sewage treatment plant discharge)	Limited aquatic life	Warmwater sport fish	Point source discharge eliminated Establish effluent limits to protect Brighton Creek

Source: Wisconsin Department of Natural Resources and SEWRPC.

the replacement or rehabilitation of failing private sewage systems. In order for residences or small commercial establishments to be eligible for State grants, the county where the grant applicants are located must be designated as a participating governmental unit, as specified in Section 145.245(9). Both Kenosha and Racine Counties are participating governmental units.

The Code identifies the following three categories of failing private systems:

- Category 1: Private systems, the failure of which results in the discharge of sewage in surface water or groundwater; the introduction of sewage into saturation zones; or the discharge of sewage to a drain tile or into bedrock zones.

- Category 2: Private systems discharging sewage to the ground surface.

- Category 3: Private systems which fail to accept discharges of sewage, resulting in the backup of sewage into the structure served by the system.

Only principal residences or small commercial establishments constructed prior to July 1, 1978, are eligible for financial assistance for replacement or rehabilitation of failing systems. In addition, eligible principal residences must have annual family incomes of $45,000 or less, and eligible small commercial establishments must have annual gross revenues of $362,500 or less.

Effluent Reporting and Monitoring System
Section 299.15 of the *Wisconsin Statutes* directs the WDNR to require by rule that persons discharging industrial wastes, toxic and hazardous substances, or air contaminants submit a report on such discharges to the Department. The law further establishes an annual monitoring fee to provide for the cost of administering the program. In response to this statutory mandate, the Department prepared and adopted Chapter NR 101 of the *Wisconsin Administrative Code*, setting forth specific rules by which the reporting and monitoring program is to be conducted.

Pollutant Discharge Permit System
Sections 283.31(1) and 283.33 of the *Wisconsin Statutes* require a permit for the legal discharge of any pollutant into the waters of the State, including groundwaters. This State pollutant discharge permit system was established by the Wisconsin Legislature in direct response to the requirements of the Clean Water Act. While the Federal law envisioned requiring a permit only for the discharge of pollutants into navigable waters, in Wisconsin, permits are required for discharges from point sources of pollution to all surface waters of the State and, additionally, to land areas where pollutants may percolate or seep to, or be leached to, groundwater. The Wisconsin Pollutant Discharge Elimination System (WPDES) permitting program provides a major vehicle for achievement of the basic goal of meeting the water use objectives for the receiving waters to the extent that the permits are consistent with the water quality management plans prepared pursuant to the terms of the Clean Water Act.

Rules relating to the WPDES are initially set forth in Chapter NR 200 of the *Wisconsin Administrative Code*, the current version of which became effective on June 1, 1985. The following types of discharges require permits under Chapter NR 200:

1. The direct discharge of any pollutant to any surface water.

2. The discharge of any pollutant, including cooling waters, to any surface water through any storm sewer system not discharging to publicly owned treatment works.

3. The discharge of pollutants other than from agricultural uses for the purpose of disposal, treatment, or containment on land areas, including land disposal systems such as ridge and furrow, irrigation, and ponding systems.

4. Discharge from an animal feeding operation where the operation causes the discharge of a significant amount of pollutants to waters of the State and the owner or operator of the operation does not implement remedial measures as required under a notice of discharge issued by the WDNR under Chapter NR 243, which deals with animal waste management.

Certain discharges are exempt from the permit system, as set forth under Chapter NR 200, including discharges to publicly owned sewerage works, discharges from vessels and discharges from properly functioning marine engines and discharges of domestic sewage to septic tanks and drain fields, regulated under another chapter of the *Wisconsin Administrative Code*. Also exempted are the disposal of septic tank pumpage and other domestic waste, also regulated by another chapter of the *Wisconsin Administrative Code*; the disposal of solid wastes, including wet or semi-liquid wastes, when disposed of at a site licensed pursuant to another chapter of the *Wisconsin Administrative Code*; discharges from private alcohol fuel production systems; and discharges included under a general permit. The WPDES enables the accumulation of data concerning point sources of pollution and requires a listing of the treatment requirements and a schedule of compliance setting forth dates by which various stages of the requirements imposed by the permit shall be achieved.

As noted earlier in this chapter, the 1987 amendments to the Federal Clean Water Act established a Federal program for permitting stormwater discharges. The State of Wisconsin obtained certification from the U.S. EPA which enabled the State to administer the stormwater discharge permitting program as an extension of the existing WPDES program. Section 283.33 of the Statutes, which provides authority for the issuance of stormwater discharge permits by the State, was enacted in 1993. The administrative rules for the State stormwater discharge permit program are set forth in Chapter NR 216 of the Administrative Code, which took effect on November 1, 1994.

The following entities are required to obtain discharge permits under Chapter NR 216:

1. Municipal separate storm sewer systems serving incorporated areas with a population of 100,000 or more.

2. Municipalities in Great Lakes areas of concern.

3. Municipalities which have populations of 50,000 or more and which are located in priority watersheds.

4. Discharges from a municipal separate storm sewer system which either contribute to a violation of a water quality standard or are a significant contributor of pollutants to waters of the State. Such municipal discharges may be designated by the WDNR or nominated for permitting by other designated municipalities or the public, and then approved by the Department. The municipalities listed under 1 through 3 above may designate others for permitting.

5. Industries identified in Section NR 216.21.

6. Construction sites, except those associated with agricultural land uses, those for commercial buildings regulated by Chapters COMM 50 through 64 of the *Wisconsin Administrative Code*,[6,7] and Wisconsin Department of Transportation projects which are subject to the liaison cooperative agreement between the WDNR and WisDOT.

The only community in the Des Plaines River watershed that is currently required to obtain a stormwater discharge permit under Chapter NR 216 is the Town of Mt. Pleasant. The Town was designated on the basis that runoff from the Town is tributary to the stormwater infrastructure system of the City of Racine, which is required to obtain a permit based on its population and location in the Root River priority watershed. The City of Kenosha and the Village of Pleasant Prairie are likely to be included under Phase II of the stormwater discharge permit program in 2003. All counties in Southeastern Wisconsin, including Kenosha and Racine Counties, have preliminarily been identified as urbanized areas that could be required to obtain permits under Phase II for county-owned and operated properties.

State Performance Standards for Control of Nonpoint Source Pollution

Through 1997 Wisconsin Act 27, the State Legislature required the WDNR and DATCP to develop performance standards for controlling nonpoint source pollution from agricultural and nonagricultural land and from transportation facilities.[8] These performance standards serve as an important element of land and water resource management activities and programs.

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[6]*COMM 50.115 describes procedures to be followed regarding filing a notice of intent for coverage under a WPDES General Permit for stormwater discharges associated with construction activities.*

[7]*Construction of one- and two-family dwellings is generally regulated by the Wisconsin Department of Commerce. COMM 21.125 sets forth erosion control procedures for construction of one- and two-family dwellings. Owners of properties on which such dwellings are to be constructed would only have to apply for a permit under Chapter NR 216 if the land disturbing activities associated with the development involved the disturbance of five or more acres .On March 10, 2003, the disturbance area automatically reduces to one acre.*

[8]*The State performance standards are set forth in the Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code. *Additional Code chapters that are related to the redesign of the State nonpoint source pollution control program include: Chapter NR 152, "Model Ordinances for Construction Site Erosion Control (Footnote Continued)*

Agricultural Performance Standards
Agricultural performance standards cover the following areas:

- Cropland soil erosion control,
- Manure management and storage,
- Nutrient management, and
- Clean water diversions.

Nonagricultural (urban) Performance Standards
The nonagricultural performance standards encompass two major types of land management. The first includes standards for areas of new development and redevelopment and the second includes standards for developed urban areas. The performance standards address the following areas:

- Construction sites for new development and redevelopment,
- Post construction phase for new development and redevelopment,
- Developed urban areas, and
- Nonmunicipal property fertilizing.

Transportation Facility Performance Standards
Transportation facility performance standards have been drafted covering the following areas:

- Construction sites,
- Post-construction phase, and
- Developed urban areas

Sanitary Sewerage System Plans
Under Wisconsin law and administrative rules, the State of Wisconsin is required to review and take action to approve or reject plans for proposed sewerage facilities. The review and action is guided by the adopted areawide water quality management plan. Under Chapter 281 of the *Wisconsin Statutes*, the State must find certain actions to be in accordance with the adopted and endorsed plan. These actions by the State include, among others, approval of locally proposed sanitary sewer extensions. In addition, the water quality management plan recommends that important natural resources, including surface waters and associated floodlands and shorelands, wetlands, woodlands, wildlife habitat, and areas of steep slope and rough topography, be preserved in natural, open uses.

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and Storm Water Management," Chapter NR 153, "Runoff Management Grant Program," Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions," and Chapter NR 155 "Urban Nonpoint Source Water Pollution Abatement and Stormwater Management Grant Program." Those chapters of the Wisconsin Administrative Code *became effective in October 2002. To reflect the program redesign, Chapter NR 216, "Storm Water Discharge Permits," was amended. Chapter NR 120, "Priority Watershed and Priority Lake Program," and Chapter NR 243, "Animal Feeding Operations," were proposed to be repealed and recreated. The Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) revised Chapter ATCP 50, "Soil and Water Resource Management," to incorporate changes in DATCP programs as required under 1997 Wisconsin Act 27.*

Chapters NR 110 and COMM 82 of the *Wisconsin Administrative Code* require that the WDNR, with respect to public sanitary sewers, and the Wisconsin Department of Commerce, with respect to private sanitary sewers, make a finding that all proposed sanitary sewer extensions be in conformance with adopted areawide water quality management plans. These Departments, in carrying out their responsibilities, require that the Southeastern Wisconsin Regional Planning Commission, as the designated areawide water quality management planning agency for the Southeastern Wisconsin Region, review and comment on each proposed sewer extension as to its relationship to the approved water quality management plan.

More specifically, with respect to the granting of a public sanitary sewer service extension permit, under Sections NR 110.08(4) and NR 121.05, the WDNR must make a finding that the area proposed to be served is located 1) within an approved sewer service area, and 2) outside of areas having physical or environmental constraints which, if developed, would have adverse water quality impacts. Areas having such physical or environmental constraints may include wetlands, shorelands, floodways and floodplains, steep slopes, highly erodible soils and other limiting soil types, and groundwater recharge areas.

With respect to the granting of a private sewer connection permit, under Section COMM 82.20(4), the Wisconsin Department of Commerce, like the WDNR as described above, must make a finding that the buildings proposed to be served through a private sewer connection are located 1) within an approved sewer service area and 2) outside of areas having physical or environmental constraints which, if developed, would have adverse water quality impacts.

In order properly to reflect local, as well as areawide, planning concerns in the execution of this review responsibility, the Regional Planning Commission, in adopting the areawide water quality management plan, recommended that steps be taken to refine and detail each of the sanitary sewer service areas delineated in the plan. The preparation of refined sanitary sewer service area plans and sewerage facilities plans is intended to provide the means to adjust the recommended sewer service areas to meet local needs and objectives within the framework of the regional plans.

Private Sewage System Regulation
The Wisconsin Department of Commerce is charged with the responsibility of regulating the installation of private sewage systems, including septic tank, mound, aerobic, and sand filter sewage disposal systems. Such systems often contribute to the pollution of surface water and groundwater. Pursuant to Chapter 236 of the *Wisconsin Statutes*, the Department of Commerce reviews plats of all land subdivisions not served by public sanitary sewerage systems and may object to such plats if sanitary waste disposal facilities are not properly provided for in the plat layout. Basic regulations governing the installation of private sewage systems are set forth in Chapter Comm 83 of the *Wisconsin Administrative Code*.

Chapter NR 113.07 (1)(e) of the *Wisconsin Administrative Code* requires that large commercial, industrial, or residential development sewage holding tank systems that singly, in combination, or as increased by successive additions, generate 3,000 gallons of holding tank waste per day or more must have a contract with a public wastewater treatment facility for the treatment of the waste. The sewer service area attendant to the wastewater treatment facility must include the commercial, industrial, recreational, or residential development. The WDNR may not indicate sufficient disposal capacity to the Department of Commerce until the needed sewer service area adjustments have been completed and approved.

Wisconsin Environmental Policy Act
In April 1972, the Wisconsin Legislature created Section 1.11 of the *Wisconsin Statutes* concerning governmental consideration of environmental impact. In many ways, the State legislation parallels the NEPA of 1969 discussed earlier in this chapter. Under this legislation, all agencies of the State must include an environmental assessment in every recommendation or report on proposals for legislation or other major actions which would significantly affect the quality of the human environment. The required contents of this assessment parallel the contents required in the Federal environmental assessments. The effect of the State legislation is, therefore, to extend the environmental assessment concept to all State action not already covered under the Federal action.

The Act requires that an assessment be prepared on: 1) the environmental impact of a proposed action, 2) any adverse environmental effects which cannot be avoided should a proposal be implemented, 3) alternatives to a proposed action, 4) the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, 5) any irreversible and irretrievable commitments of resources which would be involved in a proposed action should it be implemented, and 6) the details of the beneficial aspects of a proposed project, both short-term and long-term, and the economic advantages of the proposal. As such, the Wisconsin Environmental Policy Act has been designed to encourage more environmentally sensitive decisions by State agencies and to encourage a broader citizen participation in the decision-making process.[9]

Chapter NR 150 of the *Wisconsin Administrative Code* sets forth the general policy concerning actions by State agencies and the effects of these actions on the environment, sets forth the criteria for determining whether an environmental assessment or impact statement must be prepared, and establishes guidelines for the preparation and review of any required environmental evaluation of State actions.

Under Chapter NR 150, the WDNR specifies its intention to encourage productive and enjoyable harmony among people and their environment, to promote efforts that minimize harm to the environment, and to promote the understanding of the important ecological systems and natural resources of the State. The Department also recognizes its responsibilities as the State environmental agency for evaluating, coordinating, and communicating information on all actions by State and Federal agencies which may affect natural resources and overall environment for life in the State.

Under Chapter NR 150, the Department identifies potential action types by State and Federal agencies and establishes categories for those actions, importantly including regulatory actions, for which environmental impact evaluations would be required.[10]

Type I actions are "major" actions which would significantly affect the quality of the human environment. The preparation of an environmental impact statement is required for any Type I action by a State or Federal agency. Examples of Type I actions include establishment of land acquisition projects over 1,000 acres in size involving a proposed change in land use, State regulatory action involving a new hazardous waste disposal facility over 80 acres in size, and State regulatory action involving new large electric generating facilities.

Type II actions are actions which have the potential to have significant environmental effects and may involve unresolved conflicts in the use of available resources. The preparation of an environmental assessment is generally required for Type II actions. Examples of Type II actions include approvals to change the course of more than 500 feet of stream; permits to divert water for nonagricultural purposes; permits to enclose navigable waterways; establishment of land acquisition projects less than 1,000 acres in size or those acquisition projects larger than 1,000 acres in size not resulting in a land use change; habitat management activities involving filling or draining of wetlands; draining or filling affecting wetlands greater than five acres in size; acquisition of parcels located outside of established project boundaries where the total area planned for acquisition exceeds 160 acres; and stocking or introduction of fish or wildlife species that are not native to, or established in, the State.

Type III actions are actions which normally do not have the potential to have significant environmental effects, normally do not significantly affect energy usage, and normally do not involve unresolved conflicts in the use of available resources. Type III actions generally require the issuance of a news release and may require the

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[9]A Citizen Guide to the Role of the Wisconsin Environmental Policy Act in DNR Decision-Making*, Madison, Wis., Wisconsin Department of Natural Resources, 1993.*

[10]*Section NR 150.02 defines "action" as "any final decision by the Department to commence, engage in, fund, approve, disapprove, conditionally approve, or otherwise carry out any activity, pursuit, or procedure, including proposals for legislation, which may affect the quality of the human environment."*

preparation of an environmental impact report providing information on the proposed action. Examples of Type III actions include approvals to change the course of 500 feet or less of a stream, draining or filling affecting wetlands less than five acres in size, permits to divert water for agricultural and irrigation purposes, acquisition and development of public sites for access to public waters, acquisition of parcels less than 160 acres in size located outside of established project boundaries, prescribed burning affecting less than 60 acres within State property, and silvicultural harvesting involving less than 160 acres within State property during a calendar year.

Type IV actions include enforcement activities; emergency activities to protect public health, safety, and welfare; and other actions which do not significantly affect the quality of the human environment, do not significantly affect energy usage, and do not involve unresolved conflicts in the use of available resources. Type IV actions generally do not require an environmental impact statement, an environmental assessment, or a news release, and are generally exempt from requirements under Chapter NR 150. Examples of Type IV actions include authority to construct bridges and roadway culverts across navigable waterways, approval of priority watershed plans, approval of floodplain zoning ordinances and amendments, nonpoint source pollution abatement grants, acquisition of parcels within established project boundaries, lake and stream habitat improvement, and trail construction for wildlife management purposes.

Under Chapter NR 150, guidelines for issue identification are set forth; the required contents of environmental impact statements, assessments, and reports are identified; procedures for statement, assessment, and report review are established; and public review and comment procedures are set forth.

Certain actions recommended in the Des Plaines River watershed plan could be classified as actions for which an environmental assessment or environmental impact report must be prepared.

Local Water Quality Management

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 the regulative sphere by virtue of its potential danger to health and welfare. Such local ordinances could not, however, conflict with Federal and State legislation.

Special Units of Government

In addition to providing broad grant of authority to general-purpose units of local government, the *Wisconsin Statutes* currently provide for the creation of six types of special-purpose units of government through which water pollution can be abated and water quality protected. These are: 1) metropolitan sewerage districts, 2) utility districts, 3) inland lake protection and rehabilitation districts, 4) town sanitary districts, 5) joint sewerage systems, and 6) cooperative action by contract.

Metropolitan Sewerage Districts

In 1972 the Wisconsin Legislature enacted into law new enabling legislation for the creation of metropolitan sewerage districts outside Milwaukee County. This legislation is set forth in Sections 200.01 through 200.15 of the *Wisconsin Statutes*. This legislation stipulates that proceedings to create a metropolitan sewerage district may be initiated by resolution of the governmental body of any municipality. Such resolution, which must set forth a description of the territory proposed to be included in the district and a description of the functions proposed to be performed by the district, is submitted to the WDNR. Upon receipt of the resolution, the Department is required to schedule a public hearing for the purpose of permitting any persons to present information relating to the matter of the proposed metropolitan sewerage district. Within 90 days of the hearing, the Department must either order or deny the formation of the proposed district. The Department must order the formation of the district if it finds that the district consists of at least one municipality in its entirety and all or part of other municipalities; if the district is determined to be conducive to management of a unified system of sewage collection and treatment; if the formation of the district will promote sound sewerage management policies and operation and is consistent with adopted plans of municipal, regional, and State agencies; and if the formation of the district will promote the public health and welfare and effect efficiency and economy in sewerage management. No territory of a city or village jointly or separately owning or operating a sewage collection or disposal system may be included in the district, however, unless it has filed with the WDNR a certified copy of a resolution of its governing body consenting to the inclusion of its territory within the proposed district. No metropolitan sewerage districts had been created in the Des Plaines River watershed as of 1995; however, as set forth in a subsequent section of this chapter, the 1991 sanitary sewer system and water supply plan for the greater Kenosha area recommends the formation of an authority similar to a metropolitan sewerage district with the exception that the authority would also provide water supply service.

Utility Districts
Section 66.0827 of the *Wisconsin Statutes* permits towns, villages, and cities of the third and fourth class to establish utility districts for a number of municipal improvement functions, including the provision of sanitary sewer service. Funds for the provision of services within the district which are not paid for through special assessments are provided by levying a tax upon all property within the district. The establishment of utility districts requires a majority vote in towns and a three-fourths vote in cities and villages. Prior to establishing such a district, the local governing bodies are required to hold a formal public hearing.

There are several utility districts which provide sewer or water service, or both, within the Des Plaines River watershed. Such districts are located in the Villages of Paddock Lake and Pleasant Prairie and in the Towns of Bristol and Salem. The districts are described in Chapter III of this report.

Inland Lake Protection and Rehabilitation Districts
Inland lake protection and rehabilitation districts are special-purpose units of government created pursuant to Chapter 33 of the *Wisconsin Statutes*. There are three such districts in the watershed: 1) the George Lake Protection and Rehabilitation Inland District, 2) the Hooker Lake Management District, and 3) the Paddock Lake Inland Lake Protection and Rehabilitation District.

Town Sanitary Districts
Town sanitary districts may be created, pursuant to Section 60.70 of the *Wisconsin Statutes*, to plan, construct, and maintain sanitary and storm sewers and sewage treatment and sewage disposal systems. A town sanitary district may offer its services outside its jurisdictional area on a reimbursable basis. In addition, the Wisconsin Legislature, in Section 60.71(5) of the *Wisconsin Statutes*, evidenced an intent that town sanitary districts be created to provide auxiliary sewer construction in unincorporated areas of metropolitan sewerage districts. Town sanitary districts are usually created by the town board upon petition of 51 percent of the property owners or the owners of 51 percent of the property within the proposed district. The WDNR may, however, upon finding that private sewage disposal or water supply systems constitute a public health menace and that there is no local action evident to correct the situation, order the creation of such districts. One such district, the Town of Pleasant Prairie Sanitary District No. 73-1, was created in the Des Plaines River watershed in 1975. That District continued to operate following incorporation of the Town as a Village in 1989.

Joint Sewerage Systems
Section 281.43 of the *Wisconsin Statutes* provides the authority for a group of governmental units, including cities, villages, and town sanitary or utility districts, to construct and operate a joint sewerage system following a hearing and approval by the WDNR. The Statute stipulates that when one governmental unit renders such service as sewage conveyance and treatment to another unit under this section, reasonable compensation is to be paid. Such reasonable charges are to be determined by the governmental unit furnishing the service. If the governmental unit receiving this service deems the charge unreasonable, the Statutes provide for either binding arbitration by a panel of three reputable and experienced engineers or judicial review in the circuit court of the county of the governmental unit furnishing the service. As an alternative, the jointly acting governmental units may create a sewerage commission to plan, construct, and maintain in the area sewerage facilities for the collection, transmission, and treatment of sewage. Such a commission becomes a municipal corporation and has all the powers of a common council and board of public works in carrying out its duties. However, all bond issues and appropriations made by such a commission are subject to approval by the governing bodies of the units of

government which initially formed the commission. The Statutes stipulate that each governmental unit must pay its proportionate share of constructing, operating, and maintaining the joint sewerage system. Grievances concerning the same may be taken to the circuit court of the county in which the aggrieved governmental unit is located. There were no joint sewerage systems in the Des Plaines River watershed as of 2002 and, given the governmental structure in the watershed, none are likely to be needed or created in the future.

Cooperative Action by Contract

Section 66.0301 of the *Wisconsin Statutes* permits the joint exercise by municipalities, broadly defined to include the State or any department or agency thereof or numerous other units of government, including, but not limited to, any city, village, town, county, public inland lake protection and rehabilitation district, sanitary district, farm drainage district, metropolitan sewerage district, sewer utility district, water utility district, or regional planning commission, of any power or duty required of, or authorized to, individual municipalities by Statute. To exercise any such power jointly, such as the transmission, treatment, and disposal of sanitary sewage, municipalities would have to create a commission by contract. Appendix A of SEWRPC Technical Report No. 6, *Planning Law in Southeastern Wisconsin*, contains a model agreement creating such a cooperative contract commission.

Within the Des Plaines River watershed, there are currently contracts in force between the City of Kenosha and the Village of Pleasant Prairie and between the Village of Pleasant Prairie and the Town of Bristol for the provision of sewer and water service.[11]

Regulation of Private Sewage Disposal Systems

Sections 59.70 and 145.01(5) of the *Wisconsin Statutes* require that all Wisconsin counties, except counties with a population of 500,000 or more, adopt and administer an ordinance regulating private sewerage systems within the County. Kenosha and Racine Counties, in accordance with Chapters 59 and 145 of the State statutes, both enacted regulations applying to private sewage disposal systems in July 1980. The codes regulate the location, construction, installation, design, use, and maintenance of private waste disposal in the Counties. Regulations in the ordinance pertaining to private sewerage systems apply throughout each County, including cities and villages as well as unincorporated areas. The County sanitary code establishes site requirements for soil absorption sewage disposal systems, including percolation rates and minimum allowable depth to groundwater and bedrock.

Shoreland Regulation

The State Water Resources Act of 1965 provides for the regulation of shoreland uses along navigable waters to assist in water quality protection and pollution abatement and prevention. In Section 59.692(1) of the *Wisconsin Statutes*, the Legislature defines shorelands as all that area lying within the following distances from the ordinary high water mark of all natural lakes and of all streams, ponds, sloughs, flowages, and other waters which are navigable under the laws of the State of Wisconsin: 1,000 feet from a lake, pond, flowage, or glacial pothole lake and 300 feet from a stream or to the landward side of the floodplain, whichever is greater.[12]

Section 281.31 of the *Wisconsin Statutes* specifically authorizes municipal zoning regulations for shorelands. This Statute defines municipality as a county, city, or village. The shoreland regulations authorized by this Statute have

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[11] *The findings and recommendations of sanitary sewer and water supply system planning for the greater Kenosha area are presented in a report prepared by Ruekert & Mielke, Inc.,* A Coordinated Sanitary Sewer and Water Supply System Plan for the Greater Kenosha Area*, October 1991. The planning report recommends the creation of an areawide sewer and water authority serving the City of Kenosha, the Village of Pleasant Prairie, the Town of Somers, and portions of the Towns of Bristol and Paris. Because the authority would provide water-supply service, as well as sanitary-sewer service, enabling legislation would be required for the formation of the recommended authority.*

[12] *Definitive determination of navigability on a case-by-case basis is the responsibility of the Wisconsin Department of Natural Resources.*

been defined by the WDNR to include land subdivision controls and sanitary regulations. The purposes of zoning, land subdivision, and sanitary regulations in shoreland areas include the maintenance of safe and healthful conditions in riverine areas; the prevention and control of water pollution; the protection of spawning grounds, fish, and aquatic life; the control of building sites, placement of structures, and land use; and the preservation of shore cover and natural beauty.

The standards and criteria for county shoreland ordinances are set forth in Chapter NR 115 of the *Wisconsin Administrative Code*. Chapter NR 117 of the *Wisconsin Administrative Code* sets forth rules regarding shoreland-wetland zoning for cities and villages. The WDNR retains oversight responsibility for the implementation and enforcement of Chapters NR 115 and NR 117. In addition, the Department must review and approve all shoreland-wetland zoning ordinances, determine compliance, and monitor the rule.

County General and Floodland-Shoreland Zoning Ordinances
Zoning ordinances represent one of the most important means available to county and local units of government for managing land use in the public interest. In Wisconsin, counties, in cooperation with the towns, may enact a general, or comprehensive, zoning ordinance applicable to all unincorporated areas of the county. Such a general county zoning ordinance, however, becomes effective only in those towns which act to ratify the county ordinance.

In addition to the general zoning ordinance, counties are required, under the State Water Resources Act of 1965 and Section 59.692 of the *Wisconsin Statutes*, to adopt a shoreland zoning ordinance and Section 87.30 requires the adoption of a floodland zoning ordinance. Because of the interrelationship of the shoreland and floodland areas, Kenosha and Racine Counties have each enacted a combined floodland-shoreland ordinance. This ordinance is intended to promote public safety and health by discouraging the location of flood-damage-prone land uses in areas subject to flood hazard and help preserve important natural resources in the floodland-shoreland area, thereby protecting and enhancing water quality. Town ratification of floodland-shoreland ordinances is not required and, indeed, towns have no zoning jurisdiction in shoreland areas in those cases where towns are under the County-sponsored zoning program.

The standards and criteria for county shoreland ordinances as set forth in Chapter NR 115 of the *Wisconsin Administrative Code* include restrictions on lot sizes, including a minimum average width of 65 feet and minimum area of 10,000 square feet for lots served by public sanitary sewer and a minimum average width of 100 feet and a minimum area of 20,000 square feet for lots not served by public sanitary sewer; on building setbacks, including a normal minimum setback of 75 feet from the ordinary high water mark of any surface waterbody; on the cutting of trees and shrubbery; and on filling, grading, and dredging.

Under Chapter NR 115, counties are also required to place all wetlands five acres or larger in size as shown on the final Wisconsin Wetland Inventory Maps and located in the statutory shoreland zoning jurisdictional area into a shoreland-wetland zoning district, to establish land division regulations, and to establish sanitary regulations under a County private sewage system ordinance.

Permitted uses within the shoreland-wetland zoning district include hiking, fishing, hunting, trapping, harvest of wild crops, silviculture, pasturing of livestock, cultivation of crops provided that such "cultivation can be accomplished without filling, flooding, or artificial drainage of the wetland," repair of existing drainage systems, construction of certain utility lines, and construction and maintenance of duck blinds, piers, docks and walkways "provided that no filling, flooding, dredging, draining, ditching, tiling, or excavating is done."[13]

Counties are required to keep their regulations current and effective in order to remain in compliance with the statutes and minimum standards established by the WDNR. Chapter NR 115 of the Administrative Code requires

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[13] *See Chapter NR 115.05 (2)(c)* Wisconsin Administrative Code.

that any rezoning of wetlands within the shoreland area meets specific criteria. A rezoning, as well as a conditional use or variance, may not take place if the development permitted by the proposed rezoning would result in a significant adverse impact upon any of the following characteristics of the shoreland area:

1. Stormwater and floodwater storage capacity;

2. Maintenance of dry season streamflow, the discharge of groundwater to a wetland, the recharge of groundwater from a wetland to another area, or the flow of groundwater through a wetland;

3. Filtering or storage of sediments, nutrients, heavy metals, or organic compounds that would otherwise drain into navigable waters;

4. Shoreline protection against soil erosion;

5. Fish spawning, breeding, nursery, or feeding grounds;

6. Wildlife habitat; or

7. Areas of special recreational, scenic, or scientific interest, including scarce wetland types.

The county zoning agency must notify the WDNR of the proposed rezoning, hold a public hearing, and submit findings and recommendations to the county board. The Department must review and approve any proposed amendment of the zoning ordinance text or district map. If the county board approves the proposed zoning amendment and the Department determines, after review against the criteria set forth above, that the proposed rezoning would no longer comply with State requirements, the WDNR, after notice and hearing, must act to adopt a complying ordinance for the county.

Regulations related to floodland zoning regulations for counties, cities, and villages are set forth in Chapter NR 116 of the *Wisconsin Administrative Code*. Those regulations are described in more detail in a subsequent section of this chapter.

The Counties and Towns of Kenosha and Racine Counties have acted together to implement cooperatively the County-sponsored floodland and shoreland zoning ordinances. For all proposed activities within the floodland-shoreland jurisdictional area, the Counties seek town review, comments, and recommendations before taking action to approve or deny any proposed activity.[14]

Kenosha County most recently amended its combination general and floodland-shoreland zoning ordinance in August 1994. The ordinance is set forth in Chapter 12 of the Kenosha County Municipal Code. Racine County most recently amended its combination general and floodland-shoreland zoning ordinance in June 1999. The ordinance is set forth in Chapter 20 of the Racine County Municipal Code.

In both the Kenosha and Racine County ordinances, basic, or "underlying" zoning districts are applied to all lands and waters in those towns which have ratified the County ordinance. The regulations set forth for these basic districts are intended to guide the development and use of all structures, lands, and waters in these towns.

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[14]*An exception to the application of county zoning regulations in unincorporated areas of the watershed occurs in the Town of Mt. Pleasant, which administers a Town zoning ordinance. That ordinance establishes a Wetland-Floodplain zoning district. Under that Ordinance, the Town and Racine County share zoning regulation within the shoreland jurisdictional boundary. In general, within that boundary, the more restrictive of the Town or County zoning ordinances is applicable. Routine zoning decisions by the Town do not require the review and approval of County staff, but Town zoning ordinance amendments are subject to approval by the County Board.*

Under the Kenosha and Racine County combination general and floodland-shoreland zoning ordinances, "overlay" zoning districts are applied to those portions of the Counties lying within the regulatory shoreland jurisdictional area. The regulations set forth for these overlay districts are intended to prevent harm to public water resources and to guide the development and use of all structures, lands, and waters in the regulatory shoreland areas of the County. When the regulations in the overlay districts are more restrictive than those in the basic underlying districts, the regulations and restrictions of the overlay districts must be applied.

There is one basic district in the Kenosha County zoning ordinance, the C-1 Lowland Resource Conservancy District, and one overlay district, the FPO Floodplain Overlay District, which are applicable to shoreland-floodplain areas in Kenosha County within the Des Plaines River watershed. Shoreland-wetlands are included in the C-1 District. Under the ordinance, any filling within the Floodplain Overlay District must be offset by the provision of compensatory storage in an amount equal to the volume of filling below the 100-year recurrence interval flood stage.

There are two overlay districts, the GFO General Floodplain Overlay District and the SWO Shoreland-Wetland Overlay District, which are applicable to shoreland-floodplain areas in Racine County within the Des Plaines River watershed. Under the ordinance, any filling within the General Floodplain Overlay District requires a Limited Floodplain Boundary Adjustment, which stipulates that compensatory floodwater storage must be provided in an amount equal to the volume of filling below the 100-year recurrence interval flood stage.

City and Village Shoreland-Wetland Zoning
Shoreland-wetland zoning is also required by State law for cities and villages. The two sections of the *Wisconsin Statutes* applying to shoreland-wetlands in incorporated territory are 62.231 for cities and 61.351 for villages. Both sections require cities and villages to zone protectively those wetlands shown on the Wisconsin Wetland Inventory maps that are five acres or larger in size and located within the shoreland zone.

Chapter NR 117 of the State Administrative Code sets forth rules regarding shoreland-wetland zoning for cities and villages. The criteria concerning permitted uses, functional values and uses, and State review and oversight are, for the most part, the same as for county shoreland-wetland zoning. However, the rules regarding minimum lots sizes, building setbacks, and cutting of trees and shrubbery established in Chapter NR 115 for counties do not apply to cities and villages.

Wisconsin Wetland Inventory
To facilitate the protection of shoreland wetlands, the State Legislature in 1978 mandated the mapping of all wetlands in the State. The wetlands mapping program, officially known as the Wisconsin Wetland Inventory, resulted in the preparation by the Regional Planning Commission for the WDNR of wetland maps covering each U.S. Public Land Survey township in the seven-county Region. Wetlands in Kenosha and Racine Counties were delineated on Commission 1980 one inch equals 400 feet scale ratioed and rectified aerial photographs. The delineations were then transferred to Commission one inch equals 2,000 feet scale ratioed and rectified aerial photographs for duplicating purposes. The maps enable identification of the general location of wetlands; however, the determination of actual wetland boundaries related to activities which are to be located or conducted in the vicinity of wetlands requires a field identification and survey.

The Wisconsin Wetland Inventory maps serve as the basis for the identification of those wetlands to be regulated under Chapters NR 115 and 117. Under the procedures established by the WDNR to implement provisions of Chapters NR 115 and NR 117, preliminary wetland maps for each survey township within each respective county and for the affected cities and villages were provided by the State to the county zoning administrator or the appropriate city or village officials for review. Chapter NR 115 also required that the county zoning committee hold a public hearing to receive comments on the accuracy and completeness of the preliminary maps, that hearing notices be mailed to all town clerks, and that hearing notices be published as class one notices. Chapter NR 117 allowed for a similar hearing and notice procedure with the exception that the public hearing was not mandatory. Under both Chapters NR 115 and 117, following the review period and hearing, the final wetland maps were prepared and each county was required to amend, within six months of receiving the final maps, its shoreland-wetland zoning ordinance to protect all mapped wetlands within the shoreland areas.

Shoreland Zoning Regulations in Annexed Lands

According to Section 59.692(7)(a) of the *Wisconsin Statutes*, county shoreland zoning regulations remain in effect in areas which are annexed by a city or village after May 7, 1982, or for a town which incorporates as a city or village after April 30, 1994, unless the ordinance requirements of the annexing or incorporating city or village are at least as stringent as those of the county. The only exception to this condition is if, after annexation, the annexing municipality requests the county to amend the county ordinance to delete or modify provisions that establish specified land uses or requirements associated with those uses. In such a situation, stipulations regarding land uses or requirements may be amended only if the amendment does not provide less protection to navigable waters than was provided prior to the amendment.

Specific Floodland and Shoreland Zoning Requirements in the City of Kenosha and the Villages of the Des Plaines River Watershed

The City of Kenosha has a basic Floodway District and a Floodplain Fringe Overlay District which applies to floodlands which lie outside of the floodway. A Shoreland-Wetland Overlay District protects from urban encroachment all wetlands five acres or greater in area that are located within the statutory shoreland area as defined above.

There are no floodplains delineated within the Village of Paddock Lake under the National Flood Insurance Program (NFIP) and the Village has no floodplain zoning ordinance. The Village adopted a shoreland-wetland zoning ordinance on March 16, 1994.

Upon its incorporation in 1989, one of the first actions of the Village of Pleasant Prairie was to adopt an ordinance for the "carryover of functions and duties after incorporation." With the passage of that ordinance, the Village effectively adopted the Kenosha County zoning ordinance as its own. The Village zoning ordinance has been amended since incorporation. The amendments include creation of a Lowland Resource Conservancy District which protects shoreland wetlands. The Village shoreland-wetland ordinance was approved by the WDNR on March 30, 1995. On October 19, 1998, the Village of Pleasant Prairie adopted a rewritten Floodplain Overlay Zoning District section as an amendment to its "General Zoning and Shoreland/Floodplain Zoning Ordinance." The amendment specifically adopted the floodplain/floodway maps that were developed under this watershed study. The Village ordinance requires that any filling in the floodplain be offset by the provision of an equal volume of compensating storage in the floodplain.

The Village of Union Grove floodplain zoning requirements are set forth in Chapter 17 of the Village Code of Ordinances. The zoning ordinance establishes a General Floodplain Overlay District. In the Des Plaines River watershed, there are no flood-hazard areas within the Village which have been delineated under the National Flood Insurance Program. The Village of Union Grove does not have a shoreland-wetland zoning ordinance, because there are no wetlands larger than five acres in size located within the corporate boundaries of the Village.

State and County Soil and Water Conservation Programs

Chapter 92 of the *Wisconsin Statutes* designates the Department of Agriculture, Trade and Consumer Protection as the State agency responsible for "setting and implementing Statewide soil and water conservation policies and administering the State's soil and water conservation program." Chapter 92 also provides the authority for the establishment of the State Land and Water Conservation Board and requires the establishment of County Land Conservation Committees. The county committees carry out programs to control erosion, sedimentation, and nonpoint source water pollution. Those programs include the distribution of Federal, State, and county funds for soil and water conservation programs; the construction of facilities for flood control and water conservation, development, and utilization; the preparation and administration of a county erosion control plan; the monitoring of farmland preservation agreements to ensure that such agreements include soil and water conservation plans; the establishment of soil and water conservation standards; the enactment of ordinances to promote soil and water conservation and the abatement of nonpoint source pollution; and the establishment of a soil and water resource management program.

Chapter 92 also empowers counties, cities, and villages to establish agricultural shoreland management ordinances. In April 1995 the Department of Agriculture, Trade and Consumer Protection published a model agricultural shoreland management ordinance. The enactment of a State-approved ordinance by a local unit of government is a requirement prior to distribution to the unit of government or to landowners within that unit of government of State cost share funds for agricultural shoreland management measures.

Both Kenosha and Racine Counties have adopted agricultural soil erosion control plans pursuant to Section 92.10 of the *Wisconsin Statutes*.[15] Neither County has an ordinance for the purpose of soil and water conservation and the control of nonpoint source pollution.

However, as a result of passage of Wisconsin Act 27 in 1997, Chapter 92 was revised, leading to the requirement that each county in Wisconsin develop a land and water resource management plan to address both rural and urban nonpoint source problems. In September of 2000, both Racine and Kenosha Counties completed their land and water resource management plans,[16] as required under Chapter ATCP 50[17] of the *Wisconsin Administrative Code.*

Private Steps for Water Pollution Control

The foregoing discussion deals exclusively with the water pollution control and water quality preservation regulations available to units and agencies of government. However, direct action may also be taken by private individuals or organizations effectively to abate water pollution. There are two legal categories of private individuals who can seek direct action for water pollution control: riparians, or owners of land along a natural body of water, and nonriparians.

Riparians

It is not enough for a riparian proprietor seeking an injunction to show simply that an upstream riparian is polluting the stream and thus he, the downstream 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 its present attempts, if any, to treat wastes. The utility of the defendant's activity is weighed against the extent of the plaintiff's damage within the framework of reasonable alternatives open to both. On the plaintiff's side, the court may inquire into the size and scope of his operations, the degree of water purity that he actually requires, and the extent of his actual damages. This approach may cause the court to conclude that the plaintiff is entitled to a judicial remedy. Whether this remedy will be an injunction or merely an award of damages depends on the balance which the court strikes after reviewing all the evidence. For example, where a municipal treatment plant or industry is involved, the court, recognizing equities on both sides, might not grant an injunction stopping the defendant's activity but might compensate the plaintiff in damages. In addition, the court may order the defendant to install certain equipment or to take certain measures designed to minimize the future polluting effects of his waste disposal.

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[15]*See SEWRPC Community Assistance Planning Report No. 160,* Racine County Agricultural Soil Erosion Control Plan*, July 1988, and SEWRPC Community Assistance Planning Report No. 164,* Kenosha County Agricultural Soil Erosion Control Plan*, April 1989.*

[16]*SEWRPC Community Assistance Planning Report, No. 255,* A Land and Water Resource Management Plan for Kenosha County: 2000-2004, *September 2000; SEWRPC Community Assistance Planning Report, No. 259,* A Land and Water Resource Management Plan for Racine County: 2000-2004, *September 2000.*

[17]*ATCP refers to the Department of Agriculture, Trade and Consumer Protection.*

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; small riparians can be, and have been, adequately protected by the courts. Riparians along waterbodies in the Southeastern Wisconsin Region are not prevented by Federal, State, or local pollution control efforts from attempting to assert their common law rights in courts. The court may ask the WDNR to act as its master in chancery, especially where unbiased technical evidence is necessary to determine the rights of litigants. A master in chancery or a "master in litigation" is a person or agency brought into court as a technical expert to supply expertise on a particular issue or topic. 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 is intended. Thus, the courts are not prevented from entertaining an original action brought by a riparian owner to abate pollution.

Nonriparians

The rights of nonriparians to take direct action through the courts are less well defined than the rights of riparians. The Wisconsin Supreme Court set forth a potentially far-reaching conclusion in *Muench v. Public Service Commission*[18] when it concluded that:

> "The rights of the citizens of the State to enjoy our navigable streams for recreational purposes, including the enjoyment of scenic beauty, is a legal right that is entitled to all the protection which is given financial rights."

This language, however, was somewhat broader than necessary to meet the particular situation at hand, since the case involved an appeal of a State agency ruling. The more traditional view would be that a nonriparian citizen must show special damages in a suit to enforce his public rights.

It should be noted that Section 299.91 of the *Wisconsin Statutes* enables six or more citizens, whether riparian or not, to file a complaint leading to a full-scale public hearing by the WDNR on alleged or potential acts of pollution. The Clean Water Act also provides for citizen suits. Under this law, any citizen, meaning a person or persons having an interest which is, or may be, adversely affected, may commence a civil action on his or her own behalf against any person, including any governmental agency, alleged to be in violation of any effluent standard, limitation, or prohibition of any pollution discharge permit or condition thereof, or against the EPA Administrator when there is alleged failure by the Administrator to duly carry out any nondiscretionary duty or to act under the Clean Water Act. Prior to bringing such action, however, the citizen commencing the action must give notice to the alleged violator. When issuing final orders in any action under this section, the courts may award the costs of litigation to any party.

STATE LAWS AND REGULATIONS RELATED TO NAVIGABLE WATERS

The Public Trust Doctrine and Public Waters

Wisconsin's "public trust doctrine" is based upon an original concept of English common law under which the Crown held tidal waters in trust for the public. This concept was advanced in the Northwest Ordinance of 1787, under Article IV, where it was held that "the navigable waters leading into the Mississippi and St. Lawrence [Rivers], and the carrying places between the same shall be common highways, and forever free . . . ." The Wisconsin Enabling Act of 1836 admitted Wisconsin as a territory. That Act, under Section 3, incorporated the Northwest Ordinance language concerning navigable waters. Later, in 1848, the Territorial Convention acted to adopt the Wisconsin Constitution. The public trust with respect to navigable waters was carried forward under Section 1, titled "Jurisdiction on Rivers and Lakes; Navigable Waters," of Article IX, "Eminent Domain and Property of the State," of the Wisconsin Constitution. Section 1 states that "the state shall have concurrent

[18] *261 Wis. 492, 53 N.W. 2d 514 (1952).*

jurisdiction on all rivers and lakes bordering on this state . . and the navigable waters leading into the Mississippi [River] and St. Lawrence [River] and the carrying places between the same, shall be common highways and forever free . . . ."

The Wisconsin courts have construed the public trust doctrine liberally and noted in *Diana Shooting Club v. Husting* (1914)[19] that the "wisdom of the policy which steadfastly and carefully preserved to the people the full and free use of public waters cannot be questioned. Nor should it be limited by narrow constructions." This ruling further affirmed the State as ". . . a trustee of the people charged with the faithful execution of the trust created for their benefit."

The Wisconsin courts have also expanded the public trust doctrine in recognition of changes in public needs and uses. For example, the court held, in *Muench v. Public Service Commission* (1952),[20] that the enjoyment of scenic beauty is a public right. Later, in *Claflin v. Department of Natural Resources* (1973),[21] the State Supreme Court upheld an order for the removal of a boathouse based upon its adverse aesthetic impacts. The Court stated that ". . . the natural beauty of our northern lakes is one of the most precious heritages Wisconsin citizens enjoy."

The ownership of navigable waters and their beds have been established under case law. *Diedrich v. Northwestern Union Railroad Co.* (1877)[22] established that the beds of navigable lakes are owned by the State, while *Munninghoff v. Wisconsin Conservation Commission* (1949)[23] established that the beds of navigable streams are owned by the riparian owner. Noted, however, was the concept that the water over the streambed was held in the public trust. The navigable waters of Wisconsin include the entire area of the lakes and ponds that are located below the ordinary high water mark of such waterbodies.[24] In addition, such waters must have a well-defined bed and banks.

Several court cases have addressed what, in effect, amounts to a definition of a lake and pond. In *Ne-pee-nauk Club v. Wilson* (1897), *Ne-pee-nauk Club v. Wilson*, 96 Wisc 290 (1897).[25] the Court distinguished between a lake and stream, stating that a stream has natural motion, a current, while a lake, in its natural state, is substantially at rest. The Court went on to state that the difference between lakes and streams is independent of the size of the waterbody. The Court further recognized that navigable lakes could be properly called a marsh or swamp as a result of low water conditions in which large expanses of mud or vegetation are exposed. This latter condition was further supported in *Illinois Steel Co. v. Bilot*,[26] in which the Court declared:

> "The mere fact that the water was very shallow, so that marsh grass appeared above the surface, that it was called a marsh, and that the water was not deep enough to admit navigation, or that the surface was not at all times wholly submerged, does not preclude its being, in fact, a lake."

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[19]Diana Shooting Club v. Husting*, 156 Wis. 261 (1914).*

[20]Muench v. Public Service Commission*, 261 Wisc. 492 (1952).*

[21]Claflin v. DNR*, 58 Wisc. 2D 182 (1973).*

[22]Diedrich v. Northwestern Union Railroad Co.*, 42 Wis 248 (1877).*

[23]Munninghoff v. Wisconsin Conservation Commission*, 255 Wis 252 (1949).*

[24]*Navigable waters of the State are defined in s.144.26(2)(d). Also, the ordinary high water mark was defined in* Diana Shooting Club v. Husting*, 156 Wis. 261 (1914).*

[25]Ne-pee-nauk Club v. Wilson*, 96 Wisc 290 (1897).*

[26]Illinois Steel Co. v. Bilot*, 109 Wisc 418 (1901).*

This fact was further supported in *State v. Trudeau*,[27] in which the Court held that a lakebed need not be navigable in fact: "if land is part of a navigable lake, then the fact that the specific area cannot be navigated is irrelevant."[28]

Navigable waters in Wisconsin also include streams and flowages. Specifically, navigable streams have clearly been defined in case law. *DeGaynor and Company, Inc., v. Department of Natural Resources* (1975)[29] expanded the definition of navigability from the old saw log test (see *Olson v. Merrill* [1877] [30])to:

> "any stream is `navigable in fact' which is capable of floating any boat, skiff, or canoe, of the shallowest draft used for recreational purposes . . . ."
>
> ". . . [further] the test [for navigability] is whether the stream has periods of navigable capacity which ordinarily recur from year to year, e.g. spring freshets, or has continued navigability long enough to make it useful as a highway for recreation or commerce."

In addition, a navigable stream must have a bed and banks, as well as a direction of flow.

Chapter 30, Navigable Waters, Harbors, and Navigation

Under Chapter 30 of the *Wisconsin Statutes*, the WDNR has the authority to regulate the deposition of materials upon the bed of any navigable body of water, the straightening or altering of the courses of a stream, the dredging of material from the bed of a lake or river, the enlargement of any navigable waterway, and diversions from any body of water. Navigable waters include those wetland areas below the ordinary high water mark of an adjacent navigable lake or stream. The issuance of a Chapter 30 permit for any of the abovementioned activities in navigable waters would be subject to the policies and standards stipulated in Chapters NR 1.95 and NR 103 of the *Wisconsin Administrative Code* and to the provisions of the Wisconsin Environmental Policy Act.

One of the initial steps in the issuance of any Chapter 30 permit is the determination of navigability of the affected surface waterbody or adjacent wetland. Section 30.10 of the *Wisconsin Statutes* indicates that "all lakes . . . which are navigable in fact are declared to be navigable and public waters . . . ." Section 30.10 also indicates that "all streams, sloughs, bayous, and marsh outlets, which are navigable in fact for any purpose whatsoever, are declared navigable . . . ." The Wisconsin Supreme Court, in its decision on *Muench v. Public Service Commission* in 1952, pointed out that, in Wisconsin since 1911, navigable waters had been defined as those which are navigable in fact for any purpose whatsoever. In addition, as noted above, the Court, in its decision on *DeGayner and Company, Inc., v. Department of Natural Resources* in 1975, indicated that this test of navigability does not require that the surface waters be capable of floating a recreational boat or canoe on every day of the year or for every rod of its length or surface area. If it is determined that a surface waterbody is not navigable, the State may not have jurisdiction over the surface waterbody.

The determination of navigability is made on a case-by-case basis by the staff of the WDNR. Because of budgetary constraints, no jurisdictional maps of the navigable waters of the State have been prepared. The navigability or nonnavigability of a surface waterbody may change over the years as urban development; agricultural practices, including conversion of agricultural lands to natural open use; or other natural causes affect the amount of water flowing through the surface water system. Under Section 30.10(4)(c) of the *Wisconsin*

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[27]State v. Trudeau*, 139 Wisc 2d 91 (1987).*

[28]*Cain, Michael, and Roberta Borchardt,* Topical List of Water Law Cases*, Madison, Wis., Wisconsin Department of Natural Resources, 1992.*

[29]DeGaynor and Co., Inc. v. DNR*, 70 Wisc 2d 936, 236 N. W. 2d 217 (1975).*

[30]Olson v. Merrill*, 42 Wis. 203 (1877).*

Statutes, “farm drainage ditches are not navigable . . . unless it is shown that the ditches were navigable streams before ditching.”

Chapter 31, Regulation of Dams and Bridges Affecting Navigable Waters
Under Chapter 31 of the *Wisconsin Statutes*, the WDNR has authority to regulate the location, construction, and operation of dams and bridges affecting a navigable body of water. Administrative rules governing dam design and construction standards are set forth in Chapter NR 333 of the *Wisconsin Administrative Code*. The issuance of a Chapter 31 permit would be subject to the policies stipulated in Chapter NR 1.95 and the standards set forth in Chapter NR 103 of the *Wisconsin Administrative Code* and to the provisions of the Wisconsin Environmental Policy Act.

FLOODLAND REGULATION AND CONSTRUCTION OF FLOOD CONTROL FACILITIES

Effective abatement of flooding can be achieved only through a comprehensive approach to the problem. That approach ideally strikes a balance between preserving existing undeveloped floodlands in open space uses; providing physical protection from flood hazards in areas of existing or committed development through the construction of dams, flood control reservoirs, levees, channel modifications, and other water control facilities; and implementing nonstructural flood control measures where such measures are feasible. As urbanization proceeds within a watershed, it becomes increasingly necessary to develop an integrated program of land use regulation of the floodlands within the entire watershed to supplement required water control facilities if efforts to provide such facilities are not to be self-defeating.

Definition of Floodlands and Description of Floodplain Components
The precise delineation of floodlands is essential to the sound, effective, and legal administration of floodland regulation. This is particularly true in such rapidly urbanizing areas as portions of the Des Plaines River watershed. Chapter NR 116 of the *Wisconsin Administrative Code* defines the floodplain as “that land which has been or may be covered by flood water during the regional flood.”[31,32]

In planning for the proper use of floodlands, it is useful to subdivide the total floodland area on the basis of the hydraulic or hydrologic functions which the various subareas perform, as well as on the basis of the differing degrees of flood hazard that may be present in those subareas. Floodlands may be considered as consisting of two components: 1) a floodway, which effectively conveys the 100-year recurrence interval flood discharge, and 2) a floodplain fringe, which does not effectively convey flow, but which is inundated during floods and which temporarily stores floodwaters.

Under ideal conditions, the entire natural floodplain would be maintained in an open, essentially natural state, and, therefore, would not be filled and utilized for incompatible, intensive urban land uses. Conditions permitting an ideal approach to floodland regulation, however, generally occur only in rural areas. In areas which have already been developed for intensive urban use without proper recognition of the flood hazard, a practical regulatory approach may have to incorporate the concept of a floodway. Land use controls applied to the floodway should recognize that the designated floodway area is not suited for human habitation and should essentially prohibit all fill, structures, and other development that would impair floodwater conveyance by adversely increasing flood stages or velocities. Normally, filling and urban development may be permitted in the floodplain fringe, subject to restrictions which will minimize flood damages, including the provision of compensatory floodwater storage. Under actual conditions, the floodplain fringe may include buildings

[31]*The regional flood is defined as the 100-year recurrence interval flood, or that flood which has a 1 percent probability of occurring in any given year.*

[32]*This definition is consistent with the definition of a floodplain which has been applied by the Regional Planning Commission in its comprehensive watershed plans and other floodland management efforts.*

constructed in natural floodlands prior to the advent of sound floodland regulations. The delineation of the limits of the floodland regulatory area should be based upon careful hydrologic and hydraulic studies such as have been conducted under the Des Plaines River watershed study for the Des Plaines River, its major tributaries, and several minor tributaries.

Principles of Floodland Regulation

Certain legal principles must be recognized in the development of land use regulations designed to implement a comprehensive watershed plan. With respect to the floodland areas of the watershed, these are as follows:

1. Sound floodland regulation must recognize that the flood hazard is not uniform over the entire floodland area. Restrictions and prohibitions in floodlands should, in general, be more rigorous in the channels themselves and in the floodways than in the floodplain fringe.

2. While it is most desirable that floodland regulations seek to retain floodlands in open space uses, sound floodland regulation may contemplate permitting certain buildings and structures at appropriate locations in the floodplain fringe. Any such structures, however, should comply with special design, anchorage, and building material requirements.

3. Sound floodland regulation must recognize, and be adjusted to, existing land uses in the floodlands. Structures already may exist in the wrong places. Fills may be in place, restricting flood flows or limiting the flood storage capacities of the river. The physical effects of such misplaced structures and materials on flood flows, stage, and velocities can be determined. Floodland regulation based on such determinations must include legal measures to bring about the removal of at least the most troublesome of offenders.

4. In addition to the physical effects of structures and materials, sound floodland regulation must be concerned with the social and economic effects, particularly the promotion of public health and safety. Beyond this, sound floodland 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 floodland regulation must coordinate all forms of land use controls, including zoning, subdivision control, and official map ordinances, as well as housing, building, and sanitary codes.

Land Use Regulations in Floodlands

On the basis of the principles above and the definition of floodplains, the Commission has proposed that the local units of government within the Region utilize a variety of land use controls to effect proper floodland development. The use of these controls is discussed in SEWRPC Planning Guide No. 5, *Floodland and Shoreland Development*, and, therefore, will not be repeated here. The following section, however, will summarize the various land use regulatory powers available to State, county, and local units of government for use in regulating floodland development.

Channel Regulation

Sections 30.11, 30.12, and 30.16 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 the approval of the WDNR, 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 line, consistent with the appropriate floodway zoning ordinance. A WDNR permit is required for the 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 WDNR permit has first been obtained.

Regulation of Floodway and Floodplain Fringe

The regulation of floodlands in Wisconsin is governed primarily by the rules and regulations adopted by the WDNR pursuant to Section 87.30 of the *Wisconsin Statutes*.[33] In addition, the enactment of floodland regulation in Wisconsin is further governed by rules promulgated by the Federal Emergency Management Agency (FEMA). In essence, floodland regulation in Wisconsin is a partnership between the local, State, and Federal levels of government.

State Floodplain Management Program

The Wisconsin Legislature long ago recognized that the regulation of stream channel encroachments was an areawide problem transcending county and municipal boundaries and, therefore, provided for State regulation. However, it was not until passage of the State Water Resources Act in August 1966 that a similar need was recognized for floodway and floodplain-fringe regulation. In that Act, the Legislature created Section 87.30 of the *Wisconsin Statutes*. This section authorizes and directs the WDNR to enact floodland zoning regulations where it finds that a county, city, or village has not adopted reasonable and effective floodland regulations. The cost of the necessary floodplain determination and ordinance promulgation and enforcement by the State must, under the Statute, be assessed and collected as taxes by the State from the county, city, or village.

Chapter NR 116 of the *Wisconsin Administrative Code* sets forth the general criteria for counties, cities, and villages to follow in enacting reasonable and effective floodland regulations. The current version of that chapter of the State Administrative Code took effect on March 1, 1986. The version of the Code now in effect established more stringent requirements regarding the permissible increase in the 100-year recurrence interval flood stage resulting from activities in the floodplain and it set forth criteria for regulating floodplains in reaches downstream from dams.

State Agency Coordination

On November 26, 1973, Governor's Executive Order No. 67 was issued. It was designed to promote a unified State policy of comprehensive floodplain and shoreland management. The key provisions of the executive order are as follows:

1. State agencies are required to consider flooding and erosion dangers in the administration of grant, loan, mortgage insurance, and other financing programs.

2. All State agencies involved in land use planning are required to consider flooding and erosion hazards when preparing and evaluating plans. In addition, all State agencies directly responsible for new construction of State facilities, including buildings, roads, and other facilities, are required to evaluate existing and potential flood hazards associated with such construction activities.

3. All State agencies that are responsible for the review and approval of subdivision plats, buildings, structures, roads, and other facilities are required to evaluate the existing or potential flood hazards associated with such construction activities.

The provisions of this executive order are extremely important in that it requires all State agencies to utilize the flood-hazard data that have been, and are being, developed. Thus, the provisions assist in assuring that State-aided action, such as highway construction, will not contribute to increasing flooding and erosion hazards or to changing the character of the flooding. The order also assures that State agency actions will be consistent with local floodland regulations.

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[33]*Section 87.30(1m) of the Wisconsin Statutes stipulates that "a floodplain zoning ordinance. . .does not apply to lands adjacent to farm drainage ditches if: 1) such lands are not within the floodplain of a natural navigable stream or river, 2) those parts of the drainage ditches adjacent to these lands were nonnavigable streams before ditching, and 3) such lands are maintained in nonstructural agricultural use."*

Federal Flood Insurance Program

A program to enable property owners to purchase insurance to cover losses caused by floods was established by the U.S. Congress in the National Flood Insurance Act of 1968. Taking note that many years of installation of flood protection works had not reduced losses caused by flood damages, the Congress sought to develop a reasonable method of sharing the risk of flood losses through a program of flood insurance, while at the same time setting in motion local government land use control activity that would seek to ensure, on a Nationwide basis, that future urban development within floodlands would be held to a minimum.

The Act created the National Flood Insurance Program under the direction of the Federal Emergency Management Agency, which was given broad authority to conduct all types of studies relating to the determination of floodlands and the risks involved in insuring development that may be situated in natural floodland areas. The Act provided for the establishment of a National flood insurance fund, part of which would be established by Congressional appropriations, designed to assist in subsidizing insurance rates where necessary to encourage the purchase of flood insurance by individual landowners and thus reduce the need for periodic Federal disaster assistance. The Congress emphasized, however, that the establishment of such a program was not intended to encourage additional development in floodprone areas, but rather to assist in spreading the risks created by existing floodland development while taking effective action to ensure that local land use control measures effectively reduce future flood losses by prohibiting unwise floodland development.

Participation in the National Flood Insurance Program is on a voluntary, community-by-community basis. A community must act affirmatively to make its residents eligible to purchase flood insurance. Once a community makes it known to FEMA that it wishes to participate in the program, FEMA authorizes appropriate studies to be made to determine the special areas of flood hazard that may exist within the community and the rates at which flood insurance may be made available. In the Southeastern Wisconsin Region, such flood insurance studies build upon, and at times supplement, the flood-hazard data made available by the Regional Planning Commission under the comprehensive watershed planning programs.

When the Federal studies are completed, FEMA publishes a flood insurance rate map, or maps, which identify floodprone areas and divide the community into various zones for insurance purposes. Any landowner in such a community is then eligible to go to any private insurance agent and purchase flood insurance up to certain specified maximums at the rates established by FEMA. Such rates can be Federally subsidized if the actuarial rates are such that widespread participation in the program would be unlikely.

For its part, the community must enact land use controls which meet Federal standards for floodland protection and development. For all practical purposes, once a community enacts floodland regulations that meet the State requirements set forth in Chapter NR 116 of the *Wisconsin Administrative Code*, it will have been deemed to meet all Federal requirements for similar controls.

In 1973 the U.S. Congress expanded the National Flood Insurance Program through enactment of the Federal Flood Disaster Protection Act of 1973. In addition to increasing the amount of both subsidized and unsubsidized flood insurance coverage available for all types of properties, this Act expanded the insurance program to include erosion losses caused by abnormally high water levels. In addition, the Act stipulates that the purchase of flood insurance is required for all structures within flood hazard areas when a purchaser acquires a mortgage through a Federally supervised lending institution. And, as a condition of future Federal disaster assistance in flood-hazard areas, the Act requires flood insurance to be purchased so as to ensure that the next time a property is damaged by floods, the losses will be covered by insurance and Federal disaster assistance will not be needed.

On May 24, 1977, the President of the United States issued Executive Order 11988 concerning floodplain management. Appropriate Federal agencies were directed to accomplish the following tasks:

1. Evaluate the potential effects of any actions the agency may take in a floodplain;

2. Ensure that the agency's planning programs and budget requests reflect consideration of flood hazards and floodplain management;

3. Identify any proposed action to take place in a floodplain in any new requests for appropriations from the Office of Management and Budget;

4. Consider floodplain management when formulating or evaluating any water resource use appropriate to the degree of hazard involved; and

5. Issue new or amend existing regulations to comply with the Executive Order.

The Executive Order was issued in furtherance of the NEPA of 1969, the National Flood Insurance Act of 1968, and the Federal Flood Disaster Protection Act of 1973.

The National Flood Insurance Reform Act of 1994 amended both the National Flood Insurance Act of 1968 and the Federal Flood Disaster Protection Act of 1973. Key provisions of the amendments include:

- Establishment of incentives under the Community Rating System program for communities that adopt and enforce measures to reduce flood risks to a greater degree than required under minimum established standards.[34] The program promotes protection of "natural and beneficial floodplain functions."

- Establishment of a Mitigation Assistance Program to award states and communities grants "for planning and carrying out activities designed to reduce the risk of flood damage to structures covered under contracts for flood insurance." The National Flood Mitigation Fund was established to provide grant money. To be eligible for such funding, a State or community must develop a flood risk mitigation plan that is approved by FEMA.

- Increasing maximum flood insurance coverage amounts for residential and nonresidential properties and their contents.

- Establishment of a procedure for Federal review of FEMA flood hazard maps at least once every five years and for updating those maps as necessary.

- Establishment of a Technical Mapping Advisory Council to make recommendations for standards and guidelines to modernize Federal flood insurance rate maps (FIRM).

State and Federal Policies Relating to Floodland Management and to the Construction of Flood Control Facilities

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, possibly including the construction of flood control facilities, be formulated to deal with the interrelated problems of the watershed as a

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[34]*Since October 1990, the Federal Emergency Management Agency has administered a Community Rating System. That system enables communities which were participating in the regular National Flood Insurance Program to obtain reduced flood insurance rates through the implementation of more-stringent floodplain management measures than are required for participation in the regular program. Such measures include: 1) preparation of comprehensive floodplain management plans meeting Federal requirements, 2) public information activities, 3) mapping and regulatory activities, 4) flood damage reduction activities, and 5) flood preparedness activities.*

whole. A watershed, however, typically is divided in an irregular fashion by a complex of man-made political boundaries: county, city, village, town, and special-district. When such public works projects as flood control works, covering and serving an entire watershed, are required, these artificial demarcations become important because they limit the jurisdiction, the physical area, within which any one particular arm of county or local government may act.

With respect to the Des Plaines River watershed, this limitation may be overcome by delegation of the planning tasks to the Regional Planning Commission and attendant designation of the plan implementation tasks to various existing units of government, including Kenosha and Racine Counties, the City of Kenosha, the Villages and Towns in the watershed, and the one remaining legally constituted farm drainage district in the Dutch Gap Canal subwatershed.

Historic channel modification projects in the watershed, including channel deepening, widening, and straightening, have generally been carried out by legally constituted farm drainage districts or riparian landowners for the purpose of improving agricultural drainage, or by the Wisconsin Department of Transportation in conjunction with highway construction projects. The locations of these channel modifications are shown on Map 37.

State of Wisconsin Guidelines Regarding Channel Modifications

In November 1987, the Secretary of the Wisconsin Department of Natural Resources established a policy on the regulation of stream channelization projects for urban flood control. The policy enumerated Department concerns regarding channel modification as follows:

1. Loss of aquatic habitat.

2. Adverse impacts on public rights and interests, including boating, fishing, swimming, maintenance of environmental quality, and enjoyment of scenic beauty.

3. Loss of floodplain storage volume and decrease in the time for runoff to travel through the channelized reaches, with attendant increases in downstream flood flows and flood stages. The Department policy recognizes, however, that such problems are attributable to the implementation of channel modification without an areawide systems approach which deals with a watershed as a whole.

4. Creation of safety problems due to increases in flow velocities, particularly when the modified channel is lined with concrete.

5. The implementation of single-purpose channel modification projects for flood control in cases where multiple objective projects utilizing detention storage for the control of both water quantity and quality could be used.

In light of the Department concerns listed, the 1987 policy document calls upon Department staff involved in the review of channel modification projects to:

1. Presume that stream channelization is not the best overall solution to flooding or stormwater runoff problems.

2. Require consideration of alternative approaches, including stormwater management practices and nonstructural flood control measures.

3. Issue permits only for, or recommend not opposing, channelization projects when there are no other reasonable alternatives to solving a recognized flooding problem, the adverse impacts of channelization have been minimized to the extent practicable, and the project meets all other legal requirements.

The Department policy directly affects the planning effort for the Des Plaines River watershed in that it severely limits the potential application of channel modifications as a feasible means for the resolution of identified flood damage, stormwater management, and agricultural drainage problems. Therefore, the most viable option for floodland management in the Des Plaines River watershed is to preserve the existing flood hazard areas in essentially open space uses, recognizing that under planned, as well as existing, land use conditions, the existing channel conditions must remain essentially unaltered. In addition to full utilization of natural storage areas, flood-damage-control measures may include constructed detention storage facilities, supplemented by nonstructural flood control measures such as structure floodproofing, elevation, or removal. The only stream reaches along which channel modifications may be considered in the planning process are those which may have been found to exhibit very high flood damages, which may have been found to require widening and deepening to accommodate existing urban stormwater drainage facilities, or those where a channel modification may meet multiple objectives of flood control, water quality improvement, and stream habitat restoration.

State of Wisconsin Policy Regarding Detention Facilities in Wetlands

An unwritten State policy regarding the construction of floodwater storage facilities in wetlands has been formulated through application of the Chapter NR 103 wetland water quality standards since those standards took effect in 1991. On the basis of Commission staff experience with the application of those standards by WDNR staff, it is concluded that such facilities will meet with negative reaction by the Department if proposed and will generally not be approved. It is, however, assumed for purposes of this plan preparation that there will be instances where the development of such facilities will potentially be sound and should not be dismissed out of hand. Such would be the case where a dual-purpose detention storage facility to provide both water quantity and water quality control can be designed to rehabilitate a degraded wetland and result in a higher quality wetland environment than currently exists.

Interbasin Water Diversion

The legal problems encountered concerning interbasin water diversion are discussed in Chapter IX of SEWRPC Technical Report No. 2, 2nd Edition, *Water Law in Southeastern Wisconsin*. The traditional common-law riparian doctrine forbade the transfer of water between watersheds. However, states by legislative action, can create, and have created, exceptions to this general doctrine.

In contemplating a stream diversion, 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 municipal agencies carrying out the diversion. The first group consists of those riparians along the stream from which the diversion is made. The reasonableness of the diversion, the "taking" of private property involved, and the issue of compensation are all legal factors to be considered. The second group of individuals who may be in a position to assert legal rights are those whose lands abut the streams or lakeshore into which the diversion is made. Again, the diverter is liable to these riparians for land taken or damages caused as a consequence of the unnaturally increased flow.

Wisconsin Statutes Section 30.18, dealing with water diversions, stipulates that ". . . no water shall be so diverted to the injury of public rights in the streams . . . ." The Statute also states that only "surplus water," i.e., any water of a stream which is not being beneficially used, can be diverted and such diversions can be made only for the purpose of maintaining normal stream or lake levels in other watercourses. The only apparent exception to this section applies to agricultural and irrigation purposes, for which water other than "surplus water" may be diverted, but only with the consent of all of the riparians who would be injured by the diversion. To effect even these limited types of diversions, hearings would have to be held and permits issued by the WDNR. The Wisconsin Supreme Court case of *Omernik v. State*[35] stated that Section 30.18 applied to nonnavigable streams from which water was diverted as well as to navigable streams. If the anticipated use of diverted water is other than for one of the categories stipulated under Section 30.18 of the *Wisconsin Statutes*, then the common-law test of reasonableness will be invoked.

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[35] *64 Wis. 2d 6, 218 N.W. 2d 734 (1974).*

Diversion of water across the subcontinental divide between the Lake Michigan and Upper Mississippi River Basins is an issue related to the provision of sanitary sewer facilities and water supply facilities to certain municipalities in the Des Plaines River watershed. The Village of Pleasant Prairie has obtained permission to divert a maximum of 3.2 million gallons of water per day from Lake Michigan because of the threat to public health presented by the presence of radium in the Village groundwater supply. That diversion is to be eliminated by the year 2010 as a condition of the approval for the diversion. The creation of areawide sanitary sewerage and water supply systems serving the City of Kenosha, the Village of Pleasant Prairie, the Town of Somers, and portions of the Towns of Bristol and Paris, as recommended in the coordinated sanitary sewer and water supply system plan for the greater Kenosha area, would eliminate the current diversion of water because potable water would be drawn from Lake Michigan and treated effluent would be discharged to Lake Michigan.

Farm Drainage Districts

Pursuant to Sections 88.11 and 93.07(1) of the *Wisconsin Statutes*, the Department of Agriculture, Trade and Consumer Protection promulgated rules regarding farm drainage districts under Chapter ATCP 48 of the *Wisconsin Administrative Code* on July 1, 1995. Those rules were amended effective September 1, 1999. The rules establish procedures for assessing drainage district costs and benefits, inspecting drainage districts, construction and maintenance projects, landowner actions affecting drainage districts, drainage district records, and enforcement and variances.

As described in Chapter III of this report, the Bristol (Dutch Gap Canal) Farm Drainage District is the only legally constituted farm drainage district within the watershed in Kenosha County. The Kenosha County Farm Drainage Board is currently inactive, as is the Bristol Drainage District.

Very small portions of the Norway-Dover-Yorkville-Raymond Farm Drainage District and the Hoods Creek Farm Drainage District are located within the watershed in Racine County. Those districts operate under the governance of the Racine County Farm Drainage Board.

Stormwater Drainage District

Wisconsin Act 53, which was enacted on December 19, 1997, amended and expanded Section 66.0821 of the *Wisconsin Statutes* to specifically grant municipalities the legal authority to assess service charges to users of a stormwater and surface water sewerage system. This legislation granted municipalities essential authorities for the establishment of stormwater utilities.

The portion of the watershed in the Town of Mt. Pleasant is included in the Town of Mt. Pleasant Stormwater Drainage Utility District. The District is responsible for stormwater drainage in both urban and rural areas. The portion of the District located in the watershed is not taxed for utility district purposes.

RELATIONSHIP BETWEEN FEDERAL, STATE, AND LOCAL REGULATORY PROGRAMS FOR WETLANDS

The wetland water quality standards which are set forth in Chapter NR 103 of the *Wisconsin Administrative Code* are related primarily to the shoreland-wetland regulations in Chapters NR 115 and 117 of the *Wisconsin Administrative Code*; Chapters 30, 31, 281, 283, and 299 of the State Statutes; and Sections 401 and 404 of the Federal Clean Water Act.

The determination of permissible, or potentially permissible, activities in wetlands within the Des Plaines River watershed may involve shoreland-wetland regulations as administered by Kenosha and Racine Counties, the City of Kenosha, and the Villages of Paddock Lake, Pleasant Prairie, and Union Grove, all under the oversight of the WDNR; wetland water quality standards set forth by the WDNR in Chapter NR 103 of the *Wisconsin Administrative Code*; and regulations administered by the U.S. Army Corps of Engineers (USCOE) under Section 404 of the Federal Clean Water Act regarding the discharge of dredged or fill materials to wetlands. U.S. Department of Agriculture (USDA) policies and programs regarding benefits to farmers may also be of concern.

Federal Wetland Regulatory Program

The U.S. Congress has provided for the regulation of certain wetlands of the Nation. Section 404 of the Clean Water Act, as amended, provides the principal Federal authority in the regulation of wetland use. That statute requires the U.S. Department of the Army Corps of Engineers (USCOE), working in cooperation with the USEPA, to regulate the discharge of dredged and fill materials into waters of the United States, including lakes, rivers, and wetlands. All interstate wetlands, regardless of size, are regulated under the provisions of the statutes. The USEPA maintains a permit veto and enforcement authority under the Act should a particular application be judged to have adverse environmental consequences.

In carrying out this regulatory responsibility, the USCOE identifies interstate waters of the United States, including wetlands, and determines when permits are required for the discharge of dredged and fill materials. The USCOE may permit a project either through the issuance of a general permit, letter of permission, or through a specific individual permit, depending upon the scope and potential consequences of the project. For example, wetland fill or excavation projects which involve more than two acres of a wetland would typically require an individual permit. Similar projects involving filling or excavating of less than two acres of a wetland would require notification to the USCOE, and would be handled under the general permit or letter of permission procedure (GP/LOP).[36] There are four categories to the GP/LOP, which include the following:

- General Permitting – Non Reporting;
- General Permitting – Provisional;
- Letter of Permission – Provisional; and
- General Permitting – Programmatic.

The nonreporting option of the general permit is for very small scale projects that are anticipated to have a negligible effect on the resource and include practices such as streambank stabilization and boat ramp construction. Projects that fall under the non reporting option do not require notification to the USCOE. It is the landowner or project manager's responsibility to ensure that the USCOE criteria are satisfied. The provisional option of the general report is suited for projects that primarily involve discharges into Federal waters which could be related to utility lines, bridge construction, or hydropower plants, or other discharges into wetlands or Federal waters that involve less than up to one-tenth of an acre. The letter of permission is issued for larger projects that impact between one-tenth and two acres of wetlands, or up to five acres for projects administered by the Wisconsin Department of Transportation (WisDOT) that are subject to the WDNR/ WisDOT cooperative agreement. Finally, the programmatic option of the general permit is also for larger projects that impact up to two acres, and for projects that are not covered by one of the previous options. The USCOE maintains a discretionary authority under which it may override any permit on a case-by-case basis, as it deems appropriate.

Silvicultural and agricultural activities in waters of the United States and adjacent wetlands are exempt from the permitting process provided that they do not cause a release of toxic contaminants and do not change the use of the waters. Certain minor activities, such as sand blankets, boat ramp construction, and shore stabilization activities, may be undertaken under a non-reporting general permit.

The USCOE has limited jurisdiction for areas of isolated wetlands. In a case that was decided by the Supreme Court on January 9, 2001, "Solid Waste Association of Northern Cook County v. U.S. Army Corps of Engineers," the Court ruled that the USCOE has no jurisdiction over nonnavigable (i.e., not connected to Federal waters), isolated, intrastate waters. The USCOE determines whether or not an isolated wetland is ultimately connected to Federal waters. This ruling removed significant areas of wetland from regulation, and it prompted the State of Wisconsin to pass legislation extending State authority over isolated wetlands, as described below.

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[36] *The GP/LOP permitting process replaced the nationwide permit in Wisconsin in April of 2000.*

Under the provisions of Section 401 of the Clean Water Act, the issuance of Federal permits must be consistent with State water quality policies and standards. The State of Wisconsin has established procedures to review all activities which may involve the discharge of dredged or fill material into the waters of the State, including wetlands. The procedures for the review of Federal permits are set forth in Chapter NR 299 of the *Wisconsin Administrative Code*, which requires the WDNR to deny certification for any discharge which does not meet the guidelines set forth in Chapters 30, 31, and 281 of the State statutes, to grant certification if such guidelines are met, or to waive certification if such guidelines do not apply. In cases where State certification is denied, the U.S. Department of the Army permit would also be denied.

State of Wisconsin Wetland Regulatory Program Related to Wetlands
The Wisconsin wetlands preservation, protection, and management policies are set forth generally in Chapter NR 1.95 of the *Wisconsin Administrative Code*; the Wisconsin water quality standards for shoreland and nonshoreland wetlands, prepared pursuant to Chapter 281 of the State statutes, are set forth in Chapter NR 103 of the *Wisconsin Administrative Code*. Chapters NR. 1.95 and 103 were both updated in 2002 to provide for the administration of a compensatory wetland mitigation program.

Chapter NR 1.95 establishes the policy by which the WDNR administers its regulatory and management authorities regarding wetlands. Such policy require the Department to evaluate all reasonable alternatives, including the alternative of no action, in making regulatory decisions concerning such processes requiring permits as sanitary sewer extensions, dredging and filling, the construction of dams and bridges, and streamcourse alterations where adverse impacts to wetlands may occur as a result of such activities. In addition, Chapter NR 1.95 indicates that State land acquisition programs should emphasize acquisition of high-value wetlands; that State enforcement activities regarding unlawfully altered wetlands should, to the extent practicable, require restoration; and that the avoidance or minimal use of wetlands should be advocated in liaison activities with Federal, State, and local units and agencies of government. Under Chapter NR 1.95, administrative rules and legislation aimed at protecting and enhancing wetland values and ecology, and at providing education about wetlands, may be promulgated by the Department.

Prior to the January 2001, Supreme Court ruling, "Solid Waste Association of Northern Cook County v. U.S. Army Corps of Engineers," the Department had limited jurisdictional authority regarding isolated non-shoreland wetlands. Since that ruling, the Wisconsin Legislature passed Wisconsin Act 6, which became effective on May 8, 2001. Wisconsin Act 6 amends Chapter 23 and more significantly Chapter 281 of the *Wisconsin Statutes.* The Department now has the jurisdictional authority to regulate fill placement into nonfederal wetlands. Fill placement into a nonfederal wetland requires water quality certification under Chapter NR 299 of the *Wisconsin Administrative Code.* There are some exemptions to Wisconsin Act 6, which primarily involve silvicultural and agricultural activities.

Wisconsin Act 6 provides for the issuance of general water quality certifications for types of discharges, instead of individual certifications, subject to a Department finding of minimal individual and cumulative adverse environmental effects.

Chapter NR 103 of the *Wisconsin Administrative Code* establishes water quality standards for wetlands. These standards, like the more general policies set forth for wetlands protection under Chapter NR 1.95, are applied by the WDNR in the exercise of State authority and in State review of applications for permits under Section 404 of the Federal Clean Water Act. Chapter NR 103 applies to all wetlands and these standards are effected when a State permit or State water quality certification is required. The water quality standards for wetlands are intended to provide protection of all waters of the State, including wetlands, for all present and potential future uses, such as for public and private water supply; for use by fish and other aquatic life, as well as wild and domestic animals; for preservation of natural flora and fauna; for domestic and recreational uses; and for agricultural, commercial, industrial, and other uses.

Under Chapter NR 103, the WDNR is responsible for the protection of the functions of wetlands. The functional values of wetlands include stormwater and floodwater storage and retention and the moderation of water level fluctuation extremes; hydrologic functional values, such as maintenance of dry season streamflow, the discharging and recharging of groundwater and maintenance of groundwater flow; filtration or storage of sediments, nutrients, or toxic substances which might otherwise adversely affect other waters of the State; shoreline protection against erosion; habitat for aquatic organisms; habitat for resident and transient wildlife; and all other recreational, cultural, educational, scientific, aesthetic, and natural values.

The rules set forth in Chapter NR 103 consist of two parts: 1) alternatives analysis, and 2) a set of standards intended to protect the functional values of wetlands.

A project would not be in compliance with the provisions of Chapter NR 103 if it is not a wetland dependent use, meaning that it does not necessarily require location in or adjacent to wetlands to fulfill its basic purpose, and if a practicable alternative to the project exists that does not involve the filling of wetlands. Under a practicable alternatives analysis, the proposed project would be compared to other alternatives considering relative monetary costs, logistical limitations, technological limitations, and other pertinent positive or negative aspects. If there is an alternative to the project which is practicable, will not adversely impact wetlands, and will not have other significant adverse environmental consequences, that alternative may be selected.

If, following the analysis of practicable alternatives, no suitable alternative is identified, an assessment of the potential significant impacts of the project on the functional values of the wetland must be made. Those impacts would then be considered by the Department in making a determination whether the basic requirements of Chapter NR 103 are satisfied.

Considerations Related to Federal and State Approval of Urban and Agricultural Drainage Projects Involving Wetlands

Installation of agricultural drain tiles, sanitary sewers, or urban storm sewers, and construction of urban or agricultural drainage channels through wetlands could involve the temporary discharge of fill material and would, therefore, require a Federal Section 404 permit and/or water quality certification by the State of Wisconsin under Chapter NR 103. In considering a permit application to discharge dredged or fill material to wetlands, the USCOE and/or the WDNR may also consider other impacts (secondary impacts) of the proposed project, such as whether the project would result in draining of wetlands. As part of the permit issuance, the use of special construction techniques may be required. Such requirements may include providing for agricultural drain tiles or storm sewer pipes to be sealed so that the wetland would not be drained, covering the trench with six inches of native soil, and restoring the original grade and vegetation. Thus, such agricultural drain tile lines could, under such a conditional permit, be used only for improving drainage from upstream areas, not for restoring drainage to the areas which have reverted to wetlands.

U.S. Natural Resources Conservation Service Involvement in Wetland Issues

Involvement in wetland matters by the Natural Resources Conservation Service (NRCS), formerly the U.S. Soil Conservation Service, is primarily related to the administration of programs distributing USDA benefits as mandated under the Federal Food, Agriculture, Conservation and Trade Act of 1990, commonly referred to as the 1990 Farm Bill.[37]

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[37]*The Wisconsin Wetland Inventory maps are described in Chapter III of this report. The U.S. Natural Resources Conservation Service has also prepared wetland maps on one inch equals 660 foot scale and on one inch equals 1,000 foot scale aerial photographs. Those maps are used by the NRCS in administering programs mandated under the Food, Agriculture, Conservation and Trade Act of 1990, commonly referred to as the 1990 Farm Bill. The NRCS wetland maps and the Wisconsin Wetland Inventory maps are used by the USCOE in administering its regulatory program for wetlands.*

Land Classifications

The NRCS has established four land classification categories which relate to the status of agricultural lands as wetland or cropland. These classifications are defined as follows:

1. Prior Converted Cropland: Land that may contain wetlands that were cleared, drained, filled, or otherwise manipulated to make them cropable prior to December 23, 1985. These lands are flooded for no more than 14 consecutive days during the growing season. If prior converted cropland is not cropped, managed, or maintained for agricultural production for five consecutive years and the land reverts to wetland, the land would be regulated by the USCOE under Section 404. Reversion to wetland requires that the land exhibit the three mandatory wetlands criteria set forth under the USCOE and EPA wetland definition: hydric soils, wetland vegetation, and hydrologic characteristics associated with wetlands. Also, prior converted cropland that is located in a shoreland jurisdictional zone, as designated in Chapters NR 115 or 117 of the *Wisconsin Administrative Code,* is regulated as a shoreland wetland.

2. Farmed Wetland: Land that was cleared or drained or filled and cropped prior to December 23, 1985, and, in many years, still floods or ponds in the spring or fall. These lands are flooded for 15 or more consecutive days during the growing season or for 10 percent of the length of the growing season, whichever time is shorter. These wetlands are regulated under Section 404, but normal farming of these lands is allowed.

3. Wetland: Land that has wet, saturated soils and would support wetland vegetation if not tilled or mowed.

4. Not Inventoried: Land that may contain wetlands but has not been designated, either because the existing vegetation makes wetland designation difficult or because the area has low potential for use as cropland.

The NRCS periodically obtains aerial photographs at a scale of one inch equals 660 feet and those photographs are used to identify saturated soils and to document land use practices, including determinations of the number of consecutive years for which land has not been cropped. Conversions of wetlands which occur after December 23, 1985, can affect the eligibility of landowners to receive U.S. Department of Agriculture subsidies. If a drainage district converts wetland to cropland, the landowner of the converted wetland who is assessed by the drainage district and who uses the conversion to increase agricultural production could lose his rights to Federal subsidies. If a drainage district implements measures which convert wetland areas after November 28, 1990, and the conversion is beyond the control of the landowner of the property containing the wetland, Federal subsidies would not be lost if no agricultural commodities are planted or if no hay or forage crops are harvested.

If a wetland conversion began prior to December 23, 1985, and attempts to improve drainage have occurred since 1985, the project may be classified as a commenced conversion and the landowner or farmer may be able to produce an agricultural commodity on the land without losing Federal subsidies. When a drainage district is involved in a conversion, it is necessary that: 1) a detailed drainage plan was officially adopted, 2) the installation of drainage measures began before December 23, 1985, or that contracts were executed before December 23, 1985, for the purchase of materials for the conversion of the wetlands, and 3) the landowner or farmer was assessed for the project or legally obligated to pay such an assessment before December 23, 1985.

Decisions by an NRCS field office regarding the wetland status of a particular parcel of land may be appealed by the landowner. The initial appeal would be made to the field office, the staff of which would make a field determination in response to the appeal. Further appeals would be made to the NRCS Area, State, and Washington, D.C., offices.

DIFFUSED WATER LAW

This area of the law relates to what is commonly termed stormwater, which consists of runoff from rain, snowmelt, and springs prior to collection in a watercourse or lake. Under the "common enemy" doctrine which was enforced in the State of Wisconsin until 1974, "a landowner could drain diffused surface water onto another's property regardless of the harm caused."[38]

In 1974, the "common enemy" doctrine was replaced by the "reasonable use" rule as a result of the findings of the Wisconsin Supreme Court in the case of *State v. Deetz*.[39] This rule permits the reasonable discharge of diffused surface water. An unreasonable discharge is defined as one which results in an intentional invasion of another's land and either: "1) the gravity of the harm caused by the discharge outweighs the utility of the conduct of the discharge or 2) the harm caused by the discharge is substantial and the financial burden of compensating for the harm does not render the conduct causing the discharge infeasible."[40]

An example of the application of the "reasonable use" rule is the case of *Crest Chevrolet v. Willemsen*.[41] In this case the court applied the reasonable use rule and ruled in favor of the plaintiff, who claimed that the raising of the grade of the defendant's property obstructed the discharge of runoff from the plaintiff's property, flooding the plaintiff's parking lot.

SPECIFIC LEGAL CONSIDERATIONS AND INVENTORY FINDINGS IN THE DES PLAINES RIVER WATERSHED

Inventories were conducted of State water regulatory permits, State water pollution abatement orders and permits, Federal water regulatory permits, floodland regulation, flood insurance eligibility, and other local water-related regulatory matters. A discussion of these legal considerations and how they apply to the Des Plaines River watershed is presented below.

State Water Regulatory Permits

As noted earlier in this chapter, the WDNR has broad authority under the *Wisconsin Statutes* to regulate the water resources of the State. A review was conducted under the Des Plaines River watershed study of Chapter 30 and 31 water regulation permits issued by the WDNR in the Des Plaines River watershed. It was found that permits have been granted for projects in the watershed involving the construction of bridges (Section 30.123), the installation of culverts (Section 30.12), the creation of ponds (Section 30.19), and the construction of dams (Section 31.33). The locations of projects for which such permits were granted are shown on Map 57 and the projects are listed in Table 94. In addition, permits have also been granted for the construction of utility crossings (Sections 30.12 and 30.20), dredging (Section 30.20), the placement of sand blankets or pea gravel on lakebeds (Section 30.12), the emergency diversion of water (Section 30.18), the construction of piers (Section 30.13), grading (Section 30.19), and the placement of riprap (Section 30.12).

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[38]*University of Wisconsin-Extension Environmental Resources Center and the University of Wisconsin Law School,* Wisconsin Water Law Handbook: A Guide to Water Rights and Regulations*, draft, Madison, April 1994.*

[39]State v. Deetz*, 66 Wis. 2d 1, 224 N.W. 2d 407 (1974).*

[40]Ibid.

[41]Crest Chevrolet v. Willemsen*, 129 Wis. 2d 129, 144-45, 384 N.W. 2d 692 (1986).*

State Water Pollution Abatement Permits
An inventory was conducted of all effluent discharge permits and of all outstanding pollution abatement orders in the Des Plaines River watershed. The following section presents the findings of that inventory.

Effluent Discharge Permits
As noted earlier in this chapter, the Wisconsin Pollutant Discharge Elimination System permit structure was established by the WDNR pursuant to Chapter 283 of the *Wisconsin Statutes*. A permit is required for all industrial and municipal waste discharges. The inventory revealed that through 1993 a total of 10 industrial waste discharge permits, four municipal sewage treatment plant discharge permits, and four private sewage treatment plant discharge permits have been issued in the Des Plaines River watershed. Pertinent characteristics pertaining to each of these permits are set forth in Table 95 and the location of the discharges shown on Map 58.

Federal Water Regulatory Permits
The U.S. Department of the Army, Corps of Engineers, requires permits for work or structures in navigable waters of the United States, waste outfalls in navigable waters, the discharge of dredged or fill materials into navigable waters, and the transportation of dredged material for the purpose of dumping into ocean waters. Federal laws prohibit such activity unless the activity is authorized by a Department of the Army permit. It was determined that from 1985 through 1994 four individual permits were issued in the Des Plaines River watershed for road construction and the placement of fill in wetlands. Also, two additional permits for the placement of fill in wetlands were modified.

Floodland Regulation and Flood Insurance Eligibility
Kenosha and Racine Counties, the City of Kenosha, the Village of Pleasant Prairie, and the Village of Union Grove have adopted floodplain zoning ordinances and are participating in the National Flood Insurance Program. The Village of Pleasant Prairie received WDNR approval and in 1998 dopted the floodplains delineated under this watersled study. No flood hazard areas have been identified in the Village of Paddock Lake under the National Flood Insurance Program and the Village does not have a floodplain zoning ordinance.

Local Water-Related Regulatory Matters
An inventory was conducted under the Des Plaines River watershed study of other local ordinances relating to water quality and water use. Information on those municipalities which have regulations regarding water quality and water use is presented below. Authority to enact construction site erosion control and stormwater management ordinances are granted to counties, cities, villages, and towns under Sections 59.693, 62.234, 61.354, and 60.627, respectively, of the *Wisconsin Statutes*.[42]

The City of Kenosha Land Division and Platting Ordinance, set forth in Chapter 17 of the City Code of General Ordinances, includes requirements regarding the provision of stormwater drainage facilities for new development, including a requirement that a surface water drainage plan be prepared. All City streets are required to be constructed with urban street cross-sections with curb and gutter. The City has adopted a construction erosion control ordinance based on the State model ordinance.[43] In addition, the City recently adopted Chapter 35 of the Code of General Ordinances, which is entitled “Impact Fees.” That ordinance provides for the assessment of stormwater management impact fees for new development.

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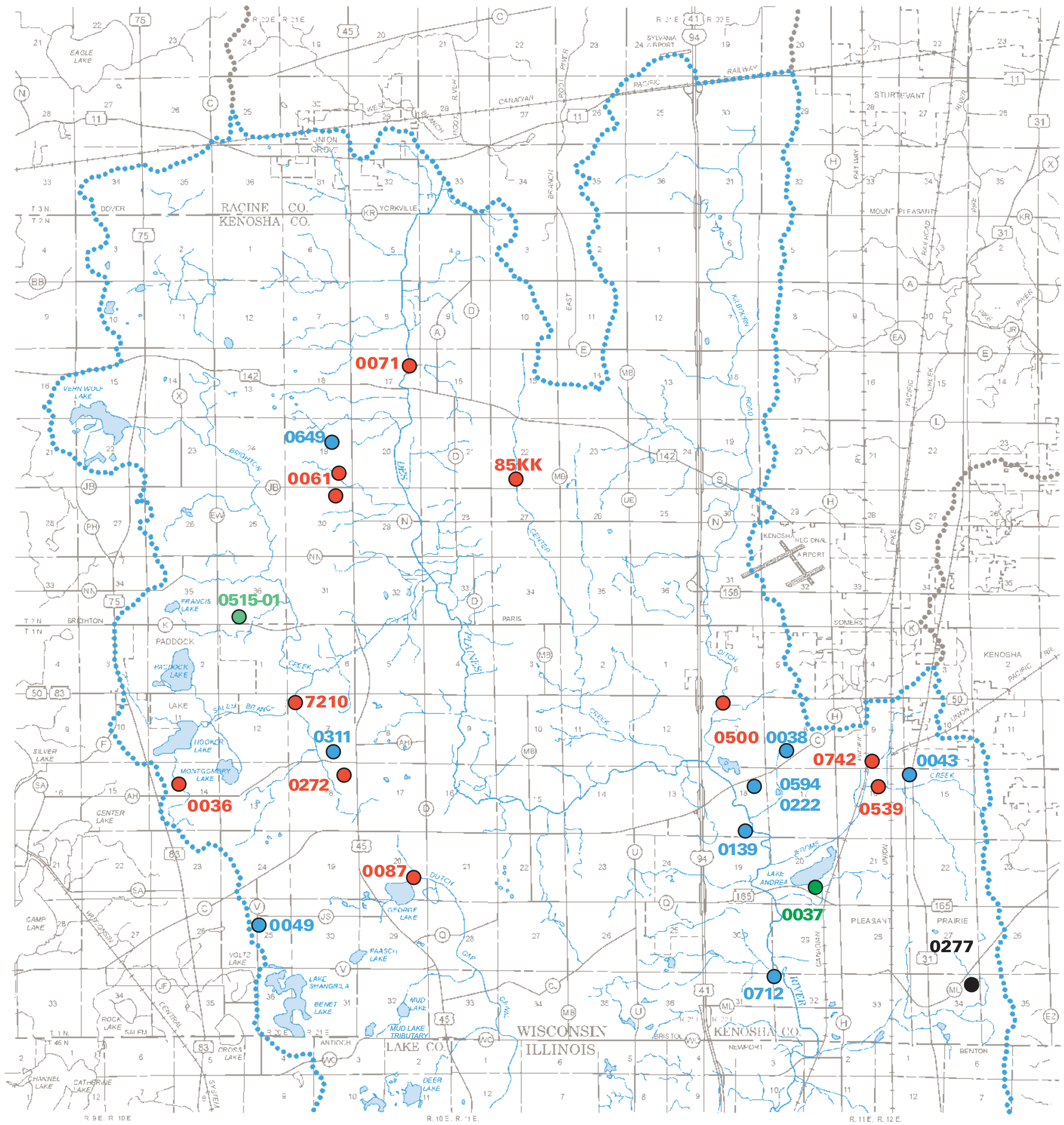
[42]*Sections 101.65 and 101.653 of the* Wisconsin Statutes *establish the authority for county, city, village, or town regulation of construction site erosion for single- and two-family residential construction. Such programs are generally administered by local building inspectors, with review of each local program by the Wisconsin Department of Commerce.*

[43]*See Wisconsin Department of Natural Resources,* Wisconsin Construction Site Best Management Practice Handbook*, Appendix A, Madison, Wisconsin DNR, latest revision April 1994.*

Map 57

PERMITS ISSUED IN THE DES PLAINES RIVER WATERSHED UNDER CHAPTERS 30 AND 31 OF THE WISCONSIN STATUTES: 1972-1994



0036 PERMIT ISSUED UNDER SECTION 30.12 OF THE WISCONSIN STATE STATUTES AND WISCONSIN DEPARTMENT OF NATURAL RESOURCES (WDNR) DOCKET NUMBER

0049 PERMIT ISSUED UNDER SECTION 30.19 OF THE WISCONSIN STATE STATUTES AND WDNR DOCKET NUMBER

0277 PERMIT ISSUED UNDER SECTION 30.20 OF THE WISCONSIN STATE STATUTES AND WDNR DOCKET NUMBER

0037 PERMIT ISSUED UNDER SECTION 31.33 OF THE WISCONSIN STATE STATUTES AND WDNR DOCKET NUMBER

NOTE: SEE TABLE 94 FOR ADDITIONAL INFORMATION

GRAPHIC SCALE
0 1/2 1 MILE
0 2,000 4,000 6,000 FEET

The permits shown on this map have been granted for projects involving the construction of bridges (Section 30.12), the installation of culverts (Section 30.12), the creation of ponds (Section 30.19), and the construction of dams (Section 31.33).

Source: SEWRPC.

Table 94

PERMITS ISSUED IN THE DES PLAINES RIVER WATERSHED UNDER CHAPTERS 30 AND 31 OF THE WISCONSIN STATUTES: 1972-1994[a,b]

Statute Section	Permit Docket Number	Year Permit Issued	Description
30.12	7210	1972	Culvert in the Salem Branch of Brighton Creek
	0539	1976	Culvert in Jerome Creek
	0742	1979	Replace culvert in Jerome Creek
	85KK	1991	Culvert in Center Creek
	0071	1992	Culvert in Des Plaines River
	0087	1993	Bridge over Unnamed Tributary No. 3 to Dutch Gap Canal (George Lake Outlet Channel)
	0500	1993	Culvert in Kilbourn Road Ditch
	0272	1994	Temporary culvert in Brighton Creek
	0061	1994	Two culverts in unnamed tributaries to the Des Plaines River
	0036	1994	Culvert in unnamed tributary No. 1 to Hooker Lake
30.19	0139	1992	Pond construction
	0594 and 0222	1993	Pond construction
	0311	1993	Pond construction
	0043	1994	Pond construction
	0038	1994	Pond construction
	0649	1994	Pond construction
	0049	1994	Pond construction
30.20	0277	1990	Culvert removal and replacement in unnamed tributary to the Des Plaines River
31.33	0515-01	1977	Dam on unnamed tributary to Brighton Creek
	0037	1994	Dam creating unnamed quarry lake in the Village of Pleasant Prairie

[a]*See Map 57 for permit locations.*

[b]*This table lists permits for the construction of bridges and dams, the installation of culverts, and the creation of ponds. Other Chapter 30 permits have been issued for the construction of utility crossings, dredging, the placement of sand blankets and/or pea gravel, the emergency diversion of water, the construction of piers, grading, and the placement of riprap.*

Source: SEWRPC.

The City applies a set of criteria for the design of storm sewers and for stormwater detention within the City which are not specifically included in any City ordinance. The criteria call for the provision of onsite detention storage facilities for both water quantity and water quality control. The post-development peak rate of flow from storms with recurrence intervals ranging from 10 through 100 years, over a range of storm durations, is required to be controlled to no more than the predevelopment peak rate of flow during a 10-year recurrence interval storm. The guidelines also require that a 10-year recurrence interval storm be used for the design of storm sewers.

The Village of Paddock Lake Land Division Ordinance was adopted in April 1992, pursuant to Section 66.035 of the State statutes. The Ordinance, set forth in Chapter 38 of the Village Code of Ordinances, includes requirements regarding construction erosion control and stormwater management facilities. The Ordinance calls for the use of a 10-year recurrence interval design storm and urban street cross-sections with concrete curbs

Table 95

WASTE DISCHARGE PERMITS ON FILE WITH THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES FOR DISCHARGES IN THE DES PLAINES RIVER WATERSHED: 1993

Facility Name	County	Permit Type	Permit Number	Standard Industrial Classification Code	Industrial Activity	Receiving Water	Treatment System[a]
Industrial Permits							
American Roller Company	Racine	General	0044938-3	3069	Fabricated rubber products	Des Plaines River via storm sewer and unnamed tributary	- -
Bardon Rubber Products Company, Inc.	Racine	General	0044938-3	3069	Fabricated rubber products	Des Plaines River via unnamed tributary	- -
Bristol Water Utility	Kenosha	General	0045640-1	4941	Water supply	Des Plaines River via unnamed tributary	- -
Contact Rubber Corporation	Kenosha	General	0044938-3	3069	Fabricated rubber products	Salem Branch Creek via unnamed tributary	- -
I.T.O. Industries, Inc.	Kenosha	General	0046540-2	3679	Electrical components	Des Plaines River via unnamed tributary	- -
Paddock Lake Water Utility	Kenosha	General	0057681-1	4941	Water supply	Groundwater discharge Des Plaines Basin	- -
Plastic Parts, Inc.	Racine	General	0044938-3	3089	Plastics products	Des Plaines River via storm sewer and unnamed tributary	- -
Stokely Van Camp, Union Grove	Kenosha	General	0057657-1	4953	Landspreading sludge	Center Creek	- -
Tri-Clover, Inc.	Kenosha	General	0044938-3	3494	Valves and pipe fittings	Des Plaines River via unnamed tributary	- -
Wisconsin Electric Power, Pleasant Prairie	Kenosha	Specific	0043583	4911	Electric services	Jerome Creek	1,2,3,4
Municipal Sewage Treatment Plants							
Town of Bristol Utility District No. 1	Kenosha	Specific	0022021	- -	- -	Des Plaines River via Bristol Creek Tributary	3,5,7
Village of Paddock Lake	Kenosha	Specific	0025062	- -	- -	Brighton Creek via unnamed tributary no. 6	2,3,6,7,8, 9
Village of Pleasant Prairie Sanitary District No. 73-1	Kenosha	Specific	0030741	- -	- -	Des Plaines River via unnamed tributary	3,5,7,10, 11
Village of Pleasant Prairie Sewer Utility District D	Kenosha	Specific	0028380	- -	- -	Des Plaines River via Pleasant Prairie Tributary	3,6,7,12
Private Sewage Treatment Plants							
Hickory Haven Mobile Home Park	Racine	Specific	0026689	- -	- -	Des Plaines River via Fonks Tributary and the Union Grove Industrial Tributary	13,15,16
Brightondale County Park	Kenosha	Specific	0060348	- -	- -	Soil absorption	13,14,15
Kenosha Beef International	Kenosha	Specific	0050784	2011	- -	Soil absorption	3,17,18,19
Rainbow Lake Manor Mobile Home Park	Kenosha	Specific	0030481	- -	- -	Soil absorption	1,3,13

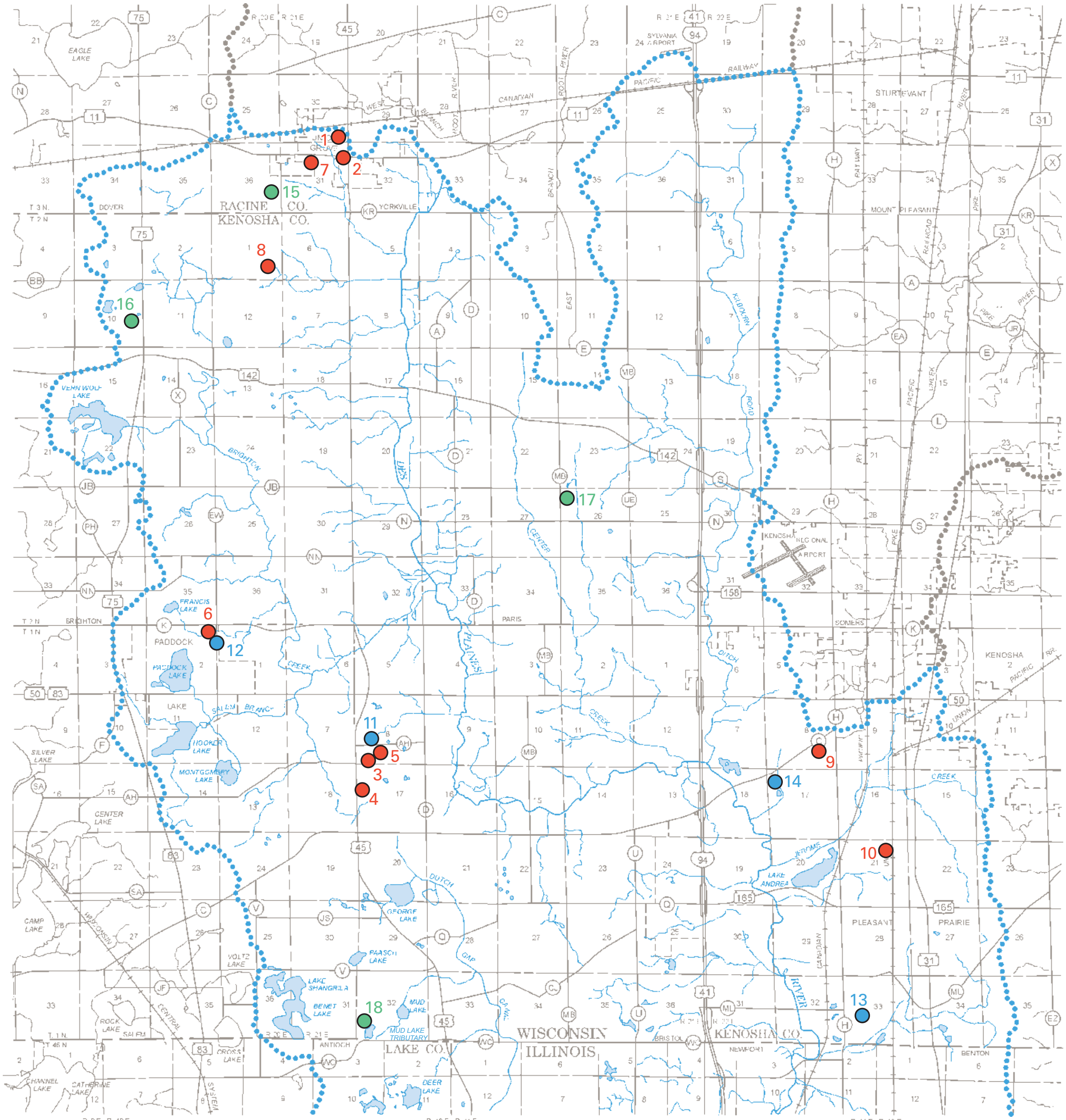
[a] *The number code refers to the following treatment systems:*

1. Holding pond
2. Dechlorination
3. Chlorination
4. pH Control
5. Contact stabilization activated sludge
6. Oxidation ditch
7. Clarification
8. Microscreen
9. Ultraviolet disinfection
10. Chemical phosphorus removal
11. Sand filtration
12. Post aeration
13. Activated sludge extended air
14. Activated sludge
15. Polishing pond
16. Aerobic digestion
17. Primary gravity sedimentation
18. Oil and grease removal
19. Ridge and furrow

Source: SEWRPC.

Map 58

LOCATIONS OF DISCHARGES PERMITTED IN THE DES PLAINES RIVER WATERSHED UNDER THE WISCONSIN POLLUTANT DISCHARGE ELIMINATION SYSTEM: 1993



INDUSTRIAL PERMITS

1. AMERICAN ROLLER CO.
2. BARDON RUBBER PRODUCTS COMPANY INC.
3. BRISTOL WATER UTILITY
4. CONTACT RUBBER CORP.
5. I.T.O. INDUSTRIES, INC.
6. PADDOCK LAKE WATER UTILITY
7. PLASTIC PARTS, INC.
8. STOKELY VAN CAMP - UNION GROVE
9. TRI - CLOVER, INC.
10. WISCONSIN ELECTRIC POWER - PLEASANT PRAIRIE

MUNICIPAL SEWAGE TREATMENT PLANTS

11. TOWN OF BRISTOL UTILITY DISTRICT NO. 1
12. VILLAGE OF PADDOCK LAKE
13. VILLAGE OF PLEASANT PRAIRIE SANITARY DISTRICT NO. 73 - 1
14. VILLAGE OF PLEASANT PRAIRIE SEWER UTILITY DISTRICT D

PRIVATE SEWAGE TREATMENTS PLANTS

15. HICKORY HAVEN MOBILE PARK
16. BRIGHTONDALE COUNTY PARK
17. KENOSHA BEEF INTERNATIONAL
18. RAINBOW LAKE MANOR MOBILE HOME PARK

GRAPHIC SCALE
0 1/2 1 MILE
0 2,000 4,000 6,000 FEET

Source: SEWRPC.

and gutters. Rural cross-sections with roadside swales may only be used in minor land divisions. If adequate stormwater drainage facilities are not available downstream from a proposed development, the Ordinance requires the provision of onsite detention or retention storage facilities to limit peak post-development flows during a 100-year recurrence interval, 24-hour storm to the peak existing condition rate of runoff during a 10-year recurrence interval, 24-hour storm. The Village has adopted a separate construction erosion control ordinance based on the State model ordinance.

The Village of Pleasant Prairie Land Division and Development Control Ordinance was adopted in May 1991, and amended and recodified in May 1998, pursuant to Sections 236.45, 61.34, 61.354, and 703.27 the State statutes. The Ordinance, set forth in Chapter 18 of the Village Code of Ordinances, includes requirements regarding construction erosion control and stormwater management facilities. The Ordinance calls for the use of a 10-year recurrence interval design storm and urban street cross-sections with concrete curbs and gutters. If adequate stormwater drainage facilities are not available downstream from a proposed development, the Ordinance requires the provision of onsite detention or retention storage facilities to limit the peak post-development flow during a 100-year recurrence interval, 24-hour storm to the peak existing condition rate of runoff during a 10-year recurrence interval, 24-hour storm. The Village has adopted a separate construction erosion control ordinance based on the State model ordinance.

Stormwater management requirements for the Village of Union Grove are set forth in the Village Subdivision Control Ordinance, Section 6.10 of the Public Works Chapter of the Village Code of Ordinances. Construction erosion control requirements are established under the Village Building Code. The Ordinance calls for the use of urban street cross-sections with concrete curbs and gutters. The ordinance does not make a general requirement for the provision of onsite detention storage for all new development; however, for large commercial and residential developments, the ordinance requires the provision of onsite detention storage facilities to limit the peak post-development flow during a 100-year recurrence interval storm to the peak existing condition rate of runoff during a 10-year recurrence interval storm.

The Towns of Brighton and Paris do not have stormwater management or construction erosion control ordinance requirements.

Chapter 17, "Storm Water Runoff," of the Town of Bristol Code of Ordinances establishes requirements for the control of the quality and quantity of stormwater runoff. Where comprehensive stormwater management plans have been approved by the Town, the requirements of such plans are to be applied. In the absence of an adopted, comprehensive stormwater management plan, the Ordinance calls for the post-development peak rate of runoff from 24-hour storms with recurrence intervals ranging from 10 through 100 years to be controlled to no more than the pre-development peak rate of runoff during a 10-year storm. The Ordinance also calls for the post-development peak rate of runoff from 24-hour storms with recurrence intervals ranging from two to just less than 10 years to be controlled to no more than the pre-development peak rate of runoff during a two-year storm. If the downstream drainage system is inadequate, it may be required that the post-development 10-year storm peak flow be restricted to less than the pre-development peak rate. Construction erosion control requirements are set forth in Chapter 18, "Permit Application, Construction Site Maintenance, and Erosion Control Plan, and Permit Issuance."

The Town of Dover ordinance relating to drainage facilities and construction erosion control was adopted in 1999. Sections 16.40 and 16.44 of the Town Code of Ordinances include general requirements for stormwater drainage facilities and for a plan to minimize construction site erosion. The ordinance allows either storm sewer or roadside swale drainage facilities and allows onsite facilities to limit peak post-development flows where downstream drainage facilities are inadequate.

The Town of Mt. Pleasant applies standards for stormwater management and construction erosion control that were developed by Town Stormwater Drainage District No. 1.[44] That district is outside the Des Plaines River

[44]*The most current version of these standards is dated May 1999.*

watershed; however, the standards are applied to new development throughout the Town. The standards call for the use of a 10-year storm to size storm sewers and open channels. Following development, the standards call for no increase in stormwater runoff in comparison to pre-development conditions. The standards call for a case-by-case determination of the need for retention or detention facilities, depending on downstream conditions. In addition to the construction erosion control standards, the Town Subdivision and Platting Ordinance sets forth general requirements related to construction erosion control.

The Town of Salem Land Division Ordinance was initially adopted in October 1993, and revised in December 1995. The Ordinance, set forth in Chapter 18 of the Town Code of Ordinances, includes general requirements regarding stormwater management facilities. The Ordinance allows for the use of either rural street cross-sections with grassed roadside swales or urban street cross-sections with concrete curbs and gutters. Onsite detention or retention storage facilities or settling basins may be required for flow control and to reduce soil erosion and the resultant sedimentation of streams and lakes, but no specific control requirements are set forth in the Ordinance. In practice, the Town generally requires the peak post-development rates of runoff for the two-, 10-, and 100-year storms to be limited to the corresponding pre-development rates. The Town has adopted a separate construction erosion control ordinance based on the State model ordinance.

The Town of Somers Land Division and Platting Control and Development Ordinance was adopted in March 1990, pursuant to Section 236.45 of the State statutes, and was most recently amended in August of 1999. The Ordinance, set forth in Chapter 18 of the Town Code of Ordinances, includes general requirements regarding construction erosion control and stormwater management facilities. The Ordinance calls for the use of a 10-year recurrence interval design storm and it grants the Town Board discretion in requiring the use of urban street cross-sections with concrete curbs and gutters. The Ordinance calls for onsite facilities to limit the peak post-development flows during a 100-year storm to the peak pre-development flow for a 10-year storm or the capacity of the downstream stormwater drainage system, whichever is less.

The Town of Yorkville applies stormwater management guidelines which call for the provision of onsite detention storage facilities to limit the peak post-development flows during five-, 10- and 100-year recurrence interval storms to the peak existing condition rates of runoff during two-, five-, and 10-year recurrence interval storms, respectively. The Town does not have a construction erosion control ordinance, but it does apply guidelines that call for consistency with the WDNR *Wisconsin Construction Site Erosion Control Best Management Practice Handbook* and the State specifications for road and bridge construction.

SUMMARY AND CONCLUSIONS

This chapter has described, in summary form, the legal and regulatory framework within which the comprehensive watershed plan for the Des Plaines River watershed must be developed and implemented. The major areas of water law and Federal, State, and local regulations presented in this chapter which have particular relevance to the planning process for the Des Plaines River watershed include: 1) water quality management, 2) floodland regulation, 3) WDNR channel modification policy, 4) wetland regulation, 5) State permitting of proposed channel modifications and of surface water diversions, 6) environmental impact assessment, 7) local stormwater management, and 8) State permitting of stormwater discharges.

Water Quality

Under the 1972 amendments to the Federal Clean Water Act, water use objectives and supporting water quality standards are required for all navigable waters of the United States. Responsibility for water quality management in Wisconsin is centered in the WDNR. Within Southeastern Wisconsin, however, Federal law requires the preparation of an areawide water quality management plan, and the Department has delegated this task to the Regional Planning Commission, which completed such a plan in 1979. The water use objectives established as of 2002 by the Department for the surface waters of the Des Plaines River watershed include maintenance of a warmwater sport fishery, maintenance of a limited forage fishery, and maintenance of limited aquatic life.

Under the Des Plaines River watershed planning process, the water quality of the streams selected for study was modeled to consider both point and nonpoint sources of pollution. Alternative plans intended to achieve the recommended water use objectives through attainment of the supporting water quality standards were developed and evaluated and a recommended plan was selected from among those alternatives.

Floodplains

Chapter NR 116 of the *Wisconsin Administrative Code* sets forth the general criteria for counties, cities, and villages to follow in enacting reasonable and effective floodland regulations. Those criteria, along with the requirements of the National Flood Insurance Program, were used in the delineation under the watershed study of the floodlands along 109.2 miles of streams and watercourses within the Des Plaines River watershed.

Within the watershed, Kenosha and Racine Counties, the City of Kenosha, the Village of Pleasant Prairie, and the Village of Union Grove have adopted floodplain zoning ordinances and are participating in the National Flood Insurance program. The delineation of flood hazard areas in the Village of Paddock Lake would logically be followed by the adoption of a floodplain zoning ordinance and by participation in the National Flood Insurance Program. Following the delineation of any flood hazard areas in the portion of the Village of Union Grove lying within the Des Plaines River watershed, those floodplains would also logically be regulated under the Village floodplain zoning ordinance.

Under the watershed study, the total length of streams and watercourses with identified flood hazard areas increased from 64 to 109 miles, a 70 percent increase. The intent of the watershed plan is that the flood profiles produced under the watershed study be adopted by the cognizant units of government, including Kenosha and Racine Counties; the City of Kenosha; and the Villages of Paddock Lake, Pleasant Prairie, and Union Grove, for floodland management purposes. The delineation of flood hazard areas in the Village of Paddock Lake would logically be followed by the adoption of a floodplain zoning ordinance and by participation in the National Flood Insurance Program.

Wisconsin Department of Natural Resources Channel Modification Policy

In November of 1987, the Secretary of the WDNR established a policy on the regulation of stream channelization projects for urban flood control. That policy establishes channel modification as a last resort in the resolution of flooding problems. The policy document enumerates Department concerns regarding channel modification as such modification may affect aquatic habitat, the public rights and interests, floodwater storage, and safety problems resulting from increased flow velocities. The Department policy directly affects the planning effort for the Des Plaines River watershed in that it severely limits the potential application of channel modifications as a feasible means for the resolution of identified flood damage and stormwater management problems.

Therefore, the most viable option for floodland management in the Des Plaines River watershed is to preserve the existing flood hazard areas in essentially open space uses, recognizing that under planned, as well as existing, land use conditions, the existing channel conditions must remain essentially unaltered. In addition to full utilization of natural storage areas, flood damage control measures may include constructed detention storage facilities, supplemented by nonstructural flood control measures such as structure floodproofing, elevation, or removal. The only stream reaches along which channel modification may be considered in the planning process are those which may have been found to exhibit very high flood damages; which may have been found to require widening and deepening to accommodate existing urban stormwater drainage facilities; or those where a channel modification may meet multiple objectives of flood control, water quality improvement, and stream habitat restoration.

Wetlands

The determination of permissible, or potentially permissible, activities in wetlands within the Des Plaines River watershed may involve shoreland-wetland regulations administered by Kenosha and Racine Counties, the City of Kenosha, and the Villages of Paddock Lake, Pleasant Prairie, and Union Grove, all under the oversight of the WDNR; wetland water quality standards set forth by the WDNR in Chapter NR 103 of the *Wisconsin Administrative Code*; and regulations administered by the U.S. Army Corps of Engineers under Section 404 of the

Federal Clean Water Act regarding the discharge of dredged or fill materials to wetlands. USDA policies and programs regarding benefits to farmers are also of concern.

Application of the stringent State wetland water quality standards limits activities in wetlands, regardless of their potential overall benefits for flood control and water quality improvement in the receiving streams and lakes of the Des Plaines River watershed. Thus, in the development and evaluation of alternatives under the watershed planning effort, alternatives involving activities in wetlands were avoided wherever possible, unless such activities presented the only viable means of resolving a water quantity or quality problem or where such activities could be used to enhance or restore a degraded wetland.

Permits under Chapter 30 of the Wisconsin Statutes

Under Chapter 30 of the *Wisconsin Statutes*, the WDNR has the authority to regulate the deposition of materials upon the bed of any navigable body of water, the straightening or altering of streamcourses, the dredging of material from the bed of a lake or river, the enlargement of any navigable waterway, and diversions from any body of water.

Of particular importance to the Des Plaines River watershed study is the need for a State permit for dredging material from a streambed. Sediment accumulation in the streams of the watershed was identified as a problem by the Watershed Committee. In addition to controlling sediment eroded from the land surface at or near its source, an approach to alleviating the stream sedimentation problem is to remove sediment from streambeds. Any recommended sediment removal would require procurement of a permit under Chapter 30 of the *Wisconsin Statutes*.

Environmental Impact Assessment Process

Chapter NR 150 of the *Wisconsin Administrative Code* sets forth the general policy concerning actions by State agencies and the effects of these actions on the environment, sets forth criteria for determining whether an environmental assessment or impact statement must be prepared, and establishes guidelines for the preparation and review of any required environmental evaluation of State actions. Certain actions recommended under the Des Plaines River watershed plan potentially could be classified as actions for which an environmental assessment or environmental impact report should be prepared.

Local Stormwater Management Requirements

Construction erosion control ordinances based on the State model ordinance have been adopted by the City of Kenosha, the Villages of Paddock Lake and Pleasant Prairie, and the Town of Salem. The Village of Union Grove and the Towns of Bristol, Dover, Mt. Pleasant, and Somers have subdivision, land division and platting control, or construction site drainage facility ordinances which also address construction erosion control. The Towns of Brighton, Paris, and Yorkville do not have ordinances related to construction erosion control, but Yorkville does apply a set of guidelines. The status of construction erosion control ordinances in the various units of government was accounted for in the water quality modeling, the development and evaluation of alternative nonpoint source pollution control plans, and the formulation of a recommended water quality management plan for the Des Plaines River watershed.

No comprehensive community-wide local stormwater management plans have been prepared for any of the municipalities within the watershed. However, the City of Kenosha and all villages and towns in the watershed either have ordinance requirements or policy guidelines related to the provision of onsite detention storage facilities to limit peak post-development flows.

The Des Plaines River watershed plan includes recommendations addressing some specific local stormwater management problems and the planning effort carefully considered the potential effects of local stormwater management policies on the system of streams and watercourses of the watershed. Factors considered in the analyses included local ordinance requirements regarding the use of rural street cross-sections with roadside swales or urban cross-sections with curb and gutter; the rainfall intensities and recurrence intervals utilized in the design of local stormwater management systems; and local requirements regarding the provision of detention storage.

By definition, the watershed plan is a systems-level plan, based on quantitative analyses of the hydrology and hydraulics of the subwatersheds comprising the overall watershed. Thus, the policy approach represented by the local guidelines and ordinances, which essentially unconditionally call for onsite stormwater controls, is in conflict with the planning approach utilized in the watershed study. One of the goals of the watershed study is to provide an overall framework for the development of detailed local stormwater management plans which are consistent with the watershed development objectives and which supersede any ordinance requirements or policy guidelines calling for mandatory onsite detention storage independent of a logical evaluation of the need for such storage.

State Stormwater Discharge Permits

The 1987 amendments to the Federal Clean Water Act established a Federal program for permitting stormwater discharges. The State of Wisconsin obtained certification from the U.S. EPA to administer the stormwater discharge permitting program as an extension of the existing WPDES program. Section 283.33 of the State statutes, which provides authority for the issuance of stormwater discharge permits by the State, was enacted in 1993. The administrative rules for the State stormwater discharge permit program are set forth in Chapter NR 216 of the Administrative Code, which became effective on November 1, 1994. The following entities require discharge permits under Chapter NR 216:

1. Municipal separate storm sewer systems serving incorporated areas with a population of 100,000 or more.
2. Municipalities in Great Lakes areas of concern.
3. Municipalities which have populations of 50,000 or more and which are located in priority watersheds.
4. State- or permittee-designated discharges from a municipal separate storm sewer system which either contribute to a violation of a water quality standard or are a significant contributor of pollutants to waters of the State.
5. Industries identified in Section NR 216.21.
6. Construction sites, except those associated with agricultural land uses, those for commercial buildings regulated by Chapters COMM 50 through 64 of the *Wisconsin Administrative Code*, and WisDOT projects which are subject to the liaison cooperative agreement between the WDNR and WisDOT.

The only community in the Des Plaines River watershed that is currently required to obtain a stormwater discharge permit under Chapter NR 216 is the Town of Mt. Pleasant. The Town was designated because runoff from the Town is tributary to the stormwater infrastructure system of the City of Racine, which is required to obtain a permit. It is likely that the City of Kenosha and the Village of Pleasant Prairie will be required to obtain a permit when the State begins implementation of the Phase II permit regulations.

Chapter X

OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

The formulation of development objectives and supporting standards is one of the most important steps in the Commission watershed planning process. Soundly conceived watershed development objectives should incorporate the knowledge of many people who are informed not only about the watershed, but about the Region of which the watershed is an integral part. As much as possible, such objectives should be established by duly elected or appointed public officials legally assigned this task, assisted as necessary, not only by planners and engineers, but also by interested and concerned citizen leaders as well. This is particularly important because of the value judgments inherent in any set of development objectives. The active participation of duly elected public officials and citizen leaders in the overall regional planning program is implicit in the composition of the Southeastern Wisconsin Regional Planning Commission itself. The Commission established advisory committees to provide an even broader opportunity for the active participation of elected and appointed public officials, technicians, and citizens in the regional planning process.

One of the important functions of the Des Plaines River Watershed Committee is to assist in the formulation of a set of watershed development objectives and standards which can provide a sound basis for watershed plan design, test, and evaluation. This chapter sets forth the set of watershed development objectives and supporting principles and standards approved by the Committee. Some of these objectives, principles, and standards were originally adopted by the Commission under related regional planning programs but were deemed relevant to formulation of a comprehensive plan for the Des Plaines River watershed. Others were formulated specifically for the watershed plan.

In addition to presenting watershed development objectives, principles, and standards, this chapter discusses certain engineering design criteria and analytic procedures used in the watershed study to design alternative plan subelements, test the physical feasibility of those subelements, and make necessary economic comparisons between such subelements. The description of these criteria and procedures in this chapter is intended to provide an understanding by all concerned of the level of detail entailed in the watershed plan preparation, as well as of the need for refinement of some aspects of that plan prior to implementation.

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 similarly 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 the agreed-upon objectives.

5. Policy: a rule or course of action used to ensure plan implementation.

6. Program: a coordinated series of policies and actions to carry out a plan.

Although this chapter deals primarily with the first three of these terms, an understanding of the interrelationship of the foregoing definitions and the basic concepts which they represent is essential to the following explanation of watershed development objectives, principles, and standards.

WATERSHED DEVELOPMENT OBJECTIVES

In order to be useful in the watershed planning process, objectives not only must be logically sound and related in a demonstrable and measurable way to alternative physical development proposals, but also must be consistent with, and grow out of, regionwide 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, a number of regional development objectives relating to land use, housing, transportation, sewerage, water quality management, air quality management, flood control, and recreation and open space preservation. These objectives, together with their supporting principles and standards, are set forth in previous Commission planning reports. Some of these objectives and standards are directly applicable to the Des Plaines River watershed planning effort and are hereby recommended for adoption as development objectives for the watershed.

Land Use Development Objectives

Six of the eight regional land use development objectives adopted by the Commission under its regional land use planning program are directly applicable to the Des Plaines River watershed planning effort.[1] These are:

1. A balanced allocation of space to the various land use categories which meets the social, physical, and economic needs of the regional population.

2. A spatial distribution of the various land uses which will result in a compatible arrangement of land uses.

3. A spatial distribution of the various land uses which will result in the protection and wise use of the natural resources of the Region, including its soils, inland lakes and streams, groundwater, wetlands, woodlands, and wildlife, and the protection of the natural floodwater storage areas.

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[1]*For further information, including the other two land use plan objectives, see SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin: 2010*, January 1992.*

4. 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 services.

5. The preservation and provision of open space to enhance the total quality of the regional environment, to maximize essential natural resource availability, to give form and structure to urban development, and to facilitate the ultimate attainment of a balanced year-round outdoor recreational program providing a full range of facilities for all age groups.

6. The preservation of land areas to provide for agriculture, to provide a reserve or holding area for future urban and rural needs, and to ensure the preservation of those rural areas which provide wildlife habitat and which are essential to shape and order urban development.

Water Quality Management Objectives
Four of the five water quality management objectives adopted by the Commission under its regional water quality management planning effort[2] are directly applicable to the Des Plaines River watershed planning effort. These are:

1. The development of land management and water quality control practices and facilities, including sanitary-sewerage systems, which will effectively serve the existing regional urban development pattern and promote implementation of the regional land use plan, meeting the anticipated need for sanitary and industrial wastewater disposal and the need for stormwater runoff control generated by the existing and proposed land uses.

2. The development of land management and water quality control practices and facilities, including sanitary-sewerage systems, so as to meet the recommended water use objectives and supporting water quality standards as set forth on Map 59 and in Tables 96 and 97.

3. The development of land management and water quality control practices and facilities, including sanitary-sewerage systems, that are properly related to, and will enhance, the overall quality of the natural and man-made environments.

4. The development of land management and water quality control practices and facilities, including sanitary-sewerage systems, that are both economical and efficient, meeting all other objectives at the lowest possible cost.

5. The development of water quality management institutions—inclusive of the governmental units and their responsibilities, authorities, policies, procedures, and resources—and supporting revenue-raising mechanisms which are effective and locally acceptable, and which will provide a sound basis for plan implementation, including the planning, design, construction, operation, maintenance, repair, and replacement of water quality control practices and facilities, inclusive of sanitary sewerage systems, stormwater management systems, and land management practices.

In addition to the foregoing specific regional water quality management objectives, the following specific objective is recommended for adoption as an additional management objective for the Des Plaines River watershed:

6. The attainment of soil and water conservation practices which reduce stormwater runoff; soil erosion; and stream and lake sedimentation, pollution, and eutrophication.

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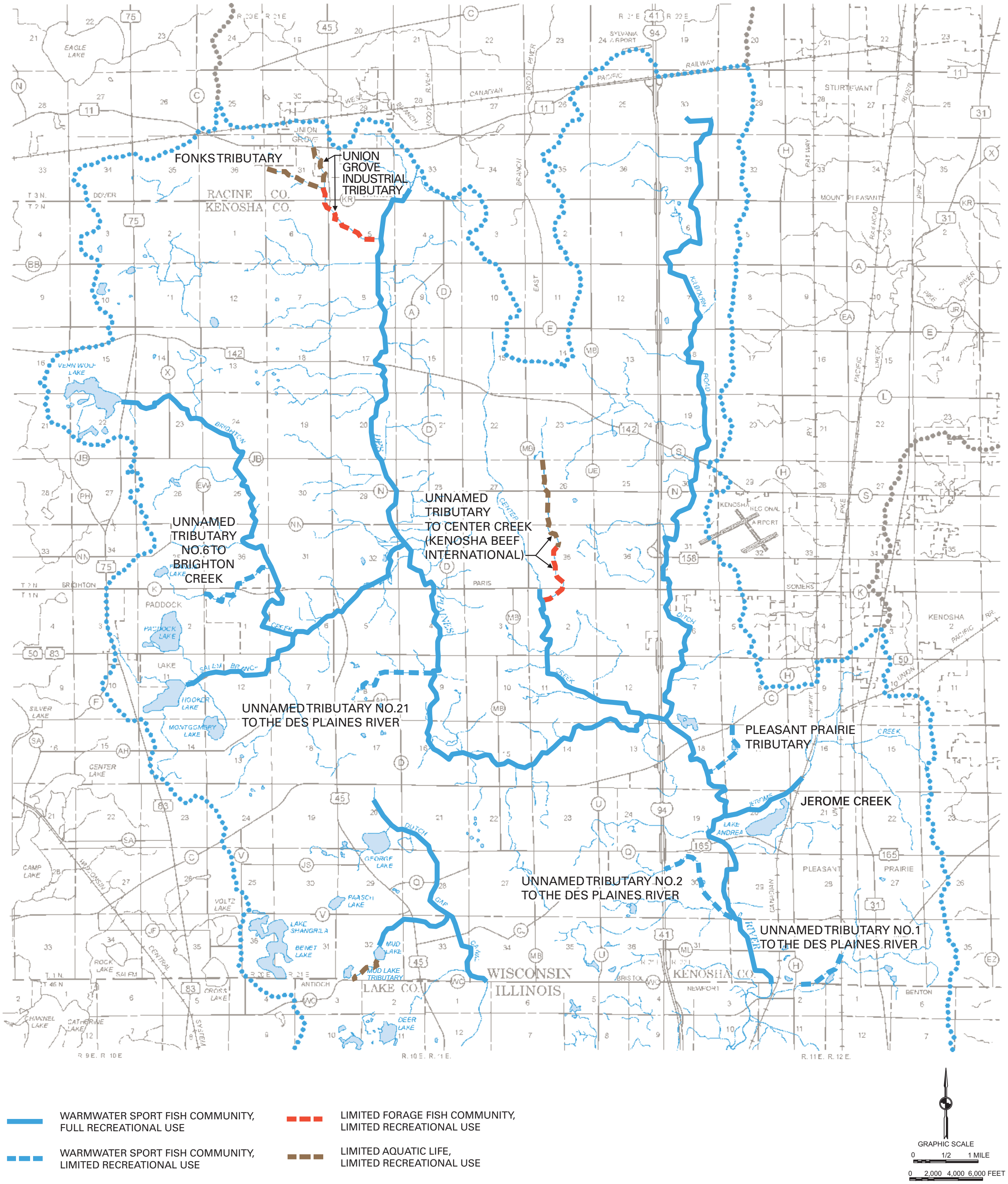
[2]*See SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000*, Volume One,* Inventory Findings*, 1978; Volume Two,* Alternative Plans*, 1979; Volume Three,* Recommended Plan*, 1979.*

Map 59

RECOMMENDED WATER USE OBJECTIVES FOR SURFACE WATERS IN THE DES PLAINES RIVER WATERSHED



Under the regional water quality management planning program, analyses were conducted to determine the feasibility of achieving a level of water quality that would make all surface waters “fishable and swimmable" as envisioned by the U.S. Congress in Public Law 92-500. Approximately 62 miles of stream in the Des Plaines River Watershed are assigned water use objectives which meet the national goal of “fishable and swimmable” water. An additional 11 miles of stream are assigned objectives which do not meet the goal.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 96

APPLICABLE WATER USE OBJECTIVES AND WATER QUALITY STANDARDS FOR LAKES AND STREAMS WITHIN THE DES PLAINES RIVER WATERSHED[a]

Water Quality Parameters	Combinations of Water Use Objectives Adopted for Southeastern Wisconsin Inland Lakes and Streams[b,c]			
	Warmwater Sport Fish Community and Full Recreational Use	Warmwater Forage Fish Community and Limited Recreational Use	Limited Forage Fish Community and Limited Recreational Use[d]	Limited Aquatic Life and Limited Recreational Use
Temperature[e,f,g] (°F)	89.0 maximum	89.0 maximum	- -	- -
Dissolved Oxygen[g] (mg/l)	5.0 minimum[h]	5.0 minimum[h]	3.0 minimum[i]	3.0 minimum[i]
pH Range[j] (S.U.)	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0
Total Phosphorous[k] (mg/l)	0.1, 0.02 maximum	- -	- -	- -
Un-ionized Ammonia Nitrogen (mg/l)	0.04 maximum	0.04 maximum	3.0, 6.0 maximum[l]	- -
Chloride[m] (mg/l)	1,000 maximum	1,000 maximum	1,000 maximum	- -
Fecal Coliform (MFFCC)	200, 400 maximum[n]	1,000; 2,000 maximum[o]	1,000; 2,000 maximum[o]	1,000; 2,000 maximum[o]

[a]*Wisconsin Department of Natural Resources and additional categories established under the areawide water quality management planning program, plus those combinations of water use categories applicable to the Southeastern Wisconsin Region. It is recognized that under both extremely high and extremely low flow conditions, instream water quality levels can be expected to violate the established water quality standards for short periods of time without damaging the overall health of the stream. It is important to note the critical differences between the official State and federally adopted water quality standards—composed of "use designations" and "water quality criteria"—and the water use objectives and supporting standards of the Regional Planning Commission described here. The U.S. Environmental Protection Agency and the Wisconsin Department of Natural Resources, being regulatory agencies, utilize water quality standards as a basis for enforcement actions and compliance monitoring. This requires that the standards have a rigid basis in research findings and in field experience. The WDNR objectives and standards are appropriate for all regulatory and permitting purposes. The Commission, by contrast, must forecast regulations and technology far into the future, documenting the assumptions used to analyze conditions and problems which may not currently exist anywhere, much less in or near Southeastern Wisconsin. As a result, more recent—and sometimes more controversial—study findings must sometimes be applied. This results from the Commission's use of the water quality standards as criteria to measure the relative merits of alternative plans.*

[b]*All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water, floating or submerged debris, oil, scum, or other material, and material producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the State. Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life.*

[c]*Standards presented in the table have been applied for planning purposes to lakes over 50 acres in surface area and to major streams of the Region.*

[d]*No un-ionized ammonia nitrogen standard has been established for streams or lakes classified as supporting limited forage fish communities. The maximum standard for total ammonia, as set forth in Chapter NR 104 of the* Wisconsin Administrative Code, *is included in the table.*

[e]*There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the natural temperature shall not exceed 5°F for streams.*

[f]*There shall be no significant artificial increases in temperature where natural trout reproduction is to be maintained.*

[g]*Dissolved oxygen and temperature standards apply to continuous streams and the epilimnion of stratified lakes and to the unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. However, trends in the period of anaerobic conditions in the hypolimnion of deep inland lakes should be considered important to the maintenance of their natural water quality.*

Table 96 - Footnotes (continued)

[h]*Standard noted is applied using a probabilistic analyses approach as defined in SEWRPC Memorandum Report No. 93,* Regional Water Quality Management Plan Update and Status Report*; absolute minimum standard of 3.0 mg/l of dissolved oxygen also applies.*

[i]*Standard noted is applied using a probabilistic analyses approach as defined in SEWRPC Memorandum Report No. 93; absolute minimum standard of 1.5 mg/l of dissolved oxygen also applies.*

[j]*The pH shall be within the stated range with no change greater than 0.5 units outside the estimated natural seasonal maximum and minimum.*

[k]*In streams classified for full recreational use, the total phosphorus concentration shall not exceed 0.1 mg/l. In lakes classified for full recreational use, the total phosphorus concentration shall not exceed 0.02 mg/l during spring when maximum mixing is underway. A phosphorus standard does not apply to streams and lakes classified for limited recreational use. Total phosphorus standards were developed by the Commission for use in the initial water quality management plan from U.S. Environmental Protection Agency recommendations set forth in* Quality Criteria for Water*, 1976.*

[l]*Standard is for total ammonia. Ammonia Nitrogen, expressed as N, at all points in the receiving water of Limited Forage Fish Communities should not be greater than 3 mg/l during warm temperature conditions (May - October), and 6 mg/l during cold temperatures (November - April), to minimize the zone of toxicity and to reduce dissolved oxygen depletion caused by oxidation of the ammonia.*

[m]*Threshold concentration for the propagation of freshwater fish above which the effects on aquatic life may become significant as determined by the California State Water Pollution Control Board, 1952.*

[n]*The fecal coliform count (MFFCC) should not exceed 200 per 100 ml as a geometric mean based on no less than 5 samples per month, nor exceed 400 per 100 ml in more than 10 percent of all samples during any month.*

[o]*The fecal coliform count (MFFCC) should not exceed 1000 per 100 ml as a geometric mean based on no less than 5 samples per month, nor exceed 2000 per 100 ml in more than 10 percent of all samples during any month.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Outdoor Recreation and Open Space Preservation Objectives

Two of the seven park and open space objectives adopted by the Commission under its regional park and open space planning program and also set forth in the park and open space plans prepared by the Commission for Kenosha and Racine Counties[3] are directly applicable to the Des Plaines River watershed planning effort. These are:

1. The provision of an integrated system of public general-use outdoor recreation sites and related open space areas which will allow the resident population of the Region adequate opportunity to participate in a wide range of outdoor recreation activities.

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[3]*For further information, including the other five park and open space objectives, see SEWRPC Community Assistance Planning Report No. 131,* A Park and Open Space Plan for Kenosha County*, November 1987, and SEWRPC Community Assistance Planning Report No. 134,* A Park and Open Space Plan for Racine County*, September 1988.*

Table 97

ACUTE AND CHRONIC TOXICITY CRITERIA[a]

Water Quality Parameters	Acute Toxicity (Φg/l)			Chronic Toxicity (Φg/l)		
	Water Use Objectives					
	Warmwater Sport and Forage Fish, Limited Forage Fish, and Limited Aquatic Life with Full or Limited Recreation			All Water Uses		
	Hardness ($mgCaCO_3$/l)			Hardness ($mgCaCO_3$/l)		
	50	100	200	50	100	200
Cadmium	13.3	29.0	63.3	0.2	0.5	1.0
Copper	8.6	16.6	31.9	6.0	11.2	22.1
Lead	70.0	169.1	408.6	4.2	10.1	24.4
Zinc	62.7	112.8	202.9	27.6	49.6	89.2

[a]*Values set forth in Chapter NR 105 of the* Wisconsin Administrative Code*.*

Source: Wisconsin Department of Natural Resources.

2. The preservation of sufficient high-quality open space lands for the protection of the underlying and sustaining natural resource base and the enhancement of the social and economic well-being and environmental quality of the Region.

Water Control Facility Development Objectives
Two of the specific water control facility development objectives adopted by the Commission under its other comprehensive watershed planning programs are applicable to the Des Plaines River watershed planning effort. These are:

1. An integrated system of drainage and flood control facilities and floodland management programs which will effectively reduce flood damage under 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 land management and water quality control facilities and point and nonpoint source pollution abatement measures adequate to ensure a quality of surface water necessary to meet the established water use objectives and supporting water quality standards.

Principles and Standards
Complementing each of the foregoing land use, water quality management, outdoor recreation and open space, and water control facility development objectives are a planning principle, which supports the objective and asserts its inherent validity, and a set of quantifiable planning standards, which can be used to evaluate the relative or absolute ability of alternative plan designs to meet the stated objective. These principles and standards, as they apply to watershed planning and development, are set forth in Appendix C and serve to facilitate quantitative application of the objectives during plan design, test, and evaluation.

It should be noted that the planning standards herein recommended for adoption 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 should serve as aids, not only 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.

Water Use Objectives and Water Quality Standards

The Wisconsin Department of Natural Resources (WDNR) currently applies the following water use objectives to selected portions of the Des Plaines River watershed stream system: 1) warmwater sport fish community and full recreational use, 2) limited forage fish and limited recreational use, and 3) limited aquatic life and limited recreational use. These currently adopted water use objectives and the supporting standards are set forth in Chapter IX.

Recommended water use objectives are shown on Map 59 and Table 98. The water quality standards associated with the water use objectives are set forth in Tables 96 and 97. The recommended water use objectives for the Des Plaines River, Unnamed Tributaries No. 1 and 2 to the Des Plaines River, Unnamed Tributary No. 21 to the Des Plaines River in the Town of Bristol south of STH 50, Unnamed Tributary No. 6 to Brighton Creek, the Pleasant Prairie Tributary, Brighton Creek, the Salem Branch of Brighton Creek, Center Creek, the Dutch Gap Canal, Jerome Creek, Kilbourn Road Ditch, and the Mud Lake Outlet call for the support of a warmwater sport fish community and limited or full recreational use. The recommended water use objectives for the Union Grove Industrial Tributary downstream of the junction with Fonks Tributary and the downstream reach of the Unnamed Tributary to Center Creek that is located east of CTH MB and downstream of the Kenosha Beef International plant call for support of a limited forage fish community and limited recreational use. The recommended water use objectives for Fonks Tributary, the Union Grove Industrial Tributary upstream of the junction with Fonks Tributary, the Mud Lake Tributary, and the upstream reach of the Unnamed Tributary to Center Creek that is located east of CTH MB and downstream of the Kenosha Beef International plant call for the support of limited aquatic life and limited recreational use.

As shown in Table 98, a comparison of the recommended water use objectives with the water use objectives established by the WDNR indicates that the two sets of objectives are identical with the exception of those for the Salem Branch of Brighton Creek, the Pleasant Prairie Tributary; Unnamed Tributaries No. 1, 2, and 21 to the Des Plaines River; and Unnamed Tributary No. 6 to Brighton Creek. The Department objectives were established in 1989, prior to the abandonment of the Town of Salem Utility District No. 1 sewage treatment plant, which discharged to the Salem Branch, and of the Wisconsin Department of Transportation (WisDOT) Tourist Information Center sewage treatment plant, which discharged to Unnamed Tributary No. 2 to the Des Plaines River. The objectives for Salem Branch and Unnamed Tributary No. 2 to the Des Plaines River recommended under the watershed study recognize 1) the higher potential uses of the streams following abandonment of the treatment plants and 2) the preliminary field inventories conducted by the WDNR staff that indicate the potential for higher water use objectives than are currently set forth in the Code. The recommended objective for Unnamed Tributary No. 6 to Brighton Creek recognizes the relocation of the outfall from the Village of Paddock Lake treatment plant. The recommended objective for Unnamed Tributary No. 21 to the Des Plaines River recognizes that the effluent limits for the Town of Bristol Utility District No. 1 treatment plant were established to be protective of the Des Plaines River. The objective for the Pleasant Prairie Tributary recommended under the watershed study recognizes that the Village of Pleasant Prairie Sewer Utility District "D" sewage treatment plant is recommended for abandonment and that preliminary field inventories conducted by the WDNR staff indicate the potential for a higher water use objective than is currently set forth in the Code. The objective for Unnamed Tributary No. 1 to the Des Plaines River recommended under the watershed study recognizes that the Village of Pleasant Prairie Sanitary District No. 73-1 sewage treatment plant is recommended for abandonment.

The six major lakes in the watershed, Benet-Shangrila Lake, Vern Wolf Lake, George Lake, Hooker Lake, Paddock Lake, and Lake Andrea in the Village of Pleasant Prairie, are all assigned a recommended water use objective which calls for the support of a warmwater sport fish community and full recreational use.

Table 98

COMPARISON OF WATER USE OBJECTIVES FOR STREAMS AND RIVERS IN THE DES PLAINES RIVER WATERSHED

Stream or River	Recommended Des Plaines River Watershed Study Water Use Objective	Water Use Objective Established by the Wisconsin Department of Natural Resources
Des Plaines River, Brighton Creek, Center Creek, Dutch Gap Canal, Jerome Creek, Kilbourn Road Ditch, and Mud Lake Outlet	Warmwater sport fish community and full recreational use	Warmwater sport fish community and full recreational use
Salem Branch of Brighton Creek	Warmwater sport fish community and full recreational use	Limited forage fish community and limited recreational use
Pleasant Prairie Tributary; Unnamed Tributaries No. 1, 2, and 21 to the Des Plaines River; and Unnamed Tributary No. 6 to Brighton Creek	Warmwater sport fish community and limited recreational use	Limited aquatic life and limited recreational use
Union Grove Industrial Tributary Downstream of Confluence with Fonks Tributary, and Downstream Reach of Unnamed Tributary to Center Creek (Kenosha Beef International)	Limited forage fish community and limited recreational use	Limited forage fish community and limited recreational use
Mud Lake Tributary, Fonks Tributary, Union Grove Industrial Tributary Upstream of Confluence with Fonks Tributary, and Upstream Reach of Unnamed Tributary to Center Creek (Kenosha Beef International)	Limited aquatic life and limited recreational use	Limited aquatic life and limited recreational use

Source: Wisconsin Department of Natural Resources and SEWRPC.

The water quality standards supporting the preliminary recommended water use objectives are set forth in Appendix C. Those standards were developed for planning purposes considering the standards set forth in the initial areawide water quality management plan and in the Wisconsin Administrative Code, Chapters NR 102, 104, and 105, as well as from additional sources, including U.S. Environmental Protection Agency (EPA) water quality criteria.

The recommendations for a total of about 62 miles of stream, including the Des Plaines River, Unnamed Tributaries No. 1, 2, and 21 to the Des Plaines River, Brighton Creek, the Salem Branch of Brighton Creek, Unnamed Tributary No. 6 to Brighton Creek, Center Creek, the Dutch Gap Canal, Jerome Creek, Kilbourn Road Ditch, the Mud Lake Outlet, the Pleasant Prairie Tributary, and the six major lakes in the watershed are in conformance with the National water use objectives cited in Public Law 92-500, which call for the attainment wherever possible of water quality which is sufficient to support the protection and propagation of fish, shellfish, and other wildlife and for the support of human recreation in and on the waters. Analyses conducted in development of the adopted regional water quality management plan indicate that the attainment of these "fishable-swimmable" water use objectives and the supporting water quality standards is feasible and realistic if the significant water pollution sources in the areas tributary to those streams and lakes are properly abated. The attainment of "fishable-swimmable" conditions is not considered to be feasible and realistic for a total of about 11 miles of stream, including the Union Grove Industrial Tributary, Fonks Tributary, the Mud Lake Tributary, and the Unnamed Tributary to Center Creek that is located east of CTH MB and downstream of the Kenosha Beef International plant, because of sewage-treatment-plant discharges or habitat limitations.

As noted in Chapter IX of this report, Chapter NR 103 of the Wisconsin Administrative Code establishes water quality-related rules for wetlands. The rules consist of 1) a set of standards intended to protect the water quality-related functions of wetlands and 2) implementation procedures for application of the water quality standards. Because the application of the rules set forth in Chapter NR 103 is site-specific and requires consideration of the specific activity proposed within or adjacent to a wetland, wetland water quality standards are not specifically addressed in this report. The procedures documented in Chapter NR 103 must be applied by the WDNR on a site-specific, case-by-case basis.

Overriding Considerations

When applying the watershed development objectives, principles, and standards to the watershed plan elements, several overriding considerations must be recognized. First, it must be recognized that any proposed water control and water quality management facilities must constitute integral parts of a total system. It is not possible through application of these objectives and standards alone, however, to assure such system integration, since the objectives and standards cannot be used to determine the effect of individual facilities and controls on each other or on the system as a whole. This requires the application of planning and engineering techniques developed for this purpose, such as hydrologic, hydraulic, and water quality simulation, to test quantitatively the performance of the proposed facilities as part of a total system, thereby permitting adjustment of the spatial distribution and capacities of the facilities to the existing and future runoff and waste loadings derived from the adopted regional land use plan. Second, it must be recognized that it is unlikely that any one plan proposal will meet all the standards completely. Thus, 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 objective which the given standard complements. Third, it must be recognized that certain objectives may be in conflict and that such conflict will require resolution through compromise; such compromise is an essential part of any design effort. The degree to which the recommended Des Plaines River watershed plan meets the adopted objectives and standards is discussed in Chapter XV of this report.

ENGINEERING DESIGN CRITERIA AND ANALYTIC PROCEDURES

As noted earlier in this chapter, certain engineering design criteria and analytic procedures were utilized in the preparation of the watershed plan. More specifically, these criteria and procedures were used in the design of alternative plan subelements, in the test of the technical feasibility of those subelements, and in making the necessary economic comparisons. While these engineering criteria and procedures are widely accepted and firmly based in current engineering practice, it is, nevertheless, believed useful to document them here.

Rainfall Intensity-Duration-Frequency Relationships

A fundamental criterion for comprehensive watershed and floodland management planning and for detailed, local stormwater management plans to be prepared by municipalities or counties within the overall framework of the comprehensive watershed plan is the rainfall characteristics of the planning area. Under this watershed study, flood flows and volumes and water quality characteristics were estimated by using a continuous simulation hydrologic model, as described in Chapter VIII. That model utilized meteorologic data, including precipitation, from the National Weather Service meteorologic stations at the Cities of Kenosha and Milwaukee; the Village of Union Grove; Antioch, Illinois; and McHenry Lock and Dam, Illinois. In addition, the Commission has developed rainfall intensity-duration-frequency relationships, based on the 108-year (1891 through 1998) precipitation record at the Milwaukee National Weather Service station, which are representative of the Des Plaines River watershed area. These relationships are shown graphically in Appendix D. The curves in Figure D-1 are directly applicable to urban stormwater management system design within the Des Plaines River watershed.

Flood Discharge-Frequency Analyses

Each discrete location on a watershed stream system can be assigned a discharge-frequency relationship which is characteristic of certain stream channel and overbank conditions and of a given level of watershed development. The discharge-frequency relationship, which is normally presented graphically, relates possible annual peak discharges in cubic feet per second to the average frequency or recurrence interval in years at which the indicated discharge will be reached or exceeded. Discharge-frequency analyses of annual flood peaks were conducted under the Des Plaines River watershed study according to the log Pearson Type III method of analyses as recommended by the U.S. Water Resources Council[4] and as specified by the Wisconsin Department of Natural Resources.[5]

In the absence of suitable, long-term flow records at all points of interest within the watershed, the discharge-frequency analyses were applied to simulated annual peak discharges throughout the watershed stream system so as to produce, in effect, watershedwide simulated discharge-frequency relationships. The simulated annual peak discharges were obtained for various combinations of watershed development using a calibrated hydrologic-hydraulic model as described in Chapter VIII.

Design Flood

The design flood adopted for the Des Plaines River watershed is that event with a 100-year recurrence interval peak discharge under buildout land use pattern and floodland development conditions which reflect complete development of the adopted sewer service areas within the watershed, as those conditions are set forth in Chapter IV. This discharge was determined for locations distributed throughout the watershed stream system and was used to delineate the 100-year recurrence interval floodlands, which in turn served as the basis for development and testing of alternative plans and selection of the recommended plan. For example, the 100-year recurrence interval flood-hazard line was used to define those areas included in the synthesis of annual flood damages.

The selection of the design flood should be dictated by careful consideration of such factors as available hydrologic data, watershed flood characteristics, and costs attributable to flooding relative to benefits accruing from various floodplain management alternatives, but, in the final analysis, it is as much a matter of public policy as it is of engineering practice and economic analysis. Sound engineering practice dictates that the flood used to delineate floodlands for land use regulation purposes have a specific recurrence interval so that the costs and benefits of alternative floodland management plans can be analyzed along with the advantages and disadvantages of various levels and combinations of police power regulations, public acquisition, and public construction for flood damage abatement and prevention. The Commission has selected the 100-year recurrence interval flood as the design flood for all of its watershed planning efforts for the following reasons:

1. The 100-year recurrence interval flood is judged to be a reasonably conservative choice when viewed in the context of the full range of possible regulatory flood events which could be used.

2. The 100-year recurrence interval flood was recommended for use by Federal agencies for floodplain management purposes in 1969[6] by the U.S. Water Resources Council, an organization composed of representatives of Federal offices and agencies concerned with water resource problems.

3. The 100-year recurrence interval flood, also called the regional flood, serves as the basis for the floodland regulations set forth in Chapter NR 116 of the Wisconsin Administrative Code.

Flood flows corresponding to flood frequencies of two, 10, 25, and 50 years were also computed under the watershed planning effort. Those flows were used to synthesize flood damage-probability curves which were used to compute average the annual flood damages described in Chapter VI of this report. They were also used, along with the 100-year recurrence interval flood peak flow, to evaluate the impacts of floodland management

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[4]*United States Water Resources Council,* Guidelines for Determining Flood Flow Frequency*, Bulletin 17B, Washington, D.C., September 1981.*

[5]*"Wisconsin's Floodplain Management Program,"* Wisconsin Administrative Code*, Chapter NR 116, Register No. 362, February 1986.*

[6]*U.S. Water Resources Council,* Proposed Flood Hazard Evaluation Guidelines for Federal Executive Agencies*, Washington, D.C., September 1969.*

alternatives on the range of peak flood flows throughout the watershed and at the Wisconsin-Illinois state line. Finally, relative changes in the magnitude of the peak two-year recurrence interval flood flow were used to indicate whether planned land use changes, in combination with various floodland management alternatives, would result in hydraulic conditions which could accelerate streambank erosion and streambed scour.

Economic Evaluation

The concepts of economic analysis and economic selection are vital to the public planning process. A 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 implicitly based on an evaluation of benefits and costs. This is not to imply that a formal economic analysis is conducted of every expenditure. However, the decision-making process does consider whether the benefit received would be worth the amount paid. Benefits are not necessarily quantifiable 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 considering whether a potential benefit is worth its cost, consideration is given to 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 investment for future benefits is considered, one alternative that should always be considered is the benefit that could be received from investment in the money market. This benefit is expressed in the prevailing interest rate. Personal and private decisions, broadly defined, are not necessarily based upon either formal or objective evaluation of monetary benefits and costs. Public officials, however, have a responsibility to evaluate objectively and explicitly 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 desirably return to the public a value at least equal to the amount expended plus the interest income foregone from the ever-present alternative of public investment. In other words, the public should receive a value return from its tax investment at least equal to what it could receive from private investment. Therefore, economic analysis is a fundamental requirement of responsible public planning; all plans should desirably 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, services, and environmental quality 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." The monetary value of a benefit 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. In order to assure that public funds are committed and expended wisely, alternative plan elements should be formulated, developed, and analyzed; the recommended plan should be selected from those alternatives which meet watershed development objectives only after consideration of the following hierarchy of economic considerations:

1. Benefits, including intangible values, must exceed costs in order for a project to be economically justified.

2. An excess of benefits over costs, however, is not a sufficient criterion on which to base a watershed plan recommendation; therefore, among those alternative plan elements exhibiting benefit-cost ratios greater than one, the alternative with the greatest difference between benefits and cost, not the greatest benefit-cost ratio, will produce the largest absolute return on the investment.

3. Maximization of benefits minus costs is not, however, in and of itself a sufficient criterion for selection of an alternative, since the amount of public funds available or potentially available and public attitudes toward a particular plan element must be considered in selecting from among various plan elements. It may be politically and financially impossible to obtain support and funding for a plan element even though it, among all the available alternatives, would produce the greatest return on the investment.

The benefits that could be achieved through implementation of a comprehensive plan for the Des Plaines River watershed include floodland management; recreational opportunities; the provision of efficient community utilities and facilities; the enhancement of property values; and the preservation of recreational, scenic, cultural, and ecological values. Costs which could be incurred in implementation of the watershed plan include construction and land acquisition costs and the income foregone as a result of the regulation of land use.

There may be situations in which a local community affected by an alternative plan proposal subjectively evaluates the costs and benefits of that proposal in a manner differing significantly from an objective, economically sound analysis of the costs and benefits. For example, because of its subjective interpretation of benefits and costs, the community may strongly favor an alternative plan proposal that has an objectively determined benefit-cost ratio of less than one; or, conversely, the affected community may oppose an alternative with a favorable benefit-cost ratio. Adoption and implementation of areawide plan elements with objectively determined benefit-cost ratios of less than one should generally be discouraged, except possibly in situations where the costs are borne entirely and equitably by, and with the full knowledge and understanding of, the local beneficiaries.

Time-Value of Money, or 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. The benefits of one project may be realized earlier than are 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. Similarly, 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 cost of one dollar for a benefit of one dollar at some time in the future has a value of less than one dollar today. The variation in the 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 possibility of private investment as an alternative. Low interest rates tend to yield favorable benefit-cost analyses, whereas high interest rates tend to render projects uneconomical, particularly those alternatives that involve immediate capital expenditures to achieve a stream of benefits extended over a long period of time.

To be economical, a project should return to the public a benefit approximating that which might be obtained through private investment. Over the long term, money invested privately is expected to return from 4 to 8 percent interest after taxes. Since implementation of the watershed plan should return benefits to the public similar to those which could be attained through private investment, an interest rate of 6 percent is recommended for use in the economic evaluation of plans. This interest rate also approximates the cost of money for public works projects.

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 Des Plaines River watershed plan, however, will continue to furnish benefits for an indefinite time, particularly in 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 economic analysis and this period is recommended for the Des Plaines River watershed alternative plans. Using a 6 percent interest rate, benefits accrued after 50 years, when discounted to the present, are very small. 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 tangible, measurable in monetary terms, or 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 Des Plaines River watershed planning studies, tangible benefits might include reduction of flood damage, enhancement of property values, and those parts of recreation and water quality management to which a monetary value can be assigned.[7] Intangible benefits include the aesthetic factors derived from natural beauty and a pleasant environment. Intangibles also include such benefits as improved efficiencies in community utilities and facilities, which have monetary values impracticable to calculate. The specific benefits of water quality improvements were considered to be intangible in the sense that these benefits are difficult to measure, although very real, since a high level of recreational use of surface waters is possible only if applicable water quality standards are met. The exact procedures used to compute benefits commensurate with alternative plans are discussed later in this report in conjunction with the description of alternative plan synthesis and testing.

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[7]*More specifically, flood damage is defined as the physical deterioration or destruction caused by floodwaters. Flood loss refers to the net effect of flood damages on the economy and is usually expressed in monetary terms. All losses resulting from a flood can be broadly classified as direct, indirect, depreciation, or intangible. Reduction of flood loss by flood protection measures creates benefits equal to the damages protected against.*

Direct losses are defined as the monetary costs entailed in restoring flood-damaged property to preflood condition. This includes the cost of restoring flood-damaged residential, commercial, and industrial properties and the value of farm crops destroyed by flooding.

Indirect losses are defined as the monetary costs of flood-fighting and floodproofing, and of flood-caused loss of wages, sales, and production. Increased costs of carrying on normal operations during periods of flood disruption, and increased costs of transportation because of flood-caused detours, are also defined as indirect losses.

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 amount of money which will have to be expended for flood repairs. Accordingly, depreciation losses should be equal to the probable direct losses from future floods. In the Regional Planning Commission approach to flood control planning, the direct flood losses, rather than the depreciation losses, are used in the economic analyses.

Intangible losses are defined as losses that cannot be measured in monetary terms. Intangible losses include loss of life, health hazard, interruption of schooling, loss of police and fire protection, and mental aggravation. Although these losses cannot be measured in monetary terms, they often constitute the most severe flood damage experienced by the public, monetary costs notwithstanding.

Flood damages may also be classified into public-sector and private-sector losses. Direct public-sector losses include road and bridge repairs, basement pumping, and flood cleanup. Indirect public-sector losses include highway traffic rerouting and control and relief and health services.

Direct private-sector losses include damage to residential, commercial, and industrial properties and to agricultural crops. Structural damages are related to the type of building or structure involved, the value of the structures and contents, and the depths and durations of inundation. Damages to structures include, among others, damages to electrical, heating, and ventilating equipment; to ceilings, walls, floors, and fittings; to carpeting; to furniture and appliances; and to other contents.

Project Costs

The direct costs of water resource development include the construction costs of physical elements of the plan; the cost of acquiring land; and expenditures for engineering, legal work, and project administration. The costs of structural facilities were calculated using 2002 unit prices, which reflect the magnitude of work, the location in the urban region, and regional labor costs. The cost of land acquisition was based on 2002 market prices for land in the Des Plaines River watershed.[8]

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 in 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 the costs.

On the other hand, and as described above, an economic analysis 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 the people who may be affected, not just on 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.

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 permits lower initial capital investments, reduces interest costs, and allows for flexibility in continued planning. Staging developments may also allow an element to be deferred until increased demands raise its benefit-cost ratio. In planning for staged development, however, consideration must be given to the possibilities of higher costs in the future and unavailability of land. In any development, staging also serves to lower risks incurred because of unavailability of data during preparation and partial implementation of initial plans.

SUMMARY

The formulation of objectives and standards 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 planning purposes and to quantify them through standards in order to provide the framework within which watershed plans can be prepared.

Moreover, so that the watershed plans will form an integral part of the overall long-range plans for the physical development of the Region, 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 into, previously adopted regional development objectives, supplemented only as required to meet the specific needs of the Des Plaines River watershed planning program. The development objectives adopted for the watershed plan consist of six of the eight adopted regional land use planning objectives, four of the five adopted

[8] *Recommended plan costs as set forth in Chapter XV, "Recommended Comprehensive Plan," and subsequent chapters reflect 2002 costs. Costs set forth in chapters preceding Chapter XV may reflect conditions prior to 2002, but alternatives are always evaluated on a consistent basis.*

water quality management planning objectives, two of the seven adopted regional park and open space planning objectives, and two of the four water control facility objectives adopted under previous Commission comprehensive planning studies. One additional water quality management objective was formulated. That objective relates to soil and water conservation practices which will reduce both the erosion of soil from the land surface and the resultant deposition of sediment in receiving streams and lakes.

In addition to presenting and discussing the objectives, principles, and standards adopted for the Des Plaines River watershed, this chapter presents the engineering design criteria and analytic procedures used in the watershed study. These criteria and procedures were used to synthesize a Des Plaines River watershed plan capable of meeting the study objectives, and were applied in the inventory and analysis of data, in the synthesis and testing of alternative plan subelements, and in the making of economic comparisons between those subelements. The selected design criteria and analytic procedures include watershed rainfall intensity-duration-frequency relationships, a flood discharge-frequency analysis technique, and the design flood selected for the floodland management element of the watershed study. Economic evaluation is also discussed in this chapter inasmuch as it relates to important analytic procedures employed in the preparation of the watershed plan.