# PREFACE

In 1999, the City of Rochester passed a subdivision ordinance which makes references to this plan as the *Storm Water Management Plan*. The 1997 version of this plan was titled the *Surface Water Management Plan*. The 1999 revisions to this plan included changing the title to the *Storm Water Management Plan* in order to avoid making revisions to the subdivision ordinance and eliminate possible confusion.

Within this document, the term Surface Water Management Plan is often used. Both terms shall refer to this report and the official title shall be the *Storm Water Management Plan*.

# Storm Water Management Plan

## Rochester, Minnesota

## October, 1997

## Revised December, 1999




**Bonestroo, Rosene, Anderlik & Associates, Inc.**
**Engineers and Architects**

# Steering Committee Members

# Storm Water Management Plan

- John Bouquet
  Rochester Area Builders Assoc.

- Gary Smith
  Rochester Area Economic Development, Inc.
  Rochester Chamber of Commerce

- Bob DeWitz
  Rochester Planning & Zoning Commission

- Bill Anderson
  Yaggy Colby Associates

- Jan Blevins
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- Gary Swenson
  Rochester Community College

- Mike Cousino
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- Jean Michaels
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- Doug Courneya
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- Duane Meidtke
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- Gary Neumann
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- Peg Lewis
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- Tom Gjersvig
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- Wachlra Loth
  Community Health Center

- Helen Burget
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- Curt Axen
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- Greg Munson
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- David Senjem
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- Richard Augustin
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- Jim Cooper
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- Paul Wotzka
  Minnesota Department of Agriculture
- Mike Helling
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- Cathryn Manduca
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- Tony Hill
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- Richard Freese
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  Rochester Public Works
- Reid Wronski
  Rochester Public Works
- Denny Stotz
  Rochester Park & Recreation
- John Harford
  Rochester/Olmsted Planning Department

# ROCHESTER STORM WATER MANAGEMENT PLAN

## REPORT REVISIONS

## DECEMBER 15, 1999

The following changes have been made to the 1997 Storm Water Management Plan report based on discussions with City Staff.

1. Report Name
   The recent subdivision ordinance makes references to this plan as the *Storm Water Management Plan*. The 1997 version of the plan was titled the *Surface Water Management Plan*. The current revisions to the plan includes changing the title to the *Storm Water Management Plan* in order to avoid making revisions to the subdivision ordinance and eliminate possible confusion.

   Within the document, the term Surface Water Management Plan is often used. Both terms shall refer to this report and the official title shall be the *Storm Water Management Plan*.

2. Wetland Management Plan
   The Wetland Management Plan section of the 1997 report has been removed from the current draft. Removal of this information includes both Section 7 and Appendix A-7 and A-8 from the 1997 report. The Wetland Management Plan was previously bound into a separate document and delivered to the City.

3. NPDES Phase II Rules
   The Environmental Protection Agency has issued the final rule for Phase II of the National Pollution Discharge Elimination System storm water program. The 1997 version of the Storm Water Management Plan has been updated to reflect the new Phase II rules. Section 12 and 13 have been combined into one section and revised based on the new Phase II rules.

4. Public Education and Involvement
   Public education information has been incorporated into the report as part of item 3 above. Educational materials have been submitted to City Staff for review. Since the initial work on the plan in 1996, the South Zumbro Watershed Partnership has developed an extensive public education program. The plan includes recommendations that the City work together with the SZWP to continue development of a public education program.

5. Capital Improvement Program
   A CIP has been developed and included in Section 8 of the Report

6. Area Charge Rates
   We recommend that the City consider the following two alternatives for the storm water area charge rates.

   - Implement the area charge as originally proposed in the plan and reviewed by the Finance Advisory Committee, or

   - Implement an area charge that funds only the construction of storm water ponds and minimal trunk storm sewer to provide outlets to the ponds.

   We are planning to further discuss area charge rates at our meeting tentatively scheduled for January 6, 2000.

7. Electronic copies of the GIS based mapping and databases that were developed as part of this project have been submitted to the City. Electronic copies of the report text and storm water models will be submitted to the City upon completion of the plan.

8. Report Maps
   Report Maps have been revised to indicate that the mapping information is for planning purposes and not intended as a design.

9. Storm Water Ordinance
   A sample storm water ordinance has been included in Appendix A-7 of the report.

10. Design Manual
    A draft version of the design manual has been submitted to City Staff for review and comment. The environmental corridors have been removed from the copy of the Drainage System Map to be included with the design manual.

# Rochester Storm Water Management Plan

# Appendices

# Tables

# Figures



# Maps

# EXECUTIVE SUMMARY

This report presents a Comprehensive Surface Water Management Plan for the City of Rochester. The plan was developed to serve as a comprehensive guide for the expansion of the City's stormwater management system to serve new development and redevelopment areas. The plan also assists the City in developing a storm water management program to meet the recently enacted requirements of the National Pollution Discharge Elimination System Phase II program.

The City formed a Steering Committee to provide input from various sectors of the community and to guide plan development. The Steering Committee was comprised of community residents, business representatives, developers, engineering consultants, and local, state, and federal agency representatives. During the initial phases of the plan, the Steering Committee studied of the benefits of stormwater management, current management practices, and anticipated regulations. Steering Committee members worked to form a vision for Rochester's natural resources and stormwater drainage system by anticipating the worst and best possible outcomes of the City's Surface Water Management Program.

The following excerpt of the Steering Committee vision summarizes the plan's main intent:

*"The plan creates a balance between development and natural resources that meets the needs of individuals, businesses, and the community while integrating natural processes with resources. Citizens, agencies, developers, and industry work together to implement the plan and to collectively manage growth by creating developments that accomplish surface water management goals and create more desirable properties."*

The Surface Water Management Plan Steering Committee developed goals and policies for each element of the stormwater drainage system. These goals and policies were further developed into recommendations within the plan. A summary of the four main elements of the plan are discussed below.

**Stormwater Quantity:**

Stormwater quantity refers to the amount of precipitation that drains off the land. The amount of impervious surface (i.e. streets, roofs and parking lots) is the most significant factor affecting the amount of runoff from an area. As areas in and around Rochester continue to develop from rural to urban uses, runoff volumes and rates will continue to increase. Local streams, culverts and drainage ways that were once adequate for rural runoff, can become over loaded causing local flooding.

The City of Rochester currently requires new developments to limit the rate of runoff from a site to pre-development conditions. This often results in the construction of stormwater ponding areas. Over time, a high number of isolated basins will be constructed that will be difficult for the City to manage and maintain. In addition, the basins tend to be small, with few aesthetic features and minimal wildlife habitat value.

One of the Steering Committee's main goals is to prevent and/or control flood damage through floodplain management and the use of regional storage and detention areas. Regional storage and detention areas can be natural locations where stormwater basins provide the greatest benefit by taking advantage of local topography and the existing drainage system's configuration. Regional basins take advantage of the economy of scale and provide a cost-conscious approach to stormwater management by reducing maintenance costs and combining engineering, design and construction costs. In addition, adequately planned and designed regional drainage facilities not only provide flood control, but can also provide natural wildlife habitat and aesthetic benefits to a given area or neighborhood.

The Surface Water Management Plan includes:

- Locations and technical parameters for future regional basins
- Design standards for storm sewers and stormwater basins, and
- Guidelines for design and maintenance of the system necessary to collect and safely transfer stormwater runoff through Rochester's drainage system.

**Stormwater Quality:**

Stormwater quality refers to the amount of pollutants that are washed off the land and transferred by stormwater runoff to lakes, streams and wetlands. Concentrations of nutrients, pollutants, heavy metals and suspended solids typically found in urban runoff can significantly degrade downstream water bodies by increasing turbidity, water temperature and the growth of algae. Toxic substances in runoff, such as trace metals and hydrocarbons, can effect the health and welfare of humans and wildlife that come into contact with these water bodies. A significant portion of the pollutants derived from urban land use can be effectively removed from runoff through the use of Best Management Practices.

Past erosion control and stormwater quality practices have varied among individual developments. The City of Rochester currently requires developers to implement erosion control practices during development; however, current city policies do not provide the specific design requirements needed to provide efficient and cost-effective water quality protection from urban runoff.

This plan identifies water quality basins that have been preliminarily sized and located throughout future growth areas (Urban Service Area) to provide treatment of runoff on a regional basis. Regional water quality basins are usually combined with rate control basins to provide the greatest benefit at the lowest cost. The plan also provides a list of recommended Best Management Practices to be implemented during construction activity to minimize erosion. These recommendations were reviewed by the Steering Committee and included in the plan to help the City coordinate practices that will provide for development while protecting surface waters from degradation due to runoff.

**Natural Resources:**

The area in and around the City of Rochester presents a unique mixture of stream valleys, creeks and wetlands leading to the South Fork Zumbro River. As the City expands outward, these areas may be affected by development and degraded by the rate and quality of urban runoff. The current policy toward protection of the City's natural features focuses on wetland protection and replacement through the implementation of the Minnesota Wetland Conservation Act, which regulates activities that drain and fill wetlands.

The Steering Committee's goal for natural resources in the surrounding area is to protect and restore lakes, wetlands, streams and upland natural habitat areas so that their functions and values as wildlife habitat, recreation and scenic qualities are maintained or improved. The Surface Water Management Plan identifies valuable natural features in the City's Urban Service Area. Stream corridor and wetland inventories were completed to assess the existing features and identify what steps are needed to protect high-value areas. The plan recommends implementing specific management practices to protect and preserve these features.

During the initial phase of assessment by the Steering Committee, the following five stream corridors were identified to protect, preserve, and enhance some of the natural vegetation and wildlife still present today. The location of these streams can be found on Figure 1-1 in Chapter 1.

- Willow Creek
- Cascade Creek
- Bear Creek
- Kings Run
- Silver Creek

Based on the Steering Committee's discussions, these corridors were delineated with primary and secondary boundaries. Areas identified within the primary boundary are considered critical to flood control, water quality and ecosystem preservation. Areas identified within the secondary boundary directly contribute to the support and preservation of the primary corridor. Chapter 4 describes in detail the characteristics of the stream corridors, and recommends management strategies to guide the City's efforts in balancing the preservation of natural resources with the demand for new development.

During the preparation of this report, the City successfully obtained funding from the Board of Water and Soil Resources to prepare a Comprehensive Wetland Management Plan. The Wetland Management Plan provides information on the functions and values of the existing wetlands within the 2015 urban service area. This information was used during the preliminary layout and analysis of the future drainage system in the SWMP. The Wetland Management Plan is bound as separate document.

**Storm Water System Financing:**

The City of Rochester's surface water drainage system is a large and complex system. Currently, individual developers are required to provide the design and construction of stormwater ponds and trunk storm sewers within their own development area.
The Surface Water Management Plan proposes a regional approach for future construction of the City's drainage system. This approach provides an economic benefit to local developers through the economy of scale involved in larger, more efficient regional facilities and funding of the trunk storm sewers to serve upstream drainage areas. This approach also provides an economic benefit to the City by centralizing drainage facilities to reduce operation and maintenance costs and provide more aesthetic, natural and recreational areas.

The Steering Committee reviewed several methods for financing the cost associated with the City's drainage system. Three specific components of the plan were identified :

- Expansion of the drainage system to serve new development
- Operation and maintenance of the existing system
- Replacement of system components over time.

The Steering Committee discussed each of these financial components to develop an equitable strategy for funding Rochester's existing and future drainage system. The Committee recommended that the cost of expanding the drainage system for new development be financed through an area charge (financial contribution per acre) based on the proposed land use. The City would utilize the area charge for the design and construction of the regional basins and trunk storm sewers.

The Steering Committee also recommended that the cost of operations, maintenance and replacement of the drainage system be financed through a stormwater utility in which all users of the City's drainage system would pay a fee based on land use. Both the area charge and the utility fee are based on land use because different land uses require varying levels of improvements to the drainage system for stormwater quantity and quality control.

A detailed description of the Capital Improvement Program and the other elements of the plan can be found in the corresponding chapters. The last chapter provides a summary of the plan and provides a list of recommendations.

# 1. Introduction

## 1.1 Background

This report provides the City of Rochester with a Surface Water Management Plan (SWMP) that will serve as a guide for the expansion and development of the City's storm drainage system. The plan covers the area identified as the 2045 Urban Service Area as shown on Figure 1-1. This boundary was established by the City of Rochester during the preparation of the City's Wastewater Master Plan. The boundary represents the planned maximum limit that Rochester's sanitary sewer system will be extended in any direction within the next 50 years (sanitary sewer study was completed in 1995).

As part of this Surface Water Management Plan, a Natural Resources Inventory and Comprehensive Wetland Management Plan were completed. These inventories cover the area identified as the 2015 Urban Service Area as show on Figure 1-1. This boundary represents the planned maximum limits of the sanitary sewer system to the year 2015. A smaller study area was used for these inventories due to the possible changes in the landscape that can take place over the next 20 to 50 years, and the limited funds available for these studies.

Rochester has experienced steady growth over the past 20 years. The population has increased from about 57,900 in 1980, to 77,209 in 1996. The City is expected to continue its steady growth and reach an estimated population of nearly 90,000 or more in 20 years. The City currently issues an average of 300 building permits per year to meet the needs of the growing population.

The existing drainage pattern in and around the City of Rochester consists of a complex system of rolling hills, ravines and urban areas draining to natural creeks and streams. The following seven streams were studied as part of the Surface Water Management Plan.

- **Willow Creek**
- **Cascade Creek**
- **Kings Run**
- **Badger Run**
- **Hadley Valley Creek**
- **Silver Creek**
- **Bear Creek**

All seven streams flow to the South Fork Zumbro River within the current City limits. These seven streams receive runoff from areas outside the study boundary, however, the computer models created to study stormwater quantity considered the entire drainage area to each stream.

Due to Rochester's steady rate of growth and the complex drainage patterns in and around the City, this comprehensive Surface Water Management Plan is needed to plan and guide the expansion of the drainage system. The plan is intended to:

- Determine improvements needed to prevent and control potential flood damage
- Develop standards for the design and construction of storm sewers and flood storage facilities
- Provide standards for water quality and erosion control practices
- Analyze capital improvement financing options
- Provide for identification and management of natural resources, and
- Prepare the City for Phase II NPDES Stormwater Permit requirements.

A Steering Committee was formed at the onset of the planning process to developed the goals and policies that guided plan development. These goals and policies are presented in Chapter 3.

The remainder of the introduction section provides an overview of the general policies of this plan. Specific details and technical information on each element of the stormwater drainage system can be found in the appropriate chapters of the report.

Figure 1-1 - Location Map

## 1.2 Stormwater Quantity

As part of the flood control projects implemented over the past 10 years, the City of Rochester has controlled flood flows through regional detention basins or reservoirs. Seven flood control reservoirs located throughout the tributary drainage area of the City were constructed at locations that capture runoff from drainage areas ranging from 900 to 8600 acres. These facilities currently provide significant rate reductions along major streams that are tributaries to the South Fork Zumbro River. However, the location of five of the seven facilities are outside Rochester's 2045 Urban Service Area.

Converting rural land to urban uses such as streets, parking lots and roof tops during Rochester's growth will increase the volume and rate of stormwater runoff. This increase in runoff can affect the integrity of the conveyance system and local streams, and can increase local flooding.

A significant portion of the SWMP preparation involved the development of computer models to calculate the effects of development on the flow rates in all streams and drainage ways within the 2045 Urban Service Area. Regional detention basins were then located and preliminarily sized to limit runoff flow rates to protect streams from degradation and to minimize local flooding. Regional detention basins typically serve areas ranging from 75 to 200 acres.

Chapter 5 discusses the recommended design guidelines for future drainage facilities for rate control and conveyance. Preliminary design data for future detention basins and trunk storm sewers are given in Appendix A-2 and A-4 located in the back of this report.

## 1.3 Stormwater Quality

As the population of Rochester has increased, so has the desire for maintaining and improving the quality of the City's water bodies and streams. Because urban land use significantly impacts downstream water quality, the degradation of streams, wetlands and the Zumbro River has become a general concern.

The Steering Committee developed goals and policies to address the concerns over local water quality. These goals and policies can be grouped into the following two main categories:

- Reduction in pollutant loads from urban runoff, and
- Reduction in the erosion of the City's streams and drainage system.

Water quality impacts due to changes in land use can be cost-effectively and efficiently minimized by constructing water quality treatment basins. Water quality basins are designed to collect runoff from development areas and to remove pollutants before the water enters downstream water bodies. These basins remove pollutants by settling out sediment particles along with pollutants attached to the sediment, and allow vegetation in created wetland areas to absorb soluble nutrients. Water quality basins are designed based on the size of the drainage area and the type of land use that will produce a certain level of pollutant load.

This plan identifies water quality basins that have been preliminarily designed and located throughout Rochester's 2045 Urban Service Area to provide regional treatment of runoff. The cost savings in design, construction and increased efficiency benefits provided by regional water quality basins is similar to those provided by regional stormwater quantity basins. The locations of the proposed water quality basins are combined with the location of regional rate control basins throughout the study area.

This SWMP discusses erosion and sediment control practices and provides recommended guidelines for these practices. An emphasis is placed on erosion control practices for construction activity. Erosion from construction site grading is commonly the highest contributor of sediment to area water bodies.

Chapter 6 provides the recommended guidelines for the final design of regional water quality basins. Chapter 9 provides the recommended erosion control practices to be implemented during development. Technical information regarding the estimated size of the regional ponds and the calculated removal rates is provided in Appendix A-2 and A-3 in the back of this report.

## 1.4 Natural Resources

Under the guidance of the Steering Committee, an inventory of Rochester's natural resources was completed within Rochester's future growth area. The information collected during the inventory was used to develop a Comprehensive Wetland Management Plan and a Natural Resources Inventory of five stream corridors. These natural resources management tools provide a vision for the protection and enhancement of local wetlands, streams and wildlife habitat areas within Rochester.

The first step in planning the drainage system for development areas is to identify the valuable natural resources located in and along the City's streams and creeks. Once these valuable natural resource areas are identified, the areas are delineated into primary and secondary corridors based on their specific functions and qualities (see Map 3 in the back of this report). Areas identified within the primary corridor are considered critical to flood control, water quality and ecosystem preservation.

The primary zone is the area adjacent to the stream, where land uses and human activities directly impact the biological and morphological characteristics of a stream. The majority of the primary corridors consist of designated floodplain and adjacent steep slopes. The primary corridor boundary was mapped based on data collected from field survey information, available map information and input from the stormwater management Steering Committee.

The areas identified within the secondary corridor directly contribute to the support and preservation of the primary corridor. These areas include forest land and wetland areas adjacent to major streams, and other valuable natural areas. Special consideration to ecological sensitivity should be given during development in the secondary corridor. Specific recommendations for management of development within the primary and secondary corridor areas are described in Chapter 3.

A Wetland Focus Committee was formed to help establish goals, objectives and policies to preserve and/or enhance Rochester wetlands. The wetland inventory included field inspection, mapping and assessment of functions and values for all National Wetland Inventory wetlands within the city's

2015 Urban Service Area. The information developed during this planning process can be found in the Wetland Management Plan.

## 1.5 NPDES Permit

Regulations pertaining to stormwater runoff and urban storm sewer discharges continue to evolve with a trend toward more restrictive regulations. One of the main purposes of the SWMP is to prepare the City of Rochester for federal stormwater regulations that will eventually apply to the City. Based on a review of current federal regulations, the contents of the SWMP were developed to anticipate the practices that the City will be required to implement when these regulations are applied to Rochester.

The National Pollution Discharge Elimination System (NPDES) program rules were enacted through the 1987 revision to the Federal Clean Water Act. This Act requires the Environmental Protection Agency to establish NPDES permit application requirements for stormwater discharges from industrial activity as well as large and medium sized municipalities. The Clean Water Act allows the EPA to authorize states to issue permits, administer the NPDES program and set additional NPDES requirements.

The NPDES program for Minnesota regulates and permits three areas of stormwater management:

- Municipal separate storm sewers
- Industrial activity, and
- Construction site erosion and sediment control.

Under Phase I of the permit rules, municipalities with populations greater than 100,000 are required to submit a two-part application that summaries stormwater planning, programs and water quality sampling. The City of Rochester is expected to reach a population of 100,000 around the year 2020. However, the EPA has issued revisions to the NPDES program, termed Phase II rules, to include municipalities that are currently not covered by the Phase I rules (i.e., populations less than 100,000). The Phase II rules require operators of municipal separate storm sewer systems to develop a storm water management program to address the following:

- Public education and outreach
- Public involvement and participation
- Detection and elimination of illicit connections and discharges

- Control of stormwater discharges from construction sites
- Post-construction (permanent) stormwater management practices in development and redevelopment areas, and
- Prevention of pollution and good housekeeping of municipal operations.

Chapter 7 of the plan provides a description of the phase II requirements. This chapter also provides recommendations to assist the City in developing a storm water management program to meet the requirements of the NPDES rules.

## 1.6 SWMP Preparation

An outline of the steps that were involved in preparing the Surface Water Management Plan is presented below:

1. Form a SWMP Steering Committee, and through consensus building, generate a set of policies to guide plan preparation.

2. Establish a set of Stormwater Management Goals and Policies for the successful implementation of this SWMP.

3. Identify valuable natural resources and stream corridors to be protected during future development.

4. Determine major drainage district, minor drainage district, and subdistrict boundaries for use in sizing storm sewers, open channels, and ponding areas.

5. Relate existing and future land use as presented in the Land Use Plan to the probable amount of stormwater runoff anticipated.

6. Establish routing of stormwater conveyance facilities.

7. Establish location, size, and flood elevations of stormwater ponding areas for water quantity control.

8. Investigate alternatives that might affect the feasibility or economy of segments of the system.

9. Determine design criteria for nutrient treatment ponds to improve water quality in City water bodies. Establish pond wet volumes to achieve water quality goals for these water bodies.

10. Estimate the cost of storm drainage facilities to provide a guide for developing a sound and equitable financing program.

# 2. Steering Committee Goals and Policies

## 2.1 Background

The Rochester SWMP Steering Committee was formed at the onset of the planning process and has closely followed the development of the plan through regularly scheduled meetings. The steering committee's purpose was to provide a consensus-building unit to guide development of the plan and the policies that will be needed to provide cost-effective protection of area water resources. The Steering Committee is made up of members from the following groups:

- Rochester City Council
- Citizens of Rochester
- Rochester Public Works Department
- Rochester Parks Department
- Commercial/Industrial Business Representatives
- Mayo Clinic and IBM Representatives
- Local Engineering Consultants
- Local Developers
- Rochester Community and Technical College
- Olmsted County Staff
- MN Board of Water and Soil Resources
- MN Department of Natural Resources
- Olmsted County Soil and Water Conservation District
- Natural Resources Conservation Service
- Local Conservation Groups
- Olmsted County Board
- Rochester School District 535

In addition to the input and recommendations of the Steering Committee, this plan incorporates information contained in the Olmsted County Comprehensive Water Management Plan 1990; the Rochester Land Use Plan and Land Development Manual; and the Olmsted County Groundwater and Wellhead Protection Project.

## 2.2 General Objectives

This section presents the goals and policies that will form the framework of the City's stormwater management strategies of the City. The general objectives of the SWMP are as follows:

- **Minimize** flooding, erosion and sedimentation problems generated by surface flows.

- **Improve** water quality in all protected water bodies by treating runoff from the upstream drainage area.

- **Protect** groundwater quality and quantity by allowing for passive treatment and infiltration of stormwater.

- **Promote** groundwater recharge by creating additional ponding areas.

- **Protect and Enhance** water recreational facilities and fish and wildlife habitat.

- **Preserve** vegetation around stormwater detention areas by leaving them in a natural state to promote wildlife habitat, maintain natural aesthetics, and reduce maintenance.

- **Reduce** to the greatest practical extent, the public capital expenditures necessary to upgrade the stormwater system to meet water quantity and quality standards.

## 2.3 Goals and Policies

The following are the stormwater management goals and policies developed for the City of Rochester. A goal is a desired end toward which the City's policies, standards, criteria and rules are directed. A policy is a governing principle, a means of achieving an established goal. Policies prescribe a general course of conduct that leads toward achieving the goal. As with any planning tool, these goals and policies are meant to be flexible and to evolve with changing conditions in the City.

### 2.3.1 Flood Protection

**GOAL:** To prevent and/or control flooding damage through floodplain management and the use of natural storage and detention areas.

**Policies:**

1. Adopt stormwater management practices to provide a 100-year rainfall event level of protection.

2. Establish allowable elevations for the lowest floor of buildings as follows:
   a. Two feet above 100-year level near ponding areas and unmapped floodplains
   b. One foot above 100-year level near mapped floodplains
   c. One foot above the emergency overflow outlet for buildings adjacent to ponding areas.

3. Development in the 100-year flood plain should be regulated and limited to uses that are properly flood protected; do not have a detrimental effect on the floodway channel and flood plain storage; and are unharmed by flooding.

4 Establish rainfall events as design criteria for the following:
   a. Storm Drainage System: 100-year rainfall event
   b. Storm Sewer System: 10-year rainfall event

5. Upgrade existing storm sewer facilities to a 10-year level of service when practical.

6. Establish and maintain overflow routes where possible to provide relief during storm conditions that exceed design conditions.

7. Preserve the necessary storage capacities of protected waters and the conveyance capacity of watercourses as defined by the plan.

8. Require new development of vacant land and redevelopment of existing sites to conform with the Surface Water Management Plan. As redevelopment or reconstruction of public infrastructure occurs, nonconforming areas shall, where practical, be brought into compliance.

### 2.3.2 Erosion Control

**GOAL:** To control erosion and sedimentation, especially during urban construction activity.

**Policies:**

1. Require erosion and sediment control management practices on all construction sites.

2. Use urban Best Management Practices as described in:

   a. Minnesota Pollution Control Agency, Urban BMP Handbook

   b. City of Rochester Erosion Control Standards

3. Establish an inspection program and enforcement procedures to control erosion on construction sites.

4. Establish criteria to regulate runoff velocities and encourage natural cover to reduce erosion.

5. Develop a program that encourages conservation practices to be applied to all lands in the upstream watersheds of all reservoirs to slow surface water runoff and reduce the rate of siltation.

6. Minimize the impact from developing areas with highly erodible soils.

7. Adopt a program for stabilizing stream banks depending on geology, setting, soils conditions and surrounding land use.

### 2.3.3 Surface Water Quality Protection

**GOAL:** To protect and improve the water quality of Rochester's lakes, streams and wetlands for existing and future generations by meeting or exceeding National Pollutant Discharge Elimination System (NPDES) permit requirements.

**Policies:**

1. Develop regional water quality treatment facilities with acceptable standards to remove phosphorus, heavy metals and suspended solids.

2. Require the construction of water quality devices to maintain the quality of water in downstream water bodies as proposed by the Surface Water Management Plan.

3. Develop maintenance standards and practices to protect surface water quality, including street sweeping and maintenance of water quality facilities.

4. Protect existing wetlands and promote local wetland banking creation and enhancement.

5. Maximize the use of City park land through water quality enhancement projects and demonstrations of effective water quality practices. ( i.e., native vegetation along river/stream banks on City property, etc.)

6. Regulate design and location of salt or sand/salt storage sites to avoid affecting water wells, lakes, rivers, streams, ground water recharge areas and flood- prone areas.

7. Identify feasible improvements in developed areas that will improve surface water quality.

### 2.3.4 Groundwater Protection

**GOAL:** To protect and preserve the quality and quantity of groundwater for existing and future generations.

**Policies:**

1. Promote infiltration as an alternative for water quality enhancement and flood control.

2. Evaluate and manage development over groundwater recharge areas and wellhead protection areas to protect groundwater from potential contamination.

3. Establish criteria and identify critical areas that are highly sensitive to groundwater contamination or critical for the protection of Rochester's aquifers.

### 2.3.5 Natural Resources Protection

**GOAL:** To protect and restore lakes, wetlands, streams and upland natural areas to maintain or improve their functions and values as fish and wildlife habitat, and recreational and scenic areas.

**Policies:**

1. Protect high-quality, rare and unique natural communities including pristine wetlands, prairie and woodland remanents.

2. Protect endangered plant and animal species.

3. Adopt stormwater and water quality management practices designed to protect wetland functions and values.

4. Adopt a system to classify wetlands and stream corridors according to their use and value to the stormwater and natural resources systems.

5. Manage development and land use within riparian corridors to protect and restore natural plant communities, steep slope areas and bluffs.

6. Develop land use and management plans for all the flood control reservoirs and surrounding land with particular emphasis on the passive recreational use of the area and wildlife habitat.

7. Promote the use of native vegetation when developing wetlands, ponds, lakes, detention areas, trails, stream banks, steep slopes, etc.

### 2.3.6 Public Information and Education

**GOAL:** To inform and educate the public on how they can make a difference in the protection, preservation and enhancement of Rochester's natural resources.

**Policies:**

1. Educate the public on how personal activities affect the quality of surface water and groundwater.

2. Educate the public on regulations that prohibit the intentional discharge of contaminating materials such as waste oil, paint, grass clippings, leaves, and ecologically harmful chemicals into the stormwater system.

3. Educate the public on landscape planning and maintenance that emphasizes the use of native plants species.

4. Educate the public on the responsible use of fertilizers, pesticides and the benefits of proper irrigation.

5. Educate the public, staff and the development community on the functions and values of wetlands.

### 2.3.7 Plan Implementation

**GOAL:** To direct the City's stormwater management efforts toward the fulfillment of the plan goals and the application of its policies.

**Policies:**

1. Maximize cost-effective public and private capital and maintenance expenditures necessary to control excessive volumes and rates of runoff, water quality impacts, and degradation of natural resource functions and values.

2. Develop an equitable financing strategy for capital and maintenance improvements identified in the Surface Water Management plan.

3. Prioritize management activities and capital improvements in the Surface Water Management plan.

4. Evaluate the progress of the Surface Water Management plan on an annual basis with a comprehensive program review every five years.

5. Evaluate the effectiveness of the Surface Water Management plan on meeting its goals.

6. Solicit the cooperation of the other agencies and organizations within the watershed.

7. Implement Surface Water Management strategies that are flexible in achieving the plan's goals.

8. Use a corridor concept to integrate the stormwater system, park system, recreation system and natural resources in the Urban Service Area.

9. Categorize drainage facilities as by their function in meeting the goals of the stormwater management plan.

10. Implement a Comprehensive Wetland Management Plan.

# 3. Land Characteristics of the Rochester Area

## 3.1 Topography and Drainage

A majority of the Rochester area consists of terrain that is dissected into a pattern of numerous streams and creeks. These streams and creeks provide for a well-drained system with relatively few natural lakes and wetlands outside the stream corridors. Land surface elevations vary from a low of 960 to a high of 1300 feet above mean sea level. Natural slopes generally range from 2 to 5 percent in upland areas, 5 to 30 percent in stream valleys and less than 1 percent along flood plain areas.

The system of creeks and streams flows to the South Fork of the Zumbro River. The Zumbro River starts in the central portion of Dodge County and bisects Rochester flowing north to Lake Zumbro. From Lake Zumbro, the river flows northeast and empties into the Mississippi River approximately 15 miles south of Lake Pepin.

Figure 3-1 indicates the eight major watersheds within the SWMP study area. Seven major creeks within Rochester flow to the South Fork of the Zumbro River: Cascade Creek, Willow Creek, Badger Run, Bear Creek, Silver Creek, Kings Run and Hadley Valley Creek. Land tributary to these creeks combine to form a total of approximately 300 square miles of drainage area to the South Fork of the Zumbro River at the northern fringe of Rochester.

**CASCADE CREEK**

Cascade Creek starts south of the City of Byron. The watershed for Cascade Creek covers approximately 38 square miles. Three branches of Cascade Creek join west of Highway 52 at Cascade Lake. Current plans are to continue gravel mining in this area to develop Cascade Lake to approximately 160 acres. Projected development concepts include a park and recreational area with a swimming beach and other recreational uses. Water quality is a major factor in the proposed ponds located within this drainage district. In addition to existing feed lots in the western reaches of Cascade Creek watershed, additional urban development will contribute significate increases in pollutant loads to the upstream drainage system.

Figure 3.1 Study area

## WILLOW CREEK

Willow Creek watershed covers 28 square miles and consists of two main branches of Willow Creek. The west branch flows from a large wetland complex southwest of the Rochester airport to Smetka Park preserve north of Highway 52. The east branch of Willow Creek begins at the flood control structure south of 45th Street and joins the west branch at Smetka Park. The drainage area tributary to Willow Creek consists of moderate to steep terrain with a majority of the area under a mixture of urban and agricultural uses. Stream bank stabilization is the major concern of this watershed. Stormwater facilities are proposed to limit stormwater discharge rates and provide water quality treatment of runoff to the stream, wetlands and reservoirs within the watershed.

## BEAR CREEK

Bear Creek watershed covers approximately 75 square miles southeast of downtown Rochester. Badger Run and Bear Creek are the two major streams within this watershed. Badger Run begins near the Town of Marion. The stream channel flows along a flat, meandering course to Bear Creek. Several wetlands are located along the stream corridor. Bear Creek flows from an area approximately one mile southwest of the Town of Eyota to the confluence of Willow Creek and Badger Run. Bear Creek continues north to Bear Creek Park, where the Army Corps of Engineers has reconstructed the channel cross section to the South Fork Zumbro River. Significant urban and suburban development has occurred along the western portions of Bear Creek and Badger Run. Stormwater facilities are proposed to limit discharge rates from future development and provide water quality treatment from urban drainage areas.

## MAYO RUN

The Mayo Run watershed was the subject of a previous stormwater study due to flooding problems and limited conveyance in the lower portion of the watershed (Bonestroo 1990). Several regional stormwater facilities are proposed to limit peak flows along Mayo Run.

At the time of this report, design and construction documents were in the process of being prepared for the construction of the main components of the Mayo Run system. The first in a series of planned ponds (ep-16) was constructed in 1995. The construction of ponds CP-12, CP-14 and CP-15 are expected to be completed in the fall of 2000. For further details, please refer to the above documents on the Mayo Run watershed area.

### SILVER CREEK

Silver Creek watershed covers 21 square miles over the eastern portion of Rochester. Silver Creek extends from the flood control structure east of County Road 11 to the confluence with the South Fork Zumbro River at Silver Lake. A majority of the watershed is currently undeveloped. The stream bed winds through deep valleys and has outstanding scenery in some areas. These deep valleys are difficult terrain for construction of regional stormwater facilities. A fewer number of suitable sites were located in the Silver Creek watershed due to terrain limitations.

### HADLEY VALLEY CREEK

Hadley Valley Creek runs parallel to County Road 124 from Country Road 11 covering an area of approximately eight (8) square miles in the northeast portion of the City. Hadley Valley Creek flows into the South Fork Zumbro River north of Foster-Arend Park. A majority of the creek bed is in poor condition due to stream bank failure and surrounding agricultural practices. Stream restoration is needed along the western portion of the creek north of 48th Street NE.

### KINGS RUN

Kings Run watershed includes 15 square miles of gentle to moderately sloping terrain. Stream flows begin west of County Road 104 and form two defined channels along the north and south sides of the former railroad bed that has been converted to the Douglas State Bicycle Trail. The two stream channels join together in the recently constructed White Oaks regional pond east of 50th Avenue NE. Kings Run continues east past Essex Park where substantial erosion and stream bank failure has occurred east of West River Road. Recent stormwater system improvements along Kings Run have created an excellent opportunity for a natural resources corridor from Highway 52 to the Douglas State Bicycle Trail.

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## 3.2 Soil Description

The Soil Associations map (Figure 3-2) shows the pattern of soils that are found in the City of Rochester. Five common soil associations are found throughout the Rochester area. Each association has a distinct pattern of soils, relief and drainage. Typically, one or more major soils and some minor soils make up an association. The following correspond with the Soil Group numbers on Figure 3-2.

The Dickinson-Plainfield-Kolmorville (Soil Group #8) association consists of soils that are nearly level to very steep, well-drained to poorly drained soils that are loamy on outwashed terraces and silty on flood plains. This association is on terraces, foot slopes and flood plains in stream valleys. Slopes range from 0 to 30 percent. Areas covered by this association are stream corridors within the Bear Creek and South Fork Zumbro River watersheds. The Waukee-Radford-Splitville association (Soil Group #9) is similar to the Dickinson-Plainfield-Kolmorville except that slopes range from nearly level to gently sloping or 0 to 3 percent. This association is found in the stream valleys of Willow Creek and the South Fork Zumbro River.

The Rockton-Chanahorn-Atkinson association (Soil Group #3) consists of nearly level to sloping well-drained loamy soils on uplands. These areas are dominated by soils formed in a loamy mantle and in the underlying clayed residuum over bedrock. This association is generally on broad uplands that have slopes of 0 to 12 percent, dissected by deep drainage ways. This association covers the southern upland portions of Willow Creek and South Fork Zumbro River, and a majority of the upland within Bear Creek.

The Mt. Carroll-Marlean-Arenzville association (Soil Group #4) is areas dominated by soils formed in loess. These soils are nearly level to very steep, well-drained silty soils on uplands. This association is deeply dissected into may narrow ravines. These soils cover the upstream portions of Cascade Creek and Silver Creek. The Timula-Port Byron association (Soil Group #6) is similar to the Mt. Carroll-Marlean-Arenzville association with soils that are well drained on upland summits and drainage ways. Slopes range from 0 to 30 percent. This association covers a major portion of Kings Run.

The Racine-Floyd-Maxfield association (Soil Group #2) consists of silty soils on uplands and in upland drainage ways. Local relief between drainage ways and summits is about 20 to 50 feet, with slopes ranging from 0 to 18 percent. This association is located in the northern portions of Bear Creek and southern portions of Willow Creek.

Hydric soils are defined as soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper layers (Soil Conservation Service 1987). These soils usually support hydrophytic vegetation. Determining the locations of hydric soils is important because they are one of the three essential characteristics for wetlands (along with hydrology and hydrophytic vegetation). Table 3-1 provides the soil types that are identified on the

Figure 3-2 General Soils Map

Olmsted County hydric soil list.  The County Soil Survey provides the locations where these soils are located.  However, the lack of hydric soils being mapped by the soil survey for a particular site does not completely exclude the possibility of wetlands existing on the site.

**Table 3-1: Hydric Soils for Olmsted County**

| Soil Map Symbol | Soil Name | Soil Map Symbol | Soil Name |
|---|---|---|---|
| 176 | Garwin | 468 | Otter |
| 252 | Marchan | 471 | Root |
| 378 | Maxfield | 474 | Haverhill |
| 465 | Kalmarville | 486 | Marshan depressional |
| 467 | Sawhill | 1846 | Kato |
| 528B | Palms Muck | | |

The Rochester Zoning Ordinance and Land Development Manual Information Supplement identifies highly erosive soils as those listed in Table 3-2 below.  Plan reviews should include a check of the County Soil Survey for these soil types within proposed development areas.  A development site containing these soils will  require special considerations pertaining to erosion control measures that may be required at the discretion of city staff.  Erosion control measures are discussed in Chapter 9.

**Table 3-2: Highly Erosive Soils within the Rochester Area**

| Soil Map Symbol | Soil Name | Soil Map Symbol | Soil Name |
|---|---|---|---|
| 11C | Sogn Loam | 401D | Mt. Carrol |
| 27C | Dickinson | 402-D2 | Mt. Carrol |
| 73F | Bellechester | 401E | Mt. Carrol |
| 99D2 | Racine | 473D | Dorerton |
| 173F | Frontenac | 473F | Dorerton |
| 251F | Marlean | 484E | Eyota |
| | | | |

| Soil Map Symbol | Soil Name | Soil Map Symbol | Soil Name |
|---|---|---|---|
| 251G | Marlean | 488F | Brodale |
| 283E | Plainfield | 488G | Brodale |
| 301C | Lindstrom | 593D | Elbaville |
| 309D | Schapville | 593E | Elbaville |
| 322C | Timula | 898F | Brodale-Bell |
| 322D | Timula | 973D | Brodale-Sohn |
| 322E | Timula | 1819G | Dorerton-Roc |

## 3.3 Wetlands

The federal government defines wetlands as those areas that are inundated or saturated by surface or groundwater 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.

The National Wetland Inventory Maps provide a summary of wetland areas that have been mapped by use of aerial photographs. Wetlands identified on the National Wetland Inventory within the study area are shown on the Storm Drainage Map in the back of this report.

## 3.4 Floodplain

The largest recorded flood in Rochester occurred on July 6, 1978. This flood was caused by an intense thunderstorm that produced a peak discharge of 30,500 cfs on the South Fork Zumbro River. Heavy rains of 6 inches or more caused a flash flood that resulted in property losses to thousands of homes, hundreds of businesses, and numerous public properties. At the USGS gauging station at Rochester, the South Fork Zumbro River rose to its crest in 15 hours at an average rate of 1.3 feet per hour. The river remained above bank-full stage for 35 hours.

In 1993, the Army Corps of Engineers completed the updated hydrologic and hydraulic analysis for the countywide Flood Insurance Study (FIS). For the Rochester area, the Flood Insurance Study analyzed flows in Bear Creek, Cascade Creek, Silver Creek, Willow Creek and the South Fork Zumbro River. Base maps are available for these streams that indicate floodplain and floodway areas and flood elevations. Flood profiles were not calculated for Badger Run, Kings Run and Hadley Valley Creek. Flood maps are not available for these streams.

Flood control measures that have been completed in recent years have provided an increased level of flood protection for Rochester. These projects include the modification of the South Fork Zumbro River and Bear Creek through downtown Rochester, dam rehabilitation on Silver Lake, and seven flood control structures located outside the perimeter of the city. The Rochester Zoning ordinance requires that plans for proposed structures within the floodplain meet certain requirements to prevent the reduction of storage volume and flow capacity within the floodplain. A copy of these ordinance requirements can be found in the report Appendices.

## 3.5 Land Use

Land use is one of the primary mechanisms that can cause flooding and water quality problems. Olmsted County was predominately prairie, wetland/floodplain and hardwood forest prior to settlement. Land clearing for farming after the mid 1800s combined with a rapid influx of people, has transformed much of the County. This transformation has brought with it an increase in stormwater conveyance systems and runoff. The runoff from urban and agricultural areas contains pollutants and nutrients that lead to reduced water quality. This increase in runoff rate and volume can also lead to flooding problems.

Figure 3.3 indicates the planned land use within the SWMP study area. The total developable land within the SWMP study area consists of 79 percent low-density residential, 1.8 percent medium-density residential, 5.8 percent commercial, and 7.0 percent industrial. This map was used as a basis for the preliminary layout and design of regional stormwater basins for runoff quantity and quality. As previously mentioned, various land uses require differing levels of stormwater facilities. When future development occurs, Figure 3.3 should be consulted to check that the assumptions used in the layout of the system for this plan are still valid. If the future land use deviates from Figure 3-3, additional consideration must be made in the basic sizing and design information of proposed facilities in this report.

Figure 3-3 - Land Use Map (8-1/2 x 11 Color)

# 4. Rochester's Stream Corridors

## 4.1 Introduction

As part of the Rochester Surface Water Management Plan, five major tributaries to the South Fork Zumbro River were identified and recommended to the SWMP Steering Committee for inclusion in the Rochester Stream Corridor system. Selection of streams for inclusion in the corridor system was based on the evaluation of Rochester's natural resources and the input of staff from the City of Rochester, Olmsted County and the Minnesota Department of Natural Resources. The five stream corridors identified include:

- Willow Creek
- Bear Creek
- Silver Creek
- Cascade Creek
- Kings Run

Recognizing the irreplaceable functions that these streams provide in the way of flood control, water quality protection, fisheries and wildlife habitat, and open space, the SWMP Steering Committee recommended that these streams be included in the City's stream corridor system. All five streams were identified as being sensitive to the changes in stormwater runoff that occurs with development. Strategies and practices for managing stream corridor areas that help preserve these areas while allowing for some flexibility to accommodate future development are included in Section 4.4.

The improvements that are currently being implemented in the Mayo Run watershed illustrate the importance of preserving the integrity of stream corridors. The design and construction of stormwater detention and water quality basins have been underway since 1995 to replace portions of the natural stream and adjacent wetlands in the upper portions of the watershed that once provided natural detention of stormwater runoff. This work is being completed to reduce local flooding problems in the lower portions of the watershed where development adjacent to the stream bed has occurred.

## 4.2 Survey of Stream Corridors

A natural resource inventory and assessment was conducted within each stream corridor to better understand natural resource characteristics and values. Understanding the natural resource characteristics and values provides a basis for protection and management of the stream corridor. The survey of stream corridors included the following:

1. Aerial photo interpretation using 1994 color infrared photography was used initially to identify key natural resource features along the five streams. Key natural resource features include: natural communities such as forest and wetlands; areas high in scenic values; and wildlife habitat.

2. Rare occurrences of plants, animals and natural communities in the DNR Natural Heritage Program Database were reviewed and identified on a map of the City's 2015 Urban Service Area.

3. Meetings with resource managers (forestry, fisheries and wildlife) in the Minnesota DNR were used to further identify significant natural resources and existing and/or future management concerns.

4. The entire length of each stream corridor was walked to verify natural community type and quality; assess wildlife habitat; inspect stream channel for scour and sedimentation; and to note any unique and/or scenic features.

## 4.3 Description of Stream Corridors

Following is a description of each of the five corridors. In general, each corridor is described starting with the upper reaches of the stream corridor, then moving downstream.

### 4.3.1 Willow Creek Corridor

The Willow Creek Corridor is located in the southern portion of The City of Rochester. This corridor includes much of the south and southwest portions of the City's 2015 Urban Service Area.

This corridor is subdivided into three sections here to facilitate description. These sections are: Willow Creek - West Fork, Willow Creek - East Fork and Willow Creek - Lower Reach. The West Fork extends from County Road 16 just north of the Rochester Municipal Airport, downstream to Trunk Highway 63. The East Fork extends from just north of 60th Street SE, between Simpson Road and 20th Avenue SE, downstream to Trunk Highway 52. The Lower Reach includes those sections of both the east and west branches from the lower boundaries described above, downstream to the confluence of Willow Creek and Bear Creek.

***Willow Creek - West Fork***
***General Description***

The upper reaches of the west fork contains two valleys: the western-most valley containing the main stem of Willow Creek; the other valley containing a small perennial stream. In these upper reaches, the stream channel is narrow, often flowing over bedrock at a moderate to high gradient. Cattle graze on much of the land adjoining the western-most valley. The other valley is much more remote and contains several areas of good-quality forested natural communities. Below the two upper valleys is the Willow Creek Reservoir (WR-6). The Willow Creek Reservoir is approximately 70 acres in size and has a maximum depth of 22 feet. Most of the land area around the reservoir consists of old farm fields and woodland. These areas were previously used for row crops and grazing, but are now slowly reverting to woodland-brushland and forest. Downstream from Willow Creek Reservoir, the West Fork of Willow Creek flows through the Willow Creek Golf Course. Within this reach, an additional tributary joins Willow Creek from the west. After flowing through the golf course, Willow Creek flows through a narrow band of floodplain forest before passing under Trunk Highway 63.

***Natural Communities***

Based on the original survey of Olmsted County, the dominant vegetation consisted of oak savanna with scattered pockets of mesic oak forest and lowland hardwood forest occurring on moister sites in the bottom of stream valleys or on north facing slopes. Dry prairies also occurred on steep southwest facing slopes where frequent fires prevented the establishment of woody vegetation.

Today, dry to mesic oak forest and oak woodland dominate the upper reaches of Willow Creek. Most of these oak forest and woodlands have succeeded from the oak savanna which dominated this area prior to European settlement. The conversion of oak savanna and prairie to agricultural land uses and the effective suppression of wild fires is largely responsible for this succession.

The type of natural community present is largely a function of soil type, slope and aspect. Dry oak forest occurs along south and west facing hillsides and where soils are better drained. The dominant tree species in these areas include bur oak, black oak, pin oak, white oak, black cherry and trembling aspen. On the more moist, mesic sites, red oak, bur oak, basswood, sugar maple and iron wood are dominant. Along the creek itself, lowland hardwood forest, dominated by boxelder, eastern cottonwood, american elm, green ash and basswood, occurs. A complete listing of tree and shrub species is given in Appendix A-8. The quality of these forested natural communities in terms of species diversity and lack of invasive species such as buckthorn and boxelder is generally the highest in the eastern valley. The western valley is lower quality due to recent grazing and logging.

Around the Willow Creek Reservoir (WR6), the primary natural communities include oak savanna, oak woodland, lowland hardwood forest and wet meadow wetland. In addition to these communities, there are several areas along steep south-southwest facing hillsides that contain small remanents of native prairie. Shoreline areas of Willow Creek Reservoir contain scattered areas of emergent marsh. The quality of natural communities in this segment is low due to past farming and more recent disturbances resulting from the construction of Willow Creek Reservoir.

Below Willow Creek Reservoir, much of the riparian vegetation has been removed as Willow Creek flows through the golf course. Downstream from the golf course, however, the creek enters a floodplain forest dominated by boxelder, black willow, bur oak and green ash. This floodplain forest community is poor quality due to high flow, sediment deposits from flooding, and logging and grazing. Invasive species such as boxelder and buckthorn are common within this natural community.

***Wildlife***

The West Fork of Willow Creek contains high-quality wildlife habitat. This section of the corridor contains one of the larger contiguous tracts of good quality forest in the Rochester 2015 Urban Service Area. The diversity of natural communities is good, with a mixture of forest, woodland, wetland and grassland adjacent to Willow Creek and Willow Creek Reservoir. For the most part, wildlife travel through this portion of the corridor remains unimpeded due to only one road crossing and a more or less continuous strip of riparian vegetation along Willow Creek. An avian survey conducted by Anne Marie Plunkett (Plunkett, 1992) listed 205 documented species of birds in the vicinity of Willow Creek Reservoir including such rare species as peregrine falcon and bald eagle, along with a host of resident and migratory songbirds, shorebirds, waterfowl and raptors. According to Plunkett, the main reasons for such high numbers of avians is the presence of a large body of water (in a county more of less devoid of lakes) and that much of the area surrounding the reservoir is off limits to the public. Additional species noted in this section of the Willow Creek Corridor include: deer, turkey, pheasant, cottontail rabbit, grey squirrel, fox, coyote, mink, beaver and muskrat.

***Fisheries***

The primary fisheries is within Willow Creek Reservoir. Fish that have either been stocked or are proposed to be stocked in the reservoir include bluegill, largemouth bass, yellow bullhead, channel catfish, yellow perch, black crappie and small mouth bass. Fish present in both the reservoir and upstream reaches of Willow Creek include white sucker, common shiner, creek chub and green sunfish.

***Rare/Endangered Plants, Animals and Natural Communities***

According to records of the Minnesota Department of Natural Resources, Natural Heritage Program, there is one documented occupance of a fox snake (special concern) north of Willow Creek Reservoir. Unofficial records include perigine falcon (endangered), bald eagle (threatened) and common tern and caspian tern (both special concern).

***Willow Creek - East Fork***

***General Description***

The East Fork of the Willow Creek Corridor is somewhat similar to the West Fork in terms of land uses, although a greater proportion of the land adjacent to the East Fork of Willow Creek consist of grassland, which, in many cases, is no longer used for pasture or cropland. The riparian fringe, immediately adjacent to Willow Creek is a mixture of wetlands and narrow strips of lowland hardwood forest. A flood control reservoir (WR-4) which is about 40 acres in size with a maximum depth of 24 feet, is located in the upper portion of the East Fork of the Willow Creek Corridor. Much of the land adjacent to this reservoir is owned by the Gamehaven Boy Scout Ranch.

***Natural Communities***

The original vegetation based on the survey of Olmsted County shows that at the time of European settlement, the dominant vegetation consisted of oak savanna with scattered pockets of mesic oak forest and lowland hardwood forest in the south portion of the corridor, near the reservoir. To the north of the reservoir, the Corridor was dominated by prairies.

The East Fork contains a number of good-quality natural communities including bluff prairie, wet meadow and some sizable tracts of forest land. The forest land contains dry to mesic oak forest, oak woodland and lowland hardwood forest natural communities. As with the West Fork of the Willow Creek Corridor, the occupance of these different natural communities is largely a function of slope, aspect and soil types. The bluff prairie is of moderate to good quality and dominated by native grasses, including side oats gramma, indian grass, little blue stem, big blue stem and prairie dropseed. Many of the wetland natural communities are wet meadow-seepage fens occurring at the base of hillsides along the creek. Common plant species include hummock sedge, prairie cordgrass, blue joint grass and shrubs such as pussy willow and red oiser dogwood. The forest communities contain many of the species listed for the same forest communities found in the West Fork portion of the corridor.

***Wildlife***

The highest quality wildlife habitat is located in the vicinity of the reservoir. It is in this area that the largest blocks of good-quality forest natural communities remain. In addition, species with specialized habitat requirements, such as those requiring native prairie or high-quality wetlands, may be present in this area due to the occupance of these rare natural communities. Although not as rich in avian diversity as the West Fork of the Willow Creek Corridor, a total of 97 species of birds were documented near the East Fork reservoir (Plunkett, 1992). Other wildlife species present in the upper portion of the East Fork would include those listed for forest, wetland and prairie communities as given in Appendix A-8. Wildlife habitat in the northern portion of the East Fork is not as high in quality due to a lack of continuous vegetation along the creek. In some areas of the north portion of this corridor, the creek flows through pasture with little in the way of natural vegetation along the creek.

***Fisheries***

The DNR Lake Management Plan for the reservoir (WR4) calls for stocking bluegill, largemouth bass, channel catfish, yellow bullhead, yellow perch, black crappie and small mouth bass. No other fisheries survey information was available to indicate what fish species are native to the East Fork of Willow Creek, although other species of fish common to small, warm water streams such as fathead minnows, shiners and suckers were probably present before the reservoir was constructed and are likely present today.

***Rare/Endangered Plants Animals and Natural Communities***

Two rare natural communities are listed by the DNR Natural Heritage Program including dry prairie (bedrock bluff subtype) and wet meadow. The dry prairie is located on the boy scout camp property on several steep bluffs above the reservoir. The wet meadow is located downstream from the reservoir between the creek and railroad grade. A plant, Valeriana edulis ssp. (threatened) is documented from both the dry prairie and wet meadow natural communities listed above. Another species of plant, Oxypolis rigidior (cowbane), is also listed by the Natural Heritage Program. This plant does not have a legal status, but is considered rare by the DNR and has been documented from the wet meadow listed above.

***Willow Creek - Lower Reach***

***General Description***

The Lower Reach of the Willow Creek Corridor occupies a floodplain area dominated by wetlands. Within this reach, the East Fork and West Fork of Willow Creek converge. Shortly downstream from this point, Willow Creek discharges into Bear Creek. Because much of the Lower Reach of the Willow Creek Corridor lies within the floodplain, there is only limited agricultural land uses. Most of the Lower Reach is currently in parks and open space with some areas along Willow Creek featuring walking/biking trails. Along the Highway 63 corridor, industrial/commercial uses are present within floodplain fringe areas.

***Natural Communities***

Natural communities characteristic of the Lower Reach include such wetlands communities as sedge meadow, wet meadow, shrub swamp, emergent marsh and flood plain forest. Species common to the sedge meadow communities include hummock sedge, lake sedge, blue vervain, giant goldenrod and water hemlock. Several of the sedge meadow communities in this section of the corridor are among the better quality wetlands in the City. Wet meadows are generally of poor quality and occur where drainage from ditching and/or tiling has occurred. These sites are dominated by reed canary grass, an aggressive, nonnative grass species. Within shrub swamp natural communities, reed canary grass is also a dominant species, along with shrubs such as red oiser dogwood, pussy willow, sandbar willow, black willow and a low diversity of wetland forbs including some of those found in sedge meadow wetlands. Many of the sedge meadow and wet meadow wetlands appear to be succeeding to shrub swamp, possibly due to hydrologic alterations in the watershed and lack of fires to kill back the woody vegetation.

Floodplain forest natural communities occur almost continuously along the creek where sediment deposits create a linear fringe of slightly higher (and dryer) land where trees grow. Dominant trees include boxelder, green ash, american elm and black willow. Buckthorn, a non-native, invasive shrub generally dominates the understory, along with occasional clumps of native dogwoods, willows and currents.

***Wildlife***

The diversity of different wetland natural communities, coupled with the meandering channel of Willow Creek, provides for high-quality wildlife habitat. In this section of Willow Creek, the creek is considerably deeper and flows are more continuous. As a result, aquatic invertebrates, fish, turtles, amphibians, waterfowl, shorebirds, and aquatic fur bearing mammals are all present. Some of the more common species noted include mink, muskrat, beaver, raccoon, coyote, grey squirrel, white-tail deer, pheasant, roughlegged hawk (late fall migrant) and a variety of songbirds. Although the floodplain forests generally have a low diversity of tree, shrub and ground cover plant species, many large trees containing cavities provide shelter and food for many species of birds and mammals. Perhaps the biggest impediment to wildlife in this section of the corridor is the presence of highways 63 and 52, both of which act as potential barriers to wildlife movement up and down the stream corridor.

***Fisheries***

DNR Fisheries have not conducted any stream surveys for this section of Willow Creek. However, because the lower reach of Willow Creek is contiguous with Bear Creek and the South Fork Zumbro River, it is likely that many of the fish species present in these waters are also found in Willow Creek. A listing of dominant fish species in Bear Creek should also apply to this reach of Willow Creek.

***Rare/Endangered Plants Animals and Natural Communities***

No records exist for rare features in this section of the corridor; however, the presence of good-quality wetlands suggest that some rare plant species may be present, which are found in other nearby wetlands.

## 4.3.2 Bear Creek Corridor

**INTRODUCTION**

The Bear Creek Corridor is located in the southeast portion of Rochester's 2015 Urban Service Area. In addition to the main stem of Bear Creek, the Bear Creek Corridor also includes Badger Run. The Bear Creek Corridor was subdivided into three segments to facilitate description. These segments are: Bear Creek - Upper Reach, Badger Run and Bear Creek - Lower Reach. Bear Creek - Upper Reach extends from County Road 11, dowstream to Marion Road. Badger Run extends from County Road 11, downstream to the 30th Avenue bridge between Pinewood Road and Marion Road. The Lower Reach includes Bear Creek downstream from Marion Road and Badger Run, downstream from the 30th Avenue bridge to Highway 14.

***Bear Creek - Upper Reach***

***General Description***

The Upper Reach of Bear Creek meanders through a narrow forested floodplain. Adjacent to the floodplain, upland forest and agricultural land uses are dominant. The Bear Creek channel is generally about 30 feet wide and less than one foot deep. In many places, severely eroded streambanks are scoured out by the current and slump down into the creek, redepositing fine sediments into Bear Creek. Just downstream from County Road 11, an unnamed tributary joins Bear Creek from the north. This tributary contained substantial flow and was approximately 15 feet in width and six inches deep. A narrow strip of floodplain forest runs along this tributary for much of its length, making it a significant component of the Bear Creek Corridor.

***Natural Communities***

The original vegetation of the Upper Reach of Bear Creek consisted mostly of forest and woodland natural communities. Near Bear Creek, floodplain and lowland hardwood forest was present. Farther back from the creek, on higher ground, oak forest, oak woodland-brushland and oak savanna were found. On ridge tops, above the creek valley, scattered patches of prairie were present.

Today lowland hardwood forest, floodplain forest and oak woodland-brushland are the dominant natural communities in the Upper Reach of the Bear Creek Corridor. The quality of lowland hardwood forest in the Bear Creek Corridor is generally much higher than other potions of the City. Along the Upper Reach of Bear Creek, groundwater seepage seems to be the primary source of water, not inundation from the nearby creek. Dominant tree species include green ash, eastern cottonwood, bur oak, american elm, silver maple and boxelder. Native shrubs such as american hazel, speckled alder and chokecherry were present in this lowland hardwood forest. Ground cover species were not surveyed.

Upland forest communities in the Upper Reach of the Bear Creek Corridor are generally mesic oak forest on north and east facing slopes and oak woodland - brushland on dry, well-drained areas adjacent to the creek floodplain. Within mesic oak forest natural communities, red oak, bur oak, basswood, black cherry and green ash are the common tree species. In oak woodland-brushland areas bur oak, pin oak, black oak, trembling aspen and black cherry are the dominant tree species. In general, the shrub layer is dominated by such species as buckthorn, prickly gooseberry, black current, prickly ash and raspberry. The overall quality as measured by species diversity and impacts from human disturbances (logging and grazing) is moderate to high in these upland forested natural communities.

Several significant wetlands occur in this reach. One of the better quality wetlands is bisected by County Road 11, just north of creek. This wetland is a seepage meadow with old creek oxbows bisecting it in several places. Small areas of emergent marsh occur in these oxbows. The wet meadow seepage areas are dominated by sedges and wool grass; the emergent areas by river bullrush, cattail, wild mint and reed canary grass. Although exotic species such as reed canary grass are present, and grazing continues to occur in this wetland, the overall quality of this wetland is good.  The species composition of this wetland is representative of other wetlands in the Upper Reach of the Bear Creek Corridor.

***Wildlife***

Due to the high quality and good diversity of natural communities and the connectivity of these natural communities to Bear Creek, wildlife habitat values in the Upper Reach are high.

***Fisheries***

The Upper Reach of Bear Creek is classified by the DNR as a rough fish-forge fisheries.  Some of the more common fishes include white sucker, creek chub, fathead minnow, black redhorse and golden redhorse.  The DNR maintained a marginal fishery for brown, rainbow and brook trout through stocking up until 1975.  Stocking was discontinued after it was determined that suitable habitat for trout in Bear Creek is very limited for two primary reasons: Suitable trout habitat is scarce in Bear Creek; and low productivity due to fine sand substrates and warm water temperatures.  In some portions of Bear Creek where springs provide cold water sources, the potential for future trout establishment exists.  Reestablishment of trout in Bear Creek, however, does not appear to be a high priority of the DNR.  The main fisheries in Bear Creek will likely be a  children's fishery for suckers and chubs.

***Rare/Endangered Plants Animals and Natural Communities***

A number of rare and endangered animals are documented from the Upper Reach of Bear Creek.  Two records of blandings turtle (threatened) and two records of  blue racer snakes (special concern) are shown for this area.  The black redhorse is a special concern fish species found only in a few drainage areas of southeast Minnesota.  This species has been documented during fishery surveys of Bear Creek.

***Badger Run***

***General Description***

The upper portion of Badger Run, just downstream from County Road 11, flows through, or adjacent to, a series of wet meadow/sedge meadow wetlands.  The wetlands and the slightly higher land adjacent to them are presently used for pasture.  The lower portion of Badger Run flows through pastured areas of hobby farms and residential areas.  Much of the riparian fringe in this reach of Badger Run is affected by debris and fill dumped in the floodplain.  Runoff from residential septic systems (outlet pipes from drain fields) and livestock is evident in places along this reach.  This section of the Bear Creek Corridor would have good potential if  proper clean up efforts were undertaken.

***Natural Communities***

At the time of European settlement, the vegetation of Badger Run was dominated by oak savanna and oak woodland-brushland. Along the creek itself, wet prairie and wet meadow wetlands would have also been present.

The upper portion of Badger Run just below County Road 11 contains numerous wet meadow wetlands. Because of drainage and cattle grazing, most of these wetlands are degraded and are dominated by reed canary grass with scattered pockets of hummock sedge and blue vervain. The surrounding pastures are grazed heavily and generally contain a mixture of brome and blue grass. The lower portion of Badger Run (downstream from 30th Avenue, S.E.) is characterized by a narrow riparian fringe of low-quality floodplain forest dominated by boxelder and eastern cottonwood or shrub swamp dominated by willow, dogwood and reed canary grass. Along Pinewood Road, several tracts of oak forest and oak woodland-brushland are present. The more moist, mesic forested natural communities occur on north facing slopes and are dominated by bur oak, basswood, red oak, white oak and american elm.

***Wildlife***

Wildlife habitat quality is moderate within Badger Run. The quality of wildlife habitat is reduced due to the poor overall quality of natural communities in this corridor and the lack of a connection between Badger Run and upland wildlife habitat.

***Fisheries***

No fisheries surveys have been conducted in Badger Run. It is likely that many of the fish species present in the lower portions of Bear Creek are present in, or would migrate into, Badger Run. Beaver dams (which were present in several locations) and low water levels may act as a barrier to upstream fish migration during some years.

***Rare/Endangered Plants Animals and Natural Communities***

One record of a blandings turtle (threatened) is shown for the upper portion of this reach. The occurance of blandings turtles is possible along much of Badger Run due to the number of wetlands along the creek. Within the lower portions of Badger Run, the occurance of the black redhorse (a fish species of special concern) is likely due to the presence of this species within Bear Creek.

***Bear Creek - Lower Reach***

***General Description***

The lower reach of Bear Creek lies within a level floodplain. Within this reach, Willow Creek and Badger Run discharge into Bear Creek. Floodplain forest runs continuously along Bear Creek and its tributaries in this reach. Because most of this area lies within the floodplain, land uses are mostly limited to agricultural fields and city park. Within this reach, Bear Creek is a sizable stream, averaging 37 feet wide and more than 1 foot deep. The banks of Bear Creek in this lower reach are generally quite high (8-10 feet) due to the sediment deposits and creek channel downcutting.

***Natural Communities***

The original vegetation in this section of the Bear Creek Corridor consisted of oak savanna, oak woodland-brushland and oak forest. Oak forest occurred in areas protected by fires (such as areas adjacent to the creek). Oak savanna occurred on well-drained alluvial soils where fires and activities of large grazing animals, such as bison, prevented the establishment of woody vegetation. Some parts of the lower reach of the Bear Creek Corridor still superficially resemble oak savanna. These areas contain the original bur oak trees but have largely lost their native assemblages of grasses and forbs. The dominant natural community along Bear Creek today is floodplain forest. Dominant tree species include box elder, silver maple, green ash, american elm and willow. The shrub layer is generally open and is dominated by buckthorn, an exotic shrub. Where the elevation is somewhat higher and flooding is not as frequent, dry oak forest dominated by bur oak, white oak, pin oak, black oak, black cherry and trembling aspen is found. These areas have probably succeeded from a more open oak woodland-brushland due to the lack of fires. Forested natural communities in the Lower Reach of Bear Creek contain large numbers of exotic and/or weedy species such as boxelder and buckthorn and, therefore, are of low to moderate quality.

In addition to forested natural communities, wet meadows and scrub shrub wetlands are scattered throughout this reach in depressional areas. These wetlands are generally of low to moderate quality for reasons stated above and are dominated by reed canary grass, red oiser dogwood, willows and buckthorn.

***Wildlife***

The Lower Reach of Bear Creek provides significant wildlife habitat in spite of the generally low quality of natural communities. The forested communities typically contain may large trees with numerous cavities. Many of these dead trees, referred to as snags, are still standing. The snags provide habitat for many species of wildlife that use tree cavities for nesting and as a food source (dead trees typically contain a lot of insects). In addition to the numerous snag trees, large white and bur oaks common to this area provide food for a host of different wildlife species.

There are other reasons that the Lower Reach of Bear Creek Corridor is significant for wildlife. The creek itself contains such food items as fish and crayfish and other aquatic invertebrates and important to species such as herons, mink and raccoons. Perhaps the most important factor, though, is that this area serves as a link among other areas of significant wildlife habitat including: Willow Creek, Badger Run and the Upper Reach of Bear Creek, linking all of these corridors to allow for the movement of birds, mammals, reptiles and amphibians. A major threat to the corridor links, is fragmentation from road crossings and urban development. Fragmentation results when physical barriers such as roads and other obstacles limit the movement of wildlife between different areas. Road crossings in particular should be designed to provide for the safe movement of wildlife.

***Fisheries***
The same comments made for the Upper Reach of Bear Creek apply to the Lower Reach of Bear Creek.

***Rare/Endangered Plants Animals and Natural Communities***
The black redhorse (fish species of special concern) has been collected from this reach of Bear Creek.

### 4.3.3 Silver Creek Corridor

**INTRODUCTION**
The Silver Creek Corridor is located in the eastern portion of the City of Rochester. The Corridor extends from County Road 11, just below the Silver Creek Reservoir, downstream to Silver Lake. The Silver Creek Corridor includes an intermittent tributary that drains land to the southeast along College View Road and the Quarry Hill Nature Center.

***General Description***
The upper part of the Silver Creek Corridor is a deep valley with a mixture of forest, pasture and cropland. In the upper reaches, Silver Creek is a small, meandering stream averaging about 11 feet in width. Prior to construction of the flood control reservoir, flows in Silver Creek were intermittent during dry years. Flows are now more consistent due to steady discharges from the upstream impoundment. About a mile downstream from County Road 11, the channel of Silver Creek widens and the gradient increases with sections of the creek flowing over boulders and rubble. With this reach of Silver Creek the scenery is outstanding with the creek flowing through a broad, sweeping valley. Land uses in this section are a mixture of forest, pasture and row crops. Below Silver Creek Road, the creek enters into a broad floodplain, where it more or less follows a railroad grade into the City of Rochester.

### *Natural Communities*

The presettlement vegetation of the Silver Creek Corridor was dominated by prairie and oak savanna. Today, the prairies have mostly been converted to cropland and the oak savanna has either succeeded to oak woodland/forest or is used for pasture.

The upper and middle portion of the Silver Creek Corridor contains a mixture of forest, wet meadow and pasture. On south and west facing valley slopes, oak forest and oak woodland - brushland is found; on north and east facing slopes, mesic oak and maple-basswood forest is found. Wet meadow and small areas of lowland hardwood forest are characteristic of the low areas adjacent to Silver Creek. Generally, the natural communities in the upper to middle reaches of the Silver Creek Corridor are of moderate quality. Although the diversity of trees is good in many of the forest communities, the shrub layer is almost completely dominated by exotic and/or weedy native shrubs. In addition, many of the native ground cover grasses and forbs are absent from these areas due to grazing.

Below Silver Creek Road, Silver Creek flows through moderate to poor quality floodplain forest dominated by black willow, eastern cottonwood and boxelder. Like the upper reach, the shrub layer of these forest is almost completely dominated by exotic shrubs such as buckthorn. One of the best-quality wetlands inventoried in the City is located along the tributary entering Silver Creek from the southeast. This good-quality sedge meadow/emergent marsh wetland is dominated by such species as lake sedge, hummock sedge, cattail, with scattered willow and meadowsweet shrubs. To the north of Silver Creek, dry oak forest and oak woodland-brushland are dominant within the Quarry Hill Nature Center. These oak forest and woodlands are generally of low quality due to invasion by buckthorn and past logging and grazing activities

### *Wildlife*

The Silver Creek Corridor contains good quality wildlife habitat along most of its length. Some of the species observed include deer, turkeys, pheasant, beaver, mink, raccoon, blue heron and wood ducks. The upper portion of the corridor is generally remote and contains forest communities with large wildlife snag trees, which as stated before, provide good habitat for wildlife. In contrast to the other corridors, the upper portion of Silver Creek Corridor contained several active beaver ponds which provide habitat for other furbearers and water fowl such as wood ducks. According to the DNR, river otter, a species rare to Southeast Minnesota, have recently been sighted in Silver Creek.

### *Fisheries*

Silver Creek is classed as a rough fish/forge fish fisheries by the DNR. The upper and middle portions of the creek contains such species as the central stoneroller, common shinner, fathead minnow, blacknose dace and johnny darter. The lower portion of Silver Creek may provide spawning and nursery habitat for smallmouth bass and black redhorse. Other species of fish in Silver Lake may use the small minnow-like fish found in Silver Creek as a forage base.

***Rare/Endangered Plants Animals and Natural Communities***

The Silver Creek Corridor contains the largest number of rare and endangered elements of the five corridors. Two significant natural communities are listed by the DNR for this corridor: the wet meadow wetland described for the southeast tributary and a bedrock bluff prairie on a west facing bluff within Quarry Hill Nature Center. An additional remanent of bedrock bluff prairie is located west of the intersection of County Road 11 and County Road 50. This site contains rattlesnake master, a special concern plant species. An additional occurrence is a wood turtle (threatened) west of Quarry Hill Nature Center.

## 4.3.4 Kings Run Corridor

**INTRODUCTION**

Kings Run Corridor extends from just south of the Douglas Trail along 50th Avenue NW, east to Essex Park. The Kings Run Corridor provides a logical connection between the Douglas Recreational Trail System on the west end of the corridor and Essex Park to the east along the South Fork Zumbro River.

***General Description***

Kings Run Creek is a small stream draining the northwestern portion of the 2015 service area. Along most of its length, Kings Run Creek is ditched, although in some sections, pools, riffles and meanders have become reestablished. The dominant land use in Kings Run Corridor is agricultural row crops with some areas of industrial and commercial landscaping in the western portion of the corridor.

***Natural Communities***

The original vegetation of Kings Run was prairie in the upper and middle sections of the corridor and oak savanna in the lower portions of the corridor near the junction of Kings Run Creek and the South Fork Zumbro River. The majority of the prairies have now been converted to agricultural land. Most of the oak savanna has succeeded to oak forest or has been cleared for agricultural land uses.

The upper portion of Kings Run Corridor contains small tracts of oak forest in the vicinity of the Douglas Trail. Most of these upland forest areas occur as linear strips along the old railroad right-of-way which now is part of the Douglas Trail System. Along the Creek itself, and in both the upper and middle sections of the corridor, a narrow band of lowland hardwood forest dominated by boxelder, eastern cottonwood and willow is found. Disturbances from agricultural activities and invasion by exotic species is significant due to the small size and linear shape of these communities. For these reasons, the quality of forested natural communities in the upper and middle reaches of the corridor is low. Forest in the lower portion of the corridor, particularly in Essex Park, are of good quality and include floodplain forest along the creek and near the South Fork Zumbro River and mesic oak forest on areas of higher ground.

Most wetland natural communities in this corridor have been altered through drainage and/or invasion by reed canary grass. Other areas that were once open wetlands such as wet meadows have probably succeeded to the lowland hardwood forest communities now common along the creek channel.

***Wildlife***

Some of the more common wildlife species observed in Kings Run Corridor include beaver, raccoon, mink, pheasant and deer. Due to the small size, linear shape and overall poor quality of natural communities in the upper and middle portions of Kings Run Corridor, only habitat generalist species of wildlife, such as deer, are likely to be found. Furbearers such as beaver, mink and muskrat that travel within the creek itself were present at the time the corridor was field inspected. These species will continue to be present as long as some natural vegetation is maintained along the creek. The lower portion of Kings Run (Essex Park) is contiguous with the South Fork Zumbro River and contains higher quality natural communities and better wildlife diversity. Overall, Kings Run does not have high value due to the poor condition and lack of natural communities.

***Fisheries***

No information on fisheries was available for this corridor. Presumably, many of the smaller minnow-like species found in other small streams outletting into the South Fork Zumbro River would also be present in the lower portions of Kings Run Creek.

***Rare/Endangered Plants Animals and Natural Communities***

No occurrences of rare features are known in this corridor. There are however, three nearby records: one record of a timber rattlesnake (special concern) and two records of blandings turtle (threatened). These three records occur within one-half mile of the corridor. In addition, the black redhorse (special concern) is listed from several nearby locations on the South Fork Zumbro River and likely occurs on a periodic basis in the lower reaches of Kings Run Creek.

### 4.3.5 Cascade Creek Corridor

**INTRODUCTION**

The Cascade Creek Corridor is located in the west portion of the 2015 service area. The corridor consists of two forks and the lower reach. The North Fork extends from 50th Avenue NW (just south of Valley High Road NW), downstream to where the North Fork Tributary to Cascade Creek crosses under Highway 14 just west of the junction of Highways 14 and 52. The South Fork extends from 60th Avenue SW (just south of Country Club Road, W.), downstream to where Cascade Creek crosses under Country Club Road. The Lower Reach includes those portions of the corridor between the North and South Forks and Highway 52. Due to the relatively small size of the North, South and Lower Reaches, they will be discussed together.

***General Description***

The main stem of Cascade Creek (South Fork) is a small stream with intermittent flows during dry years. Much of the upper portion of Cascade Creek flows through agricultural land. Segments of the upper portions of the stream channel have exposed banks needing stabilization. Within the lower portion of the South Fork corridor, Cascade Creek flows through the newly constructed Meadow Lakes Golf Course. Just downstream from the golf course, Cascade Creek flows through several gravel mining pits. The tributary to Cascade Creek flowing through the North Fork portion of the corridor is small, intermittent and ditched along much of its length. This tributary flows through several wetland areas before discharging into the main stem of Cascade Creek, just downstream from the gravel mining area. The Lower Reach contains the gravel mining area of the corridor. The gravel mine area within the Lower Reach will eventually be reclaimed as a lake according to the City's Cascade Lake Concept Plan. This future lake will eventually encompass much of the land within the Lower Reach of Cascade Creek Corridor.

***Natural Communities***

The original vegetation of Cascade Creek Corridor consisted largely of prairie and wetlands with scattered pockets of oak savanna and oak woodland. Today, most of the prairie has been converted to agricultural row crops. Most of the oak savanna or oak woodland has either been converted to urban or agricultural uses or has succeeded to oak forest.

Today, riparian wetland communities comprise the majority of natural communities remaining in the Cascade Creek Corridor. Wetland communities present in the Cascade Creek Corridor include wet meadow, sedge meadow, emergent marsh, shrub swamp and floodplain forest. The most common of these wetland communities is low-quality wet meadow dominated by reed canary grass. Sedge meadow wetlands are generally dominated by hummock sedge, wool grass, blue joint grass and prairie cordgrass remain.  Most of the wet meadow and sedge meadow wetlands also contain scattered boxelder, red osier dogwood and willow.

Forested natural communities include floodplain forest along the creek and oak forest on upland areas.  Flood plain forest communities are generally dominated by boxelder with other species such as green ash, american elm, black willow and eastern cottonwood also present.  Oak forest communities are generally dominated by bur oak, basswood, black cherry, box elder and ironwood. For both floodplain forest and oak forest the dominant shrub species is buckthorn, an invasive, nonactive shrub that chokes out other shrub and ground cover species.  The overall quality of forest communities in the Cascade Creek Corridor is low due to the generally small size of communities, fragmentation by roads and home sites and invasion by exotic and/or invasive species such as buckthorn and boxelder.

***Wildlife***

Many of the more common wildlife species found along streams and within wetlands are likely present in the Cascade Creek Corridor.  Some of the mammal species observed include mink, beaver, striped skunk, grey fox and white-tail deer.  Bird species include red tailed hawk, great horned owl, belted kingfisher, herring gull and a variety of migrating warblers.  The majority of wildlife species in this corridor are associated with wetland communities although sizable areas of upland forest habitat occur just outside the corridor and contain forest species such as grey fox and deer.  In the Lower Reach, waterfowl and shorebirds are likely associated with the open water and shoreline mudflats of the gravel pits.  During the field survey of this area, hundreds of Canada Geese and herring gulls were present on the gravel pits.  Overall, wildlife values in the Cascade Creek Corridor are moderate.  This is due to the generally low quality and fragmentation of natural communities in the corridor.   In spite of the condition of natural communities, wildlife use of this area is fairly high due to the numerous wetlands and open water areas of the gravel pits.

***Fisheries***

The DNR classifies Cascade Creek as a Class III, warm water feeder stream.  A limited fishery providing occasional bluegills, crappies and smallmouth bass exists in the lower two miles of Cascade Creek.  Above the lower two miles (which is approximately to where Cascade Creek Corridor extends downstream) the fish population is made up of small minnow-like fish including common shiner, creek chub, white sucker and johnny darter.  Only one area (upstream from a sheet piling dam located below the gravel pits) showed evidence of recreational fishing activities.  The upper portion of Cascade Creek has intermittent flows during dry years.  Beaver dams (which were present at the time of the survey) may also restrict flows to waters downstream or block upstream movement of fish. Although no information was found on fishes in the gravel pits, presumably most of the fish present in the creek are also present in the gravel pits.

***Rare/Endangered Plants Animals and Natural Communities***
Three rare feature records from DNR Natural Heritage Program occur within or just outside the Cascade Creek Corridor. These records include a colonial water bird nesting site (great blue herons), valerian (threatened plant species) and black redhorse (special concern). All of these rare features occur within or near wetland areas of the corridor.

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## 4.4 Stream Corridor Management

The stream corridors identified along the streams described above were separated into primary and secondary zones based on the specific functions and values. The primary and secondary zones are shown of Map-3 included at the end of this report. The following areas were identified during the process of delineating the corridor areas:

1. The preservation of the floodway and the immediately adjacent natural resources;

2. The upland area next to the stream where the vegetation supplements the stream to provide an ecosystem compatible with urban life;

3. Steep slopes and areas with highly erodible soils prone to erosion located in the direct drainage area of the stream; and

4. Areas with high infiltration or groundwater contamination potential.

The corridor boundaries shown on Map #3 in the back of this report are approximate and may need minor adjustment when a particular property is considered for development. The Steering Committee developed the following definitions for the primary and secondary zones so that these zones can be identified for a specific site. The Steering Committee also reviewed a list of best management practices that should be applied to protect the primary and secondary zones as described below.

### 4.4.1 Primary Zone

The primary corridor zone is defined by the floodway designated on the City's Flood Insurance Rate Maps and/or wetlands contiguous to the corridor stream. The primary corridor zone is the area where land use and human activities directly impact the biological and morphological characteristics of the stream. Table 4-1 contains the strategies and practices available for the protection of the resources located within this area.

**Table 4-1: Strategies and practices for Primary Corridor Areas**

| **Strategies** | **Practices** |
| --- | --- |
| Floodway Preservation | Minimize grading and disturbance within the floodway to maintain stream capacity and preserve ecosystem. |
| Stream Bank Stability | Inspect stream banks and delineate buffer areas within a development site during the initial development planning phase by a qualified professional. |
| Corridor Wetlands | Minimize wetland impacts within corridor to the greatest extent possible. Replace corridor wetland impacts on-site. |
| Wildlife Habitat | Preserve existing trees and significant vegetation within corridor. Replace removed trees along corridor. |
| Education | Educate citizens as to the values of the corridor and damage that occurs with dumping of fill, debris and yard waste. |

### 4.4.2 Secondary Zone

The secondary corridor zone is the area where land use and human activities have an impact on the critical upland ecosystem of the stream. The secondary corridor encompasses the primary corridor and those areas with direct drainage to the stream. The secondary corridor is defined by land use zoning districts and physical features. The following is a review of these features.

**Land Use Districts:**

*Floodplain District*: In all cases, the secondary corridor includes the boundaries of the 100-year floodplain as shown on FEMA Flood Insurance Rate Maps.

*Shoreland District*: The Shoreland Zoning District overlaps with the Floodplain Zoning District and generally extends 300 feet from the ordinary high water mark (OHW) or to the extent of the 100-year floodplain, which ever is greater. The entire shoreland zoning district is assumed to fall within the secondary corridor.

**Physical Features**

The secondary corridor is identified as those areas consisting of the following physical features:

*Steep Slopes*: Where steep slopes (greater than 12 percent over a horizontal distance of 50 feet or more) are contiguous with the stream floodplain.

*Upland Natural Communities*: This category includes forest, prairie, and wetland communities occurring above the floodplain (perched or hillside seepage wetlands) that are contiguous to streams, floodplains or steep slopes.

*Wetlands or Hydric Soils*: Where these features are contiguous with the floodplain or other features listed above.

Table 4-2 contains the strategies and practices recommended for the protection of the resources located within this area.

**Table 4-2: Strategies and Practices for Secondary Corridor Areas**

| **Strategies** | **Practices** |
|---|---|
| Corridor Preservation | Minimize tree removal for development. Promote diverse tree plantings and landscaping. Promote connecting of corridor with other natural areas. |
| Wetland Banking and Replacement | Replace wetland impacts within designated mitigation and banking areas in corridor. Promote wetland restoration over creation. |
| Buffer Areas | Provide buffer areas along edge of primary corridor boundary. Minimize actions that break corridor into segments. |
| Nutrient Management | Control use of fertilizers and pesticides through development agreements and education. |
| Steep Slopes | Minimize distrurbance of existing slopes steeper than 4:1. Stabilize problem areas using bio-engineering or BMP methods. |
| Stormwater Runoff | Direct all stormwater runoff from urban development to specified regional stormwater facilities or provide on-site stormwater ponding if a regional facility is not feasible. |

# 5. Stormwater Quantity

## 5.1 Background

The main purpose of the stormwater quantity portion of the Surface Water Management Plan is to serve as a guide for the expansion of the storm drainage system. As land is converted from rural to urban land uses, the volume and rate of stormwater runoff increases, which can increase the occurance of local flooding and erosion damage to existing streams. This chapter identifies opportunities for improving the quantity portion of the existing system and provides standards for the design of future facilities. The application of these standards will allow for the expansion of the storm drainage system as the City develops while minimizing the cost and inconvenience of local flooding and stream damage repairs.

The storm drainage facilities discussed in this study consist of interconnected open channels, wetlands, ponds and pipes. The preliminary design of the stormwater drainage system for the Rochester SWMP involved the following aspects:

- Division of the City into major drainage districts and subdistricts based upon topographic information and future land use projections
- Computation of runoff using ultimate land use projections within the study area;
- Selection of a consistent method for conveying runoff
- Identification of high quality streams and high priority water bodies
- Use of ponding areas for storage, sediment and pollutant trapping, and nutrient uptake
- Regulation of peak flows in creeks, rivers and natural corridors to minimize erosion and impacts to stream morphology, and
- Integration of upland features to protect designated stream's ecosystems.

The preliminary design of stormwater pond areas is an essential part of the SWMP. Since the mid 1970s, stormwater management authorities have emphasized the use of stormwater ponding to control increased rates and volumes of runoff from developing areas. The City currently requires each individual development to analyze and design stormwater practices to control runoff. However, this approach will eventually result in a large number of facilities that will be difficult for the city to manage and maintain.  Local flooding may still occur under this approach when the entire system is not analyzed on a watershed basis.

The Rochester SWMP follows a regional stormwater basin approach by consolidating individual basins that would normally be constructed in each subdivision or development, into central facilities within the subdistrict.  Several individual ponds can be combined into one efficiently designed basin to control runoff for several developments.  Regional basins provides a cost-conscious approach to stormwater management by providing the following benefits.

- Combining engineering, design and construction cost for individual developments
- Using naturally occurring depressions and existing topography to minimize excavation costs
- Reducing total land required for stormwater management by providing efficiently designed central facilities in place of several individual facilities
- Minimizing the cost to manage the system by creating fewer stormwater basins
- Lowering the cost of maintenance and up-keep for fewer central facilities, and
- Providing flexibility in design of larger central facilities to incorporate recreational opportunities, create wildlife habitat areas and improve aesthetic benefits for area residents.

To illustrate the use of regional ponds, the hydrograph resulting from a typical low-density residential watershed of 125 acres is shown in Figure 5-1.  The runoff curve number for this example was 72, which corresponds to a typical low density  residential development in the City.  The outflow from a proposed regional stormwater pond that is located to reduce peak flow rates can be plotted as shown in Figure 5-1.  The graph corresponds to a 30" storm sewer outlet with a total head of 5 feet resulting from a difference of 5 feet between the normal and high water levels.  The resulting outflow hydrograph illustrates that the peak flow rate is reduced by temporarily storing runoff to be discharged at a lower rate.  The second graph in Figure 5-1 illustrates the effects of down stream ponds as additional runoff enters the system.  The resulting outflow hydrograph becomes lower and longer as increased volumes are passed down stream.

The pond storage and outflow rates were determined by computer simulation for all of the ponds identified in this report.  Figure 5-1 is provided only as an example to show the principles of pond storage and the reduction of peak flows possible through the use of detention ponds.

Ponds with oversized outlets reduce the available flow capacity in downstream pipes and tend to empty sooner than desired. This problem can be resolved by constructing outlet control structures such as orifices and weirs, which are recommended for some ponds.  Outlet control structures are designed to reduce the outflow from a pond to a level that is lower than the level possible with a culvert.

The SWMP provides the preliminary layout of the future trunk storm sewer system.  Trunk storm sewers convey runoff from the upper portions of watersheds to the proposed regional pond facilities. Trunk storm sewers are defined as storm sewer pipes that are 30 inch or greater in diameter with a minimum conveyance rate of 40 cfs for the 10-year storm event as described in the next section. Storm sewers that convey runoff flows **from** a regional stormwater basins are also considered trunk storm sewer.

The Trunk Storm Sewer Map in the back of this report provides a schematic layout of the future trunk storm sewer system.  The location of trunk storm sewers shown on this map are for planning purposes only.  The final location and size of these sewers will be determined at the time these areas develop.

## Fig 5-1: Hydrographs

## 5.2 Design Criteria

### 5.2.1 Precipitation

Stormwater runoff is defined as that portion of precipitation that flows over the ground surface during, and for a short time after, a storm. The quantity of runoff is dependent on the intensity of the storm, the length of storm, the amount of previous rainfall, the type of surface the rain falls onto and the slope of the ground surface.

The intensity of a storm is described by the amount of rainfall that occurs over a given time interval. A specific rainfall amount over a given time interval will statistically occur in a given time span, usually years. This is called a return frequency. A return frequency designates the average time span during which a single storm of a specific magnitude is likely to occur. Thus, the degree of protection afforded by storm sewer facilities is determined by selecting a return frequency to be used for design based on good economic sense and current engineering practices.

The City of Rochester uses a 10-year frequency storm event for storm sewer design, while the greater of the 100-year, 24-hour frequency rainfall event or the 10-day snowmelt event is used for overland drainage and pond storage design. These storm events were selected for the analysis and design of the drainage system for the Surface Water Management Plan. A 10-year frequency storm (4.3 inches in 24 hours) has a 10 percent chance of occurring or being exceeded in any given year, whereas a 100-year, 24-hour frequency storm (6.2 inches in 24 hours) has a 1 percent chance of occurring or being exceeded in any given year. The 10-day snowmelt event (7.5 inches of runoff in 10 days) also has a 1 percent chance of occurring or being exceeded in any given year.

Complete protection against large, infrequent storms with return intervals greater than 100 years are typically justified only for very large flood control projects. For most developing areas, the cost of constructing a large capacity storm drainage system is much greater than the amount of property damage that would result from flooding caused by a storm that a smaller capacity system could not accommodate.

The excess runoff caused by storms greater than that used for design will be accommodated by ponding in low spots in streets for short periods of time and providing outflow through overland drainage routes. This short-term flooding and overland drainage will minimize much of the damage to property that would occur if those facilities were not provided. Provisions should be made to provide or preserve overland drainage routes for emergency overflows. When possible, stormwater pond designs should include an emergency overflow to provide an outlet below the lowest floor elevation of any adjacent structure for added safety.

An SCS 24-hour Type II storm distribution with 100-year intensity was used for the design of ponds and drainage systems. The Type II distribution is the storm event recommended for the upper-midwest portion of the United States, which the Soil Conservation Service has determined from National Weather Bureau data. The Type II storm distribution with a 100-year intensity is shown graphically in Figure 5-2.

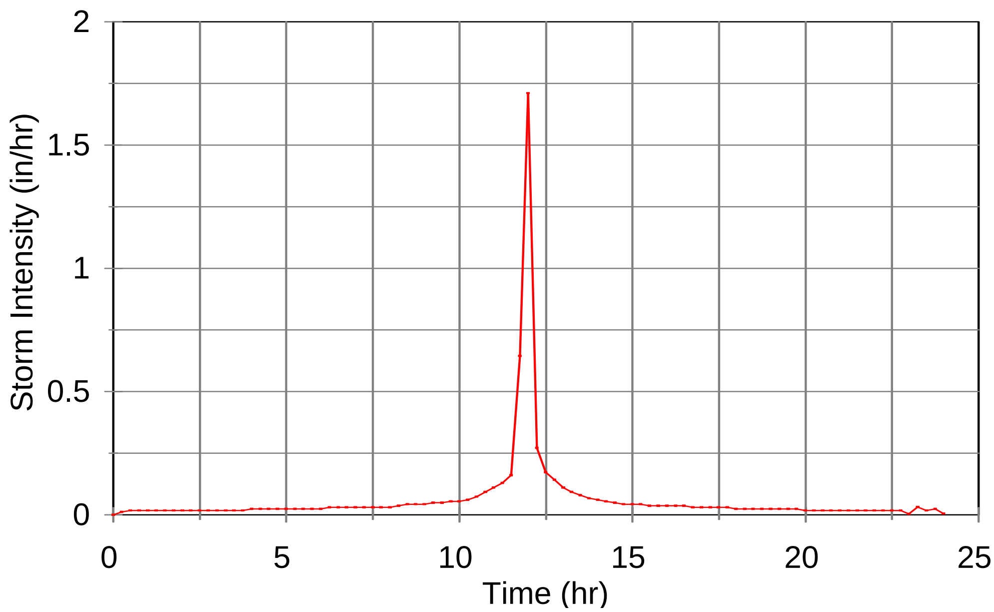


**Figure 5-2: 100 year - Type II Storm Distribution**

Stormwater detention facilities with peak discharge rates less than 2 cfs/40 acres are typically susceptible to exceeding high water levels during snowmelt conditions. Special consideration of the snowmelt condition becomes more critical for some areas with curve number values less than 70 that typically remain frozen later in the season (such as wooded areas). These areas produce low runoff rates under normal summer conditions. Final basin design must consider snowmelt conditions when sizing outlet structures.

### 5.2.2 Stormwater Runoff

A number of methods have been developed to determine the expected maximum rate of runoff for an area under a certain design storm. The preliminary trunk storm sewer design presented in this plan is based on the Rational Method, which is the most widely used method for designing storm sewer systems. Regional pond design is based on the XP-SWMM computer program, which produces runoff hydrographs based on SCS runoff methodology.

The Rational Method requires the selection and/or computation of a time of concentration and a runoff coefficient. The time of concentration is the time required for the runoff from a storm to become established and for the flow from the most remote point (in time, not distance) of the drainage area to reach the design point. The time of concentration will vary with the type of surface that the rain falls on and the slope of the surface.

A minimum concentration time of 20 minutes for residential areas and 15 minutes for commercial/industrial areas has been selected for design of the trunk storm sewer system. These minimum times should be considered in the design of lateral systems. As the stormwater runoff enters the system, the flow time in the storm sewer is added to the concentration time and compared to downstream drainage area concentration time. The maximum value is used downstream, which results in a longer concentration time and a lower average rainfall intensity as the flow moves downstream from the initial design point.

The percentage of rainfall falling on an area that must be collected by a storm sewer facility is dependent on watershed variables such as soil perviousness, ground slope, vegetation, surface depressions, type of development and antecedent rainfall. These factors are taken into consideration when selecting a runoff coefficient (C) for the Rational Method or a runoff curve number (CN) for use in SCS methodology.

The runoff coefficient for urban areas varies from 0.2 for parks to 0.95 for asphalt and concrete surfaces. The runoff curve number varies from 58 for parks to 98 for asphalt and concrete surfaces. Under ultimate (fully developed) conditions, the values of the coefficient will increase with increases in the amount of impervious surfaces caused by street surfacing, building construction, and grading.

The antecedent moisture condition (AMC) relates to the moisture content of the soil prior to a given storm event. Curve numbers based on land use can be adjusted based on an assumed moisture condition. For purposes of the model, normal antecedent moisture conditions (AMC II) was assumed. Curve number values given below can be adjusted for dry conditions (AMC I) or wet conditions (AMC III).

Curve numbers are also dependent on the type of soil in a given drainage area. Soil types are classified into four basic groups. Group A soils consist of deep sand and aggregated silts. Group B consists of sandy loams. Group C soils are low in organic content and are made up of clay loams and soils high in clay. Group D soils consist of heavy plastic-type clay soils. Group B soils were assumed for the Rochester area based on the majority of soils found in the county soil survey. Soils within the floodplain, where some group C/D soils are found, were considered saturated for modeling of the 100-year, 24-hour storm event. Development plans should consider post-development site soil conditions when choosing runoff coefficients for design.

Average runoff coefficients and CN values for each land use type are used in the design of the storm drainage facilities in undeveloped areas. For the modeling of existing facilities, CN values were determined for each type of development and current zoned land use in each subdistrict. Runoff coefficients and equivalent CN values for Antecedent Moisture Content Type II and Group B soils are presented in Table 5-1.

**Table 5-1. Runoff Coefficients**

| Land Use Type | Runoff Coefficient C | | | CN Value |
|---|---|---|---|---|
| | 5 Year | 10 Year | 100 Year | |
| Parks and Public Land | 0.2 | 0.25 | 0.3 | 58 |
| Rural & Estate Residential | 0.3 | 0.35 | 0.4 | 66 |
| Low Density & Single Family Residential | 0.4 | 0.45 | 0.5 | 72 |
| Medium Density Residential* | 0.5 | 0.55 | 0.6 | 78 |
| High Density Residential* | 0.6 | 0.65 | 0.7 | 84 |
| Commercial, Industrial* | 0.6 | 0.67 | 0.7 | 84 |
| Special | As required | | | |

* May be adjusted for site specific amount of impervious surface.

New development must follow 10-year storm sewer design standards. Runoff calculations for the design of storm sewers and ponds for low density residential development must use the runoff coefficients given in Table 5-1 when the drainage area is located in areas consisting of group B soils as indicated in the County soil survey. Other land uses can vary significantly in the amount of proposed impervious surface. Final adjustment to runoff curve numbers for these land uses must be adjusted using acceptable engineering standards such as those given in the Natural Resources Conservation Service (formerly SCS) publication TR-55. Five-year runoff coefficients are included in Table 5-1 for situations where existing down stream systems are undersized and are not expected to be upgraded.

## 5.3 Computer Modeling

The computer modeling of stormwater quantities for the drainage system was carried out using the computer software XP-SWMM, which is being used nationally for many applications in stormwater quantity and quality. XP-SWMM is a version of the Environmental Protection Agency's Surface Water Management Model with a user interface. The program performs dynamic routing of stormwater through the ponds and storm sewers based on gradually varied, one-dimensional flow. The program can model backwater, free surface, and pressurized pipe flow. Hydrograph routing through ponding areas is performed by level-surface reservoir methods. Final pond designs may be completed using programs such as TR-20 and HydroCad if care is given to backwater effects at downstream outlets.

Results of the computer model for the system are presented in Appendix A-2. The maximum peak discharge rates for the 100-year, 24-hour storm event are presented at all proposed pond locations indicated on Map-1 in the back of this report. Complete hydrographs for these and other locations throughout Rochester are available through the SWMM model on record with City Staff.

## 5.4 Stormwater Conveyance Requirements

Storm sewers are the actual conduits used to transport stormwater runoff. The capacity of the storm sewer conduit is dependent on the pipe slope, pipe diameter, and the roughness of the inner surface of the pipe. Computations for storm sewer conduit capacity are based on the following Manning's formula:

$$Q = \frac{1.49}{n} \left(\frac{A}{P}\right)^{2/3} S^{1/2} A$$

Where:

Q = Storm sewer conduit capacity in cubic feet per second (cfs)
n = Roughness coefficient
A = Cross-sectional area of conduit
P = Wetted perimeter of conduit
S = Slope of conduit

A roughness coefficient (n) of 0.013 was used for concrete storm sewer pipe, and 0.024 for corrugated metal pipe. These roughness coefficients take into account losses due to bends and manholes in the system and the roughness of the inner pipe surface. Only major storm sewer trunks, 30 inches and larger, have been considered in this study.

A trapezoidal cross-section with 4:1 maximum side slopes (4-feet horizontal to 1-foot vertical) was the basis for design wherever existing and proposed open channels are used. The same Manning's formula was used to determine channel capacity with the roughness coefficient (n) increased to 0.030. For open channels, P in the equation becomes the wetted perimeter of the channel.

Proper design of a storm sewer system requires that all sewer lines be provided with access through manholes for maintenance and repair operations. Spacing of manholes should be no greater than 400 feet for sewer lines 15 inches or less in diameter, and 500 feet for sewer lines 18 inches to 30 inches in diameter. Intervals on larger diameter lines can be increased since the pipes are sufficiently large for a person to physically enter the storm sewer pipe itself for maintenance operations. Regardless of sewer size, manholes should normally be provided at all junction points and at points of abrupt alignment or grade changes.

Although lateral systems are designed for 10-year storm events, their performance must be analyzed for storms exceeding the design storm. It should be anticipated that surcharging of the system will occur when the design storm is exceeded. During surcharging, the system works as a closed conduit and the pipe network becomes pressurized with different pressure heads throughout the system. Low areas that are commonly provided with catch basins become small detention ponds often performing like pressure relief valves (water rushing out in some locations). For this reason, it is extremely important to ensure that these low areas have an acceptable overland drainage route with proper transfer capacity.

Ponding on streets must meet all of the requirements of the 100-year design criteria as a minimum. For safety reasons, the maximum depth should not exceed three feet at the deepest point and the lowest exposed building elevation should be at least one foot above the high water overflow level. The high water overflow level for temporary street ponding is defined as the elevation to which water rises before overflowing through adjacent overland routes.

**The minimum elevation for the lowest exposed floor or opening elevation of buildings near ponds must be two feet above the 100 year high water level or one foot above the emergency overflow elevation, which ever is greater.** The City may require additional freeboard for landlocked areas or ponds where emergency overflows can not be provided. Overland flow routes should be incorporated into the design for ponds and maintained during development. The lowest exposed floor or opening elevation of structures adjacent to ponds should be indicated on the site grading plan to ensure adequate freeboard.

All storm sewer facilities, especially those conveying large quantities of water at high velocities, should be designed with efficient hydraulic characteristics. Manholes and other structures at points of transition should be designed and constructed to provide gradual changes in alignment and grade. Pond outlet control structures should be designed to allow water movement in natural flow line patterns, minimize turbulence, provide good self-cleaning characteristics, and prevent damage from erosion.

Intake structures should be liberally provided at all low points where stormwater collects and at points where overland flow is to be intercepted. Inlet structures are of special importance, since it is a poor investment to have an expensive storm sewer line flowing partially full while property is being flooded due to inadequate inlet capacity. Inlets should be placed and located to eliminate overland flow in excess of 1,000 feet on streets or a combination of streets and swales, and 600 feet on collector and arterial streets. Additionally, inlet grates must have the capacity to collect the drainage from the 10-year storm event. This may require multiple catch basins or the use of special high capacity grates at some locations.  Intake grates and openings should be of self-cleaning design to minimize capacity reduction when clogged with twigs, leaves and other debris.

Effective energy dissipation devices or stilling basins to prevent streambank or channel erosion at all stormwater outfalls must be provided.  The following recommendations must be considered when designing an outlet:

1. **Inlet and outlet pipes of stormwater ponds should be extended to the normal water level whenever possible.**

2. **Outfalls with velocities less than 4 fps that project flows downstream into a channel in a direction at less than 30 degrees from the normal channel axis generally do not require energy dissipators or stilling basins, but do require rip rap protection.**

3. **Where an energy dissipator is used, it should be sized to provide an average outlet velocity of less than 6 fps, unless rip rap is also used.  In the latter case, the average outlet velocity should not exceed 8 fps.**

4. **Where outlet velocities exceed 8 fps, the design should be based on the unique site conditions present.  Submerging the outlet or installing of a stilling basin approved by the City is required when excessive outlet velocities are expected.**

5. **Rip rap should be provided at all storm sewer outlets to drainage channels and natural streams.  Rip rap should be placed on a suitably graded filter material over geotextile fabric to ensure that soil particles do not migrate through the rip rap and reduce its stability.  Rip rap should be placed to a thickness at least 2.5 times the mean rock diameter to ensure it will not be undermined or rendered ineffective by displacement.  If rip rap is used to protect overland drainage routes, grouting may be recommended.  See Figures 5-2 and 5-3 for design recommendations.**

6. **Overland drainage routes where velocities exceed 8 fps should be reviewed and approved by the City.  Permanent turf reinforcement mats must be provided if velocities exceed 7 fps.**

Figure 5-2: Rip-rap design figure.

Figure 5-3: Rip-rap design figure.

Open channels are recommended where flows and small grade differences prohibit the economical construction of an underground conduit and in areas where an open channel-type drainage will enhance the aesthetic or wildlife qualities of an area. A minimum slope of 1.0 percent should be maintained in unlined open channels and overland drainage routes in developed areas whenever possible. Slopes of less than 1.0 percent are difficult to construct and maintain and can create problems with water pockets without an underdrain system. Side slopes should be a maximum of 4:1 (horizontal to vertical) with gentler slopes being very desirable.

Rock rip rap must be provided at all juncture points between two open channels and where storm sewer pipes discharge into a channel. The design velocity of an open channel should be sufficiently low to prevent bottom erosion. Rip rap or permanent turf reinforcement mats should be provided in areas where high velocities cannot be avoided. Periodically cleaning an open channel to ensures that the design capacity is maintained. Therefore, all channels must be designed to allow easy access for equipment including a 12-foot wide maintenance path with 15 percent maximum grade at storm sewer outfalls, road crossings and connections to other channels or streams.

Both storm drainage facilities and sanitary sewer lines are designed to take advantage of natural draws and usually follow a ravine, creek or gully. As more area develops in the City, the total runoff in natural drainage ways will increase; correspondingly, the water level will rise. In certain areas, water could enter the sanitary sewer system, causing capacity problems and added costs for stormwater treatment.

For this reason, sanitary sewer manholes that could be subject to temporary inundation should be equipped with water tight castings. Added precautions should be taken when constructing these manholes to prevent stormwater from entering. Sanitary manholes located near ponding areas should be raised above the 100-year high water level and the adjacent areas filled when access is required at all times. If access is not required, water tight castings should be installed. Future storm drainage construction should include provisions for improving the seal of nearby sanitary sewer manholes. All newly constructed sanitary manholes in the vicinity of ponding areas and open channels described in this report should be waterproof.

## 5.5 Stormwater Detention Basin Requirements

Incorporating ponding areas as recommended in the Rochester Surface Water Management Plan is important to maintain creek stability and natural corridors. Ponding areas provide the necessary storage required to retain high intensity stormwater runoff peaks and reduce the possibility of flooding down stream. The storage requirements established for each pond must be maintained to prevent property flooding. The discharge flow rates computed for each ponding area must also be maintained to insure the storage volume provided is used and downstream flows are not exceeded. The peak flows indicated in the plan for proposed basins occur at the high water level, usually under pressurized conditions.

The following list includes the major parameters that must be included into the final design of the quantity portion of stormwater facilities. Site specific details must be considered at the time of final design.

1. **Consult with City Staff and the SWMP for planned peak discharge rates at the proposed pond location in relation to the overall ultimate drainage system plan.**

2. **Model 100-year, 24 hour storm event to calculate the High Water Level (HWL) of the pond.**

3. **Model a multi-stage outlet for maximum peak discharge reduction for the one- and two-year events.**

4. **Check pond outlet capacity to insure 10-day snowmelt event does not exceed 100-year HWL.**

5. **Maintain a minimum of two feet above the 100-year HWL for the lowest opening elevations of structures adjacent to basins.**

6. **Provide an emergency overflow outlet a minimum of one foot below the lowest opening elevation of adjacent structures.**

7. **Limit the maximum side slopes leading to the normal water level to 4:1.**

8. **Provide a minimum aquatic bench of 10 feet at a 10:1 slope below the normal water level ( see Figure 5-4).**

9. **Provide a minimum maintenance bench of 10 feet at a 10:1 slope above the normal water level if side slopes adjacent to the basin are steeper than 5:1 ( see Figure 5-4).**

10. **Design erosion control or energy dissipators at pond inlets and the outfalls of basin outlet pipes or weirs.**

11. **Provide a clear approach and trash rack at the basin outlet.**

12. **Provide a 12-foot wide maintenance access at a maximum grade of 15 percent to the normal water level of all basins. Access must be provided to the basin outlet structure, all inlets to the basin, and to the first cell of a multi-cell basin.**

14. **Include other design parameters as required by regulatory agencies.**

15. **Basin design must include the method and schedule for stabilizing adjacent slopes and consideration of wetland plantings around the perimeter.**

**Figure 5-4 Insert Here**

# 6. Stormwater Quality

## 6.1 Background

The main purpose of the stormwater quality portion of the Surface Water Management Plan is to provide guidelines for protecting and improving the water quality of Rochester's lakes, streams and wetlands. This section of the report provides the recommended practices for implementing post construction best management practices as required by the NPDES Phase II rules. Post construction BMPs are intended to reduce the pollutant loads associated with urban land use.

Post development BMPs can be separated into two categories; prevention and treatment. Prevention focuses on reducing the amount of pollutants released into the environment by educating the public on such issues such as responsible lawn care practices and the proper storage and disposal of waste material. Prevention type BMPs are further discussed in Chapter 7.

Examples of treatment type BMPs include; vegetative swales, buffer areas, infiltration basins and detention ponds. Detertion ponds are the most common and effective BMP used for treatment of storm water runoff. Stormwater ponding areas are an essential part of reducing the amount of pollutants being transported downstream by providing locations where ponding will allow sediments and many pollutants to settle out and be effectively removed from stormwater runoff.

The Rochester Surface Water Management Plan uses a regional stormwater approach by locating stormwater facilities to serve 75- to 200-acre drainage areas. The regional approach provides more efficient maintenance requirements by centralizing pond areas in fewer locations. This approach also provides cost effective design, land acquisition and construction expenditures for development.

Map 1 shows the location of planned water quality treatment ponds. These locations are for planning purposes only. However, the preliminary locations were identified in areas which provide for the economical and cost effective construction of these facilities.

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## 6.2 Stormwater Management Basin Types

Stormwater basins are an essential part of a storm drainage system. These areas provide locations where ponding caused by restricted flow can be allowed, thereby minimizing flood damage and stream bank failure. The effective use of stormwater basins enables the installation of outflow sewers with reduced capacities. The design storm duration is effectively increased over the total time required to fill and empty the ponding reservoirs.

Equally as important is the use of basin areas to:

1. Improve water quality
2. Return stormwater to the groundwater table, and
3. Increase water amenities in developments for aesthetic, recreational and wildlife purposes.

Stormwater quality is improved by allowing nutrients and sediments carried by runoff to settle below the pond normal water level and allowing fringe vegetation to assimilate additional pollutants. Restricting outflow rates from pond areas promotes groundwater recharge by increasing the detention time and allowing the runoff to infiltrate. Amenity aspects are maximized by careful planning in the initial development of an area.

Stormwater facilities used in the Rochester Surface Water Management Plan can be divided into five types depending on their storage characteristics and water quality function. These basin types use differing number of cells and wet volumes to achieve their intended function for quantity and quality. All basin types can be used to varying degrees for rate control. Figure 6-1 illustrates a profile view of the basin types.

Figure 6-1 Basin Types

### 6.2.1 Rate Control Basins

This type of facility normally contains no water during dry weather. These basins are usually located in a naturally occurring depression and are produced by an embankment constructed across the drainage way. The controlled outlet of this type of basin is located to provide complete drainage of the basin as shown in Figure 6-1. Inlets discharging into the area are normally located at the upper end of the basin so that some overland flow exists from any storm condition. A shallow ditch-shaped passageway should be constructed into these ponds to confine overland flow from the inlets to the outlet points during storms of low intensity and during emptying periods. In cases where development and economics allow, a small diameter pipe could be placed below the basin bottom to allow low flows to be carried directly to the outlet. This would help eliminate nuisance flows and erosion of the basin bottom during an average small storm.

If it is desirable and economically feasible, a permanent wet pond can also be constructed in this type of basin. This can be done either by dredging out material below the present bottom of the basin or, in cases where hydraulics of the system allow it, the outlet can be raised to provide a desired depth of water in the basin. If a permanent pond is desired at a location shown on the enclosed Map-1, it can be incorporated into this system at the time of final design.

### 6.2.2 Sedimentation Basins

These basins consists of a one-cell pond with open water to a minimum mean depth of four feet as shown in Figure 6-1. Storage volume for discharge rate control is acquired by a differential in water levels. The outlet operates by gravity when the water elevation of the pond is above the normal water level. This type of pond allows larger suspended solids particles to settle below the normal water level and, thus, be removed from water draining down stream. The basin efficiency should remove sediment particles larger than approximately 5 to 10 microns. Maintenance access must be provided around the perimeter of this type of basin to remove sediment buildup over time.

### 6.2.3 Nutrient Removal Basins

This type of basin consists of a two cell pond as shown in Figure 6-1. The first cell consists of a sedimentation basin to remove large particles prior to discharging to the second cell. The second cell must be designed to maximize the detention time for nutrient removal and promote plug flow treatment to remove fine particles. This requires the pond design to maximize the distance between the intake and outlet structure for the pond. Special attention should be given in the design to provide access for maintenance work to the first cell and outlet structure of this type of basin. Total suspended soils removal should be greater than 90 percent. Total phosphorus removal should be greater than 65 percent.

Due to increased emphasis on water quality, nutrient removal basins should have outlets with the capability of preventing floating materials such as an oil spill from flowing from the pond. This would reduce potential contamination of downstream creeks and water bodies. As development occurs, it is highly recommended to provide this type of pond with an outlet structure similar to the one shown in Figure 6-2.

It is frequently desirable to create a pond with a more natural appearance, particularly along environmental corridors in the City. An example of a more naturally shaped nutrient removal basin is shown in Figure 6-3. Also included in this figure are guidelines for wetland and upland plantings in and around the pond. These plantings will improve the treatment efficiency of the pond and provide better aesthetics and wildlife habitat.

### 6.2.4 Vegetation Filter Basins

Basin areas identified as vegetation filter basins are intended to be designed as three-cell pond systems as shown in Figure 6-1. The first two cells should be similar to a nutrient removal basin. The third cell should consist of a shallow, highly vegetated wetland cell containing wetland species with high nutrient and pollutant uptake characteristics.

Submerged berms should be incorporated into the design to promote plug flow throughout the entire pond. The third cell should be terraced to provide a mean depth between 0 and 2.0 feet. The maximum water level fluctuation for the 10-year, 24-hour storm event should generally not exceed two feet to protect vegetation within the third cell.

### 6.2.5 Created or Restored Wetlands

This type of basin consists of created or restored wetland area intended to improve water quality. Stormwater detention is not a dominant design factor in this design. The variation in water level should be less than two feet for a 10-year, 24-hour storm event. These ponds are usually located where runoff from upstream drainage areas has been treated by nutrient removal ponds or consist of undeveloped or undisturbed areas. Wetland mitigation and banking credits may be available from wetlands created from this type of basin. The current rules of the Wetland Conservation Act, the Army Corps of Engineers and the Rochester Wetland Management Plan should be consulted during final design to determine the availability of wetland credits and the specific design requirements.

Figure 6-2 - Free flow skimmer with restricted outlet

Figure 6-3 - Typical nutrient removal basins design

## 6.3 Design Criteria for Water Quality

Wet detention basins are the most effective means of removing sediment and the pollutants associated with it such as trace metals and nutrients. The percent removal of these pollutants is based on the detention time that runoff is held in the basin. Settling column studies have shown that the majority of urban sediments, that can be removed, settle out within the first six to eight hours of detention. However, longer detention times are needed to remove fine sediments and establish ideal settling conditions. The results of this study on urban runoff are shown in Figure 6-4 (OWML 1983).

Figure 6-4 indicates that removal rates asymptotically approach their maximum level after 24 to 48 hours of detention time. Therefore, a pond that will retain all runoff from a tributary area for periods in excess of 48 hours will maximize the available water quality treatment properties provided by stormwater quality ponds.

Based on a review of the average precipitation data for the Rochester area, the City has selected the 1-year, 6-hour storm event as the criteria for sizing the water quality (permanent pool) volume for treatment ponds. For the Rochester area, this event is equal to 1.8 inches of rainfall. The volume is similar to the recommended water quality volume by the Pollution Control Agency. Figure 6-5 provides the runoff depth for the 1-year, 6-hour storm event based on the corresponding curve number of the tributary drainage area.

During Plan development, the City determined that newly constructed water quality treatment facilities should be capable of operating for a minimum of 20 years without a significant reduction in efficiency due to excessive sediment accumulation. Table 6-1 provides the recommended 20 year sediment accumulation rates based on land use. This volume must be added to the volume determined from Figure 6-5 to calculate the total minimum water quality volume for a given storm water basin.

**Table 6-1: Approximate 20-year Sediment Buildup Volume per Acre**

| LAND USE | 20 Year Sediment Vol. ( Cubic yards/ac ) |
|---|---|
| Low Density Residential | 9.8 |
| Medium Density Residential | 12.7 |
| High Density Residential | 15.5 |
| Commercial | 18.4 |
| Industrial | 16.4 |

Figure 6-4  Removal Efficiency

Figure 6-5  Runoff depth

Pond design characteristics are critical in achieving the maximum pollutant removal efficiency of a water quality treatment facility.  The following design standards should be followed whenever possible.

1. Pond design should maximize detention time by preventing short-circuiting.  This can be accomplished by maximizing the distance between the inflow pipes and the pond outlet. Basins should have an approximate length to width ratio of 3:1.

2. Basins should be separated into multiple cells to maximize treatment efficiency.  A sedimentation bay, or first cell, should be provided to remove and collect large sediment particles that constitute a majority of the sediment volume.  Maintenance costs are reduced by limiting sediment removal operations to this first cell.  Maintenance access must be provided to the first cell as a minimum.

3. A minimum ten foot aquatic bench at the normal water level of the pond must be provided with a 10:1 slope for one foot below the normal water level of the basin.  Measures should be taken to establish emergent vegetation along the bench to stabilize the soil and provide for additional nutrient assimilation.

4. Water quality treatment basins shall have a mean depth greater or equal to four feet.  The mean depth shall be determined by dividing the permanent pool volume by the surface area of the normal water level.  Pond maximum depths should not exceed 10 feet to prevent thermal stratification.

## 6.4 Water Quality Model

The computer program XP-SWMM was used to estimate the level of water quality treatment for the proposed stormwater treatment facilities shown on Map 1 and described in the Appendices. The computer program used in the water quality analysis calculated pollutant loadings to treatment ponds based on land use. The program uses a specific event mean pollutant concentration for each land use within a drainage area. The concentrations indicated in Table 6-2 are used as input for land use pollutant concentrations based on the National Urban Runoff Program (NURP) data contained in "Protecting Water Quality in Urban Areas" (MPCA 1989). Appendix A-3 provides the results of the water quality model.

**Table 6-2: Event Mean Concentrations (mg/L) for Land Use for the SWMP Model.**

| Pollutant | Low Density Residential | Medium Density Residential | Commercial / Industrial | Ag. / Crop Land | Park / Open Space |
|---|---|---|---|---|---|
| TSS | 140. | 101. | 90. | 216. | 10 |
| TP | 0.460 | 0.330 | 0.240 | 0.230 | 0.350 |
| TKN | 2.35 | 1.44 | 1.40 | 1.36 | 2.1 |
| PB | 0.180 | 0.190 | 0.130 | 0.054 | 0.005 |
| ZN | 0.180 | 0.190 | 0.330 | 0.230 | 0.012 |

Although pollutant concentrations may not vary greatly between land use, pollutant loadings are a function of both runoff volume and concentration. The volume of runoff is directly related to the amount of impervious surface from a particular land use. For example, if *Area A* has twice the runoff due to higher impervious land cover as *Area B* with the same pollutant concentration, *Area A* will have twice the pollutant loading. This illustrates the major difference in water quality between residential and commercial land uses.

# 7. NPDES Program

## 7.1 Background

In October 1999 the Environmental Protection Agency issued the Phase II regulations of the National Pollution Discharge Elimination System (NPDES). The Phase II regulations expand the existing phase I NPDES storm water program to address storm water discharges from small municipal separate storm sewer systems in areas with populations under 100,000 and for construction sites that disturb less than 5 acres. The Environmental Protection Agency believes that the phase II program will result in a significant reduction in pollutant discharges and an improvement in surface water quality.

The phase II rules require operators of municipal separate storm sewer systems to, at a minimum, develop, implement, and enforce a storm water management program designed to reduce the discharge of pollutants from storm sewer systems to the maximum extent practical, to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act. A storm water management program must include the following minimum control measures:

- Public education and outreach on storm water impacts
- Public Involvement/Participation
- Illicit discharge detection and elimination
- Construction site storm water runoff control
- Post construction storm water management in new development and redevelopment area
- Pollution prevention / good housekeeping for municipal operations

## 7.2 Preliminary Schedule for Phase II

The Minnesota Pollution Control Agency will be the permitting authority implementing the phase II program in Minnesota under the direction of the Environmental Protection Agency. The Pollution Control Agency has indicated the following preliminary schedule for the phase II program

1. December 2000 - Pollution Control Agency completes development of the phase II program and

issues a list of recommended best management practices. New guidelines for best management practices are currently being developed by the PCA.

2. March 2003 - Operators of municipal separate storm sewer systems must file a Notice of Intent including the following:
   - A list of best management practices to be implemented into a storm water management program
   - Measurable goals for implementation of a storm water management program

3. Operators of MS4s have five years to implement the program and come into full compliance with the NPDES phase II permit.

The PCA will review the City's Notice of Intent to verify that the best management practices and measurable goals are consistent with the requirement to reduce pollutants and protect water quality under the phase II program.

## 7.3 Control Measures

The following is a summary of the control measures that are required as part of a storm water management program. The summary below includes the description of how this SWMP addresses the minimum requirement or provides recommendations for the City to develop additional policies and procedures for developing a storm water management program under the Phase II requriement.

The PCA will be developing guidelines for all of the control measured listed below during the interim period of program development indicated above.

### 7.3.1 Public Education and Outreach on Storm Water Impacts

As part of the Phase II permit, the city is required to implement a pubic education program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of storm water discharges on water bodies and the steps to reduce storm water pollution. The purpose of the public education program focuses on informing individuals on the cause of storm water pollution and the steps that individuals can take to reduce or prevent storm water pollution. A majority of the current public education and outreach efforts within the City of Rochester are coordinated through the South Zumbro Watershed Partnership (SZWP). The main task of the SZWP is to provide educational materials and promote interaction with the public on the protection of water resources and the environment. The following is a partial list of the materials and programs related to public education through the South Zumbro Watershed Partnership.

- Educational Resources Library - A library of storm water management materials is available for public use. This material is located at the Olmsted County Human Services Building and can be accessed by contracting Tony Hill (SZWP) or Terry Lee (Olmsted County). The SZWP maintains a copy of the Water Education Resource Manual, which provides a summary of the more popular education materials and programs that are being implemented throughout the County.

- Lawn Care Brochures - The SZWP is implementing a public education program on lawn care practices. The SZWP is conducting soil sampling of lawns and distributing informational folders that provide recommended practices for the responsible use of fertilizers and pesticides.

- Annual Children's Water Festival - The SZWP conducts an annual festival each spring to educate local school students on water resources topics. Past festivals have had an attendance of over 1000 students.

- Volunteer Newsletter - The South Zumbro Watershed district publishes a quarterly newsletter for volunteers of the watershed partnership. The newsletter highlights the programs that are being implemented throughout the watershed.

The phase II rules encourage government units to combine efforts in filling the requirements of the permit. City Staff and the South Zumbro Watershed Partnership should work together in implementing a successful educational program. The City should focus on gaining more local media attention on water quality issues. The goal should be to have a minimum on one newspaper article and several local television news stories each year on such topics as the benefits of low phosphorus lawn fertilizer, waste oil / hazardous waste drop off sites, and volunteer sampling and clean-up efforts. The City should appoint a person to be responsible for promoting public education on water quality issues on the City's behalf.

### 7.3.2 Public Involvement / Participation

The phase II rules require that the City comply with applicable State and local public notice requirements when developing the Notice of Intent and storm water management program for the NPDES phase II permit. The EPA also recommends a public participation process with efforts to reach out and engage the public in the storm water management process.

The City of Rochester has been dedicated to public involvement throughout the development of the storm water management plan. A steering committee was formed at the onset for the planning process and has closely guided the development of the plan. The steering committee included citizens of Rochester, commercial and industrial business representatives, local developers, local engineering consultants, Rochester Community and Technical College representatives and local / state government representatives. Chapter 2 provides additional background on the Steering Committee and its actions.

Other public participation programs for storm water management are being implemented by the South Zumbro Watershed Partnership for the City of Rochester. Current programs that encourage public involvement and participation include the following:

- Volunteer Stream Sampling Program - The Benthic Macroinvertebrate Stream Sampling program is an annual program sponsored by the South Zumbro Watershed Partnership and the Mn Department of Natural Resources. The program involves high school student volunteers in collecting samples from area streams and performing lab analysis on the samples. The program has included John Marshal, Century, Mayo, and Dover-Eyota high school students. The program database is assembled and stored by Winona State University.

- Annual Volunteer River Clean-Up Program - The South Zumbro Watershed District sponsors annual river clean-up programs using high school students, citizen volunteers, and volunteers from other civic groups.

- Storm Drain Program - The SZWP sponsors the storm drain marking program. Volunteers are supplied with either stencils or glue-on markers that indicate no dumping in catch basins. Volunteers also distribute door hangers throughout the neighborhood where markers are being installed.

### 7.3.3 Illicit Discharge Detection and Elimination

Under the Phase II rules, operators of municipal separate storm sewer systems must implement and enforce a program to detect and eliminate illicit discharges from the storm sewer system. The program must include the following parts:

- The City must maintain the storm sewer base map to include the location of all storm sewer outfalls. The City currently has a storm sewer base map. This map should be updated annually based on record plans for completed projects each year.

- The City must effectively prohibit, through ordinance, or other regulatory mechanism, non-storm water discharges into the storm sewer system and implement appropriate enforcement procedures and actions. The City Attorney's office should review the existing City ordinances to determine if this item is adequately addressed. If not, the Pollution Control Agency will provide guidance in developing an ordinance to meet this requirement.

- The City must develop and implement a plan to detect and address non-storm water discharges to the storm sewer system. The plan should include procedures for locating priority areas likely to have illicit discharges, procedures for tracing the source of an illicit discharge, procedures for removing the source of the discharge, and procedures for program evaluation and assessment. The Pollution Control Agency will provide assistance and guidelines in developing the program when the formal permit application is issued to municipalities in 2002.

### 7.3.4 Construction Site Storm Water Runoff Control

The Phase II rules require operators of municipal separate storm sewer systems to develop, implement, and enforce a program to reduce pollutants in any storm water runoff for construction activities that result in a land disturbance of one or more acres. Construction activity on sites disturbing less than one acre must be included in the program if the construction activity is part of a larger common plan of development or sale that would disturb one acre or more.

The City will be required to develop a program to address the following items related to construction site storm water runoff control:

- An ordinance to require erosion and sediment controls, as well as sanctions to ensure compliance. Current City ordinance dose require grading permits to address the manner in which soil erosion and sediment will be minimized during construction. A sample storm water ordinance is included in Appendix A-7 for review. This ordinance provides an example of more detailed erosion control requirements. The PCA can provide additional guidance for ordinance revisions.

- Requirements for construction site operators to implement appropriate erosion and sediment control best management practices (BMPs). A list of recommended BMPs is provided in Chapter 8 of the SWMP.

- Requirements for construction site operators to control waste such as trash, litter, chemical and sanitary waste. These items should be incorporated into future storm water ordinance revisions.

- Procedures for site plan review which incorporate consideration of potential water quality impacts. A example of submittal requirements is included in the sample ordinance in Appendix A-7.

- Procedures for receipt and consideration of information submitted by the public. Public Works and Building Inspections Staff must develop procedures for addressing questions and reported violations concerning erosion control.

- Procedures for site inspection and enforcement of control measures. The City must develop standard procedures for erosion control plan reviews, field inspection, and enforcement.

### 7.3.5 Post-construction storm water management in new development and redevelopment

The City must develop, implement, and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the Municipal separate storm sewer system. The City's storm water program must ensure that controls are in place that would prevent or minimize water quality impacts. The following controls are required as part of the phase II rules:

- Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs). This SWMP provides the recommended guidelines for storm water quantity and quality management. Design guidelines are provided in this report. The Public Works department also has a design manual available, which summarized the recommended design standards for storm water management.

- Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects. The sample ordinance in Appendix A-7 provides an example of language to address post-construction runoff.

- Ensure adequate long-term operation and maintenance of BMPs. Chapter 11 provides recommended procedures for the operation and maintenance of the City's storm water drainage system.

### 7.3.6 Pollution Prevention / Good Housekeeping for Municipal Operations

As part of the Phase II rules, the City must develop and implement an operation and maintenance program that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations.

The City should form a storm water work group made up of City employees including staff from the street maintenance, engineering, and parks departments. The work group should focus on addressing the following tasks.

- Provide in-house training sessions for public works staff on methods to prevent and reduce storm water pollution from activities such as park and open space maintenance, fleet and building maintenance, and storm water system maintenance. Materials are available from the EPA and PCA for the above mentioned topics.

- Evaluate the City's street sweeping program and develop standard procedures for adding new development areas to the program, identification of problem areas where higher levels of material are collected, and procedures for the safe and stable disposal of material.

- Conduct a site evaluation to review procedures for salt and sand storage locations and snow disposal areas. Additional information and recommendations are provided in Chapter 11 of this report.

- Complete annual reviews of operations and maintenance procedures for storm drainage system components such as storm water pond outfalls and outlet control structures, annual inspections, sediment removal, and post construction erosion control.

# 8. Storm Water Management Financing

## 8.1 Background

One of the objectives of the SWMP was to identify methods of financing the total cost of Rochester's stormwater drainage system. The total cost of the system includes financing the maintenance of the existing system and construction of future improvements to the system. A Finance Advisory Committee (FAC) was formed by the Steering Committee to study the available financing alternatives for the drainage system.

The cost associated with Rochester's existing drainage system is currently financed from the City's general tax levy. System maintenance and replacement of older components are budgeted on an annual basis. Expanding the drainage system for future development is currently completed by individual developers. The design and construction of stormwater detention/water quality facilities and trunk storm sewers are completed on a individual basis with limited consideration for the effect of the overall drainage system. As previously discussed, this approach can eventually result in a high number of smaller pond facilities that are difficult to manage and more costly to maintain.

## 8.2 Cost Associated with the Drainage System

The goal of the Finance Advisory Committee was to study the total cost associated with the city's stormwater drainage system and to analyze feasible methods of funding. The various costs identified during this process were organized into three categories. These categories were then studied to identify equitable methods of financing. The following categories were identified as part of the analysis.

1. Infrastructure Improvements
2. Operations and Maintenance
3. System Replacement

### 8.2.1 Infrastructure Improvements

The infrastructure cost associated with new development focuses on the expansion of the drainage system to provide conveyance, rate control and water quality treatment as the system is expanded to serve additional areas. These costs include the construction of trunk storm sewer systems, regional stormwater quantity and quality basins and stream stabilization.

The committee discussed the regional stormwater approach and concluded that regional basins provide a cost-conscious approach to stormwater management by consolidating individual basins that would normally be constructed in each development, into central facilities within the watershed. This approach saves money by reducing maintenance costs, combining engineering design and construction costs and providing for more efficient basin design.

The Finance Advisory Committee (FAC) discussed two alternatives for financing the future regional improvements to the drainage system. These include a stormwater area charge based on the total improvement cost for each watershed, and a stormwater area charge based on a citywide ultimate cost estimate.

The FAC concluded that the entire community benefits from managed stormwater and preservation of water resources throughout the city. The flood control structures that were previously constructed were located based on optimal location and existing terrain to achieve rate reduction in a cost-efficient manner. Certain watersheds have, therefore, been provided greater flood control than other watersheds. After considering both options, the FAC recommended that a stormwater area charge based on the citywide cost of total improvements was the most logical form of funding. Section 8.3 provides a detailed description of how the area charge is calculated.

Drainage system improvements will be required in areas that are re-developed in the future. Improvements to the existing system may be needed to convey higher flows and remove higher pollutant loads that can be produced by redevelopment. One example may be if older commercial land is redeveloped with a higher percentage of impervious surface. Improvements would be needed for storm sewer structures and basins to maintain runoff rates, remove increased pollutant loads and provide additional capacity.

The FAC recommended that a redevelopment fee be collected that would be calculated based on the land use as discussed in Section 8.4. A credit could be given for the existing land use or the existing amount of impervious area. A landowner would then be responsible for only the change in stormwater runoff from that which exists prior to redevelopment.

During the development of the surface water management plan, areas outside of the 2045-year Urban Service Area were identified as optimal locations for stormwater basins that can provide significant rate reductions and water quality benefits at a lower cost due to existing land features. Most of these improvements require construction of a outlet control structure with minimal grading, in addition to purchasing the land. These areas were tabulated separately from the proposed facilities within the study area because development is not expected to occur in these areas until after the year 2045. Coordination between the City and Olmsted County will be essential in completing these projects.  The FAC recommended that suburban development that occurs outside of the Rochester city limits that drains to a stormwater facility identified in this report include the construction and land acquisition of that particular facility.  The possibility of Local, State and Federal grants should also be investigated to finance these projects.

### 8.2.2 Operations, Maintenance and Replacement

The FAC discussed the cost associated with operating and maintaining the existing drainage system.  The estimated annual budget for operations and maintenance over the next three years is approximately $700,000 (1997).  This amount will increase as the drainage system expands to serve future development.  The following items are included in the annual budget estimate:

- Manhole and storm sewer cleaning
- Street Sweeping - (5 times per year)
- Pond dredging of accumulated sediment
- Pond outlet inspection and cleaning program
- Energy dissipators and erosion repair (rip-rap, channel lining, etc.)
- Ditch and drainage channel repair of erosion or bank stability
- Back yard drainage correction projects

Maintaining the drainage system will require the eventual replacement of most system components.  Just as streets and other utilities are eventually replaced after years of service, several components of the drainage system will eventually need to be replaced.  This will include the replacing storm sewer catch basins, manholes, and storm sewer pipes.  The current annual replacement budget is approximately $200,000 (1997).  Similar to the cost of maintenance, annual replacement costs will increase as the drainage system is expanded.

## 8.3 Stormwater Utility

A stormwater drainage system must be maintained in good working order for it to function as anticipated. An annual investment in the operations and maintenance of the drainage system can prevent costly problems due to flooding and long-term water quality impacts to surface waters.

The Steering Committee discussed alternative methods of financing the operations, maintenance and replacement of the drainage system. The Steering Committee recommended that the City pursue the development of a stormwater utility to provide an equitable form of financing the system's existing and future up-keep. A stormwater utility is similar to other fees for services, such as water and sewer, which are provided to the City's businesses and residents. Many developing cities in Minnesota have elected to implement a stormwater utility with typical rates for low density residential in the range of $4 to $20 per year.

The fee is based on the cost of providing stormwater drainage for a particular land use. Land use that consists of higher levels of impervious surface require larger storm sewer pipes and larger stormwater quality and quantity ponds to be maintained for the system. Therefore, the utility rate for each land use is generally determined by multiplying the base low-density residential rate by a land use factor that is calculated based on the amount of impervious surface.

The Steering Committee also discussed how the funds are managed for financing all aspects of the drainage system. The FAC concluded that the most rational approach to stormwater management financing would be to create a stormwater management account that would have separate funds to finance: 1) Stormwater Improvements, 2) Operations and Maintenance, and 3) System Replacement. This would provide the city with a means of more accurately budgeting and tracking the annual cost of each aspect of the drainage system.

## 8.4 Financing Stormwater Improvements for New Development

In addition to identifying financing options for the total drainage system, the SWMP focused on developing the method for financing the construction cost of the proposed regional facilities found in this plan. A major portion of the effort in developing the SWMP was in the preliminary layout of the trunk storm sewers and stormwater ponds. A summary of the construction cost estimates for all of the proposed trunk storm sewer pipe and the stormwater basins are presented in Appendix A-4 and Appendix A-6, respectively. The cost summaries include construction of the recommended facilities, along with any associated appurtenances. Engineering, capitalized interest, and administration costs plus a contingency factor are included in the costs.

Cost estimates presented in this report are based on 1997 construction costs and can be related to the March 1997 ENR Construction Cost Index of 5759. Future changes in this index are expected to fairly accurately reflect cost changes in the proposed facilities. During interim periods between full evaluation of projected costs, capital recovery procedures can be related to this index.

For the purpose of estimating costs, the stormwater drainage system was considered to include all of the proposed facilities shown on Map 2. Generally, trunk storm sewers include pipes 30 inches in diameter or greater. Also, all storm sewers that serve as detention pond outlets are considered trunk facilities.

For the proposed stormwater ponds, both quantity (flood attenuation) ponds and water quality ponds are considered part of the stormwater drainage system. Excavation, outlet structures, and other costs associated with these ponds are included in the cost estimates. This SWMP includes a flat rate cost for stream restoration. A major portion of the City drains to the main tributaries through natural creeks and streams. As the City develops, many of these streams will require some stabilization or conveyance improvements. A flat rate of $30 / linear foot was assumed for stream restoration.

Currently, individual developers are required to provide the design and construction of stormwater detention/water quality facilities and trunk storm sewers. If a development happens to be located at the bottom of a watershed, a developer is currently responsible for constructing storm sewer to convey all flows through the development.

The SWMP Steering Committee recommends that the expansion and improvements to the City's future drainage system be financed through a storm sewer area charge (SSAC). In exchange for the area charge contribution, the City would help design and construct trunk storm sewers and stormwater ponding areas under the recommended area charge finance system. Regional pond facilities would be constructed under the City's direction to serve drainage areas of approximately 75 to 200 acres. Trunk storm sewers would be financed and constructed to serve upstream portions of the watershed under fully developed conditions. Individual developers would be responsible for the cost of conveying local drainage through the trunk storm sewers.

## 8.5 Land Use Factors

Land use rates are calculated based on the specific contribution to the total cost of the system for trunk storm sewers, water detention facilities and water quality facilities. Once the total cost of the system was established for these three factors, a percent contribution for the need for these facilities was calculated based on land use.

For example, high density residential areas require larger storm sewer pipes per acre as compared to low density residential areas due to a higher percentage of impervious surface. The fraction (1.73) which accounts for this was determined by the rational formula using time of concentration, runoff coefficients and rain depths. In addition, trunk storm sewer costs represent 52 percent of the cost of the total future system improvements. The composite land use factors indicated in Table 8-1 are based on both the contributing factor for each land use and the percentage that each facility represents to the total system cost (e.g., 55 percent of composite land use factor for high density residential is 1.73).

Appendix A-4 tabulates the total estimated trunk storm sewer cost for the development of the drainage system to the 2045 Urban Service Area as shown on Map-1. Appendix A-5 tabulates the total estimated cost of the ponding facilities for water quality and quantity as proposed on Map-1. These costs contribute to the total cost of the system as follows.

- Trunk Storm Sewer 52 percent
- Water Quantity 20 percent
- Water Quality 28 percent

The land use factor for commercial / industrial areas is calculated based on the percentage of impervious surface that is proposed for a particular site. The land use factors for commercial/industrial given in Table 8-1 are given for illustrative purposes. The actual land use factor is determined by first calculating the percentage of impervious surface for a site and then using the graph on Figure 8-1 to determine the land use factor. This method was recommended by the Steering Committee as an equitable solution to the possible wide variation in the percentage of impervious surface for various commercial /industrial sites.

Table 8-1

## Table 8-1: Parameters For Composite Land Use Factor

| Land Use | Area Percent Impervious | Composite Curve Number | 10-yr storm Runoff Coefficient | Time of Concentration (min) | 10 Year Rain Depth (in) | 1.8 in -6hr Runoff depth (in) | Pollutant Load Factor | 6.2 in -24 hr Runoff depth (in) | Trunk Sewer Factor **52%** | Water Quality Factor **28%** | Water Quantity Factor **20%** | **Composite Land Use Factor** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Low Density Residential** | 25 | 70 | 0.35 | 38 | 3.0 | 0.28 | 1.0 | 2.96 | 1.00 | 1.00 | 1.00 | **1.0** |
| **Med. Density Residential** | 37 | 75 | 0.43 | 33 | 3.2 | 0.42 | 1.2 | 3.45 | 1.32 | 1.80 | 1.17 | **1.4** |
| **High Density Residential** | 51 | 80 | 0.53 | 29 | 3.5 | 0.59 | 1.3 | 3.96 | 1.73 | 2.74 | 1.34 | **1.9** |
| **Com. / Indust.** | | | | | | | | | | | | |
| Low Imperv. ( < 55% ) | 50 | 80 | 0.53 | 29 | 3.5 | 0.59 | 1.3 | 3.96 | 1.73 | 2.74 | 1.34 | **1.9** |
| Med. Imperv. ( 55 - 70% ) | 65 | 85 | 0.63 | 24 | 3.9 | 0.80 | 1.5 | 4.49 | 2.32 | 4.29 | 1.52 | **2.7** |
| High Imperv. ( > 70% ) | 85 | 92 | 0.79 | 19 | 4.3 | 1.17 | 1.9 | 5.27 | 3.21 | 7.94 | 1.78 | **4.3** |
| **Suburban** | 6 | 63 | 0.23 | 48 | 2.5 | 0.14 | 0.7 | 2.19 | 0.54 | 0.35 | 0.74 | **0.5** |

**Note:**

Percent Impervious for land use taken from City of Rochester Land Data

Curve Number calculated using CN = 98 for impervious surface and CN = 61 for pervious surface

Time of Concentration calculated using SCS Lag Method for a 40 acre, square watershed

Trunk Storm Sewer Factor Calculated using Runoff Coefficient * 10 year intensity rainfall depth

Composite Land Use Factor Calculated based on total trunk cost (52%) , water quality cost (28%) and water quantity cost (20%)

Pollutent load factor calculated using MPCA annual load equation

## 8.6 Recommended Area Charge Rate

Table 8-2 indicates how the land use factors are used to calculate the area rate for low density residential development. This table uses the total developable land that is estimated to develop for each land use within the SWMP study area to the year 2045. Each composite land use factor is multiplied by the total developable land zoned for that land use to calculate the total equivalent low density residential area.

The equivalent low density residential acres are then summed for all land uses, and the total cost of the system is divided by this total area to arrive at a cost per acre of low density residential for the ultimate 2045 Urban Service Area drainage system. **Once the low density residential rate has been established, other land use rates are the product of the low density residential rate and the corresponding land use factor.**

The total area of developable land for each land use was taken from the City of Rochester Sanitary Sewer Master Plan. This plan assumed that 48 percent of the land would develop within the same study area as the SWMP by the year 2045. The total drainage system costs shown on Table 8-2 have also been scaled by 48 percent to reflect the amount of proposed stormwater facilities that will be constructed within this time frame.

The land use factors for commercial and industrial areas used in Table 8-2 were calculated from Figure 8-1 using percentage impervious data for existing development provided the City of Rochester. This was done based on the assumption that future commercial / industrial development will resemble similar impervious characteristics as existing development of this type in Rochester. Rates for commercial, industrial, and high density residential areas are significantly higher than for low density residential areas. The higher rates are justified because these areas typically have a larger percentage of roofed and paved areas that increase the amount of runoff. The velocity of runoff on impervious surfaces is also greater, which results in lower times of concentration, higher peak runoff rates, and larger required storm sewer pipes and detention facilities. In addition, higher pollutant loads are generated from sites with greater impervious surfaces. These increased loads require larger water quality treatment volumes to preserve the quality of down stream waterbodies.

Figure 8-1 Land Use Factor

Figure 8-2 Tables

# Table 8-2: Area Charge Rates for Future Drainage System

| Land Use | Development (1) Area (Acres) | Land Use Factor | Product | Area Charge ($ / Acre) |
|---|---|---|---|---|
| Low Density Residential | 19,704 | 1.0 | 19,704 | $1,852 |
| Medium Density Residential | 441 | 1.4 | 617 | $2,593 |
| High Density Residential | 6 | 1.9 | 10.8 | $3,520 |
| Commercial (2) | 1,446 | 3.4 | 4,916 | $6,298 |
| Industrial (2) | 1,749 | 2.6 | 4,547 | $4,816 |
| | | TOTAL EQUIV. AREA = | 29,795 Acres | |

| | Cost of all Drainage System Improvements | Cost of Drainage System (3) Improvements to the year 2045 |
|---|---|---|
| Trunk Sewer Cost: | $28,181,544 | $13,527,141 |
| Pond Construction: | $22,705,431 | $10,898,607 |
| Stream Restoration | $4,305,000 | $2,066,400 |
| TOTAL = | $55,191,975 | $26,492,148 |

(1) Area data from Table III-4 of City of Rochester Comprehensive Plan
(2) Land Use factor from Fig. 9-1 using City of Rochester land use data for impervious surface coverage of ezisting development
(3) Assumes 48 percent of 2045 urban service area develops by year 2045 (taken from Rochester's Sanitary Sewer Master Plan).

## 8.7 Capital Improvement Program

Table 8-3 provides a list of projected storm water improvements within the 2045 urban service area. These improvements were identified based on projected development through the years 2000, 2005, 2010, and 2015. This table should be reviewed annually and adjusted based on actual development patterns.

Table 8-3  CIP

## Table 8-3: Storm Water Capital Improvement Plan

| 2000 CIP | | 2005 CIP | | 2010 CIP | | 2015 CIP | |
|---|---|---|---|---|---|---|---|
| Basin Improvement | Estimated Cost | Basin Improvement | Estimated Cost | Basin Improvement | Estimated Cost | Basin Improvement | Estimated Cost |
| **Kings Run Watershed District** | | | | | | | |
| kr-p2.2a | $360,100 | kr-p1.6 | $72,400 | kr-p1.10 | $54,600 | kr-p1.8c | $374,800 |
| kr-p2.3 | $125,900 | kr-p1.7a | $145,600 | kr-p1.18a | $68,400 | kr-p2.13c | $114,400 |
| kr-p3.1 | $226,700 | kr-p2.8b | $95,200 | kr-p1.18b | $60,600 | kr-p2.8a | $96,500 |
| | | kr-p2.9b | $80,500 | | | kr-p2.9a | $68,400 |
| **Cascade Creek Watershed District** | | | | | | | |
| cc-p2.10a | $65,500 | cc-p2.10c | $124,800 | cc-p4.2b | $34,600 | cc-p1.5b | $99,000 |
| | | cc-p4.2d | $43,600 | cc-p4.2a | $15,000 | cc-p2.7 | $290,100 |
| | | cc-p4.3 | $48,100 | cc-p4.2c | $46,800 | | |
| | | cc-p3.7 | $336,700 | | | | |
| **Zumbro River Watershed District** | | | | | | | |
| zr-p1.8b | $74,000 | zr-p4.3c | $56,800 | zr-p2.8 | $111,300 | zr-p2.1a | $95,300 |
| | | zr-p2.7 | $39,200 | zr-p2.1b | $128,400 | zr-p1.6 | $85,800 |
| | | zr-p4.5b | $41,300 | zr-p2.5a | $75,200 | zr-p1.7b | $116,300 |
| | | | | zr-p2.5b | $73,900 | zr-p4.6 | $164,700 |
| | | | | zr-p2.5c | $102,500 | | |
| **Willow Creek Watershed District** | | | | | | | |
| wc-p6.13b | $300,600 | wc-p6.13a | $152,000 | wc-p6.1 | $116,600 | wc-p6.8 | $59,300 |
| | | wc-p6.3 | $221,200 | wc-p6.2 | $121,000 | wc-p6.9 | $65,400 |
| | | wc-p6.4 | $180,200 | wc-p6.10 | $340,000 | | |
| | | wc-p6.5 | $296,100 | | | | |
| **Bear Creek Watershed District** | | | | | | | |
| | | bc-p2.16a | $65,200 | bc-p1.24 | $124,800 | bc-p2.15 | $83,400 |
| | | bc-p1.25 | $94,100 | bc-p1.23 | $96,200 | bc-p1.21 | $260,600 |
| | | | | | | bc-p2.12 | $190,200 |
| **Silver Creek Watershed District** | | | | | | | |
| | | sc-p1.12a1 | $88,200 | sc-p1.12a2 | $81,900 | sc-p1.12b | $67,200 |
| | | | | | | sc-p1.11 | $191,500 |

## Table 8-3: Storm Water Capital Improvement Plan

| | 2000 CIP | | 2005 CIP | | 2010 CIP | | 2015 CIP |
|---|---|---|---|---|---|---|---|
| Basin Improvement | Estimated Cost | Basin Improvement | Estimated Cost | Basin Improvement | Estimated Cost | Basin Improvement | Estimated Cost |
| **Hadley Valley Watershed District** | | | | | | | |
| | | | | hv-p1.5 | $259,900 | hv-p1.8a | $58,800 |
| | | | | hv-p1.11 | $160,300 | hv-p1.8b | $105,900 |
| | | | | hv-p1.13 | $99,300 | hv-p1.9 | $201,800 |
| **Mayo Run Watershed District** | | | | | | | |
| | | cp-10 | $191,900 | ep-14 | $38,700 | ep-15 | $29,900 |
| | | ep-11 | $62,100 | ep-12 | $119,700 | ep-10 | $32,000 |
| **Totals** | $1,152,800 | | $2,435,200 | | $2,329,700 | | $2,851,300 |

Estimated construction costs are based the March 1997 ENR Costruction Cost Index of 5759
Basins are identified based on predicted development areas within the City's 2045 urban service area.
List should be reviewed annually and revised based on actual development areas

# 9. Erosion Control

The City of Rochester recognizes that it is essential to promote, preserve and enhance the quality of the city's water resources, and to protect those resources from the adverse effects of land use. To protect water quality in the City, erosion control measures are essential to limit the loading of sediment, phosphorus and other pollutants, and to minimize the need for future restoration programs.

Steps important to limiting the impacts from land use include the use of Best Management Practices for construction, conservation practices, and agricultural management to reduce the degradation of downstream water resources.

## 9.1 Best Management Practices for Construction

Implementing of erosion control is most important during the construction phase of development when erosion rates can be 10 to 100 times the rate of undisturbed areas. In areas of the City where extensive development is taking place, stormwater discharging to streams and wetlands frequently contains substantial quantities of solids and other pollutants. Even with extensive erosion control practices, sediment and airborne particulates enter the city's surface waters.

Table 9-1 indicates the standard stormwater Best Management Practices that must be considered when preparing all development grading plans submitted to the City for review. Grading plans should indicate the location of the proposed BMPs and provide a detail plate for the design and installation of the practice when applicable. Information indicating when the BMP is to be installed or completed must also be placed on the grading plan to avoid disagreement between contractors, inspectors and City Staff. In addition to the BMP listed in Table 9-1, City Staff may require additional practices based on the specific conditions of a particular grading site. The MPCA's Urban BMP Handbook provides information on many more Best Management Practices that are available.

**Table 9-1: Construction BMPs**

| **Practice** | **Intended Result** |
|---|---|
| Temporary Sediment Basins | Collect and contain sediments on-site |
| Seeding Requirement / Schedule | Stabilize soils soon after grading completion |
| Storm Sewer Inlet Protection | Prevent sediment for entering storm sewer |
| Filter Fabric Fence Placement | Limit sediment in overland flow |
| Fit Development to Existing Terrain | Limit changes in grade and drainage |
| Limit Area of Disturbance | Reduce the amount of exposed soils |
| Phasing of Earth Work | Limit amount of soil exposed at one time |
| Stabilized Vehicle Exit | Reduce amount of mud tracking onto streets |

### 9.1.1 Temporary Sediment Ponds

Since runoff from many areas of the City will enter natural drainage swales or channels prior to arriving at a regional stormwater facility, development projects must provide temporary settling ponds in low areas of the site. These ponds must intercept sediment-laden stormwater from the property and prevent solids from entering the trunk storm sewer system and downstream water bodies and wetlands. **Temporary ponding during the mass grading phase of development should retain a minimum of 1.0 inches of runoff (wet volume) from the entire grading area**. Temporary ponding should be provided with emergency overflows to ensure that serious property damage does not occur during high intensity storms while the ponds are in use.

After topsoil placement, seeding and mulching are completed on the site, the pond can be reduced so that it retains only 0.5 inches of runoff. After 75 percent of the site has been developed, the ponding requirements can be further reduced to the management criteria outlined in this SWMP. Temporary sediment ponds must be constructed prior to mass grading of the site.

In cases where other erosion control practices are not maintained on a development site, temporary sediment ponds can be completely filled with sediment that would have otherwise been transported downstream. Temporary ponds will require periodic inspection and may need to be dredged to maintain the wet volume. Water quality problems can be significantly reduced by limiting the area under mass stripping and excavation at any given time.

If the outlet for a sediment basin is located below the normal water surface, these basins can also serve to confine floating solids that may otherwise enter downstream water bodies. Periodically skimming the basin to remove floating solids should be completed once or twice a year. If a major spill of a hazardous product such as fuel oil occurs, it would be retained within the basin and provide a point of easy access for prompt cleanup.

For developments that discharge directly to regional water quality facilities, temporary sediment ponding may be replaced by dredging sediment from the first cell of the pond after grading is completed. In cases where regional basins are being constructed simultaneously with active development, temporary sediment pond requirements may be substituted with the over excavation of the regional facility. These exceptions should be reviewed and approved by the City at the time of development.

### 9.1.2 Other BMPs

Even with the best and most expensive solids removal system, of pond and lake contamination will occur unless careful attention is given during the development phase and continued use of the land. Developers must use best management practices to minimize erosion during home construction in addition to the mass grading phase. Property owners must use care when developing their yards and sodding bare areas. Debris is frequently raked from lawn areas before and after sodding and left in the street gutters which, if not cleaned up, will be washed into the storm sewer, eventually reaching ponding areas.

Seeding and mulching is the most effective method of controlling erosion at the point of inception. Establishing turf and disk anchoring of mulch stabilizes the soil to help prevent erosion. Disturbed areas should be seeded as soon as grading is completed or if disturbed areas will be left for long periods of time. The Minnesota Department of Transportation Specification Book provides a detailed description of seed mixtures and placement guidelines.

Temporary rock construction entrances provide an area where mud from vehicle tires can be removed. This prevents mud from being tracked onto local streets where it can enter the storm sewer system and be transported to downstream water bodies. The majority of soil tracked onto streets occurs during the construction phase of development. Once the foundation or basement is constructed and backfilled, a gravel base should be placed in the driveway area to provide a stable access to the site.

After development is complete, streets must be kept clean by conscientious efforts from citizens to avoid littering or poor housekeeping practices, and by the City with frequent street sweeping to remove sand, dirt, and litter before it washes into the storm sewer system. Chemicals such as sodium chloride must be minimized in ice control programs on streets and highways. Citizens must also make judicious use of fertilizers, especially those using phosphorus and other chemicals that wash into the ponds, streams and rivers and cause degrade the water quality.

It is important that an inspection program and enforcement procedures be developed for erosion control on construction sites. The Minnesota Pollution Control Agency reviews and enforces erosion control for construction sites disturbing more than five acres through the NPDES program. However, a limited number of MPCA staff are responsible for the entire state and are not likely to field inspect a particular site unless a violation is reported. Local water resources are best protected through regular site erosion control inspections.

The City requires that grading permit applications address the manner in which soil erosion and sedimentation will be minimized during site development. Conformance with erosion control plans should be field checked during the early phases of mass grading and periodically until turf has been established on the site.

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## 9.2 Conservation Practices

Several conservation practices are essential in reducing the rate of siltation and surface water runoff from watersheds upstream of major reservoirs, lakes and streams. Conservation practices can significantly preserve water quality downstream. The following list highlights some of the more common conservation practices.

1. Implementation of regional stormwater basin approach - Regional stormwater facilities can reduce discharge rates for large drainage areas when properly designed and located in a watershed.

2. Buffer Areas - The establishment of buffer areas along existing and future drainage ways and streams provide filtration of sediments and pollutants in stormwater runoff and stabilize stream banks against erosion and stream meandering.

3. Top Soil - A minimum of six inches of top soil should be placed over disturbed areas to help establish vegetative cover for soil stabilization.

4. Preservation of Existing Wetlands - Existing wetlands provide natural water quality ponding for stormwater runoff. Wetland impacts should be mitigated to water quality functions.

5. Location of Development - Areas with existing steep slopes or areas of highly erodible soils should be preserved to the greatest extent possible. These areas should be identified for protection.

6. Sedimentation Ponds - Areas with moderate to highly erodible soils may require permanent on-site sedimentation ponds prior to discharging runoff to downstream regional stormwater facilities. Proposed development within areas containing soil units listed in Table 3-1, Highly Erosive Soils, shall include permanent BMPs to minimize chronic erosion problems. Additional conservation practices may be required at the discretion of City Staff.

7. Stream Banks - An on-going program should be developed to field identify stream bank stabilization problem areas based on information collected on the geology of the stream bed, soil conditions and anticipated land use. The Olmsted Soil and Water Conservation District can provide assistance in this area and may have funds available to complete stream bank stability projects.

## 9.3 Agricultural Practices

Agricultural non-point source pollution can significantly affect the quality of streams, wetlands and reservoirs. The upper reaches of all watersheds in the Rochester area are currently under significant agricultural use. Land management, crop arrangement and tillage practices can reduce the amount of erosion and pollutants from being transported downstream. Most practices are effective in reducing non-point source pollutants and are easy to implement in the field.

Figure 9-1 indicates 30 types of conservation and management practices that can be implemented to provide protection to surface and groundwater and to provide habitat for wildlife. The following is a summary of suggested practices from a publication entitled “Conservation Choices” from the US Department of Agriculture:

Figure 9-1 Agricultural Management Practices (COLOR)

1. Woodland management can provide ground cover and liter for soil stabilization. Existing and newly planted trees can be thinned and harvested to maintain desired production, add income and provide wildlife habitat.

2. Planned grazing by setting a pre-arranged schedule of livestock rotation can maximize production while reducing sediment and nutrient runoff. Moving livestock between fenced areas can increase forage quality and production while evenly distributing manure nutrient resources.

3. Manure storage structures that collect and contain manure can prevent high levels of nutrient runoff such as phosphorus. These structures can contain manure from feedlots on-site for field applications when conditions are optimal.

4. Farm ponds created by a dam or pit can collect and treat runoff from a farmstead. These ponds provide water for livestock and wildlife. Sediment and pollutants are removed from runoff by settling, similar to a constructed water quality pond.

5. Wildlife upland habitat areas that are maintained or planted with trees and other vegetation provide food and cover that can attract wildlife to an area. These areas also filter runoff and increase infiltration while reducing erosion on a site.

6. Wildlife food plots, consisting of standing crops of unharvested grain and corn, provide wildlife with food that may otherwise not be accessible after heavy snows or ice.

7. Filter strips of grass or trees along the fringe of streams or drainage ways provide filtration and removal of contaminants before entering the drainage system. Filter strips also provide stream bank stability by preventing land disturbances immediately adjacent to these water ways.

8. Grade control structures built across steep drainage ways can prevent gully erosion and reduce flow velocities by dropping water from one stabilized grade to another. These structures prevent overfall gullies from advancing up a slope.

9. Critical areas that experience excessive erosion can be planted with grasses or other vegetation to slow water flows and prevent rain drop splash, which causes erosion.

10. Contour strip cropping by alternating equal widths of corn or soybeans with strips of oats, grass or legumes can significantly reduce soil erosion by slowing runoff and trapping sediment.

11. Diversion embankments can direct runoff away from areas such as bottom lands and feed lots.

12. Grassed waterways established along natural drainage patterns prevents gullies and filters runoff.

13. Contour buffer strips placed across a field can trap sediments and nutrients similar to stip cropping.

14. Contour farming by placing row patterns nearly level around a hill can reduce soil erosion by as much as 50 percent from up-and-down hill farming.

15. Field borders located in place of end rows that would normally be planted up-and-down can reduce erosion and protect steep field edges.

16. Well protection involving the management and reduction of chemicals used near a farmstead can reduce the risk of contaminating water sources.

17. Windbreaks consisting of rows of trees and shrubs can protect areas from wind erosion and reduce energy costs for heating.

18. Pasture planting in low-producing areas and steep, eroding cropland can reduce soil loss to lower areas.

19. Stream protection by fencing off stream buffer zones can reduce livestock from trampling banks, destroying vegetation and stirring up sediments.

20. Manure testing to determine nutrient content promotes proper nutrient application to fields.

21. Tree planting to establish trees in areas adapted to woodlands protects soil from rill and sheet erosion.

22. Crop residue management such as no-till, mulch till and ridge till shields soil particles from rain and wind until plants can produce a protective canopy.

23. Wetland enhancement to manage water levels provides natural filtration of nutrients, chemicals and sediment from runoff.

24. Sequential crop can reduce fertilizer need by cycling nitrogen replacing crops and pesticide needs by breaking the cycle of weeds and insects.

25. Nutrient management such as soil testing can reduce excessive fertilizing that can affect downstream water quality

26. Wetland creation similar to wetland enhancement provides for natural water quality treatment and wildlife habitat.

27. Pest management such as tailored pest management systems can reduce crop and environmental damage due to excessive pesticide use.

28. Water rate control basins created by low earthen dams can reduce flooding and erosion due to high runoff rates.

29. Terrace construction can lower field grades to prevent erosion and guide excess water off fields.

30. Cover crops temporarily placed on fields can add organic matter to the soil, trap nutrients and reduce weed competition.

# 10. Groundwater

The water used for domestic consumption for the City of Rochester comes from groundwater. Groundwater originates as precipitation that infiltrates into the soil and then moves into geologic reservoirs called aquifers. Protecting aquifers from pollution is essential to preserving the quality of domestic water for the city. Surface water infiltrated into the ground and reaching aquifers can carry a variety of contaminants ranging from nutrients to hazardous materials. The goal of the surface water management plan is to identify areas that are sensitive or have a high potential for polluting aquifers and areas directly contributing to municipal wells.

The evaluation and management of development over critical groundwater areas must consider the site location and potential for discharging pollutants to the groundwater. The following table details the critical locations and land use issues that must be reviewed to assess the possible effects that a particular development may have on groundwater. City staff should review proposed land uses on an individual basis. The City may require special provisions to protect groundwater from contamination.

**Table 10-1: Groundwater Issues for Land Use**

| Critical Groundwater Locations | Land Use Issues |
|---|---|
| Highly Sensitive Groundwater Areas | Potential hazardous materials stored/produced on-site |
| Well Head Protection Areas | Type of containment and storage methods |
| Groundwater Recharge Areas | Potential impact to groundwater for the site |
| Protection Areas Identified by Agencies | Implementation of a site spill response program |
| | Site inspection requirements and schedules |
| | Method of cleanup or remediation required for a spill |
| | Time required to remediate a spill or contamination |
| | History of contamination or spills for the Land Use |

## 10.1 Groundwater Sensitivity

The sensitivity of groundwater to surface land use can be measured by the length of time that it takes rain water to infiltrate the ground and reach the underlying aquifers. Areas where rain water can quickly carry pollutants to aquifers are considered very sensitive. This travel time is influenced by the geological materials and thicknesses within an area.

The Minnesota Geological Survey has mapped areas within Rochester based on the geologic sensitivity as shown in Figure 10-1. An estimate of sensitivity was based on the ability of the existing geologic materials to retard the downward movement of dissolved or liquid contaminants into the water table.

The geological considerations used in the creation of Figure 10-1 can be grouped into two categories.

1. Permeability / Karst Geology - the permeability of the material between the ground surface and the water table effects the travel time for rain water to enter an aquifer. The overburden and bedrock materials can vary significantly in permeability rates. Sands vs. clay type soils and confining bedrock were part of this evaluation. Olmsted County contains Karst geology, which is defined as areas where mildly acidic groundwater slowly dissolves carbonate bedrock, producing karsts. These karsts can form underground conduits, which can quickly transport surface water to aquifers.

2. Thickness of Geologic Material - The thickness of the geologic material that separates the surface from critical underlying aquifers can effect the sensitivity of an area. Thick layers of low permeable material have a greater likelihood of retarding the movement of pollutants to the water table.

Figure 10-1 indicates the level of geologic protection to the local groundwater for the Rochester area. This map does not indicate where groundwater is contaminated. Although no field studies were conducted in constructing Figure 10-1, locations were checked using county data on nitrate-nitrogen. Nitrate levels in groundwater can be used to indicate the possible presence of other contaminants.

Groundwater Sens. Figure 10-1

## 10.2 Groundwater Recharge

The US Geological Survey conducted a study of the Rochester area to account for groundwater flow and storage in the Rochester-Zumbro groundwater watershed. This study identified and calculated the rates of groundwater recharge in five hydrogeologic zones. A majority of the recharge (55 percent) was found to occur along the edge of the Decorah confining unit (Delin 1991). This unit consists of a sequence of rock formations that separate upper aquifers from the underlying St Peter-Prairie Du Chien-Jordan aquifer, which supplies groundwater to Rochester's municipal wells.

The USGS computer model found that groundwater recharge accounts for 91 percent of inflows to the St Peter-Prairie Du Chien-Jordan aquifer while leakage from streams accounts for about 9 percent of inflow to the aquifer (CWP 1994). Figure 10-2 indicates the areas contributing a major portion of the recharge to the St. Peter-Prairie Du Chien-Jordan aquifer. This figure indicates that the edge of the DeCorah - Platteville - Glenwood confining unit provides the highest rate of groundwater recharge. The approximate location of this recharge zone is indicated by light shading of Map 3 at the end of this report.

## 10.3 Wellhead Protection

Areas that directly influence the groundwater used for domestic consumption have been termed wellhead protection areas. These areas are determined through computer groundwater models using geologic, pumping rate and groundwater flow information. Modeling was conducted for Rochester's municipal wells through the Clean Water Partnership program (CWP). The Rochester Public Utilities Department purchased the software Modflow and Modpath to conduct the modeling.

The delineation of wellhead protection areas were determined based on time of travel. The thresholds chosen for calculations were the 5, 10, 20 and 50-year travel times. From the calculations, wellhead capture zones were plotted for municipal wells. Well #16 was not modeled because it draws water from an aquifer that was not part of the study and from the airport well, which produced accuracy problems due to grid spacing requirements. The results of the well capture zones calculated for this study are found in the report entitled *Olmsted County Groundwater and Wellhead Protection Project, 1994.* Figures delineating the well capture zones are found on pages 193-195 of this document (CWP 1994).

Figure 10-2 infiltration areas

## 10.4 Infiltration

The increase in impervious surface area associated with development increases the rate of runoff by decreasing the time of concentration, and the volume of runoff. Stormwater ponds can control runoff rates through temporary storage. However, the increase in runoff volume must still be discharged downstream. As drainage systems become more complex, the increase in runoff volume becomes a critical factor in downstream flood control. Although it is very important that urban runoff infiltration is limited in groundwater sensitive areas, infiltration can be used in other areas to recharge ground water levels and reduce the amount of runoff volume associated with development.

There are several practices that can be used in areas that are not within wellhead protection areas or in areas identified as highly sensitive to groundwater contamination. These practices include the use of grass swales, infiltration trenches and infiltration ponds.

Infiltration ponds and trenches operate much like an on-site waste water treatment system. Runoff first enters a forbay or sedimentation basin to remove sediment and particulate pollutants. A skimmer device can be provided to detain oil compounds. The runoff is then discharged into an area where it is infiltrated into the ground, filters through soils and recharges groundwater.

Several standards must be followed in the design and construction of infiltration basins and trenches. These standards will provide for protection of groundwater resources and help insure proper operation of the facility.

1. Sensitivity Analysis - All proposed sites should be reviewed for the potential for ground water impacts due to urban runoff. Infiltration facilities shall not be constructed within areas identified as wellhead protection zones or very high or highly sensitive areas as discussed in Section 10.1. Infiltration basins receiving runoff from industrial sites are not recommended without extensive investigation of potential groundwater impacts.

2. Soil Conditions - Soils within a potential infiltration site should be of hydraulic group A or B as defined by the County Soil Survey. Soils within the site should have the capacity to infiltrate 0.25 to 0.3 inches / hour to be effective in operation.

3. Water Table Depth - The bottom of an infiltration structure must be separated from underlying bedrock or the water table to allow the filtration or removal of pollutants before water enters the groundwater. The Environmental Protection Agency's criteria for on-site

waste water treatment systems recommends a separation distance of 2 to 4 feet between the bottom of the structure and the seasonally high water table.

4. Facility Size - Infiltration ponds must be designed to function as detention ponds for storms greater than the designed infiltration capacity. The design **must** include an emergency spillway or outlet, 100-year storm protection of adjacent structures and other standards required for detention ponds. Infiltration trenches should be designed for a maximum of 6 days holding time. Based on data in Table 6-3, the average monthly minimum time between storms for Rochester is 6.4 days.

5. Pre-treatment - Urban stormwater runoff usually contains high levels of sediment that can seal an infiltration facility and significantly reduce its capacity. Runoff should be pre-treated by a sedimentation pond or grassed swale before discharging to an infiltration structure.

6. Adjacent Structures - Site locations for infiltration structures must consider possible damage to foundations and basements near the site. The stability of steep slopes near these facilities must also be considered in the design

7. Construction Scheduling - Infiltration basins should be graded to within one foot of the final grade until disturbed areas of the upstream watershed have been stabilized. Final pond grading should be completed with light track equipment to minimize compaction of the pond floor. Infiltration trenches should be constructed after the grading is complete.

8. Inspection - Access must be provided to infiltration structures for maintenance and inspection. An inspection port should be provided for infiltration trenches to monitor the water levels within the trench.

## 10.5 Pond Lining

Areas that are identified as High-Moderate to Very High in sensitivity and areas within wellhead protection areas should not contain infiltration ponds. Stormwater facilities within these areas must be sealed with heavy clay-type soils to limit infiltration through the basin sides and bottoms.

The existing topsoil within a proposed basin site must be analyzed for possible use for pond lining of the basin. If the topsoil on-site is determined to be adequate for lining, the material should be stock piled in designated areas for latter use. Clay-type soils may need to be imported to the site. The approximate thickness of highly plastic soils that should be placed within a basin's sides and bottom to provide an adequate seal are as follows:

- High-Moderate sensitivity areas - 12 inches
- High sensitivity areas - 18 inches
- Very High sensitivity areas - 30 inches.

These values should be reviewed based on specific soil characteristics in the field.

# 11. Operations and Maintenance

## 11.1 Stormwater Basins

Stormwater basins represent a sizable investment in the City's drainage system. General maintenance of these facilities can help insure proper performance and reduce the need for major repairs. Periodic inspections should be performed to identify possible problems in and around the basin. Finally, water quality sampling can insure that stormwater basins are operating correctly and can detect abnormal pollutant discharges within the watershed.

The most important part of the inspection of stormwater basins is to insure the outlet of the basin can perform at design capacity. The area around the outlet should be free and clear of debris, litter and heavy vegetation. Trash guards should be installed and maintained over all outlets to prevent the downstream storm sewer from clogging. Trash guards must be inspected at least once a year, preferably in early spring, to remove debris that may clog the outlet. Emergency overflow outlets should be provided for all ponds when possible. Emergency overflow outlets should be clear of equipment or materials and properly protected against erosion.

Basin inlets should be inspected for erosion. In cases where erosion occurs near an inlet, an energy dissipator or rip-rap material may be required. Sediment deposits or deltas may form at the inlet from poor erosion control practices upstream. This may occur during mass grading of sites within the drainage area. Large sediment deposits may reduce the ability of water to discharge from the storm sewer system during large storm events and may cause surcharging upstream.

The side slopes of basins must be kept well vegetated to prevent erosion and sediment deposition into the basin. Severe erosion along side slopes can decrease the quality of water discharging from the basin and require dredging of sediments from the basin. Noxious weeds may need to be periodically removed from around basins. Some basins in highly developed areas may require mowing. If mowing is performed, a buffer strip adjacent to the normal water level should be maintained to provide filtration of runoff from side slopes and protection of wildlife habitat. The buffer strip width should be based on the type of basin, but should be a minimum of 20 feet.

Periodic inspection of stormwater basins should include checking for evidence of illicit dumping or discharges. The most common of these is yard waste dumped into the pond. Signs may need to be posted prohibiting dumping in areas where this occurs. Oil sheens can also be present in areas were waste motor oil is dumped into upstream storm sewers. Skimmer devices placed at basin outlets can help prevent oil spills from being transported down stream. Skimmer structures should be periodically inspected for damage from freeze-thaw cycles. Inspections performed during dry weather periods should check for flows at basin inlets. Dry weather flows can indicate illicit dumping or connections to the storm sewer system.

Figures 11-1a and 11-1b provide an example of a periodic inspection form for stormwater basins. The form provides an outline of areas requiring inspection as described above.

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## 11.2 Sediment Removal

Removing sediment deposits will likely be the most expensive portion of maintenance for stormwater basins. The removal efficiencies of basins for water quality treatment can be significantly reduced if sediment is allowed to accumulate to excessive depths. As a general guideline for maintenance scheduling, Table 11-1 indicates the approximate rate of sediment buildup in basins, based on land use.

**Table 11-1: Approximate 20-year Sediment Buildup Volume per Acre**

| LAND USE | 20 Year Sediment Vol. ( Cubic yards/ac ) |
|---|---|
| Low Density Residential | 9.8 |
| Medium Density Residential | 12.7 |
| High Density Residential | 15.5 |
| Commercial | 18.4 |
| Industrial | 16.4 |

Sediment sampling in basins should be conducted before disposal to detect possible high levels of harmful materials. If excessive hazardous waste levels are detected in sediment tests, materials must be disposed of under MPCA guidelines provided in Appendix A-10. If high levels are not detected, sediment disposal sites should be located adjacent to the basin when possible. The material should be disposed of in a location where it will be stable and not in contact with humans such as playgrounds or parks. Sediments should be covered with topsoil and revegetated to prevent erosion of the material.

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## 11.3 Open Channels

Overland routes constitute an important part of the surface water drainage system. Open channels are typically vegetated and ocasionally lined with more substantial materials. The lined channels typically require little or no maintenance. Vegetated channels require periodic inspection and maintenance as high flows create erosion within the channel. Eroded channels will contribute to the water quality problems in downstream water bodies as the soil is continually swept away. If not maintained, the erosion of open channels will accelerate and repairs will become increasingly more costly.

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## 11.4 Piping System

The storm sewer piping system constitutes a multi-million dollar investment for any City. A comprehensive maintenance program is recommended to maximize the life of the facilities and optimize capital expenditures. To accomplish this, the following periodic inspection and maintenance procedures are recommended.

- Inspect catch basin and manhole castings; clean and replace as necessary.

- Inspect catch basin and manhole rings and replace and/or regrout as necessary.

- Inspect catch basin and manhole structures and repair or replace as needed. Check pipe inverts, benches, steps (verify integrity for safety) and walls. Cracked, deteriorated and spalled areas need to be grouted, patched or replaced.

- Inspect storm sewer piping either manually or by television to assess pipe condition. Items to look for include root damage, deteriorated joints, leaky joints, excessive spalling, and sediment buildup. The piping system should then be programmed for either cleaning, repair, or replacement as needed to ensure the integrity of the system.

## 11.5 De-Icing Practices

Minnesota receives approximately 54 inches of snow during a typical year. This requires that a large amount of de-icing chemicals be applied to roads and sidewalks each winter. The main chemical used for de-icing is salt or sodium chloride. Minnesota applies approximately 225,500 tons of road salt and 328,000 tons of sand to its roads each winter (Lakeside Minnesota 1997). Improper storage and over use of salt will increase the chance of high chloride concentrations in runoff and ground water. High chloride concentrations can be toxic to fish, wildlife and vegetation.

Estimates indicate that 80 percent of the environmental damage caused from de-icing chemicals is a result of inadequate storage of the material (MPCA 1989). Therefore, proper storage of salt is critical in reducing the amount of chloride that is transported to the environment. The following procedures can be used as a guideline for de-icing storage practices.

1. Store de-icing material in water proof sheds. If this is not possible, stockpiles should be covered with polyethylene.

2. Divert off-site runoff from storage locations. Berms and shallow drainage swales may need to be constructed.

3. Place stockpiles on impervious surfaces. Infiltration of runoff high in chloride content can pollute the ground water. Impervious surfaces also provides easier year-end cleanup of loading areas and will not become muddy during the spring.

4. Contain runoff from stockpile locations. Runoff from stockpiles should not be allowed to flow directly into streams or wetlands where environmental damage can occur.

5. Road de-icing stockpiles should not be located in well head protection areas or in other sensitive ground water areas.

Practices should also be followed to reduce the amount of salt that is applied to roads. One method is to limit the amount of salt applied to low traffic areas and straight level areas. Streets should be inspected for the need for de-icing prior to application. Equipment should be maintained in good working order to evenly distribute salt on roadways and should be properly calibrated to prevent excessive application.

## Table 11-1a Basin Inspection Form

**Table 11-1b Basin Inspection form**

# 12. System Management Description

## 12.1 General

The City was divided into eight major drainage districts as shown in Map 1. The major drainage districts were designated as shown in Table 12.1.

**Table 12.1 Major Drainage Districts**

| Major Drainage District | Abbreviation |
|---|---|
| Willow Creek | WC |
| Bear Creek | BC |
| Mayo Run | MR |
| Silver Creek | SC |
| Hadley Valley Creek | HV |
| Kings Run | KR |
| Cascade Creek | CC |
| South Fork Zumbro River | ZR |

Each major drainage district was further subdivided into minor drainage districts and subdistricts. All subdistrict are identified by the abbreviation of the major drainage district in which it is located, followed by the letter A and the number of its minor drainage district, followed by a number to differentiate it from the other subdistricts. The numbering system starts at the upstream end of the district and numerically increases downstream. For example, subdistrict SC-A4.8 is the eighth subdistrict of minor district A4 located in the Silver Creek District. The areas of each subdistrict are presented in Appendix A-1; their boundaries are shown on Map 1 at the end of this report.

The stormwater conveyance system (storm sewer trunks and stream channels) is broken into segments by point designations. These points identify the addition of flow into the system from drainage areas or ponds. The points are identified by the abbreviation of the watershed district in which they are located and the number of the minor district, followed by an additional number to differentiate them from the other point designations within the subdistrict. For example, point BC3.6 is located in the third minor district of the Bear Creek District. The point-by-point capacity and size of the existing and proposed drainage facilities are presented in Appendix A-3. The pipe sizes and capacities that are indicated for the proposed system are based on an assumed pipe grade. While the pipe size and grade can be changed in the final design, the pipe capacity of each segment should only be reduced after additional engineering analysis.

Ponding areas, drainage ways and storm sewer locations are shown on Map 1 and Map 2. A drainage way consists of a stream channel and its floodplain. Ponds are identified by the abbreviation of the major drainage district in which they are located, followed by the letter P and the number of the minor drainage district and subdistrict. For example, pond CC-P1.15 is in the fifteenth subdistrict of minor drainage district A1 located in the Cascade Creek District. Basin data including pond area, storage volume, normal and high water levels, and peak outflow are presented in Appendix A-4. The storage volume and outflow rate of a pond are important to preserve for each ponding area to successfully maintain the integrity of the storm drainage system. Pond areas and water levels may change in the final design of the ponding area to best suit the proposed development, but care must be exercised so that the outflow rates do not exceed the capacity of the downstream drainage facilities.

Peak pond outflow rates presented in Appendix B are based on the discharge through either a pipe or special outlet control structure with the pond at the high water level (HWL). In the case of a two-stage outlet or some other outlet control structure, suitable computer modeling of the final design is required.

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## 12.2 Willow Creek District

Drainage Area: 16,500 acres
Number of stormwater Basins: 58
Major Reservoirs: WR-4 (39.7 acres), WR6-A (71.8 acres)
Major Streams: East Fork, Southeast Fork, Southeast Branch and West Tributary to Willow Creek

The Willow Creek District includes the largest amount of area within the 50-year Urban Service Area. This district consists of the drainage area that drains to the large wetland within Smetka Park. This wetland discharges under Simpson Road north of Willow Creek Junior High School and into Bear Creek. Streams within the Willow Creek District drain the area as far south as Interstate-90 and as far west as County Road 8.

Two large reservoirs were constructed for flood control within the Willow Creek District. The eastern reservoir (WR-4) receives drainage from 2,815 acres of primarily agricultural land to the south. The western reservoir (WR6-A) receives runoff from 5,450 acres of land consisting of a mixture of agricultural, forested, industrial, residential and airport land.

A summary of some of the special concerns are given below.

WC-A1.3 and WC-A1.5 both discharge under 65th Street S.E. through seven-foot diameter corrugated metal pipes. WC-P1.5 requires all of the capacity of this pipe to prevent overtopping of the road bed for the 100-year storm event. Additional pond construction was not proposed at this location due to the heavily forester ravine leading to the culvert. The location of WC-P1.3 makes it a potential site for constructing a sediment removal basin for the upstream drainage area. Both ponds are located outside of the 50-year service area.

WC-P1.7 was designed to perform as a three-cell basin with a majority of the area dedicated to wetland restoration and banking for replacement credits. A large sediment forbay must be provided for high levels of sediment expected from the upstream agricultural watershed. Areas containing exotic plant species, such as reed canary grass, should be inundated with 1 to 2 feet of water through construction of berms across the floodplain. This site will provide for wildlife habitat and water quality treatment of runoff discharging to reservoir WR-4.

WC-P3.3 and WC-P2.5 are to be located where the storm sewer from these subdistricts can best cross the existing rail road bed. These basins were designed to remain outside of the wetlands located west of the rail road. Outlets of these basins are to discharge into the wetland areas to use their nutrient removal capabilities to the greatest extent practical.

WC-P2.6 and WC-P2.8 are designed to function mainly as rate control basins under large storm events. WC-P2.8 is to discharge to WC-P2.6 over a seven-foot weir. Rate control for WC-P2.6 can be accomplished by constructing of a drop-type weir with a crest length of 16 feet. Excavation in combination with an outlet structure placed at the existing culvert crossing of Highway 52 will provide water quality wet storage for small precipitation events to WC-P2.6.

WC-P3.2 and WC-P3.3 were designed to control peak discharge rates for their combined drainage area of 1,380 acres. Although a majority of WC-A3.2 is located south of the 50 year service area, computer modeling indicated that peak flow rates for subdistrict A3 were best controlled by reducing the peaks within the upper reaches of the drainage district. Basins WC-P3.2 and WC-P3.3 should be final designed simultaneously using the existing depressions and outlet control structures to create wet volumes. The outlet control structures should consist of a 13.0 weir for WC-P3.2 and a 15.0 weir for WC-P3.3.

WC-P3.12 is located on Map 1 to indicate the need for a control structure on the west side of the wetland complex within WC-A3.12. The wet volume designed for this pond should be subdivided into specific storm sewer discharge points to pre-treat runoff before entering the wetland. The outlet control structure is designed to maximize pond volume and direct flows to the trunk storm sewer pipe to carry flows down the steep slopes to Highway 63 as indicated on Map 2.

WC-P3.14 is the site of current gravel mining along Highway 63. The model used 42.9 acre-feet of detention storage for this basin. Site closure of the gravel mining operation should include the restorating of the pond banks and grading a stabilized outlet for the basin.

Basin WC-P4.5 is also a site of current gravel mining located west of 31st Avenue S.E. The model used a detention storage volume of 81.1 acre-feet of detention storage available at this location. Gravel should be mined to an elevation that will use this area for storage volume to reduce peak rates to the greatest extent possible.

WC-P4.2 and WC-P4.3 were designed to control peak runoff rates and provide water quality treatment for the industrial zoned area located southwest of the airport. This area could be highly variable in impervious surface coverage due to the future density of industrial development and future expansion of the airport. Formal development concept plans for this area should be developed during final design of these basins to confirm the required quantity and quality volumes of the basins.

WC-P4.9 and WC-P4.10 were designed to control runoff from future industrial development west of 11th Avenue S.E. Water quality and peak discharge reduction are both crucial factors in the final design of these ponds. Steep side slopes along the stream corridor leading to reservoir KR6-A can easily erode due to increased overland flow. All runoff from imperious surfaces for this area must be directed to one of these two basins.

WC-P4.12 was designed to be a one-cell sedimentation basin to treat runoff from the upstream drainage area for small storm events. This basin will be inundated by the reservoir during the 100-year storm event.

Basin WC-P4.13 consists of a degraded monotypic wetland located east of 31st Avenue S.E. This location has excellent potential for wetland restoration for banking credits. The final design should include beam construction to inundate the reed canary grass and provide water quality wet volume for treatment of upstream runoff. A sedimentation forbay should be provided for future mainanence.

All future development within subdistricts WC-A4.7 and WC-A4.11 must provide on-site runoff control prior to discharging from the site. A central regional facility could not be designed due to terrain limitations in this area.

WC-P5.9 was designed to treat runoff from WC-A5.8 and provide wetland treatment for runoff from the upstream golf course. This area has been identified as possibly the best location for wetland creation and restoration in the City of Rochester. A majority of the area is currently pasture with a small section of row crop in the northern floodplain area. A meandering stream flows north from the crossing of 48th Street to 40th Street. The stream channel is degraded from meandering and failure of the banks. Wetland areas could be created by berming and grading across the pasture area with drop structures to decrease the overall grade. The row crop area located near the floodplain forest to the north appears currently to be wet in some areas. The 100-year discharge rate from this basin was calculated at 1337 cfs.

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## 12.3 Bear Creek District

Drainage Area: 30,473 acres
Number of Stormwater Facilities: 24
Major Reservoirs: BR-1 (118.4 acres)
Major Streams: Bear Creek, Badger Run

The Bear Creek District includes the drainage area southeast of Rochester and extends to the confluence with the South Fork Zumbro River. Flood control structure BR-1 was constructed approximately three miles west of Eyota to control stream flows in Bear Creek from the 8,280 acres of upstream drainage. Bear Creek continues west from this structure to the confluence with Badger Run at Bear Creek Park. Badger Run begins east of the Town of Marion and flows parallel to

Highway 52 to Bear Creek. Suburban development has occurred along both Bear Creek and Badger Run. Stormwater facilities were designed to control runoff rates and treat stormwater in locations along both streams where development has not occurred.

Bear Creek and Badger Run have similar characteristics within the 50-year service area in that they are both low gradient streams with wide, flat floodplains in most areas. Protecting the floodplain areas for both streams is essential to maintain conveyance capacity and flood storage volumes.

A summary of the special concerns is given below.

Basins BC-P1.3, BC-P1.4, BC-P1.6, BC-P1.14 and BC-P1.17 are all located outside of the 2045 service area. These basins receive runoff from 4,955 acres of primarily agricultural land draining to Badger Run. This area constitutes approximately 47 percent of the total drainage area to Badger Run. Significant rate reductions and water quality improvements can not be achieved without controling runoff from these areas. These basins were designed to take advantage of existing terrain to reduce peak flows and remove high levels of suspended solids associated with agricultural runoff. The construction of these basins will require berms and weir outlet control devices at the existing road crossings for each basin. Funding for these basins will likely require joint participation among Olmsted County, the City of Rochester and state agencies.

Subdistricts BC-A1.7, BC-A1.8 and BC-A1.9 all drain to the existing box culvert at 55th Street S.E. (Total drainage area of 507 acres). The proposed basin BC-P1.9 is identified to reduce the peak flow rate from this area through construction of a control structure and excavation to provide detention volume for a 100-year discharge rate of 246 cfs. The basins final design must include an analysis of the current and ultimate downstream capacity through the residential subdivision north of Marion Road. The channel currently flows through subdivided lots that have not been developed (existing homes are greater than 10 years old). If future development requires this channel to be diverted, flows from BC-P1.9 should be channeled to BC-P1.11. A detailed hydraulic analysis will be required for BC-P1.11 to compensate for increased volumes and required outlet capacity. BC-P1.8 is an existing basin within BC-A1.8 and currently does not have a stabilized outlet. Appendix A-4 provides the proposed discharge characteristics for this basin.

BC-P1.11 is located within an existing gravel mining site. Runoff from subdistricts BC-A1.7, BC-A1.8, and BC-A1.9 must be directed to this basin by constructing a channel between the existing crossing at 55th Avenue S.E. and the pond normal water level. Future gravel mining in this area should be oriented toward developing this basin and channel excavation.

BC-P1.15 is indicated on Map 1 as a two-cell pond split by Marion Road. The pond was designed to operate as one pond under large storm events. The second cell west of Marion Road acts as the control for water levels in both cells. This will require an equalizer pipe between the two ponds. A 48-inch pipe was assumed in the design. Depending on specific future development of the area, both cells may be shifted to either side of Marion Street if site conditions are adequate.

BC-P1.21 is located on map 1 between Marion Street and Badger Run. Final basin design must insure that the tail water effect from the 100-year high water level of Badger Run does not cause this basin to exceed the 100-year high water level.

BC-P1.23 is indicated as a two-cell pond split by the crossing of 30th Avenue S.E. due to existing land constraints in the lower portion of the drainage area. Optimum final pond design would shift both cells to one side of the road if sufficient land can be acquired at the time of construction. The stream bank and floodplain along the south side of Badger Run in this area would benefit greatly from the combined effects of stream bank restoration and pond construction.

BC-P2.8 has been located north of 19th Street S.E. based on the current level of suburban development in the area. An alternative location for this basin, depending on future development, would shift BC-P2.8 west to the north of 20th Street S.E. Trunk storm sewer indicated on Map 2 would then be realigned to direct flows from 19th Street to this basin.

BC-P2.15 was designed to control runoff from subdistrict BC-A2.15. Future development north of 20th Street S.E. should include grading the ditch along 20th street and channel construction to direct flows to this basin. This basin was located based on existing forested areas south of 20th Street. Future reconstruction of 20th street should include the construction of truck storm sewer as indicated in Map 2.

Subdistricts BC-A2.16 A and B includes 405 acres of land zoned for low-density residential and commercial development. Approximately 60 percent of the area in the lower portion of the watershed has been developed. A stormwater facility to control runoff rates has not been constructed at this time. Basin BC-P2.16a is proposed to decrease the discharge rate to downstream storm sewers to prevent surcharging. Future development within subdistrict BC2.16a that can not be directed to this basin must insure that the downstream storm sewers have adequate capacities.

## 12.4 Mayo Run District

Drainage Area: 2,200 acres
Number of Stormwater Facilities: 19 Regional
Major Reservoirs: None
Major Streams: Mayo Run Environmental Corridor

The Mayo Run watershed was the subject of a previous stormwater study prompted by flooding problems and limited conveyance in the western portion of the watershed (Bonestroo 1990). Several regional stormwater facilities are proposed to limit peak flows along Mayo Run.

At the time of this report, design and construction documents were in the process of being prepared for constructing the main components of the Mayo Run system. Construction of ponds CP-12, CP-14 and CP-15 is expected to be completed in the fall of 1998. For further detail on the Mayo Run watershed area, the above documents should be referenced.

Subdistricts MR-E, MR-C, MR-SWP and MR-A4 are within the minor district of Mayo Run. Runoff from approximately 2,000 acres must pass under 13th Avenue through the existing 4' x 10' box culvert with a capacity of 225 cfs (Bonestroo 1991).

## 12.5 Silver Creek District

Drainage Area: 12,260 acres
Number of Proposed Basins: 15
Major Reservoirs: SR-2 (98.3 acres)
Major Streams: Silver Creek

The Silver Creek District drains to the South Fork Zumbro River through two stream channels. Silver Creek extends east from Reservoir SR-2 west of County Road 11 to Silver Lake. The predominant feature of the Silver Creek District is the steep slopes along the stream corridors that are fractured by deep ravines extending out from the flat floodplain area. These ravines form small tributaries which channel the runoff and direct flow to the creek. Minimal development has occurred within the Silver Creek Drainage area.

Regional facilities could not be designed for all subdistricts due to the gradient along many ravines. These areas must include the use of conservation and best management practices to control the discharge rates and levels of pollutants.

SC-P1.4a and SC-P1.5a are both existing basins within ravines draining to Silver Creek. SC-P1.4a will require the construction of an outlet with the capacity of a 24-inch RCP and grading to provide 8.8 ac-ft of detention storage to control flow rates. Development along Haverhill Road within subdistrict SC-P1.5a should include storm sewer to direct flows to SC-P1.5a. This basin should limit the 100-year discharge rate to 9.5 cfs within 6.7 ac-ft of detention storage available.

SD-P1.6b was designed to provide the maximum peak rate control within the ravine shown on Map 1. Due to the steep gradient on adjacent slopes, this basin may have to be separated into multiple cells to obtain adequate detention volumes. A detention volume of 13.1 ac-ft and peak discharge of 104 cfs should be considered a guide in the final design.

SC-P1.7b2 is located in a nearly landlocked portion of subdistrict SC-A1.7b. The discharge from this basin must be conveyed by open channel to the railroad crossing at College View Road. This intersection is at nearly the same elevation of SC-P1.7b2 located 2000 feet to the west. Final design of the basin must limit the 100-year discharge to capacity of the existing channel if improvements are not completed at the time of basin construction.

Subdistrict SC-A1.8 contains a high-quality wetland complex located within the State Wildlife Refuge. A regional stormwater facility was not designed north of Highway 14 in this area to receive runoff. Development within this area must include on-site stormwater basins to limit peak discharge rates and provide water quality wet volume for runoff from a 1.8 inch, 6-hour storm event. SC-P1.8 was designed as a two-cell pond to treat runoff from future development south of Highway 14.

## 12.6 Hadley Valley Creek District

Drainage Area: 6,300 acres
Number of Proposed Basins: 12
Major Reservoirs: None
Major Streams: Hadley Valley Creek

Hadley Valley Creek runs parallel to County Road 124 from Country Road 11, covering an area of approximately 8 square miles in the northeast portion of the City. Hadley Valley Creek flows into the South Fork Zumbro River north of Forest-Arend Park. A majority of the creek bed is in poor condition due to stream bank failure and surrounding agricultural practices.

Field observation shows that the original channel flowed from east to west approximately 500 feet north of the existing channel. It appears that the original channel was diverted into the roadside ditch, which has caused the degradation of what appears to be Hadley Valley Creek today. The original low-lying swale can still be seen running through the agricultural fields to the north. This situation provides a good opportunity to acquire a strip of land through the fields and restore the original stream bed, floodplain and wetlands. The existing channel section could then be returned to its intended function of a roadside ditch. Approximately 2,700 acres drain to this section of Hadley Valley Creek.

HV-P1.6a, HV-P1.7a and HV-P1.8a are all existing soil conservation service structures that were constructed to reduce peak flow rates within the ravines in these subdistricts. These subdistricts have been identified as areas with highly erosive soils. Additional erosion control measures must be implemented during development. The outlet structures for these basins are proposed to be modified as indicated in Appendix A-2 to operate under fully developed conditions. Pond improvements must include certification that the impoundment berms are adequately stable and that protected emergency overflows are provided for each basin.

The existing channel section between HV-P1.2 and HV-P1.4 is highly degraded and under sized to convey the peak flow rates predicted for the 100-year event. Flooding of 48th Street and adjacent area can be expected for large storm events. This stream channel should be reconstructed to convey a peak flow rate of 810 cfs under fully developed conditions. Channel design should include a low flow section with an overflow section for large storm events.

HV-P1.9 is identified on Map-1 to indicate the need for individual basins to be constructed during development within subdistrict HV-A1.9. Runoff from upstream drainage districts flows through the existing drainage channel through the central portion of the subdistrict. A regional basin could not adequately control rates and provide water quality treatment for the local drainage area with the upstream drainage directed through the basin. The basin data in Appendix A-4 indicates the ultimate maximum discharge rate for subdistrict HV-A1.9 to guide in the final design of the individual basins.

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## 12.7 Kings Run District

Drainage Area: 9,675
Number of Proposed Basins: 33
Major Reservoirs: none
Major Streams: Kings Run, 34th Street Tributary

The Kings Run District is located in the northwest portion of Rochester. A majority of the district drains to two tributaries to the South Fork Zumbro River. Kings Run begins west of County Road 104 in two branches that flow to West Circle Drive. The two branches join and continue along the south side of 55th Street to Essex Park near the confluence of the South Fork Zumbro River. Urban residential development has occurred along the eastern portion of Kings Run. The stream area includes a reasonable buffer on both sides in a majority of the urbanized area.

A second tributary flows from west of Highway 52 near 37th Street through a developed residential area. The tributary course parallels 34th Street to its confluence with the South Fork Zumbro River at 37th Street. This tributary has a drainage area of 708 acres.

KR-P1.1 and KR-P1.2 were designed to reduce peak flows from the western drainage area outside of the study area. The existing channel capacity along the north side of the Douglas State Bicycle trail was determined to overtop its banks under large storm events. Basin KR-P1.2 may be incorporated into KR-P1.1 at the time of final basin design based on land availability. The culvert crossing at 60th Avenue does not have the capacity to convey flows without overtopping the road bed under existing conditions. The ultimate model used three, 36-inch culverts to prevent overtopping with the completion of upstream ponds.

KR-P1.4 was designed to reduce peak flows and provide water quality treatment to 710 acres southwest of the Douglas Trail. The basins outlet discharges to the channel along the north side of the Douglas Trail.

KR-P2.7 was located to control runoff from both the current and future development area north of 55th Street. This location is the last available area for an off-line stormwater facility for the subdistrict. Trunk storm sewer facilities will be required along 55th Street to convey flows to this basin as shown on Map 2.

KR-P2.8b and KR-P2.9b were designed to perform in series to reduce peak flows and treat runoff. KR-P2.8b should be minimized during final design due to the amount of excavation required to construct the basin. This basin will discharge under 18th Avenue to KR-P2.9b where flows can be reduced to the maximum extent practical for large storm events. The outlet of KR-P2.9b will cross 55th Street and discharge to a channel section that is currently under construction. It appears that this channel will have limited flow capacity that must be calculated at the time of final basin design.

KR-P2.2 and KR-P2.3 are two basins designed to control runoff from the IBM site and adjacent future commercial / industrial development. The model predicted a peak flow rate of 678 cfs within downstream subdistrict KR-P2.5a for the 100-year event. KR-P2.2 will discharge to two existing 48-inch CMPs north of 41st Street. The storage volume for this basin is required to prevent overtopping of 31st Avenue N.W. due to the capacity of these pipes.

KR-P2.5a and KR-P4.3 are located within substantially developed areas. Both basins were designed in locations with limited area for ponding. Basin KR-P2.5a was designed mainly for rate reduction for the downstream portion of Kings Run. Basin KR-P4.3 was designed to reduce pollutant loadings to the South Fork Zumbro River for the fully developed upstream subdistrict. The detention volumes and percent peak discharge reductions could change significantly during the final design. Preliminary feasibility studies are recommended for both basins.

KR-P2.13b consists of an existing degraded flood control structure to the west of West River Road. Two options are available for this basin. The first option includes reconstructing the outlet structure to restore it to a rate control facility and direct the discharge to KR-P2.13c for water quality treatment. The second option would be to excavate wet volume into the pond and maintain the crossing under West River Road. The second option would allow a reduction in size for KR-P1.13c at the time of final design. The SWMP used the first option. If the second option is implemented, a further reduction in rate control should be designed into KR-P2.13b based on the crossing capacity of West River Road than is indicated in Appendix A-4.

## 12.8 Cascade Creek District

Drainage Area: 24,500 acres
Number of stormwater Basins: 17

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| Major Reservoirs: | KR-3 (24.9 acres), KR-7 (48.3 acres), KR-6 (28.8 acres), Cascade Lake (160 acres proposed) |
| Major Streams: | North Run of the North Fork of Cascade Creek, South Run of the North Fork of Cascade Creek, North Fork of Cascade Creek, Cascade Creek |

The Cascade Creek District consists of the area draining to Cascade Creek, which extends from the City of Byron to the confluence with the South Fork Zumbro River at 3rd Avenue. Three flood control structures located within the district provide a high level of rate reduction along the northern portion of the district. The extent of Cascade Creek that is within the 50-year service area flows along the southern portion of the district.

The City of Rochester has had engineering and conceptual development studies conducted to evaluate the future development of Cascade Lake. Current gravel mining within the floodplain west of Highway 52 is developing a basin that could eventually expand into a lake as large as 170 acres. Desired uses of the lake include swimming, limited boating and fishing.

The quality of runoff draining to Cascade Creek is a major concern if recreational activities are to occur in Cascade Lake. Approximately 10,400 acres drains to the main branch of Cascade Creek outside of the 50-year service area. A detailed study of the water quality in this outlying area was not within the scope of the SWMP. Land use was assumed to be uniform agricultural. Stormwater facilities were designed to provide water quality treatment to runoff within the service area and along the North Fork of Cascade Creek.

CC-P1.1 was designed to provide water quality treatment to runoff from the 10,400-acre drainage area to the west. This basin is one of many facilities that are needed along Cascade Creek to lower the peak flow rates and remove nutrients for runoff. However, CC-P1.1 is located within a natural depression and can be created by constructing a control structure near the bridge crossing at County Road 104. The 100-year peak discharge rate of 2,470 cfs was calculated at this location.

CC-P1.10 is the existing basin separate from Cascade Lake to the west. Water quality modeling assumed that development of Cascade Lake would remain separate from CC-P1.10. This basin will act to treat runoff from the upstream watershed. Future development around CC-P1.10 should include adequate buffer from the shoreline and planting of wetland vegetation to assist in nutrient removal. The conveyance capacity of a 10-foot trapezoidal channel must be provided between CC-P1.10 and Cascade Lake.

CC-P2.8 is shown on Map 1 to indicate the need for individual site stormwater ponds within subdistrict CC-P2.8. Due to the amount of upstream flow, a regional facility would not significantly lower the peak flow rates or provide proper water quality treatment. Industrial site development within this subdistrict must provide water quality treatment and rate reduction on-site to predevelopment conditions.

CC-P 3.6 is located in an area that is expected to become a gravel mining site in the near future. At this time, it is difficult to estimate the extent of future mining. Modeling assumed a basin with a normal water level surface area of 17 acres. Mining should be coordinated with the end use of the site becoming a regional stormwater facility. This pond will provide water quality wet volume for subdistrict CC-A3.6, which is zoned commercial / industrial.

Subdistrict CC-A3.7a covers the drainage area immediately upstream of 7th Street N.W. Information obtained from the City indicates that the 2,210-acre upstream drainage area crosses under 7th Street through a 35-inch CMP pipe and a 72"w x 53"h CMPA culvert. The model predicted that under fully developed conditions, the road bed would be overtopped with all proposed upstream basins in operation due to the low elevation of the road and significant tail water effects to the east. Future reconstruction of 7th Street must include culvert capacity to pass a minimum of 436 cfs under 4.4 feet of hydraulic head. The system model assumed four, 48-inch RCP to prevent overtopping.

Subdistrict CC-P4.2 includes the land that will eventually drain directly to Cascade Lake. Developments within this subdistrict must provide on-site water quality treatment similar to CC-P2.8 as described above.

Cascade Lake water quality will be significantly effected by land use within the upstream watershed. A recent study of the Cascade Creek watershed predicted phosphorus concentrations between 315 and 2410 ppb due to feedlots within the upstream portions of the drainage area (Barr 1994). For this region, the MPCA recommends phosphorus concentrations to be less than 40 ppb for full use swimming conditions.

Water quality field monitoring will be needed to calibrate the XP-SWMM model used to determine the concentrations of pollutants within all districts. Particularly important will be any data that is collected for Cascade Creek at County Road 104. Data from this location can be used to substantiate the contribution of agricultural land use and feedlots to the future quality of Cascade Lake.

## 12.9 South Fork Zumbro District

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| Drainage Area: 99,700 acres | |
| Number of stormwater Basins: 15 | |
| Major Reservoirs: | Mayowood Lake (48.4 ac), Bamber Lake (38.2 ac), Lake George (21.8 ac) |
| Major Streams: | South Fork of the Zumbro River, Bamber Valley Tributary |

The South Fork Zumbro District covers the entire area draining directly to the South Fork of the Zumbro River. The district is located to the southwest of Rochester and continues through the central portion of the City along a narrow band to the northern study limits. The undeveloped portion of this district within the 50-year service area represents the smallest study area for the SWMP. The terrain is very steep along the stream valley in the southern portion of the district. Stormwater facilities were located where ponding could be achieved in undeveloped areas.

Bamber Valley tributary consists of the steep grade stream flowing north along Bamber Valley Road. A total of 1,700 acres drain to the point at which the stream crossed under Mayowood Road. Several culverts exist at this crossing. It appears that these culverts were installed at different times to prevent road bed overtopping.

Severe erosion problems exist south of the crossing due to high peak flow rates in the stream channel and downstream culvert ends. Several stormwater basins are identified upstream within the tributaries as shown on Map 1. These basins were designed for the primary purpose of peak rate reduction and a secondary function for water quality improvement. The model calculated a peak flow rate of 662 cfs at the Mayowood Road crossing under fully developed conditions. Due to the variable terrain within the stream valleys in this area, final design of these basins will require field survey and site analysis information to determine detention volumes.

ZR-P2.1a has been designed as a rate control basin to decrease peak discharge at the point where multiple branches of the stream intersect. This location is forested and it maybe necessary to remove trees. Final design should utilize the existing stream channel for temporary detention storage.

ZR-P3.5a is indicated on map 1 to identify the need for a rate control basin within the stream corridor of subdistricts ZR-A3.5 a and b. The lower portions of these subdistricts have been developed close to the stream channel. Land acquisition will be key in the final design of this basin.

Water quality data sets for Mayowood Lake, Bamber Lake, and Lake George do not exist at this time. Several water quality basins have been designed north of Salem Road to treat future urban runoff to Bamber Lake. The drainage area to Lake George has been developed. Lawn care practices to limit nutrient runoff within this subdistrict will be the primary method of controlling the water quality of Lake George.

# 13. Summary and Recommendations

## 13.1 Summary

The Rochester SWMP has a dual purpose:

- To serve as a comprehansive guide for the expansion of the City's storm water management system to serve new development and redevelopment areas; and
- To assist the City in developing a storm water management program to meet the recently enacted requirements of the National Pollution Discharge Elimination System Phase II program.

The following issues have been incorporated into this SWMP:

1. Division of the City into major and minor drainage districts and subdistricts based on contour maps, grading plans and natural topography,
2. Determination of stormwater runoff under fully developed land use conditions within the SWMP study area,
3. General layout of trunk storm sewer,
4. Estimation of storage volumes, peak discharge rates, and high water levels of regional ponding areas,
5. General planning and preparation for NPDES Phase II control measures,
6. Estimated implementation costs for the SWMP,
7. Development of design guidelines for storm water improvements,
8. Review of operation and maintenance procedures,
9. Identification of sensitive groundwater areas, and
10. Identification of Natural Resources Corridors.

The primary function of an urban storm drainage system is to minimize economic loss and inconvenience due to periodic flooding of streets and other low-lying areas. Adequately designed storm drainage facilities provide flood control, minimize hazards and inconvenience associated with flooding, and protect or enhance water quality. The SWMP considers fully developed conditions within the entire study area.

The numerous natural depressions found throughout the City have been incorporated into the SWMP as ponding areas. The effective use of ponding areas enables the installation of outflow sewers with reduced capacities since the design storm duration is effectively increased over the total time required to fill and empty the ponding reservoirs. Storm sewers represent a sizable investment for the community and this investment can be more efficiently used by ponding stormwater in designated ponding areas and allowing smaller diameter pipes to be used as outfall lines.

Equally as important as the cost considerations is the use of ponding areas to:

1. Improve water quality

2. Return stormwater to the groundwater table

3. Increase water amenities in developments for aesthetic, recreational and wildlife purposes.

For water quality ponds, the wet volume is the most important consideration. The area and depth of the ponds may differ from the values presented here, but the wet volume should be provided so that the prescribed phosphorus loading of the system is not exceeded. It can be assumed that water quality ponds will function in reducing pollutants if the design guidelines in chapter 6 are followed. The XP-SWMM model was selected for use in estimating pollutant and nutrient loads from the major drainage districts. The XP-SWMM model predicts pollutant removal rates using event mean concentrations based on land use and pond removal efficiencies based on sediment settling removal.

Amenity aspects are maximized by careful planning in the initial development of any residential or industrial area and by integrating the ponding system into the park development program wherever possible. Coordination between a storm drainage system and a park and public lands system may result in more efficient use of a community's open space. Open channels can also serve as part of a trail system; easements can include installation of storm sewer pipe. The wildlife aspects of the ponding areas should be maximized in designs. The proper location of the trail system will allow good access to these areas for wildlife observation.

The stormwater system alignments shown in the SWMP are conceptual in nature. It is extremely important that each area be reevaluated at the time of final design to confirm the criteria used in this study and to make any changes that a proposed development may dictate. Special consideration must be given to areas that develop differently than shown in the Land Use Plan, especially when a higher runoff coefficient is likely to result from development.

All storm sewer facilities, especially those conveying large quantities of water at high velocities, should be designed with efficient hydraulic characteristics. Special attention should be given during final design to those lines that have extreme slopes and create high hydraulic heads.

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## 13.2 Recommendations

The following recommendations are presented for the City Council's consideration based upon the data compiled in this report:

1. The SWMP as presented herein be adopted by the Rochester City Council;

2. Standard review procedures be established to ensure all development activity within the City is in compliance with the general guidelines of this plan;

3. Strategies and practices described in Chapter 4 be implemented to guide development within the primary and secondary natural resources corridors;

4. Temporary sediment basins and regional stormwater facilities be constructed during the initial phase of development within the watershed;

5. Detailed hydrologic analysis be required during the final design and configuration of the drainage system within a developing subdistrict based on the information contained in Appendix A-2 through A-4 and computer models developed for the SWMP;

6. Final high water levels governing building elevations adjacent to ponding areas and floodplains be established as development occurs or when drainage facilities are constructed as described in Chapter 5;

7. Emergency overflow routes be incorporated into the final design of the drainage system and maintained to provide relief during extreme storm conditions which exceed design conditions as described in Chapter 5;

8. A stormwater system maintenance program be established to ensure the successful operation of the system including periodic inspection of storm sewers, channels and ponding areas as described in Chapter 11;

9. An erosion and sedimentation control guidance manual be developed to assist the development community in designing and implementing effective erosion control practices. The manual should incorporate the recommended practices described in Chapter 9. This effort should be coordinated with the Olmsted Soil and Water Conservation District to avoid a duplication of effort;

10. A City Staff member be appointed to coordinate educational efforts with the South Zumbro Watershed Partnership;

11. The City create a storm water work group made up of staff to guide internal storm water policy and practices, and internal educational efforts;

12. The City adopt a storm sewer area charge to provide an equitable method of financing the expansion of the drainage system to serve future development.

13. The City adopt a stormwater utility to finance the operations and maintenance of the drainage system.

14. The City begin working to update existing ordinances to comply with the NPDES phase II requirements.

15. A water quality monitoring and sampling program be implemented by the City to detect pollution sources, calibrate the hydrologic models and prepare for the NPDES permit application.

# Glossary

**Acre-Feet:** Volume of water which would cover an acre of land to a depth of one foot. 43,560 cubic feet.

**Background Phosphorus Export:** Naturally occurring level of phosphorus export from land before development.

**Chlorophyll a:** The primary photosynthetic pigment in plants, a measure of the algal biomass in lakes.

**Degradation:** A decrease in quality. In lakes, this is called eutrophication.

**Dissolved Oxygen (D.O.):** Oxygen which is dissolved in water. Fish and other water organisms "breathe" dissolved oxygen.

**Down Cutting:** The process by which a river or stream erodes and lowers its bed, eventually resulting in the formation of a valley or ravine.

**Ecosystem:** A community represented by interaction among animals, plants, and microorganisms, and the physical, biological and chemical environment in which they live.

**Empirical:** Based on experiment and observation; used to describe water quality models which are developed from measured data.

**Epilimnion:** Upper warm layer of a lake during thermal stratification.

**Export Coefficient:** An estimate of the expected annual amount of a nutrient carried from its source to a lake.

**Eutrophication:** The process of over-enrichment of lakes with nutrients, particularly phosphorus. The term also refers to the results of nutrient enrichment such as algae blooms and excessive plant growth.

**Exotic Species:** A species that has been introduced to an area by humans or that is present in the area as a result of human-caused change.

**Flushing Rate:** The number of times per year that a volume of water equal to the lake's volume flows through the lake.

**Hypolimnion:** Lower cooler layer of a lake during thermal stratification.

**Hydrology:** The science and study of water in nature, including its circulation, distribution, and its interaction with the environment.

**Hydrophyte:** A plant adapted to growing in water or on wet soils that are periodically saturated and deficient in oxygen.

**Impervious Surface:** A surface which is impermeable to the downward seepage of water; e.g., pavement and roof tops.

**Macrophytes:** Higher plants which grow in water, either submerged, emergent, or floating. Reeds and cattails are examples of emergent macrophytes.

**µg/l:** Micrograms per liter, also parts per billion (pbb).

**mg/l:** Milligrams per liter, also parts per million (ppm).

**Model:** A mathematical representation of an event or process.

**Nonpoint Source:** Runoff (usually containing nutrients and other pollutants) from sources not discharged from a single point, e.g., runoff from farm fields or paved streets.

**Nutrient Budget:** An itemized estimate of nutrient inputs and outputs (usually for a period of one year), taking into account all sources and losses.

**Nutrient Loading:** The input of nutrients to a lake.

**Nutrient Trap:** A type of pond or wetland which is effective at removing nutrients from water.

**pH:** A measure of the acidic or basic nature of the water; it is defined as the logarithm of the reciprocal of the hydrogen-ion concentration in moles/liter.

**Phosphorus:** A nutrient essential to plant growth. Phosphorus is the nutrient most commonly limiting plant growth in lakes.

**Phosphorus Export:** The amount of phosphorus carried off of a given area of land by stormwater.

**Phytoplankton:** Open water algae; it forms the base of the lake's food chain and produces oxygen.

**Secchi Disc:** A device measuring the depth of light penetration in water, typically a 9 inch, white circular plate attached to a rope. Used to measure water transparency.

**Sedimentation:** The process by which matter (usually soil particles) settles on substrate following transport by water, wind or ice.

**Suspended Solids:** Particulate material which floats in or is carried along in water (e.g., algae, soil particles).

**Total Phosphorus:** A measure of all of the different forms of phosphorus in water. Includes phosphorus dissolved in the water, suspended or incorporated in algae or other organisms.

**Watershed:** The area of land draining into a specific body of water.

**Water Transparency:** A measure of the clarity of water. The depth at which an object can be seen in water.

**Wetland Types:**

- Seasonally Flooded Basins or Flats (Type 1) - Soil is covered with water or is waterlogged during variable seasonal periods but usually is well drained during much of the growing season.

- Inland Fresh Meadows (Type 2) - Soil is usually without standing water during most of the growing season but is waterlogged within at least a few inches of the surface.
- Inland shallow fresh Marshes (Type 3) - Soil is usually waterlogged early during the growing season and often covered with as much as 6 inches or more of water.

- Inland Deep Fresh Marshes (Type 4) - Soil is usually covered with 6 inches to 3 feet or more of water during the growing season.

- Inland Open Fresh Water (Type 5) - Shallow ponds and reservoirs are included in this type of wetland. Water is usually less than 10 feet deep and fringed by a border of emergent vegetation similar to open areas of Type 4.

- Shrub Swamps (Type 6) - Areas where shrub species are growing in soil that is usually water logged during the growing season and is often covered with as much as 6 inches of water.

- Wooded Swamps (Type 7) - Areas where trees and forested areas are located in soil that is waterlogged at least to within a few inches of the surface during the growing season.

- Bogs (Type 8) - Soil is usually waterlogged and supports a spongy covering of mosses.

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