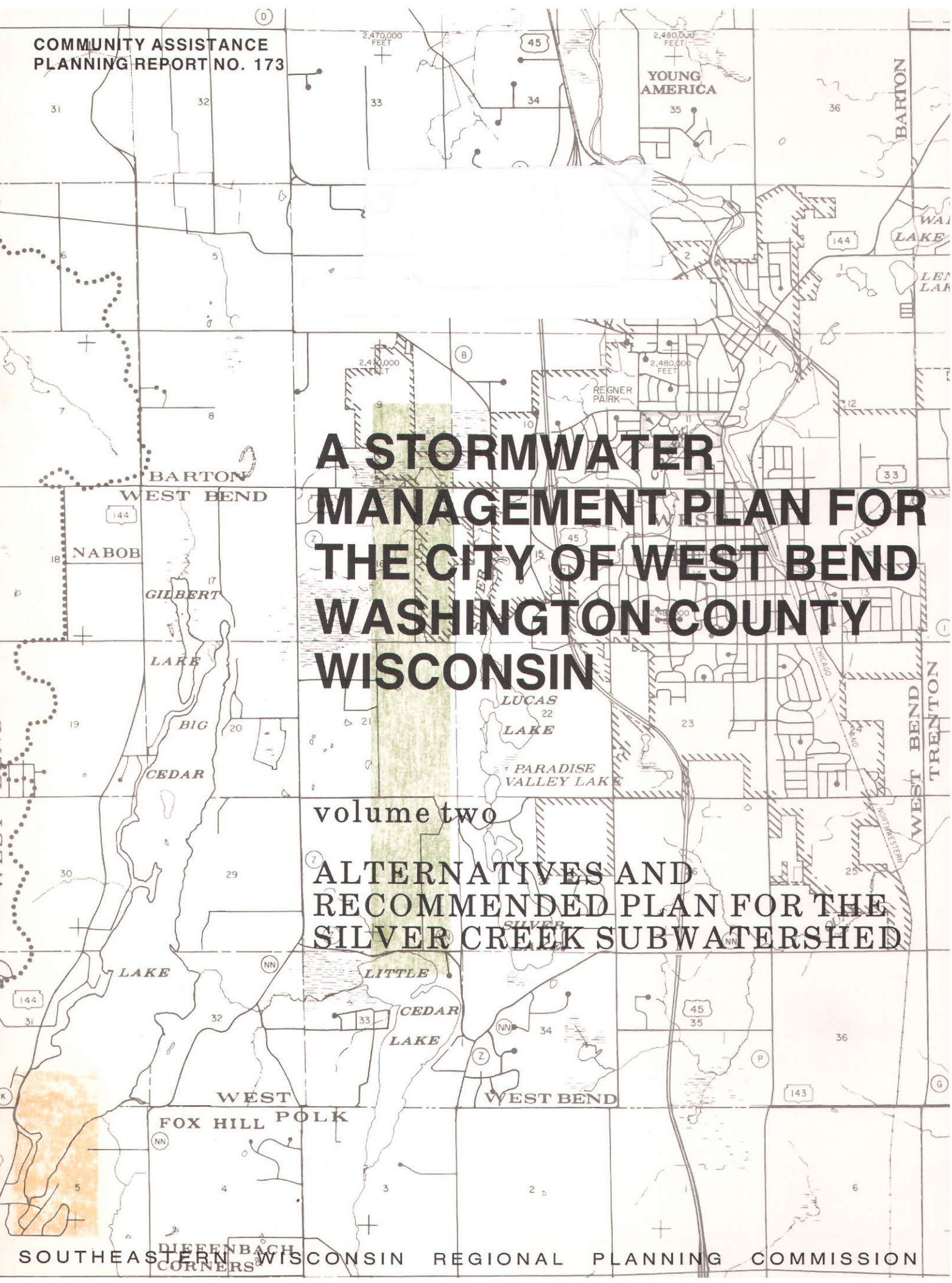
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 173



A STORMWATER MANAGEMENT PLAN FOR THE CITY OF WEST BEND WASHINGTON COUNTY WISCONSIN

volume two

ALTERNATIVES AND RECOMMENDED PLAN FOR THE SILVER CREEK SUBWATERSHED

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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Kenneth M. Pesch, P.E.

Special acknowledgement is due Mr. Allen S. Wojtasiak, Civil Engineer II, for his contribution to the preparation of this report.

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Special acknowledgement is due Mr. Michael G. Hahn, SEWRPC Principal Engineer, for his contribution to the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 173

A STORMWATER MANAGEMENT PLAN FOR THE CITY OF WEST BEND

CITY OF WEST BEND
WASHINGTON COUNTY, WISCONSIN

Volume Two

ALTERNATIVES AND RECOMMENDED PLAN FOR THE SILVER CREEK SUBWATERSHED

Prepared by the
Southeastern Wisconsin Regional Planning Commission
P. O. Box 1607
Old Courthouse
916 N. East Avenue
Waukesha, Wisconsin 53187-1607

June 1990

Inside Region $5.00
Outside Region $10.00

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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June 21, 1990

Mayor, City Council, and
City Plan Commission
c/o City Clerk
City of West Bend
100 N. Sixth Avenue
West Bend, Wisconsin 53095

Ladies and Gentlemen:

In January 1985, the City of West Bend requested the Southeastern Wisconsin Regional Planning Commission to assist the City in the preparation of a stormwater management plan for the City of West Bend and environs. This volume is the second in a series of four volumes, which together present the major findings and recommendations of the resulting stormwater management planning program. The first volume set forth the basic principles and concepts underlying the planning effort; presented existing and forecast resident population levels and land use within the study area; described the existing stormwater drainage system; and identified general stormwater management problems. The first volume also described the various components of a typical stormwater management system and presented a set of stormwater management objectives, standards, and design criteria for use in plan design, test, and evaluation.

This, the second volume presents the findings of an evaluation of the existing stormwater management system serving that portion of the planned urban service area of the City of West Bend lying within the Silver Creek subwatershed; describes and evaluates alternative stormwater management plans designed to serve that subwatershed through the design year 2010; and recommends a stormwater management system plan for the subwatershed. Subsequent volumes will present similar information and recommendations for the Quaas Creek subwatershed and the Milwaukee River direct drainage area.

The information presented herein is consistent with regional as well as local land use development, water quality management, and flood control objectives, and is intended to serve, along with the other volumes, as a guide to city officials in the making of sound decisions over time concerning the development of stormwater management facilities in the City of West Bend.

The Regional Planning Commission is appreciative of the assistance offered by city officials and staff in the preparation of this report. The Commission staff stands ready to assist the City in the adoption and implementation of the plan over time.

Sincerely,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

This volume is the second in a series of four volumes, which together present the major findings and recommendations of a stormwater management planning program for the City of West Bend and environs. The first volume sets forth the basic principles and concepts underlying the planning effort; presents forecasts of anticipated future land use within the study area; describes the existing stormwater drainage system; and identifies generally existing stormwater management problems. The first volume also describes the various components of a typical stormwater management system and presents the stormwater management objectives, standards, and design criteria applied in the synthesis of the stormwater management plan for the City of West Bend.

This, the second volume, presents the findings of an inventory and evaluation of the existing stormwater management system serving that portion of the planned urban service area of the City of West Bend which lies within the Silver Creek subwatershed; describes and evaluates alternative stormwater management plans designed to serve that subwatershed through the design year 2010; and recommends a stormwater management system plan for the subwatershed. Subsequent volumes present similar information and recommendations for the Quaas Creek subwatershed and the Milwaukee River direct drainage area.

Following this introductory chapter, the second chapter of this volume presents the findings of the inventory and evaluation of the existing stormwater management system in the Silver Creek subwatershed. As indicated in Chapter IV of Volume One of this report, a 10-year recurrence interval storm event was used to evaluate the minor system components consisting of backyard and sideyard swales, roadside swales, curbs and gutters, inlets, storm sewers, storage facilities, and related appurtenances. A 100-year recurrence interval storm event was used to evaluate the major system components, including the entire street cross-section and interconnected drainage swales and watercourses.

The third chapter describes and evaluates alternative conceptual approaches to stormwater management which could be applied in the subwatershed to mitigate existing stormwater management problems and accommodate runoff from planned development to the design year 2010.

The fourth chapter presents and evaluates four specific alternative stormwater management system plans for the subwatershed. The alternatives to be considered for inclusion within the recommended stormwater management system plan are selected by hydrologic unit, enabling formulation of a recommended plan which best meets the objectives and supporting standards set forth in Chapter IV of Volume One of this report.

The fifth chapter presents the recommended stormwater management system plan. The recommended plan includes a stormwater drainage element, a flood control element, and a water quality management element. This chapter also presents certain auxiliary plan recommendations regarding preservation of natural resources and open spaces; revisions to the City's floodplain map; maintenance of stormwater management facilities; and stormwater management system costs, including a possible apportionment of the costs of the plan between the public and private sectors.

The sixth chapter describes the hydraulic and water quality impacts of the recommended system plan. The seventh chapter stresses plan implementation and includes a preliminary implementation schedule. The eighth and final chapter presents the recommended plan in brief, summary form.

The design of the recommended plan was based upon careful consideration of many factors, with primary emphasis, however, upon the degree to which the recommended stormwater management objectives and supporting standards are satisfied. Most important among the considerations were those relating to cost, to the ability of the system components to accommodate flows resulting from the design storm events without exacerbating downstream drainage and flooding problems, and to the ability of the system components to abate nonpoint source pollution.

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Chapter II

EVALUATION OF THE EXISTING STORMWATER MANAGEMENT SYSTEM

INTRODUCTION

In order to characterize the existing stormwater management system, the components of that system need to be definitively described. Such a description permits the hydraulic capacities of the existing conveyance and storage facilities to be calculated, along with the required capacities under the design storms and under planned future and existing land use development conditions in the tributary catchment areas. Those system components that are unable to accommodate the runoff expected from the design storms under either existing or future land use conditions, or both, are thus identified. Those components can then be addressed in the design of alternative stormwater management system plans.

The evaluation of the existing stormwater management system was directed toward the storm sewers, storage facilities, open channels, roadside swales, and culverts of the minor system and toward the open watercourses and related bridges and culverts of the major system. In the evaluation it was assumed that the backyard and sideyard drainage swales, the roadside swales and curbs and gutters, and the inlets would have adequate capacity to convey the stormwater flows generated by storms up to and including the 10-year recurrence interval event to the receiving conveyance and storage facilities of the minor system. In addition, it was assumed that the street cross-sections and interconnecting drainage swales of the major system would have adequate capacity to convey the stormwater flows generated by storms in excess of the 10-year recurrence interval event and up to the 100-year recurrence interval event to the watercourses of the major system, except at locations such as mid-block sags and streets with extremely flat slopes where the alternatives were specifically designed to handle flows up to those generated by a 100-year event. The system components assumed to be adequate for the purpose of designing and evaluating alternative system plans were, however, subject to quantitative analysis in the development of the recommend plan.

Physical Characteristics

The 9.03-square-mile Silver Creek subwatershed was divided into 151 subbasins for analytical purposes, as shown on Map 1. Of the total of 151 subbasins, 63, with a total drainage area of 2.86 square miles, are internally drained. The existing stormwater drainage systems are primarily comprised of roadway curbs and gutters, storm sewer inlets, storm sewers, roadside swales, and open channels and associated culverts, together with the streams to which the outlets of the engineered and constructed system components discharge. The existing stormwater management systems are described in Chapter II of Volume One of this report.

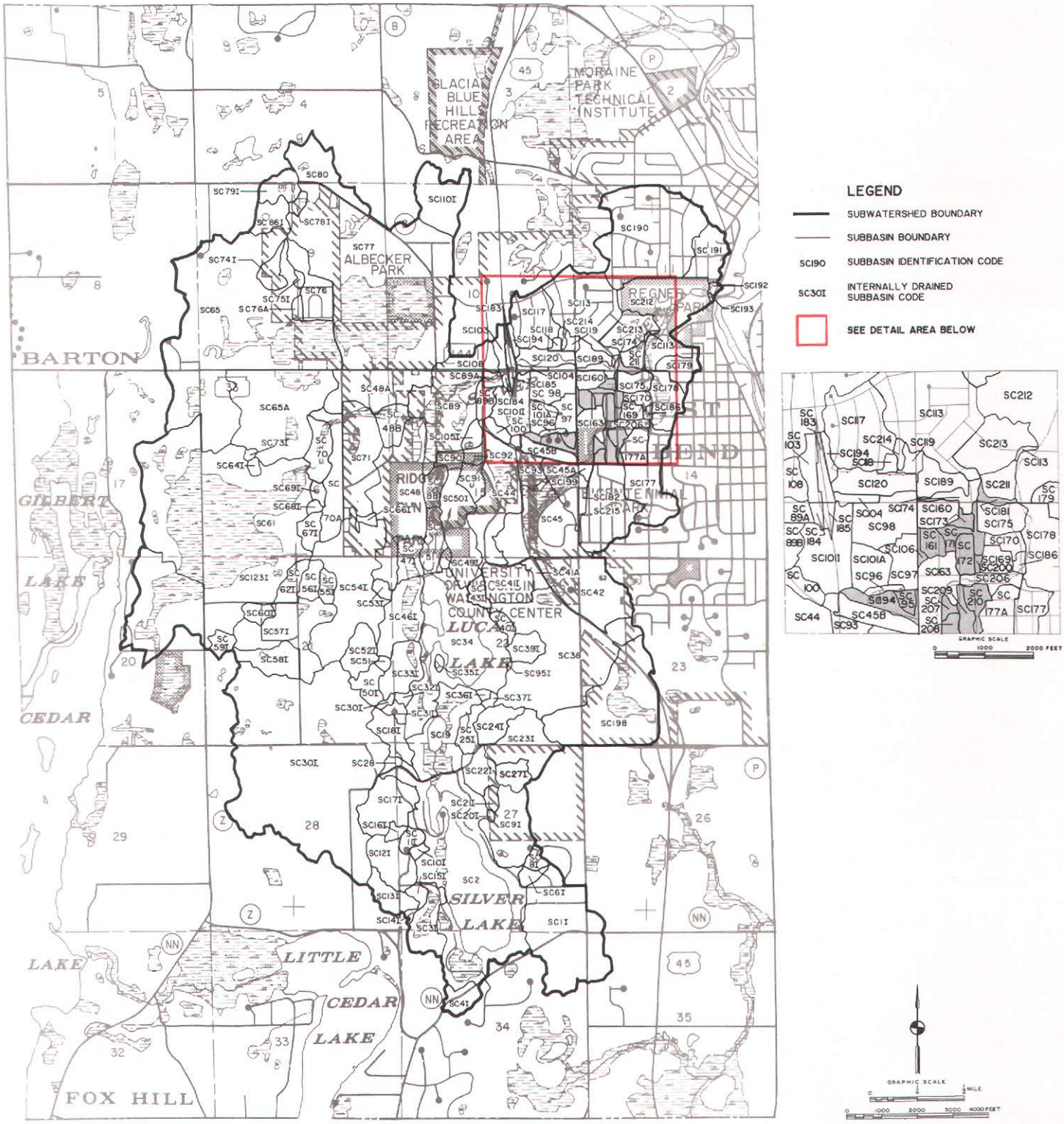
Hydraulic Capacities of Conveyance Systems and Storm Flows

The hydraulic capacity of conveyance facilities—storm sewers, roadside swales, culverts, and open channels—is determined by the shape and dimensions of the cross-section of the facility, by the facility's composition and lining and elevation and gradient, and by the roughness of the surface—as represented by Manning's "n" value. The methods used to determine the hydraulic capacity of the system components are described in Chapter IV of Volume One of this report. The capacities of storm sewers, storage facilities, and open channels and culverts in the minor stormwater management system and of selected watercourses of the major stormwater management system were calculated.

Peak rates of stormwater runoff, as determined by the hydrologic and hydraulic characteristics of each catchment area, were estimated utilizing the methods described in Chapter IV of Volume One of this report. Peak rates of flow were also estimated for catchment areas within subbasins in order to determine the hydraulic loadings, as appropriate, on each segment of the storm sewer and drainage channel. Where these stormwater flows exceed the capacities of conveyance facili-

Map 1

SUBBASINS WITHIN THE SILVER CREEK SUBWATERSHED



Source: SEWRPC.

ties, surface ponding, flooding, and surcharging of upstream or downstream drainage facilities may be expected to occur.

Identified Problem Areas

The calculated capacities of each of the components of the existing drainage system were compared to the anticipated stormwater flow rates to identify those areas where problems may be expected under sign storm conditions. As already noted, the evaluation considered the capacity of the minor system components in relation to the stormwater flows and volumes generated by a 10-year recurrence interval rainfall event; and the capacity of the major system components in relation to the stormwater flows and volumes generated by a 100-year recurrence interval rainfall event. In identifying problems in the existing system, consideration was given to the potential impact of excessive flows. In some cases, problems were not created even though the capacity of the system component was exceeded—for example in inundated areas that were undeveloped and in which no buildings, transportation facilities, or other damage-prone improvements were affected; and in areas where Standard Number 3 of Objective Number 1 as set forth in Chapter IV of Volume One—relating to acceptable levels of street flooding during a 10-year recurrence interval event—was satisfied.

Map 2 shows the locations of those existing system components that were found to have inadequate hydraulic capacity and the attendant problems under existing and planned land use conditions. A brief description of these problems is provided in Table 1. Problems were not identified in Hydrologic Units A, G, H, I, and J. The identified problems can be grouped into one of the following two general types:

1. The hydraulic capacity of a culvert, storm sewer, or open channel is exceeded under both existing and planned land use conditions and may be expected to result in the inundation of adjacent streets and associated urban development.

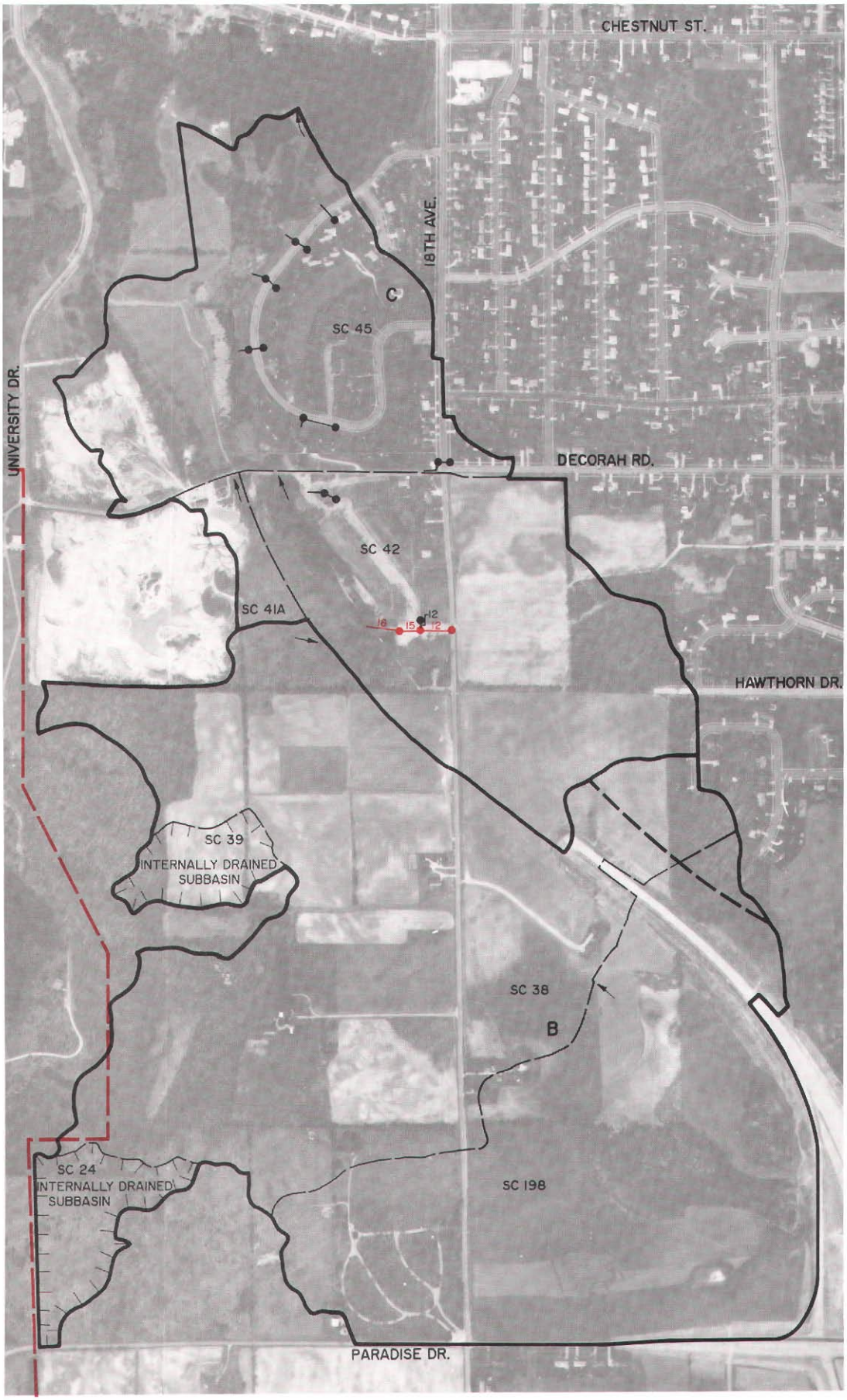
2. The hydraulic capacity of a culvert, storm sewer, or channel is not exceeded under existing land use conditions but is expected to be exceeded under planned land use conditions, and may be expected to result in the inundation of adjacent streets and associated urban development.

In addition, areas of significant stream bank erosion related to stormwater drainage were identified, as set forth in Chapter II of Volume One of this report.

Map 2

IDENTIFIED POTENTIAL PROBLEM AREAS IN THE EXISTING CITY OF WEST BEND STORMWATER DRAINAGE SYSTEM WITHIN THE SILVER CREEK SUBWATERSHED UNDER PLANNED LAND USE CONDITIONS

HYDROLOGIC UNITS B AND C



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- B — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 198 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA

COMPONENTS WITH IDENTIFIED CAPACITY PROBLEMS

- MANHOLE OR CATCH BASIN
- 12 — STORM SEWER (SIZE IN INCHES)

COMPONENTS WITH ADEQUATE CAPACITY ASSUMING NO SIGNIFICANT SURCHARGING AND RELATED STREET FLOODING

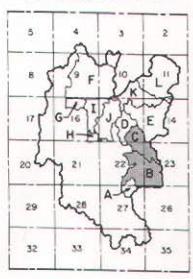
- MANHOLE OR CATCH BASIN
- 12 — STORM SEWER (SIZE IN INCHES)

TYPE OF STORM SEWER

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



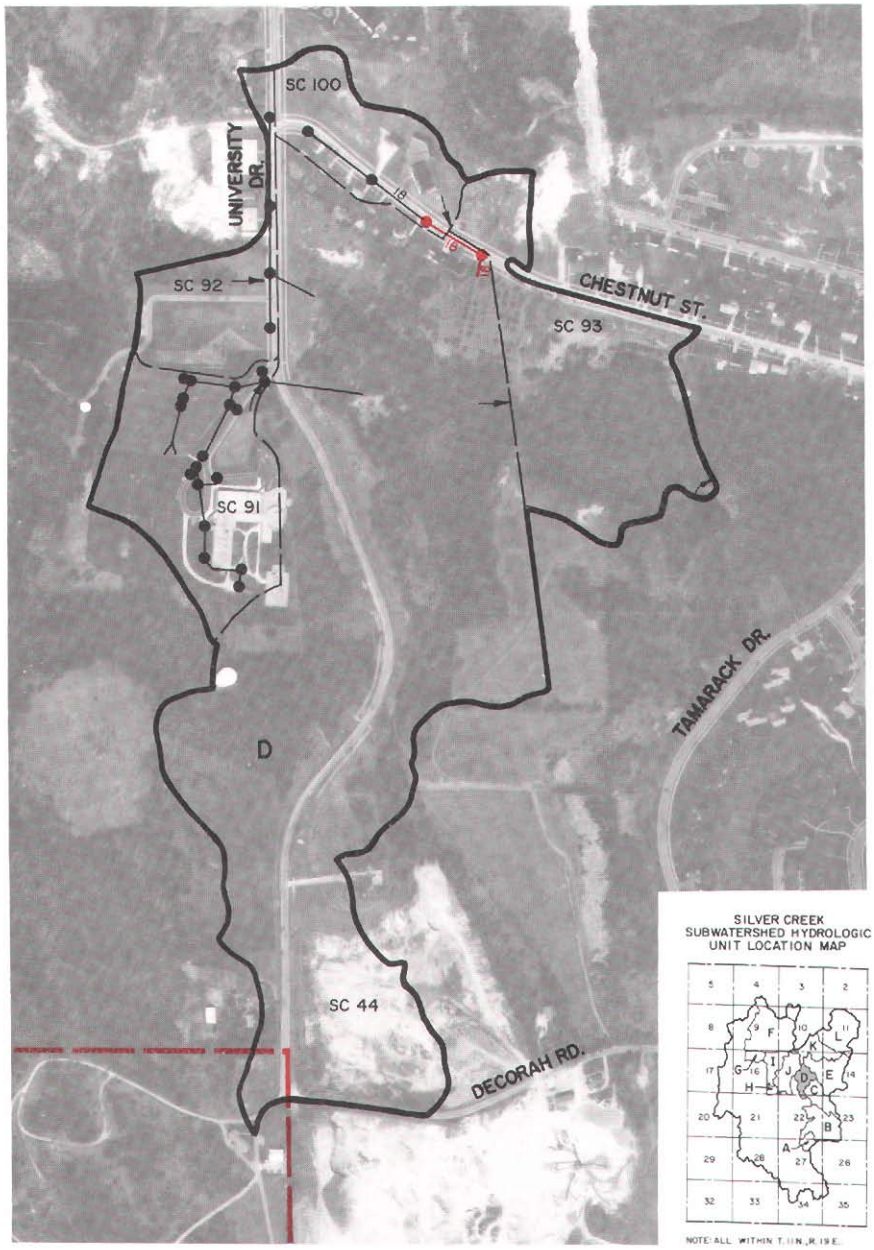
NOTE: ALL WITHIN T.11N., R.19E.

GRAPHIC SCALE

0 400 800 FEET

Map 2 (continued)

IDENTIFIED POTENTIAL PROBLEM AREAS IN THE EXISTING CITY OF WEST BEND STORMWATER DRAINAGE SYSTEM WITHIN THE SILVER CREEK SUBWATERSHED UNDER PLANNED LAND USE CONDITIONS HYDROLOGIC UNIT D



SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

NOTE: ALL WITHIN T.11N.,R.19E.

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- D — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 100 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA

COMPONENTS WITH IDENTIFIED CAPACITY PROBLEMS

- MANHOLE OR CATCH BASIN
- 18 — STORM SEWER (SIZE IN INCHES)

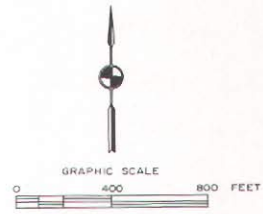
COMPONENTS WITH ADEQUATE CAPACITY ASSUMING NO SIGNIFICANT SURCHARGING AND RELATED STREET FLOODING

- MANHOLE OR CATCH BASIN
- 18 — STORM SEWER (SIZE IN INCHES)

TYPE OF STORM SEWER

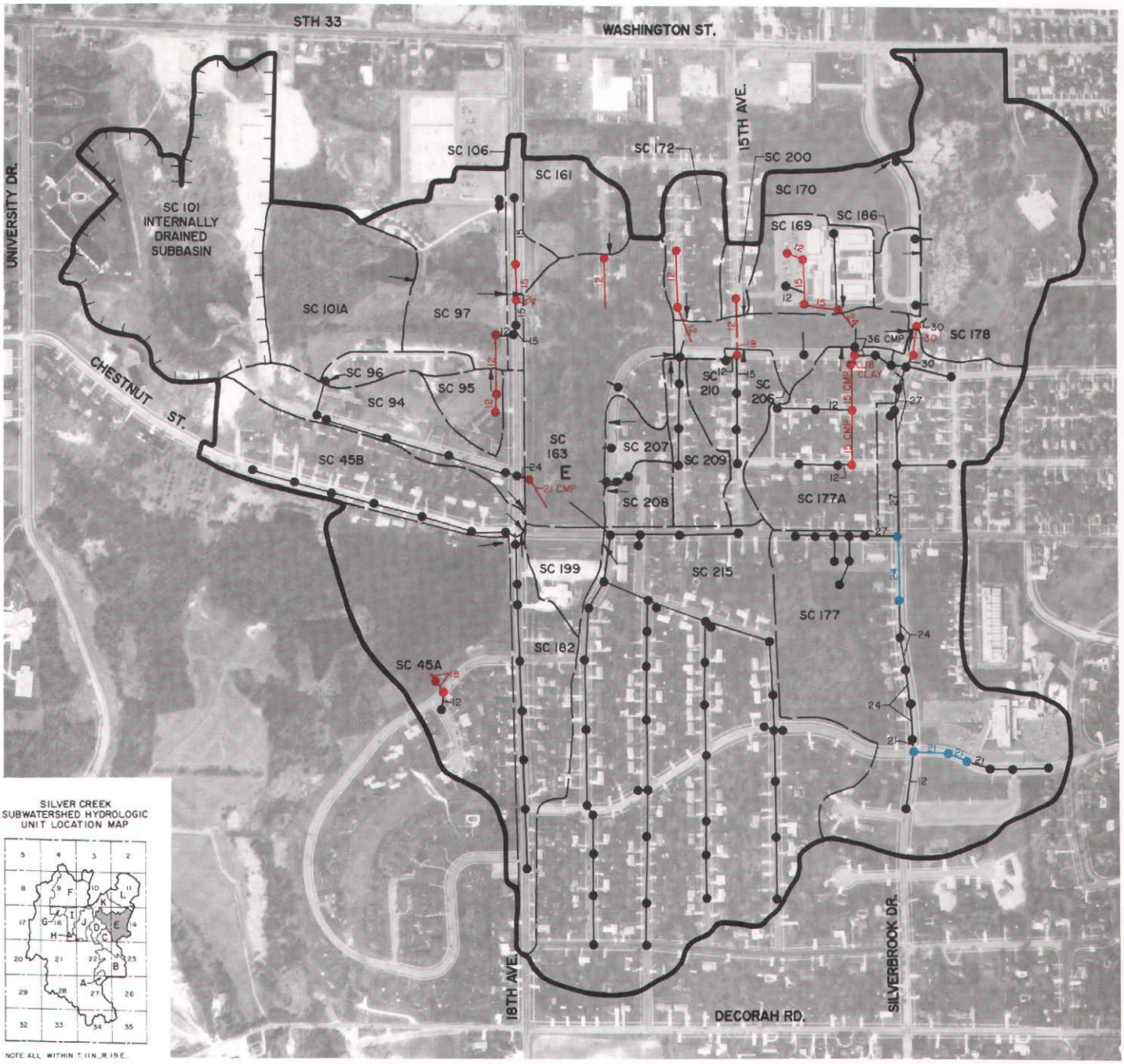
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS



IDENTIFIED POTENTIAL PROBLEM AREAS IN THE EXISTING CITY OF WEST BEND STORMWATER DRAINAGE SYSTEM WITHIN THE SILVER CREEK SUBWATERSHED UNDER PLANNED LAND USE CONDITIONS

HYDROLOGIC UNIT E



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- E — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 208 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET

COMPONENTS WITH IDENTIFIED CAPACITY PROBLEMS

- MANHOLE OR CATCH BASIN
- 12 — STORM SEWER (SIZE IN INCHES)

COMPONENTS WITH ADEQUATE CAPACITY ASSUMING STREET AND GUTTER CONVEY FLOW UP TO THE LEVEL PERMITTED BY STANDARD NO. 3 OF OBJECTIVE NO. 1 IN VOLUME 1, CHAPTER IV

- MANHOLE OR CATCH BASIN
- 21 — STORM SEWER (SIZE IN INCHES)

COMPONENTS WITH ADEQUATE CAPACITY ASSUMING NO SIGNIFICANT SURCHARGING AND RELATED STREET FLOODING

- MANHOLE OR CATCH BASIN
- 12 — STORM SEWER (SIZE IN INCHES)

TYPE OF STORM SEWER

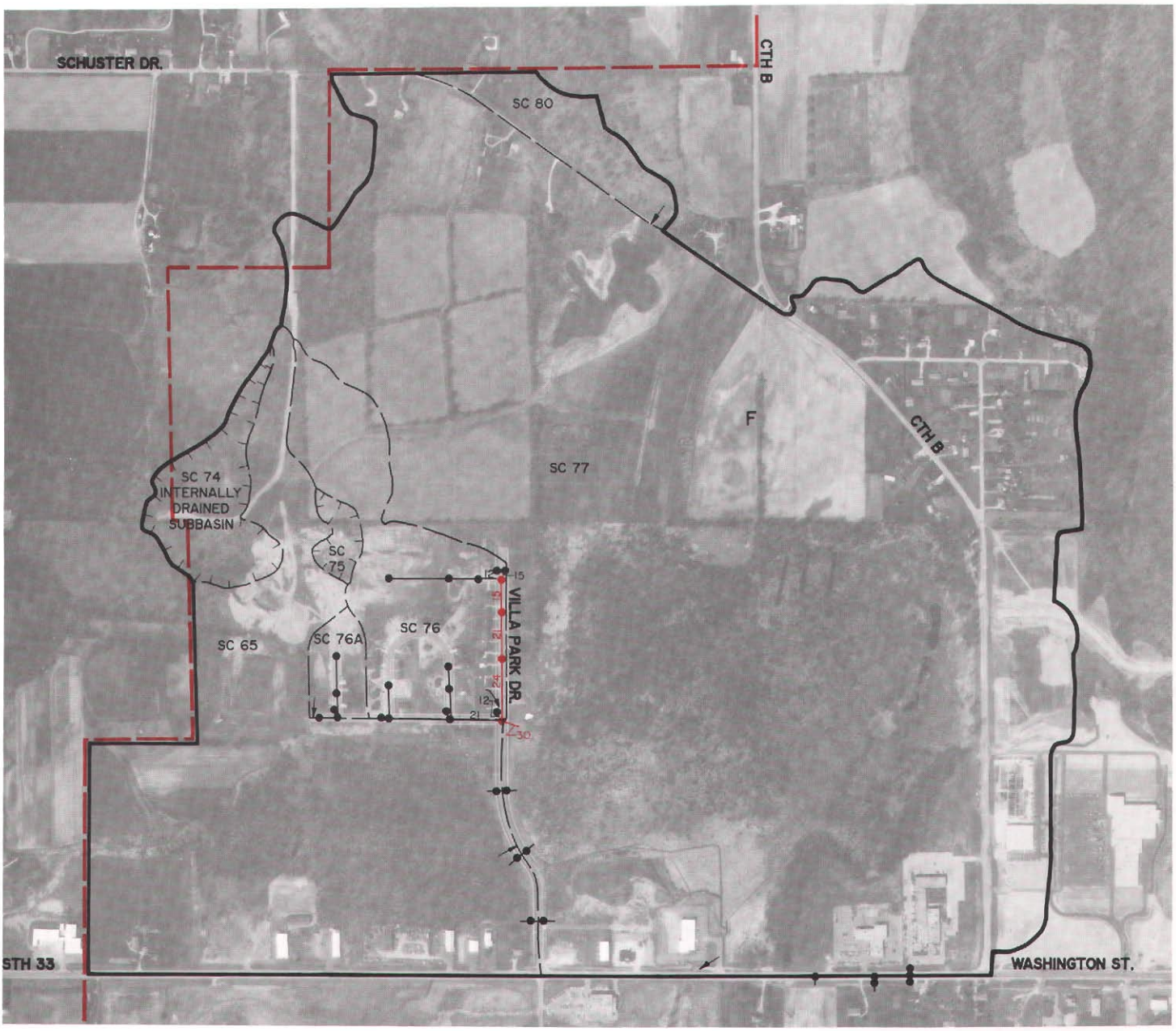
- CMP — CORRUGATED METAL PIPE
- CLAY — CLAY PIPE
- NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

IDENTIFIED POTENTIAL PROBLEM AREAS IN THE EXISTING CITY OF WEST BEND STORMWATER DRAINAGE SYSTEM WITHIN THE SILVER CREEK SUBWATERSHED UNDER PLANNED LAND USE CONDITIONS

HYDROLOGIC UNIT F



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- F — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 76 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA

COMPONENTS WITH IDENTIFIED CAPACITY PROBLEMS

- MANHOLE OR CATCH BASIN
- 15 — STORM SEWER (SIZE IN INCHES)

COMPONENTS WITH ADEQUATE CAPACITY ASSUMING NO SIGNIFICANT SURCHARGING AND RELATED STREET FLOODING

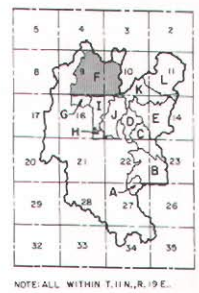
- MANHOLE OR CATCH BASIN
- 12 — STORM SEWER (SIZE IN INCHES)

TYPE OF STORM SEWER

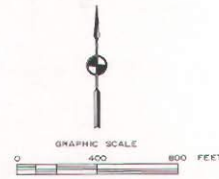
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



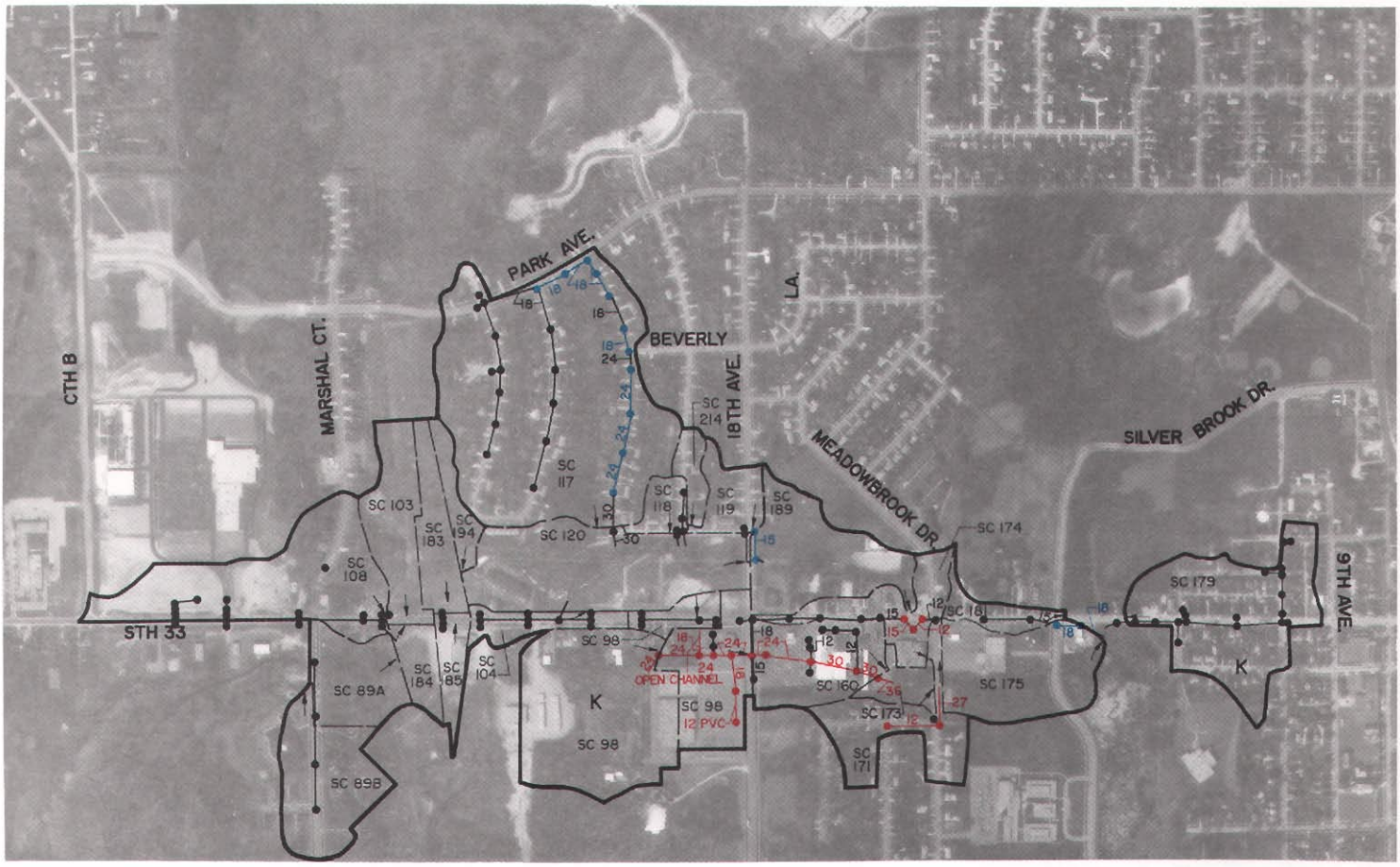
NOTE: ALL WITHIN T.11 N., R.19 E.



Map 2 (continued)

IDENTIFIED POTENTIAL PROBLEM AREAS IN THE EXISTING CITY OF WEST BEND STORMWATER DRAINAGE SYSTEM WITHIN THE SILVER CREEK SUBWATERSHED UNDER PLANNED LAND USE CONDITIONS

HYDROLOGIC UNIT K



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- K — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 175 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET

COMPONENTS WITH IDENTIFIED CAPACITY PROBLEMS

- MANHOLE OR CATCH BASIN
- 24 — STORM SEWER (SIZE IN INCHES)

COMPONENTS WITH ADEQUATE CAPACITY ASSUMING STREET AND GUTTER CONVEY FLOW UP TO THE LEVEL PERMITTED BY STANDARD NO. 3 OF OBJECTIVE NO. I IN VOLUME I, CHAPTER IV

- MANHOLE OR CATCH BASIN
- 24 — STORM SEWER (SIZE IN INCHES)

COMPONENTS WITH ADEQUATE CAPACITY ASSUMING NO SIGNIFICANT SURCHARGING AND RELATED STREET FLOODING

- MANHOLE OR CATCH BASIN
- 24 — STORM SEWER (SIZE IN INCHES)

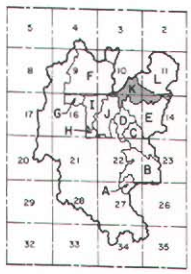
TYPE OF STORM SEWER

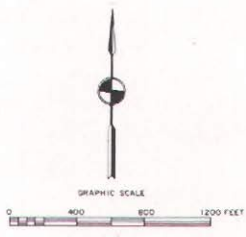
- PVC — POLYVINYL CHLORIDE PIPE

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

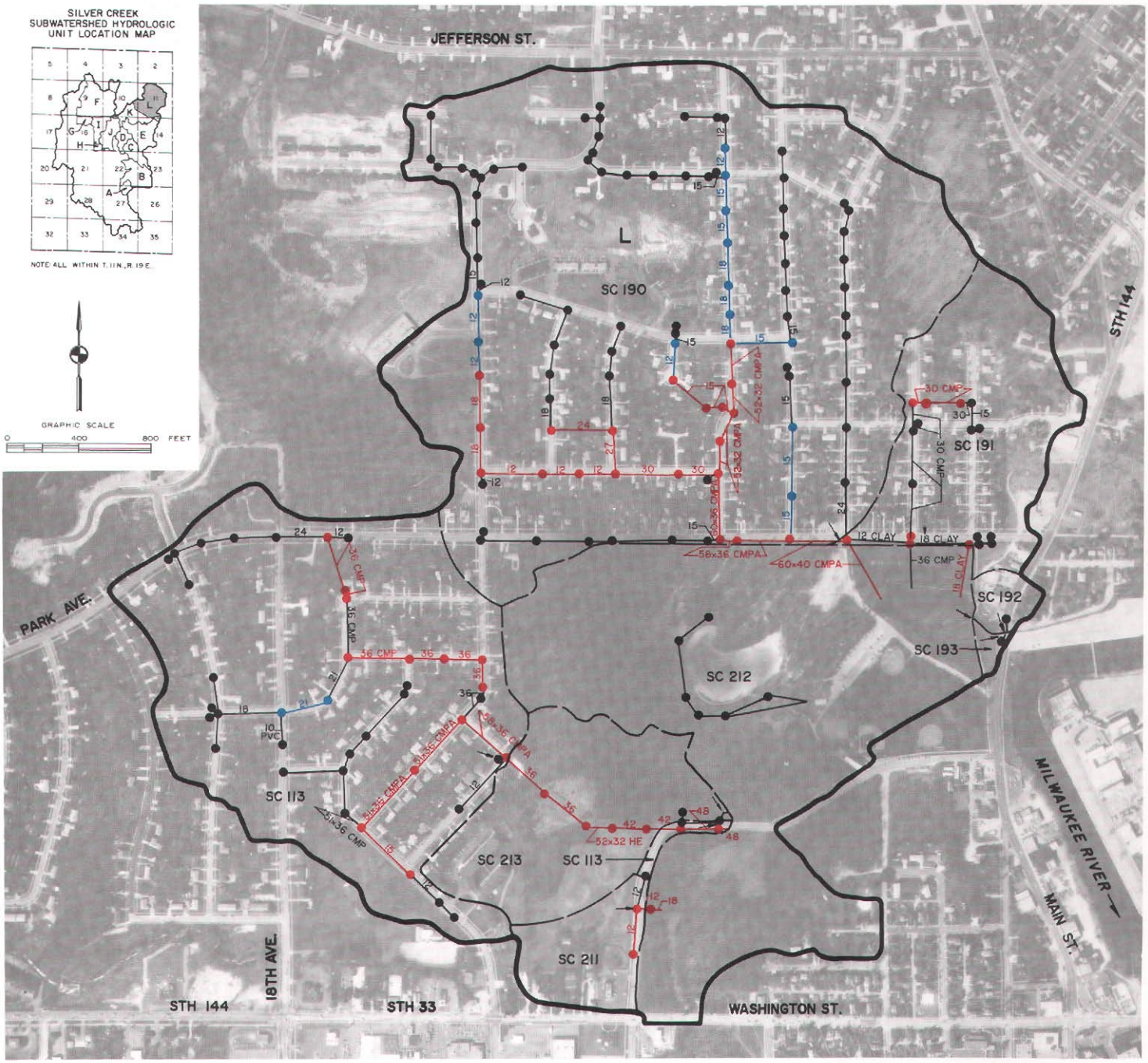




Map 2 (continued)

IDENTIFIED POTENTIAL PROBLEM AREAS IN THE EXISTING CITY OF WEST BEND STORMWATER DRAINAGE SYSTEM WITHIN THE SILVER CREEK SUBWATERSHED UNDER PLANNED LAND USE CONDITIONS

HYDROLOGIC UNIT L



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- L — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 212 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET

COMPONENTS WITH IDENTIFIED CAPACITY PROBLEMS

- MANHOLE OR CATCH BASIN
- STORM SEWER (SIZE IN INCHES)

COMPONENTS WITH ADEQUATE CAPACITY ASSUMING STREET AND GUTTER CONVEY FLOW UP TO THE LEVEL PERMITTED BY STANDARD NO. 3 OF OBJECTIVE NO. 1 IN VOLUME 1, CHAPTER IV

- MANHOLE OR CATCH BASIN
- STORM SEWER (SIZE IN INCHES)

COMPONENTS WITH ADEQUATE CAPACITY ASSUMING NO SIGNIFICANT SURCHARGING AND RELATED STREET FLOODING

- MANHOLE OR CATCH BASIN
- STORM SEWER (SIZE IN INCHES)

TYPE OF STORM SEWER

CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CLAY	CLAY PIPE

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

Source: SEWRPC.

Table 1

IDENTIFIED PROBLEM AREAS IN THE EXISTING SILVER CREEK SUBWATERSHED UNDER EXISTING AND PLANNED LAND USE CONDITIONS[a]

Subbasin Designation	System Component	Location	System Component Description[b,c]	Problem Under Existing (E) or Planned (P) Land Use Conditions
191	Minor	Regner Park south of intersection of Park Avenue and 8th Avenue	18-inch clay	E
191	Major	Between 9th Avenue and 8th Avenue north of High Street	30-inch CMP	E
190	Minor	Regner Park south of intersection of Park Avenue and 10th Avenue	60" x 40" CMPA	E
190	Minor	Park Avenue from 10th Avenue to 11th Avenue	60" x 40" CMPA	E
190	Major	Park Avenue from 11th to 12th Avenue	58" x 36" CMPA	E
190	Major	12th Avenue from Alder to Park Avenue	60" x 36" CMPA	E
190	Major	12th Avenue north of Alder Street	52" x 32" CMPA	E
190	Minor	12th Avenue from Wayne Road to the south	52" x 32" CMPA	E
190	Major	Alder Street from Angela Court to 12th Avenue	30 inches	E
190	Major	Alder Street from 13th Avenue to Angela Court	30 inches	E
190	Minor	Alder Street from Green Tree Road to 13th Avenue	12 inches	E
190	Minor	Green Tree Road north of Alder Street	18 inches	E
190	Major	From 13th to 14th Avenues north of Alder Street	24 inches	E
190	Major	From Glen Court southeast to Alder Street	15 inches	E
113	Minor	Silverbrook Drive west of Silver Creek	48 inches	E
113	Minor	Silverbrook Drive and Wood Way extended west of Silver Creek	42 inches	E
113	Minor	Wood Way extended	36 inches	E
113	Major	Wood Way from Sherman Way to Green Tree Road	58" x 36" CMPA	E
113	Major	Green Tree Road from Meadowbrook Drive to Wood Way	51" x 36" CMPA	E
113	Minor	Meadowbrook Drive from Green Tree Road to Sherman Way	15 inches	P
113	Major	Green Tree Road from Sherwood Place to the south	36 inches	E
113	Major	Sherwood Place from Green Tree to Meadowbrook Drive	36 inches	E

Table 1 (continued)

Subbasin Designation	System Component	Location	System Component Description[b,c]	Problem Under Existing (E) or Planned (P) Land Use Conditions
113	Major	Sherwood Place from Meadowbrook Drive to Beverly Lane	36-inch CMP	E
211	Minor	Silver Creek to Silverbrook Drive north of Washington Street	18 inches	E
211	Minor	Silverbrook Drive west of Silver Creek and north of Washington Street	12 inches	E
171	Minor	15th Avenue from Concord Lane to Silver Creek	27 inches	E
171	Minor	Concord Lane from 15th Avenue to 16th Avenue	12 inches	E
160	Minor	West of 15th Avenue between Washington Street and Concord Lane	36 inches	E
160	Minor	West of 15th Avenue between Washington Street and Concord Lane	30 inches	E
160	Minor	South of Washington Street and east of 18th Avenue (Farm and Fleet parking lot)	30 inches	E
98/160	Minor	South of Washington Street from east of 18th Avenue to west of 18th Ave	24 inches	E
98	Minor	West of 18th Avenue and south of Washington Street (K-Mart parking lot)	24 inches	E
98	Minor	West of 18th Avenue and south of Washington Street (K-Mart parking lot)	12 inches	E
98	Minor	West of 18th Avenue and south of Washington Street (K-Mart parking lot)	18 inches	E
98	Minor	South of Washington Street and west of State Central Credit Union Building	Open ditch with adverse slope	E
174	Major	Southwest of intersection of 15th Avenue and Washington Street (Red Owl Store parking lot)	15 inches	E
174	Major	Southwest of intersection of 15th Avenue and Washington Street (Red Owl Store parking lot)	12 inches	E
177	Minor	Silverbrook Drive south of Silverbrook Creek	30 inches	E
177A	Major	Walnut Street west of Silverbrook Drive	18-inch clay	E
177A	Major	West of Silverbrook Drive between Balsam Place and Poplar Street	15-inch CMP	E
169	Minor	Silverbrook School west of Silverbrook Drive and north of Silverbrook Creek	24 inches	E

Table 1 (continued)

Subbasin Designation	System Component	Location	System Component Description[b,c]	Problem Under Existing (E) or Planned (P) Land Use Conditions
169	Minor	Silverbrook School parking lot east of 15th Avenue and north of Silverbrook Creek	15 inches	E
210	Minor	15th Avenue from Silverbrook Creek to the south	18 inches	E
200	Major	15th Avenue from Silverbrook Creek to the north	12 inches	E
172	Major	16th Avenue from Silverbrook Creek to the north	12 inches	E
94	Minor	From Miller Street and 18th Avenue southeast to Silverbrook Creek	21-inch CMP	E
100	Major	Chestnut Street west of USH 45	18 inches	E
161	Minor	Concord Lane	12 inches	E
106	Major	18th Avenue north of tributary to Silverbrook Creek	15 inches	E
95	Minor	Northwest of Miller Street and 18th Avenue	12 inches	P
45A	Minor	Tamarack Drive and Tamarack Court	18 inches	E
42	Major	Julen Circle west of 18th Avenue	12 inches	P
42	Major	Julen Circle west of 18th Avenue	15 inches	P
42	Major	Julen Circle west of 18th Avenue	18 inches	P
76	Minor	Southeast of Villa Park Drive and Stanford Lane	30 inches	P
76	Minor	Villa Park Drive north of Stanford Lane	24 inches	P
76	Minor	Villa Park Drive north of Stanford Lane	21 inches	P
76	Minor	Villa Park Drive and Mediterranean Avenue	15 inches	P

NOTE: CMP = Corrugated metal pipe
CMPA = Corrugated metal pipe arch

[a]*System components have inadequate hydraulic capacity resulting in inundation of streets and adjacent land.*

[b]*Reinforced concrete pipe unless specified otherwise.*

[c]*Anticipated exceedance of the hydraulic capacity of the system structures is based on calculated stormwater flows during a 10-year recurrence interval storm event for the minor system components, and during a 100-year recurrence interval event for the major system components. In instances where a trunk storm sewer line conveys flow from both an upstream storm sewer branch required to pass the runoff from a 100-year storm event owing to inadequate hydraulic capacity of the street and an upstream storm sewer branch required to pass only the runoff from a 10-year storm event, the trunk storm sewer is classified as a component of the major system. In such a case, the required capacity of the trunk sewer would actually be greater than the flow resulting from a 10-year storm event occurring over the area tributary to the trunk storm sewer, but less than the flow resulting from a 100-year recurrence interval storm event.*

Source: SEWRPC.

Chapter III

DESCRIPTION AND EVALUATION OF ALTERNATIVE STORMWATER MANAGEMENT APPROACHES

INTRODUCTION

As indicated in Chapter II of Volume One of this report, urban land use within the planning area may be expected to increase significantly between 1985 and the year 2010. This urbanization may be expected to produce an increase in the peak rate and the volume of stormwater runoff for a given storm event. Stormwater runoff from urban land also contains different types—and, in some cases, increased amounts—of pollutants compared to stormwater runoff from undeveloped land. Increased urbanization, accordingly, may be expected to place increased demands on the existing stormwater management system, requiring additional engineered drainage facilities to accommodate the increased loadings. The facilities are designed to minimize the occurrence of stormwater management problems and the associated disruption of the urban environment and adverse water quality impacts.

To accommodate these increased loadings and to abate existing, as well as future, stormwater management problems, several stormwater management approaches were considered. These approaches to stormwater management were first evaluated on a conceptual basis, considering the technical feasibility, applicability, and advantage and disadvantages of each approach. Elements of the most feasible approaches were then incorporated into four systems-level alternative stormwater management plans for the portion of the planned urban service area of the City of West Bend that lies within the Silver Creek subwatershed.

ALTERNATIVE STORMWATER MANAGEMENT APPROACHES

Alternative approaches to stormwater management that were considered for application in the West Bend area included conventional conveyance, centralized detention, decentralized or onsite detention, centralized retention, decentralized or onsite retention, "blue-green" systems, and nonstructural measures. Pertinent characteristics of each of these alternative approaches are set forth in Table 2. Based upon consideration of these characteristics, the general feasibility and applicability of each approach to the West Bend area were determined.

Storm Sewer Conveyance

This conveyance approach would utilize storm sewers and concrete-lined or composite channels and related appurtenances to provide for the collection and rapid conveyance of stormwater runoff to the receiving streams within the urban service area. The major advantages of this type of system are the minimization of onsite inconvenience because the water is rapidly collected and conveyed downstream, and ready applicability to both existing and newly developing urban areas. Nonpoint source pollution abatement measures appropriate under this approach would be increased street and parking lot sweeping, improved leaf collection, construction site erosion control and pet waste control, onsite infiltration devices, and public education programs. Properly designed, constructed, and maintained storm sewers present no hazard to the public health and safety; and the hydraulic design procedures, as well as the construction techniques, are simple, well developed, and commonly used. The disadvantages of the conveyance approach are that downstream peak flows and stages may be increased, leading to a possible increase in areas of inundation and in the potential for stream bank erosion, streambed scour, and loss of habitat; pollutants are not removed from the runoff; there is little potential for multipurpose uses of the system; and this approach usually has a high capital cost.

Since most of the developed portion of the City of West Bend currently relies on a storm sewer conveyance system, further application of the conveyance approach would represent a continuation of the existing practices and policies. Hence, this approach would likely be understood and accepted by local public officials and citizens alike. Technically, existing stormwater problems experienced by the City, as well as probable future problems, could be most surely and effectively abated using the conveyance approach. In the Silver Creek subwatershed, existing natural and man-made detention basins

Table 2

CHARACTERISTICS OF ALTERNATIVE STORMWATER MANAGEMENT APPROACHES

Characteristic	Conveyance	Centralized Detention	Onsite Detention	Centralized Retention	Onsite Retention	"Blue-Green" System	Nonstructural
Function	Provide for the collection of stormwater runoff and the rapid conveyance of stormwater from the area so as to minimize disruptive and possibly damaging surface ponding in streets and low-lying areas and possible inundation of residential and other sites and structures	Provide for the temporary storage of stormwater runoff in the service area for subsequent slow release to downstream channels or storm sewers, thus minimizing disruption and damage within and downstream of the service area and reducing the required size and therefore cost of any constructed downstream conveyance facilities	Provide for the temporary storage of stormwater runoff at small sites located close to the source of the runoff to be controlled	Provide for the storage of stormwater runoff for subsequent evaporation and infiltration to groundwater, thus removing the area runoff from the surface drainage system and reducing the required size and therefore cost of downstream conveyance facilities	Provide for the storage of stormwater runoff for subsequent evaporation and infiltration to groundwater at small sites located close to the source of generation of the runoff to be retained	Provide for the temporary storage and/or conveyance of stormwater runoff using natural or vegetated channels which slow the runoff rate and allow a portion of the runoff to infiltrate into the soil	Primarily to reduce damages from excessive stormwater runoff and flooding, rather than controlling the runoff rates or flood levels themselves
Components Principal	Improved open drainage channels, storm sewers, and roadside swales	Surface or subsurface detention facilities	Parking lot storage facilities Rooftop storage facilities Relatively small detention facilities Swales, over-sized channels, and diversions	Surface retention facilities Construction site erosion and pet waste control	Relatively small surface retention facilities Subsurface infiltration systems (drywells, etc.)	Open vegetated channels Swales Natural surface depressions and wetlands Over-sized channels Ponds and lakes Construction site erosion and pet waste control	Floodproofing of structures Relocation of structures Land use regulations Open space and floodland preservation Increased street and parking lot sweeping Improved leaf collection Construction site erosion and pet waste control
Secondary	Storm inlets Culverts Outfalls Manholes Increased street and parking lot sweeping Improved leaf collection Construction site erosion and pet waste control	Open drainage channels Storm inlets Culverts Outfalls Manholes Inlet and outlet works and/or pumping facilities Construction site erosion and pet waste control	Same as centralized detention	Open drainage channels Storm inlets Culverts Outfalls Manholes	Same as centralized retention	A "blue-green" system may be supplemented with storm sewers, storm inlets, outfalls, manholes, and culverts	Can be used with other stormwater management facilities
Applicability	Suitable for installation in existing and newly developing urban areas	Most suitable for incorporation in newly developing urban areas if suitable surface or subsurface sites are available	Suitable for installation in existing and newly developing urban areas. May be more suitable than centralized detention in many existing urban areas because of reduced site requirements	Most suitable for incorporation in newly developing urban areas with permeable soils but may be used in existing urban areas if suitable sites are available	Same as centralized retention	Suitable for incorporation in developing urban areas. A "blue-green" system may be undesirable in moderate- or high-density urban development and it may be difficult to develop an economically feasible open channel system which can accommodate the high peak flows from developed urban areas	Suitable for implementation in existing and newly developing urban areas
Downstream Impact Quantity	Tends to significantly increase—relative to predevelopment conditions—downstream discharges, stages, and areas of inundation	May be designed to cause no significant increase, relative to predevelopment conditions, in downstream discharges, stages, and areas of inundation. Decreased discharges, stages, and areas of inundation are possible	Same as centralized detention, although onsite detention facilities are designed for smaller storms and shorter detention times than are centralized detention facilities	Same as centralized detention	Same as onsite detention	May be designed to allow storm runoff to be temporarily stored in a low gradient channel, reducing downstream peak discharge	Minimal impact, although preservation of open space lands may maintain higher levels of natural storage and infiltration than if these lands were developed
Quality	A relatively low level of removal of pollutants from nonpoint sources would be achieved by a storm sewer conveyance system, but significant levels of removal are possible with a roadside swale system	Provides for removal, by the natural settling process, of sediment and other suspended material, thus reducing the pollutant loading on receiving waters. Provides an opportunity for physical-chemical treatment such as disinfection, coagulation-flocculation, and swirl concentration	Provides some pollutant removal, but may be less than by centralized detention if detention time is shorter. Less opportunity for physical-chemical treatment than with centralized facilities	Provides removal of suspended and settleable pollutants but dissolved pollutants may percolate to the water table without reduction	Same as centralized retention	Provides for removal of pollutants in storm runoff by infiltration into the soil, settling of solids, and filtration by vegetation	Minimal impact

Table 2 (continued)

Characteristic	Conveyance	Centralized Detention	Onsite Detention	Centralized Retention	Onsite Retention	"Blue-Green" System	Nonstructural
Multipurpose Capability	*Storm sewers* serve only a stormwater collection and conveyance function Open drainage channels can provide a focus for development of linear park and open space areas	Quantity control Quality control Can provide park and open space areas	Same as centralized detention	Quantity control Quality control *Recreation benefits* Aesthetic benefits Groundwater recharge Wildlife habitat	Same as centralized retention	Quantity control Quality control Park and open space areas *Aesthetic benefits* Wildlife habitat	Park and open space areas
Operation and Maintenance Requirements	Periodic cleaning and repair of storm inlets, channels, and storm sewers required Maintenance of open channel lining material required Increased street and parking lot sweeping Improved leaf collection	Pumping and/or inlet-outlet control operation and maintenance required Insect and odor control may be required Periodic cleaning and maintenance of facility lining required Dam maintenance may be required	Same as centralized detention except that maintenance of onsite facilities may be less intensive but required at a larger number of sites	Operation and maintenance required Sediment removal required Insect control may be required Weed and algae control and water pollution control may be required Bank maintenance required	Same as centralized retention except that maintenance of onsite facilities may be less intensive but required at a larger number of sites	Periodic cleaning of channels and inlets required Maintenance of open channel vegetative cover required	Increased street and parking lot sweeping Improved leaf collection
Impact on Sanitary Sewer System	Surcharging of storm sewers accompanied by inundation of streets may result in infiltration of stormwater from storm sewers to adjacent sanitary sewers and inflow of stormwater into sanitary sewers through manholes. Flow in excess of stormwater channel capacity may also result in surface inundation and inflow into sanitary sewers	Runoff volumes in excess of available storage volume, and runoff rates in excess of the capacity of tributary storm sewers and channels, accompanied by inundation of streets may result in infiltration of stormwater from storm sewers to adjacent sanitary sewers and inflow of stormwater into sanitary sewers through manholes	Same as centralized detention	Percolation waters may result in excessive infiltration of stormwater into sanitary sewers	Same as centralized retention	Exceedence of channel capacity accompanied by inundation of streets may result in infiltration of stormwater into adjacent sanitary sewers and inflow of stormwater into sanitary sewers through manholes	Minimal
Hazards	Minimal hazard associated with storm sewers High velocities in roadside swales and improved open channels may pose a safety hazard, particularly to children	Minimal hazard associated with subsurface storage, but surface storage may pose a health and safety hazard, particularly to children	Ponded water in parking lots, small detention facilities, and swales may pose a health and safety hazard, particularly to children, though the size and depth of onsite facilities are frequently minimal	Ponded water may pose a health and safety hazard, particularly to children	Ponded water may pose a health and safety hazard, particularly to children, though the size and depth of onsite facilities are frequently minimal	Flowing channels may pose a health and safety hazard, particularly to children	Minimal
Hydrologic-Hydraulic Analysis	Requires determination only of the peak rate of flow associated with a specified recurrence interval. This is normally obtained with the relatively simple and widely accepted rational method	Requires determination of both a peak rate and a volume of inflow associated with a specified recurrence interval, an estimate of allowable outflow rate and storage, and design of pumps or control works to satisfy the discharge conditions. A hydrograph-developing technique *must be used to* simulate peak flow and volume conditions	Same as centralized detention	Requires determination of both a peak rate and a volume of inflow associated with a specified recurrence interval and estimate of percolation rate and storage to satisfy conditions. A hydrograph-developing technique must be used to simulate peak flow and volume conditions	Same as centralized retention	Requires determination of peak rate of flow, flow volumes, velocity, and flow depths. This can be obtained by using the hydrograph-developing technique	Requires delineation of areas affected by flooding and poor stormwater drainage. The Hydrologic Engineering Center (HEC-2) model may be used to determine flood stages under various recurrence interval storm events
Ability to Meet Stormwater Management Objectives and Supporting Standards	All objectives and supporting standards can be met	All objectives and supporting standards can be met	All objectives and supporting standards can be met	All objectives and supporting standards can be met	All objectives and supporting standards can be met	Some objectives and supporting standards would probably not be met because of the difficulty in accommodating the design flows efficiently and economically using this approach	This alternative would not satisfy the recommended objectives and supporting standards by itself, and must be combined with other alternatives

Source: SEWRPC.

located downstream from areas of planned development would attenuate peak flows from areas served by conveyance systems, thereby reducing the downstream impacts of increased flows. Given the advantages of the conveyance approach, it was utilized in the development of alternative stormwater management plans for the West Bend area.

Roadside Swale Conveyance

This conveyance approach would utilize roadside swales and grass-lined or natural channels to provide for the collection and conveyance of stormwater runoff to receiving streams. The major advantages of this type of system are relatively low cost; some reduction in peak flow rates and volumes in comparison with storm sewer conveyance due to increased flow travel times, in-line storage, and infiltration of runoff through the swale sides and bottom; and a reduction in nonpoint source pollutant loadings due to infiltration and filtering. The disadvantages of the roadside swale conveyance approach include potential safety hazards and difficulties in adapting such a system to areas of higher density development where right-of-way is limited and driveway culverts are closely spaced.

At present, there is only limited application of roadside swale conveyance systems within the City of West Bend. The general policy of the City is to provide full curb and gutter and storm sewers in developing areas. Use of roadside swale conveyance systems outside areas of low-density development may be resisted by public officials and citizens. Given the advantages of the roadside swale conveyance approach, it was utilized in areas of existing or planned low-density development when formulating alternative stormwater management plans for the West Bend area.

Centralized Detention

A centralized detention approach would utilize major surface or subsurface detention facilities to provide for the temporary storage of stormwater runoff for subsequent slow release to downstream channels or storm sewers. The centralized detention facilities would be located on a few strategic sites to maximize benefits, and not all areas would drain to a centralized facility. The centralized detention facilities could be supplemented by improved conveyance facilities as necessary. Nonpoint source pollution control can be provided by various types of centralized detention facilities, along with measures such as construction site erosion control and pet waste control.

The major advantages of a centralized detention approach are that if properly applied, the facilities can limit the effects of urban development on downstream discharges, areas of inundation, stream bank erosion, streambed scour, and aquatic habitat; a substantial amount of sediment and other particulate pollutants can be removed; the size and resultant cost of downstream conveyance facilities can be reduced; and the facilities can be combined with recreation and open space areas to provide multipurpose-use areas. The disadvantages of a centralized detention approach are that large, relatively level, open areas are usually required, thereby reducing the availability of potential sites; the facility may not be cost-effective if the site costs cannot be offset by providing smaller conveyance facilities downstream; the operation and maintenance requirements may be substantial; for a permanent pool facility, the ponded water may be perceived as a public health and safety hazard; and odor and insect problems may be produced. While readily applicable as an integral part of large-scale urban development proposals, the approach is more difficult to apply to areas of existing urban development.

Within the West Bend area, centralized detention facilities could be used to abate some of the existing and potential stormwater runoff problems. Higher maintenance requirements and an opposition to ponds or dry basins in urban areas by some citizens for aesthetic or health and safety reasons may make this approach unacceptable in the service area. Because of its potential benefits, however, the centralized detention approach was utilized in the development of alternative stormwater management plans.

Onsite Detention

Like centralized detention, onsite detention provides for the temporary storage of stormwater runoff, but the storage sites are located close to, or at, the source of runoff generation. Hence, these detention sites tend to be smaller than centralized detention facilities. Onsite detention measures include small detention basins, parking lot storage, swales, and large channels with gentle slopes. Onsite detention is, in effect, included in all alternative approaches to stormwater management in the West Bend

area, since the Commission recommends the preservation of most of the remaining floodlands, wetlands, and other natural open areas, all of which effectively serve as onsite detention areas. The onsite detention systems, like the centralized detention systems, can also be supplemented by improved conveyance facilities. Nonpoint source control can be achieved by various types of onsite detention measures, along with measures such as construction site erosion control and pet waste control.

The advantages of the onsite detention approach are similar to those of the centralized detention approach with regard to downstream water quantity and quality control and to the potential for reducing the size of downstream conveyance systems. Onsite facilities, however, have smaller unit site requirements than do centralized facilities, and therefore may be more readily applicable—although not without difficulty—in existing as well as newly developing urban areas. Onsite facilities may be less suitable for multipurpose uses such as recreation and open space, but more suitable for uses such as parking or yard space in residential areas. The disadvantages of the onsite detention approach are that maintenance requirements may be substantial; the ponded water in a detention pond may cause localized inconvenience and represent a health and safety hazard; odor and insect problems may be produced; and the costs may be high if not offset by smaller downstream conveyance systems. While readily applicable as an integral part of large-scale urban development proposals, the concept is difficult to effectively implement with small-scale, piecemeal development proposals and in areas of existing urban development.

The onsite detention approach could be used to abate the existing and potential stormwater runoff problems in the West Bend area. Although there may be some citizen opposition to ponded water in urban areas, the smaller affected sites and greater availability of potential sites may make this approach more acceptable than the centralized approach. Because of its potential benefits, the onsite detention approach was utilized in the development of alternative stormwater management plans.

Centralized Retention

Retention facilities provide for the storage of stormwater runoff for subsequent evaporation and/or infiltration. This approach can be supplemented by improved conveyance facilities. Nonpoint source control can be achieved by various types of centralized retention facilities, along with measures such as construction site erosion control and pet waste control.

The major advantages of the centralized retention approach are that if properly applied, the facilities can limit the effects of urban development on downstream peak discharges, areas of inundation, stream bank erosion, streambed scour, and aquatic habitat; sediment and other particulate pollutants are removed; the size and resultant cost of downstream conveyance facilities can be reduced and the need for reconstruction sometimes avoided; the facilities can be combined with recreation and open space to provide multipurpose-use areas; and the facilities can provide groundwater recharge. The disadvantages of the retention approach are that the facilities require large, relatively level, open areas; the facilities may be more expensive than detention facilities; less permeable soils require larger facilities; maintenance requirements are substantial; and the water quality of a permanent pool may be poor because of the generally higher pollutant levels of urban runoff. The effects on groundwater levels may create problems such as wet basements, costly excessive operation of sump pumps, and excessive infiltration of clear water into sanitary sewers. Because of the large site requirements, this approach is generally suitable only in newly developing urban areas. Any permanently ponded water may present a health and safety hazard, and the hydraulic design and construction techniques are more involved than for conveyance systems.

Portions of the planned urban service area for the City of West Bend, including the western part of the Silver Creek subwatershed, are located in the Kettle Moraine area which is characterized by numerous deep depressions or "kettles." These kettles can be used as natural retention basins, resulting in a significant capital cost reduction over construction basins. Because of the availability of natural retention basins, the occurrence of suitable soils in the area, and generally favorable groundwater levels, the use of natural centralized retention facilities was considered as a component of the alternative stormwater management plans developed for the West Bend area.

Onsite Retention

Like centralized retention, onsite retention provides for the temporary storage and subse-

quent infiltration and/or evaporation of stormwater runoff, but the storage sites are located close to, or at, the source of runoff generation. Hence, these sites tend to be smaller than centralized retention facilities. Onsite retention measures include above-ground and subsurface infiltration systems. Nonpoint source control measures appropriate under the onsite retention approach may include various types of infiltration devices, construction site erosion control, and pet waste control.

The advantages of the onsite retention approach are similar to those of the centralized retention approach with regard to water quantity and quality control downstream, and to the potential for reducing the size of downstream conveyance systems. However, onsite facilities have smaller unit site requirements, thereby being more readily applicable—although not without difficulty—in existing as well as newly developing urban areas. Onsite facilities may be less suitable for multipurpose uses such as recreation and open space, but more suitable for uses such as parking or yard space in residential areas. The disadvantages of the onsite retention approach are that maintenance requirements may be substantial. The ponded water may cause localized inconvenience and represent a health and safety hazard; odor and insect problems may be produced; and the costs may be high if not offset by smaller downstream conveyance systems. The effects on groundwater levels may create severe problems such as wet basements, costly excessive operation of sump pumps, and excessive infiltration of clear water into sanitary sewers. While readily applicable as an integral part of large-scale urban development proposals, the concept is more difficult to implement effectively and dependably with small-scale, piecemeal development proposals and in areas of existing urban development.

Onsite retention was considered in the development of alternative stormwater management plans because of the potential water quality benefits in areas of existing development, the occurrence of suitable soils in the area, and generally favorable groundwater levels.

"Blue-Green" System

The "blue-green" stormwater management system consists of vegetation-lined channels, preferably "free-form" as opposed to geometrically shaped, interconnected natural surface depressions, and wetlands. Such a system provides for the temporary storage and conveyance of stormwater runoff in the vegetation-lined channels and associated depression and wetland areas, which slow the runoff and allow ponding and infiltration. The drainage system of an area may consist almost entirely of "blue-green" channels, or it may be supplemented by other management measures including storm sewers. Nonpoint source control measures appropriate under the "blue-green" approach may include certain types of stormwater detention and retention facilities, turf-lined open channels, construction site erosion control, and pet waste control.

The advantages of the "blue-green" approach are that downstream peak flows may be reduced; pollutants in storm runoff may be removed by filtration through the soil and vegetation and by sedimentation; the "free-form" open channels and related drainage areas can serve as part of park and open space sites following the multiuse concept; construction costs may be relatively low; and the aesthetic qualities of a "natural" drainage system may be particularly attractive to some citizens. The disadvantages of the "blue-green" approach are that it becomes increasingly uneconomical to develop an open channel system which can effectively accommodate the high peak flows generated from medium to high-density urban areas served by storm sewers; the flowing channels may be perceived as a safety hazard; the channels are difficult to properly clean and maintain; and some citizens and local public officials may not desire open channel flow in urban areas.

Within the West Bend area there are "blue-green" system components, including natural channels and wetlands, which could be used to abate stormwater runoff problems. Although there may be some citizen opposition to the short-term standing and flowing water, and to the more extensive land areas required, the existing "blue-green" system features were incorporated in each of the alternative stormwater management plans for the West Bend area.

Nonstructural Measures

The nonstructural approach to stormwater management primarily involves reducing damages from unusually high stormwater runoff and inundation rather than controlling the runoff rates or inundation levels themselves. Nonstructural measures include structure floodproofing, relocation of structures, land use regulations, and open space and floodland preservation.

Appropriate nonstructural nonpoint source abatement measures may include increased street and parking lot sweeping, improved leaf collection, construction site erosion control, and pet waste control. The nonstructural approach is not in itself an alternative in that in medium- to high-density urban areas the stormwater management problems usually cannot be abated by nonstructural measures alone, although the impact of these problems may be reduced. Hence, nonstructural measures are usually considered only in combination with the alternative approaches described above.

The advantages of the nonstructural approach are that the measures are suitable for use in existing as well as newly developing urban areas; the measures are highly flexible and adaptable to different situations; the cost of nonstructural measures is generally low; the measures can often be used to create needed park and open space; and there are few hazards associated with nonstructural measures. The disadvantages of the nonstructural approach are that downstream water quantity and quality is generally not controlled; most stormwater problems are not abated; condemnation of private property may be necessary; and some measures may benefit relatively few individuals.

Because of its applicability under a wide array of situations, the nonstructural approach was considered in the evaluation of the portion of the recommended plan dealing with flood control measures that would be required along major receiving streams under planned conditions.

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Chapter IV

ALTERNATIVE STORMWATER MANAGEMENT PLANS

INTRODUCTION

Utilizing the alternative stormwater management approaches, as described above, the following four alternative stormwater management plans were developed for the portion of the West Bend planned urban service area within the Silver Creek Subwatershed: 1) a storm sewer conveyance plan; 2) a storm sewer-roadside swale conveyance plan; 3) a centralized detention plan; and 4) a decentralized detention plan.

During the alternative plan development and evaluation stage, components of the minor drainage system, such as storm sewers and off-channel detention facilities, were considered, as were such components of the major drainage system as major engineered drainage channels, natural watercourses, and on-channel detention facilities. In areas with existing or planned urban street patterns, the alternative plans included a complete system of minor system components. In areas planned to be developed for urban use but for which no street layout had been established, only certain key components of the minor system such as trunk storm sewers and roadside swales, important open drainage channels, and centralized detention facilities could be explicitly considered. Smaller collector storm sewers, some onsite storage sytems, culverts, curbs and gutters, and inlets could be only implicitly considered through the simulation modeling. Nonpoint source pollution abatement measures were considered only in a general manner in the development and evaluation of the alternative system plans. However, these components, together with the major system, were specifically considered in the design and evaluation of the recommended plan. Each alternative proposes preservation of natural wetlands and floodplains for storage purposes and for integration with conveyance facilities.

In order to compare and evaluate the alternative plans, the portion of the West Bend planned urban service area within the Silver Creek subwatershed was divided into 12 hydrologic units. Each unit was comprised of one or more subbasins tributary to the same conveyance system component, or to a detention facility and its associated downstream conveyance system. Each hydrologic unit under each alternative plan is described in terms of individual components and the estimated costs. The hydrologic unit boundaries are shown on Maps 3, 4, 5 and 6. It was not considered necessary to develop detailed alternatives for two of the hydrologic units. One of those units has been completely developed and is internally drained under developed conditions. Most of the other hydrologic unit consists of parkland and primary environmental corridor. The relatively small amount of planned land development in that hydrologic unit would not be expected to have a significant impact on the quantity or quality runoff.

The four alternative plans were all designed to serve the portion of the City of West Bend planned urban service area within the Silver Creek subwatershed. Stormwater management facilities for areas outside the planned urban service area but within the study area were not specifically designed, although the peak flow rates to be generated under each alternative at the locations where stormwater flows enter the planned urban service area were considered in the design and evaluation of the alternative plans.

STORM SEWER CONVEYANCE ALTERNATIVE PLAN

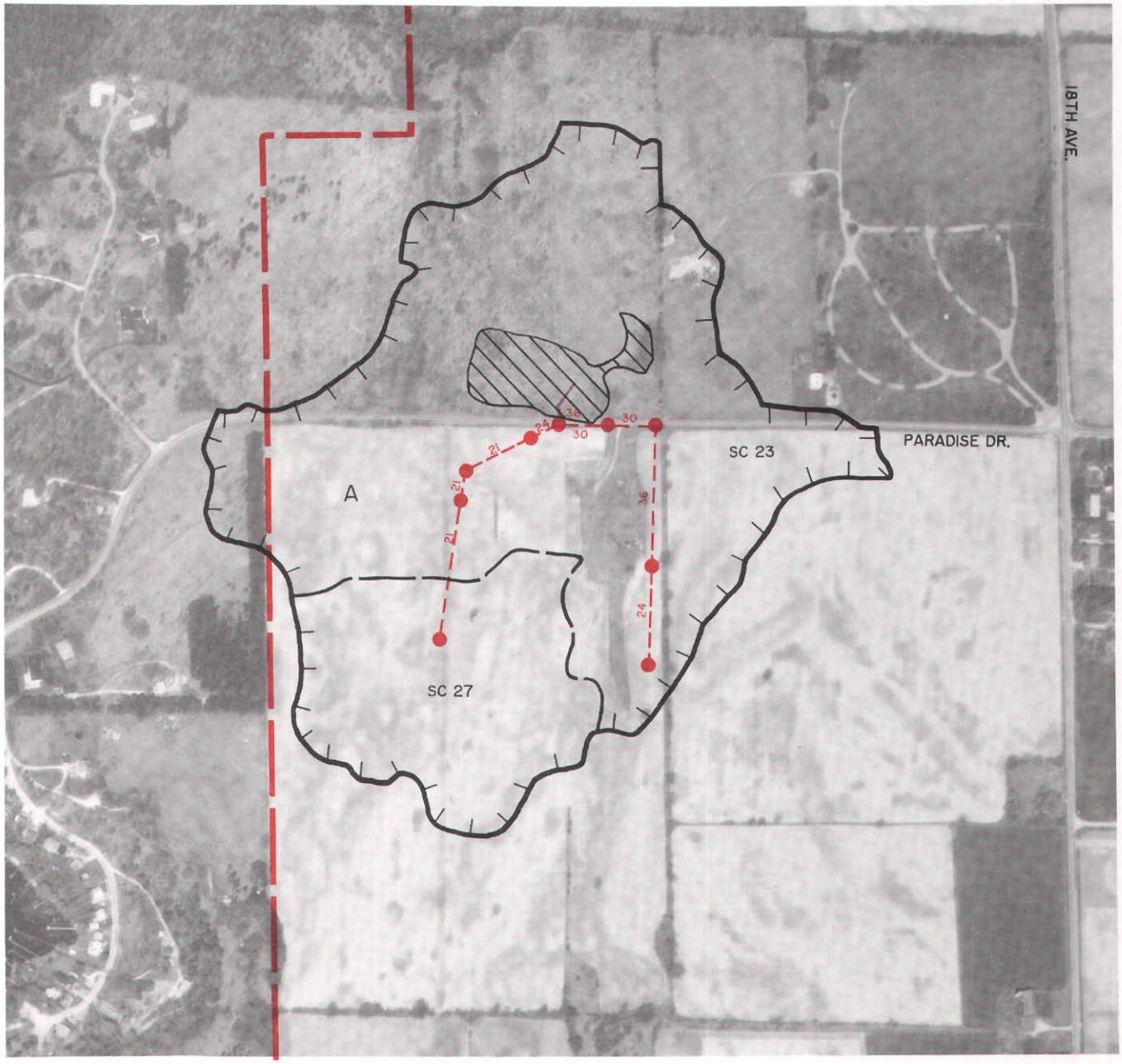
The storm sewer conveyance alternative plan primarily involves the provision of new storm sewers and engineered open channels to abate existing stormwater runoff problems and to effectively serve planned new urban development in the planned urban service area. Map 3 shows the approximate location and alignment of new storm sewers and engineered open channels proposed under the alternative. Table 3 presents the salient characteristics and estimated costs of the new storm sewers and channels comprising this alternative plan.

The storm sewer conveyance alternative includes 36,705 lineal feet of new storm sewers in areas of planned development. New circular storm sewers range in diameter from 12 to 60 inches. Horizontal elliptical (H.E.) storm sewer sizes range from 38 inches by 24 inches to 68 inches by 43 inches. A 51-inch by 31-inch

(Continued on Page 39)

Map 3

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT A



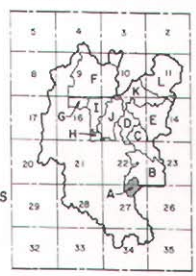
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- A — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 23 — SUBBASIN IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL RETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED STORM SEWER (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

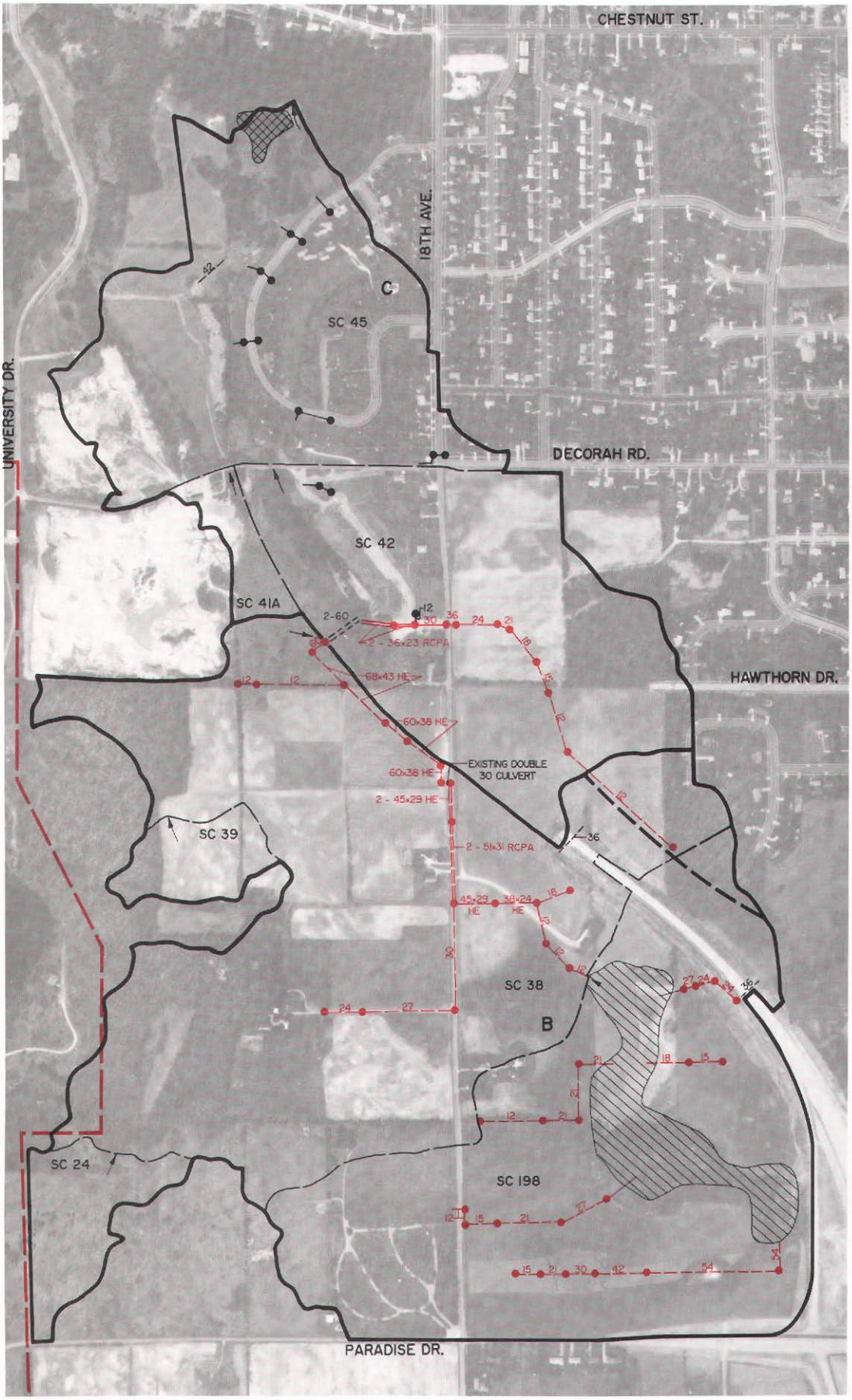


NOTE: ALL WITHIN T.11N., R.19E.

GRAPHIC SCALE
0 200 400 FEET

Map 3 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED HYDROLOGIC UNITS B AND C



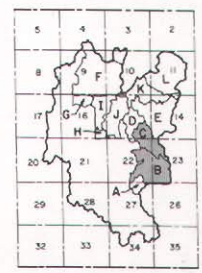
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- B — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 38 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 12 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 12 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING CONSTRUCTED WET DETENTION BASIN
- EXISTING NATURAL RETENTION BASIN
- PROPOSED MANHOLE
- 12 — PROPOSED STORM SEWER (SIZE IN INCHES)
- 12 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



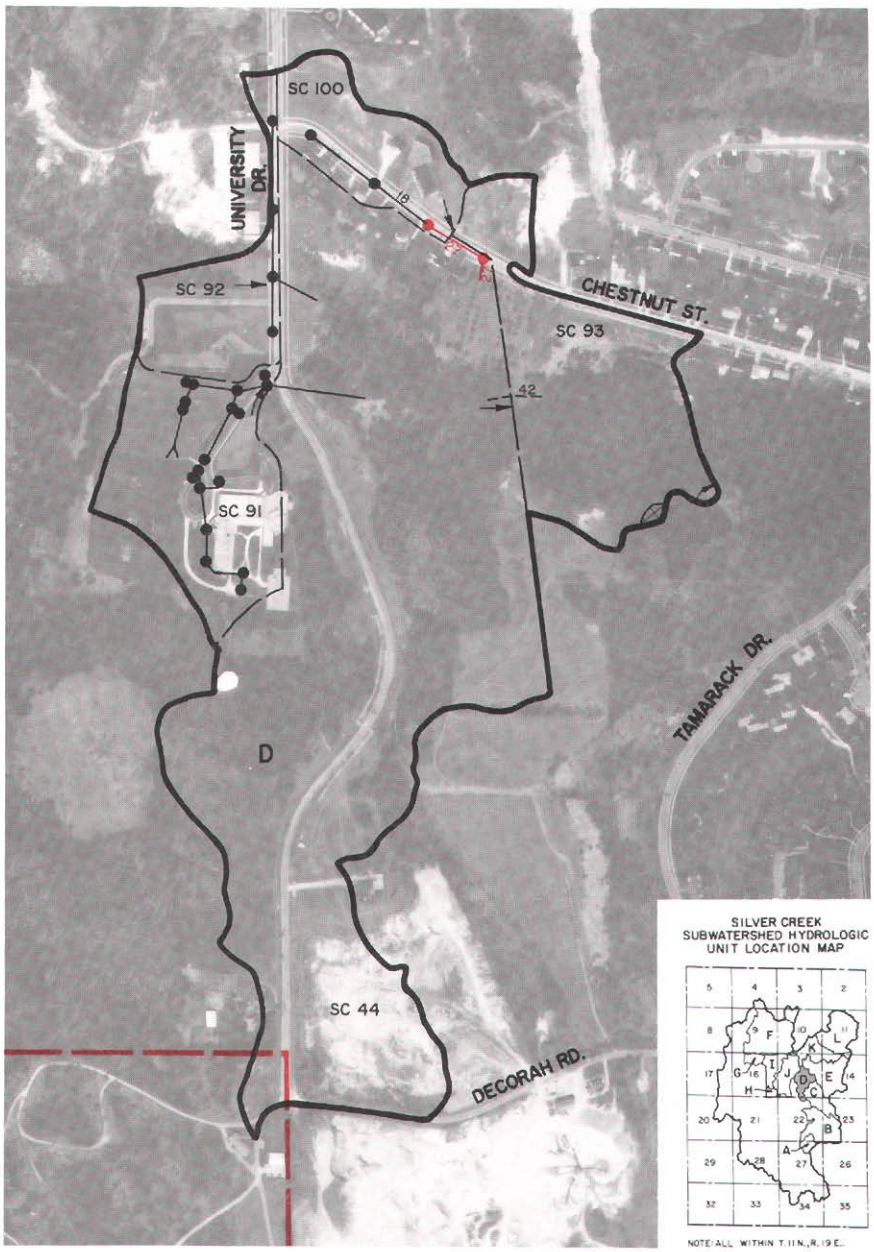
NOTE: ALL WITHIN T.11N.,R.19E.

GRAPHIC SCALE
0 400 800 FEET

Map 3 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT D



SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

NOTE: ALL WITHIN T.11N.,R.19E.

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- D — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 44 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 18 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 42 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 27 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

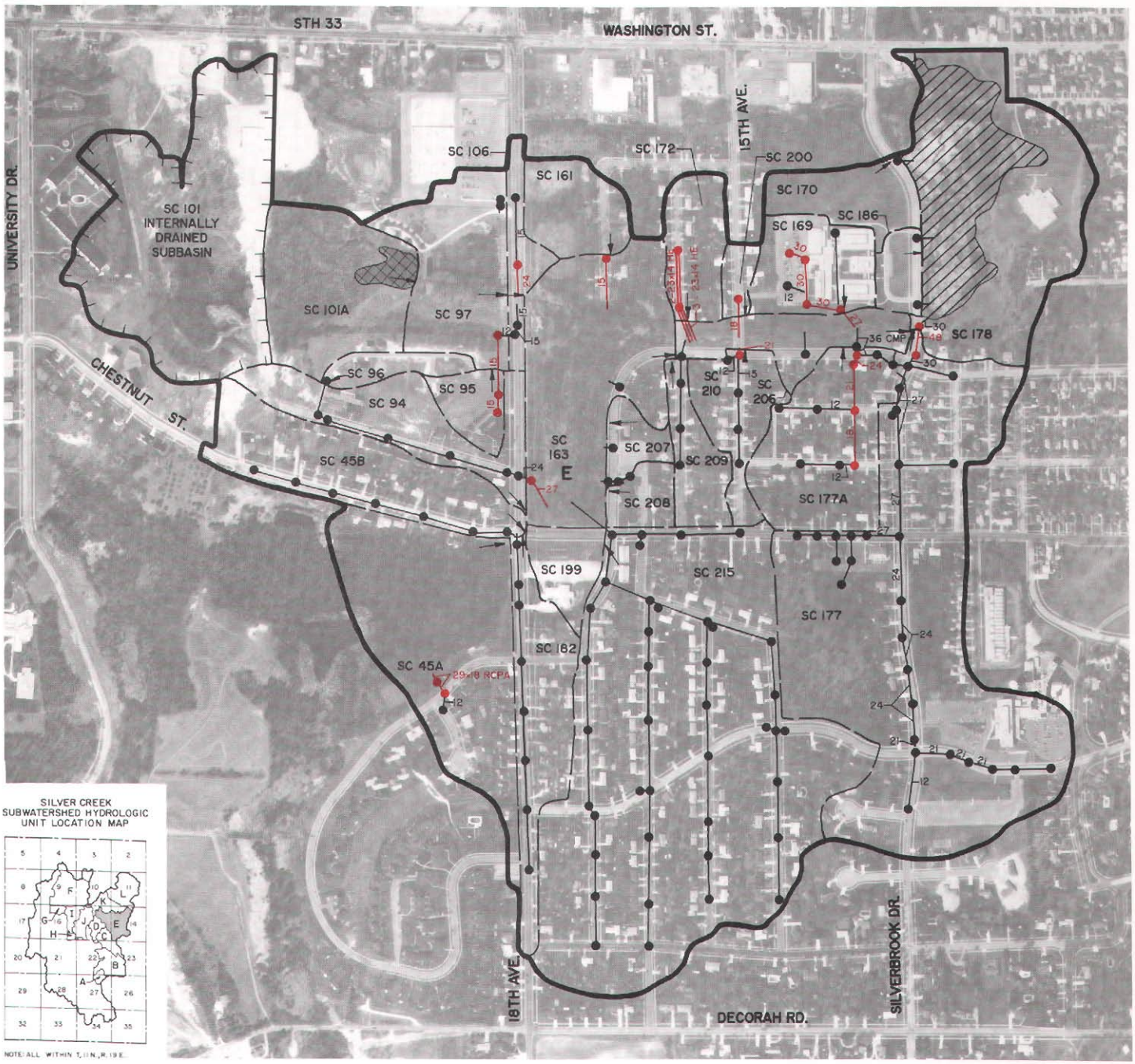
EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

Map 3 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT E



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- E — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 94 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 15 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH
- CMP — CORRUGATED METAL PIPE

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

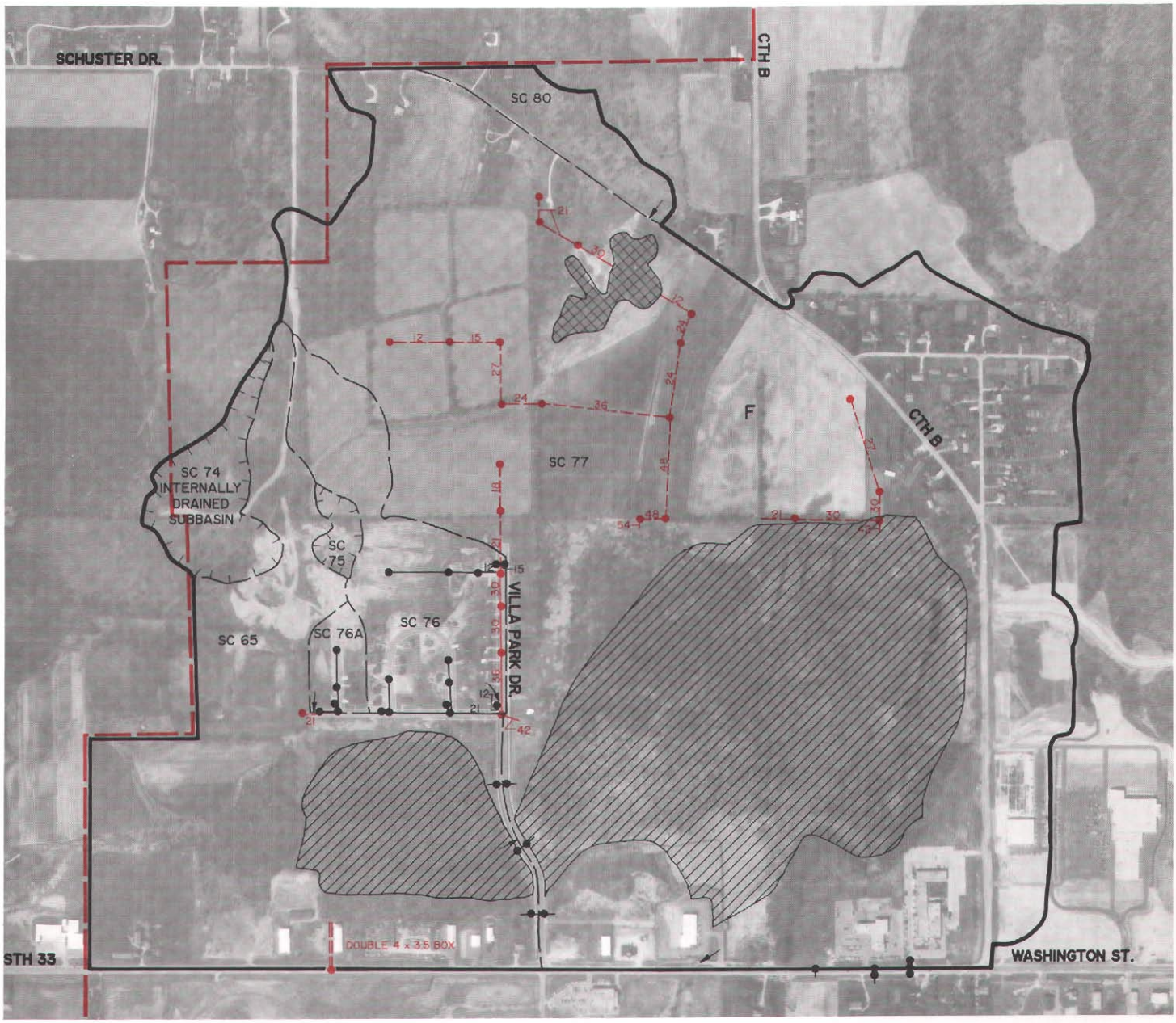
EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

Map 3 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT F



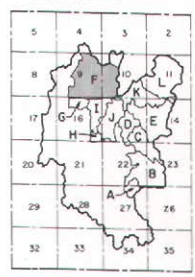
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- F — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 77 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 12 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 30 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



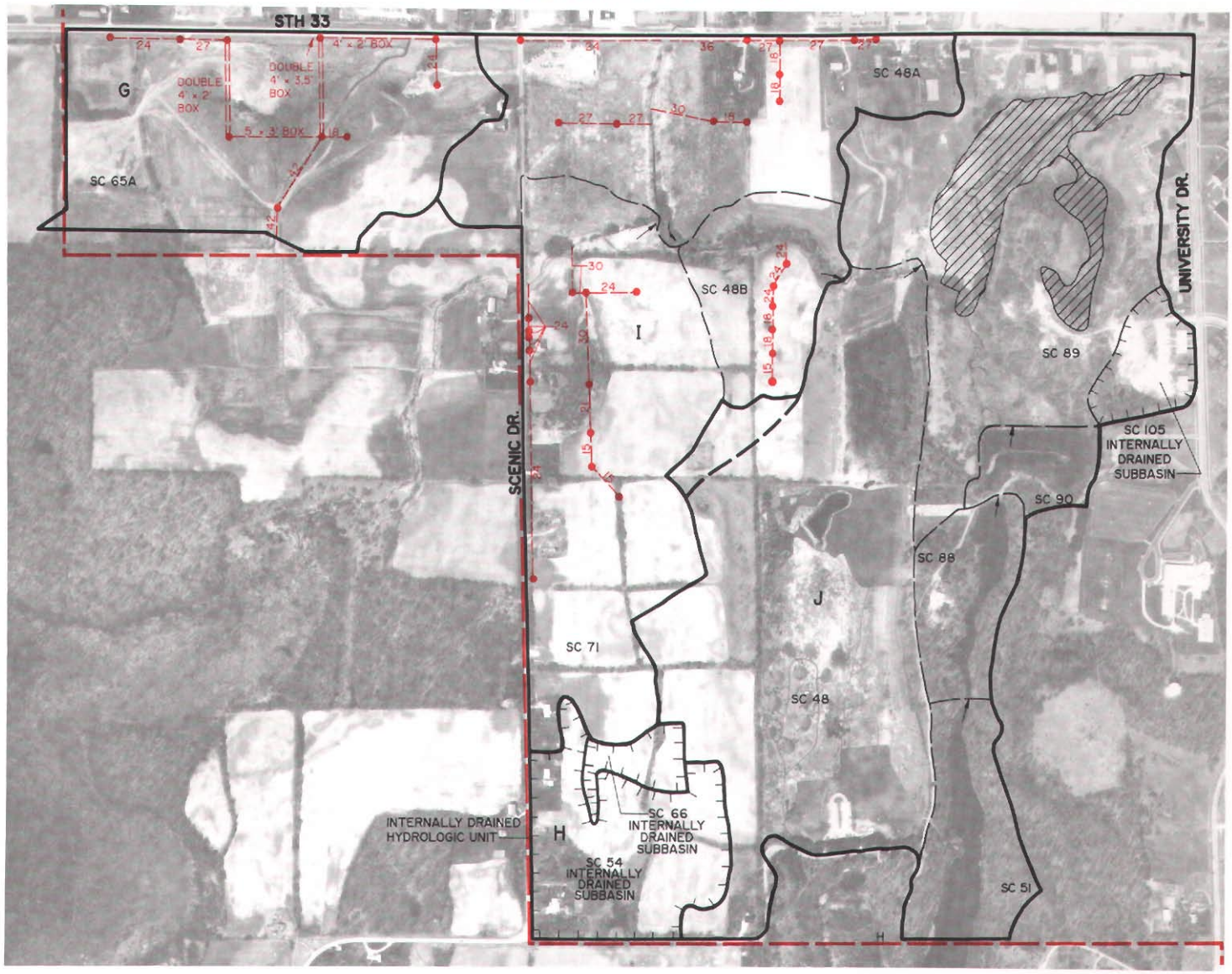
NOTE: ALL WITHIN T.11N.,R.19E.

GRAPHIC SCALE
0 400 800 FEET

Map 3 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNITS G, H, I, AND J



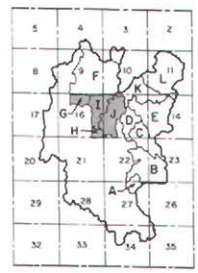
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- J — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 66 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 24 — PROPOSED STORM SEWER (SIZE IN INCHES)

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



NOTE: ALL WITHIN T.11 N., R.19 E.

GRAPHIC SCALE 0 400 800 FEET

Map 3 (continued)

STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

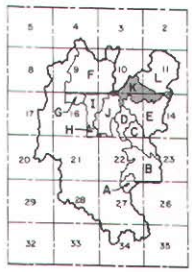
HYDROLOGIC UNIT K

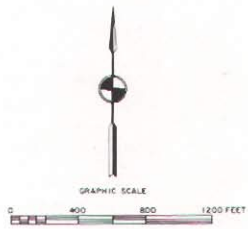
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- K — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 179 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 24 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 24 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 24 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- RCPA — REINFORCED CONCRETE PIPE ARCH
- NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP





STORM SEWER CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT L

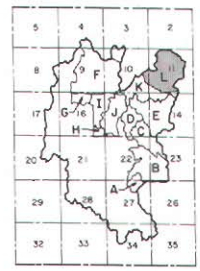
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- L — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 212 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- PROPOSED MANHOLE
- 24 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 24 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH
- CMP — CORRUGATED METAL PIPE
- CLAY — CLAY PIPE
- PVC — POLYVINYL CHLORIDE PIPE

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



NOTE: ALL WITHIN T.11N., R.19E.

GRAPHIC SCALE
0 400 800 FEET

Source: SEWRPC.

Table 3

COMPONENTS AND COSTS OF THE STORM SEWER CONVEYANCE ALTERNATIVE WEST BEND STORMWATER MANAGEMENT PLAN FOR THE SILVER CREEK SUBWATERSHED

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
A	Southeastern Portion of Planned Urban Service Area Along Paradise Drive		
	1. 785 feet of 21-inch storm sewer	$ 37,000	$ 300
	2. 380 feet of 24-inch storm sewer	21,000	100
	3. 310 feet of 30-inch storm sewer in Paradise Drive	22,000	100
	4. 40 feet of 36-inch storm sewer in Paradise Drive.	4,000	0
	5. 470 feet of 36-inch storm sewer	41,000	100
	6. Construct 120-foot-long grass-lined channel at storm sewer outlet to retention basin and provide riprap erosion protection	3,000	100
	7. Existing kettle used for retention basins	- -	400
	8. Engineering, administration, and contingencies	45,000	0
	Subtotal	$ 173,000	$ 1,100
B	Southern Portion of Silverbrook Creek Subbasin		
	1. 1,100 feet of 12-inch storm sewer	$ 33,000	$ 400
	2. 615 feet of 15-inch storm sewer	22,000	300
	3. 500 feet of 18-inch storm sewer	21,000	200
	4. 1,365 feet of 21-inch storm sewer	64,000	500
	5. 590 feet o9f 24-inch storm sewer	32,000	200
	6. 895 feet of 27-inch storm sewer	56,000	400
	7. 820 feet of 30-inch storm sewer	57,000	300
	8. 280 feet of 42-inch storm sewer	29,000	100
	9. 1,035 feet of 54-inch storm sewer	155,000	200
	10. 110 feet of 60-inch storm sewer	19,000	- -
	11. 245 feet of 38-inch x 24-inch concrete horizontal elliptical (H.E.) storm sewer	20,000	100
	12. 255 feet of 45-inch x 29-inch H.E. storm sewer	25,000	100
	13. 505 feet total of twin 45-inch x 29-inch H.E. storm sewer	50,000	100
	14. 850 feet total of twin 51-inch x 31-inch reinforced concrete pipe arch (RCPA) storm sewer	105,000	200
	15. 505 feet of 60-inch x 38-inch H.E. storm sewer	76,000	100
	16. 590 feet of 68-inch x 43-inch H.E. storm sewer	101,000	100
	17. Construct 250-foot-long grass-lined channel at storm sewer outlet to natural detention basin north of Paradise Drive and west of USH 45. Provide riprap at outlet	5,000	200
	18. Construction 215-foot-long, grass-lined channel at storm sewer outlet to natural detention basin and provide riprap at outlet	5,000	200
	19. Provide riprap erosion protection at remaining storm sewer outlets to natural detention basin	5,000	200
	20. Outlet structure for natural detention basin	2,000	100

Table 3 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
B (continued)	21. 660 feet of 12-inch storm sewer for outlet of natural detention basin	$ 20,000	$ 300
	22. Engineering, administration, and contingencies	315,000	- -
	Subtotal	$1,214,000	$ 4,400
C	Central Portion of Silverbrook Creek Subbasin		
	1. 1,290 feet of 12-inch storm sewer	$ 39,000	$ 500
	2. 190 feet of 15-inch storm sewer	7,000	100
	3. 300 feet of 18-inch storm sewer	12,000	100
	4. 70 feet of 21-inch storm sewer	3,000	- -
	5. 230 feet of 24-inch storm sewer	13,000	100
	6. 115 feet of 36-inch storm sewer	10,000	0
	7. Replace 180 feet of 12-inch storm sewer and 100 feet of 15-inch storm sewer in Julen Circle and 170 feet of 18-inch storm sewer west of Julen Circle with 180 feet of 30-inch storm sewer and a total of 540 feet of twin 36-inch x 23-inch RCPA storm sewer	80,000	100
	8. Engineering, administration, and contingencies	57,000	0
	Subtotal	$ 221,000	$ 900
D	Western Portion of Silverbrook Creek Subbasin		
	1. Replace 321 feet of 18-inch storm sewer in Chestnut Street with 27-inch storm sewer	$ 28,000	$ 0
	2. Engineering, administration, and contingencies	10,000	0
	Subtotal	$ 38,000	$ 0
E	Northern Portion of Silverbrook Creek Subbasin		
	1. Replace 352 feet of 12-inch storm sewer in Concord Lane north of Silverbrook Creek with 15-inch storm sewer	$ 15,000	$ 0
	2. Replace 480 feet of 12-inch storm sewer west of 18th Avenue with 15-inch storm sewer	21,000	0
	3. Replace 174 feet of 12-inch storm sewer in 15th Avenue north of Silverbrook Creek with 18-inch storm sewer at an increased slope of 0.62 percent	10,000	0
	4. Replace 276 feet of 15-inch corrugated metal pipe (CMP) storm sewer between Balsam Place and Poplar Street with 18-inch storm sewer	15,000	0
	5. Replace 82 feet of 18-inch storm sewer in 15th Avenue with 21-inch storm sewer at an increased slope of 2.1 percent	12,000	0
	6. Replace 293 feet of 15-inch CMP storm sewer between Balsam Place and Walnut Street with 21-inch storm sewer	19,000	0
	7. Replace 28 feet of 18-inch clay storm sewer in Walnut Street with 24-inch storm sewer	2,000	0

Table 3 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
E (continued)	8. Replace 160 feet of 15-inch storm sewer in 18th Avenue with 24-inch storm sewer	$ 12,000	$ 0
	9. Replace 120 feet of 24-inch storm sewer at Silverbrook School with 27-inch storm sewer	10,000	0
	10. Replace 425 feet of 15-inch storm sewer at Silverbrook School with 30-inch storm sewer	43,000	0
	11. Replace 238 feet of 21-inch CMP storm sewer west of 18th Avenue between Miller Street and Chestnut Street with 27-inch storm sewer	20,000	0
	12. Replace 126 feet of 30-inch storm sewer in Silverbrook Drive between Walnut Street and Silverbrook Creek with 48-inch storm sewer	24,000	0
	13. Replace 311 feet of 12-inch storm sewer in 16th Avenue north of Silverbrook Creek with 622 feet total of twin 23-inch x 14-inch H.E. storm sewer	35,000	100
	14. Replace 106 feet of 12-inch storm sewer in 16th Avenue north of Silverbrook Creek with 480 feet total of triple 23-inch x 14-inch H.E. storm sewer at a reduced slope of 0.26 percent	27,000	100
	15. Replace 64 feet of 18-inch storm sewer at the intersection of Tamarack Drive and Tamarack Court with 24-inch storm sewer	3,000	0
	16. Engineering, administration, and contingencies	94,000	- -
	Subtotal	$ 362,000	$ 200
F	Northern Portion of Washington Creek Subbasin		
	1. Replace 212 feet of 15-inch storm sewer and 304 feet of 21-inch storm sewer in Villa Park Drive with 516 feet of 30-inch storm sewer	$ 36,000	$ 0
	2. Replace 315 feet of 24-inch storm sewer in Villa Park Drive with 36-inch storm sewer	41,000	-100
	3. Replace 61 feet of 30-inch storm sewer outlet from Villa Park Drive with 42-inch storm sewer	9,000	0
	4. 300 feet of 18-inch storm sewer in Villa Park Drive extended	12,000	100
	5. 350 feet of 21-inch storm sewer in Villa Park Drive extended	16,000	100
	6. 60 feet of 21-inch storm sewer in Stanford Lane extended	3,000	0
	7. 435 feet of 12-inch storm sewer	13,000	200
	8. 310 feet of 15-inch storm sewer	11,000	100
	9. 580 feet of 21-inch storm sewer	27,000	200
	10. 1,075 feet of 24-inch storm sewer	59,000	400
	11. 975 feet of 27-inch storm sewer	60,000	400
	12. 1,160 feet of 30-inch storm sewer	81,000	500
	13. 645 feet of 36-inch storm sewer	57,000	100
	14. 20 feet of 42-inch storm sewer	2,000	0

Table 3 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
F (continued)	15. 865 feet of 48-inch storm sewer	$ 112,000	$ 200
	16. 20 feet of 54-inch storm sewer	3,000	0
	17. Outlet structure for existing pond located southeast of Schuster Drive	2,000	300
	18. 405 feet of 12-inch storm sewer for detention basin outlet	12,000	200
	19. Construct 540-foot-long grass-lined channel at storm sewer outlet to natural detention basin west of Villa Park Drive and provide riprap erosion protection	13,000	500
	20. Engineering, administration, and contingencies	199,000	0
	Subtotal	$ 768,000	$ 3,200
G	Western Portion of Washington Creek Subbasin		
	1. 135 feet of 18-inch storm sewer	$ 5,000	$ 100
	2. 660 feet of 24-inch storm sewer	36,000	200
	3. 320 feet of 27-inch storm sewer	20,000	100
	4. 1,115 feet total of double 4-foot x 2-foot concrete box storm sewer	139,000	200
	5. 630 feet of 4-foot x 2-foot concrete box storm sewer	88,000	0
	6. 485 feet of 5-foot x 3-foot concrete box storm sewer	87,000	100
	7. 1,785 feet total of double 4-foot x 3.5-foot concrete box storm sewer	268,000	400
	8. 730 feet of 42-inch storm sewer	77,000	200
	9. Engineering, administration, and contingencies	252,000	0
	Subtotal	$ 972,000	$ 1,400
H	No New Stormwater Management Measures Considered	--	--
I	Southern Portion of Washington Creek Subbasin		
	1. 645 feet of 15-inch storm sewer	$ 23,000	$ 300
	2. 705 feet of 18-inch storm sewer	29,000	300
	3. 300 feet of 21-inch storm sewer	14,000	100
	4. 3,570 feet of 24-inch storm sewer	196,000	1,400
	5. 1,305 feet of 27-inch storm sewer	81,000	500
	6. 1,225 feet of 30-inch storm sewer	86,000	500
	7. 465 feet of 36-inch storm sewer	41,000	100
	8. Engineering, administration, and contingencies	165,000	0
	Subtotal	$ 635,000	$ 3,200
J	No New Stormwater Management Measures Considered	--	--
K	Central Portion of Silver Creek Subwatershed		
	1. Replace 133 feet of 24-inch storm sewer located east of K-Mart store at the intersection of Washington Street and 18th Avenue with 42-inch storm sewer	$ 20,000	$ 0

Table 3 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
K (continued)	2. Replace 238 feet of 24-inch storm sewer in K-Mart parking lot with 42-inch storm sewer	$ 36,000	$ -100
	3. Replace 220-foot-long channel located west of the State Central Credit Union building at 18th Avenue and Washington Street with 18-inch storm sewer at a slope of 0.625 percent	12,000	0
	4. Replace 260 feet of 24-inch storm sewer in K-Mart parking lot with 36-inch storm sewer	20,000	-100
	5. Replace 54 feet of 24-inch storm sewer at K-Mart entrance with 36-inch storm sewer at an increased slope of 2 percent	7,000	0
	6. Replace 121 feet of polyvinyl chloride (PVC) storm sewer in K-Mart parking lot with 30-inch storm sewer	12,000	0
	7. Replace 217 feet of 18-inch storm sewer in K-Mart parking lot with 30-inch storm sewer	22,000	0
	8. Replace 407 feet of 24-inch storm sewer in Fleet and Farm storm parking lot at the intersection of Washington Street and 18th Avenue with 36-inch storm sewer	53,000	-100
	9. Retain the 242 foot long, 30-inch storm sewer in the Fleet and Farm parking lot and add a parallel 51-inch x 31-inch RCPA storm sewer	42,000	100
	10. Replace 180 feet of 30-inch storm sewer and 82 feet of 36-inch storm sewer located downstream from the Fleet and Farm parking lot with 524 feet total of twin 51-inch x 31-inch RCPA at a slope of 0.35 percent	91,000	100
	11. Replace 72 feet of 21-inch storm sewer in Red Owl store parking lot at the intersection of Washington Street and 15th Avenue with 31-inch storm sewer	5,000	0
	12. Replace 71 feet of 12-inch storm sewer in Red Owl storm parking lot with 18-inch storm sewer	4,000	0
	13. Replace 313 feet of 12-inch storm sewer in Concord Lane west of 15th Avenue with 18-inch storm sewer	17,000	0
	14. Replace 251 feet of 27-inch storm sewer in 15th Avenue north of the intersection with Concord Lane with 27-inch storm sewer at an increased slope of 0.15 percent	22,000	0
	15. Engineering, administration, and contingencies	127,000	0
	Subtotal	$ 490,000	$ -100

Table 3 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
L	Eastern Portion of Silver Creek-Regner Park Environs		
	1. Replace 355 feet of 36-inch CMP storm sewer running from Park Avenue to Beverly Lane with 36-inch reinforced concrete pipe (RCP) storm sewer	$ 46,000	$ 0
	2. Replace 314 feet of 36-inch CMP storm sewer running from Park Avenue to Beverly Lane with 36-inch reinforced concrete pipe (RCP) storm sewer	41,000	0
	3. Replace 337 feet of 36-inch CMP storm sewer in Sherwood Place with 42-inch RCP storm sewer	51,000	0
	4. Replace 419 feet of 36-inch storm sewer in Sherwood Place with 41-inch storm sewer	63,000	0
	5. Replace 132 feet of 36-inch storm sewer in Green Tree Road with 42-inch storm sewer	20,000	0
	6. Replace 334 feet of 15-inch storm sewer in Meadowbrook Drive with 24-inch storm sewer	25,000	0
	7. Replace 825 feet of 51-inch x 36-inch corrugated metal pipe arch (CMPA) storm sewer in Green Tree Road with 58-inch x 36-inch RCPA storm sewer	173,000	0
	8. Replace 326 feet of 58-inch x 36-inch CMPA storm sewer in Wood Way with 42-inch storm sewer	49,000	0
	9. Replace 248 feet of 36-inch storm sewer in Wood Way extended with 42-inch storm sewer	37,000	0
	10. Replace 253 feet of 36-inch storm sewer in Wood Way extended with 65-inch x 40-inch RCPA storm sewer	61,000	0
	11. Replace 98 feet of 51-inch x 31-inch H.E. storm sewer in Wood Way extended with 58-inch x 36-inch RCPA storm sewer	21,000	0
	12. Replace 325 feet of 42-inch storm sewer in Wood Way extended with 65-inch x 40-inch RCPA storm sewer	79,000	0
	13. Replace 176 feet of 42-inch storm sewer in Silverbrook Drive with 65-inch x 40-inch RCPA storm sewer	43,000	0
	14. Replace 183 feet of 48-inch storm sewer in Silverbrook Drive with 73-inch x 45-inch RCPA at a slope of 0.40 percent	53,000	0
	15. Replace 249 feet of 12-inch storm sewer in Silverbrook Drive south of Wood Way extended with 27-inch storm sewer	21,000	0
	16. Replace 10 feet of 12-inch storm sewer in Silverbrook Drive and the 7-foot-long, 18-inch diameter outlet storm sewer discharging to Silver Creek with 17 feet total of 30-inch storm sewer	2,000	0
	17. Replace 192 feet of 52-inch x 32-inch CMPA storm sewer in 12th Avenue south of Wayne Road with 30-inch storm sewer at a slope of 1.5 percent	19,000	0
	18. Replace 160 feet of 52-inch x 32-inch CMPA storm sewer in 12th Avenue with 45-inch x 29-inch H.E. storm sewer at a slope of 0.75 percent	22,000	0

Table 3 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
L (continued)	19. Replace 264 feet of 15-inch storm sewer running between Glen Court and 12th Avenue with 24-inch storm sewer	$ 20,000	$ 0
	20. Replace 97 feet of 15-inch storm sewer between Glen Court and 12th Avenue with 24-inch storm sewer at a reduced slope of 0.64 percent to accommodate the replacement storm sewer in 12th Avenue	7,000	0
	21. Replace 204 feet of 52-inch x 32-inch CMPA storm sewer in 12th Avenue with 45-inch x 29-inch H.E. storm sewer at a slope of 0.98 percent	28,000	0
	22. Replace 180 feet of 52-inch x 32-inch CMPA storm sewer in 12th Avenue north of Alder Street with a total of 360 feet of twin 53-inch x 34-inch H.E. storm sewer	63,000	0
	23. Replace 242 feet of 18-inch storm sewer in Green Tree Road south of Wayne Road with 24-inch storm sewer	18,000	0
	24. Replace 245 feet of 18-inch storm sewer in Green Tree Road north of the intersection with Alder Street with 30-inch storm sewer	25,000	0
	25. Replace 527 feet of 12-inch storm sewer in Alder Street with 21-inch storm sewer	34,000	0
	26. Replace 176 feet of 12-inch storm sewer in Alder Street with 27-inch storm sewer	15,000	0
	27. Replace 301 feet of 24-inch storm sewer running between 13th and 14th Avenues north of Alder Street with 27-inch storm sewer	26,000	0
	28. Replace 244 feet of 27-inch storm sewer in 13th Avenue north of the intersection with Alder Street with 36-inch storm sewer	39,000	-100
	29. Replace 359 feet of 30-inch storm sewer in Alder Street east of the intersection with 13th Avenue with 42-inch storm sewer	54,000	-100
	30. Replace 234 feet of 30-inch storm sewer in Alder Street west of the intersection with 12th Avenue with 36-inch storm sewer	30,000	-100
	31. Replace 363 feet of 58-inch x 36-inch CMPA storm sewer in 12th Avenue north of the intersection with Park Avenue with a total of 726 feet of twin 60-inch storm sewer	152,000	100
	32. Replace 383 feet of 58-inch x 36-inch CMPA storm sewer in Park Avenue east of 12th Street with 54-inch storm sewer	84,000	0

Table 3 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
L (continued)	33. Replace 300 feet of 60-inch x 40-inch CMPA storm sewer in Park Avenue between 10th and 11th Streets with 60-inch storm sewer	$ 77,000	$ 0
	34. Replace 300 feet of 60-inch x 40-inch CMPA storm sewer running from Park Avenue at 10th Street to the Regner Park pond with a total of 600 feet of twin 42-inch storm sewer	90,000	100
	35. Replace 294 feet of 30-inch CMP storm sewer running between 8th and 9th Avenues north of High Street with 36-inch storm sewer at a slope of 0.2 percent	37,000	100
	36. 330 feet of 24-inch RCP in 9th Avenue extended north of High Street	18,000	100
	37. Replace 64 feet of 30-inch CMP storm sewer at intersection of 9th Avenue and Park Avenue with 27-inch RCP storm sewer	6,000	0
	38. Replace approximately 250 feet of 18-inch clay storm sewer running from Park Avenue at 8th Street to the Regner Park pond with 24-inch storm sewer at a slope of 0.5 percent	19,000	0
	39. Engineering, administration, and contingencies	584,000	0
	Subtotal	$2,252,000	$ 100
Total		$7,125,000	$14,400

[a] *All new and replacement storm sewers are concrete pipe.*

[b] *Costs were noted to be zero when the project proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lesser operation and maintenance cost than the cost of the existing facility.*

Source: SEWRPC.

(Continued from Page 23)

reinforced concrete pipe arch (RCPA) storm sewer is also proposed. Box culvert sizes range from 4 feet wide by 2 feet high to 5 feet wide by 3 feet high. The alternative also includes 19,610 lineal feet of replacement storm sewer in areas of existing development. Replacement circular storm sewers range in diameter from 15 inches to 60 inches. Horizontal elliptical storm sewer sizes range from 23 inches by 14 inches to 60 inches by 38 inches.

Reinforced concrete pipe arch sizes range from 36 inches by 23 inches to 73 inches by 45 inches.

A total of about 1,125 feet of new grass-lined open channels would be provided at the outlets of storm sewers. As shown on Map 3, this alternative would also utilize five existing natural detention basins located in wetland areas, one existing natural retention basin, and three existing man-made detention basins.

Under the storm sewer conveyance alternative plan, abatement of pollutants from nonpoint sources would be achieved through the installation of parking lot infiltration devices in areas of existing development, along with certain public works activities. The frequency of street

sweeping during spring and fall would be increased. Leaf and vegetative debris collection during fall would be increased. The City would continue enforcement of its construction site erosion ordinance. Public education programs would be developed to encourage good urban "housekeeping" practices and to promote the acceptance and understanding of the proposed abatement measures and the importance of water quality protection.

STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN

The storm sewer-roadside swale conveyance alternative plan primarily involves the provision of new storm sewers, roadside swales, and engineered open channels to abate existing stormwater runoff problems and to effectively serve planned new urban development in the planned urban service area. Map 4 shows the approximate location and alignment of new storm sewers, roadside swales, and engineered open channels proposed under the alternative. Table 4 presents the salient characteristics and estimated cost of the new storm sewers, roadside swales, and channels.

This alternative plan includes 11,200 feet of roadside swales in areas of planned residential development with lot sizes of 0.5 acre or more, and in areas of planned office park development. The standard City of West Bend rural roadway cross-section, as shown in Figure 2 in Chapter III in Volume One of this report, was assumed for all roadside swales. The alternative calls for 23,560 lineal feet of new storm sewers in areas of planned development. New circular storm sewers range in diameter from 12 to 54 inches. Horizontal elliptical storm sewer sizes range from 38 inches by 24 inches to 45 inches by 29 inches. A 51-inch by 31-inch reinforced concrete pipe arch storm sewer is also proposed. Box culvert sizes range from 4 feet by 2 feet to 5 feet by 3 feet. The alternative also includes 19,610 lineal feet of replacement storm sewer in areas of existing development. Replacement circular storm sewers range in diameter from 15 inches to 60 inches. Horizontal elliptical storm sewer sizes range from 23 inches by 14 inches to 60 inches by 38 inches. Reinforced concrete pipe arch sizes range from 36 inches by 23 inches to 73 inches by 45 inches.

A total of about 2,535 feet of new grass-lined open channels would be provided. As shown on Map 4, this alternative would also utilize five existing natural detention basins located in wetland areas, one existing natural retention basin, and three existing man-made detention basins.

Under the storm sewer-roadside swale conveyance alternative plan, abatement of pollutants from nonpoint sources would be achieved through the filtering and infiltration effects of the grass swales, the installation of parking lot infiltration devices in areas of existing development, and certain public works activities. The frequency of street sweeping during spring and fall would be increased. Leaf and vegetative debris collection during fall would be increased. The City would continue enforcement of its construction site erosion ordinance. Public education programs would be developed to encourage good urban "housekeeping" practices and to promote the acceptance and understanding of the proposed abatement measures and the importance of water quality protection.

Abatement of urban nonpoint source pollution would also result from the use of the existing natural and man-made detention and retention basins within the Silver Creek subwatershed. Predominantly due to the effects of the roadside swales, the overall level of nonpoint source pollution reduction achieved under this alternative would be greater than under the storm sewer conveyance alternative.

CENTRALIZED DETENTION ALTERNATIVE PLAN

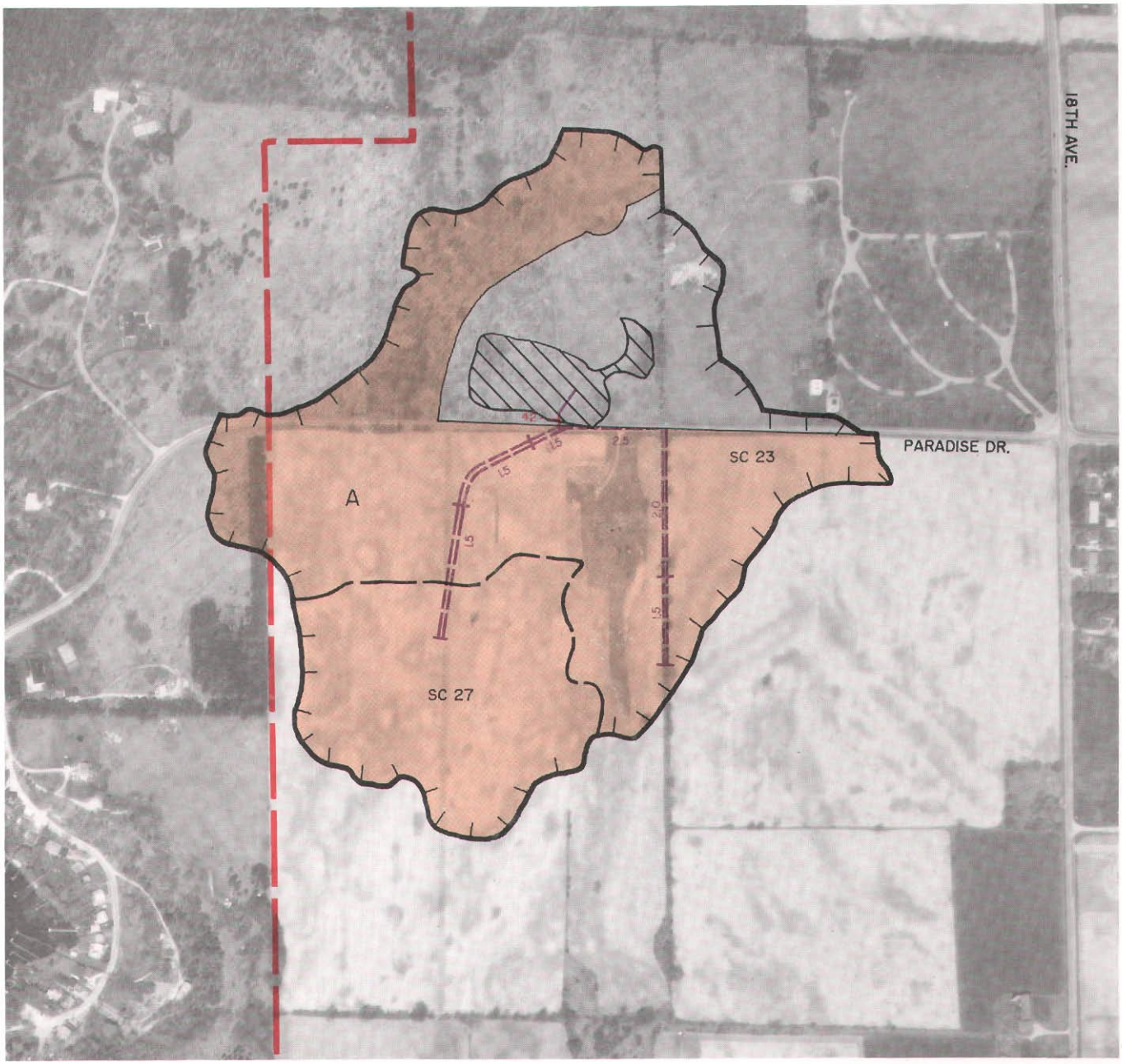
The centralized detention alternative plan would provide for the construction of three new detention basins, the expansion of one existing basin, and the utilization of one existing wetland as a detention basin, as shown on Map 5. In addition, the other existing natural and man-made detention basins in the subwatershed would be used along with certain storm sewer, roadside swale, and open channel components. These existing and proposed detention facilities would reduce downstream discharges, allowing, in some cases, the use of smaller conveyance facilities downstream. The detention basins, along with supplementary conveyance facilities, would serve to abate existing stormwater drainage problems, to effectively accommodate increased runoff from new urban development, and to reduce nonpoint

(Continued on Page 52)

Map 4

STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT A



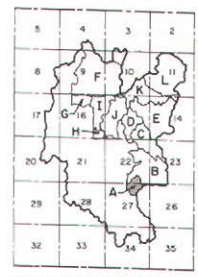
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- A — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 27 — SUBBASIN IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL RETENTION BASIN
- 42 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- L5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



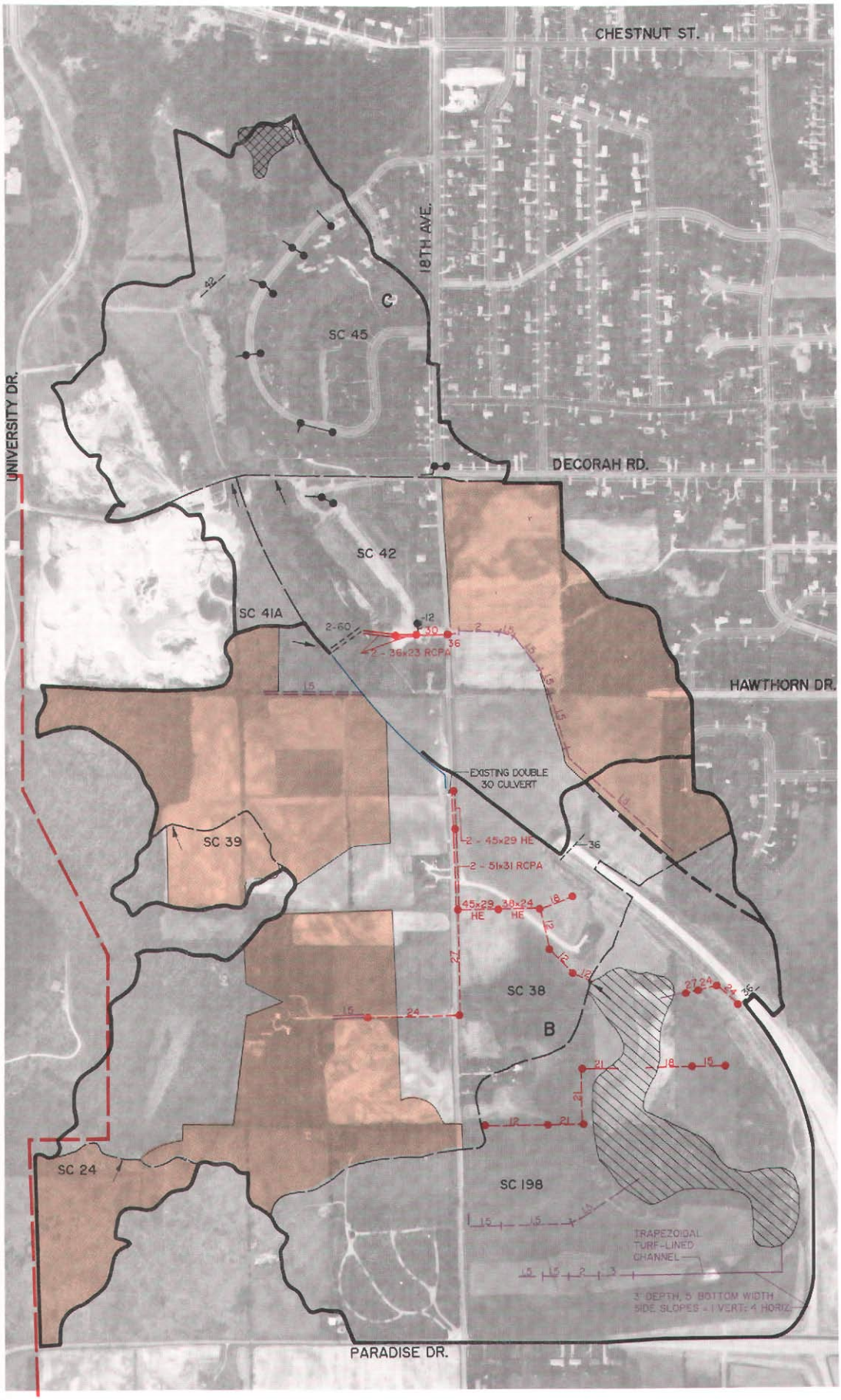
NOTE: ALL WITHIN T. 11 N., R. 19 E.

GRAPHIC SCALE
0 200 400 FEET

Map 4 (continued)

STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNITS B AND C



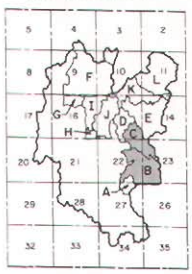
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- B — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 38 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 12 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 36 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING NATURAL RETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 12 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 12 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- 1.5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

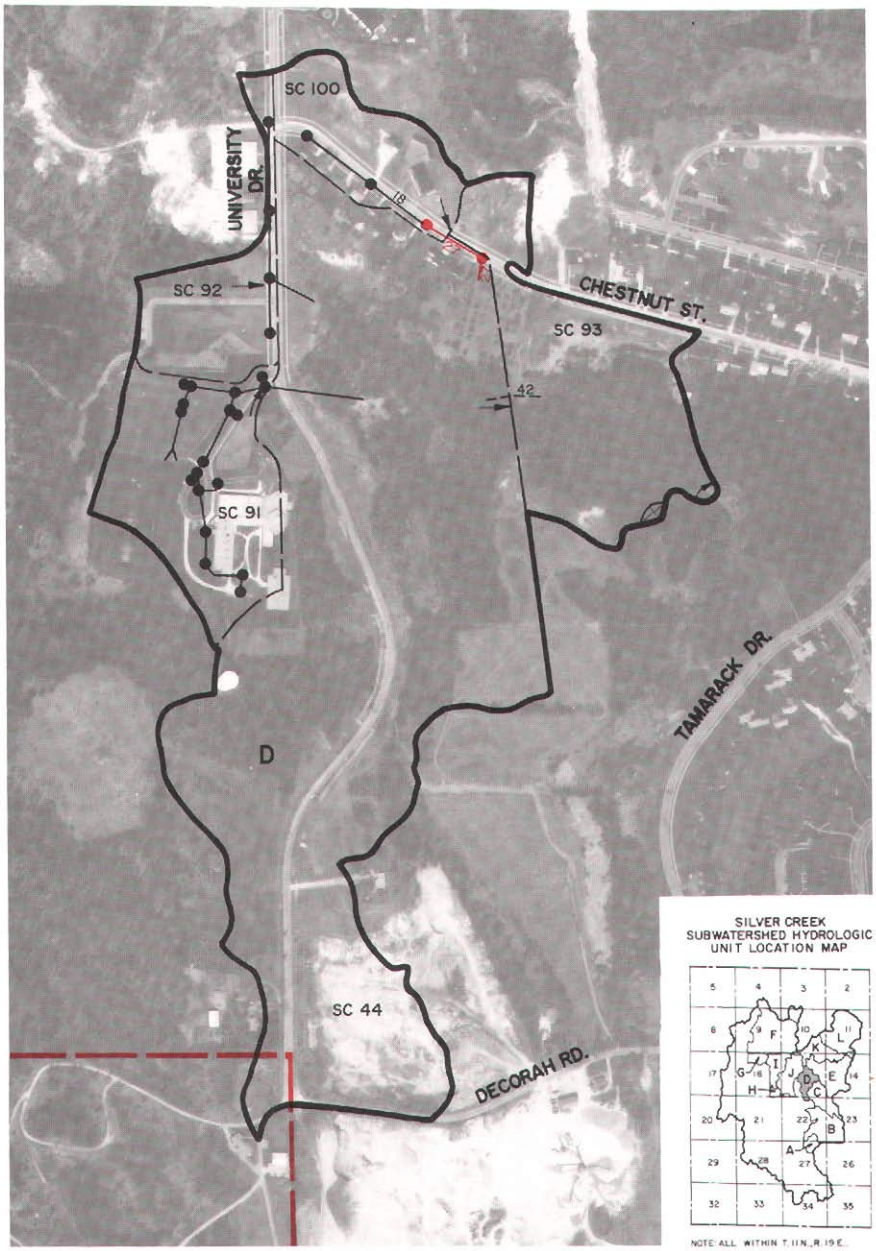
SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



NOTE: ALL WITHIN T.11 N., R.19 E.

GRAPHIC SCALE
0 400 800 FEET

STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT D



SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

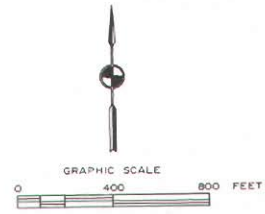
NOTE: ALL WITHIN T.11N.,R.19E.

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- D — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 44 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 18 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 42 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 27 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)

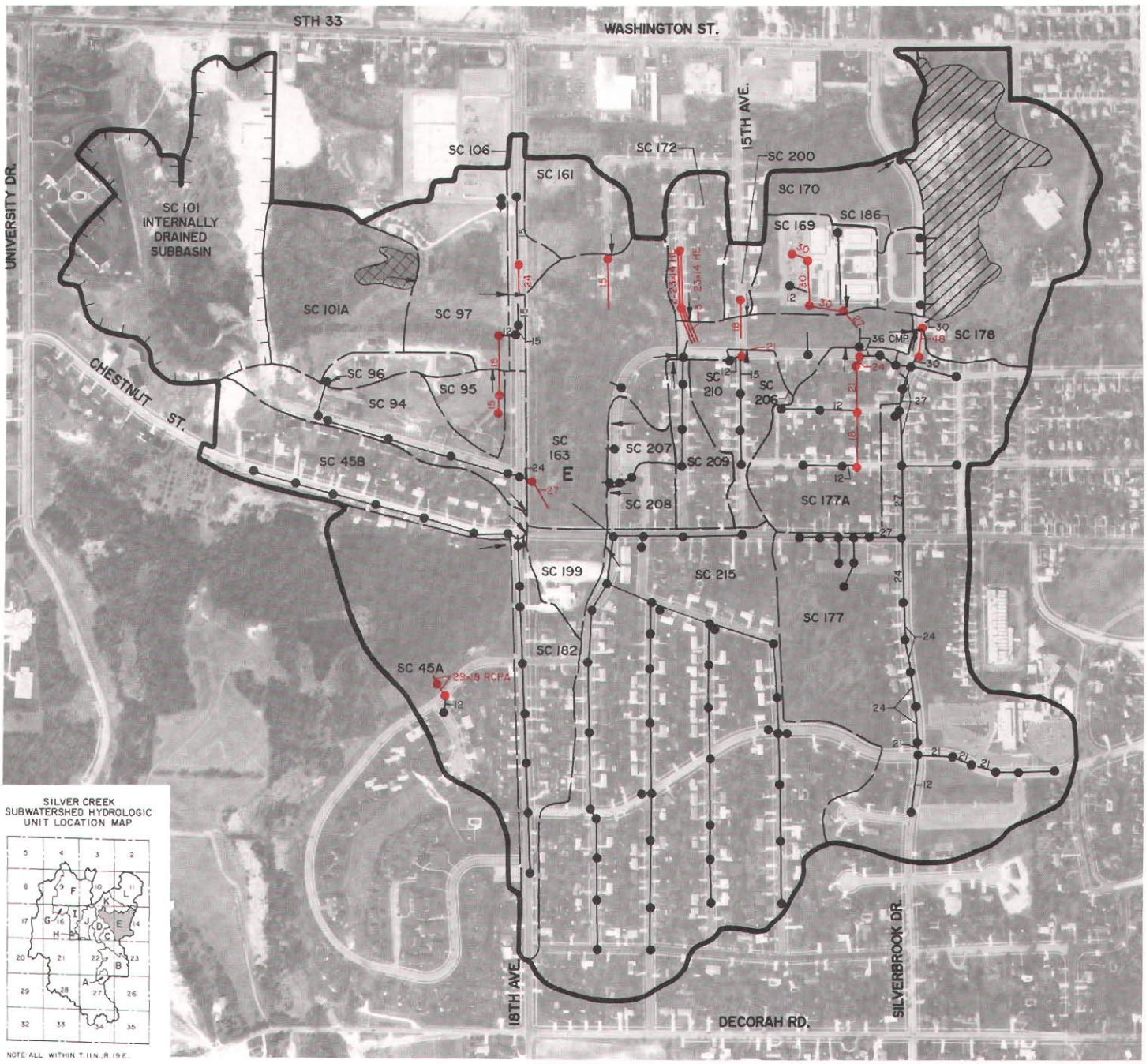
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS



STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT E



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- E — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 94 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 15 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH
- CMP — CORRUGATED METAL PIPE

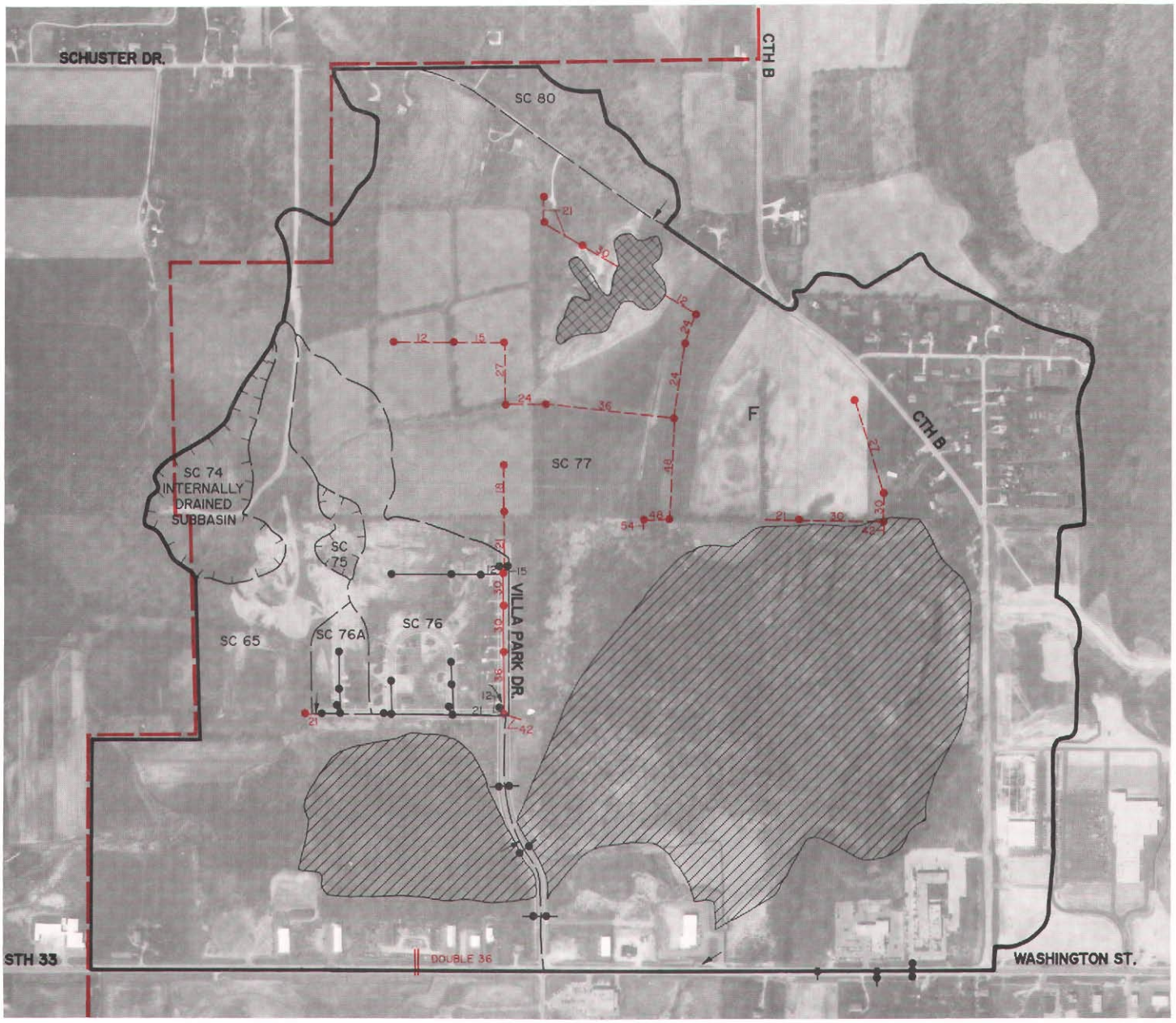
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT F



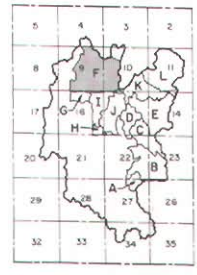
LEGEND

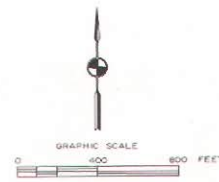
- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- F — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 77 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 12 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 30 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

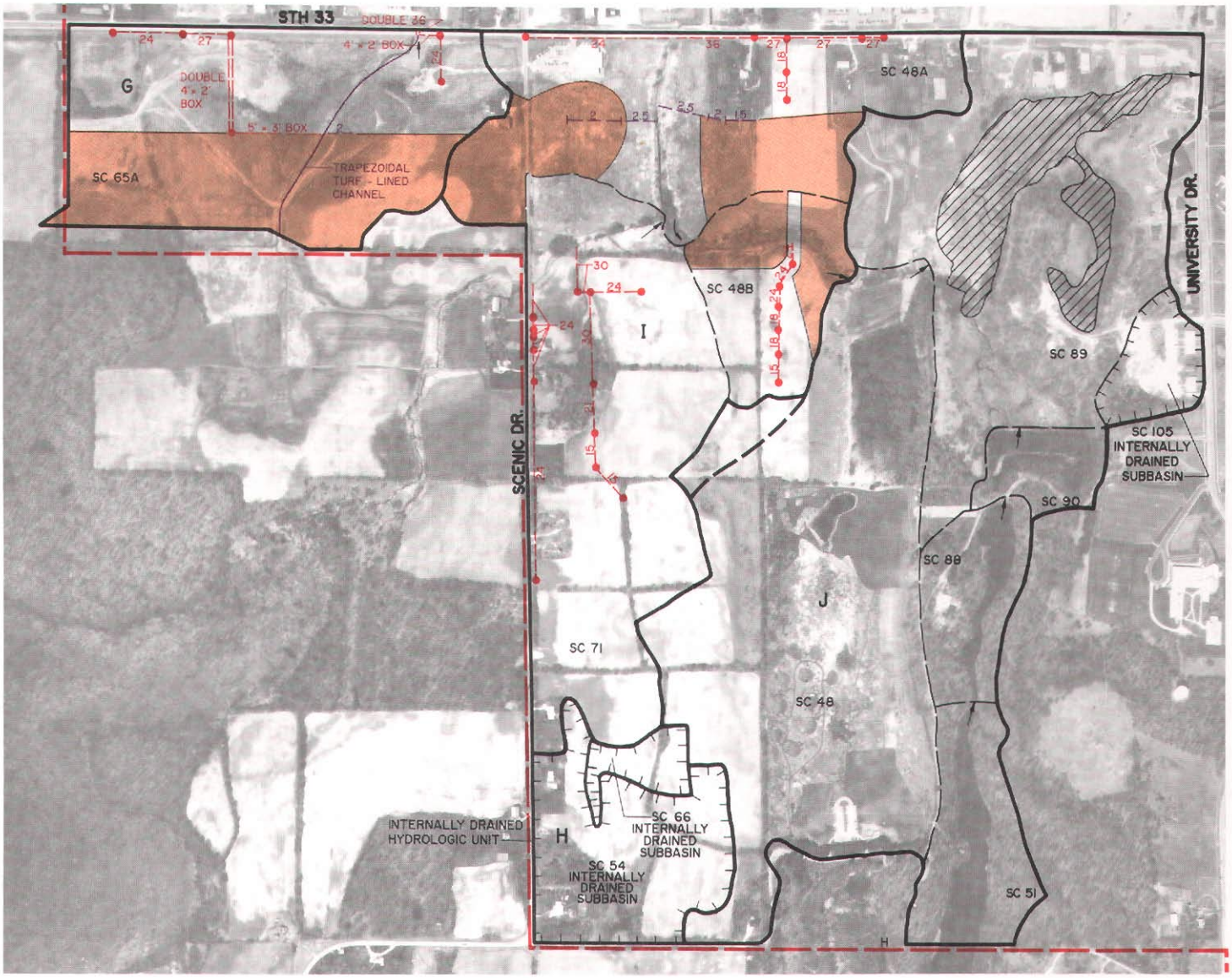
SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP





STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNITS G, H, I, AND J



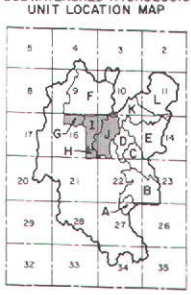
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- J — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 89 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 24 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- 2.5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



NOTE: ALL WITHIN T.11N.,R.19E.

GRAPHIC SCALE
0 400 800 FEET

STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

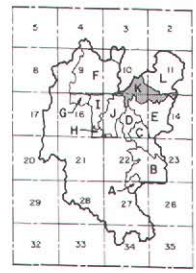
HYDROLOGIC UNIT K

LEGEND

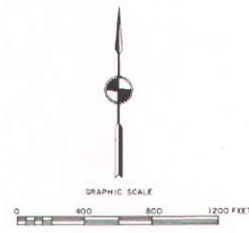
- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- K — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 179 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 24 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 24 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 24 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- RCPA — REINFORCED CONCRETE PIPE ARCH
- NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

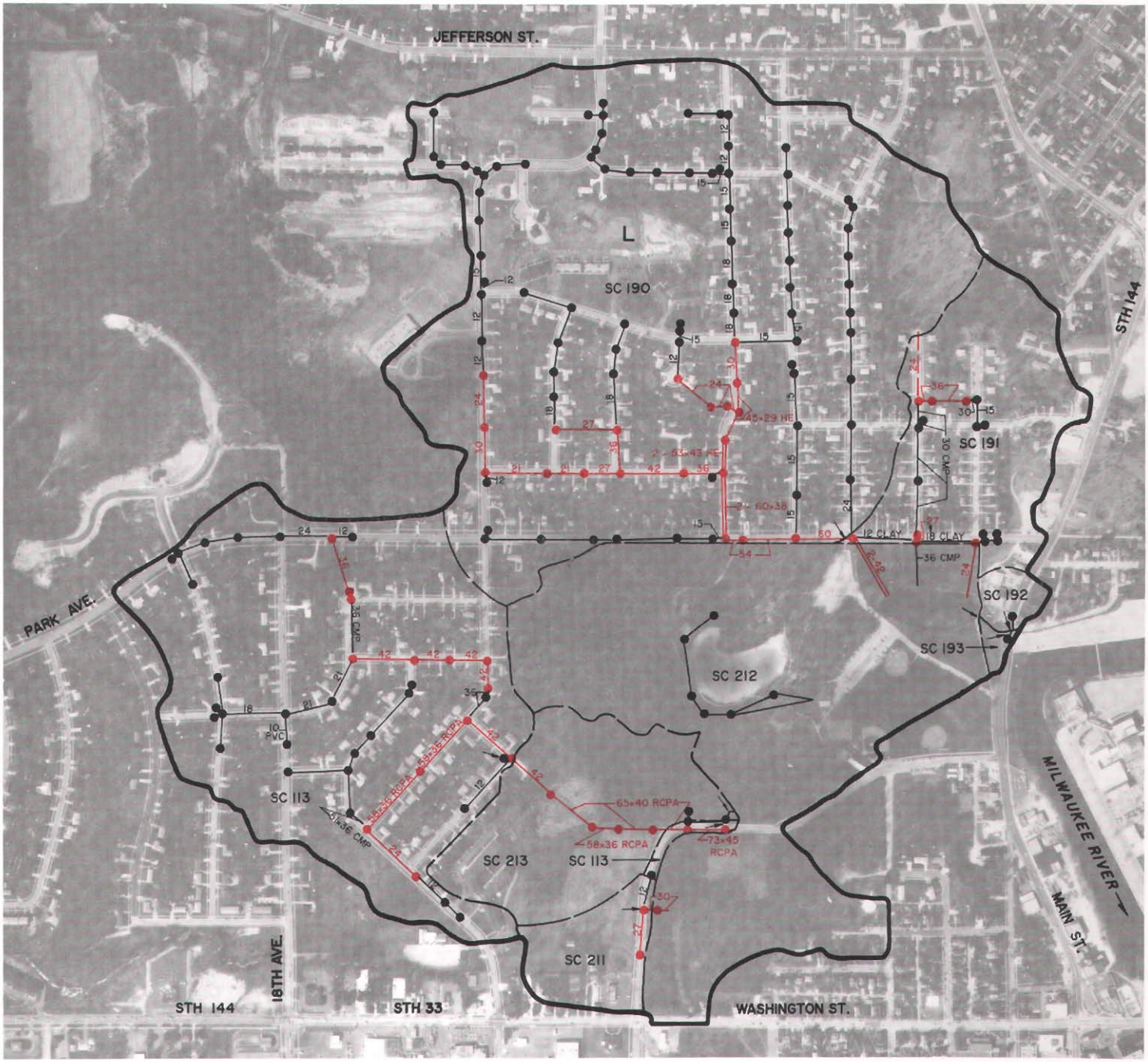


NOTE: ALL WITHIN T. 11 N., R. 19 E.



STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT L



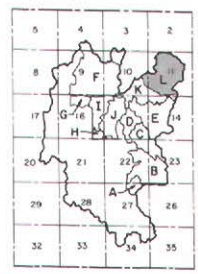
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- L — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 212 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- PROPOSED MANHOLE
- 24 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 24 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH
- CMP — CORRUGATED METAL PIPE
- CLAY — CLAY PIPE
- PVC — POLYVINYL CHLORIDE PIPE

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



GRAPHIC SCALE
0 400 800 FEET

Source: SEWRPC.

Table 4

COMPONENTS AND COSTS OF THE STORM SEWER-ROADSIDE SWALE CONVEYANCE ALTERNATIVE WEST BEND STORMWATER MANAGEMENT PLAN FOR THE SILVER CREEK SUBWATERSHED

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
A	Southeastern Portion of Planned Urban Service Area Along Paradise Drive		
	1. 2,330 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 21,000	$ 800
	2. 310 feet of 2.5-foot-deep roadside swale with driveway culverts	4,000	100
	3. 40 feet of 42-inch culvert at Paradise Drive	4,000	0
	4. 940 feet of 2-foot-deep roadside swale with driveway culverts	10,000	400
	5. Construct 120-foot-long grass-lined channel at storm sewer outlet to retention basin and provide riprap erosion protection	3,000	100
	6. Existing kettle used for retention basins	--	400
	7. Engineering, administration, and contingencies	15,000	0
	Subtotal	$ 57,000	$ 1,800
B	Southern Portion of Silverbrook Creek Subbasin		
	1. 3,960 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 38,000	$ 1,500
	2. 170 feet of 2-foot-deep roadside swale with driveway culverts	2,000	100
	3. 280 feet of 3-foot-deep roadside swale with driveway culverts	5,000	100
	4. 1,035 feet of 3-foot-deep trapezoidal channel with one vertical on four horizontal side slopes and a 5-foot-wide bottom	22,000	400
	5. 495 feet of 12-inch storm sewer	15,000	200
	6. 250 feet of 15-inch storm sewer	9,000	100
	7. 500 feet of 18-inch storm sewer	21,000	200
	8. 815 feet of 21-inch storm sewer	38,000	300
	9. 815 feet of 24-inch storm sewer	45,000	300
	10. 710 feet of 27-inch storm sewer	44,000	300
	11. 245 feet of 38-inch x 24-inch concrete horizontal elliptical (H.E.) storm sewer	20,000	100
	12. 255 feet of 45-inch x 29-inch H.E. storm sewer	25,000	100
	13. 505 feet total of twin 45-inch x 29-inch H.E. storm sewer	50,000	100
	14. 850 feet total of twin 51-inch x 31-inch reinforced concrete pipe arch (RCPA) storm sewer	105,000	200
	15. Construct 250-foot-long grass-lined channel at storm sewer outlet to natural detention basin north of Paradise Drive and west of USH 45. Provide riprap at outlet	5,000	200
	16. Construction 215-foot-long, grass-lined channel at storm sewer outlet to natural detention basin and provide riprap at outlet	5,000	200
	17. Provide riprap erosion protection at remaining storm sewer outlets to natural detention basin	2,000	100

Table 4 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
B (continued)	18. Outlet structure for natural detention basin	$ 3,000	$ 300
	19. 660 feet of 12-inch storm sewer for outlet of natural detention basin	20,000	300
	20. Engineering, administration, and contingencies	166,000	0
	Subtotal	$ 640,000	$ 5,100
C	Central Portion of Silverbrook Creek Subbasin		
	1. 1,850 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 18,000	$ 700
	2. 230 feet of 2-foot-deep roadside swale with driveway culverts	3,000	100
	3. 115 feet of 36-inch storm sewer	10,000	0
	4. Replace 180 feet of 12-inch storm sewer and 100 feet of 15-inch storm sewer in Julen Circle and 170 feet of 18-inch storm sewer west of Julen Circle with 180 feet of 30-inch storm sewer and a total of 540 feet of twin 36-inch x 23-inch CPA storm sewer	80,000	100
	5. Engineering, administration, and contingencies	39,000	0
	Subtotal	$ 150,000	$ 900
D	Western Portion of Silverbrook Creek Subbasin		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 38,000	$ 0
E	Northern Portion of Silverbrook Creek Subbasin		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 362,000	$ 200
F	Northern Portion of Washington Creek Subbasin		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 768,000	$ 3,200
G	Western Portion of Washington Creek Subbasin		
	1. 115 feet of 2-foot-deep drainage swale	$ 1,000	$ 100
	2. 660 feet of 24-inch storm sewer	36,000	200
	3. 320 feet of 27-inch storm sewer	20,000	100
	4. 1,115 feet total of double 4-foot x 2-foot concrete box storm sewer	139,000	200
	5. 130 feet of 4-foot x 2-foot concrete box storm sewer	18,000	0
	6. 485 feet of 5-foot x 3-foot concrete box storm sewer	87,000	100

Table 4 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
G (continued)	7. 790 feet of trapezoidal channel with a 10-foot-wide bottom, 370 feet of trapezoidal channel with a 5-foot-wide bottom, and 250 foot of trapezoidal channel with a 2.5-foot-wide bottom, all having one vertical on four horizontal side slopes	$ 100,000	$ 600
	8. 365 feet total of twin 36-inch culvert	32,000	100
	9. Engineering, administration, and contingencies	152,000	0
	Subtotal	$ 585,000	$ 1,400
H	No New Stormwater Management Measures Considered	--	--
I	Southern Portion of Washington Creek Subbasin		
	1. 200 feet of 1.5-foot-deep roadside swale with driveway culvert	$ 2,000	$ 100
	2. 470 feet of 2-foot-deep roadside swale with driveway culverts	6,000	200
	3. 440 feet of 2.5-foot-deep roadside swale with driveway culverts	6,000	200
	4. 645 feet of 15-inch storm sewer	23,000	300
	5. 505 feet of 18-inch storm sewer	21,000	200
	6. 300 feet of 21-inch storm sewer	14,000	100
	7. 3,570 feet of 24-inch storm sewer	196,000	1,400
	8. 745 feet of 27-inch storm sewer	46,000	300
	9. 875 feet of 30-inch storm sewer	62,000	300
	10. 465 feet of 36-inch storm sewer	41,000	100
	11. Engineering, administration, and contingencies	146,000	0
	Subtotal	$ 563,000	$ 3,200
J	No New Stormwater Management Measures Considered	--	--
K	Central Portion of Silver Creek Subwatershed		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 490,000	$ -100
L	Eastern Portion of Silver Creek-Regner Park Environs		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$2,252,000	$ 100
	Total	$5,905,000	$15,800

[a] *All new and replacement storm sewers are concrete pipe.*

[b] *Costs were noted to be zero when the project proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lesser operation and maintenance cost than the cost of the existing facility.*

Source: SEWRPC.

(Continued from Page 40)

source pollutant loadings within the Silver Creek subwatershed. Table 5 presents the salient characteristics and estimated costs of the new storm sewers, roadside swales, channels, and detention basins comprising this plan.

This alternative includes three new detention basins with surface areas of 0.42 acre, 0.63 acre, and 1.92 acres, and corresponding surcharge storage volumes of 0.6 acre-foot, 0.5 acre-foot, and 1.1 acre-feet, respectively, under 10-year recurrence interval runoff conditions. In addition, the surcharge storage above the existing normal level of the pond in Bicentennial Park would be expanded, increasing the surface area from 3.3 acres to 7.1 acres and the surcharge storage volume from 8.7 acre-feet to 13.5 acre-feet under 10-year recurrence interval runoff conditions. Also, under this alternative, an existing wetland in Hydrologic Unit G, which is classified by the Regional Planning Commission as an isolated natural area, would be retained for use as a detention basin.

The supplementary conveyance facilities include 11,200 lineal feet of roadside swales and 23,375 lineal feet of new storm sewers in areas of planned development. New circular storm sewers range in diameter from 12 to 54 inches. Horizontal elliptical storm sewer sizes range from 38 inches by 24 inches to 45 inches by 29 inches. A 51-inch by 31-inch reinforced concrete pipe arch is also proposed. Box culvert sizes range from 4 feet by 2 feet to 4 feet by 3 feet. The alternative also includes 18,255 lineal feet of replacement storm sewer in areas of existing development. Replacement circular storm sewers range in diameter from 15 inches to 60 inches. Horizontal elliptical storm sewer sizes range from 23 inches by 14 inches to 60 inches by 38 inches. Reinforced concrete pipe arch sizes range from 36 inches by 23 inches to 58 inches by 36 inches. Also, a total of about 1,125 feet of new grass-lined open channels would be provided.

For the evaluation of alternatives, the new detention facilities were sized as dry basins with no permanent pool for abatement of nonpoint source pollutant loadings. If included in the recommended plan, the basins could be enlarged into wet basins which would be effective in removing nonpoint source pollutant loadings, primarily through the sedimentation of particulate pollutants and the biological uptake of nutrients. The roadside swales and engineered open channels would abate nonpoint source pollution through filtering and infiltration. Additional nonpoint source pollution reduction would be achieved through the control of construction site erosion, through the installation of parking lot infiltration devices in areas of existing development, and by implementation of a public education program. This alternative plan would achieve a greater level of abatement of nonpoint source pollutants than that achieved by either of the conveyance alternative plans.

DECENTRALIZED DETENTION ALTERNATIVE PLAN

The decentralized detention alternative plan, which is shown on Map 6, provides for construction of about 33 relatively small detention basins in certain areas of planned development, along with onsite parking lot detention. This alternative enables certain components of the downstream conveyance system to be reduced in size in comparison to the conveyance alternatives. The alternative also utilizes existing natural and man-made detention and retention basins, along with certain storm sewer, roadside swale, and open channel components. This plan would serve to abate existing stormwater runoff problems and accommodate increased runoff from new urban development within the planned urban service area. Table 6 presents the characteristics and estimated costs of the facilities comprising this alternative.

Under a 10-year recurrence interval storm, the 33 decentralized basins would have pond areas ranging from 0.1 acre to 0.45 acre and storage volumes ranging from 0.2 acre-foot to 1.3 acre-feet. In addition, parking lot detention facilities would provide one acre-foot of storage volume at a maximum depth of six inches during a 10-year recurrence interval storm.

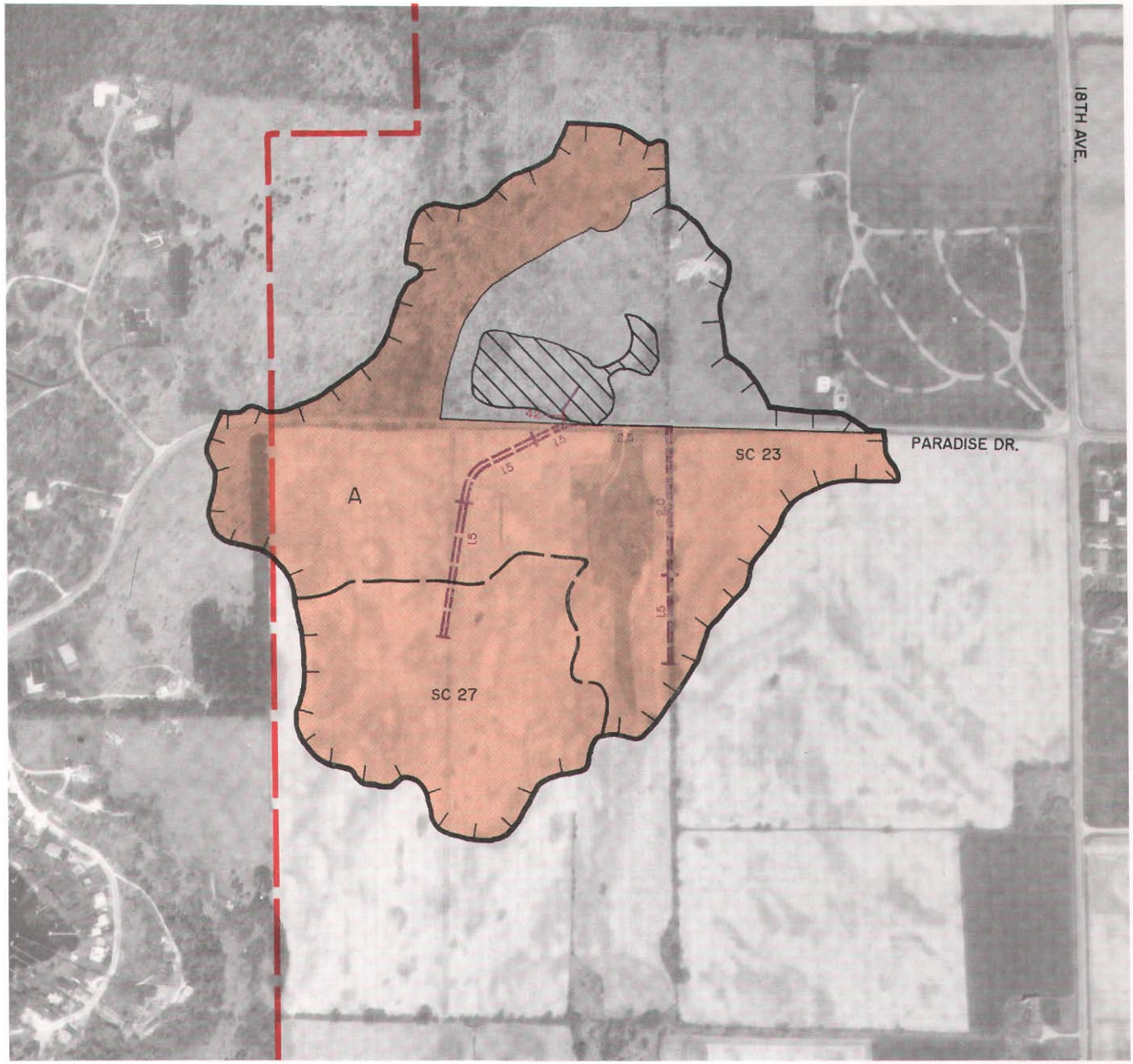
The supplementary conveyance facilities include 23,375 lineal feet of new storm sewers in areas of planned development. New circular storm sewers range in diameter from 12 to 36 inches. Horizontal elliptical storm sewer sizes range from 38 inches by 24 inches to 45 inches by 29 inches. A 51-inch by 31-inch reinforced concrete pipe arch is also proposed. Box culvert sizes range from 4 feet by 2 feet to 4 feet by 3 feet. The alternative also includes 19,060 lineal feet of replacement storm sewer in areas of existing

(Continued on Page 63)

Map 5

CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT A



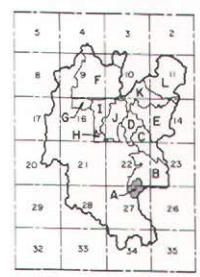
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- A — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 27 — SUBBASIN IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL RETENTION BASIN
- 42 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- L5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES

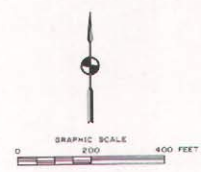
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



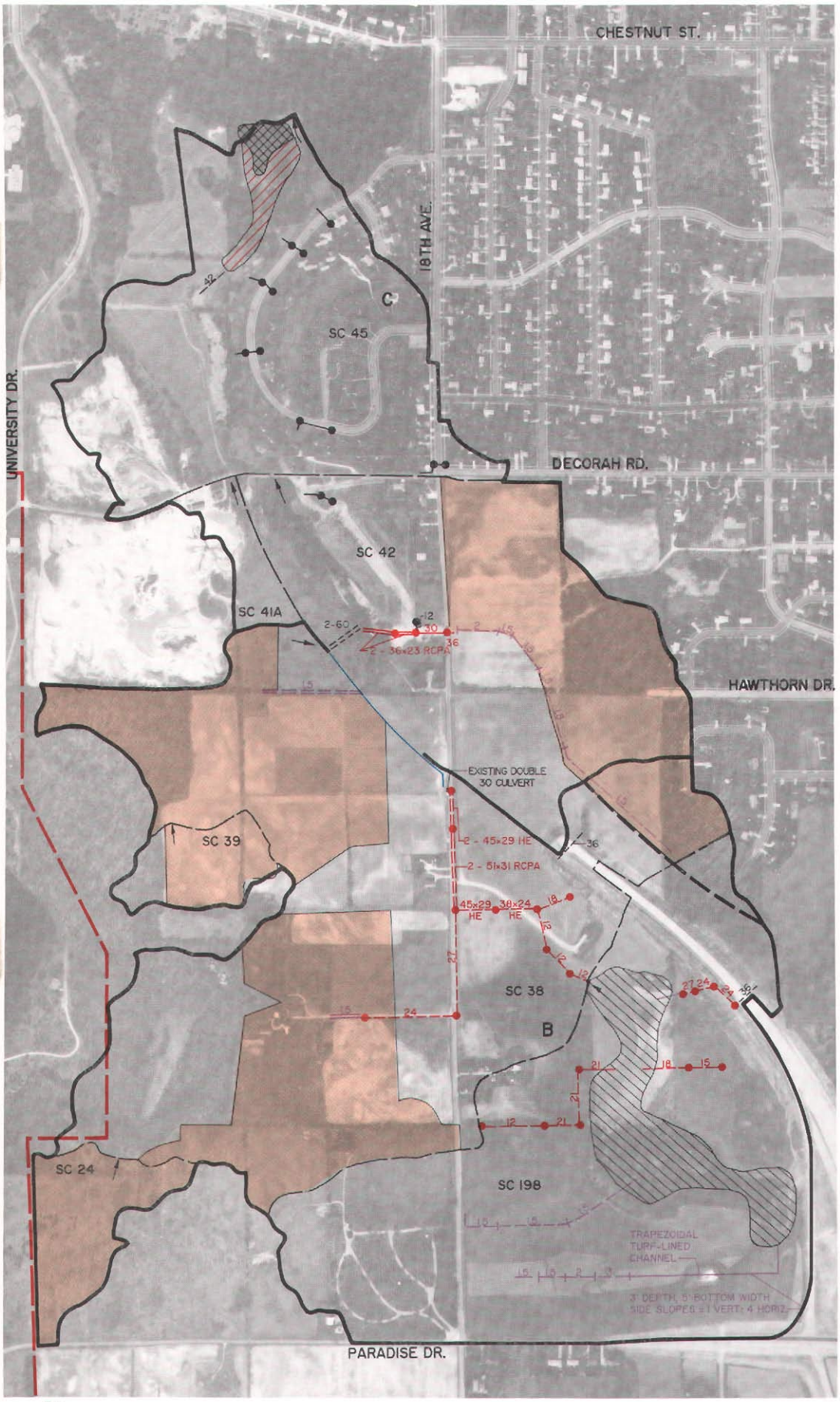
NOTE: ALL WITHIN T.11N., R.19E.



Map 5 (continued)

CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNITS B AND C



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- B — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 38 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 12 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 36 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING NATURAL RETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 12 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 12 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- 1.5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES
- PROPOSED DETENTION BASIN
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

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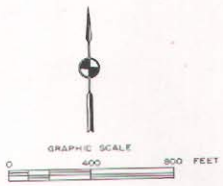
SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

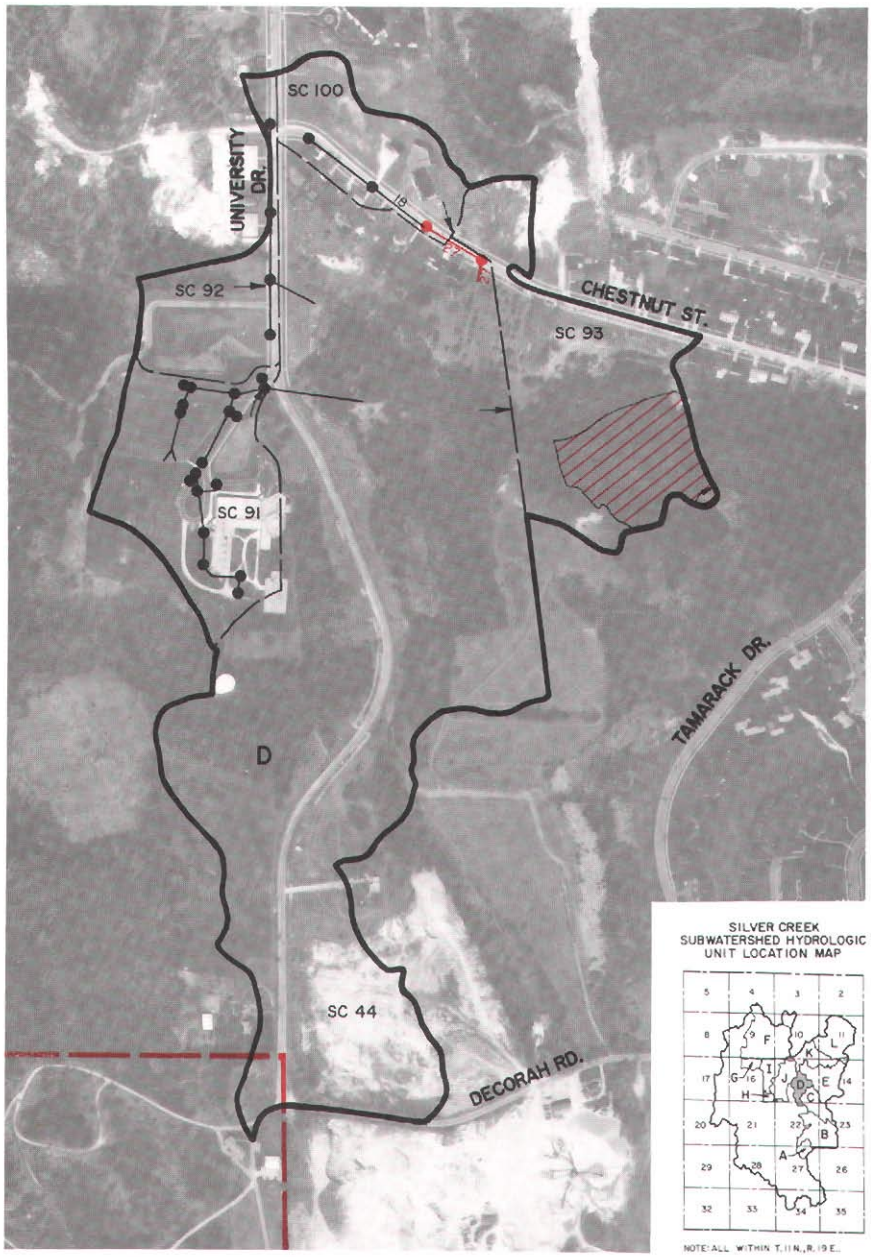
NOTE: ALL WITHIN T.111N., R.19E.



Map 5 (continued)

CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT D

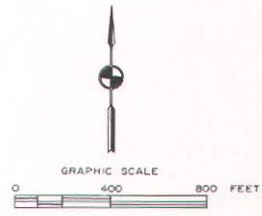


LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- D — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 44 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 18 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 42 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 27 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED DETENTION BASIN

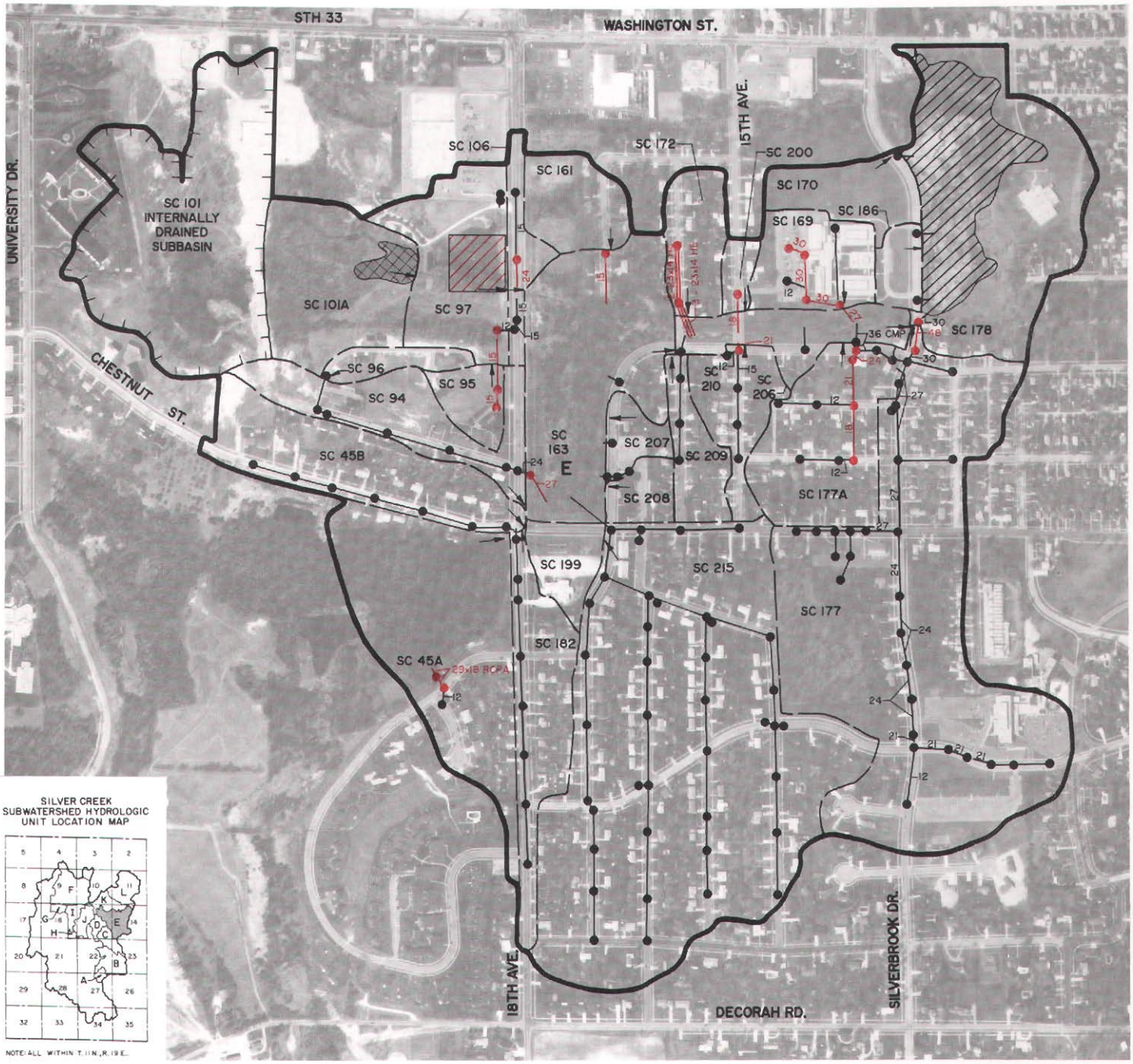
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS



CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT E



SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

NOTE: ALL WITHIN T.11N.,R.19E.

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- E — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 94 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 15 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED DETENTION BASIN
- CMP — CORRUGATED METAL PIPE
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

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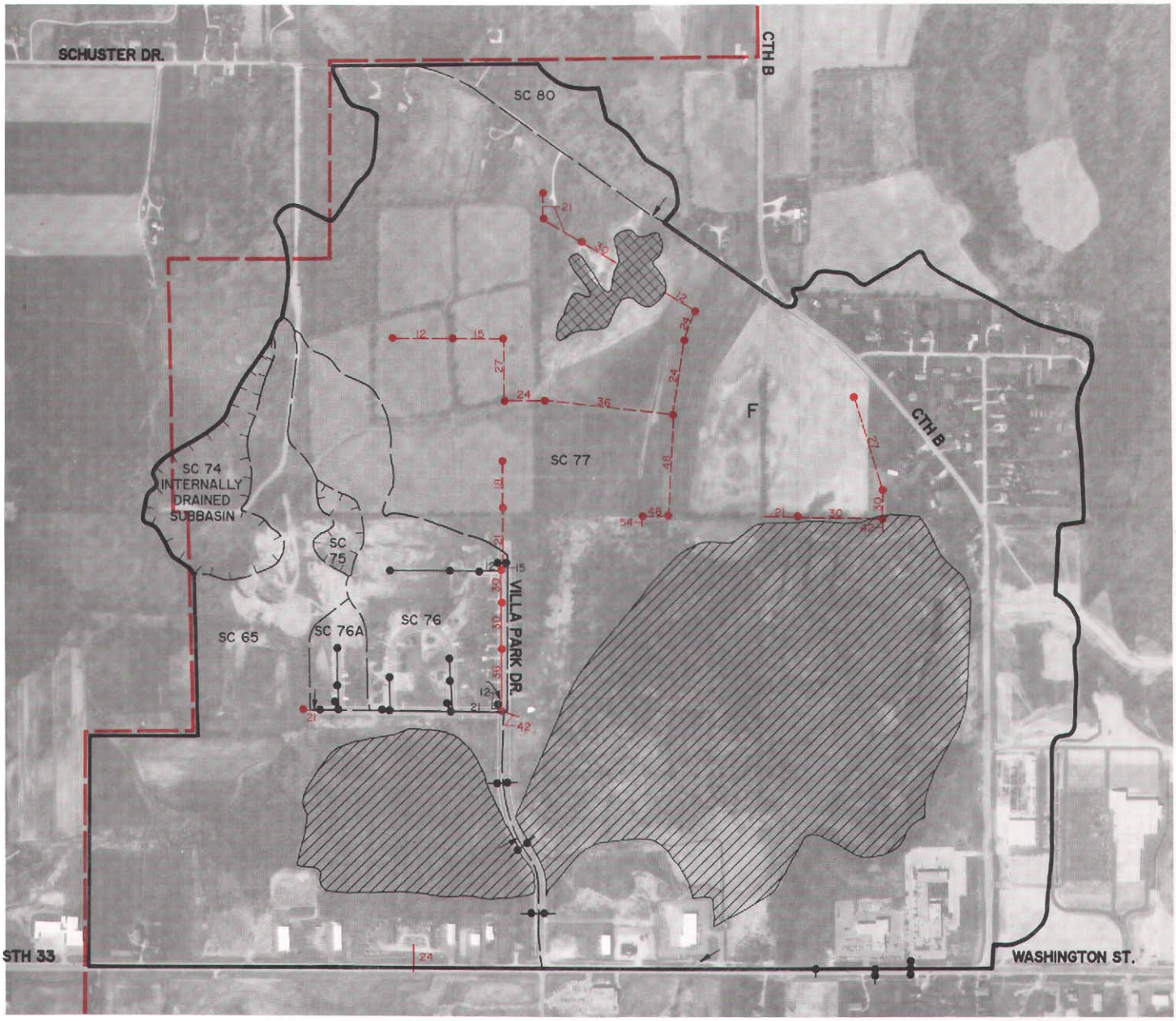
GRAPHIC SCALE
0 400 800 FEET

Map 5 (continued)

CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT F



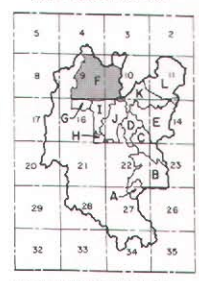
LEGEND

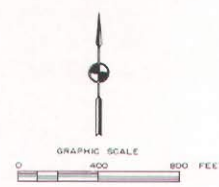
- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- F — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 77 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 12 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 30 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

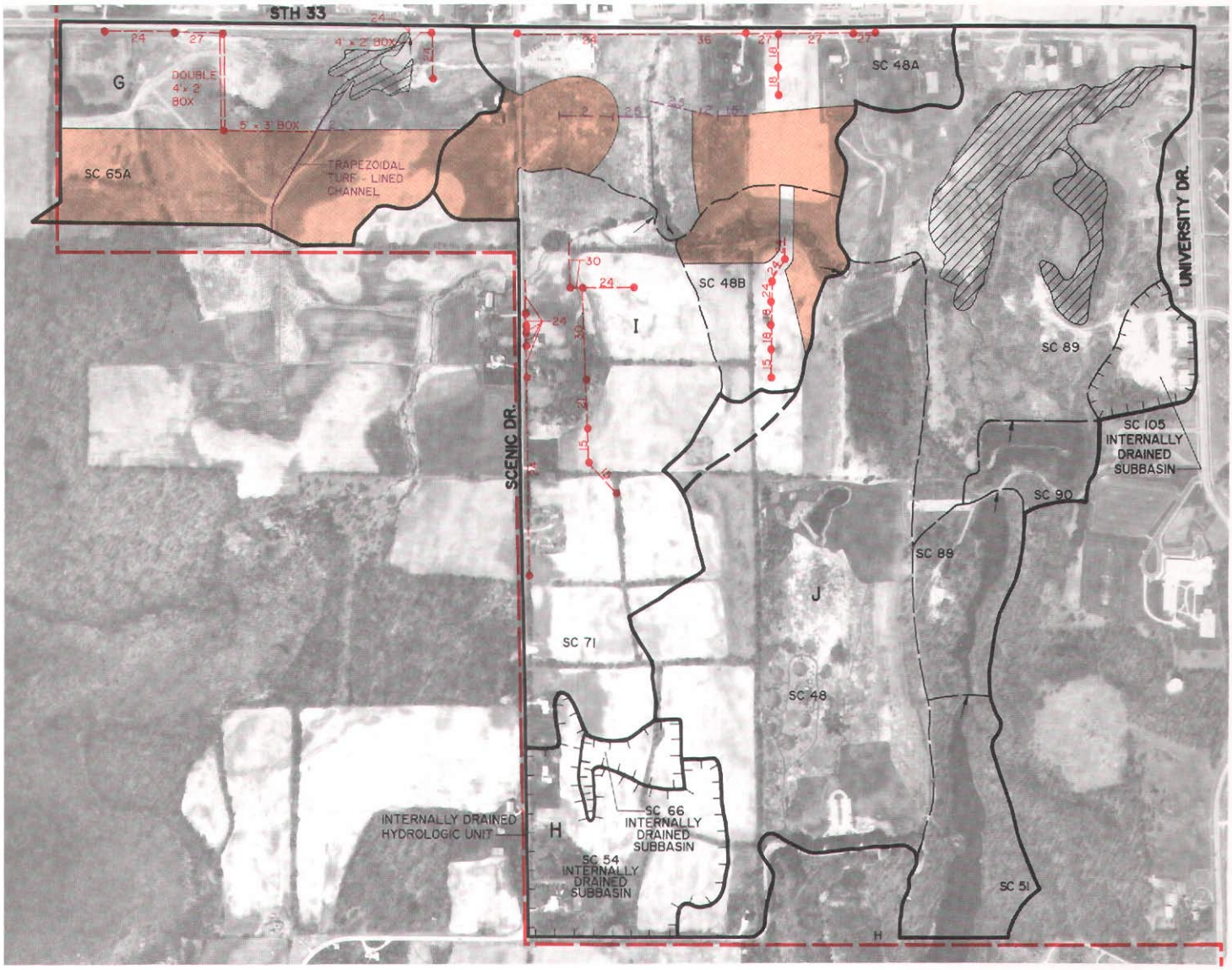




Map 5 (continued)

CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNITS G, H, I, AND J



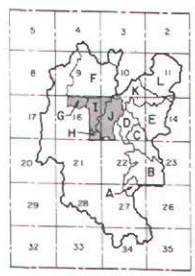
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- J — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 89 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 24 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- 2.5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



NOTE: ALL WITHIN T.11N., R.19E.

GRAPHIC SCALE
0 400 800 FEET

CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

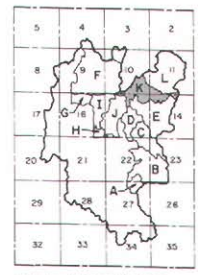
HYDROLOGIC UNIT K

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- K — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 179 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 24 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 24 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 24 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- RCPA — REINFORCED CONCRETE PIPE ARCH
- NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



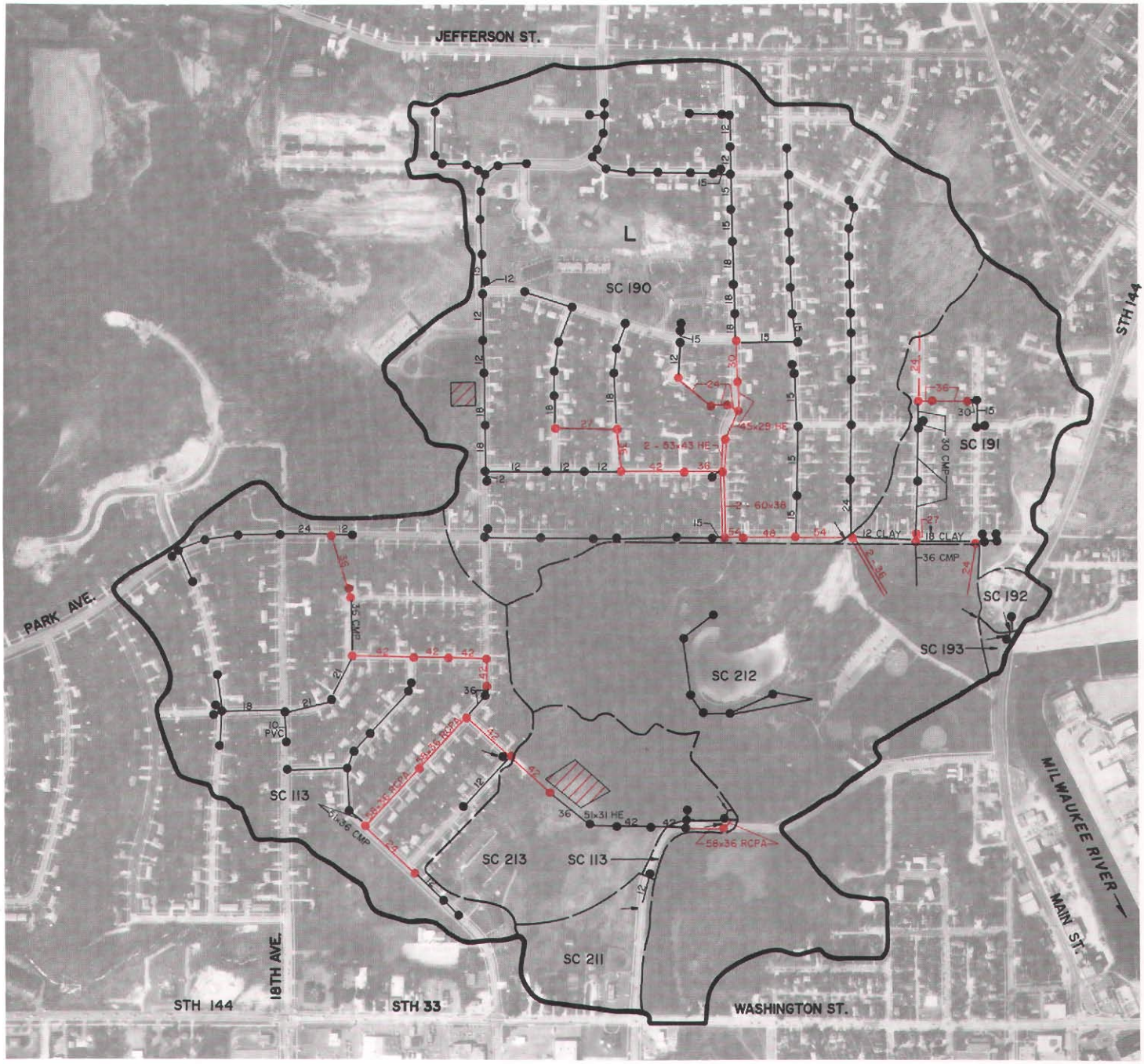
NOTE: ALL WITHIN T.11N., R.19E.

GRAPHIC SCALE
0 400 800 1200 FEET

Map 5 (continued)

CENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT L



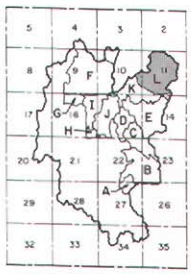
LEGEND

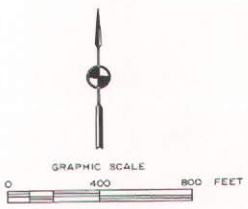
- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- L — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 212 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- PROPOSED MANHOLE
- 24 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 24 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED DETENTION BASIN
- CMP — CORRUGATED METAL PIPE
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- CLAY — CLAY PIPE
- PVC — POLYVINYL CHLORIDE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP





Source: SEWRPC.

Table 5

COMPONENTS AND COSTS OF THE CENTRALIZED DETENTION ALTERNATIVE WEST BEND STORMWATER MANAGEMENT PLAN FOR THE SILVER CREEK SUBWATERSHED

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
A	Southeastern Portion of Planned Urban Service Area Along Paradise Drive		
	Same components as Storm Sewer-Roadside Swale Conveyance Alternative		
	Subtotal	$ 57,000	$ 1,800
B	Southern Portion of Silverbrook Creek Subbasin		
	Same components as Storm Sewer-Roadside Swale Conveyance Alternative		
	Subtotal	$ 640,000	$ 5,100
C	Central Portion of Silverbrook Creek Subbasin		
	1 through 4 Same as Storm Sewer-Roadside Swale Conveyance Alternative	$ 111,000	$ 900
	5. Increase surcharge storage volume of existing pond in Bicentennial Park by 3.8 acre-feet	66,000	5,000
	6. Engineering, administration, and contingencies	39,000	0
	Subtotal	$ 239,000	$ 5,900
D	Western Portion of Silverbrook Creek Subbasin		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 38,000	$ 0
E	Northern Portion of Silverbrook Creek Subbasin		
	1 through 15 Same as Storm Sewer Conveyance Alternative	$ 268,000	$ 200
	16. Construct a 2.5-acre-foot detention basin on a tributary to Silverbrook Creek located south of Washington Street and west of 18th Avenue	54,000	4,000
	17. Land acquisition for detention basin	80,000	0
	18. Engineering, administration, and contingencies	141,000	0
	Subtotal	$ 543,000	$ 4,200
F	Northern Portion of Washington Creek Subbasin		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 768,000	$ 3,200

Table 5 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
G	Western Portion of Washington Creek Subbasin		
	1 through 5 Same components as Storm Sewer-Roadside Swale Conveyance Alternative	$ 214,000	$ 600
	6. 485 feet of 4-foot x 3-foot concrete box storm sewer	75,000	100
	7. 180 feet total of 24-inch culvert	9,000	100
	8. Engineering, administration, and contingencies	104,000	0
	Subtotal	$ 402,000	$ 800
H	No New Stormwater Management Measures Considered	--	--
I	Southern Portion of Washington Creek Subbasin		
	Same components as Storm Sewer-Roadside Swale Conveyance Alternative		
	Subtotal	$ 563,000	$ 3,200
J	No New Stormwater Management Measures Considered	--	--
K	Central Portion of Silver Creek Subwatershed		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 490,000	$ -100
L	Eastern Portion of Silver Creek Subwatershed-Regner Park Environs		
	1 through 9 Same components as Storm Sewer Conveyance Alternative	$ 505,000	$ 0
	10 through 13 Existing storm sewers are adequate	0	0
	14. Replace 183 feet of 48-inch storm sewer in Silverbrook Drive with 58-inch x 36-inch RCPA at a slope of 0.40 percent	38,000	0
	15 through 22 Same as Storm Sewer Conveyance Alternative	182,000	0
	23 through 26 Existing storm sewers are adequate	0	0
	27 through 31 Same as Storm Sewer Conveyance Alternative	301,000	-200
	32. Replace 70 feet of 58-inch x 36-inch CMPA storm sewer in Park Avenue east of 12th Avenue with 54-inch storm sewer	15,000	0
	32a. Replace 313 feet of 58-inch x 36-inch CMPA storm sewer in Park Avenue east of 12th Avenue with 48-inch storm sewer	59,000	0
	33. Replace 300 feet of 60-inch x 40-inch CMPA storm sewer in Park Avenue between 10th and 11th Avenues with 54-inch storm sewer	66,000	0

Table 5 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
L (continued)	34. Replace 300 feet of 60-inch x 40-inch CMPA storm sewer running from Park Avenue at 10th Avenue to Regner Park pond with twin 36-inch storm sewer	$ 77,000	$ 100
	35 through 38 Same as Storm Sewer Conveyance Alternative	80,000	100
	39. Construct a 0.6-acre-foot detention basin west of Green Tree Road and southeast of Green Tree School	39,000	3,000
	40. Land acquisition for Green Tree detention basin	15,000	0
	41. Construct a 1.0-acre-foot detention basin north of Wood Way extended	42,000	3,000
	42. Engineering, administration, and contingencies	497,000	0
	Subtotal	$1,916,000	$ 6,000
Total		$5,656,000	$30,100

[a] *All new and replacement storm sewers are concrete pipe.*

[b] *Costs were noted to be zero when the project proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lesser operation and maintenance cost than the cost of the existing facility.*

Source: SEWRPC.

(Continued from Page 52)

development. Replacement circular storm sewers range in diameter from 15 inches to 60 inches. Horizontal elliptical storm sewer sizes range from 23 inches by 14 inches to 60 inches by 38 inches. Reinforced concrete pipe arch sizes range from 36 inches by 23 inches to 73 inches by 45 inches. Also, a total of about 1,125 feet of new grass-lined open channels would be provided.

For the evaluation of alternatives, the new detention facilities were sized as dry basins, with no permanent pool for abatement of nonpoint source pollutant loadings. If included in the recommended plan, the basins could be enlarged into wet basins which would be effective in removing nonpoint source pollutant loadings, primarily through the sedimentation of particulate pollutants and the biological uptake of nutrients. The roadside swales and engineered open channels would abate nonpoint source pollution through filtering and infiltration. Additional nonpoint source pollution reduction would be achieved through the control of construction site erosion, through the installation of parking lot infiltration devices in areas of existing development, and by implementation of a public education program. This alternative plan would achieve a greater level of abatement of nonpoint source pollutants than that achieved by either conveyance alternative plan.

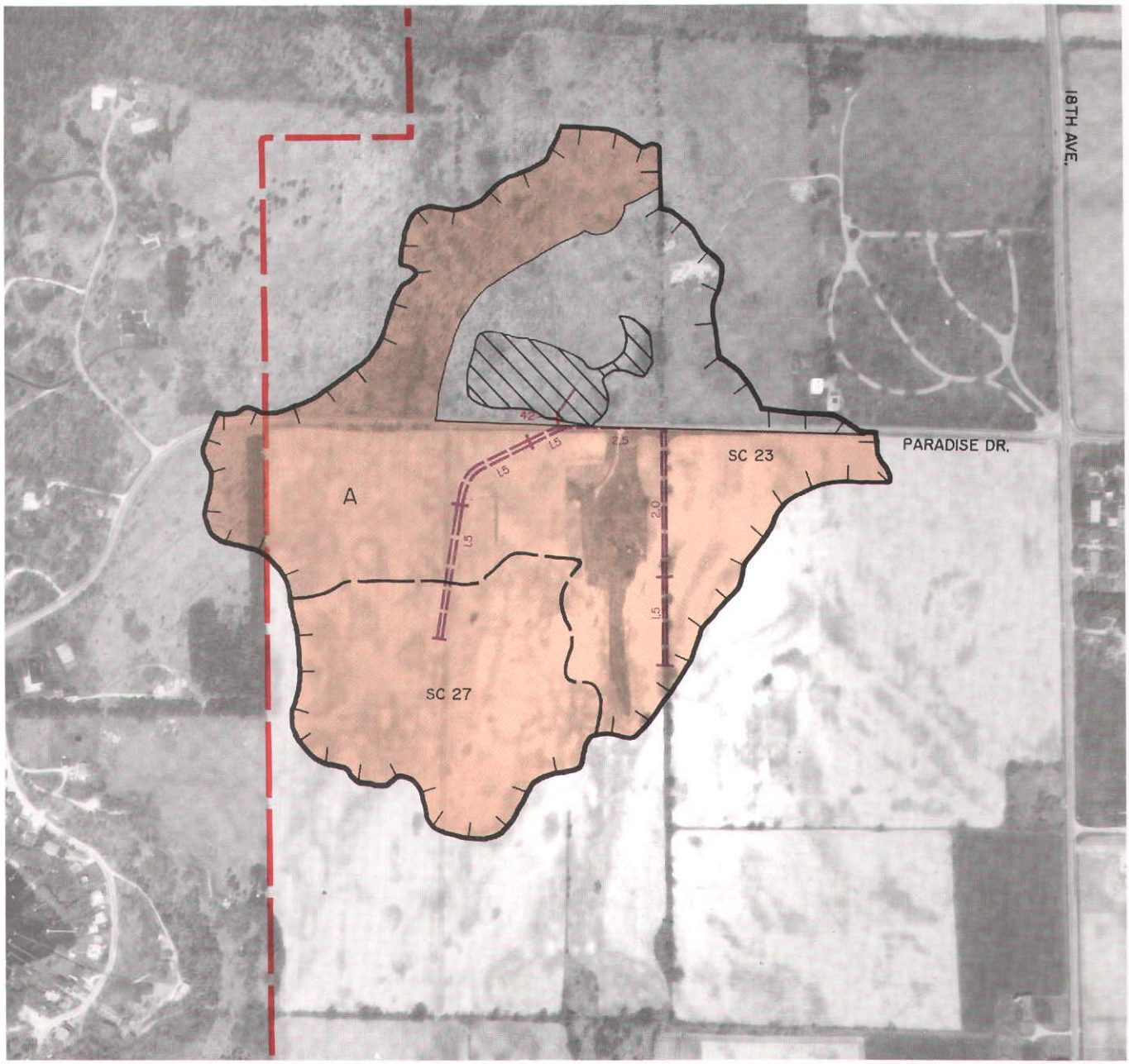
The parking lot detention facility would be a dry detention basin in that a permanent pool of water would not be provided. A relatively small amount of particulate pollutants could be deposited during storm events on the parking lot surface and removed by subsequent sweeping of the parking lot. However, the overall pollutant removal effectiveness of this facility would be expected to be insignificant.

(Continued on Page 76)

Map 6

DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT A



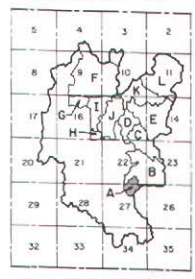
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- A — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 27 — SUBBASIN IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL RETENTION BASIN
- 42 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- L5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



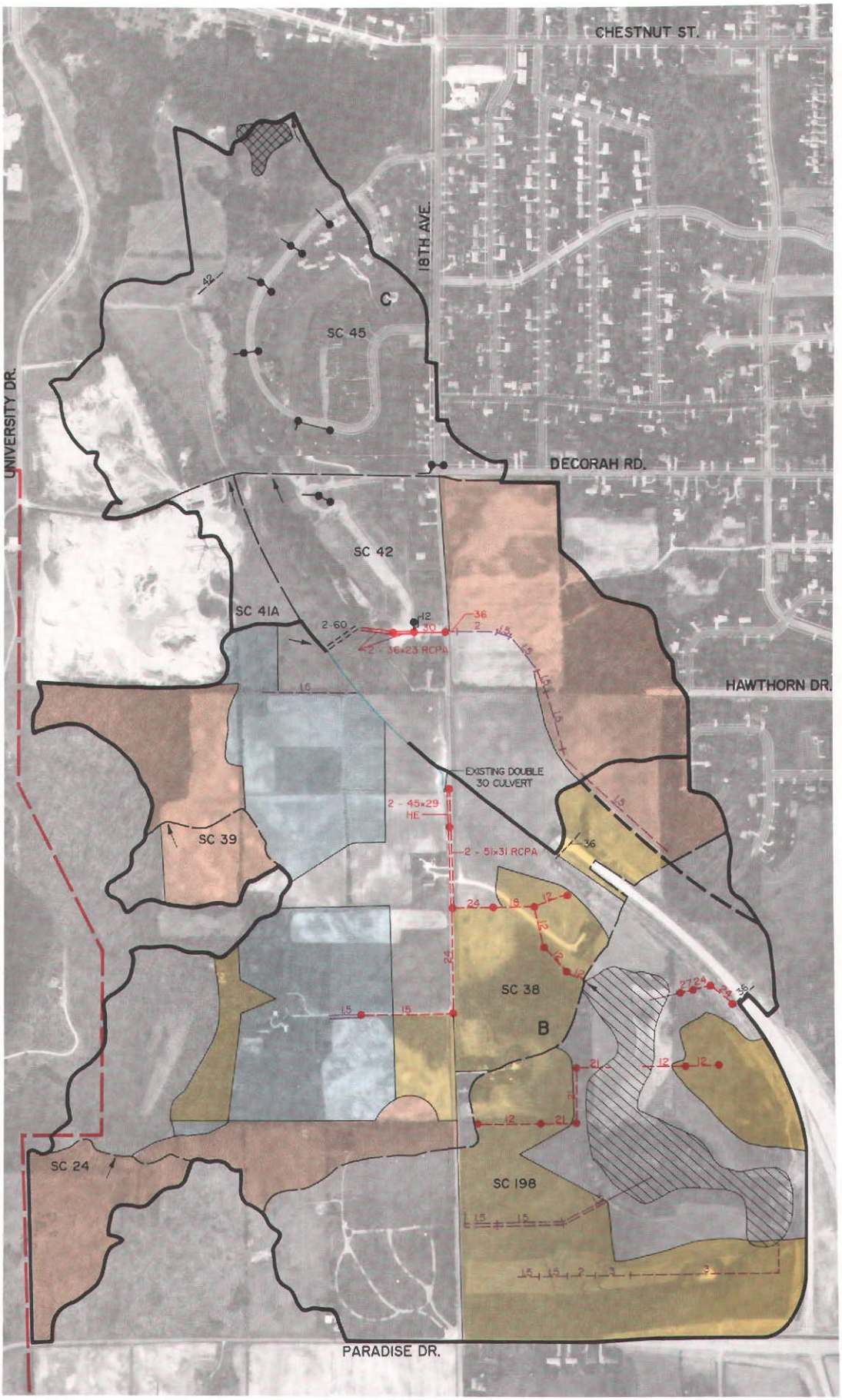
NOTE: ALL WITHIN T.11N., R.19E.

GRAPHIC SCALE
0 200 400 FEET

Map 6 (continued)

DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNITS B AND C



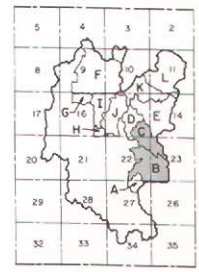
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- B — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 198 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 15 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 36 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING CONSTRUCTED WET DETENTION BASIN
- EXISTING NATURAL RETENTION BASIN
- PROPOSED MANHOLE
- 27 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 30 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- 15 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES
- CATCHMENT AREAS WITH PROPOSED DRY DETENTION BASINS
- CATCHMENT AREAS WITH PROPOSED DRY DETENTION BASINS AND ROADSIDE SWALES
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



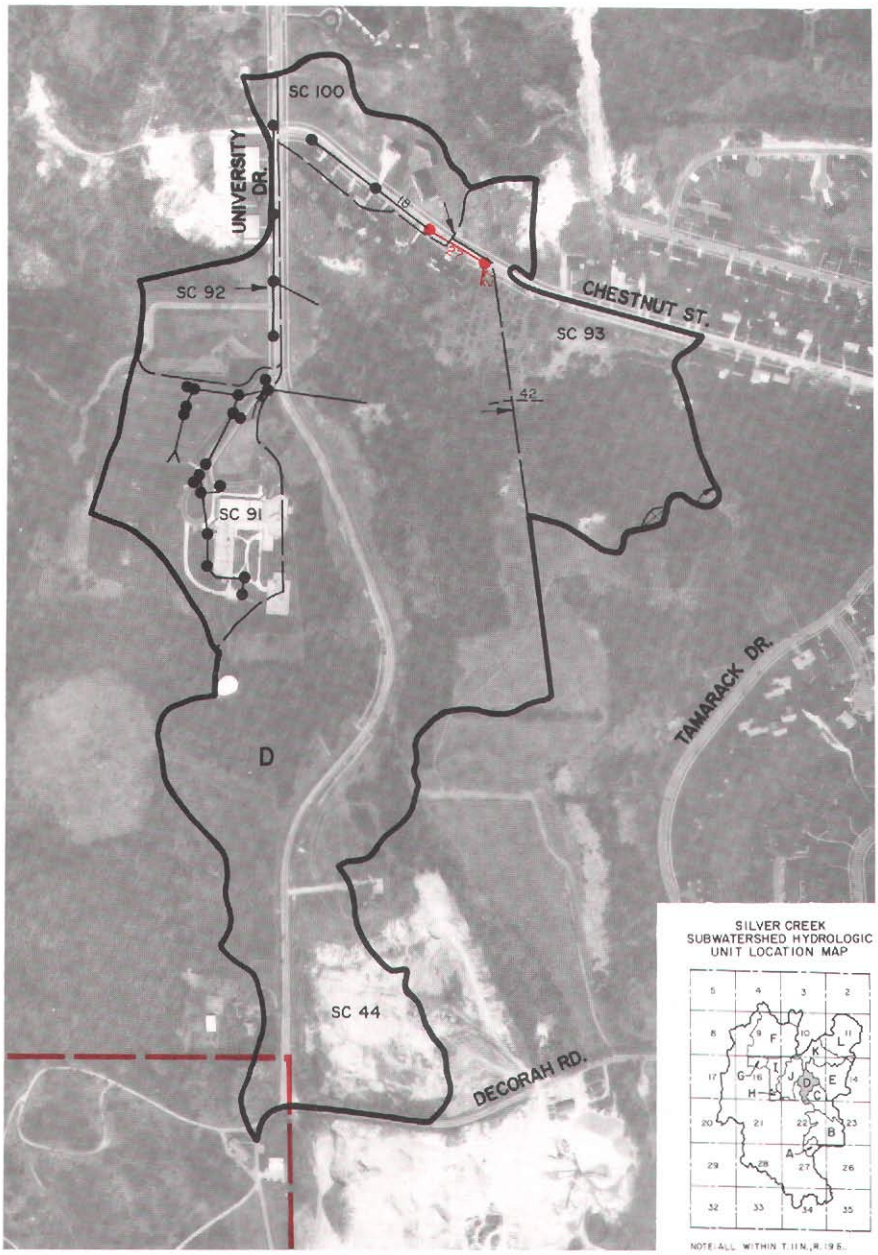
NOTE: ALL WITHIN T. 11 N., R. 19 E.

GRAPHIC SCALE
0 400 800 FEET

Map 6 (continued)

DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT D



SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

NOTE: ALL WITHIN T.11N., R.19E.

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- D — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 44 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 18 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 42 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 27 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)

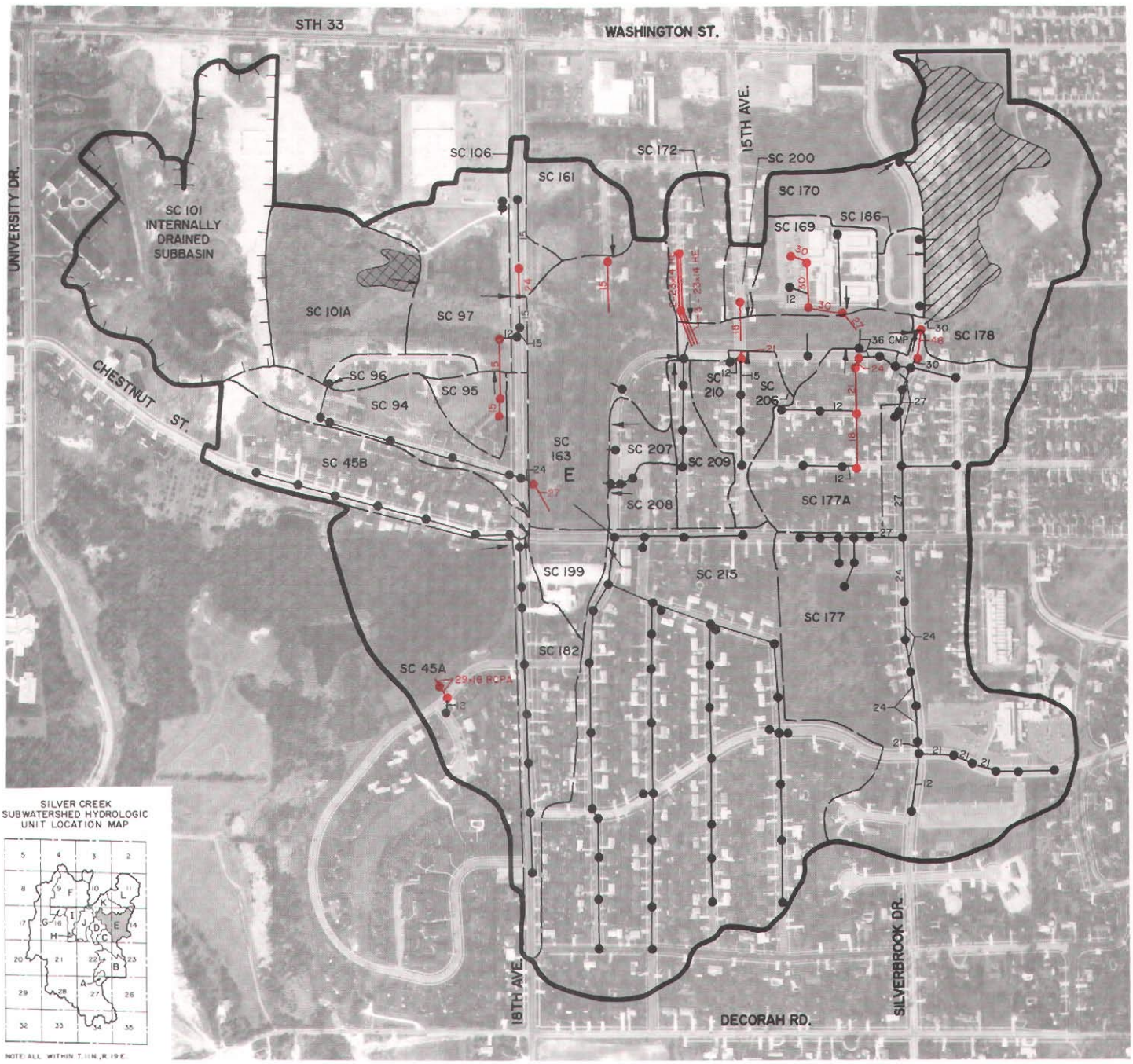
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT E



SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

NOTE: ALL WITHIN T.11N., R.19E.

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- E — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 94 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 15 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH
- CMP — CORRUGATED METAL PIPE

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

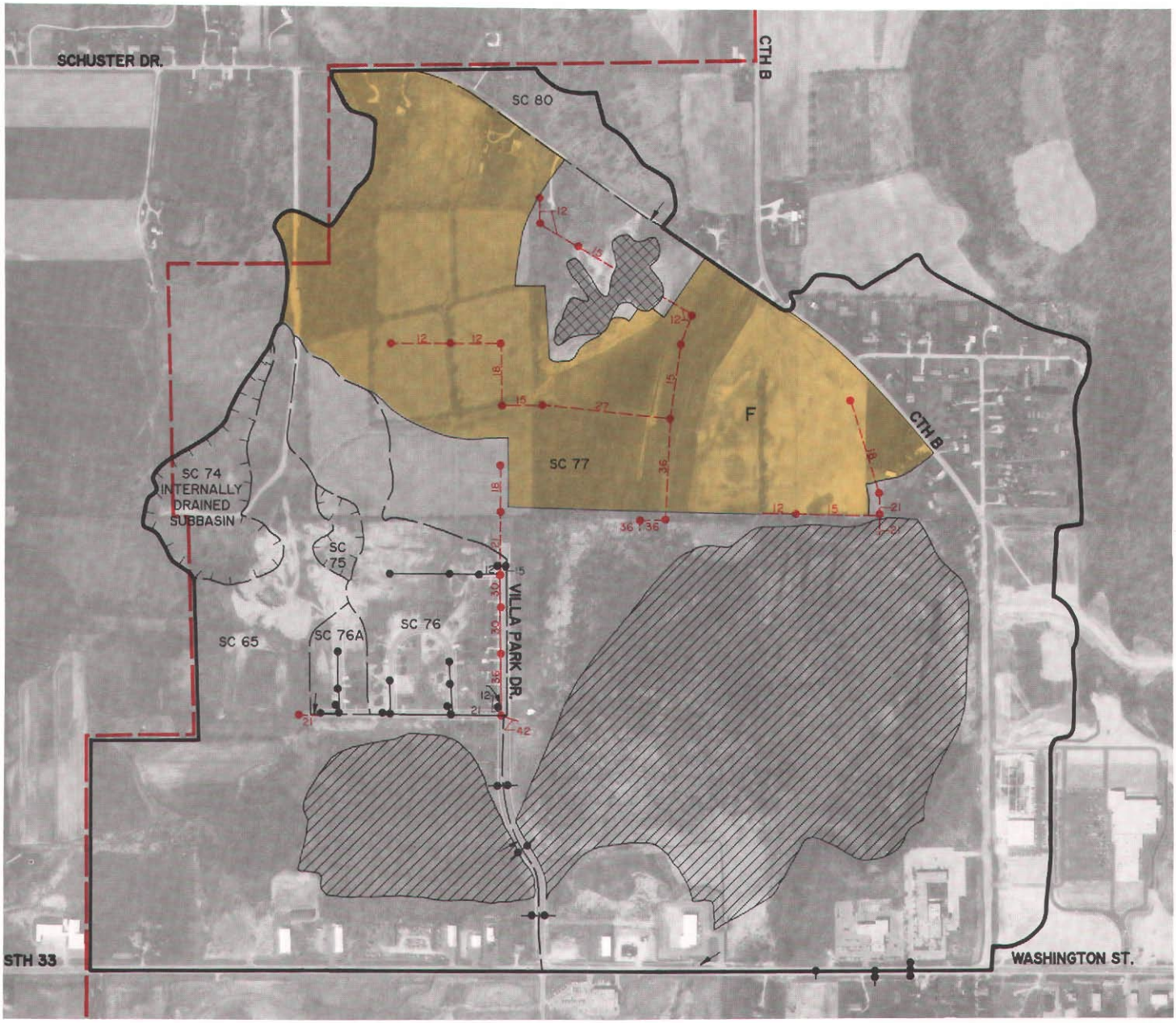
EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

Map 6 (continued)

DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT F



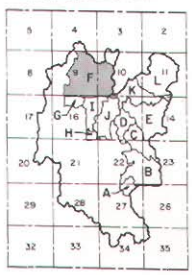
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- F — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 77 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 21 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 15 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 36 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- CATCHMENT AREAS WITH PROPOSED DRY DETENTION BASINS

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

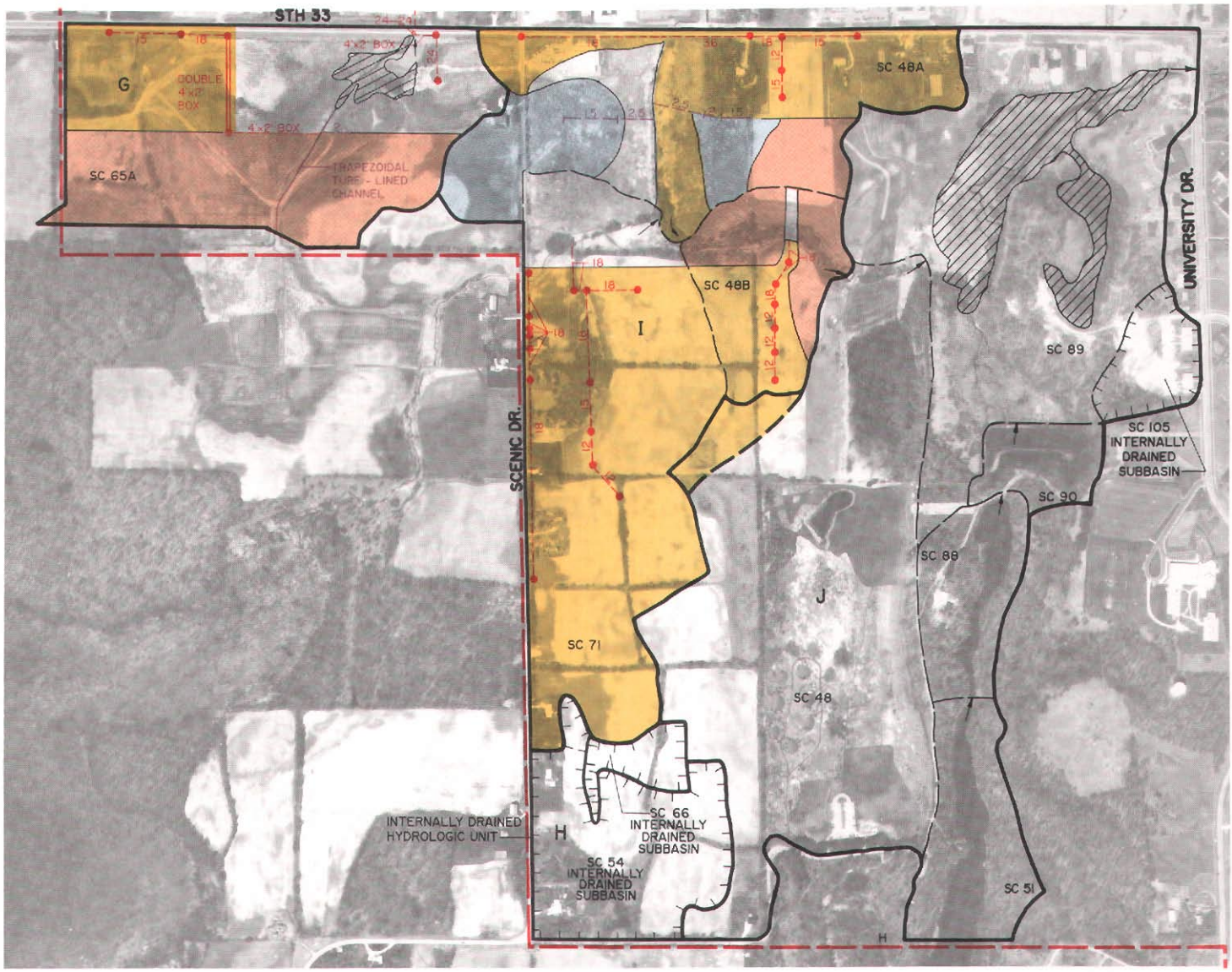


NOTE: ALL WITHIN T.11N., R.19E.

GRAPHIC SCALE
0 400 800 FEET

DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNITS G, H, I, AND J



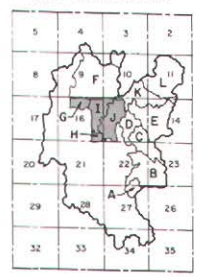
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- J — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 70 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 24 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- 2.5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES
- CATCHMENT AREAS WITH PROPOSED DRY DETENTION BASINS
- CATCHMENT AREAS WITH PROPOSED DRY DETENTION BASINS AND ROADSIDE SWALES

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

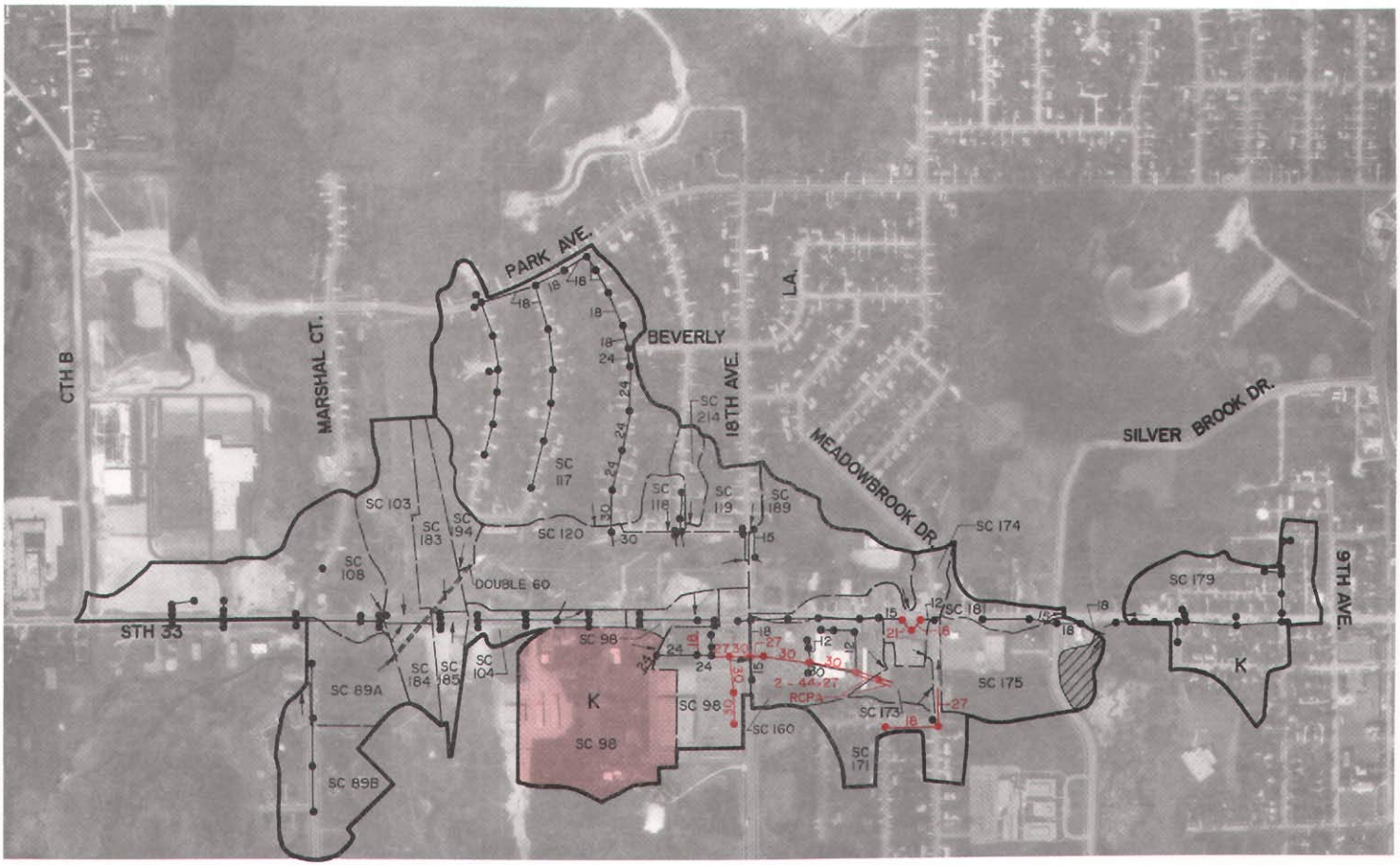
SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



NOTE: ALL WITHIN T.11N., R.19E.

DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT K



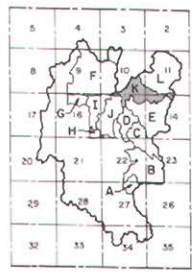
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- K — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 98 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 24 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 24 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 30 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED ONSITE PARKING LOT DETENTION AREA
- RCPA — REINFORCED CONCRETE PIPE ARCH

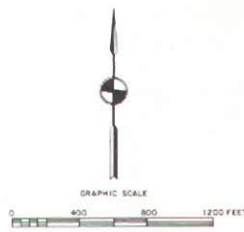
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

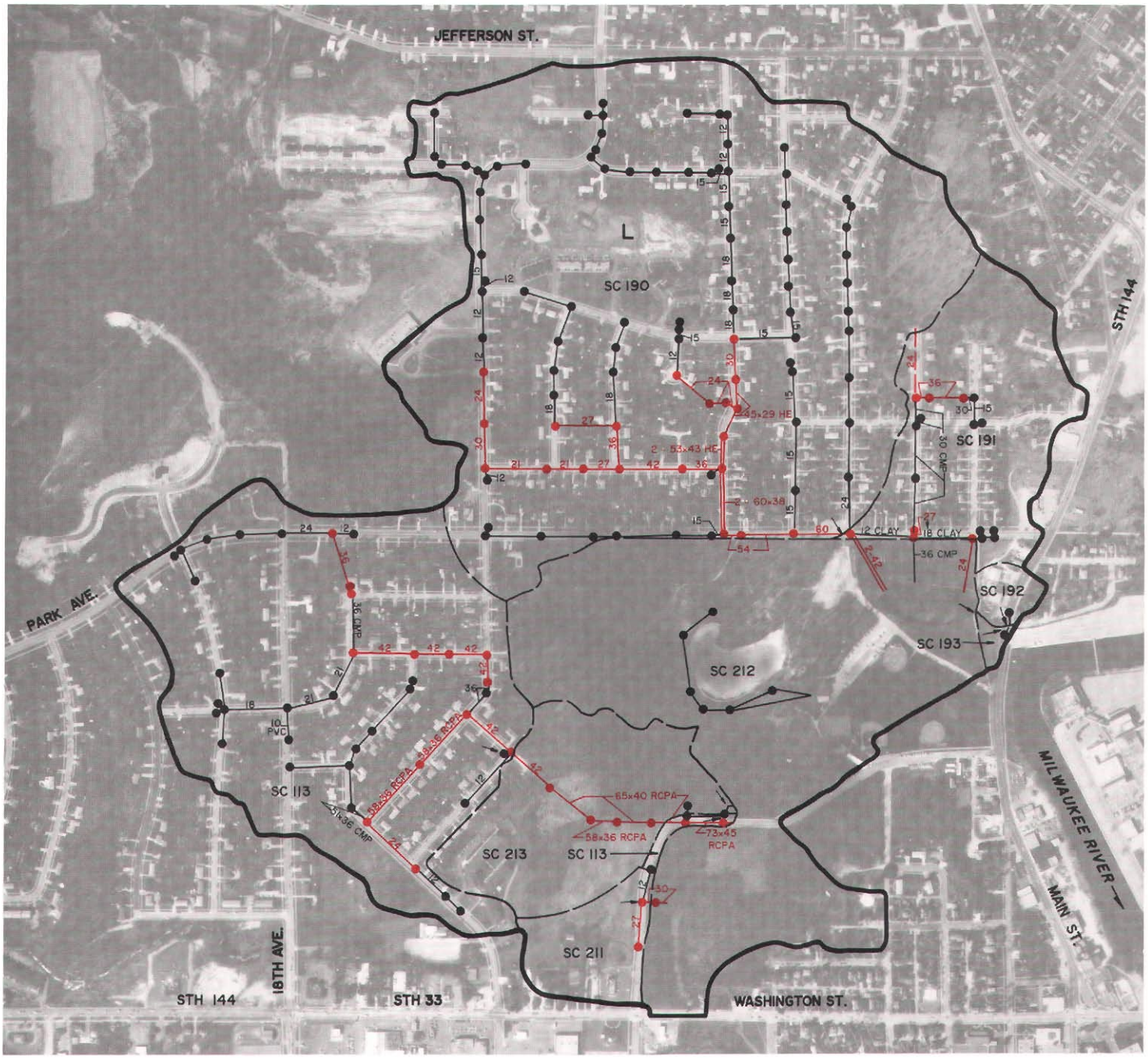


NOTE: ALL WITHIN T.11N.,R.19E.



DECENTRALIZED DETENTION ALTERNATIVE PLAN FOR STORMWATER MANAGEMENT IN THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT L



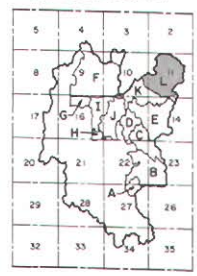
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- L — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 212 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- PROPOSED MANHOLE
- 24 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 24 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH
- CMP — CORRUGATED METAL PIPE
- CLAY — CLAY PIPE
- PVC — POLYVINYL CHLORIDE PIPE

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



GRAPHIC SCALE
0 400 800 FEET

Source: SEWRPC.

Table 6

COMPONENTS AND COSTS OF THE DECENTRALIZED DETENTION ALTERNATIVE WEST BEND STORMWATER MANAGEMENT PLAN FOR THE SILVER CREEK SUBWATERSHED

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
A	Southeastern Portion of Planned Urban Service Area Along Paradise Drive		
	Same components as Storm Sewer-Roadside Swale Conveyance Alternative		
	Subtotal	$ 57,000	$ 1,800
B	Southern Portion of Silverbrook Creek Subbasin		
	1 through 4 Same components as Storm Sewer-Roadside Swale Conveyance Alternative	$ 67,000	$ 2,100
	5. 695 feet of 12-inch storm sewer	21,000	300
	6. 735 feet of 15-inch storm sewer	26,000	300
	7. 545 feet of 18-inch storm sewer	23,000	200
	8. Same as Storm Sewer-Roadside Swale Conveyance Alternative	38,000	300
	9. 1,234 feet of 24-inch storm sewer	68,000	500
	10. 60 feet of 27-inch storm sewer	4,000	0
	11. 245 feet of 38-inch x 24-inch concrete horizontal elliptical (H.E.) storm sewer called for in Storm Sewer-Roadside Swale Conveyance Alternative would be eliminated	0	0
	12. 255 feet of 45-inch x 29-inch H.E. storm sewer called for in Storm Sewer-Roadside Swale Conveyance Alternative would be eliminated	0	0
	13 through 19 Same components as Storm Sewer-Roadside Swale Conveyance Alternative	190,000	1,400
	20. Construct about 12 decentralized detention basins with a total surcharge storage volume of 2.5 acre-feet in areas indicated on Map 6	457,000	31,000
	21. Land acquisition for decentralized detention basins	10,000	0
	22. Engineering, administration, and contingencies	316,000	0
	Subtotal	$1,220,000	$ 36,100
C	Central Portion of Silverbrook Creek Subbasin		
	Same components as Storm Sewer-Roadside Swale Conveyance Alternative		
	Subtotal	$ 150,000	$ 900

Table 6 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
D	Western Portion of Silverbrook Creek Subbasin		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 38,000	$ 0
E	Northern Portion of Silverbrook Creek Subbasin		
	Same components as Storm Sewer Conveyance Alternative		
	Subtotal	$ 362,000	$ 200
F	Northern Portion of Washington Creek Subbasin		
	1 through 6 Same components as Storm Sewer Conveyance Alternative	$ 117,000	$ 100
	7. 1,615 feet of 12-inch storm sewer	49,000	600
	8. 1,510 feet of 15-inch storm sewer	53,000	600
	9. 240 feet of 21-inch storm sewer	11,000	100
	10. 855 feet of 24-inch storm sewer called for in Storm Sewer Conveyance Alternative would be eliminated and replaced by smaller storm sewer. 220 feet of 24-inch storm sewer would be retained	12,000	100
	11. 645 feet of 27-inch storm sewer	40,000	300
	12. 1,160 feet of 30-inch storm sewer called for in Storm Sewer Conveyance Alternative would be eliminated and replaced by smaller storm sewer	0	0
	13. 885 feet of 36-inch storm sewer	78,000	200
	14. 20 feet of 42-inch storm sewer called for in Storm Sewer Conveyance Alternative would be eliminated and replaced by smaller storm sewer	0	0
	15. 865 feet of 482-inch storm sewer called for in Storm Sewer Conveyance Alternative would be eliminated and replaced by smaller storm sewer	0	0
	16. 20 feet of 54-inch storm sewer called for in Storm Sewer Conveyance Alternative would be eliminated and replaced by smaller storm sewer	0	0
	17 through 19 Same components as Storm Sewer Conveyance Alternative	27,000	1,000
	20. 975 feet of 18-inch storm sewer	40,000	400

Table 6 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
F (continued)	21. Construct about nine decentralized detention basins with a total surcharge storage volume of 3.5 acre-feet in areas indicated on Map 6	$ 362,000	$ 25,000
	22. Land acquisition for decentralized detention basins	13,000	0
	23. Engineering, administration, and contingencies	281,000	0
	Subtotal	$1,083,000	$ 28,400
G	Western Portion of Washington Creek Subbasin		
	1. Same as Storm Sewer-Roadside Swale Conveyance Alternative	$ 1,000	$ 100
	2. 290 feet of 24-inch storm sewer	16,000	100
	3. 320 feet of 27-inch storm sewer called for in Storm Sewer-Roadside Swale Conveyance Alternative would be eliminated and replaced by smaller storm sewer	0	0
	4 and 5 Same as Storm Sewer-Roadside Swale Conveyance Alternative	157,000	200
	6 and 7 Same as Centralized Detention Alternative	84,000	100
	8. 320 feet of 18-inch storm sewer	13,000	100
	9. Construct two decentralized detention basins with a total surcharge storage volume of 1.4 acre-feet in area indicated on Map 6	79,000	6,000
	10. Land acquisition for decentralized detention basins	32,000	0
	11. Engineering, administration, and contingencies	134,000	0
	Subtotal	$ 516,000	$ 6,600
H	No New Stormwater Management Measures Considered	--	--
I	Southern Portion of Washington Creek Subbasin		
	1. 560 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 2,000	$ 200
	2. 110 feet of 2-foot-deep roadside swale with driveway culverts	1,000	100
	3. Same as Storm Sewer-Roadside Swale Conveyance Alternative	6,000	200
	4. 1,010 feet of 15-inch storm sewer	36,000	400
	5. 4,445 feet of 18-inch storm sewer	182,000	1,700
	6. 300 feet of 21-inch storm sewer called for in Storm Sewer-Roadside Swale Conveyance Alternative would be eliminated and replaced by smaller storm sewer	0	0

Table 6 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
I (continued)	7. 3,570 feet of 24-inch storm sewer called for in Storm Sewer-Roadside Swale Conveyance Alternative would be eliminated and replaced by smaller storm sewer	$ 0	$ 0
	8. 745 feet of 27-inch storm sewer called for in Storm Sewer-Roadside Swale Conveyance Alternative would be eliminated and replaced by smaller storm sewer	0	0
	9. 875 feet of 30-inch storm sewer called for in Storm Sewer-Roadside Swale Conveyance Alternative would be eliminated and replaced by smaller storm sewer	0	0
	10. Same as Storm Sewer-Roadside Swale Conveyance Alternative	41,000	100
	11. 1,185 feet of 12-inch storm sewer	36,000	500
	12. Construct about 10 decentralized detention basins with a total surcharge storage volume of 4.5 acre-feet in areas indicated on Map 6	373,000	25,800
	13. Land acquisition for decentralized detention basins	61,000	0
	14. Engineering, administration, and contingencies	258,000	0
	Subtotal	$ 996,000	$ 29,000
J	No New Stormwater Management Measures Considered	--	--
K	Central Portion of Silver Creek Subwatershed		
	1. Retain the existing 133 feet of 24-inch storm sewer located east of K-Mart store at the intersection of Washington Street and 18th Aveenue	$ 0	$ 0
	2. Retain the existing 238 feet of 24-inch storm sewer in K-Mart parking lot	0	0
	3. Same as Storm Sewer Conveyance Alternative	12,000	0
	4. Replace 200 feet of 24-inch storm sewer in K-Mart parking lot with 27-inch storm sewer	17,000	0
	5. Replace 54 feet of 24-inch storm sewer at K-Mart entrance with 30-inch storm sewer at an increased slope of 2 percent	6,000	0
	6 and 7 Same as Storm Sewer Conveyance Alternative	34,000	0
	8. Replace 407 feet of 24-inch storm sewer in Fleet Farm store parking lot at the intersection of Washington Street and 18th Avenue with 92 feet of 27-inch and 315 feet of 30-inch storm sewer	40,000	0
	9. Retain the 242-foot-long, 30-inch storm sewer in the Fleet Farm parking lot and add a parallel 30-inch RCPA storm sewer	24,000	100

Table 6 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
K (continued)	10. In the Fleet Farm parking lot, replace 180 feet of 30-inch storm sewer with a total of 360 feet of twin 44-inch x 27-inch RCPA storm sewer, and replace 82 feet of 36-inch storm sewer with 164 feet total of twin 44-inch x 27-inch RCPA storm sewer	$ 73,000	$ 0
	11 through 14 Same as Storm Sewer Conveyance Alternative	48,000	0
	15. Provide one acre-foot of parking lot detention volume in subbasin 98	5,000	100
	16. Engineering, administration, and contingencies	91,000	0
	Subtotal	$ 350,000	$ 200
L	Eastern Portion of Silver Creek-Regner Park Environs Same components as Storm Sewer Conveyance Alternative	$2,252,000	$ 100
Total		$7,024,000	$103,300

[a]*All new and replacement storm sewers are concrete pipe.*

[b]*Costs were noted to be zero when the project proposed replacement of a component with a component having similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lesser operation and maintenance cost than the cost of the existing facility.*

Source: SEWRPC.

(Continued from Page 63)

EVALUATION OF ALTERNATIVE STORMWATER MANAGEMENT PLANS

The preceding sections described the four alternative stormwater management system plans considered for the portion of the planned urban service area for the City of West Bend that lies within the Silver Creek subwatershed. The information presented was intended to provide a basis for a comparative evaluation of the four alternative plans. Each alternative was designed to resolve the identified existing drainage problems, as well as to serve anticipated future development within the planned urban service area, and to accommodate stormwater flows from upstream areas under planned land use conditions. Thus, the principal criteria for the comparative evaluation were reduced to cost and nonpoint source pollutant removal effectiveness. The advantages and disadvantages of each alternative are summarized in Table 7.

For each hydrologic unit within the planning area, Table 8 compares the capital costs, the annual operation and maintenance costs, and the present value of the cost of each alternative. A comparison of the ability of each alternative plan to meet the recommended stormwater management objectives and supporting standards is provided in Table 9 for those objectives and standards which differ in level of achievement between the plans.

Table 7

SUMMARY OF PRINCIPAL COMPONENTS AND ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE STORMWATER MANAGEMENT PLANS FOR THE PORTION OF THE CITY OF WEST BEND URBAN SERVICE AREA WITHIN THE SILVER CREEK SUBWATERSHED

Alternative	Principal New Components	Advantages	Disadvantages
Storm Sewer Conveyance	36,705 feet of storm sewer in areas of planned development 19,610 feet of replacement storm sewer in areas of existing development 1,125 feet of engineered open channel Utilization of existing natural and man-made retention and detention basins	Stormwater drainage components are acceptable and well known to the public; minimal operation and maintenance is required. Use of existing natural and man-made detention and retention basins limits peak discharges and flow volumes downstream of most areas of planned development	Peak discharges and flow volumes are increased downstream of some areas of planned development; some public officials and citizens may oppose high capital cost; relatively low level of reduction in pollutant loadings from nonpoint sources is achieved; higher incremental cost for nonpoint source abatement
Storm Sewer-Roadside Swale Conveyance	11,200 feet of roadside swales in areas of planned development 2,535 feet of engineered open channel 23,560 feet of storm sewer in areas of planned development 19,610 feet of replacement storm sewer in areas of existing development Utilization of existing natural and man-made retention and detention basins	Storm sewer drainage components are acceptable and well known to the public. Roadside swales are proposed only in areas of office park and low-density residential development, where their use should be more acceptable to the public and to public officials. Use of existing natural and man-made detention and retention basins limits peak discharges and flow volumes downstream of most areas of planned development. Roadside swales are effective in reducing nonpoint source pollutant loadings	Peak discharges and flow volumes are increased downstream of some areas of planned development; because of relatively low nonpoint source pollutant loadings from areas of low-density residential development, use of roadside swales in those areas may not significantly reduce overall pollutant loadings in receiving streams
Centralized Detention	Three new centralized detention basins Expansion of one existing centralized detention basin Utilization of existing natural retention and detention basins 11,200 feet of roadside swales 585 feet of engineered open channel 23,155 feet of storm sewer in areas of planned development 18,255 feet of replacement storm sewer in areas of existing development	Minimizes future increases in peak discharges and areas of inundation; reduces the required size and resultant cost of some downstream conveyance systems; relatively high level of reduction in pollutant loadings from nonpoint sources	Maintenance requirements are substantial; land requirements are considerably greater than under the conveyance alternatives; some public officials and citizens may oppose ponded water in urban areas
Decentralized Detention	Construction of about 33 decentralized detention basins in areas of planned development Onsite parking lot detention facility 11,200 feet of roadside swales 1,125 feet of engineered open channel 23,375 feet of storm sewer in areas of planned development 19,060 feet of replacement storm sewer in areas of existing development Utilization of existing natural retention and detention basins	Minimizes future increases in peak discharges and areas of inundation; reduces the required size and resultant cost of some downstream conveyance systems; relatively high level of reduction in pollutant loadings from nonpoint sources	Maintenance requirements are substantial; land requirements are considerably greater than under the conveyance alternatives; some components are necessarily located on private property, so implementation may be difficult; some local opposition of onsite detention facilities may occur; some public officials and citizens may oppose ponded water in urban areas

Source: SEWRPC.

Table 8

COSTS OF THE ALTERNATIVE STORMWATER MANAGEMENT PLANS FOR THE PORTION OF THE SILVER CREEK SUBWATERSHED WITHIN THE CITY OF WEST BEND PLANNED URBAN SERVICE AREA

ESTIMATED COST—PLAN YEAR LAND USE CONDITIONS

Hydrologic Unit Designation	Storm Sewer Conveyance Alternative			Storm-Sewer Roadside Swale Conveyance Alternative			Centralized Detention Alternative			Decentralized Detention Alternative		
	Capital	Annual and Operation Maintenance	Present Value[a]	Capital	Annual and Operation Maintenance	Present Value[a]	Capital	Annual and Operation Maintenance	Present Value[a]	Capital	Annual and Operation Maintenance	Present Value[a]
A	$ 173,000	$ 1,100	$ 191,000	$ 57,000	$ 1,800	$ 85,000	$ 57,000	$ 1,800	$ 85,000	$ 57,000	$ 1,800	$ 85,000
B	1,214,000	4,400	1,284,000	640,000	5,100	721,000	640,000	5,100	721,000	1,220,000	36,100	1,789,000
C	221,000	900	235,000	150,000	900	164,000	239,000	5,900	332,000	150,000	900	164,000
D	38,000	0	38,000	38,000	0	38,000	38,000	0	38,000	38,000	0	38,000
E	362,000	200	365,000	362,000	200	365,000	543,000	4,200	609,000	362,000	200	365,000
F	768,000	3,200	818,000	768,000	3,200	818,000	768,000	3,200	818,000	1,083,000	28,400	1,531,000
G	972,000	1,400	994,000	585,000	1,400	607,000	402,000	800	414,000	516,000	6,600	620,000
H	--	--	--	--	--	--	--	--	--	--	--	--
I	635,000	3,200	685,000	563,000	3,200	614,000	563,000	3,200	614,000	996,000	29,000	1,453,000
J	--	--	--	--	--	--	--	--	--	--	--	--
K	490,000	-100	488,000	490,000	-100	488,000	490,000	-100	488,000	350,000	200	353,000
L	2,252,000	100	2,254,000	2,252,000	100	2,254,000	1,916,000	6,000	2,012,000	2,252,000	100	2,254,000
Total	$7,125,000	$14,400	$7,352,000	$5,905,000	$15,800	$6,154,000	$5,656,000	$30,100	$6,131,000	$7,024,000	$103,300	$8,652,000

[a] *Present value computations assume a 50-year life and 6 percent annual interest.*

Source: SEWRPC.

A review of the alternative plan maps and cost information presented indicates that Hydrologic Unit D has essentially the same components and costs under each alternative plan. Accordingly, it was not considered necessary to further consider that hydrologic unit in the following discussion. The remaining hydrologic units are considered in the discussion of each alternative plan.

Storm Sewer Conveyance Alternative Plan

Under the storm sewer conveyance alternative plan, the City of West Bend would continue to rely on storm sewers and open channels to convey stormwater runoff as quickly and directly as practicable to receiving surface watercourses in the Silver Creek subwatershed. The alternative would entail a capital cost of about $7.12 million and an incremental average annual operation and maintenance cost of about $14,400, and would have a present value cost of about $7.35 million.

For the planning area as a whole, the storm sewer conveyance alternative has the highest capital cost and the second highest present value cost of the four alternatives considered, ranking only behind the decentralized detention alternative; however, the annual operation and maintenance cost of the storm sewer alternative is the lowest. In Hydrologic Units E and F, the components of the storm sewer conveyance alternative are proposed under three of the four alternatives. The capital cost and the operation and maintenance cost of the storm sewer alternative are less than the corresponding costs of the single differing alternative in each hydrologic unit.

When compared to the other alternative system plans, the advantages of the storm sewer conveyance alternative plan, in addition to low operation and maintenance costs, are that the proposed system would be readily implementable and would likely be more acceptable to local officials and citizens. Importantly, few health and safety hazards or aesthetic nuisances would be created.

The major disadvantage of the storm sewer conveyance alternative plan is the high capital cost. Another significant disadvantage is that in some areas, downstream peak discharges may be expected to be higher than existing discharges, and to be higher than discharges under the other alternatives. Other disadvantages include a relatively low level of nonpoint source pollution removal, and the lack of any multipurpose-use benefits.

Table 9

ABILITY OF THE STORMWATER MANAGEMENT ALTERNATIVE PLANS TO MEET THE RECOMMENDED STORMWATER MANAGEMENT OBJECTIVES AND SUPPORTING STANDARDS

Stormwater Management Objective[a]	Supporting Standards	Storm Sewer Swale Conveyance	Storm Sewer-Roadside Swale Conveyance	Centralized Detention	Decentralized Detention
The development of a stormwater management system which will abate nonpoint source water pollution and help achieve the recommended water use objectives and supporting water quality standards for surface water bodies	1. Stormwater management and flood control facilities should not impede the achievement of existing water use objectives and supporting water quality standards for lakes, streams, and wetlands, nor degrade existing habitat conditions for fish and aquatic life	Partially met through provision of onsite controls for nonpoint source pollutants	Partially met through provision of onsite controls and through pollutant loading reductions resulting from infiltration and filtering in swales	Can be met	Can be met
	2. Stormwater drainage and flood control facilities should be designed to minimize adverse impacts on wetlands	Can be met through provision of grassed swales, grassed flow strips, infiltration trenches, or wet detention basins at storm sewer outlets	Can be met through provision of grassed swales, grassed flow strips, infiltration trenches, or wet detention basins at storm sewer outlets	Can be met through provision of grassed swales, grassed flow strips, infiltration trenches, or wet detention basins at storm sewer outlets	Can be met
The development of a stormwater management system which will efficiently and effectively meet all of the other stated objectives at the lowest practicable cost	1. The sum of stormwater management system capital investment and operation and maintenance costs should be minimized	Partially met; this alternative has the lowest total present value cost for 3 of the 10 hydrologic units	Partially met; this alternative has the lowest total present value cost for 4 of the 10 hydrologic units	Partially met; this alternative has the lowest total present value cost for 2 of the 10 hydrologic units	Partially met; this alternative has the lowest total present value cost for 1 of the 10 hydrologic units
	2. Maximum feasible use should be made of all existing stormwater management components, as well as the natural storm drainage system. The latter should be supplemented with engineered facilities only as necessary to serve the anticipated stormwater management needs generated by existing and proposed land use development and redevelopment	Partially met; would not use all components of natural drainage system	Met	Met	Met
	3. To the maximum extent practicable, the location and alignment of new storm sewer and engineered channels and storage facilities should coincide with existing public rights-of-way to minimize land acquisition or easement costs	Can be met	Can be met	Partially met; two detention basins would be located on property which is currently privately owned	Partially met; the proposed detention basins and onsite parking lot detention would be located on private property
	4. Stormwater storage facilities—consisting of retention facilities and of both *centralized and onsite detention facilities* —should, where hydraulically feasible and economically sound, be considered as a means of reducing the size and resultant costs of the required stormwater conveyance facilities immediately downstream of these storage sites	Partially met through utilization of natural *detention basins in existing* wetlands	Partially met through utilization of natural detention basins in existing wetlands	Met	Met

[a] *The stormwater management objectives and supporting standards are set forth in Table 14 in Chapter IV of Volume One of this report. This table compares only those objectives and supporting standards which differed in the degree to which they are met by the alternatives.*

Source: SEWRPC.

Most of the agreed-upon stormwater management objectives could be met by the storm sewer conveyance alternative plan, although a lower level of nonpoint source pollution reduction would be provided than under the other plans considered. Based on the cost analyses and other considerations, it was concluded that storm sewer conveyance plan facility components should be considered further for Hydrologic Units E and F in the preparation of a recommended plan.

Storm Sewer-Roadside Swale Conveyance Alternative Plan

Under the storm sewer-roadside swale conveyance alternative plan, the City of West Bend would rely on storm sewers, roadside swales, and open channels to convey stormwater runoff to receiving surface watercourses. The alternative would entail a capital cost of about $5.90 million and an average annual operation and maintenance cost increase of about $15,800, and would have a present value cost of $6.15 million.

For the planning area as a whole, the storm sewer-roadside swale alternative has the second lowest capital and operation and maintenance costs of all the alternatives. The capital cost of this alternative is only 1 percent more than that of the centralized detention alternative. Also the annual operation and maintenance cost of the storm sewer-roadside swale conveyance alternative is within 10 percent of the lowest operation and maintenance cost, that for the storm sewer alternative. In Hydrologic Units A, B, C, and I, the present value cost of the storm sewer-roadside swale alternative is significantly lower than the present value cost of the other alternatives that have different components.

In Hydrologic Unit G, the present value cost of the storm sewer-roadside swale alternative is greater only than the present value cost of the centralized detention alternative. However, the centralized detention alternative assumes retention of the existing 7.1-acre shoreland wetland in the hydrologic unit, while the storm sewer-roadside swale alternative assumes filling of portions of the wetland to accommodate development.

Of the two lowest cost alternatives, the storm sewer-roadside swale alternative for Hydrologic Unit G permits the most flexibility in future utilization of the land within the hydrologic unit. The level of development assumed for the storm sewer-roadside swale alternative can be accomplished in an environmentally sound manner through the provision of appropriate nonpoint source pollution controls, and possibly through the establishment of adjacent wetlands to replace the filled portions of the existing wetland.

When compared to the other alternative system plans, the advantages of the storm sewer-roadside swale conveyance alternative plan, in addition to low capital and operation and maintenance costs, are that the proposed system would be readily implementable and likely to be more acceptable to local officials and citizens than the detention alternatives, and, in certain areas, downstream peak discharges would be less than discharges under the storm sewer conveyance alternative. Importantly, few health and safety hazards or aesthetic nuisances would be created.

A significant disadvantage of the alternative is that downstream peak discharges may be expected to be higher than existing discharges, and to be higher than discharges under the detention alternatives. Other disadvantages include a relatively low level of overall nonpoint source pollution abatement due to the location of roadside swales in areas of low-density development where pollutant loadings would be low, and the lack of any multipurpose-use benefits.

Most of the agreed-upon stormwater management objectives could be met by the storm sewer-roadside swale conveyance alternative plan, although in some locations a lower level of nonpoint source pollution reduction would be provided than under the detention alternatives. Based on the cost analyses and other considerations, it was concluded that storm sewer-roadside swale conveyance plan facility components should be considered further for Hydrologic Units A, B, C, G, and I in the preparation of a recommended plan.

Centralized Detention Alternative Plan

The centralized detention alternative plan would provide for three new centralized detention basins, the expansion of one existing basin, and the utilization of one existing wetland as a detention basin. The alternative would entail a capital cost of about $5.66 million, an annual operation and maintenance cost increase of about $30,100, and a present value cost of $6.13 million.

For the planning area as a whole, the capital cost of the centralized detention alternative is the lowest of all the alternatives. The annual operation and maintenance cost is approximately double that of the two conveyance alternatives, but only about 29 percent that of the decentralized detention alternative. Combining the centralized detention capital and operation and maintenance costs yields the lowest present value cost of all four alternatives. New centralized detention components, in addition to the existing natural and man-made detention and retention components common to all four alternatives, were introduced only in Hydrologic Units C, E, G, and L. The centralized detention alternative had the lowest present value of the four alternatives for Hydrologic Units G and L. Hydrologic Unit G had a lower cost because an existing wetland was utilized as a detention area, eliminating the need for construction of an open channel to convey runoff. As discussed in the section of this chapter evaluating the storm sewer-roadside swale conveyance alternative, despite the somewhat higher cost of the conveyance alternative, that alternative is recom-

mended for further consideration because it allows the most flexibility to accommodate potential conditions. Hydrologic Unit L had a lower cost because of the effects of two proposed detention basins which reduced the flows from a 10-year recurrence interval storm sufficiently so that existing storm sewers did not require replacement or replacement storm sewers could be reduced in size in comparison with those required by the other alternatives. The detention basins proposed for Hydrologic Unit L would also provide nonpoint source pollution control if constructed as wet detention basins. It was found that expansion of the surcharge storage volume of Bicentennial Park pond in Hydrologic Unit C would not reduce peak flows in downstream areas because, owing to the routing effects of the pond, peak outflows from the pond occur after the higher peak flows in downstream areas; therefore, pond outflows will not contribute significantly to the downstream peak flow.

The advantage of the centralized detention alternative is the reduction of both peak rates of discharge and downstream pollutant loadings. The disadvantages of the centralized detention alternative include the increased land area required for the proposed detention facilities, and, in some cases, higher costs in comparison to the conveyance alternatives.

Most stormwater management objectives could be met by the centralized detention alternative plan. Based on the cost analyses and other considerations, it was concluded that centralized detention plan facility components should be considered further for Hydrologic Unit L in the preparation of a recommended plan.

Decentralized Detention Alternative Plan

The decentralized detention alternative plan provides for the construction of about 33 small detention basins, along with the provision of onsite parking lot detention. The alternative would entail a capital cost of about $7.02 million and an annual operation and maintenance cost increase of about $103,300, and would have a present value cost of $8.65 million.

For the planning area as a whole, the capital cost of the decentralized detention alternative is the second highest of the four alternative plans. Also, the annual operation and maintenance cost is 3.4 times the cost of the centralized detention alternative and 7.2 times the cost of the storm sewer alternative. Combining the capital and operation and maintenance costs as a present value shows the decentralized detention alternative has a substantially higher present value cost than any of the other alternatives. There are decentralized detention components in Hydrologic Units B, F, G, I, and K. Of those five units, the only one in which the decentralized detention alternative has the lowest capital and present value costs is Hydrologic Unit K. Onsite parking lot storage proposed to be provided in that area would enable downstream replacement storm sewer sizes to be significantly reduced, resulting in an overall cost savings.

The most significant advantage of the decentralized detention alternative is that peak rates of discharge would be considerably less than under the conveyance alternatives. Another advantage is that significant reductions would be achieved in downstream pollutant loadings.

The primary disadvantages of the decentralized detention alternative include high capital and operation and maintenance costs and the required location of the onsite detention facilities on what is now private property, which could make implementation and funding of this alternative difficult.

Most stormwater management objectives could be met by the decentralized detention alternative plan. Based on the cost analyses, it was concluded that decentralized detention plan components should be considered further for Hydrologic Unit K.

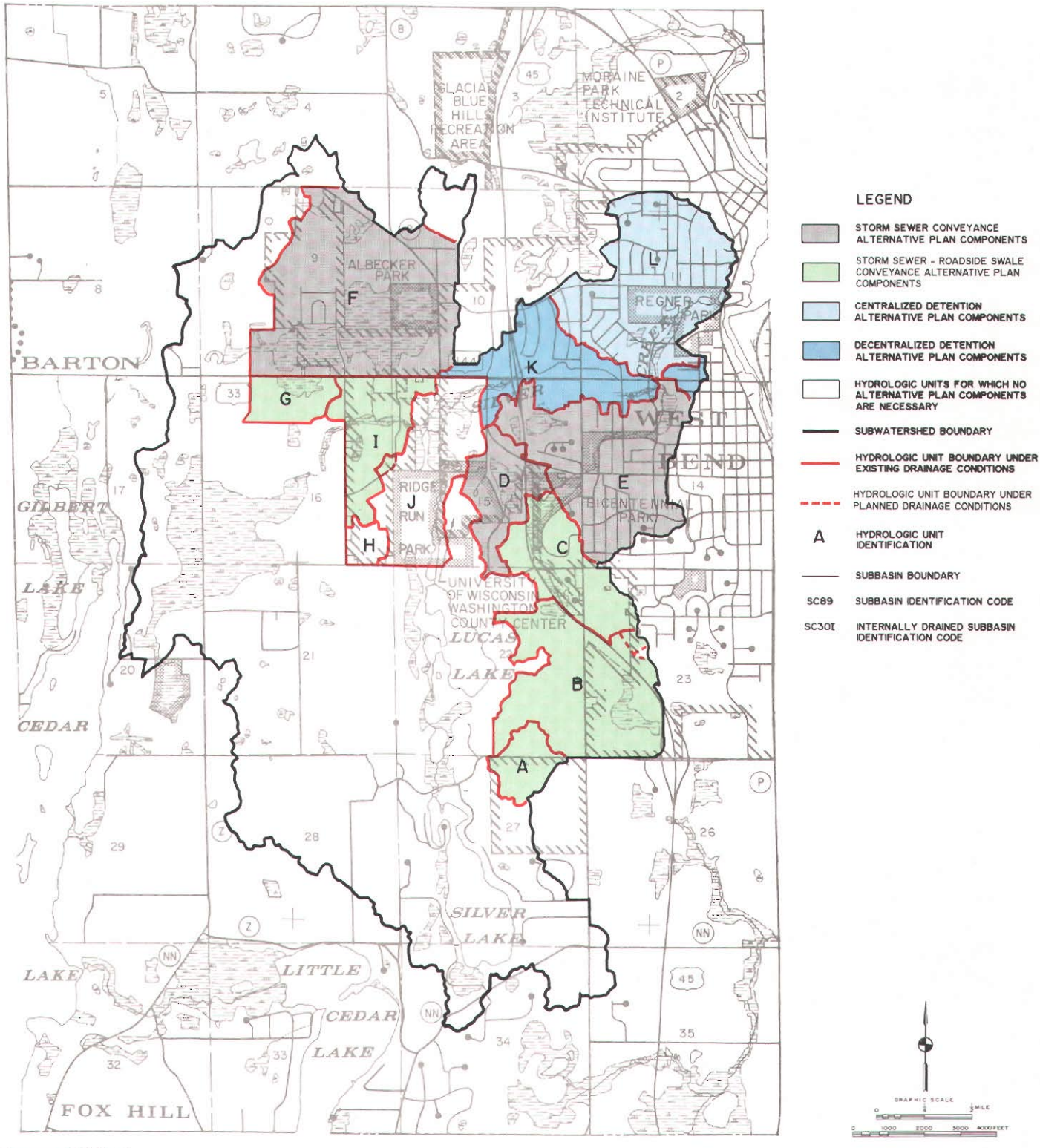
Summary of Evaluation of Alternatives

The comparative evaluation of four alternative stormwater management system plans for the City of West Bend study area indicated that the capital cost of such plans would range from $5.66 million to $7.12 million, and the annual operation and maintenance incremental costs would range from $14,400 to $103,300.

The comparative evaluation also indicated that a combination of storm sewer conveyance, storm sewer-roadside swale conveyance, centralized detention, and decentralized detention alternative plan components should be considered in the synthesis of a recommended plan—incorporating in that plan for each hydrologic unit the most cost-effective elements of each plan. Such a combined plan should provide beneficial water quantity and quality control at the least cost, be

Map 7

SELECTED COMBINATION OF ALTERNATIVE STORMWATER DRAINAGE PLANS FOR THE SILVER CREEK SUBWATERSHED



Source: SEWRPC.

implementable, and fully satisfy the stormwater management objectives and standards formulated under the study.

The portion of the City of West Bend planned urban service area within the Silver Creek subwatershed was divided for plan preparation purposes into 12 hydrologic units. Based upon the evaluation of the components of each of the alternative plans considered, it was concluded that the alternative plan components shown on Map 7 should be further considered for application to each hydrologic unit. For three hydrologic units the storm sewer conveyance alternative was judged to be the best. For five hydrologic units, the storm sewer-roadside swale alternative was judged to be the best. The centralized and decentralized detention alternatives were each judged to be the best for one hydrologic unit. As already noted, it was not considered necessary to develop detailed alternatives for the other two hydrologic units.

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Chapter V

PLAN RECOMMENDATIONS

INTRODUCTION

The recommended stormwater management system plan consists of three plan elements: a stormwater drainage plan element, a flood control plan element, and a water quality management plan element. Each of these elements is discussed in detail below.

STORMWATER DRAINAGE PLAN ELEMENT

Based on the comparative evaluation of the various alternative plans considered, the minor and major stormwater management system components recommended for inclusion in the stormwater drainage plan element are set forth in Table 10 by hydrologic unit. The recommended stormwater drainage plan is summarized in graphic form on Map 8.

The recommended plan components presented in Table 10 and shown on Map 8 reflect certain refinements and revisions to the recommended plan as originally presented to the City of West Bend Plan Commission. These refinements and revisions were made as a result of comments and requests of City Plan Commission members and city staff present at the Plan Commission meetings of June 22, 1988, and October 25, 1988, where the alternative plans and the preliminary recommended plan were reviewed. The revisions to the preliminary recommended plan include substitution of storm sewers for roadside swales in Hydrologic Units C, G, and I. In addition, certain components of the storm sewer alternative that were called for in portions of the original recommended plan for Hydrologic Units C, F, I, and L were refined.

The minor stormwater management system includes conveyance, centralized detention, and decentralized detention system components which have been designed to convey and contain flows for storm events up to and including the 10-year recurrence interval storm. Onsite detention, centralized retention, onsite retention, and "blue-green" system components were utilized in conjunction with other alternative approaches. The conveyance components include storm sewers and related inlets, manholes, and outfalls, along with roadside swales and open channels. The centralized detention components include surface detention basins and ponds with associated facility inlets and outlets. The decentralized detention component consist of onsite parking lot detention. The ability of yard swales and roadway cross sections to collect and convey drainage to the minor conveyance system was considered in the design of the system.

The major stormwater management system includes conveyance components that have been designed to accommodate flows from a 100-year recurrence interval storm. Conveyance components include street cross-sections, major open channel drainageways, and receiving watercourses. The major stormwater management system consists of those minor stormwater management system components necessary to meet drainage requirements, together with certain components recommended to offset adverse impacts of the recommended minor system facilities on downstream flood flows. The major and minor systems of the recommended stormwater drainage plan element utilize existing natural and man-made detention and retention basins to the maximum extent practicable. A description of the recommended minor and major system components, along with their costs, is presented in Table 10.

The recommended stormwater drainage plan element envisions that the full street cross-section will be utilized to convey flows in excess of those generated by a 10-year recurrence interval storm event and up to the flows generated by a 100-year recurrence interval storm event. As already noted, in areas with existing urban street patterns, or in areas where street pattern plans were available, the capacity of the streets to convey the stormwater was calculated and evaluated. In other areas it was assumed that street patterns and grades would be developed to be compatible with stormwater drainage needs. Recommended typical street cross-sections for arterial, collector, and minor land access streets are provided in Chapter III of Volume One of this report.

(Continued on Page 93)

Table 10

COMPOSITION AND COSTS OF THE MINOR AND MAJOR COMPONENTS OF THE RECOMMENDED STORMWATER DRAINAGE PLAN ELEMENT FOR THE SILVER CREEK SUBWATERSHED

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
A	Southeastern Portion of Planned Urban Service Area Along Paradise Drive		
	1. 2,330 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 21,000	$ 800
	2. 310 feet of 2.5-foot-deep roadside swale with driveway culverts	4,000	100
	3. 40 feet of 42-inch culvert at Paradise Drive	4,000	0
	4. 940 feet of 2.0-foot-deep roadside swale with driveway culverts	10,000	400
	5. Construct 120-foot grass-lined channel at storm sewer outlet to retention basin and provide riprap erosion protection	3,000	100
	6. Existing kettle used for retention basin	--	400
	7. 1,490 feet of 15-inch reinforced concrete pipe storm sewer to serve as retention basin outlet	52,000	600
	8. Engineering, administration, and contingencies	33,000	0
	Subtotal	$ 127,000	$ 2,400
B	Southern Portion of Silverbrook Creek Subbasin		
	1. 1,730 feet of 1.5-foot-deep roadside swale with driveway culverts	$ 17,000	$ 700
	2. 715 feet of 18-inch storm sewer	30,000	300
	3. 190 feet of 21-inch storm sewer	9,000	100
	4. 1,115 feet of 24-inch storm sewer	61,000	400
	5. 1,510 feet of 27-inch storm sewer	94,000	600
	6. 460 feet of 30-inch storm sewer	32,000	200
	7. 480 feet of 36-inch storm sewer	42,000	100
	8. 390 feet of 42-inch storm sewer	41,000	100
	9. 245 feet of 38-inch x 24-inch concrete horizontal elliptical (H.E.) storm sewer	20,000	100
	10. 255 feet of 45-inch x 29-inch H.E. storm sewer	25,000	100
	11. 505 feet total of twin 45-inch x 29-inch H.E. storm sewer	50,000	100
	12. 850 feet total of twin 51-inch x 31-inch reinforced concrete pipe arch (RCPA) storm sewer	105,000	200
	13. 250-foot grass-lined channel at storm sewer outlet to natural detention basin north of Paradise Drive and west of USH 45. Provide riprap at outlet	5,000	200
	14. 215-foot, grass-lined channel at storm sewer outlet to natural detention basin and provide riprap at outlet	5,000	200

Table 10 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
B (continued)	15. Riprap erosion protection at remaining storm sewer outlets to natural detention basin	$ 2,000	$ 100
	16. Outlet structure for natural detention basin	3,000	300
	17. 660 feet of 12-inch storm sewer for outlet of natural detention basin	20,000	300
	18. Engineering, administration, and contingencies	196,000	0
	Subtotal	$ 757,000	$ 4,100
C	Central Portion of Silverbrook Creek Subbasin		
	1. 1,290 feet of 12-inch storm sewer	$ 39,000	$ 500
	2. 190 feet of 15-inch storm sewer	7,000	100
	3. 300 feet of 18-inch storm sewer	12,000	100
	4. 370 feet of 21-inch storm sewer	17,000	100
	5. 60 feet of 24-inch storm sewer	4,000	100
	6. Construct a 5.8-acre-foot wet detention basin at the intersection of Julen Circle and 18th Avenue	85,000	3,900
	7. Land acquisiton for detention basin	27,000	0
	8. Engineering, administration, and contingencies	67,000	0
	Subtotal	$ 258,000	$ 4,800
D	Western Portion of Silverbrook Creek Subbasin		
	1. Replace 321 feet of 18-inch storm sewer in Chestnut Street with 27-inch storm sewer	$ 28,000	$ 0
	2. Engineering, administration, and contingencies	10,000	0
	Subtotal	$ 38,000	$ 0
E	Northern Portion of Silverbrook Creek Subbasin		
	1. Replace 352 feet of 12-inch storm sewer in Concord Lane north of Silverbrook Creek with 15-inch storm sewer	$ 15,000	$ 0
	2. Replace 480 feet of 12-inch storm sewer west of 18th Avenue and north of Miller Street with 15-inch storm sewer	21,000	0
	3. Replace 174 feet of existing 12-inch storm sewer in 15th Avenue north of Silverbrook Creek with 18-inch storm sewer at an increased slope of 0.62 percent	10,000	0
	4. Replace 276 feet of existing 15-inch corrugated metal pipe (CMP) storm sewer between Balsam Place and Poplar Street with 18-inch storm sewer	15,000	0
	5. Replace 82 feet of 18-inch storm sewer in 15th Avenue with 21-inch storm sewer at an increased slope of 2.1 percent	5,000	0
	6. Replace 293 feet of 15-inch CMP storm sewer between Balsam Place and Walnut Street with 21-inch storm sewer	19,000	0

Table 10 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
E (continued)	7. Replace 28 feet of 18-inch clay storm sewer in Walnut Street west of Silverbrook Drive with 24-inch storm sewer	$ 2,000	$ 0
	8. Replace 160 feet of 15-inch storm sewer in 18th Avenue with 24-inch storm sewer	12,000	0
	9. Replace 120 feet of 24-inch storm sewer at Silverbrook School with 27-inch storm sewer	10,000	0
	10. Replace 425 feet of 15-inch storm sewer at Silverbrook School with 30-inch storm sewer	43,000	0
	11. Replace 238 feet of 21-inch CMP storm sewer east of 18th Avenue between Miller Street and Chestnut Street with 27-inch storm sewer	20,000	0
	12. Replace 126 feet of 30-inch storm sewer in Silverbrook Drive between Walnut Street and Silverbrook Creek with 48-inch storm sewer	24,000	0
	13. Replace 311 feet of 12-inch storm sewer in 16th Avenue north of Silverbrook Creek with 622 feet total of twin 23-inch x 14-inch H.E. storm sewer	35,000	100
	14. Replace 160 feet of 12-inch storm sewer in 16th Avenue north of Silverbrook Creek with 480 feet total of triple 23-inch x 14-inch H.E. storm sewer at a reduced slope of 0.26 percent	27,000	100
	15. Construct 100-foot-long, 3.0-foot-deep riprap-lined channel south of K-Mart parking lot and west of 18th Avenue	1,000	100
	16. Construct 400-foot-long, 3.0-foot-deep grass-lined channel parallel to 18th Avenue and south of K-Mart parking lot	5,000	400
	17. Grade 750 lineal feet of unnamed tributary to Silverbrook Creek located east of 18th Avenue	10,000	700
	18. Replace 64 feet of 18-inch storm sewer at the intersection of Tamarack Drive and Tamarack Court with 24-inch storm sewer	3,000	0
	19. Engineering, administration, and contingencies	97,000	0
	Subtotal	$ 374,000	$ 1,400
F	Northern Portion of Washington Creek Subbasin		
	1. 300 feet of 18-inch storm sewer in Villa Park Drive extended	$ 12,000	$ 100
	2. 350 feet of 21-inch storm sewer in Villa Park Drive extended	16,000	100
	3. 180 feet of 21-inch storm sewer outlet from Villa Park Drive extended	9,000	100
	4. 240-foot grass-lined channel at outlet for Villa Park Drive extended. Provide riprap at outlet	3,000	100
	5. 60 feet of 21-inch storm sewer in Stanford Lane extended	3,000	0
	6. 435 feet of 12-inch storm sewer	13,000	200

Table 10 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
F (continued)	7. 310 feet of 15-inch storm sewer	$ 11,000	$ 100
	8. 580 feet of 21-inch storm sewer	27,000	200
	9. 1,075 feet of 24-inch storm sewer	59,000	400
	10. 975 feet of 27-inch storm sewer	60,000	400
	11. 1,160 feet of 30-inch storm sewer	81,000	500
	12. 645 feet of 36-inch storm sewer	57,000	100
	13. 20 feet of 42-inch storm sewer	2,000	0
	14. 865 feet of 48-inch storm sewer	112,000	200
	15. 20 feet of 54-inch storm sewer	3,000	0
	16. Outlet structure for existing pond located southeast of Schuster Drive	2,000	300
	17. 405 feet of 12-inch storm sewer for detention basin outlet	12,000	200
	18. Construct 540-foot-long, grass-lined channel at storm sewer outlet to natural detention basin west of Villa Park Drive and provide riprap erosion protection	13,000	500
	19. Engineering, administration, and contingencies	173,000	0
	Subtotal	$ 668,000	$ 3,500
G	Western Portion of Washington Creek Subbasin		
	1. 135 feet of 18-inch storm sewer	$ 5,000	$ 100
	2. 660 feet of 24-inch storm sewer	36,000	200
	3. 320 feet of 27-inch storm sewer	20,000	100
	4. 1,245 feet total of double 4-foot x 2-foot concrete box storm sewer	157,000	200
	5. 485 feet of 5-foot x 3-foot concrete box storm sewer	87,000	100
	6. 390 feet of trapezoidal channel with a 10-foot-wide bottom, 370 feet of trapezoidal channel with a 5-foot-wide bottom, and 250 feet of trapezoidal channel with a 2.5-foot-wide bottom, all having one vertical on four horizontal side slopes	65,000	400
	7. 365 feet of twin 36-inch culvert	32,000	100
	8. Engineering, administration, and contingencies	141,000	0
	Subtotal	$ 543,000	$ 1,200
H	No New Stormwater Management Measures Recommended	--	--
I	Southern Portion of Washington Creek Subbasin		
	1. 880 feet of 12-inch storm sewer	$ 26,000	$ 300
	2. 400 feet of 15-inch storm sewer	14,000	200
	3. 850 feet of 18-inch storm sewer	35,000	300
	4. 960 feet of 21-inch storm sewer	45,000	400
	5. 2,735 feet of 24-inch storm sewer	150,000	1,100
	6. 920 feet of 27-inch storm sewer	57,000	400
	7. 1,115 feet of 30-inch storm sewer	79,000	400
	8. 725 feet of 36-inch storm sewer	64,000	100
	9. 550 feet of 24-inch polyvinyl chloride storm sewer	35,000	200

Table 10 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
I (continued)	10. 185 feet of 38-inch by 24-inch H.E. storm sewer	$ 15,000	$ 100
	11. Engineering, administration, and contingencies	182,000	0
	Subtotal	$ 702,000	$ 3,500
J	Southern Portion of Silver Creek Subbasin		
	1. 330 feet of 15-inch storm sewer	$ 12,000	$ 100
	2. 300 feet of 18-inch storm sewer	12,000	100
	3. 125 feet of 21-inch storm sewer	6,000	100
	4. Engineering, administration, and contingencies	11,000	0
	Subtotal	$ 41,000	$ 300
K	Central Portion of Silver Creek Subwatershed		
	1. Replace 220-foot-long channel located west of the State Central Credit Union building at 18th Avenue and Washington Street with 18-inch storm sewer at a slope of 0.625 percent	$ 12,000	$ 0
	2. Replace 200 feet of 24-inch storm sewer in K-Mart parking lot with 27-inch storm sewer	17,000	0
	3. Replace 54 feet of 24-inch storm sewer at K-Mart entrance with 30-inch storm sewer at an increased slope of 2 percent	6,000	0
	4. Replace 121 feet of polyvinyl chloride (PVC) storm sewer in K-Mart parking lot with 30-inch storm sewer	12,000	0
	5. Replace 217 feet of 18-inch storm sewer in K-Mart parking lot with 30-inch storm sewer	22,000	0
	6. Replace 407 feet of 24-inch storm sewer in Fleet Farm store parking lot at the intersection of Washington Street and 18th Avenue with 92 feet of 27-inch and 315 feet of 30-inch storm sewer	40,000	0
	7. Retain the 242-foot-long, 30-inch storm sewer in the Fleet Farm parking lot and add a parallel 30-inch storm sewer	24,000	100
	8. In the Fleet Farm parking lot, replace 180 feet of 30-inch storm sewer with a total of 360 feet of twin 44-inch x 27-inch RCPA storm sewer, and replace 82 feet of 36-inch storm sewer with 164 feet total of twin 44-inch x 27-inch RCPA storm sewer	73,000	0
	9. Replace 72 feet of 15-inch storm sewer in Red Owl store parking lot at the intersection of Washington Street and 15th Avenue with 21-inch storm sewer	5,000	0
	10. Replace 71 feet of 12-inch storm sewer in Red Owl store parking lot with 18-inch storm sewer	4,000	0
	11. Replace 313 feet of 12-inch storm sewer in Concord Lane west of 15th Avenue with 18-inch storm sewer	17,000	0

Table 10 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
K (continued	12. Replace 251 feet of 27-inch storm sewer in 15th Avenue north of the intersection with Concord Lane with 27-inch storm sewer at an increased slope of 0.15 percent	$ 22,000	$ 0
	13. *Provide one acre-foot of* parking lot detention volume in subbasin 98	5,000	100
	14. Engineering, administration, and contingencies	91,000	0
	Subtotal	$ 350,000	$ 200
L	Eastern Portion of Silver Creek Subwatershed-Regner Park Environs		
	1. Replace 355 feet of 36-inch CMP storm sewer running from Park Avenue to Beverly Lane with 36-inch *reinforced concrete* pipe (RCP) storm sewer	$ 46,000	$ 0
	2. Replace 337 feet of 36-inch CMP storm sewer in Sherwood Place with 48-inch storm sewer	64,000	0
	3. Replace 419 feet of 36-inch storm sewer in Sherwood Place with 48-inch storm sewer	80,000	0
	4. Replace 373 feet of 36-inch storm sewer in Green Tree Road with 48-inch storm sewer	71,000	0
	5. Replace 334 feet of 15-inch storm sewer in Meadowbrook Drive with 24-inch storm sewer	25,000	0
	6. Replace 825 feet of 51-inch x 36-inch corrugated metal pipe arch (CMPA) storm sewer in Green Tree Road with 58-inch x 36-inch RCPA storm sewer	173,000	0
	7. Replace 326 feet of 58-inch x 36-inch CMPA storm sewer in Wood Way with 48-inch storm sewer	60,000	0
	8. Replace 249 feet of 12-inch storm sewer in Silverbrook Drive south of Wood Way extended with 27-inch storm sewer	21,000	0
	9. Replace 10 feet of 12-inch storm sewer in Silverbrook Drive and the 7-foot-long, 18-inch diameter storm sewer outfall discharging to Silver Creek with 17 feet total of 30-inch storm sewer	2,000	0
	10. Replace 192 feet of 52-inch x 32-inch CMPA storm sewer in 12th Avenue south of Wayne Road with 30-inch storm sewer at a slope of 1.5 percent	19,000	0
	11. Replace 106 feet of 52-inch x 32-inch CMPA storm sewer in 12th Avenue with 45-inch x 29-inch H.E. storm sewer at a slope of 0.75 percent	22,000	0
	12. Replace 264 feet of 15-inch storm sewer running between Glen Court and 12th Avenue with 24-inch storm sewer	20,000	0
	13. Replace 97 feet of 15-inch storm sewer between Glen Court and 12th Avenue with 24-inch storm sewer at a reduced slope of 0.64 percent to accommodate the replacement storm sewer in 12th Avenue	7,000	0

Table 10 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
L (continued)	14. Replace 204 feet of 52-inch x 32-inch CMPA storm sewer in 12th Avenue with 45-inch x 29-inch H.E. storm sewer at a slope of 0.98 percent	$ 28,000	$ 0
	15. Replace 180 feet of 52-inch x 32-inch CMPA storm sewer in 12th Avenue north of Alder Street with a total of 360 feet of twin 53-inch x 34-inch H.E. storm sewer	63,000	0
	16. Replace 242 feet of 18-inch storm sewer in Green Tree Road north of Alder Street with 24-inch storm sewer	18,000	0
	17. Replace 245 feet of 18-inch storm sewer in Green Tree Road north of Alder Street with 30-inch storm sewer	25,000	0
	18. Replace 527 feet of 12-inch storm sewer in Alder Street with 21-inch storm sewer	34,000	0
	19. Replace 176 feet of 12-inch storm sewer in Alder Street with 27-inch storm sewer	15,000	0
	20. Replace 301 feet of 24-inch storm sewer running between 13th and 14th Avenue north of Alder Street with 27-inch storm sewer	26,000	0
	21. 410 feet of 21-inch storm sewer in Angela Court running to 12th Avenue	19,000	200
	22. Replace 359 feet of 30-inch storm sewer in Alder Street east of the intersection with 13th Avenue with 42-inch storm sewer	54,000	-100
	23. Replace 234 feet of 30-inch storm sewer in Alder Street west of the intersection with 12th Avenue with 36-inch storm sewer	30,000	-100
	24. Replace 363 feet of 58-inch x 36-inch CMPA storm sewer in 12th Avenue north of the intersection with Park Avenue with a total of 726 feet of twin 65-inch x 40-inch RCPA storm sewer	176,000	100
	25. Replace 70 feet of 58-inch x 36-inch CMPA storm sewer in Park Avenue east of 12th Avenue with 73-inch x 45-inch RCPA storm sewer	20,000	0
	26. Replace 313 feet of 58-inch x 36-inch CMPA storm sewer in Park Avenue east of 12th Avenue with 58-inch x 36-inch RCPA storm sewer	66,000	0
	27. Replace 300 feet of 60-inch x 40-inch CMPA storm sewer in Park Avenue between 10th and 11th Avenue with 65-inch x 40-inch RCPA storm sewer	73,000	0
	28. Replace 300 feet of 60-inch x 40-inch CMPA storm sewer running from Park Avenue at 10th Avenue to Regner Park pond with 58-inch x 36-inch RCPA storm sewer	63,000	0
	29. Replace 294 feet of 30-inch CMP storm sewer running between 8th and 9th Avenues north of High Street with 36-inch storm sewer at a slope of 0.2 percent	37,000	0

Table 10 (continued)

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
L (continued)	30. 330 feet of 24-inch RCP in 9th Avenue extended north of High Street	$ 18,000	$ 100
	31. Replace approximately 250 feet of 18-inch clay storm sewer running from Park Avenue at 8th Street to Regner Park pond with 24-inch storm sewer at a slope of 0.5 percent	19,000	0
	32. Construct an 8-acre-foot wet detention basin north of Wood Way extended	140,000	5,600
	33. Engineering, administration, and contingencies	537,000	0
	Subtotal	$1,967,000	$ 5,800
Total		$5,929,000	$27,200

[a]*All new and replacement storm sewers are concrete pipe, unless otherwise noted.*

[b]*Costs were noted to be zero when the project proposed replacement of a component with a component that has similar operation and maintenance costs. Negative costs were noted when the replacement component was estimated to have a lesser operation and maintenance cost than the cost of the existing facility.*

Source: SEWRPC.

(Continued from Page 85)

Approximate street pavement crown elevations are recommended for all intersections and for any mid-block sags. These are intended to assure the proper functioning of the major stormwater drainage system, as well as to facilitate the design of the minor system, and are intended to be used as guides in the establishment of street grades throughout the City.

Recommended Stormwater Drainage Plan Element by Hydrologic Unit

A brief summary of the stormwater drainage needs and the recommended plan components for each of the 12 hydrologic units in the planned urban service area is provided below.

Hydrologic Unit A: Hydrologic Unit A was essentially undeveloped in 1985. For the plan design it was assumed that 80 percent of the area would be developed for urban uses. The area is internally drained under existing conditions. The anticipated future development will require the construction of minor and major drainage systems.

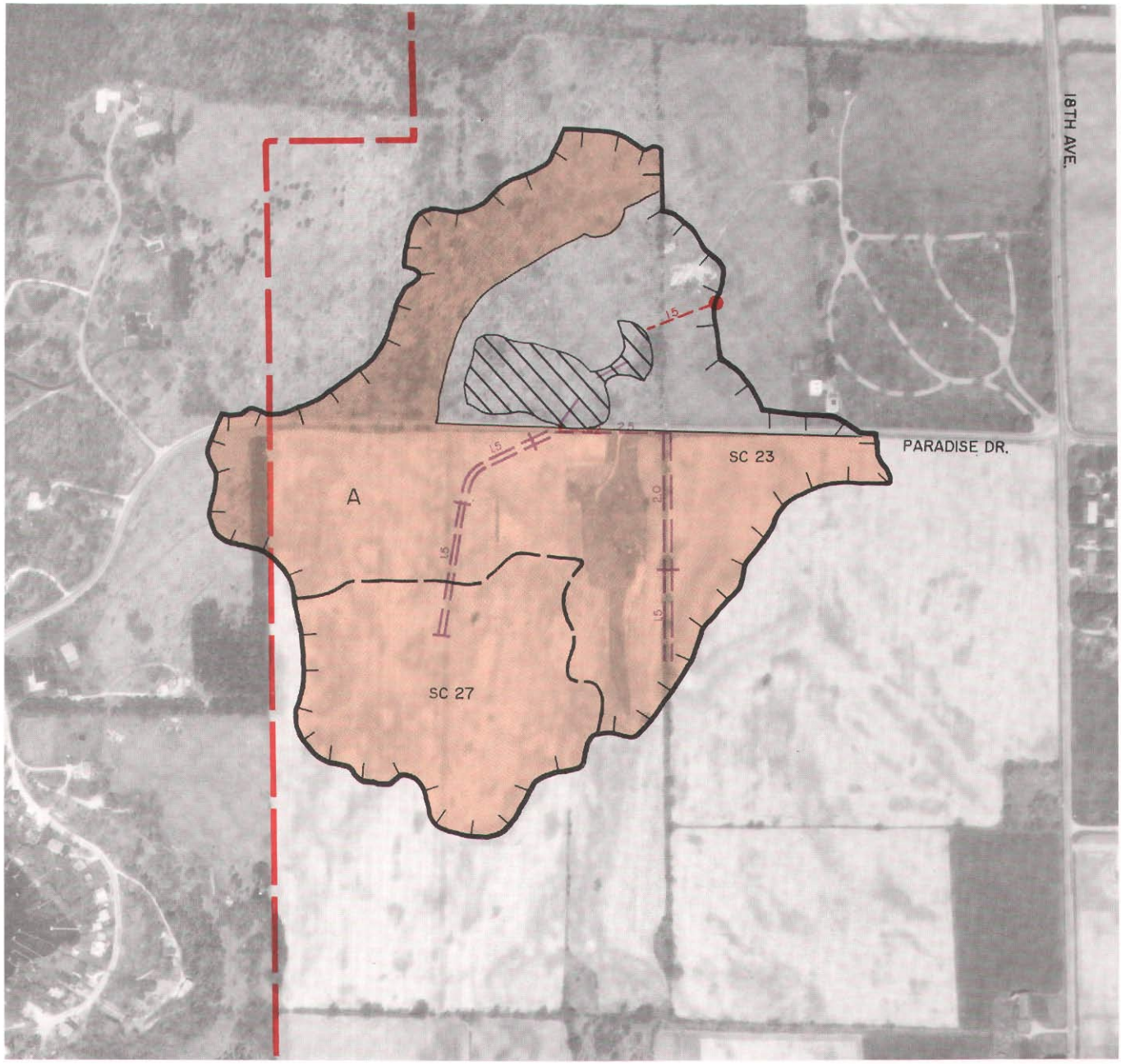
To accommodate the increased runoff from planned land use development, the recommended plan proposes the construction of 2,230 feet of 1.5-foot-deep roadside swales, 940 feet of 2.0-foot-deep roadside swales, and 310 feet of 2.5-foot-deep roadside swales. All roadside swales are assumed to conform to the standard City of West Bend rural street cross-section which calls for a triangular channel with a one vertical on four horizontal side slope adjacent to the road and a one vertical on three horizontal side slope away from the road. In addition, a 42-inch-diameter, 40-foot-long reinforced concrete pipe culvert, flowing to the north, is to be installed under Paradise Drive. A 120-foot-long turf- and riprap-lined channel is to be constructed from the culvert outlet to the existing kettle located north of Paradise Drive. The kettle is to serve as a retention basin which would be a component of the major and minor drainage systems. The retention basin would have a 1,490-foot-long, 15-inch-diameter reinforced concrete pipe (RCP) outlet which would limit the pond to acceptable levels during a 100-year recurrence interval

(Continued on Page 102)

Map 8

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT AND FLOOD CONTROL FOR THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT A



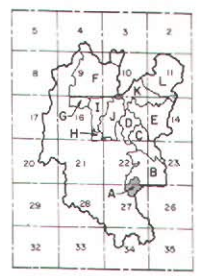
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- A — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 27 — SUBBASIN IDENTIFICATION
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL RETENTION BASIN
- PROPOSED MANHOLE
- 15 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- 2.0 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

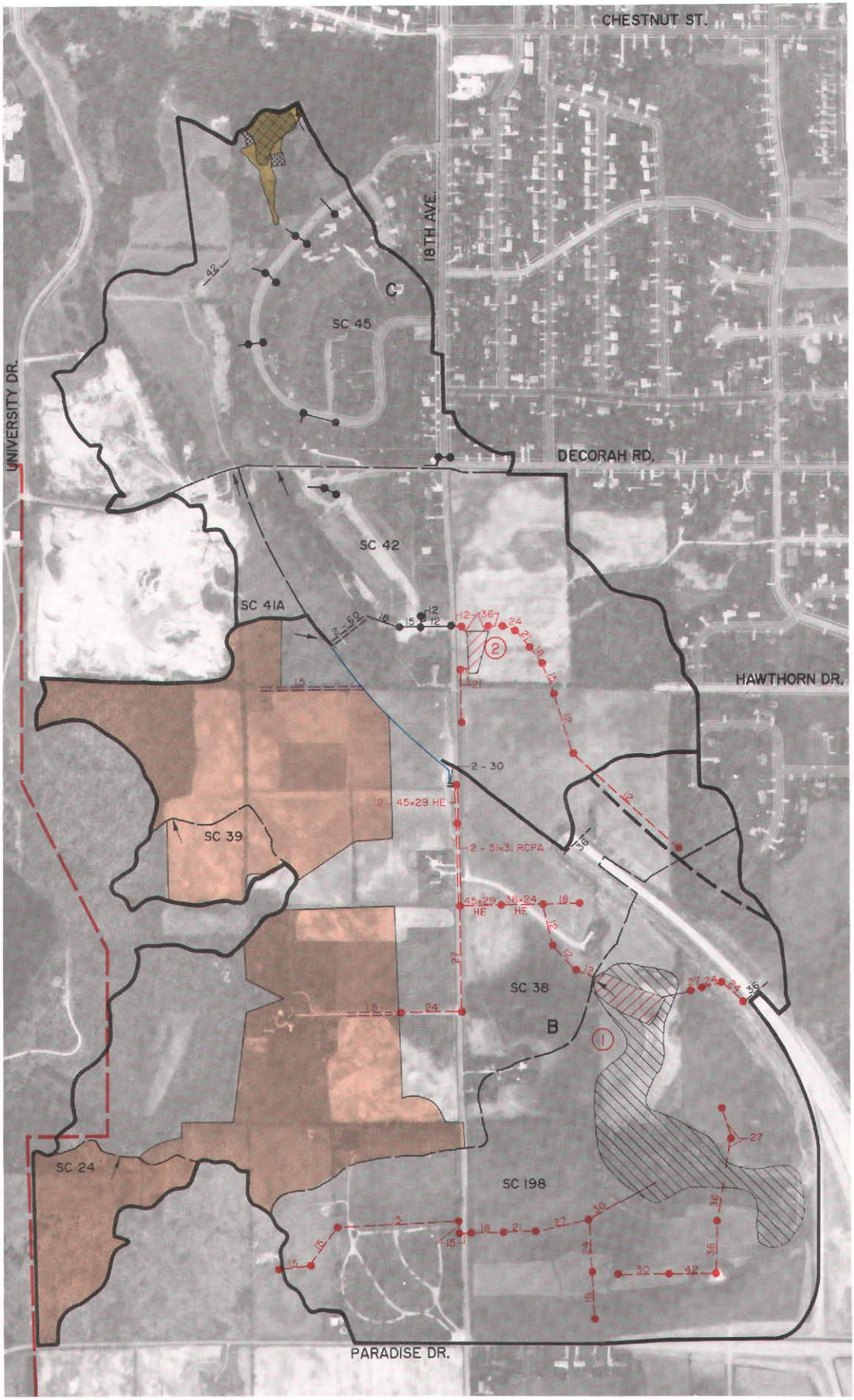


NOTE: ALL WITHIN T.11N.,R.19E.

GRAPHIC SCALE
0 200 400 FEET

Map 8 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT AND FLOOD CONTROL FOR THE SILVER CREEK SUBWATERSHED HYDROLOGIC UNITS B AND C



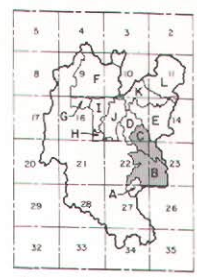
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- B — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 42 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 18 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 36 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING OPEN CHANNEL
- EXISTING CONSTRUCTED WET DETENTION BASIN
- EXISTING NATURAL RETENTION BASIN
- PROPOSED MANHOLE
- 12 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- 1.5 — PROPOSED ROADSIDE SWALE (DEPTH IN FEET)
- CATCHMENT AREA PROPOSED TO BE SERVED BY ROADSIDE SWALES
- PROPOSED WET DETENTION BASIN AND IDENTIFICATION NUMBER
- 100 - YEAR RECURRENCE INTERVAL FLOODPLAIN
- AREA OF DISTURBED TOPOGRAPHY LIMITS OF FLOODPLAIN UNDETERMINED
- HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
- RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP



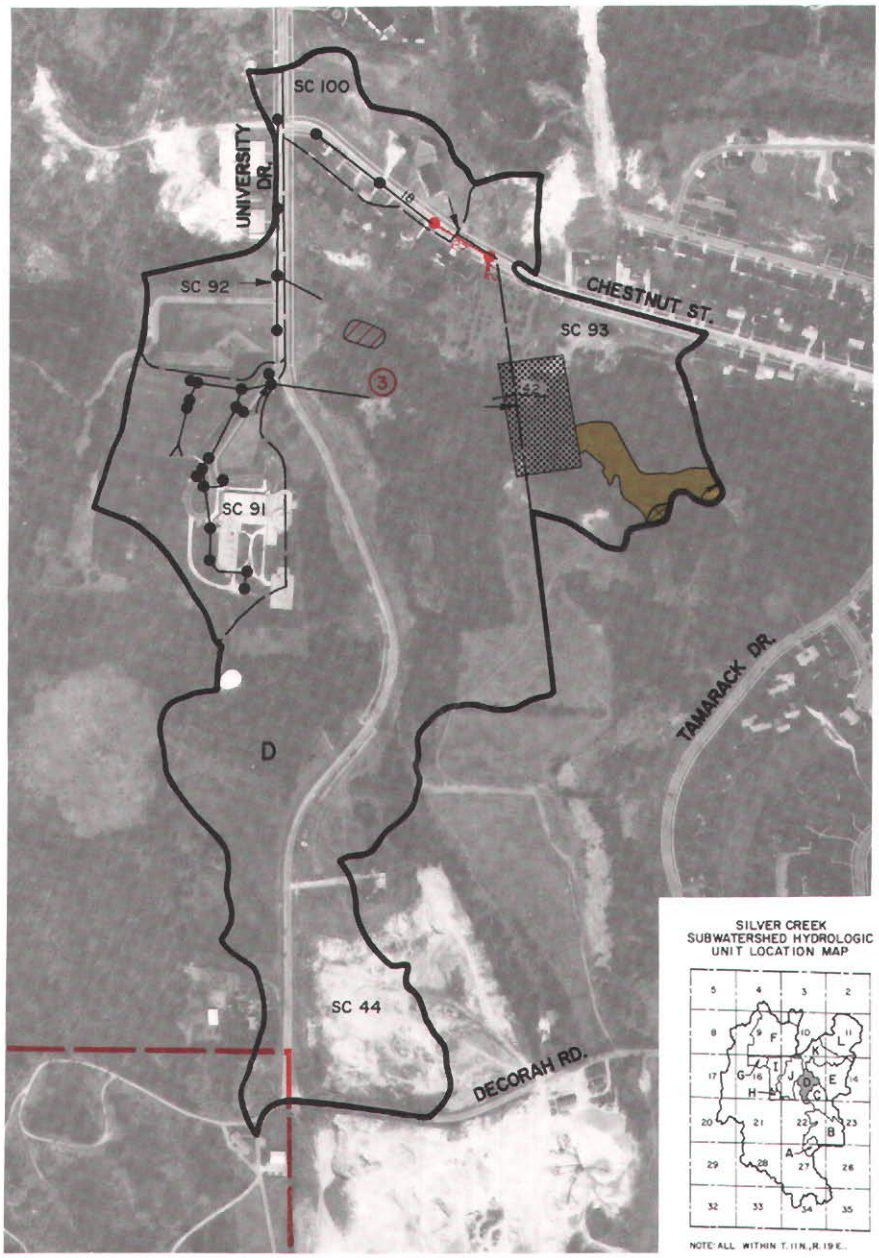
NOTE: ALL WITHIN T.11N., R.19E.

GRAPHIC SCALE
0 400 800 FEET

Map 8 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT AND FLOOD CONTROL FOR THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT D



SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

NOTE: ALL WITHIN T. 11 N., R. 19 E.

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- D — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 44 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 18 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 18 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 27 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED WET DETENTION BASIN AND IDENTIFICATION NUMBER
- 100 - YEAR RECURRENCE INTERVAL FLOODPLAIN
- AREA OF DISTURBED TOPOGRAPHY LIMITS OF FLOODPLAIN UNDETERMINED

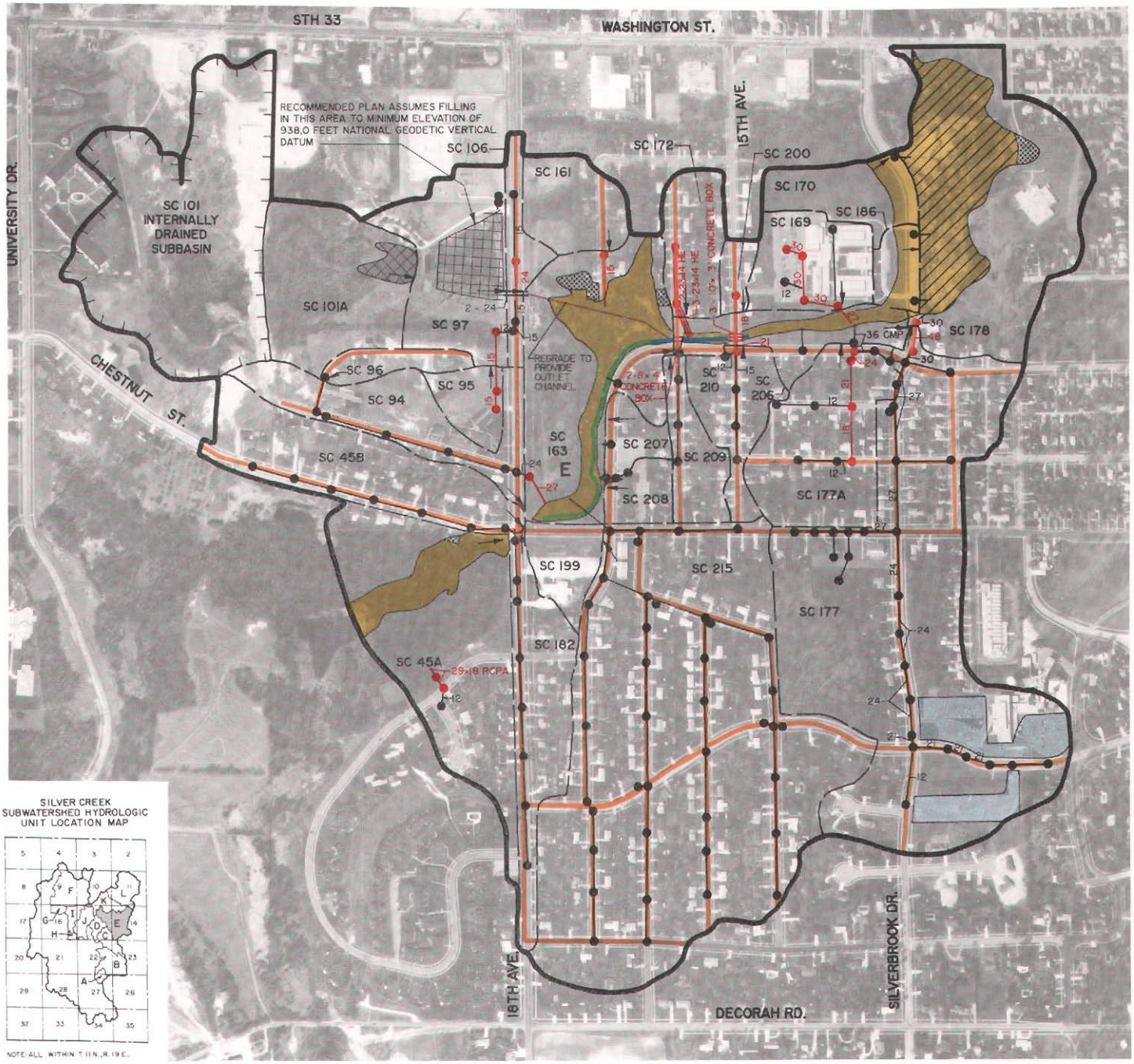
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT AND FLOOD CONTROL FOR THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT E



SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

NOTE: ALL WITHIN T.11N.,R.19E.

LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- E — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SUBBASIN BOUNDARY
- SC 101 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 24 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 24 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 24 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- PROPOSED CHANNEL MODIFICATION
- PROPOSED STREAMBANK STABILIZATION
- SWEEP STREET 5 TIMES IN SPRING AND 5 TIMES IN FALL
- PROPOSED INFILTRATION SYSTEM TO RETAIN RUNOFF FROM 50 PERCENT OF PARKING LOT AREA
- 100-YEAR RECURRENCE INTERVAL FLOODPLAIN
- AREA OF DISTURBED TOPOGRAPHY LIMITS OF FLOODPLAIN UNDETERMINED

CMP	CORRUGATED METAL PIPE
CMPA	CORRUGATED METAL PIPE ARCH
HE	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CLAY	CLAY PIPE
PVC	POLYVINYL CHLORIDE PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

Map 8 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT AND FLOOD CONTROL FOR THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT F

LEGEND

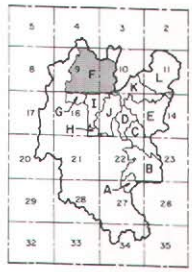
- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- F — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 77 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING MANHOLE OR CATCH BASIN
- 21 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- EXISTING CONSTRUCTED WET DETENTION BASIN
- PROPOSED MANHOLE
- 30 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 30 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- PROPOSED INFILTRATION SYSTEM TO RETAIN RUNOFF FROM 50 PERCENT OF PARKING LOT AREA
- PROPOSED WET DETENTION BASIN AND IDENTIFICATION NUMBER
- SWEEP STREET 11 TIMES IN SPRING AND 11 TIMES IN FALL

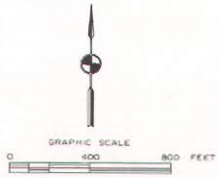
NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

- 100 - YEAR RECURRENCE INTERVAL FLOODPLAIN

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

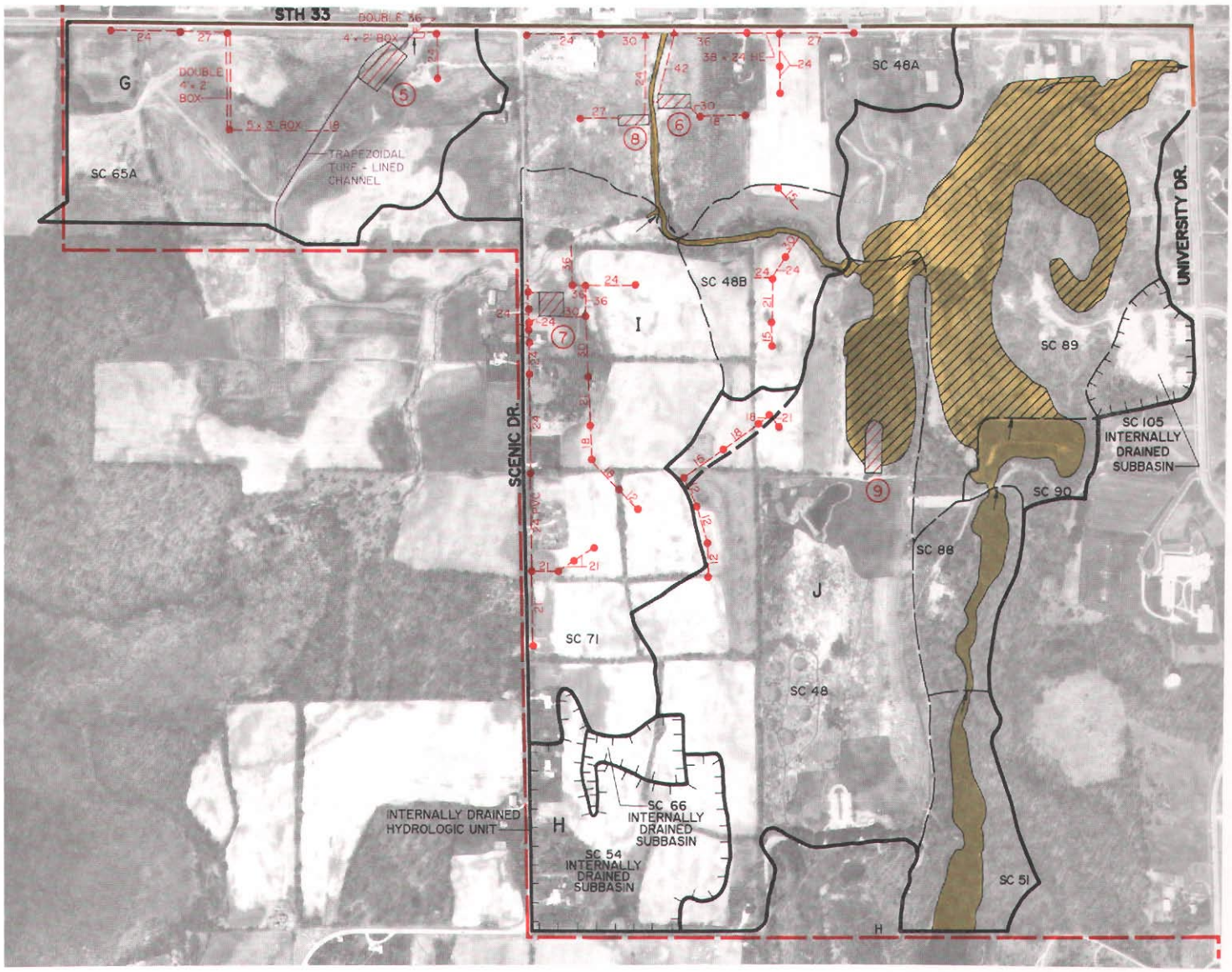




Map 8 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT AND FLOOD CONTROL FOR THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNITS G, H, I, AND J



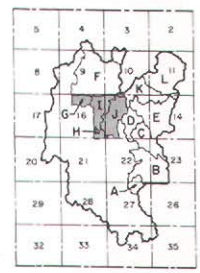
LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- HYDROLOGIC UNIT BOUNDARY UNDER PLANNED DRAINAGE CONDITIONS
- J — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 48 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- LIMITS OF PLANNED URBAN SERVICE AREA
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 21 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- PROPOSED DIVERSION STRUCTURE
- PROPOSED WET DETENTION BASIN AND IDENTIFICATION NUMBER
- SWEEP STREET 11 TIMES IN SPRING AND 11 TIMES IN FALL
- SWEEP STREET 5 TIMES IN SPRING AND 5 TIMES IN FALL
- 100 - YEAR RECURRENCE INTERVAL FLOODPLAIN

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE

NOTE: EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

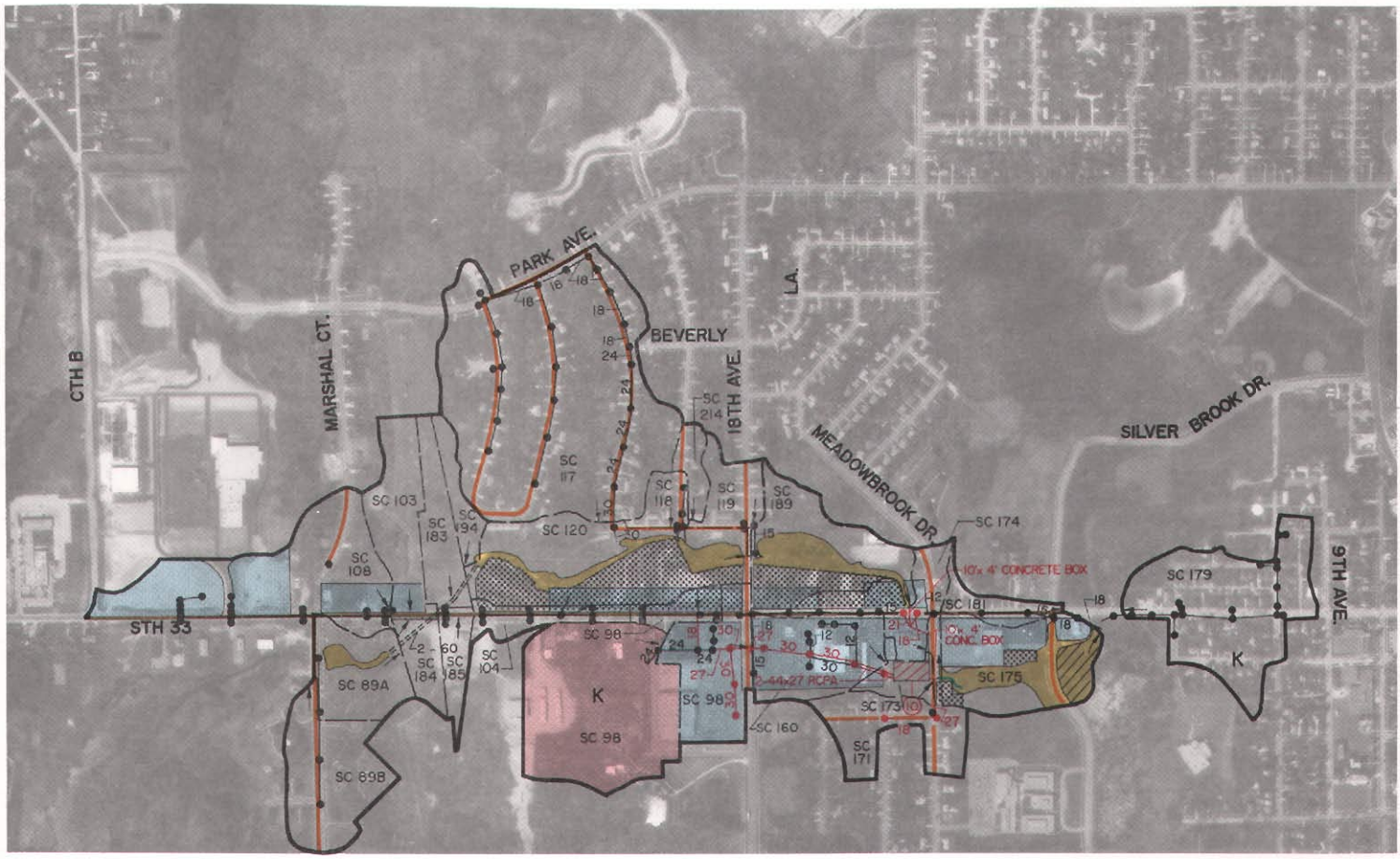


NOTE: ALL WITHIN T.11 N., R.19 E.

GRAPHIC SCALE
0 400 800 FEET

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT AND FLOOD CONTROL FOR THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT K



LEGEND

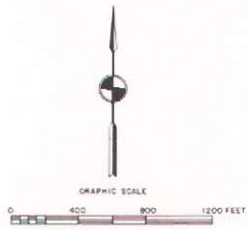
- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- K — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 98 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 24 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- 60 — EXISTING CULVERT TO BE RETAINED (SIZE IN INCHES)
- EXISTING NATURAL DETENTION BASIN
- PROPOSED MANHOLE
- 27 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED ONSITE PARKING LOT DETENTION WITH INFILTRATION SYSTEM TO RETAIN RUNOFF FROM 50 PERCENT OF PARKING LOT AREA
- PROPOSED INFILTRATION SYSTEM TO RETAIN RUNOFF FROM 50 PERCENT OF PARKING LOT AREA
- PROPOSED CHANNEL MODIFICATION
- PROPOSED WET DETENTION BASIN AND IDENTIFICATION NUMBER
- SWEEP STREET 11 TIMES IN SPRING AND 11 TIMES IN FALL
- SWEEP STREET 5 TIMES IN SPRING AND 5 TIMES IN FALL
- 100 - YEAR RECURRENCE INTERVAL FLOODPLAIN
- AREA OF DISTURBED TOPOGRAPHY LIMITS OF FLOODPLAIN UNDETERMINED
- RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

SILVER CREEK SUBWATERSHED HYDROLOGIC UNIT LOCATION MAP

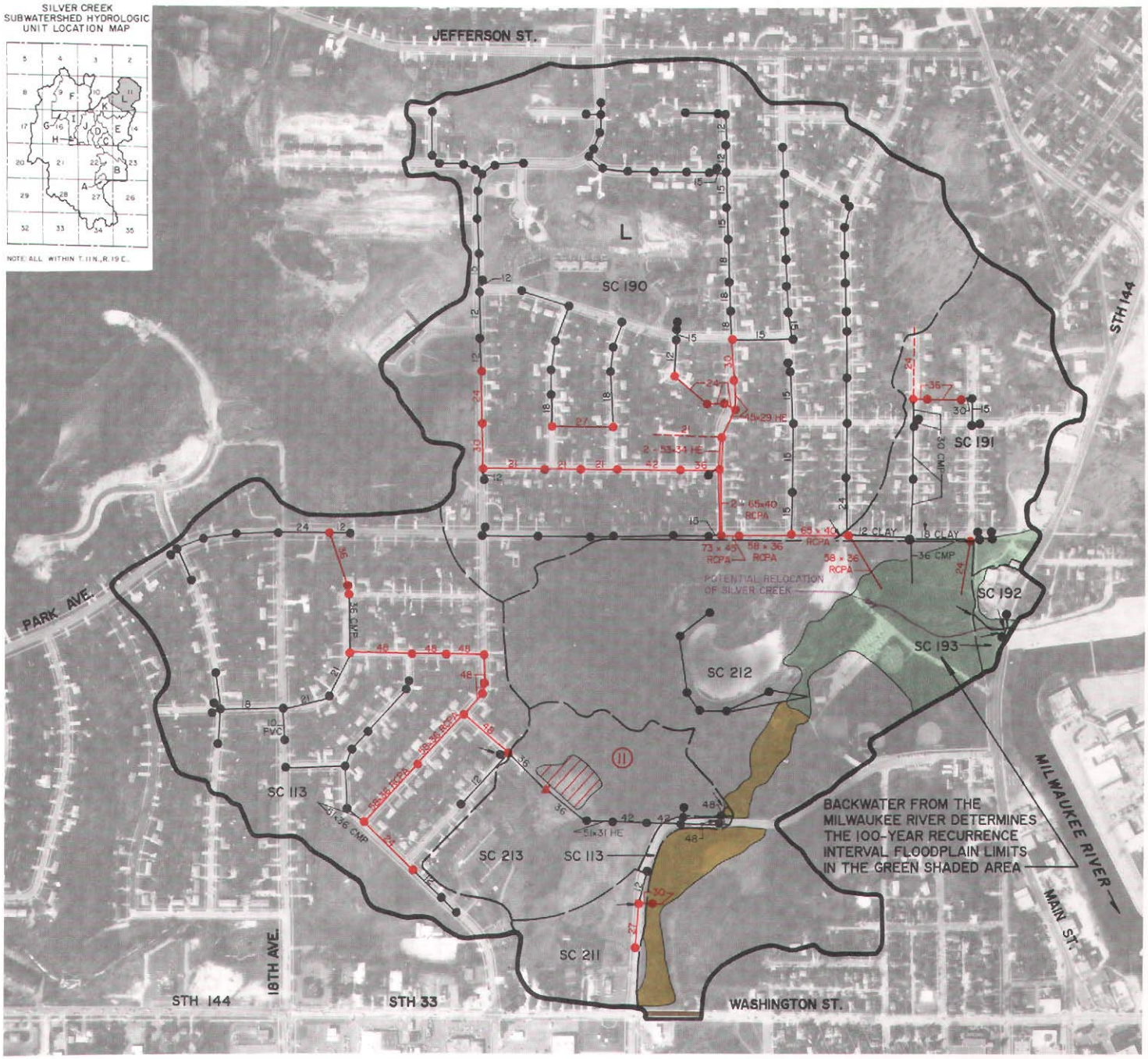
NOTE: ALL WITHIN T.11N.,R.19E.



Map 8 (continued)

RECOMMENDED SYSTEM PLAN FOR STORMWATER MANAGEMENT AND FLOOD CONTROL FOR THE SILVER CREEK SUBWATERSHED

HYDROLOGIC UNIT L



LEGEND

- HYDROLOGIC UNIT BOUNDARY UNDER EXISTING DRAINAGE CONDITIONS
- L — HYDROLOGIC UNIT IDENTIFICATION
- SUBBASIN BOUNDARY
- SC 211 — SUBBASIN IDENTIFICATION
- SUBBASIN OUTLET
- EXISTING MANHOLE OR CATCH BASIN
- 36 — EXISTING STORM SEWER TO BE RETAINED (SIZE IN INCHES)
- PROPOSED MANHOLE
- 21 — PROPOSED STORM SEWER OR CULVERT (SIZE IN INCHES)
- 21 — PROPOSED REPLACEMENT STORM SEWER (SIZE IN INCHES)
- PROPOSED OPEN CHANNEL
- PROPOSED DIVERSION STRUCTURE
- PROPOSED WET DETENTION BASIN AND IDENTIFICATION NUMBER
- SWEEP STREET II TIMES IN SPRING AND II TIMES IN FALL
- 100 - YEAR RECURRENCE INTERVAL FLOODPLAIN

CMP — CORRUGATED METAL PIPE
HE — HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
CLAY — CLAY PIPE
RCPA — REINFORCED CONCRETE PIPE ARCH

NOTE: PIPES ARE CONSTRUCTED OF REINFORCED CONCRETE UNLESS DESIGNATED AS ABOVE

EXISTING STORM SEWER SIZES GENERALLY SHOWN ONLY FOR SEWERS WITH IDENTIFIED EXISTING OR POTENTIAL CAPACITY PROBLEMS AND FOR SEWER SEGMENTS IMMEDIATELY UPSTREAM OF SUCH PROBLEM SECTIONS

GRAPHIC SCALE
0 400 800 FEET

Source: SEWRPC.

(Continued from Page 93)

storm. The outlet would function only during infrequent storms with recurrence intervals of 100 years or more. The location, configuration, and horizontal and vertical alignment of the street system required to support future urban development should be carefully laid out to provide the necessary major drainage system conveyance capacity.

Hydrologic Unit B: Approximately 15 percent of the land in Hydrologic Unit B was in urban land uses as of 1985, with the remainder in open, agricultural, woodland, and wetland uses. In the plan design it was assumed that approximately 85 percent of the hydrologic unit would ultimately be in urban uses. The components of the existing stormwater drainage system have adequate capacity to accommodate the runoff under the predominantly rural conditions. Following evaluation of the alternative stormwater management plans, a more detailed development plan for subbasin 198 in Hydrologic Unit B was supplied by the City of West Bend. Where appropriate, the recommended plan was refined to reflect the proposed street patterns and development densities of that development plan.

To accommodate anticipated runoff conditions within the entire hydrologic unit, the recommended plan proposes the construction of 1,730 lineal feet of 1.5-foot-deep roadside swales; a total of about 465 feet of turf-lined channel at storm sewer outlets; and 7,485 lineal feet of storm sewer ranging in size from 12-inch-diameter circular pipe to 51-inch by 31-inch reinforced concrete pipe arch. In addition, the isolated natural area west of USH 45 and north of Paradise Drive is proposed to be used as a detention basin, with an outlet structure provided. The location, configuration, and horizontal and vertical alignment of the street system required to support future urban development should be carefully laid out to provide the necessary major drainage system conveyance capacity.

Hydrologic Unit C: Approximately 30 percent of Hydrologic Unit C was in urban land uses as of 1985, with the remainder being in open, agricultural, recreational, woodland, and wetland uses. In the plan design it was assumed that approximately 80 percent of the hydrologic unit would be in urban uses. Under existing conditions, one minor stormwater drainage system problem was identified in this hydrologic unit.

In the section on evaluation of alternative plans, it was recommended that construction of components of the storm sewer-roadside swale conveyance alternative be considered for this hydrologic unit. However, during the City Plan Commission review of the preliminary draft of the recommended plan, it was indicated that the density of planned development in this hydrologic unit would be such that roadside swale drainage would not be acceptable to the City. As a result, the recommended plan calls for storm sewer conveyance in this hydrologic unit.

To improve the existing conditions at the identified problem areas and to accommodate anticipated runoff conditions, the recommended plan calls for 2,210 lineal feet of storm sewer, ranging in diameter from 12 inches to 24 inches; and the construction of a 5.8-acre-foot wet detention basin.

As a result of comments from city staff and Plan Commission members, four subalternatives were developed to avoid replacement of existing storm sewers in Julen Circle, as was called for in the preliminary draft of the recommended plan. Under the first subalternative, runoff from the area of planned development to the east of 18th Avenue would be conveyed to 18th Avenue as specified in the storm sewer conveyance alternative. From that point, a 27-inch storm sewer would run in a southerly direction along the east side of 18th Avenue for about 200 feet before passing under 18th Avenue and discharging into a 615-foot-long, grass-lined open channel. The channel would run along the south lot lines of the properties along Julen Circle and along the USH 45 right-of-way to the natural channel located west of Julen Circle. This subalternative would have an estimated capital cost of $47,000, annual operation and maintenance costs of $300, and a present value cost of $52,000.

The second subalternative would replace the 615-foot-long open channel called for above with a 44-inch by 27-inch reinforced concrete pipe arch (RCPA) storm sewer, and would have an estimated capital cost of $102,000, annual operation and maintenance costs of $400, and a present value cost of $108,000. The third subalternative calls for construction of a 5.8-acre-foot wet detention basin on the east side of 18th Avenue. The basin would discharge to the existing storm

sewers in Julen Circle. The basin is sized to control the 100-year recurrence interval storm. The permanent pond for control of nonpoint source pollutants would have an area of 0.6 acre and an average depth of five feet. This subalternative would eliminate the need for the 100 feet of 21-inch-diameter storm sewer and 170 feet of 24-inch-diameter storm sewer required under the other subalternatives, for a capital cost saving of $19,000 and an annual operation and maintenance saving of $100. The subalternative would have a net estimated capital cost of $133,000, annual operation and maintenance costs of $3,800, and a present value cost of $193,000. The fourth subalternative calls for replacement of the Julen Circle storm sewers as in the storm sewer conveyance alternative, and would have an estimated capital cost of $108,000, annual operation and maintenance costs of $100, and a present value cost of $110,000. The costs of obtaining drainage easements for the first and second alternatives would be based on negotiations with the affected parties, and were therefore not included in the cost estimates given above.

The third subalternative, calling for a 5.8-acre-foot wet detention basin, is the only subalternative which adequately meets the dual objectives of controlling developed condition runoff while also controlling nonpoint source pollution and protecting water quality in the environmentally valuable headwaters of Silverbrook Creek. The detention basis is an integral part of the recommended water quality management plan element set forth later in this chapter. Therefore, the third subalternative is recommended.

Hydrologic Unit D: Approximately 35 percent of the land in Hydrologic Unit D was in urban uses as of 1985. In the plan design it was assumed that approximately 40 percent of the hydrologic unit would be in urban uses. Under existing conditions, one major and minor system problem, consisting of inadequate hydraulic capacity in the storm sewer and storm sewer outfall at Chestnut Street between 18th Avenue and USH 45, was identified. Because of a mid-block sag in the street, it was necessary to provide sufficient capacity to pass the 100-year recurrence interval storm.

To improve the existing conditions at the identified problem area and to accommodate anticipated runoff conditions, the plan recommends replacing 321 lineal feet of storm sewer in Chestnut Street, including the outfall, with 27-inch storm sewer.

Hydrologic Unit E: Approximately 70 percent of the land in Hydrologic Unit E was in urban uses as of 1985, with the remainder being in open, agricultural, woodland, and wetland uses. In the plan design, it was assumed that approximately 90 percent of the hydrologic unit would be in urban uses.

Inadequate storm sewer capacity was identified at seven locations in the minor stormwater drainage system within this hydrologic unit. These locations include Concord Lane north of Silverbrook Creek, where the outfall is blocked; north of Miller Street and west of, and parallel to, 18th Avenue; 15th Avenue south of Silverbrook Creek; Silverbrook Drive between Walnut Street and Silverbrook Creek; and the intersection of Tamarack Drive and Tamarack Court. At six of the seven locations, there is a potential problem under both existing and planned conditions. The storm sewer located west of 18th Avenue and north of Miller Street would be inadequate only under planned conditions.

Inadequate storm sewer capacity was also identified at two locations in the major stormwater drainage system: at 18th Avenue north of an unnamed tributary to Silverbrook Creek and from Walnut Street to Silverbrook Creek between Silverbrook Drive and 15th Avenue. The storm sewer at 18th Avenue will be inadequate under planned conditions.

Inadequate storm sewer capacity under existing and planned conditions was identified at five locations in the minor and major stormwater drainage systems: at 15th Avenue north of Silverbrook Creek; between Balsam Place and Poplar Street; between Balsam Place and Walnut Street; at Walnut Street west of Silverbrook Drive; and at 16th Avenue north of Silverbrook Creek.

To improve the conditions in the problem areas and to accommodate anticipated runoff conditions, the recommended plan calls for 2,872 lineal feet of replacement storm sewer ranging in diameter from 15 inches to 48 inches, 1,102 lineal feet of 23-inch by 14-inch horizontal elliptical (H.E.) replacement storm sewer, 64 lineal feet of 29-inch by 18-inch RCPA replacement storm sewer, 100 lineal feet of riprap-lined

open channel, and 400 lineal feet of grass-lined open channel. The 500 total feet of open channel would collect the discharge from an existing 24-inch corrugated metal pipe (CMP) storm sewer as well as overflow from subbasin SC98 during a 100-year storm, and convey that overflow along 18th Avenue to the existing twin 24-inch RCP under 18th Avenue in subbasin SC97. The triangular channel would have a maximum depth of from three to four feet and would have the standard city roadside swale cross-section, with side slopes of one vertical on four horizontal adjacent to the street and one vertical on three horizontal away from the street. Plan, profile, and cross-section views of the proposed channel are shown in Figure A-3 of Appendix A of this volume. Also, 750 feet of the existing outlet channel for the twin 24-inch RCP under 18th Avenue would be graded to provide a positive outlet for the runoff tributary to the channel and for the storm sewer in Concord Lane. It is recommended that the hydraulic capacity of the outlet culvert in Silver Creek at Washington Street be maintained as it is under existing conditions to preserve the upstream and downstream flood control benefits provided by the flood storage volume in the wetland located southeast of the intersection of Silverbrook Drive and Washington Street.

Hydrologic Unit F: Approximately 25 percent of the land in Hydrologic Unit F was in urban land uses as of 1985, with the remainder in agricultural, open, woodland, and wetland uses. In the plan design it was assumed that approximately 60 percent of the hydrologic unit would be in urban uses.

To accommodate anticipated runoff conditions, the plan recommends the installation of 7,380 lineal feet of new storm sewer, ranging in diameter from 12 inches to 54 inches, in areas of planned development; the construction of 780 feet of grass-lined channel at two new storm sewer outfalls; and the construction of an outlet structure for the existing pond located southeast of Schuster Drive. The location, configuration, and horizontal and vertical alignment of the street system required to support future urban development should be carefully laid out to provide the necessary major drainage system conveyance capacity.

To avoid the replacement of existing storm sewers in Villa Park Drive, the storm sewer conveyance alternative that was selected for implementation in this hydrologic unit was refined to provide a 180-foot-long, 21-inch-diameter storm sewer outlet for runoff collected in storm sewers to be constructed in Villa Park Drive to the north of the existing storm sewers. Discharge from the outlet would be conveyed through a grassed channel to the wetland located east of Villa Park Drive.

The plan also recommends using the wetlands east and west of Villa Park Drive and in Albecker County Park north of Washington Street as natural detention basins for the purpose of reducing peak downstream flows. Modifications to the existing culvert outlets from those wetlands are not required, but it is recommended that the existing hydraulic capacity of the outlets be retained. Under the existing land use and stormwater management conditions, the peak water levels that would be expected in the wetlands within and adjacent to Albecker Park for 10- and 100-year recurrence interval storms would be 988.4 National Geodetic Vertical Datum (NGVD) and 988.7 feet NGVD, respectively. Under planned land use and stormwater management conditions, the peak 10- and 100-year water levels would be 988.5 feet NGVD and 988.7 feet NGVD, respectively.

Hydrologic Unit G: Hydrologic Unit G was essentially undeveloped in 1985. In the plan design it was assumed that all of the hydrologic unit would be in urban uses.

To accommodate anticipated runoff conditions, the plan recommends the installation of 1,115 lineal feet of 18-inch, 24-inch, and 27-inch circular storm sewer; 1,245 lineal feet of 4-foot by 2-foot concrete box storm sewer; 485 lineal feet of 5-foot by 3-foot concrete box storm sewer; 365 lineal feet of twin 36-inch reinforced concrete culvert; and 1,010 lineal feet of trapezoidal open channel with one vertical on four horizontal side slopes and average bottom widths ranging from 2.5 feet to 10 feet. The location, configuration, and horizontal and vertical alignment of the street system required to support future urban development should be carefully laid out to provide the necessary major drainage system conveyance capacity.

Future development could entail placement of some fill in the existing wetland area adjacent to the unnamed stream within the hydrologic unit. If the stream were determined to be navigable, the adjacent area would be classified as

a shoreland-wetland. Prior to placement of fill in a shoreland-wetland, it would be necessary to obtain concurrence of the Wisconsin Department of Natural Resources with the plan to place fill, to amend the City's shoreland-wetland zoning ordinance, and to obtain a permit for placement of fill from the U. S. Army Corps of Engineers under Section 404 of the federal Clean Water Act. It is likely that wetland mitigation, involving the establishment or improvement of an adjacent wetland which is at least as large as the filled wetland, would be required. Costs associated with the placement of fill and with wetland mitigation are considered to be costs of development separate from the provision of the stormwater management system; therefore, such costs are not included in this system plan.

Hydrologic Unit H: As of 1985, Hydrologic Unit H was entirely in rural land uses, with approximately 95 percent being in agricultural, open, wetland, or woodland uses, and the remainder in low-density residential use. Since 1985, the hydrologic unit has been developed for multi-family residential use and its current state of development is essentially that of plan year 2010 conditions. The hydrologic unit is internally drained, with runoff from the new development directed through overland flow and swales to an existing wetland.

The wetland, which has no outlet, is intended to serve as a natural retention basin. The retention basin has adequate storage volume to serve as a component of both the major and minor stormwater drainage systems, and the overland flow-swale-wetland drainage system should adequately abate nonpoint source pollution; therefore, the recommended plan contains no stormwater management measures for this hydrologic unit.

Hydrologic Unit I: Approximately 10 percent of the land in Hydrologic Unit I was in urban land uses as of 1985, with the remainder in agricultural and wetland uses. In the plan design it was assumed that approximately 95 percent of the hydrologic unit would be in urban uses.

Although consideration of the storm sewer-roadside swale conveyance alternative was recommended for this hydrologic unit, it was indicated by the City that the density of the planned development would be such that the City would require urban street cross-sections with storm sewer conveyance. Therefore, the storm sewer conveyance alternative, with certain modifications, is recommended for implementation in this hydrologic unit.

To accommodate anticipated runoff conditions, the recommended plan calls for the installation of 8,585 lineal feet of RCP storm sewer, ranging in diameter from 12 inches to 36 inches; 185 lineal feet of 38-inch by 24-inch H.E. RCP storm sewer; and 550 feet of 24-inch-diameter polyvinyl chloride (PVC) storm sewer. The location, configuration, and horizontal and vertical alignment of the street system required to support future urban development should be carefully laid out to provide the necessary major drainage system conveyance capacity.

The recommended plan for this hydrologic unit differs from the storm sewer conveyance alternative in that the plan reflects many features of the storm sewer system proposed for the planned Fox Ridge Subdivision in the central portion of the hydrologic unit. The proposed storm sewer components for the subdivision were incorporated directly in this plan in those locations where the components have adequate capacity and are consistent with the plan objectives. In other locations, this plan recommends installation of larger storm sewers to convey flow from the planned subdivision or from the subdivision plus other upstream areas of potential development.

Hydrologic Unit J: Approximately 5 percent of the land in Hydrologic Unit J was in urban land uses as of 1985, with the remainder in recreational, agricultural, open, woodland, and wetland uses. In the plan design, it was assumed that approximately 25 percent of the hydrologic unit would be developed in urban uses.

The existing stormwater drainage system is adequate for the predominantly rural hydrologic unit. Under existing conditions, runoff from the perimeter of the hydrologic unit drains, through overland flow, to a large wetland along Silver Creek. That situation will be unchanged under planned conditions with the exception of runoff from a 5.4-acre portion of the Fox Ridge Subdivision which will be conveyed in storm sewers and discharged to the wetland. That portion of the subdivision was included in Hydrologic Unit I for the evaluation of alternatives, but, under the proposed storm sewer system, the area would be part of Hydrologic Unit J.

The recommended plan for this hydrologic unit reflects the proposed storm sewer components for the Fox Ridge subdivision, calling for the installation of 755 lineal feet of RCP storm sewer, ranging in diameter from 15 inches to 21 inches.

Outflow from the hydrologic unit is controlled by a culvert located in Silver Creek at University Drive just south of Washington Street. Because of backwater from the culvert, the wetland upstream of University Drive acts as a natural detention basin, storing runoff and reducing peak downstream flows. It is recommended that the hydraulic capacity of the outlet culvert at University Drive be maintained as it is under existing conditions to preserve the downstream flood control benefits provided by the flood storage volume in the wetland.

Hydrologic Unit K: Approximately 70 percent of Hydrologic Unit K was in urban land uses as of 1985, with the remainder in open, wetland, and woodland uses. In the plan design, it was assumed that approximately 85 percent of the hydrologic unit would be in urban land uses. Stormwater drainage system problems identified within the hydrologic unit are listed in Table 1 and are shown on Map 2, both in Chapter II.

To improve existing conditions in the problem areas and to accommodate anticipated runoff conditions, approximately 2,470 lineal feet of replacement storm sewer, ranging in diameter from 18 inches to 30 inches and including segments of 44-inch by 27-inch and 51-inch by 31-inch RCPA storm sewer, are proposed to be installed. In addition, one-acre-foot of parking lot detention storage volume is to be provided in subbasin 98, as shown on Map 6. Also, the 220-foot-long open channel located west of the State Central Credit Union building at 18th Avenue and Washington Street is to be replaced with an 18-inch storm sewer. The location, configuration, and horizontal and vertical alignment of the street system required to support future urban development should be carefully laid out to provide the necessary major drainage system conveyance capacity.

Hydrologic Unit L: Approximately 75 percent of Hydrologic Unit L was developed in urban land uses as of 1985, with the remainder in open, woodland, and wetland uses. In the plan design, it was assumed that approximately 85 percent of the hydrologic unit would ultimately be in urban land uses. Storm sewer capacity problems identified within the hydrologic unit are listed in Table 1 and shown on Map 2. In addition, a problem with ponding of stormwater runoff in the vicinity of Angela Court was identified by city staff.

To improve existing conditions in the problem areas and to accommodate anticipated runoff conditions, the recommended plan calls for approximately 8,600 lineal feet of replacement storm sewer, including circular pipe with diameters from 21 inches to 48 inches, horizontal elliptical pipe with sizes of 45 inches by 29 inches and 53 inches by 34 inches, and reinforced concrete pipe arches ranging in size from 51 inches by 31 inches to 73 inches by 45 inches. In addition, 330 lineal feet of new 24-inch-diameter storm sewer would be installed in 9th Avenue extended north of High Street to accommodate anticipated development, and 410 lineal feet of new 21-inch-diameter storm sewer would be installed in Angela Court, running east to 12th Avenue, to alleviate the problem with ponding of runoff. To avoid increased ponding of runoff in backyards between 9th and 10th Avenues north of High Street, the plan calls for the lots to be developed on the west side of 9th Avenue extended under planned conditions to be graded so that all new impervious areas drain in an easterly direction to the new street. If such grading cannot be accomplished, the plan recommends that roof drains be connected to the storm sewer. The plan also proposes construction of an eight-acre-foot detention basin north of Wood Way extended. The location, configuration, and horizontal and vertical alignment of the street system required to support future urban development should be carefully laid out to provide the necessary major drainage system conveyance capacity.

The recommended plan differs slightly from the alternative plan selected for this hydrologic unit in that the recommended plan calls for the replacement of an additional 176 feet of 12-inch-diameter storm sewer in Alder Street with 24-inch-diameter storm sewer to serve as a component of the major and minor stormwater drainage systems. Without the larger replacement pipe, the major system would be unable to accommodate the runoff from a 100-year recurrence interval storm under planned conditions without causing flooding of adjacent property.

The recommended plan also differs from the alternative initially selected in that the originally proposed detention basin west of Green Tree Road and southeast of Green Tree School is eliminated and stormwater conveyance is substituted based upon local review recommendations.

Flood Control Plan Element

To alleviate existing or anticipated flooding problems, several modifications to the existing major stream system are recommended. The costs of the recommended flood control measures, stream channel modifications, and hydraulic structure replacements are given in Table 11.

Silver Creek: Modifications of the Silver Creek stream channel in the reach downstream from the culvert inlet at Washington Street just west of 15th Avenue is recommended to provide flood protection for existing buildings during floods up to and including a 100-year recurrence interval flood under planned land use and recommended stormwater drainage and channel conditions. Upon implementation of the recommended flood control measures, no existing buildings in the 100-year recurrence interval floodplain of Silver Creek would be within the planned urban service area boundaries, with the exception of the small basement compressor room of one commercial building. New construction within the 100-year floodplain is prohibited by the City's floodplain zoning ordinance.

It is recommended that a 432-foot long, 10-foot-wide by 4-foot-high reinforced concrete box culvert be installed in Silver Creek to replace the existing 432-foot-long tunnel consisting of a 105-inch by 74-inch structural plate pipe arch followed by a 6.5-foot-diameter RCP. The recommended box culvert would pass the 100-year recurrence interval flood flow under planned land use and channel conditions without overtopping Washington Street and flooding nearby buildings. It is also recommended that a 57-foot-long, 10-foot-wide by 4-foot-high reinforced concrete box culvert be installed to replace the existing 57-foot-long structural plate pipe arch (SPPA) culvert under 15th Avenue. Channel modifications are recommended in the 120-foot-long reach of Silver Creek between the two proposed box culverts. In that reach, the flood control channel bottom width would range from 6 to 10 feet and channel side slopes would range from 1.0 vertical on 2.5 horizontal to 1.0 vertical on 3.0 horizontal. The streambed and banks would be lined with riprap. The recommended box culvert along with the channel modifications would prevent overtopping of 15th Avenue and of the stream banks upstream of 15th Avenue, eliminating flooding of houses between Silver and Silverbrook Creeks due to overflow from Silver Creek during events up to and including the 100-year recurrence interval flood.

For the first 180 feet downstream of the recommended box culvert at 15th Avenue, it is recommended that a riprap-lined channel be constructed along the alignment of the existing channel. Plan, profile, and cross-section views of the modified channel are shown in Figure A-1 of Appendix A of this volume. The channel bottom width would vary from 2 to 10 feet with side slopes from 1.0 vertical on 2.85 horizontal to 1.0 vertical on 3.0 horizontal. This channel modification would prevent flooding of the apartment building located east of 15th Avenue and south and west of Silver Creek.

During the 100-year recurrence interval flood under planned land use, channel, and drainage conditions, there could be flooding of the basement compressor room of a commercial warehouse building located about 250 feet east of 15th Avenue between Washington Street and Silver Creek. The relatively small—320-square-foot—basement has one outside entrance, the sill of which is about 0.5 foot below the 100-year flood level. The basement floor is about 1.2 feet below the entrance elevation, resulting in a potential depth of inundation under a 100-year recurrence interval event of 1.7 feet above the basement floor. It is recommended that the basement be floodproofed to an elevation of 2.0 feet above the 100-year flood level.

Silverbrook Creek: The area roughly bounded by Silver Creek on the north, Silverbrook Creek on the south, 15th Avenue on the east, and Concord Lane on the west includes many buildings that would be subject to direct overland flooding during a 100-year recurrence interval flood event under planned land use and existing channel and drainage conditions. To eliminate that potential flooding and to remove the buildings from the 100-year floodplain, it is recommended that the existing 60-foot-long, 85-inch by 54-inch CMPA at 15th Avenue be replaced by a triple 10-foot by 3-foot reinforced concrete box culvert, and that the existing 60-foot-long, 85-inch by

Table 11

COMPONENTS AND COSTS OF THE RECOMMENDED FLOOD CONTROL PLAN ELEMENT FOR THE SILVER CREEK SUBWATERSHED

Hydrologic Unit	Project and Component Description[a]	Estimated Cost	
		Capital	Annual Operation and Maintenance[b]
E	Northern Portion of Silverbrook Creek Subbasin		
	1. Replace existing 60-foot-long, 85-inch x 54-inch corrugated metal pipe arch culvert at 15th Avenue with a triple 10-foot x 3-foot reinforced concrete box culvert	$ 68,000	$100
	2. Replace existing 60-foot-long, 85-inch x 54-inch corrugated metal pipe arch culvert at 16th Avenue with a double 8-foot x 4-foot reinforced concrete box culvert	48,000	100
	3. Shaping of 400 feet of Silverbrook Creek channel to accommodate new box culverts	10,000	0
	4. Engineering, administration, and contingencies	44,000	0
	Subtotal	$170,000	$200
K	Central Portion of Silver Creek Subwatershed		
	1. Replace existing 159-foot-long, 105-inch x 74-inch structural plate pipe arch; and 273-foot-long, 6.5-foot-diameter reinforced concrete pipe under Washington Street with a 432-foot-long, 10-foot x 4-foot reinforced concrete box culvert	$203,000	$ 0
	2. Modify a 230-foot-long reach of the Silver Creek channel between Washington Street and 15th Avenue	15,000	200
	3. Replace existing 57-foot-long structural plate pipe arch culvert under 15th Avenue with 57-foot-long, 10-foot x 4-foot reinforced concrete box culvert	26,000	0
	4. Modify 180-foot-long reach of Silver Creek channel downstream of new 10-foot x 4-foot box culvert, and provide riprap along streambed and banks	20,000	200
	5. Floodproof basement of one commercial building located east of 15th Avenue between Washington Street and Silver Creek	15,000	0
	6. Engineering, administration, and contingencies	98,000	0
	Subtotal	$377,000	$400
	Total	$547,000	$600

[a]Costs were noted to be zero when the project proposed replacement of a component with a component having similar operation and maintenance costs.

Source: SEWRPC.

54-inch CMPA at 16th Avenue be replaced by a double 8-foot-wide by 4-foot-high reinforced concrete box culvert. The existing channel would be modified to accommodate the recommended box culverts, beginning at a section location 100 feet upstream of 15th Avenue and extending 60 feet downstream of 15th Avenue. Also, relatively minor channel shaping would be required starting 120 feet upstream of 16th Avenue and extending 120 feet downstream of 16th Avenue. The upstream 100-foot-long reach of shaped channel is located in a wetland, and wetland vegetation would be established within the channel following excavation. Plan, profile and cross-section views of the modified channel are shown in Figure A-2 of Appendix A of this volume.

Because the flooding in this area under existing channel conditions is due to a combination of direct overland flooding from Silverbrook Creek and overflow from Silver Creek, the area would not be completely removed from the 100-year recurrence interval floodplain until both the Silver Creek and Silverbrook Creek culvert replacements are implemented.

100-Year Recurrence Interval Flood Flows: Table 12 presents estimated 100-year recurrence interval flood flows at pertinent locations throughout the study area under future land use conditions with both existing and recommended future drainage and stream channel conditions.

The increases in the 100-year recurrence interval flood flows in Silver Creek in the reach from Washington Street to the confluence with Silverbrook Creek with the planned land use and recommended drainage system and channel in place are due to recommended changes to the minor stormwater drainage system. Under existing stormwater drainage system conditions, the rate of runoff during a 10-year storm occurring over subbasin SC98 in the Silver Creek subwatershed southeast of the intersection of Washington Street and 18th Avenue exceeds the hydraulic capacity of the minor drainage system at the subbasin outlet. The excess runoff would back up in the parking lot of the department store at 18th Avenue and Washington Street and would flow overland to the south, entering the Silverbrook Creek subwatershed. Under recommended stormwater drainage conditions, the minor system capacity within the Silver Creek subwatershed would be increased to permit conveyance of the runoff from a 10-year recurrence interval storm. The increased hydraulic capacity would pass more flow to Silver Creek during storms with recurrence intervals from 10 to 100 years, thereby decreasing the flow passed to Silverbrook Creek and increasing flows in Silver Creek under recommended stormwater drainage conditions.

The increases in the 100-year recurrence interval flood flows in Silverbrook Creek in the reach downstream of the intersection of 18th Avenue and Chestnut Street with the recommended stormwater drainage system and channel in place would be due to the recommended replacement of the existing culverts at 15th and 16th Avenues along Silverbrook Creek, which would result in a lowered water surface profile and corresponding utilization of less floodplain storage upstream of 15th and 16th Avenues. The increase in flows under recommended channel and drainage system conditions as compared with existing channel and drainage system conditions may be expected to cause an increase in the 100-year recurrence interval flood stage of 0.01 to 0.42 foot in the reach of Silver Creek downstream of 15th Avenue. From 15th Avenue to the confluence with Silverbrook Creek just downstream of Silverbrook Drive, the increase in stage would be a direct result of the increase in minor system capacity at the subbasin SC98 outlet. Downstream of the confluence with Silverbrook Creek, the increases in stage would be due to a combination of the increased minor system capacity at subbasin SC98 and increased flows resulting from the replacement of the culverts at 15th and 16th Avenues. The increase in flows in Silverbrook Creek would also cause an increase in 100-year recurrence interval flood stages of 0.02 to 0.60 foot downstream from 15th Avenue. Higher flows would not significantly increase flow velocities in either Silver Creek or Silverbrook Creek; therefore, the potential for stream bank erosion would be unchanged. The increases in stages along both Silver Creek and Silverbrook Creek would not cause flooding of any existing buildings.

Much of the area along Silver and Silverbrook Creeks that would be affected by the potential increase in 100-year recurrence interval flood stages under planned land use and recommended channel and drainage conditions is in City ownership as parkland or school district

Table 12

COMPARISON OF 100-YEAR RECURRENCE INTERVAL FLOOD FLOWS FOR SILVER CREEK, SILVERBROOK CREEK, AND WASHINGTON CREEK

Location	Future Land Use and Existing Drainage System and Channel Conditions (cubic feet per second)	Future Land Use and Recommended Drainage System and Channel Conditions (cubic feet per second)
Silver Creek		
Pick Lake Outlet	15	15
Outlet to Unnamed Lake Downstream of Pick Lake	31	31
Wetland Upstream of University Drive and Downstream of the Confluence with Washington Creek	419	419
University Drive	166	166
18th Avenue	305	305
Washington Street	305	305
Silverbrook Drive Upstream of the Confluence with Silverbrook Creek	342	394
Washington Street Downstream of the Confluence with Silverbrook Creek	360	366
Park Drive in Regner Park	384	399
Confluence with Milwaukee River	506	447
Silverbrook Creek		
Outlet to Bicentennial Park Pond	267	267
Intersection of 18th Avenue and Chestnut Street	267	267
16th Avenue	331	371
Silverbrook Drive	355	398
Upstream of the Confluence with Silver Creek	374	442
Washington Creek		
0.2 Mile Downstream of Washington Street at City of West Bend Corporate Limits	136	136
Confluence with Silver Creek	296	296

Source: SEWRPC.

property, but certain floodplain areas are privately owned. Prior to modification of the minor stormwater drainage system in subbasin SC98 and prior to replacement of the culverts in Silverbrook Creek at 15th and 16th Avenues, it may be necessary to obtain flooding easements from, or to make other legal arrangements with, the property owners affected by the potential increases.

A comparison of Table 12 with Table 11 in Chapter II of Volume One of this report shows that the 100-year recurrence interval flows developed for this stormwater management system plan differ from those developed for the federal Flood Insurance Study (FIS). The 100-year flows for Silver and Washington Creeks and for Silverbrook Creek upstream of the intersection of 18th Avenue and Chestnut Street

are lower than those developed under the federal study. The 100-year flows for Silverbrook Creek downstream of the intersection of 18th Avenue and Chestnut Street are somewhat greater than those developed under the federal study. The changes in the federal study 100-year recurrence interval flows reflected in this stormwater management plan are due to several factors, including the use of more current land use data and plans, more detailed hydrologic modeling performed for the stormwater management plan, and consideration of the effects of the recommended stormwater drainage and major stream system modifications in this plan.

The 100-year recurrence interval water surface profiles computed for this system plan utilized the same base data as the federal flood insurance study, supplemented by some recently surveyed stream cross-sections and as-built data for the culverts under Washington Street at the USH 45 overpass, which were constructed following completion of the federal study. The water surface profiles were calculated using the floodway legally adopted by the City. The overall impact on the major streams of the revised 100-year flows in conjunction with the recommended flood control measures is to produce a 100-year recurrence interval water surface profile which is generally lower than the profile developed for the federal flood insurance study and incorporated in the floodplain zoning ordinance of the City. Because of refinements to the hydraulic model used to compute the profiles, there is one 0.2-mile-long reach along Silver Creek between 15th Avenue and Silverbrook Drive, and a 0.04-mile-long reach and a 0.06-mile-long reach along Silverbrook Creek downstream of the intersection of 18th Avenue and Chestnut Street where the profiles developed for this planning effort are higher than those given in the federal flood insurance study.

In addition, the 100-year recurrence interval water surface profile calculated for the 0.2-mile-long reach of Silverbrook Creek between 15th Avenue and Silverbrook Drive is higher than the profile calculated under the federal flood insurance study because the 100-year flow estimated for this system plan is slightly greater than the 100-year flow used under the federal study for that reach.

Water Quality Management Plan Element

The water quality management element of the recommended plan is intended to achieve the water quality objectives set forth in Chapter IV of Volume One of this report. The recommended measures represent a refinement of the more generalized recommendations presented in the areawide water quality management plan for southeastern Wisconsin. The recommended measures are also consistent with the nonpoint source priority watershed plan prepared by the Wisconsin Department of Natural Resources.[1] Wherever possible, the water quality management recommendations are coordinated and combined with the drainage recommendations made herein in order to minimize costs. This section describes the water quality objectives of the plan; estimates pollutant loadings to the surface waters; presents the basis for the selection of the recommended pollution load reduction measures; and describes the recommended plan element.

Water Quality Objectives: The water use objectives and supporting water quality standards to be met by surface waters in the West Bend area are set forth in Chapter IV of Volume One of this report. Silver Creek and portions of Silverbrook Creek currently support warmwater fish and aquatic life, and are suitable for full body contact recreational use—although bacterial levels are sometimes high. Portions of Silverbrook Creek are able to support some pollution-intolerant coldwater species of fish. Several wetlands lie adjacent to the streams, and Silver Creek flows through the City of West Bend's Regner Park and Washington County's Ridge Run Park. These stream and riparian lands provide opportunities for recreational activities such as fishing, wading, sightseeing, nature study, and hiking. The West Bend Swimming Pond, located in Regner Park, is used for swimming. The Regner Park fish pond, although maintaining only a limited fishery, has excessive turbidity and sedimentation, and provides poor aquatic habitat. Fishery and habitat surveys conducted by the Department of Natural

[1] *Wisconsin Department of Natural Resources, "A Nonpoint Source Control Plan for the East and West Branches of the Milwaukee River Priority Watershed," Public Review Draft, February 1, 1989.*

Table 13

ANNUAL POLLUTANT LOADINGS TO SURFACE WATERS IN THE SILVER CREEK SUBWATERSHED

Hydrologic Unit[a]	Existing Land Use			2010 Planned Land Use					
				Sediment		Phosphorus		Metals[b]	
	Sediment (pounds)	Phosphorus (pounds)	Lead (pounds)	Pounds	Percent Change	Pounds	Percent Change	Pounds	Percent Change
Planned Urban Service Area									
B	76,400	148	6.2	56,000	-27	126	-15	119.2	1,823
C	33,300	76	17.9	25,300	-24	68	-11	39.5	121
D	13,100	37	21.9	13,500	3	37	--	22.6	3
E	43,000	116	72.0	47,100	10	126	9	78.6	9
F	141,100	294	91.5	150,700	7	314	7	218.4	139
G	43,100	82	2.5	36,700	-15	66	-20	53.8	2,052
I	45,700	86	10.9	38,800	-15	79	-8	83.8	669
J	32,700	74	16.1	32,300	-1	82	11	51.6	220
K	51,900	109	120.4	46,400	-11	50	-54	131.3	9
L	40,600	110	63.9	39,800	-2	106	-4	59.0	8
Subtotal	520,900	1,132	423.3	486,600	-7	1,054	-7	857.8	103
Upstream Rural Areas	87,900	234	5.3	68,100	-23	186	-21	4.1	-23
Total Subwatershed	608,800	1,366	428.6	554,700	-9	1,240	-9	861.9	101

[a]*Hydrologic Units A and H are internally drained and do not contribute pollutants to streams in the Silver Creek subwatershed.*

[b]*Lead used as an indicator.*

Source: SEWRPC.

Resources, however, have indicated that the fishery resources in Silver Creek and Silverbrook Creek have declined over the past 10 to 25 years. Further degradation of the aquatic resources may be expected to occur if urban development of the subwatershed occurs without proper stormwater and water quality management.

Pollutant Loading Analysis: In order to assess the sources and magnitude of nonpoint source pollution in the subwatershed, annual pollutant loadings to surface waters under existing and planned future land use conditions were estimated for each of 11 hydrologic units within the urban service area, and for the upstream rural areas draining to Silver Creek. These loadings were used to identify the types of land uses and specific areas within the Silver Creek subwatershed which contribute the highest levels of pollutants to the receiving waters.

Table 13 presents estimated annual loadings of sediment, phosphorus, and lead to Silver Creek and its tributary streams under existing and planned year 2010 land use conditions. The land within the planned urban service area is estimated to account for 80 to 85 percent of the total sediment and phosphorus loadings, and 99 percent of the lead loadings, to Silver Creek. The table indicates that sediment and phosphorus loadings within the urban service area may be expected to decrease by about 7 percent by the year 2010, while lead loadings may be expected to double. Lead was used in this analysis as a representative indicator of metals and other pollutants that are contributed almost exclusively by urban sources. As shown in Table 13, loadings of lead from rural sources are relatively small. It should be noted, however, that unit-area lead loadings may decline in the future as the use of leaded gasoline is discontinued. Thus,

the future lead loadings set forth in Table 13 may overestimate the actual loadings that will occur. Loadings of other metals and pollutants contributed solely by urban sources, however, will not be affected by the discontinuance of the use of leaded gasoline, and may therefore be expected to approximately double by the year 2010 if control measures are not implemented.

The loadings presented in Table 13 represent loadings delivered to surface waters, and therefore account for existing control measures. The loadings reflect the effects of two existing wet ponds within the Silver Creek subwatershed which reduce pollutant loadings delivered to the stream system. The first pond, located southwest of Schuster Drive, is approximately 4.3 acres in size and has a volume of about 12.9 acre-feet. This pond treats runoff from a total of about 72 acres, or 2 percent of the planned urban service area. The second pond, located southwest of the intersection of Washington Street and 18th Avenue, is approximately 1.3 acres in size and has a volume of about 3.3 acre-feet. This second pond treats runoff from a total of about 14 acres, or 1 percent of the urban service area. On an annual basis, these ponds are estimated to remove about 90 percent of the sediment, 80 percent of the lead, and 50 percent of the phosphorus carried by the runoff discharged into the ponds. The resulting reduction in nonpoint source pollutant loading within the entire urban service area provided by the ponds is approximately 4 percent for sediment, 1 percent for lead, and 2 percent for phosphorus. A third pond is located in Bicentennial Park. Under existing conditions, the 633-acre area tributary to this pond is in predominantly rural land uses; however, a substantial portion of this area is anticipated to be developed in urban uses under planned conditions. The pond currently provides some control of nonpoint source pollutants from the tributary watershed, but because it is located onstream near the headwaters of Silverbrook Creek where marginally favorable conditions for coldwater fish species may still exist, it would not be desirable to utilize the pond to treat urban runoff under planned conditions. Since the pond is considered a valuable resource which is to be protected, the reductions in existing loadings which can be attributed to the pond are excluded from Table 13, and the recommended plan calls for measures to protect the water quality of the pond. Silver Creek, along with storm sewers which drain a 182-acre residential area, discharges into the 2.4-acre Regner Park fish pond. However, because the pond is very shallow, with most areas having water depths of two to three feet, and because inflow rates to the pond are high during storm events, it was concluded that the pond does not effectively trap pollutants at this time. Any pollutants that do accumulate in the Regner Park fish pond are probably resuspended and flushed from the pond during subsequent storm events.

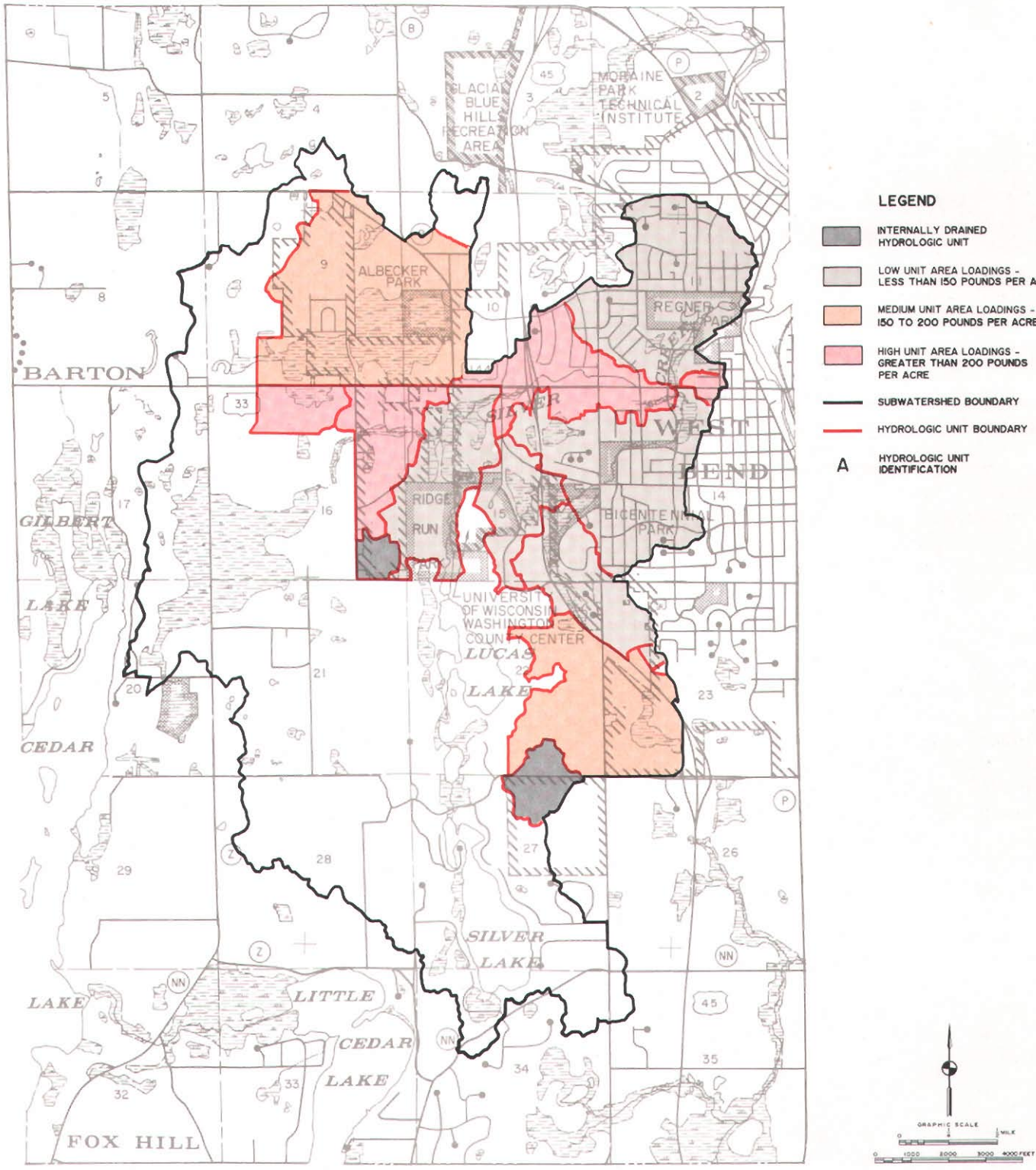
Under the current street sweeping program within the City of West Bend, all of the streets within the Silver Creek subwatershed are swept approximately four times per year. Leaf collection occurs twice during the fall. Street sweeping and leaf collection are conducted for the City on a contract basis by a private firm.

Maps 9 through 11 show the hydrologic units that are expected to contribute the highest unit-area loadings of sediment, phosphorus, and lead to surface waters under plan year 2010 land use conditions. Generally, the greatest pollutant loads are generated from those units that are expected to contain commercial, industrial, transportation, and high-density residential land uses. For example, although commercial land use covers only 8 percent of the study area, approximately 38 percent of the sediment loading, 27 percent of the phosphorus loading, and 61 percent of the lead loading are contributed from commercial land. As shown on the maps, the highest unit-area pollutant loadings—expressed in pounds of pollutant per acre per year—are expected from Hydrologic Units G, I, and K, which are generally located in the northern portion of the subwatershed adjacent to STH 33. Within these hydrologic units, the amount of developed residential land and commercial land area is expected to double by the plan design year 2010.

Selection of Recommended Water Quality Management Measures: Each of the potentially available water quality management measures provides unique benefits with respect to the plan objectives. Yet, each measure also has limitations depending on the physical constraints imposed by the subwatershed. The recommended water quality management measures were selected on the basis of the required reduction in pollutant loadings, the unit-area pollutant loadings, the cost-effectiveness of the measures, the availability of suitable sites, and the com-

Map 9

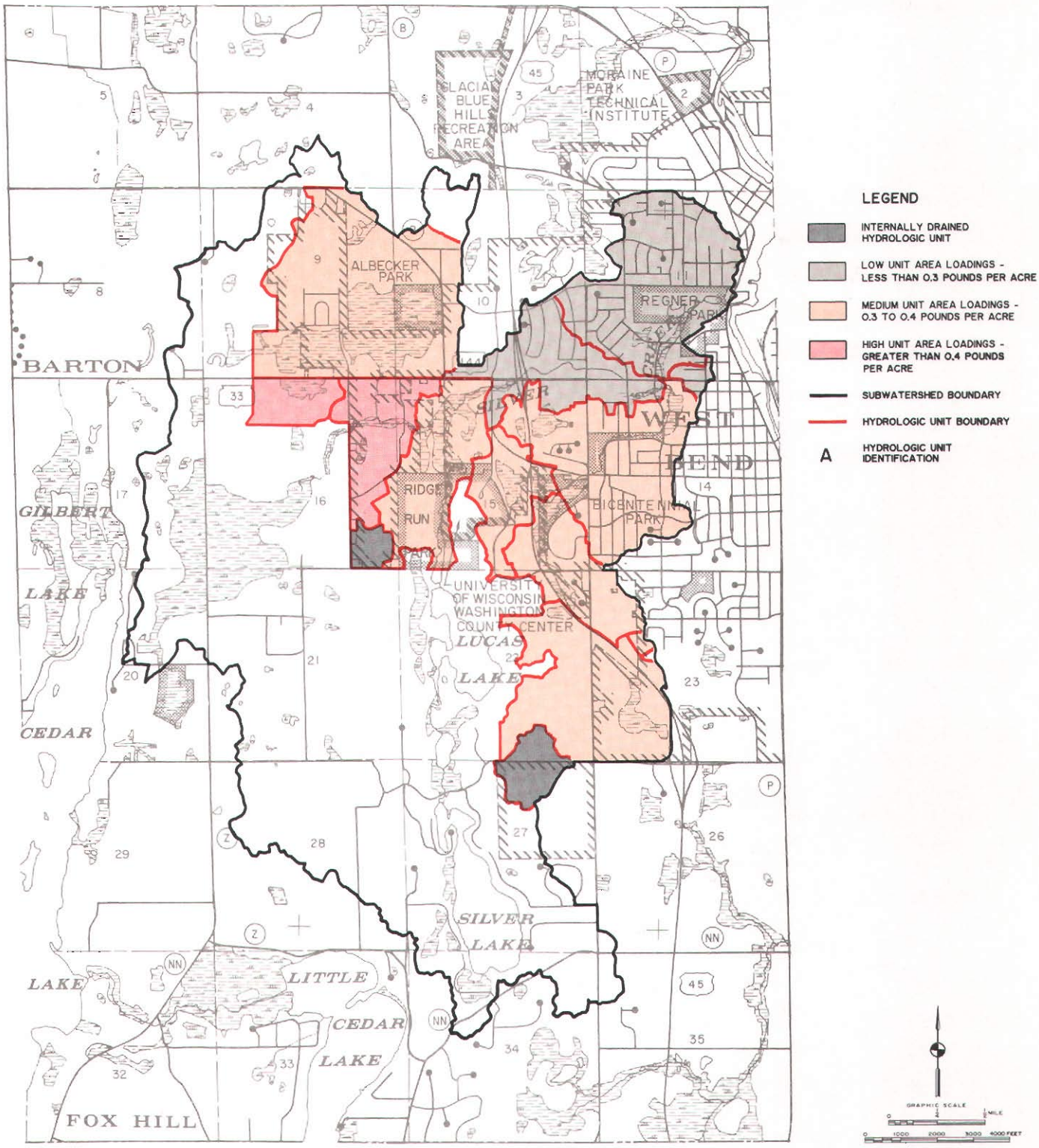
UNIT-AREA LOADINGS OF SEDIMENT WITHOUT CONTROLS: PLAN YEAR 2010



Source: SEWRPC.

Map 10

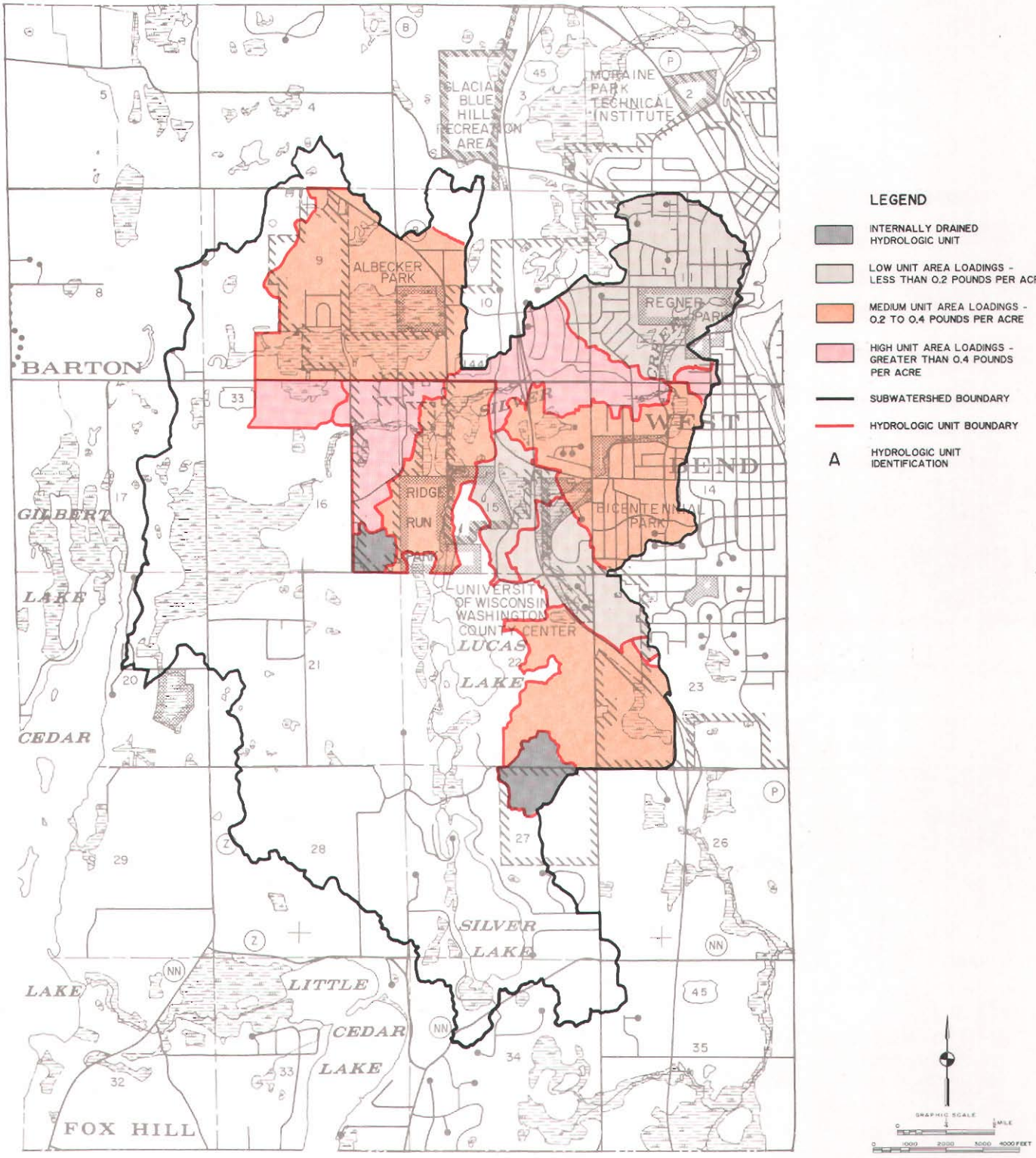
UNIT-AREA LOADINGS OF PHOSPHORUS WITHOUT CONTROLS: PLAN YEAR 2010



Source: SEWRPC.

Map 11

UNIT-AREA LOADINGS OF LEAD WITHOUT CONTROLS: PLAN YEAR 2010



Source: SEWRPC.

patibility with the stormwater drainage recommendations. The recommended measures were selected to help achieve the water use objectives at the least cost.

As noted above, the measures are designed to achieve, where practicable, the minimum target reductions in anticipated pollutant loadings. In certain instances, the measures are designed to achieve relatively high reductions in loadings to particularly valuable surface waters. Measures that reduce pollutant loadings to certain wetlands were also selected.

Where possible, water quality management measures are located in areas that generate high unit-area pollutant loadings. However, because of site restrictions and the limited applicability of certain measures, it was not possible to confine all of the recommended measures to these high-pollutant-loading areas. About 45 percent of the total capital cost of the water quality management element is for measures which treat the runoff from the three hydrologic units with the highest unit-area pollutant loadings. In order to achieve the desired level of pollution control, it was necessary to place some measures in medium- or low-pollutant-generating areas.

The evaluation of the various pollution control measures available considered the cost-effectiveness of the measures. For the purposes of this report, cost-effectiveness was measured in terms of the cost per pound of pollutant removed. Based on the results of recent studies of urban nonpoint source pollution, it was concluded that four general types of control measures may be effective and could be used in the Silver Creek subwatershed. These types are: 1) wet detention ponds, 2) infiltration systems, 3) increased street sweeping, and 4) construction site erosion control. Table 14 summarizes the estimated cost-effectiveness of these measures, as designed for the study area. As shown in the table, the cost-effectiveness of construction site erosion control and street sweeping is relatively high, while the cost-effectiveness of wet ponds and infiltration systems is lower. However, construction site erosion control is not a cost-effective method of reducing lead loadings since the lead contributions from construction sites are minimal. Studies conducted under the Nationwide Urban Runoff Program sponsored by the U. S. Environmental Protection Agency indicated that wet detention ponds and infiltration systems can achieve a relatively high level of pollution abatement.[2] Street sweeping does not achieve a high level of pollution control but is relatively inexpensive. The effectiveness of street sweeping can be enhanced by intensively sweeping in spring and fall.[3] Associated with increased street sweeping would be increased cleaning of catch basins and improved leaf collection.

Several potential pollution control measures were not included in the recommended plan because of poor cost-effectiveness. Infiltration of stormwater runoff from rooftops was not recommended because control of the low levels of pollutants in rooftop runoff did not justify the high cost. Similarly, four available wet pond sites were considered, but not included in the recommended plan. The ponds were excluded

Table 14

COST-EFFECTIVENESS OF ALTERNATIVE WATER QUALITY MANAGEMENT MEASURES

Measure	Cost-Effectiveness (cost per pound of pollutant removed)		
	Sediment	Phosphorus	Heavy Metals[a]
Wet Pond	$1.21	$ 785	$ 653
Infiltration Systems	2.20	1,450	528
Street Sweeping	1.15	642	270
Construction Site Erosion Control Measures	0.06	86	1,780

[a] *Lead was used as an indicator of metals.*

Source: SEWRPC.

[2] *U. S. Environmental Protection Agency, Results of the Nationwide Urban Runoff Program, Vol. 1, Final Report, December 1983.*

[3] *Wisconsin Department of Natural Resources, Executive Summary, Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, 1983.*

either because of excessive storm sewer costs needed to convey stormwater to the ponds, or because the pollutant loadings that would be removed were too low. Three of the ponds not included in the plan would have reduced pollutant loadings to the wetland in Washington County's Albecker Park which drains to Washington Creek, while the fourth pond would have reduced pollutant loadings to Silverbrook Creek.

The availability of suitable sites for water quality management measures, especially wet ponds and infiltration systems, constrains the use of the measures. For wet ponds, sites were considered suitable if they contained adequate open land area for the excavation of a pond, were on a well-defined drainage system, and drained an appropriately sized area which generates significant pollutant loadings. Wet ponds were not placed on major streams where such ponds could impede fish migration or alter the natural temperature regime of the stream. In general, there are few suitable wet pond sites within the established urban area; therefore, ponds are the most appropriate in areas of new urban development. Infiltration systems are limited to areas with adequate open land which are covered by relatively permeable Hydrologic Soil Group A or B soils, where the depth to bedrock and to the seasonally high water table is greater than five feet, and where the tributary land slopes do not exceed 5 percent. Infiltration systems are the most feasible when the contributing drainage areas are less than five acres. In commercial areas with limited open land available, infiltration trenches are usually more feasible than infiltration basins.

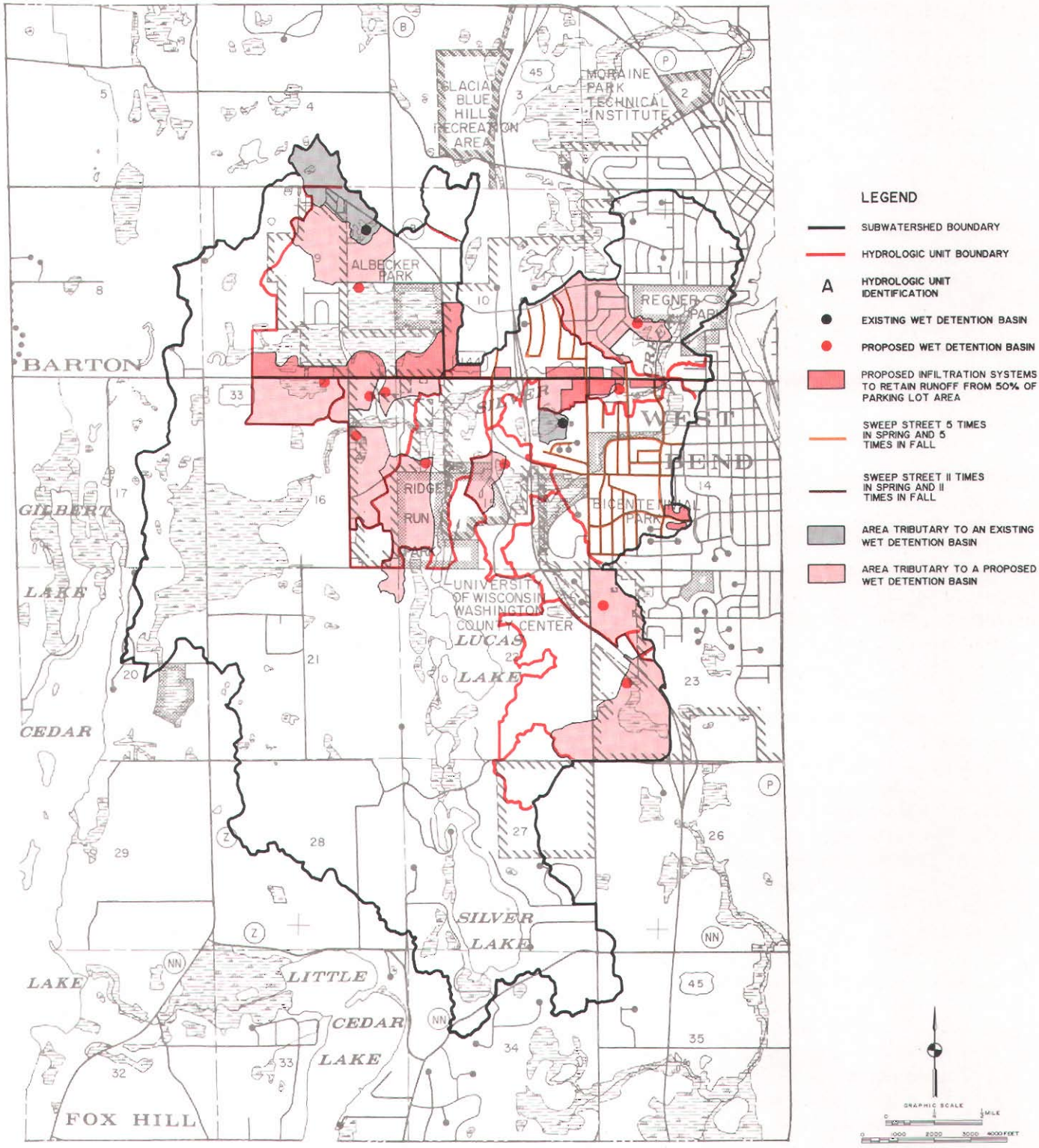
Construction site erosion control and increased street sweeping have very little impact on stormwater quantity and are therefore totally compatible with the stormwater drainage and flood control plan elements. Perhaps more than any other water quality management measure, wet ponds require careful planning and analysis with a detailed watershed hydrologic model in order to properly locate and size the ponds and to adjust outflow rates accordingly. While ponds may be used to reduce peak flow rates from larger storms with a recurrence interval of 10 years or longer and thereby reduce the required size of downstream conveyance facilities, a joint water quality-water quantity benefit seldom is possible in the Silver Creek subwatershed because most of the wet ponds are located within a relatively short distance upstream of large natural stormwater detention areas. Only two of the recommended 11 new wet ponds are intended to provide both water quality benefits and water quantity benefits during large storms. Similarly, the recommended infiltration systems would retain a very small portion of the total runoff generated during a large storm event, and the use of these systems would not affect the size of any downstream conveyance facilities. The wet detention basins and infiltration facilities can, however, be designed to control outflows from more frequent storm events with recurrence intervals of two years or shorter. Those events are important for determining the shape and size of the low-flow channel in receiving streams; therefore, control of the more frequent storm events is critical to the maintenance of a stable channel and the preservation of aquatic habitat.

Since the City of West Bend has an erosion control ordinance, it was assumed for the purpose of this systems level planning that all construction site erosion would be reduced by at least 90 percent. Wet detention ponds are recommended where suitable pond sites are available, where a significant reduction in pollutant loadings is desired, and where such ponds would be compatible with the drainage and flood control plan elements. It is recommended that the existing Regner Park fish pond be dredged to improve its pollutant-removal effectiveness and that measures be taken to allow fish to migrate freely in Silver Creek. Infiltration systems are recommended to retain a portion of the parking lot runoff and associated pollutant loadings generated from certain extensive commercial and institutional areas which do not have suitable sites for wet ponds. Finally, increased street sweeping, along with increased catch basin cleaning and improved collection of leaves and other vegetative debris, is recommended to reduce pollutant loadings from certain residential and commercial streets.

Recommended Measures: The recommended water quality management plan element for the Silver Creek subwatershed is shown in graphic summary form on Map 12. The water quality control measures selected for the plan include the construction of wet ponds and infiltration systems; the dredging of an existing pond; modifications to allow fish to migrate freely in Silver Creek and Silverbrook Creek; instream

Map 12

RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT FOR THE SILVER CREEK SUBWATERSHED



Source: SEWRPC.

habitat mitigation and stream bank stabilization measures; increased street sweeping, catch basin cleaning, and leaf collection; and construction site erosion control. In addition, it is recommended that public education programs be developed to promote the acceptance and understanding of the proposed control measures and to communicate the importance of water quality protection. On an annual basis, the combination of all recommended control measures may be expected to remove about 29 percent of the sediment, or about 161,000 pounds; 20 percent of the phosphorus, or about 248 pounds; and 42 percent of the lead, or about 362 pounds, contributed to surface waters within the Silver Creek subwatershed under plan year 2010 land use and channel conditions. The regional water quality management plan recommended that minimum, relatively low-cost, nonpoint source control measures be implemented within the Silver Creek subwatershed. It was estimated in the regional plan that these minimum control measures would result in up to a 25 percent reduction in uncontrolled loadings of most pollutants. The nonpoint source control measures recommended in this stormwater management plan are expected to provide a level of pollutant removal consistent with that proposed in the regional plan: about 29 percent for sediment, 20 percent for phosphorus, and 42 percent for lead. However, based on a review of the current state-of-the-art and the more detailed studies conducted under this planning program, it was determined that the achievement of this level of pollution control will require the implementation of more costly control measures, such as detention basins and infiltration measures, than envisioned in the regional plan. A description of the individual plan components, including their location, expected pollutant removal effectiveness, and cost, is presented in Table 15 and summarized below. A detailed cost breakdown for the recommended wet ponds is given in Table 16.

A total of 11 wet ponds, ranging in size from 0.25 acre to 1.49 acres, and in volume from 1.25 to 8.00 acre-feet, would be constructed within nine of the hydrologic units within the subwatershed. Three ponds would be located in Hydrologic Unit I, and one pond would be located in each of Hydrologic Units B, C, D, F, G, J, K, and L. All of these ponds would retain a mean permanent pool depth of about five feet. The ponds, which have tributary drainage areas ranging from 22 to 168 acres, would treat runoff from a combined total of about 860 acres, or about 27 percent of the total area of the subwatershed within the planned urban service area. On an annual basis the ponds may be expected to remove about 23 percent of the sediment, 16 percent of the phosphorus, and 27 percent of the lead contributed to surface waters within the subwatershed. It is recommended that the detailed design of wet ponds No. 1, 2, 3, 6, 7, 8, 10, and 11 provide outflow control for storms with recurrence intervals of two years or shorter.

It is also recommended that the 2.4-acre Regner Park fish pond, located in Hydrologic Unit L, be dredged to a mean depth of five feet to improve its pollutant-removal effectiveness and to enhance the aesthetic nature of the pond. This shallow pond currently retains few pollutants because resuspended sediments are flushed out. It is also recommended that the Wisconsin Department of Natural Resources, in cooperation with the City of West Bend, conduct a detailed study of methods to improve fish migration in Silver Creek, especially in the Regner Park area. Possible methods to allow fish passage include the installation of fish migration structures at the Regner Park fish pond outlet, or diversion of Silver Creek around the fish pond. If Silver Creek was diverted, the pond, once dredged, would treat runoff only from a 182-acre residential tributary area, removing about 4 percent of the sediment, 3 percent of the phosphorus, and 4 percent of the lead contributed to surface waters within the subwatershed. The recommended study should include a hydrologic analysis to determine whether the water in the pond, if isolated from the stream, would become stagnant, in which case a gated structure could be installed on Silver Creek to occasionally divert water back from the stream into the pond. It is not expected that dredging of the pond and diversion of Silver Creek would substantially change the recreational value of the pond. The pond would continue to provide a limited fishery. For the purposes of estimating the cost of this stormwater management plan, it is assumed that, subject to further study, a new channel located just south of the pond and having a length of about 1,000 feet and a bottom width of about five feet, with side slopes of about one vertical on four horizontal, would be constructed for Silver Creek.

It is recommended that instream habitat mitigation measures and stream bank stabilization measures, including the placement of boulder retards, stone riprap, and wing deflectors be developed where needed along Silver Creek and its tributaries. It is also recommended that desired communities of emergent and submergent vegetation be planted. These measures would help enhance the potential of Silver Creek and its tributary streams to support healthy populations of fish and aquatic life. Stream bank stabilization measures are specifically recommended along Silverbrook Creek in a 1,300-foot-long reach from the intersection of 18th Avenue and Chestnut Street to 16th Avenue. It is recommended that the Wisconsin Department of Natural Resources, in cooperation with the City, determine the need for, and proper design of, habitat improvement, fish passage, and stream bank stabilization measures. It is recommended that the cost of these measures, which are estimated to be $110,000, be borne by the Department.

Infiltration systems, which would likely consist mostly of infiltration trenches, are recommended to treat the stormwater runoff from about 50 percent of the commercial parking lots within Hydrologic Units F and K, and from about 50 percent of the institutional parking lots within Hydrologic Unit E. The parking lots within Hydrologic Unit E are associated with St. Joseph's Community Hospital. The commercial areas recommended for infiltration in Hydrologic Units F and K generally are located along the strip of land adjacent to STH 33. The infiltration systems would treat runoff from about 24 acres of commercial parking lots, and from about three acres of institutional parking lots. On an annual basis these systems may be expected to remove about 3 percent of the sediment, 2 percent of the phosphorus, and 6 percent of the lead contributed to surface waters within the subwatershed.

An increased street sweeping program with an intensive street sweeping effort in spring—to reduce high street surface loadings prior to the onset of heavy spring rainstorms—and in fall—to reduce high loadings of leaves and other vegetative debris—is recommended in six of the hydrologic units. Within Hydrologic Units E and K this program would include sweeping all streets an additional three times in early spring, and three times in fall. Within Hydrologic Units F, G, I, J, and K, all commercial streets would be swept an additional nine times in early spring and nine times in fall. Increased street sweeping would be conducted on a total of 13.7 curb-miles of street. On an annual basis, this increased street sweeping program may be expected to remove about 3 percent of the sediment, 2 percent of the phosphorus, and 9 percent of the lead contributed to surface waters within the subwatershed.

The City of West Bend currently has a construction site erosion control ordinance which defines land disturbance activities subject to control, sets forth standards and criteria for erosion control, describes permit application and administrative procedures, and identifies enforcement and appeal procedures. Under the ordinance, land disturbance activities covering an area of 2,000 square feet or greater require an erosion control plan to ensure that erosion and sedimentation during and after the land disturbance will not exceed that which would have eroded if the land had been left in its natural state, or if the land was properly treated with erosion control measures. For the purposes of this report, it is assumed that the erosion control measures required under the ordinance for construction activity would achieve at least a 90 percent reduction in the total uncontrolled pollutant loadings from the construction sites.

Auxiliary Plan Recommendations

The foregoing recommendations primarily address stormwater drainage system improvements, flood control, and water quality management measures. To provide a comprehensive stormwater management plan, however, these recommendations must be supplemented by plan elements relating to natural resource and open space protection, and by the continued proper maintenance of the stormwater drainage system.

Natural Resource and Open Space Preservation:

A land use plan should be prepared and adopted by the City that provides for the preservation of all of the primary environmental corridor lands within the City and environs, including associated floodlands and wetlands, in essentially natural, open uses. The protection of floodlands and wetlands from intrusion by urban land uses has important implications for stormwater management since these lands can provide needed capacity for the storage, infiltration, and transport of stormwater runoff. As presented in

Table 15

DESCRIPTION, POLLUTANT REMOVAL EFFECTIVENESS, AND COST OF THE WATER QUALITY MANAGEMENT PLAN ELEMENT

Hydrologic Unit	Plan Component Description	Estimated Reduction in Uncontrolled Future Pollutant Loadings (percent)									Estimated Cost	
		Hydrologic Unit			Urban Service Area			Silver Creek Subwatershed				
		Sediment	Phosphorus	Lead[a]	Sediment	Phosphorus	Lead[a]	Sediment	Phosphorus	Lead[a]	Capital	Annual Operation and Maintenance
A	None	--	--	--	--	--	--	--	--	--	$ --	$ --
B	Pond No. 1: 1.49-acre wet pond north of Paradise Drive between USH 45 and 18th Avenue	8.4	30.6	27.5	1.0	3.7	3.8	0.8	3.1	3.8	$ 146,400	$ 4,800
C	Pond No. 2: 0.60-acre wet pond at intersection of Julen Circle and 18th Avenue	2.1	20.6	26.2	0.1	1.3	1.2	0.1	1.1	1.2	$ --[b]	$ --[b]
D	Pond No. 3: 0.25-acre wet pond between University Drive and USH 45 south of Chestnut Street at outlet from subbasin SC91	3.4	13.9	15.2	0.1	0.5	0.4	0.1	0.4	0.4	$ 58,300	$ 2,200
E	Infiltration systems to retain stormwater runoff from 50 percent of the institutional parking lot	1.2	0.9	2.2	0.1	0.1	0.2	0.1	0.1	0.2	$ 21,100	$ 1,100
	Increased Street Sweeping: Sweep all streets an additional three times in spring and three times in fall[b]	5.7	5.2	9.2	0.5	0.6	1.2	0.5	0.5	1.2	--	4,500
	Subtotal	6.9	6.1	11.4	0.6	0.7	1.4	0.6	0.6	1.4	$ 21,100	$ 5,600
F	Pond No. 4: 1.41-acre wet pond east of Villa Park Drive extended at outlet of proposed 54-inch-diameter storm sewer	17.8	11.5	9.5	5.5	3.4	2.4	4.8	2.8	2.4	$ 148,500	$ 4,900
	Infiltration systems to retain stormwater runoff from 50 percent of the commercial parking lots	5.8	4.3	16.2	1.8	1.3	4.1	1.6	1.1	4.1	138,000	6,900
	Increased Street Sweeping: Sweep all commercial streets an additional nine times in spring and nine times in fall[c]	4.2	3.1	12.4	1.3	0.9	3.2	1.2	0.8	3.2	--	4,900
	Subtotal	27.8	18.9	38.1	8.6	5.6	9.7	7.6	4.7	9.7	$ 286,500	$16,700
G	Pond No. 5: 1.14-acre wet pond at stream outlet at STH 33	85.3	51.8	71.7	6.4	3.3	4.5	5.6	2.8	4.5	$ 180,900	$ 4,200
	Increased Street Sweeping: Sweep all commercial streets an additional nine times in spring and nine times in fall[c]	4.7	4.0	13.3	0.4	0.3	0.9	0.3	0.2	0.9	--	1,400
	Subtotal	90.0	55.8	85.0	6.8	3.6	5.4	5.9	3.0	5.4	$ 180,900	$ 5,600
H	None	--	--	--	--	--	--	--	--	--	$ --	$ --
I	Pond No. 6: 0.44-acre wet pond east of Washington Creek, south of STH 33	28.8	13.6	32.0	2.3	1.0	3.1	2.0	0.9	3.1	$ 145,300	$ 2,600
	Pond No. 7: 0.61-acre wet pond east of Scenic Drive and south of propsoed Valley Drive	26.7	21.4	21.0	2.1	1.6	2.0	1.8	1.4	2.0	98,000	2,900
	Pond No. 8: 0.32-acre wet pond west of Washington Creek, south of STH 33	19.6	9.8	21.5	1.5	0.7	2.1	1.4	0.6	2.1	147,400	2,500
	Increased Street Sweeping: Sweep all commercial streets an additional nine times in spring and nine times in fall[c]	5.4	4.1	10.5	0.5	0.3	1.1	0.4	0.3	1.1	--	1,400
	Subtotal	80.5	48.9	85.0	7.4	3.6	8.3	5.6	3.2	8.3	$ 390,700	$ 9,400

Table 15 (continued)

Hydrologic Unit	Plan Component Description	Estimated Reduction in Uncontrolled Future Pollutant Loadings (percent)									Estimated Cost	
		Hydrologic Unit			Urban Service Area			Silver Creek Subwatershed			Capital	Annual Operation and Maintenance
		Sediment	Phosphorus	Lead[a]	Sediment	Phosphorus	Lead[a]	Sediment	Phosphorus	Lead[a]		
J	Pond No. 9: 0.74-acre wet pond north of Ridge Run Park	28.6	3.6	38.4	1.9	0.3	2.3	1.7	0.2	2.3	$ 93,200	$ 3,200
	Increased Street Sweeping: Sweep all commercial streets an additional nine times in spring and nine times in fall[c]	2.2	1.4	5.0	0.1	0.1	0.4	0.1	0.1	0.4	--	900
	Subtotal	30.8	5.0	43.4	2.0	0.4	2.7	1.8	0.3	2.7	$ 93,200	$ 4,100
K	Pond No. 10: 0.50-acre wet pond south of Washington Street and west of 15th Avenue	21.3	20.3	13.8	2.0	1.0	2.1	1.8	0.8	2.1	$ 70,200	$ 2,600
	Infiltration systems to retain the stormwater runoff from 50 percent of the commercial parking lot area	8.6	12.1	11.2	0.9	0.6	1.7	0.8	0.5	1.7	62,800	3,100
	Increased Street Sweeping: Sweep all commercial streets an additional nine times in spring and nine times in fall[c]; sweep remainder of streets an additional three times in spring and three times in fall[b]	9.9	16.7	13.1	1.1	0.8	2.0	0.8	0.7	2.0	--	7,500
	Subtotal	39.8	49.1	38.1	4.0	2.4	5.8	3.4	2.0	5.8	$ 133,000	$13,200
L	Pond No. 11: 1.09-acre wet pond along Wood Way in Regner Park	40.3	20.8	52.6	3.3	2.1	3.6	2.9	1.8	3.6	$ --[d]	$ --[d]
	Measures to permit migration of fish from the Milwaukee River to Silver Creek	--	--	--	--	--	--	--	--	--	150,000	400
	Subtotal	40.3	20.8	52.6	3.3	2.1	3.6	2.9	1.8	3.6	$ 150,000	$ 400
	Total	--	--	--	32.9	23.9	42.3	28.8	20.2	42.3	$1,460,100	$62,000

[a] *Lead used as an indicator.*

[b] *This recommendation would increase the total number of street sweeping operations from two in spring and two in fall to five in spring and five in fall.*

[c] *This recommendation would increase the total number of street sweeping operations from two in spring and two in fall to 11 in spring and 11 in fall.*

[d] *Dual-purpose pond for reduction of both flood flows and pollutant loadings. Cost is listed in Table 10, which gives costs of the stormwater drainage plan element.*

Source: SEWRPC.

Chapter II of Volume One, the probable future land use pattern used in the plan design and evaluation process envisions the preservation of all designated primary environmental corridors in that portion of the Silver Creek subwatershed within the planned urban service area.

Floodplain Map Revisions: It is recommended that the City amend its floodplain zoning ordinance and request revision of the Federal Emergency Management Agency Flood Hazard Boundary Maps by the Federal Insurance Administration in two steps.

1. Immediately upon adoption of this system plan, the City should amend those portions of its floodplain zoning ordinance pertaining to Silver Creek, Silverbrook Creek, and Washington Creek to reflect the 100-year recurrence interval water surface profiles set forth in this plan for the existing channel and drainage system under future land use conditions. At that time, the City should also submit its proposed floodplain revisions to the Wisconsin Department of Natural Resources requesting revision of the Flood Hazard Boundary Maps by the Federal Insurance Administration.

Table 16

COMPONENTS AND COST OF THE RECOMMENDED WET PONDS FOR THE SILVER CREEK SUBWATERSHED

Hydrologic Unit	Project and Component Description	Capital	Annual Operation and Maintenance
B	Southern Portion of Silverbrook Creek Subbasin		
	1. Construction of 1.49-acre wet pond with a dead storage volume of 7.45 acre-feet between USH 45 and 18th Avenue (Pond No. 1)	$ 100,000	$ 4,800
	2. Land acquisition	8,400	--
	3. Engineering, administration, and contingencies	38,000	--
	Subtotal	$ 146,400	$ 4,800
C	Central Portion of Silverbrook Creek Subbasin		
	1. Construction of 0.60-acre wet pond with a total wet and surcharge storage volume of 5.8 acre-feet at intersection of Julen Circle and 18th Avenue (Pond No. 2)	$ --[a]	$ --[a]
	Subtotal	$ --	$ --
D	Western Portion of Silver Creek Subbasin		
	1. Construction of 0.25-acre wet pond with a wet storage volume of 1.25 acre-feet between University Drive and USH 45 south of Chestnut Street at outlet from subbasin SC 91 (Pond No. 3)	$ 43,200	$ 2,200
	2. Engineer, administration, and contingencies	15,100	--
	Subtotal	$ 58,300	$ 2,200
F	Northern Portion of Washington Creek Subbasin		
	1. Construction of 1.41-acre wet pond with a wet storage volume of 7.05 acre-feet east of Villa Park Drive extended at outlet of proposed 54-inch-diameter storm sewer (Pond No. 4)	$ 96,000	$ 4,800
	2. Land acquisition	11,000	--
	3. 324-foot connecting channel	38,500	--
	Subtotal	$ 148,500	$ 4,900
G	Western Portion of Washington Creek Subbasin		
	1. Construction of 1.14-acre wet pond with a wet storage volume of 5.70 acre-feet at stream outlet at STH 33 (Pond No. 5)	$ 84,000	$ 4,200
	2. Land acquisition	50,000	--
	3. Engineering, administration, and contingencies	46,900	--
	Subtotal	$ 180,900	$ 4,200

Table 16 (continued)

Hydrologic Unit	Project and Component Description	Capital	Annual Operation and Maintenance
I	Southern Portion of Washington Creek Subbasin		
	1. Construction of 0.44-acre wet pond with a wet storage volume of 2.20 acre-feet east of Washington Creek, south of STH 33 (Pond No. 6)	$ 49,600	$ 2,500
	2. Construction of 0.61-acre wet pond with a wet storage volume of 3.05 acre-feet east of Scenic Drive and south of proposed Valley Drive (Pond No. 7)	57,600	2,900
	3. Construction of 0.32-acre wet pond with a wet storage volume of 1.60 acre-feet west of Washington Creek, south of STH 33 (Pond No. 8)	43,200	2,200
	4. Land acquisition	48,000	--
	5. 370 feet of 42-inch storm sewer	39,000	100
	6. 500 feet of 24-inch storm sewer	28,000	200
	7. 340 feet of 30-inch storm sewer	24,000	100
	8. Engineering, administration, and contingencies	101,300	--
	Subtotal	$ 390,700	$ 8,000
J	Southern Portion of Silver Creek Subbasin		
	1. Construction of 0.74-acre wet pond with a wet storage volume of 3.70 acre-feet north of Ridge Run Park (Pond No. 9)	$ 64,000	$ 3,200
	2. Land acquisition	5,000	--
	3. Engineering, administration, and contingencies	24,200	--
	Subtotal	$ 93,200	$ 3,200
K	Central Portion of Silver Creek Subwatershed		
	1. Construction of 0.50-acre wet pond with a wet storage volume of 2.5 acre-feet (Pond No. 10)	$ 52,000	$ 2,600
	2. Land acquisition	--	--
	3. Engineering, administration, and contingencies	18,200	--
	Subtotal	$ 70,200	$ 2,600
	Eastern Portion of Silver Creek Subwatershed-Regner Park Environs		
	1. Construction of 1.09-acre wet pond with a total wet and surcharge storage volume of 8.0 acre-feet along Wood Way in Regner Park (Pond No. 11)	$ --[a]	$ --[a]
	Subtotal	$ --	$ --
	Total	$1,088,200	$29,900

[a]*Dual-purpose pond for reduction of both flood flows and pollutant loadings. Cost is listed in Table 10, which gives costs of the stormwater drainage plan element.*

Source: SEWRPC.

2. As the drainage and flood control improvements herein recommended are constructed and become operational, the City should again amend its floodplain zoning ordinance accordingly and request revision of the Flood Hazard Boundary Maps. Numerous citizens whose homes can be removed from the floodplain would thereby benefit from decreased insurance costs.

Maintenance of Stormwater Management Facilities: The effectiveness of the stormwater conveyance and detention facilities, once developed, can be sustained only if proper operation, repair, and maintenance procedures are carefully followed. The City has a program of annual catch basin cleaning, outfall cleaning, inspection by television camera, storm sewer pipe cleaning, street sweeping four times a year, and leaf collection twice a year. Important additional maintenance activities include the periodic repair of storm sewers, clearing of sewer obstructions, maintenance of open channel vegetative lining, clearing of debris and sediment from open channels, maintenance of detention facility inlets and outlets, maintenance of detention basin vegetative cover, periodic removal of sediment accumulated in detention basins, and sweeping of parking lots used as detention facilities. These maintenance activities are recommended to be carried out on a continuing basis to maximize the effectiveness of the stormwater management facilities and measures, and to protect the capital investment in the facilities. Cost estimates of the recommended maintenance activities are included in the total plan costs.

Stormwater Management System Costs

The capital and operation and maintenance costs of the recommended stormwater management system plan are presented in Table 17. The capital cost of the recommended plan is estimated to be $8.09 million. The annual operation and maintenance cost increase of the recommended plan is estimated to be $95,800, or $20,900 per square mile for the 4.59-square-mile portion of the Silver Creek subwatershed within the planned urban service area. The current annual cost of operation and maintenance of the stormwater management system for the 9.7-square-mile area within the corporate limits of the City is approximately $128,000, or $13,200 per square mile. Of the total capital cost of the recommended plan, about $5.93 million, or 73 percent, is for the stormwater drainage plan element; about $0.55 million, or 7 percent, is for the flood control plan element; and the remaining $1.61 million, or 20 percent, is for the water quality management plan element. Of the total annual operation and maintenance cost, about $27,200, or 28 percent, is for the stormwater drainage plan element; $600, or 1 percent, is for the flood control plan element; and about $68,000, or 71 percent, is for the water quality management plan element.

These costs are based upon full development of the portion of the urban service area within the Silver Creek subwatershed and do not include the cost of minimum-diameter collector sewers, roadside swale collectors, and road culverts that may be required to drain collector and land access roadways, the alignment of which has not as yet been determined, or the cost of roadway sections in newly developing areas that have been designated to function as a component of the major drainage system. The cost of minimum size collectors would be approximately $3,000 per acre of area served.

Schedule of Public Sector and Private Sector Costs

In general, the capital costs of each stormwater management component were assumed to be borne by the public sector if the components were designed to serve public property, or if the general public—not just the owners of new development—would benefit from the component. Capital costs were assumed to be borne by the private sector if the primary benefit of the component would accrue to new development. Public sector and private sector expenditures are listed in Table 18. The following criteria were applied to allocate capital costs to the public sector and private sector:

1. Upgrading of existing drainage system components intended to resolve existing stormwater problems for more than an isolated area, and components designed to serve public property, were assumed to be funded by the public sector.

2. Components, or portions of components, designed to serve specific, new, private urban development, or to solve an isolated problem related to existing private urban development, were assumed to be funded by the private sector.

Table 17

COSTS OF THE RECOMMENDED WEST BEND STORMWATER MANAGEMENT PLAN FOR THE SILVER CREEK SUBWATERSHED

Plan Element	Capital	Annual Operation and Maintenance	Present Value[a]
1. Major and Minor Stormwater Drainage System	$5,929,000[b]	$27,200[b]	$6,358,000
2. Flood Control Measures	547,000	600	556,000
3. Water Quality Management Measures	1,610,000[c]	68,000[d]	2,682,000
Total	$8,086,000	$95,800	$9,596,000

[a]*Present value computations assume a 50-year life and 6 percent annual interest.*

[b]*Includes dual-purpose detention basins Nos. 2 and 11.*

[c]*Includes $110,000 for stream bank stabilization and instream habitat mitigation measures. Excludes dual-purpose detention basins Nos. 2 and 11. Includes $40,000 for dredging the Regner Park fish pond.*

[d]*Includes $500 for maintenance of stream bank stabilization and instream habitat mitigation measures. Includes $5,500 for periodic dredging of the Regner Park fish pond.*

Source: SEWRPC.

3. Components intended to serve specific, new, private urban development which must be oversized to provide capacity for additional planned future or existing upstream urban development were assumed to be funded by both the public sector and the private sector. The private sector was assumed to finance the costs of serving the specific new urban development; the public sector was assumed to finance the costs of the oversizing required to service the additional upstream urban development.

4. The capital costs of the recommended infiltration systems, wet detention basins, street sweeping, and the diversion of Silver Creek were assigned to the public sector. The current policy of the Wisconsin Department of Natural Resources regarding the provision of funding for nonpoint source pollution control measures undertaken by local units of government provides for state funding of up to 70 percent of the capital cost, including engineering, of wet detention basins and infiltration systems in areas of existing urban development. Under current policy, state cost-share funds are not available for the construction of nonpoint source control measures in areas of new development, for operation and maintenance costs of any nonpoint source control measures, or for acquisition of the land required for construction of nonpoint source control measures. Although present Department policy does not provide cost sharing for these items, such cost sharing is not prohibited by Chapter NR 120 of the Wisconsin Administrative Code, which details the administrative procedures of the state nonpoint source water pollution abatement program. Chapter NR 120, however, expressly forbids provision of state cost-sharing funds for construction site erosion control. State cost-sharing funds may be

Table 18

RECOMMENDED ASSIGNMENT OF PUBLIC SECTOR AND PRIVATE SECTOR COSTS FOR SYSTEM COMPONENTS OF THE RECOMMENDED SILVER CREEK STORMWATER MANAGEMENT PLAN

Hydrologic Unit Designation	Component Designation	Public Sector		Private Sector		Total	
		Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
I. Stormwater Drainage Plan Element (refer to Table 10)							
A	1	$ --	$ 800	$ 21,000	$--	$ 21,000	$ 800
A	2	--	100	4,000	--	4,000	100
A	3	4,000	0	--	--	4,000	0
A	4	--	400	10,000	--	10,000	400
A	5	--	100	3,000	--	3,000	100
A	6	--	400	--	--	--	400
A	7	--	600	52,000	--	52,000	600
A	E,A & C	1,000	0	32,000	--	33,000	0
B	1	--	700	17,000	--	17,000	700
B	2	--	300	30,000	--	30,000	300
B	3	--	100	9,000	--	9,000	100
B	4	--	400	61,000	--	61,000	400
B	5	39,000	600	55,000	--	94,000	600
B	6	--	200	32,000	--	32,000	200
B	7	--	100	42,000	--	42,000	100
B	8	--	100	41,000	--	41,000	100
B	9	--	100	20,000	--	20,000	100
B	10	--	100	25,000	--	25,000	100
B	11	50,000	100	--	--	50,000	100
B	12	105,000	200	--	--	105,000	200
B	13	--	200	5,000	--	5,000	200
B	14	--	200	5,000	--	5,000	200
B	15	--	100	2,000	--	2,000	100
B	16	--	300	3,000	--	3,000	300
B	17	--	300	20,000	--	20,000	300
B	E,A & C	68,000	0	128,000	--	196,000	0
C	1	--	500	39,000	--	39,000	500
C	2	--	100	7,000	--	7,000	100
C	3	--	100	12,000	--	12,000	100
C	4	--	100	17,000	--	17,000	100
C	5	--	100	4,000	--	4,000	100
C	6	52,000[a]	3,900	33,000	--	85,000	3,900
C	7	12,000[a]	0	15,000	--	27,000	0
C	E,A & C	22,000	0	45,000	--	67,000	0
D	1	28,000	0	--	--	28,000	0
D	E,A & C	10,000	0	--	--	10,000	0
E	1	15,000	0	--	--	15,000	0
E	2	21,000	0	--	--	21,000	0
E	3	10,000	0	--	--	15,000	0
E	4	15,000	0	--	--	15,000	0
E	5	5,000	0	--	--	5,000	0
E	6	19,000	0	--	--	19,000	0
E	7	2,000	0	--	--	2,000	0
E	8	12,000	0	--	--	12,000	0
E	9	10,000	0	--	--	10,000	0
E	10	43,000	0	--	--	43,000	0
E	11	20,000	0	--	--	20,000	0
E	12	24,000	0	--	--	24,000	0
E	13	35,000	100	--	--	35,000	100
E	14	27,000	100	--	--	27,000	100
E	15	--	100	1,000	--	1,000	100
E	16	--	400	5,000	--	5,000	400
E	17	10,000	700	0	--	10,000	700
E	18	3,000	0	--	--	3,000	0
E	E,A & C	94,000	0	3,000	--	97,000	0

Table 18 (continued)

Hydrologic Unit Designation	Component Designation	Public Sector		Private Sector		Total	
		Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
I. Stormwater Drainage Plan Element (continued)							
F	1	$ --	$ 100	$ 12,000	$--	$ 12,000	$ 100
F	2	--	100	16,000	--	16,000	100
F	3	--	100	9,000	--	9,000	100
F	4	--	100	3,000	--	3,000	100
F	5	--	0	3,000	--	3,000	0
F	6	--	200	13,000	--	13,000	200
F	7	--	100	11,000	--	11,000	100
F	8	--	200	27,000	--	27,000	200
F	9	--	400	59,000	--	59,000	400
F	10	--	400	60,000	--	60,000	400
F	11	--	500	81,000	--	81,000	500
F	12	--	100	57,000	--	57,000	100
F	13	--	0	2,000	--	2,000	0
F	14	--	200	112,000	--	112,000	200
F	15	--	0	3,000	--	3,000	0
F	16	--	300	2,000	--	2,000	300
F	17	--	200	12,000	--	12,000	200
F	18	--	500	13,000	--	13,000	500
F	E,A & C	--	0	173,000	--	173,000	0
G	1	--	100	5,000	--	5,000	100
G	2	20,000	200	16,000	--	36,000	200
G	3	20,000	100	--	--	20,000	100
G	4	--	200	157,000	--	157,000	200
G	5	--	100	87,000	--	87,000	100
G	6	65,000	400	--	--	65,000	400
G	7	32,000	100	--	--	32,000	100
G	E,A & C	48,000	0	93,000	--	141,000	0
I	1	--	300	26,000	--	26,000	300
I	2	--	200	14,000	--	14,000	200
I	3	--	300	35,000	--	35,000	300
I	4	--	400	45,000	--	45,000	400
I	5	--	1,100	150,000	--	150,000	1,100
I	6	--	400	57,000	--	57,000	400
I	7	--	400	79,000	--	79,000	400
I	8	--	100	64,000	--	64,000	100
I	9	--	200	35,000	--	35,000	200
I	10	--	100	15,000	--	15,000	100
I	E,A & C	--	0	182,000	--	182,000	0
J	1	--	100	12,000	--	12,000	100
J	2	--	100	12,000	--	12,000	100
J	3	--	100	6,000	--	6,000	100
J	E,A & C	--	0	11,000	--	11,000	0
K	1	12,000	0	--	--	12,000	0
K	2	17,000	0	--	--	17,000	0
K	3	6,000	0	--	--	6,000	0
K	4	--	0	12,000	--	12,000	0
K	5	--	0	22,000	--	22,000	0
K	6	40,000	0	--	--	40,000	0
K	7	24,000	100	--	--	24,000	100
K	8	73,000	0	--	--	73,000	0
K	9	5,000	0	--	--	5,000	0
K	10	4,000	0	--	--	4,000	0
K	11	17,000	0	--	--	17,000	0
K	12	22,000	0	--	--	22,000	0
K	13	--	100	5,000	--	5,000	100
K	E,A & C	77,000	0	14,000	--	91,000	0

Table 18 (continued)

Hydrologic Unit Designation	Component Designation	Public Sector		Private Sector		Total	
		Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
I. Stormwater Drainage Plan Element (continued)							
L	1	$ 46,000	$ 0	$ --	$--	$ 46,000	$ 0
L	2	64,000	0	--	--	64,000	0
L	3	80,000	0	--	--	80,000	0
L	4	71,000	0	--	--	71,000	0
L	5	25,000	0	--	--	25,000	0
L	6	173,000	0	--	--	173,000	0
L	7	60,000	0	--	--	60,000	0
L	8	21,000	0	--	--	21,000	0
L	9	2,000	0	--	--	2,000	0
L	10	19,000	0	--	--	19,000	0
L	11	22,000	0	--	--	22,000	0
L	12	20,000	0	--	--	20,000	0
L	13	7,000	0	--	--	7,000	0
L	14	28,000	0	--	--	28,000	0
L	15	63,000	0	--	--	63,000	0
L	16	18,000	0	--	--	18,000	0
L	17	25,000	0	--	--	25,000	0
L	18	34,000	0	--	--	34,000	0
L	19	15,000	0	--	--	15,000	0
L	20	26,000	0	--	--	26,000	0
L	21	19,000	200	--	--	19,000	200
L	22	54,000	-100	--	--	54,000	-100
L	23	30,000	-100	--	--	30,000	-100
L	24	176,000	100	--	--	176,000	100
L	25	20,000	0	--	--	20,000	0
L	26	66,000	0	--	--	66,000	0
L	27	73,000	0	--	--	73,000	0
L	28	63,000	0	--	--	63,000	0
L	29	37,000	0	--	--	37,000	0
L	30	--	100	18,000	--	18,000	100
L	31	19,000	0	--	--	19,000	0
L	32	140,000[a]	5,600	--	--	140,000	5,600
L	E,A & C	530,000	0	7,000	--	537,000	0
Subtotal	--	$3,284,000	$27,200	$2,645,000	$--	$5,929,000	$27,200
II. Flood Control Plan Element (refer to Table 11)							
E	1	$ 68,000	$ 100	$ --	$--	$ 68,000	$ 100
E	2	48,000	100	--	--	48,000	100
E	3	10,000	0	--	--	10,000	0
E	E,A & C	44,000	0	--	--	44,000	0
K	1	203,000	0	--	--	203,000	0
K	2	15,000	200	--	--	15,000	200
K	3	26,000	0	--	--	26,000	0
K	4	20,000	200	--	--	20,000	200
K	5	--	0	15,000	--	15,000	--
K	E,A & C	92,000	0	6,000	--	98,000	0
Subtotal	--	$ 526,000	$ 600	$ 21,000	$--	$ 547,000	$ 600
III. Water Quality Management Plan Element (refer to Table 15)[a]							
B	Pond No. 1	$ 146,400	$ 4,800	$ --	$--	$ 146,400	$ 4,800
C	Pond No. 2	--[b]	--[b]	--	--	--[b]	--[b]
D	Pond No. 3	58,300	2,200	--	--	58,300	2,200
E	Infiltration	21,100	1,100	--	--	21,100	1,100
E	Sweeping	--	4,500	--	--	--	4,500

Table 18 (continued)

Hydrologic Unit Designation	Component Designation	Public Sector		Private Sector		Total	
		Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance	Capital	Annual Operation and Maintenance
III. Water Quality Management Plan Element (continued)							
F	Pond No. 4	$ 148,500	$ 4,900	$ --	$--	$ 148,500	$ 4,900
F	Infiltration	138,000	6,900	--	--	138,000	6,900
F	Sweeping	--	4,900	--	--	--	4,900
G	Pond No. 5	180,900	4,200	--	--	180,900	4,200
G	Sweeping	--	1,400	--	--	--	1,400
I	Pond No. 6	145,300	2,600	--	--	145,300	2,600
I	Pond No. 7	98,000	2,900	--	--	98,000	2,900
I	Pond No. 8	147,400	2,500	--	--	147,400	2,500
I	Sweeping	--	1,400	--	--	--	1,400
J	Pond No. 9	93,200	3,200	--	--	93,200	3,200
J	Sweeping	--	900	--	--	--	900
K	Infiltration	62,800	3,100	--	--	62,800	3,100
K	Sweeping	--	7,500	--	--	--	7,500
K	Pond No. 10	70,200	2,600	--	--	70,200	2,600
L	Pond No. 11	--[b]	--[b]	--	--	--[b]	--[b]
L	Migration Measures	150,000	400	--	--	150,000	400
	Dredging	40,000	5,500	--	--	40,000	5,500
	Stream bank Stabilization and Instream Habitat Mitigation Measures	$ 110,000	$ 500	$ --	$--	$ 110,000	$ 500
Subtotal	--	$1,610,100	$68,000	$ --	$--	$1,610,100	$68,800
Total	--	$5,420,100	$95,800	$2,666,000	$--	$8,086,100	$95,800

[a]*See Table 19 for recommended city/state cost apportionment.*

[b]*Dual-purpose pond for reduction of both flood flows and pollutant loadings. Cost is included in the stormwater drainage plan element.*

Source: SEWRPC.

provided for accelerated street sweeping above the current levels practiced by the City. The funds would cover the costs of accelerated sweeping for a two-year period, after which the City would be required to maintain the accelerated sweeping schedule for 10 years. If the City obtained state cost-sharing funds for the first two years of the recommended accelerated street sweeping program, it would realize an estimated annual operation and maintenance savings of $22,800, or a total savings of about $45,000 over the two-year period. This system plan recommends that the Department institute a policy of providing up to 70 percent cost sharing for construction of nonpoint source water pollution control measures in areas of new development and for the acquisition of the land required for implementation of nonpoint source pollution control measures in areas of existing and new development. Accordingly, the public costs for recommended wet detention basins and infiltration systems were apportioned between the State of Wisconsin and the City of West Bend assuming 70 percent cost sharing by the State. Recommended allocations of costs between the City, the State, and the private sector are given in Tables 19 and 20. Tables 21 and 22 provide possible allocations of costs between the City, the State, and the private sector based on current state cost-sharing policy. If the

Table 19

RECOMMENDED ASSIGNMENT OF CITY AND STATE CAPITAL COSTS FOR THE RECOMMENDED SILVER CREEK STORMWATER MANAGEMENT PLAN[a]

Hydrologic Unit	Plan Component Description	City of West Bend Capital Cost	State of Wisconsin Capital Cost
B	Pond No. 1	$ 43,900	$ 102,500
C	Pond No. 2	25,900	60,500
D	Pond No. 3	17,500	40,800
E	Infiltration	6,300	14,800
F	Pond No. 4	44,500	104,000
F	Infiltration	41,400	96,600
G	Pond No. 5	54,300	126,600
I	Pond No. 6	43,600	101,700
I	Pond No. 7	29,400	68,600
I	Pond No. 8	44,200	103,200
J	Pond No. 9	28,000	65,200
K	Infiltration	18,800	44,000
K	Pond No. 10	21,100	49,100
L	Pond No. 11	56,700	132,300
L	Fish migration measures near mouth of Silver Creek	45,000	105,000
L	Dredging Regner Park fish pond	12,000	28,000
--	Instream habitat mitigation measures	--	110,000
Total	--	$532,600	$1,352,900

[a]*Cost assignment assumes 70 percent of the capital cost of each component is funded by the State of Wisconsin, except for instream habitat mitigation measures which are all assigned to the State.*

Source: SEWRPC.

Table 20

RECOMMENDED APPORTIONMENT OF TOTAL CITY OF WEST BEND, STATE OF WISCONSIN, AND PRIVATE SECTOR COSTS FOR THE RECOMMENDED SILVER CREEK STORMWATER MANAGEMENT PLAN

	City of West Bend			State of Wisconsin			Private Sector		
Plan Element	Capital	Annual Operation and Maintenance	Present Value[a]	Capital	Annual Operation and Maintenance	Present Value[a]	Capital	Annual Operation and Maintenance	Present Value[a]
1. Major and Minor Stormwater Drainage System	$3,008,000[b]	$17,700[b]	$3,287,000	$ --	$--	$ --	$2,645,000	$--	$2,645,000
2. Flood Control Measures	526,000	600	535,000	--	--	--	21,000	--	21,000
3. Water Quality Management Measures	533,000[c]	77,500[c]	1,755,000	1,353,000	--	$1,353,000	--	--	--
Total	$4,067,000	$95,800	$5,577,000	$1,353,000	$--	$1,353,000	$2,666,000	$--	$2,666,000

[a]*Present value computations assume a 50-year life and 6 percent annual interest.*

[b]*Excludes dual-purpose Pond Nos. 2 and 11.*

[c]*Includes dual-purpose Pond Nos. 2 and 11 and periodic dredging of the Regner Park fish pond.*

Source: SEWRPC.

Table 21

ASSIGNMENT OF CITY AND STATE CAPITAL COSTS FOR THE RECOMMENDED SILVER CREEK STORMWATER MANAGEMENT PLAN BASED ON CURRENT STATE COST-SHARING POLICY[a]

Hydrologic Unit	Plan Component Description	City of West Bend Capital Cost	State of Wisconsin Capital Cost
B	Pond No. 1	$ 146,400	$ 0
C	Pond No. 2	86,400	0
D	Pond No. 3	17,500	40,800
E	Infiltration	6,300	14,800
F	Pond No. 4	148,500	0
F	Infiltration	41,400	96,600
G	Pond No. 5	180,900	0
I	Pond No. 6	145,300	0
I	Pond No. 7	98,000	0
I	Pond No. 8	147,400	0
J	Pond No. 9	32,700[b]	60,500[b]
K	Infiltration	18,800	44,000
K	Pond No. 10	21,100	49,100
L	Pond No. 11	56,700	132,300
L	Fish migration measures near mouth of Silver Creek	45,000	105,000
L	Dredging of Regner Park fish pond	12,000	28,000
--	Stream bank stabilization and instream habitat mitigation measures	33,000	77,000
Total	--	$1,237,400	$648,100

[a]Cost assignment assumes 70 percent of the capital cost of each eligible component is funded by the State of Wisconsin. No land acquisition costs are assigned to the State. It should be noted that the plan recommendations include provisions for additional state cost-share funding, representing a departure from current policies which was deemed necessary to achieve the pollutant reduction goals in a cost-effective manner.

[b]Differs from comparable item in Table 19 because land acquisition cost is subtracted from the state cost.

Source: SEWRPC.

recommendation of this plan for expanded cost sharing is not adopted by the State, the cost apportionment given in Tables 21 and 22 approximates the potential level of state funding.

5. All channel modifications and culvert replacements for flood control purposes were assumed to be funded by the public sector.

6. All floodproofing measures were assumed to be funded by the private sector.

In addition to cost-sharing funds provided by the Wisconsin Department of Natural Resources, it is also possible that the cost of certain recommended components of the stormwater drainage or flood control systems may be shared between the City and the Wisconsin Department of Transportation as a part of future highway construction or reconstruction projects. Because the division of costs for such measures is presently unknown, this plan assigns all such costs to the City.

All operation and maintenance costs were assumed to be financed by the public sector regardless of whether public sector or private sector funds were used to construct the facilities. It may be desirable for the operation and maintenance costs of some stormwater drainage and nonpoint source pollution control measures

Table 22

POSSIBLE APPORTIONMENT OF TOTAL CITY OF WEST BEND, STATE OF WISCONSIN, AND PRIVATE SECTOR COSTS FOR THE SILVER CREEK STORMWATER MANAGEMENT PLAN BASED ON CURRENT STATE COST-SHARING POLICY

Plan Element	City of West Bend			State of Wisconsin[a]			Private Sector		
	Capital	Annual Operation and Maintenance	Present Value[b]	Capital	Annual Operation and Maintenance	Present Value[b]	Capital	Annual Operation and Maintenance	Present Value[b]
1. Major and Minor Stormwater Drainage System	$3,008,000[c]	$17,700[c]	$3,287,000	$ --	$--	$ --	$2,645,000	$--	$2,645,000
2. Flood Control Measures	526,000	600	535,000	--	--	--	21,000	--	21,000
3. Water Quality Management Measures	1,238,000[d]	77,500[d]	2,460,000	648,000	--	648,000	--	--	--
Total	$4,772,000	$95,800	$6,282,000	$648,000	$--	$648,000	$2,666,000	$--	$2,666,000

[a] *It should be noted that the plan recommendations include provisions for additional state cost-share funding, representing a departure from current policies, which was deemed necessary to achieve the pollutant reduction goals in a cost-effective manner.*

[b] *Present value computations assume a 50-year life and 6 percent annual interest.*

[c] *Excludes dual-purpose Pond Nos. 2 and 11.*

[d] *Includes dual-purpose Pond Nos. 2 and 11.*

Source: SEWRPC.

to be borne by the private sector, depending on the specific nature of individual projects. If operation and maintenance costs for a specific project are financed by the private sector, it would be necessary for the City and the party responsible for operation and maintenance to execute a legal agreement which details both the responsibility of the private party for providing operation and maintenance and the degree of maintenance required. Those stormwater management facilities which are constructed with private funds, but are to be maintained by the City, would be dedicated to the City following construction.

Chapter VI

EFFECTS OF RECOMMENDED STORMWATER MANAGEMENT SYSTEM PLAN

HYDRAULIC EFFECTS

The primary effect of implementation of the recommended stormwater management system plan will be the safe and efficient conveyance of runoff from all storm events up to and including the 10-year recurrence interval storm event by the minor drainage system to major drainage channels. Implementation of the recommended drainage system and flood control measures would not cause any increases in flood flows on Silver Creek and its major tributaries, except in the 0.88-mile-long reach of Silver Creek from Washington Street to Park Drive in Regner Park and the 0.84-mile-long reach of Silverbrook Creek from the intersection of 18th Avenue and Chestnut Street to the confluence with Silver Creek. Recommended culvert replacements and channel modifications in portions of those reaches would, however, lower the water surface profiles for flood flows up to and including the 100-year recurrence interval flood flows, thereby removing many buildings from the 100-year floodplain. In other portions of the affected reaches, many of which include city parkland or school district lands, 100-year recurrence interval stream stages would be increased by from 0.01 to 0.60 foot, possibly requiring flood easements from, or other legal agreements with, affected private property owners.

WATER QUALITY EFFECTS

The primary benefit of the water quality management element would be improved water quality conditions within Silver Creek and its tributaries. Implementation of the recommended measures may be expected to reduce pollutant loadings to Silver Creek sufficiently to achieve water quality standards supporting full body contact recreational use and the maintenance of warmwater fish and aquatic life. For example, future loadings of sediment, phosphorus, and lead would be about 29, 20, and 42 percent lower, respectively, than if the plan recommendations were not implemented. Overall, the water quality of the surface waters may be expected to be somewhat better than under existing conditions.

The water quality management plan element would provide numerous benefits in addition to water quality enhancement. Properly designed and managed, the 11 wet ponds recommended would provide valuable habitats for wildlife, and in some cases fish. The ponds would also be attractive landscape features, offering opportunities for aesthetic enjoyment and limited recreational use—such as ice skating and nature study. The recommended infiltration systems, and to a lesser extent the wet ponds, should increase the recharge of the shallow groundwater aquifer, thereby increasing the base flow of streams during dry-weather periods. This increased base flow should, in turn, improve the ability of the streams to assimilate pollutant loads, and generally enhance aquatic habitat conditions. The recommended measures to allow fish to migrate freely within Silver Creek would significantly enhance the development of a healthy, resident warmwater fishery in the creek. The construction site erosion control measures, the stream bank stabilization measures, and the increased street sweeping would help provide an overall cleaner environment in the urban service area, enriching the quality of life for its residents. Although many of these benefits are difficult to quantify, implementation of the water quality management measures would generally help create a more pleasant environment in which to live and work.

However, the water quality management recommendations could also have significant negative effects if the measures are not properly designed and managed. Care must be taken to ensure that the infiltration systems do not contaminate the groundwater with toxic substances. Thus, appropriate site evaluations, including soil tests, must be utilized and sound design criteria applied in the design of each infiltration system. Groundwater monitoring wells may be needed. Wet ponds must be carefully located to prevent impeding important fish migration and to avoid increasing the water temperature of ecologically sensitive headwater streams. Accumulated sediments in wet ponds may contain toxic substances or metals. Sediment to be dredged should be tested to determine the appropriate means of disposal. To the extent possible, these problems have been addressed in this systems level plan. However, some modifications to the plan recommendations may be needed as urban develop-

ment occurs, and the implementing agency must be aware of these potential impacts.

The ponds must also be maintained and cleaned to control the decomposition of accumulated organic matter which consumes dissolved oxygen needed to support fish and aquatic life. Proper pond maintenance can also minimize occasional aesthetic and odor nuisance problems caused by excessive macrophytes, algae, or debris. Those ponds located in residential areas should also be designed to minimize safety hazards, especially to children.

As noted above, because the subwatershed contains several internally drained areas and natural stormwater storage areas, the recommended water quality management measures are not expected to have a significant impact on downstream flows or stream bank erosion during large storm events. However, several of the wet detention basins could be beneficial in reducing downstream flows and stages under more frequent storm events, thereby reducing the potential for increased stream bank erosion during those events. It is recommended that the final design of wet detention basins 1, 2, 3, 6, 7, 8, 10, and 11 provide outflow control for storms with recurrence intervals of two years or shorter. Except for the 0.6-acre wet basin No. 2 in Hydrologic Unit C, and the 1.1-acre wet basin No. 11 in Hydrologic Unit L, none of the recommended management measures would either increase or reduce the required size of downstream stormwater conveyance facilities.

A letter from the Wisconsin Department of Natural Resources, dated January 3, 1989, which provided comments on a preliminary draft of this report, called for additional study of the hydrologic impacts of urban development on frequently occurring flows in receiving streams in the Silver Creek subwatershed. The Commission staff does not consider such additional study to be necessary. Detention and infiltration of stormwater are the management practices that would be the most effective in controlling the more frequent flood events which have a significant effect on stream morphology, and in maintaining adequate groundwater recharge and base flow. The recommended plan provides wet detention to treat runoff from the majority of the area planned to be developed for urban uses between 1985 and 2010, and it also provides wet detention basins to the greatest degree practicable in areas of existing development. The plan recommends the use of roadside swales to the maximum degree possible under current city policy. In addition, the maximum practicable level of infiltration of parking lot runoff is recommended for areas of existing commercial and institutional development. The combined effects of the recommended wet detention basins, roadside swales, and infiltration facilities, along with the considerable flow-attenuating capacity of the existing wetlands within the subwatershed which are recommended for preservation, would provide the maximum level of control of frequent flood events and the maximum degree of groundwater recharge which could practically be achieved under planned land use conditions. Thus, no further evaluations are needed.

Chapter VII

PLAN IMPLEMENTATION

INTRODUCTION

The recommended stormwater management plan described in this volume is designed to attain, to the maximum extent practicable, the stormwater management objectives and standards set forth in Chapter IV, Volume One, of this report. In a practical sense, however, the plan is not complete until the steps to implement it—that is, to convert the plan into action policies and programs—have been specified. Following formal adoption of this plan by the City of West Bend, realization of the plan will require a long-term commitment to the objectives of the plan and a high degree of coordination and cooperation among city officials and staff, land developers, and concerned citizens in undertaking the substantial investments and series of actions needed to provide urban development in the West Bend area with an efficient and effective stormwater drainage system. The plan should be used as a guide for the development of the stormwater drainage system and related stormwater management measures within the planned urban service area.

The first section of this chapter describes the relationship of land use development and redevelopment to the effectiveness of the planned stormwater management measures. The second section discusses the importance of more detailed engineering to implementation of the plan. The third section sets forth the specific actions required to implement the plan. A preliminary plan implementation schedule is presented in the fourth section. The fifth section presents regulatory considerations. The sixth section discusses the need for periodic reevaluation and updating of the plan itself. With the exception of the section on the schedule of implementation, which applies specifically to the plan for the Silver Creek subwatershed, the comments and recommendations of this chapter are also intended to apply to the Quaas Creek and Milwaukee River subwatershed plans presented in Volumes Three and Four of this report.

RELATION TO FUTURE LAND USE DEVELOPMENT

Fundamental to implementation of a sound stormwater management plan is coordination with land use development and redevelopment. Design year 2010 planned land use conditions for the stormwater management area were presented in Chapter II, Volume One, of this report. To a large extent, the effectiveness of the recommended stormwater management measures will depend upon the degree to which future land use development and redevelopment and the stormwater management plan properly complement each other.

Importantly, the stormwater management plan identifies those areas of the subwatershed that should be preserved in open, natural uses. Such preservation will provide major economies in stormwater management—maximizing the use of natural stormwater conveyance and storage, and permitting such conveyance and storage to be incorporated into the stormwater management plan and system. If the preservation of these open areas is greatly compromised, stormwater management problems, such as localized flooding, poor drainage, and water pollution, may be expected to result.

RELATION OF DETAILED ENGINEERING DESIGN TO SYSTEM PLANNING

The systems level stormwater management plan presented in this report is intended to serve as a guide to the design and construction of stormwater management facilities. Engineering design should begin as the systems planning phase is completed. The detailed engineering design should examine in greater depth and detail the variations in the technical, economic, and environmental features of the recommended solutions to problems identified in the system plan in order to determine the best means of carrying out the plan. The resulting facility

development plans should be fully consistent with the stormwater collection, conveyance, and detention facility recommendations presented in this report.

Chapter IV of Volume One of this report presented the engineering design criteria and analytic procedures used in the preparation and evaluation of the alternative stormwater management system plans. These criteria and procedures, firmly based in current engineering practice, provided the means for quantitatively sizing and analyzing the performance of both the minor and major stormwater drainage system components. These criteria and procedures should also serve as a basis for the more detailed design of stormwater management system components in the implementation of the recommended plan. It is important that such criteria and procedures be applied uniformly and consistently in all phases of implementation of the plan if the resulting system is to perform as envisioned in the plan.

Table 23 sets forth the design criteria and analytic procedures recommended to be followed in the engineering design of the recommended plan components. Criteria and procedures are presented in the table for estimating stormwater flows; calculating hydraulic capacities of conveyance facilities; designing street cross-sections and related site grading; locating and designing storm sewer inlets; designing storm sewers; designing roadside swales, open channels, and culverts; and designing storage facilities. In this respect, it is recognized that over time new design techniques may be developed and become available for use in the design of stormwater management system components. Such techniques should, however, be carefully reviewed before adoption for consistency with the criteria and procedures set forth in the plan.

PLAN IMPLEMENTATION

Plan Adoption

An important first step in plan implementation is the formal adoption of the recommended stormwater management plan, as documented herein, by the City of West Bend Plan Commission; the Park, Recreation and Forestry Commission; the Board of Public Works; and the City Council. In addition, the plan should be endorsed by the Wisconsin Department of Natural Resources.

Upon such adoption, the stormwater management plan becomes the official guide to the making of stormwater management decisions by city officials. Such formal adoption serves to signify agreement with, and official support of, the recommendations contained in the plan, and enables the city staff to begin integrating the plan recommendations into the ongoing land use control, public works development planning and programming, and subdivision plat review processes of the City.

Implementation Procedures

It is recommended that the plan be implemented using the existing city procedures for land subdivision plat approval; capital improvement programming; and public works construction, operation, and maintenance. Funding for capital improvements and operation and maintenance may be obtained through the property tax levy, special assessments, issuance of general obligation bonds, reserve funds, private developer contributions, and grants from the State of Wisconsin. Implementation of the plan through a stormwater utility was considered and rejected. The administration of the stormwater management program through a utility would duplicate an administrative and review function already performed satisfactorily by city staff and commissions; the time required to establish the utility, and to resolve possible problems regarding the legal authority for such a utility, could unduly delay implementation of the stormwater management plan; and establishment of utility district boundaries outside the corporate limits of the City may be resisted by other local units of government involved.

In reviewing subdivision plats, the City Plan Commission would determine the compatibility of the plats with the land use assumptions set forth in the stormwater management plan. Any proposed departures from those assumptions should be carefully considered in light of the stormwater management needs of the proposed development and the impacts on upstream and downstream areas. The plat review function can and should, under Wisconsin law, be exercised extra-territorially by the City.

Capital improvements programming would be a particularly important tool for implementing the recommended stormwater management plan. Typically, a capital improvements program is a five-year program for the timing and financing of priority capital improvement projects. Such a

Table 23

DESIGN CRITERIA AND PROCEDURES RECOMMENDED TO BE FOLLOWED IN THE DETAILED ENGINEERING DESIGN OF THE RECOMMENDED STORMWATER MANAGEMENT SYSTEM COMPONENTS

Design Function	Recommended Criteria and Procedure
Storm Runoff Flows	Minor system components should be designed to accommodate flows expected from a 10-year recurrence interval storm event. Major system components should be designed to accommodate flows expected from a 100-year recurrence interval storm event. To determine peak rates of flow for the design of pure conveyance facilities with no significant upstream storage, the Rational Method, as described in SEWRPC Technical Record, Vol. 2, No. 4, April-May 1965, "Determination of Runoff for Urban Stormwater Drainage System Design," or the U. S. Soil Conservation Service Method, as described in SCS Technical Release 55, June 1986, "Urban Hydrology for Small Watersheds," should be used. The rainfall intensity, duration, and frequency curves suitable for use with the Rational Method are provided in Figure 9 in Chapter IV of Volume One of this report. When storage is to be included in the facilities and estimates of runoff volumes as well as peak rates of discharge are required, the TR55 Method for sizing detention basins or a suitable hydrologic-hydraulic simulation model should be used
Conveyance Facilities	The sizes of recommended conveyance facilities are set forth in Table 10, Chapter V of this volume. Manning's formula should be used to determine the hydraulic capacities of conveyance facilities where flow conditions approximate uniform conditions. The use of Kutter's formula is also acceptable for uniform pipe flow computations. Storm sewers should be designed to flow full during the design storm event. Flow velocities should not be less than 2.5 feet per second in storm sewers. The chart set forth in Figure 17, Chapter IV, Volume One of this report should be used to determine the hydraulic elements of the storm sewers. Manning's "n" values for roadside swales should be selected using retardance levels C or D, as shown in Figure 14, Chapter IV, Volume One. Flow velocities should not exceed six feet per second in turf-lined channels. Where flow conditions do not approach uniform conditions, backwater, drawdown, or inlet control conditions should be determined mathematically or by use of appropriate nomographs
Street Cross-Sections and Related Site Grading	Except in areas specifically recommended to have rural cross-sections, streets should be designed with urban cross-sections. Typical street cross-sections are shown in Figure 2, Chapter III, Volume One. Slopes away from all buildings, as well as the slopes of interior drainage swales, should be at least one-quarter inch per foot to provide positive drainage
Storm Sewer Inlets	Storm sewer inlet location and capacity should be dictated by the allowable stormwater spread and depth of flow in streets. Combination inlets should be used in most instances. Uncontrolled flow across streets should not be allowed when the streets are functioning as a part of the minor stormwater drainage system. At locations where storm sewers function as a part of the major drainage system and are sized to convey design flows resulting from storms with recurrence intervals greater than 10 years, and at locations where a storm sewer is intended to divert a specific design flow to an off-line detention basin, sufficient inlet hydraulic capacity should be provided to permit the design capacity of the storm sewer to be developed
Culverts	The length and size of recommended culverts are set forth in Tables 10 and 11, Chapter V of this volume. Culvert capacities should be determined by using appropriate nomographs and charts. Where appropriate, culverts should be designed to permit fish passage
Storage Facilities	The size of recommended storage facilities is set forth in Tables 10 and 15 of Chapter V of this volume. Where practical, storage facilities should be designed to limit the design outflow to no more than the capacity of the existing downstream conveyance and storage systems. The effects of storage facilities on the frequency, duration, and magnitude of downstream flows under future conditions as compared to existing conditions should be carefully examined

NOTE: For a more detailed discussion of these design criteria, see Chapter IV of Volume One of this report.

Source: SEWRPC.

program is based upon the projected financial capability of the community and is formulated from a detailed analysis of municipal revenues, debt service obligations, financing procedures, and external funding potentials. Once formulated, the program would be reevaluated, refined, and extended on an annual basis. Under this option, the City's well-developed procedure for capital improvement financing would incorporate the stormwater management plan components in a manner consistent with the construction prioritization set forth below.

Implementation of the plan through the city zoning map and ordinance would be another means of ensuring that land use development takes place in accordance with the assumptions underlying the stormwater management plan. Unlike subdivision control, which operates on a plat-by-plat basis, the zoning ordinance operates over the entire City in advance of development proposals, serving to increase public acceptance of the plan recommendations and improving coordination between upstream development and downstream stormwater management. As in the case of subdivision plat review, any zoning changes should consider the potential impacts on the facilities included in the stormwater management plan.

A common stormwater management problem facing municipalities is a lack of a continuing maintenance program for stormwater facilities, including periodic inspection and routine preventive maintenance. This problem is caused by the absence of an assured, continuous source of funding, and incomplete records to justify budgeting for this funding. Stormwater facility maintenance can be easily ignored for a limited period of time, and many officials and citizens alike incorrectly perceive that certain components, such as open channels or sewers, are self-maintaining, or that no hazards will result if such facilities become defective. However, a sound, continuing, preventive maintenance program must be given a high priority, particularly for a stormwater management system which includes various types of components such as storm sewers, roadside swales, culverts, open channels, and onsite and centralized detention facilities that are interrelated and interconnected. The City does have a maintenance program for drainage facilities. It is recommended that the public works program of the City continue to provide for the maintenance, as well as construction, of the stormwater management facilities—including periodic inspection of conveyance and detention facilities; timely repair of facilities; cleaning of storm sewers, open channels, and detention facility inlets and outlets; maintenance of open channel and detention facility lining materials; and periodic removal of accumulated sediment from conveyance, detention, and sediment control facilities.

Financing

Several means of financing stormwater management components are available to local governmental agencies that are not available to the private sector. However, although these means offer flexibility, certain constraints and limitations are imposed on these financing methods by State law, and by the approvals required of the electorate. Therefore, successful public financing of the recommended plan will require a thorough study of costs and available revenues, careful financial planning, public information programs, and a timely approach for securing public support and approvals.

In addition to using current tax revenue sources such as property taxes, the City may make use of such revenue sources as reserve funds, general obligation bonds, private developer contributions, and state grants. The City has established the legal limit of two tax incremental financing districts; therefore, that means of financing public works projects is not currently available.

Other than Wisconsin Department of Natural Resources nonpoint source pollution abatement program funds, state and federal grants are generally not available to finance stormwater management measures at this time. As discussed in Chapter V of this volume, the City may be able to obtain financial assistance from the Department of Natural Resources' Wisconsin Fund Nonpoint Source Pollution Abatement Program for the construction of many of the components of the water quality management plan element. It is also possible that the cost of certain components of the recommended stormwater drainage or flood control systems could be shared between the City and the Wisconsin Department of Transportation as a part of highway construction or reconstruction projects.

To provide a dependable source of funds necessary to meet the operation and maintenance costs attendant to implementation of the plan,

such costs would be funded out of the city general fund as part of the ongoing public works program.

For new urban developments which contain recommended stormwater management components to be financed all or in part by the private sector, provision of the recommended facilities would ordinarily be a condition of plat approval by the City. Thus, the costs would be ultimately borne at least in part by the land parcel purchasers. Contributions of materials and services to the City may also be made by land developers.

PRELIMINARY PLAN SCHEDULE FOR IMPLEMENTATION

Prioritization of Capital Improvements

A preliminary prioritization of the recommended capital improvements is given in Table 24. This prioritization is provided to identify those projects that should be implemented to alleviate the most pressing stormwater management problems and to identify a necessary sequence for implementation of certain interdependent components of the total system. For this prioritization, a project is defined as a set of stormwater management components that should be constructed in concert in order for the set to function properly by itself and within the context of the larger total system of which it is a part. In some instances, several relatively small sewer replacement projects in the same localized area were grouped together as one larger project for the purposes of prioritization. An economy-of-scale may be possible by constructing several small projects in the same area at the same time.

The projects are classified as high, intermediate, or low priority. The high-priority projects are those that address significant existing problems, or those that are required to serve new development that is actually occurring. The intermediate-priority projects are those required to serve new development that is anticipated to occur in the near future based on development proposals which have been submitted to the City and on plans for the extension of sanitary sewer service. The low-priority projects are those required to serve and promote development in the more distant future. The storm frequency for which certain projects are to be designed and the consequences of exceeding the capacity of the existing stormwater management system were also considered in the prioritization.

The sequence in which projects are actually implemented and the time at which they are implemented will ultimately depend on a number of factors not related solely to stormwater management considerations. Such factors include budgetary constraints; the need to implement other projects in the City's capital improvements program; and variations in future development patterns as determined by the urban land market. As a result, some intermediate-priority projects may actually be constructed before some high-priority projects. However, where a specific implementation sequence for a series of components comprising a unified stormwater management project is required, that sequence should be followed to ensure the proper functioning of the system.

Identification of Critical Implementation Sequences

The following discussion identifies projects for which the implementation sequence of the project components is critical.

Project No. 1—Silver Creek and Silverbrook Creek Flood Control Measures, Appurtenant Storm Sewers, and Stream Bank Stabilization: As discussed in the flood control plan element section in Chapter V of this report, resolution of the overland flooding problems along Silverbrook Creek requires implementation of flood control measures on Silver Creek in the vicinity of the intersection of 15th Avenue and Washington Street in addition to measures along Silverbrook Creek. The recommended flood control measures along both streams have therefore been grouped into a single project. Relatively minor storm sewer replacement work is included in the project because the storm sewers concerned discharge to one or more of the culverts recommended for replacement, and could most easily be replaced along with the culvert. Stream bank stabilization measures in the reach of Silverbrook Creek located upstream of the recommended culvert replacement and channel modification at 16th Avenue are included in the project because of their proximity to the flood control modifications, and because the effects of the recommended flood control and bank stabilization measures on water surface profiles and instream fish habitat should be considered together.

Table 24

PRIORITIZATION OF STORMWATER MANAGEMENT PLAN PROJECTS FOR THE SILVER CREEK SUBWATERSHED

Project Number and Description	Hydrologic Unit	Project Components as Listed in Volume Two	City of West Bend Capital Cost[a,b]	State of Wisconsin Capital Cost[a,b]	Private Sector Capital Cost[b]	Total Capital Cost of Components[a,b]
High-Priority Projects						
1. Silver and Silverbrook Creek Flood Control Measures, Appurtenant Storm Sewers, and Stream Bank Stabilization	E, K	Table 10, K 9 through K 12; Table 11, E 1 through E 4 and K 1 through K 6 Table 19	$ 605,000	$ 95,000	$ 0	$ 700,000
2. Storm Sewer Replacements North of Silverbrook Creek	E	Table 10, E 1, 3, 13, 14, and 17	131,000	0	0	131,000
3. Storm Sewer Replacement in the Vicinity of 12th Avenue and Park Avenue	L	Table 10, L 10 through 28	1,049,000	0	0	1,049,000
4. Storm Sewer Replacement in the Vicinity of 18th Avenue and Washington Street and Associated Wet Detention Basin Construction	K	Table 10, K 1 through K 8 and K 13; Table 15, K, Pond No. 10	248,00	49,000	53,000	350,000
5. Storm Sewer Replacement South of Park Avenue in the Vicinity of Green Tree Road and Wood Way and Detention Basin Construction North of Wood Way	L	Table 10, L 1 through L 7 and L 32	758,000	132,000	0	890,000
6. Storm Sewer Replacement at Intersection of Tamarack Drive and Tamarack Court	E	Table 10, E 18	4,000	0	0	4,000
7. Storm Sewer Replacement in Silverbrook Drive North of Washington Street	L	Table 10, L 8 and L 9	31,000	0	0	31,000
8. Storm Sewer Replacement at the Intersection of 8th Avenue and Park Avenue	L	Table 10, L 31	26,000	0	0	26,000
9. Storm Sewer Replacement Near Silverbrook Creek Between 16th Avenue and Silverbrook Drive	E	Table 10, E 4 through E 7, E 9, 10, and 12	146,000	0	0	146,000
10. Storm Sewer Replacement Between 8th and 9th Avenues North of High Street	L	Table 10, L 29	50,000	0	0	50,000
11. Storm Sewer Replacement at Miller Street and 18th Avenue	E	Table 10, E 11	27,000	0	0	27,000
12. Storm Sewer Replacement at Chestnut Street, West of USH 45	D	Table 10, D 1	38,000	0	0	38,000
13. Storm Sewer Replacement in 18th Avenue North of Silverbrook Creek	E	Table 10, E 8	16,000	0	0	16,000

Table 24 (continued)

Project Number and Description	Hydrologic Unit	Project Components as Listed in Volume Two	City of West Bend Capital Cost[a,b]	State of Wisconsin Capital Cost[a,b]	Private Sector Capital Cost[b]	Total Capital Cost of Components[a,b]
High-Priority Projects (continued)						
14. New Storm Sewers in Fox Ridge Subdivision and Wet Detention Basin North of Ridge Run Park	I, J	Table 10, I 1, 2, 3 (partial), 4 (partial), 5 (partial), 7 (partial), 9, and 10; J 1 through J 4; Table 15, J, Pond No. 9	$ 28,000	$ 65,000	$ 269,000	$ 362,000
15. Wet Detention Basin East of University Drive and South of Chestnut Street	D	Table 15, D, Pond No. 3	17,000	41,000	0	58,000
Intermediate-Priority Projects						
16. Storm Sewer Replacement Northwest of Intersection of 18th Avenue and Miller Street	E	Table 10, E 2	$ 28,000	$ 0	$ 0	$ 28,000
17. Storm Sewer Replacement in 18th Avenue Between Miller Street and Chestnut Street	E	Table 10, E 11	27,000	0	0	27,000
18. New Storm Sewers in Villa Park Drive and Associated Wet Detention Basin	F	Table 10, F 1 through F 4; Table 15, F, Pond No. 4	45,000	104,000	54,000	203,000
19. Storm Sewers and Wet Detention Basin Northeast of Intersection of 18th Avenue and Paradise Drive	B	Table 10, B 2 (partial), 3, 4, 5 (partial), 6, 7, 8, 13, and 15 Table 15, B, Pond No. 1	44,000	102,000	291,000	437,000
20. Drainage and Storage Facilities for Development of Portion of West Bend Mutual Site Within the Subwatershed	A	Table 10, A 1 (partial), A 2 through A 7	5,000	0	101,000	106,000
21. Infiltration Systems	E,F,K	Table 15, E, F, and K	66,000	156,000	0	222,000
22. Provision of Measures to Permit Fish Passage from Milwaukee River to Points Upstream from the Regner Park Dam, Instream Habitat Mitigation Measures, and Dredging of Regner Park Fish Pond	L	Tables 15 and 19	47,000	148,000	0	205,000
23. Storm Sewers and Associated Wet Detention Basin Southeast of the Intersection of Scenic Drive and Valley Avenue	I	Table 10, I 3 through I 5 (all partial), 7 and 8 (both partial); Table 15, I, Pond No. 7	29,000	69,000	242,000	340,000

Table 24 (continued)

Project Number and Description	Hydrologic Unit	Project Components as Listed in Volume Two	City of West Bend Capital Cost[a,b]	State of Wisconsin Capital Cost[a,b]	Private Sector Capital Cost[b]	Total Capital Cost of Components[a,b]
Intermediate-Priority Projects (continued)						
24. Storm Sewers and Wet Detention Basins West of Scenic Drive and South of Washington Street	I	Table 10, I 3 (partial), 5 (partial), 6, 7, and 8 (partial); Table 15, I, Pond Nos. 6 and 8	$ 88,000	$ 205,000	$ 232,000	$ 525,000
25. Channel West of 18th Avenue	E	Table 10, E 15 and E 16	0	0	8,000	8,000
Low-Priority Projects						
26. Projects to Serve Areas of Potential New Development Other than Those Previously Listed in Hydrologic Units:						
A	--	Table 10, A 1 (partial)	$ 0	$ 0	$ 21,000	$ 21,000
B	--	Table 10, B 1, 2, 4, and 5 (partial), B 9 through B 12, B 14, 15 (partial), 16, and 17	239,000	0	227,000	466,000
C	--	Table 10, C 1 through C 8	26,000	60,000	172,000	258,000
F	--	Table 10, F 5 through F 18	0	0	614,000	614,000
G	--	Table 10, G 1 through G 8; Table 5, G, Pond No. 5	239,000	127,000	358,000	724,000
L	--	Table 10, L 30	0	0	24,000	24,000
Total	--	--	$4,067,000	$1,353,000	$2,666,000	$8,086,000

[a] *City and state costs are apportioned as recommended in this plan.*

[b] *Including engineering, administration, and contingencies.*

Source: SEWRPC.

Direct overland flooding from Silverbrook Creek affects buildings the most; therefore, it is recommended that the Silverbrook Creek flood control measures be implemented first, followed by floodproofing of the warehouse basement north of Silver Creek and implementation of the flood control measures recommended for Silver Creek. All recommended flood control measures for a given stream should proceed from downstream to upstream to ensure that the downstream channel and hydraulic structures have adequate capacity to pass the increased flows resulting from the provision of increased upstream hydraulic capacity.

Project No. 2—Storm Sewer Replacement North of Silverbrook Creek: These storm sewer replacements are the second phase in the solution of drainage and flooding problems in the area north of Silverbrook Creek between Concord Lane and 15th Avenue. The replacements would provide adequate hydraulic capacity to prevent drainage-related, as opposed to flood-related, inundation. This project can be accomplished separately from Project No. 1 for flood control, but the design of the flood control project should include consideration of the interrelationship between the storm sewer replacement project and the channel flood control project.

Project No. 4—Storm Sewer Replacement in the Vicinity of 18th Avenue and Washington Street and Associated Wet Detention Basin Construction: These recommended improvements would be adjacent to certain flood control measures recommended for Silver Creek under Project No. 1, and the design of Project No. 1 should include consideration of the components of this project. As indicated by the priority sequence, it is recommended that this project be constructed after Project No. 1 to ensure that the hydraulic capacity of Silver Creek is increased prior to providing the more efficient conveyance facilities called for in Project No. 4. Parking lot detention storage is recommended for new commercial development in the area tributary to Project No. 4. That storage must be provided as development occurs in order to avoid exceeding the capacity of the replacement storm sewers called for under this project.

Project No. 18—New Storm Sewers in Villa Park Drive and Associated Wet Detention Basin: The recommended wet detention basin is sized to provide nonpoint source pollution control of runoff from both the area tributary to the new Villa Park Drive storm sewers and the significantly larger area to the north of the wetland bordering Villa Park Drive. Because the area to the north of the wetland is not likely to be developed at the time that the Villa Park Drive storm sewers are constructed, the wet detention basin could be designed and constructed to control only the runoff from the developed Villa Park area and the undeveloped area north of the wetland, with provisions for subsequent expansion to accommodate the remainder of the tributary area following development of that area.

REGULATORY CONSIDERATIONS

Implementation of some of the drainage improvements recommended in this system plan may require the prior approval of certain regulatory agencies other than the City, including the Wisconsin Department of Natural Resources and the U. S. Army Corps of Engineers. Because the regulatory process involved is complex, the City should seek legal counsel prior to proceeding with any drainage improvements that involve the construction or improvement of artificial waterways connecting to navigable waters; the alteration or enclosure of navigable watercourses; the removal of material from the beds of navigable watercourses; or the filling of wetlands.

The federal regulatory authority relates to the filling of wetlands and is granted under Section 404 of the Federal Water Pollution Control Act of 1972 as amended. The administering agency is the U. S. Army Corps of Engineers.

The state regulatory authority relates to the construction or improvement of artificial waterways connecting to, or located within, 300 feet of a navigable waterway; the alteration of navigable waterways; the placement of deposits or structures in the bed of navigable waterways or the enclosure of navigable waterways; and the removal of material from navigable waters. The authority is contained in Sections 30.12, 30.195, 30.196, and 30.20 of the Wisconsin Statutes. The administering agency is the Wisconsin Department of Natural Resources.

Implementation of the plan will allow the Federal Emergency Management Agency, upon the request of the City, to revise the floodplain boundary maps following submittal of substantiating information. Such revisions should be requested immediately upon adoption of this plan and also as the recommended stormwater management and flood control measures concerned are constructed. Revision will ultimately eliminate the need for many property owners in the City to purchase flood insurance.

PLAN REEVALUATION AND UPDATING

The recommended stormwater management components, as well as the forecasts and assumptions used as a basis for plan development, should be reevaluated at 10-year intervals, in light of changes in actual development in the identified area. The plan components, including the need for certain facilities and the location, size, and capacity of facilities, should be revised as necessary to reflect changing development patterns and stormwater management needs. In addition, in the initial plan development, it was necessary to limit the analysis and recommendations to major conveyance and detention facilities, since the layout of some future collector and land access streets had not been determined. A major effort in plan updating should be directed toward developing recommendations and updating inventories for smaller size conveyance elements as development plans are prepared, and incorporating this information into the master stormwater management plan.

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Chapter VIII

SUMMARY

The recommended stormwater management system plan for that portion of the West Bend planned urban service area within the Silver Creek subwatershed consists of a stormwater drainage plan element, a flood control plan element, and a water quality management plan element. The recommended plan was selected following careful evaluation of numerous alternatives considered for each of the 12 hydrologic units defined within the study area.

Based on the best alternative identified for each of the hydrologic units in the West Bend urban service area, a recommended stormwater drainage plan element was developed consisting of minor system components and major system components. The minor system components were designed for a 10-year recurrence interval peak flow, while the major system components were designed for a 100-year recurrence interval peak flow. The recommended components consist of about 48,500 lineal feet of new or replacement storm sewers with associated appurtenances; 5,210 lineal feet of new roadside swales; one acre-foot of parking lot detention storage; and one new retention facility. The components also include 4,025 lineal feet of engineered open channels.

The flood control plan element includes instream measures needed to alleviate existing or anticipated flooding problems. The recommended flood control components consist of culvert replacements at two locations in Silver Creek and two locations in Silverbrook Creek, and modifications to about 300 lineal feet of Silver Creek and 400 lineal feet of Silverbrook Creek, to control flooding. It is also recommended that the basement of one commercial building be floodproofed.

The water quality management plan element consists of 11 new wet ponds, two of which will reduce flood flows in addition to providing nonpoint source pollution control; the dredging of one existing pond; measures to allow fish to migrate freely in Silver Creek and Silverbrook Creek, which may require diversion of Silver Creek around the Regner Park fish pond; instream habitat mitigation and stream bank stabilization measures; infiltration systems to treat the stormwater runoff from about 30 acres of commercial and institutional parking lots; increased sweeping of about 13.7 curb-miles of residential and commercial streets during spring and fall, along with increased catch basin cleaning and improved collection of leaves and other vegetative debris; construction site erosion control; and public education programs. The recommended measures may be expected to reduce uncontrolled pollutant loadings from the study area by 29 percent for sediment, 20 percent for phosphorus, and 42 percent for lead. These measures will help achieve the desired water use objectives for Silver Creek and its tributaries.

The total capital cost of the recommended plan is about $8.09 million. Of that cost, about $5.93 million, or 73 percent, is for the stormwater drainage plan element; about $0.55 million, or 7 percent, is for the flood control plan element; and the remaining $1.61 million, or 20 percent, is for the water quality management plan element. Of the total capital cost of the plan, about $4.07 million, or 50 percent, is recommended to be borne by the City of West Bend; about $1.35 million, or 17 percent, is recommended to be borne by the State of Wisconsin; and about $2.67 million, or 33 percent, is recommended to be financed by the private sector, primarily land developers and land parcel purchasers. All of the approximately $95,800 annual operation and maintenance cost increase would be financed by the public sector. Of that total annual cost, about $27,200, or 28 percent, is for the stormwater drainage plan element; $600, or 1 percent, is for the flood control plan element; and about $68,000, or 71 percent, is for the water quality management plan element.

The initial step in plan implementation is formal adoption of the plan by the City Plan Commission, Parks and Recreation Commission, Board of Public Works, and City Council. It is recommended that the plan be implemented and financed using the existing city structure for review, administration, and financing of stormwater management projects. The recommended plan should be integrated into the public works program to initiate construction of the recommended facilities, as well as to ensure reliable and stable operation and maintenance of both the existing and new facilities. In order to

implement the plan, the City should review subdivision plats to determine conformance between future land uses and the recommended plan, and incorporate public expenditures for stormwater management into a sound overall capital improvements program for the City.

The plan recommends the most cost-effective means of resolving existing and probable future drainage and flooding problems in the portion of the Silver Creek subwatershed within the planned urban service area, thereby reducing the public costs attributable to improperly functioning drainage facilities. Implementation of the recommended plan would provide protection against substantial inconvenience to residents during minor storm events, and against major property damage or a significant hazard to human health and safety during major storm events. The plan would improve water quality and aquatic habitat conditions in the study area, thereby enhancing the potential use of the surface waters. It would support the continued sound land use development and redevelopment of the City, enriching the quality of life within the City.

APPENDICES

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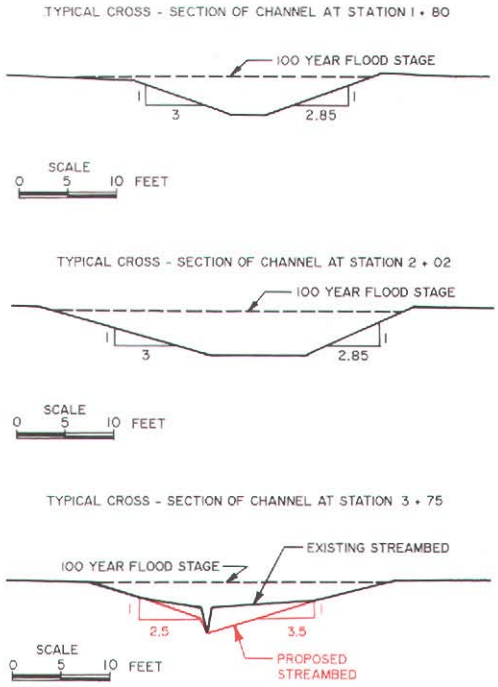
Appendix A

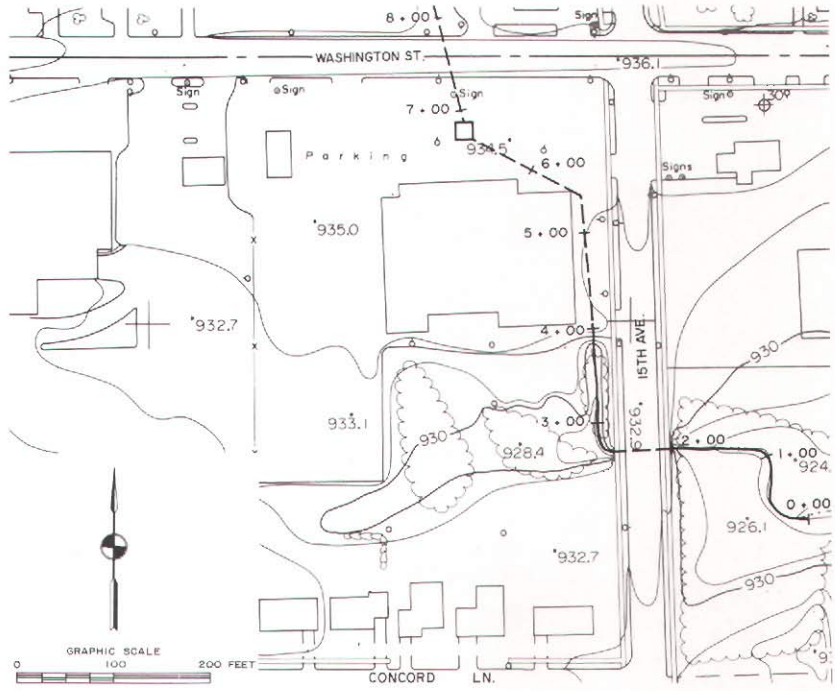
PLANS AND PROFILES OF DRAINAGEWAY AND OPEN CHANNEL COMPONENTS OF THE STORMWATER MANAGEMENT AND FLOOD CONTROL SYSTEM FOR THE CITY OF WEST BEND IN THE SILVER CREEK SUBWATERSHED

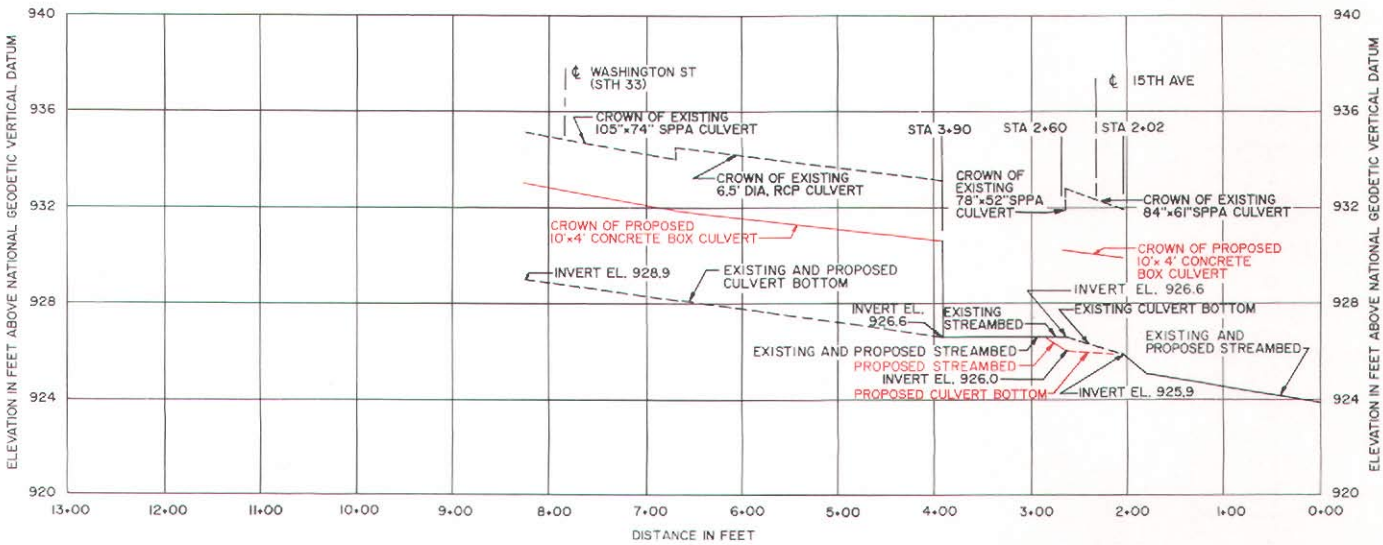
Figure A-1

PLAN AND PROFILE OF PROPOSED CULVERT REPLACEMENT AND CHANNEL MODIFICATION OF A PORTION OF SILVER CREEK NEAR THE INTERSECTION OF WASHINGTON STREET AND 15TH AVENUE

HYDROLOGIC UNIT K







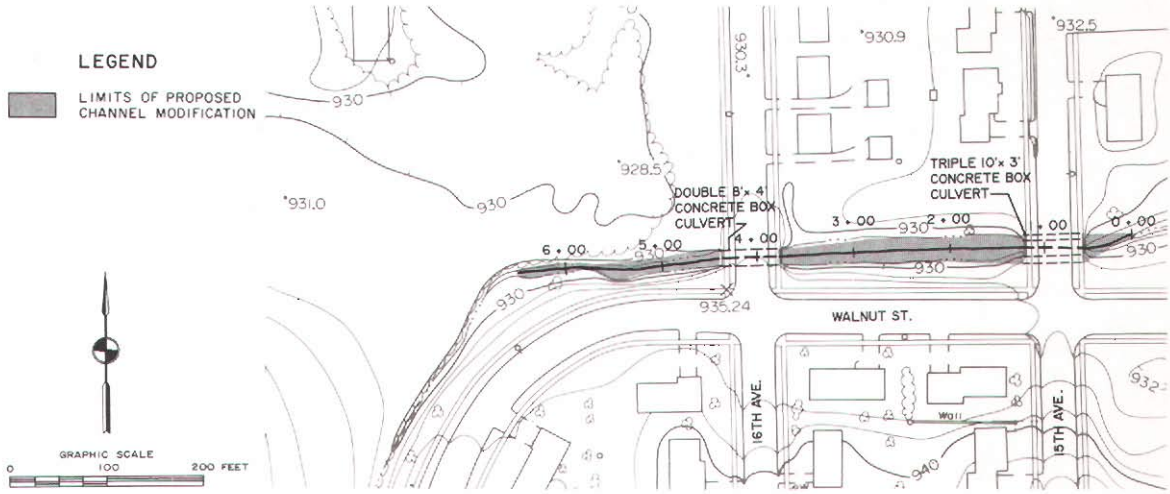
NOTE: Modified channel should be designed with a low flow channel to concentrate frequently occurring flows. Culverts should be designed to facilitate fish passage under low flow conditions.

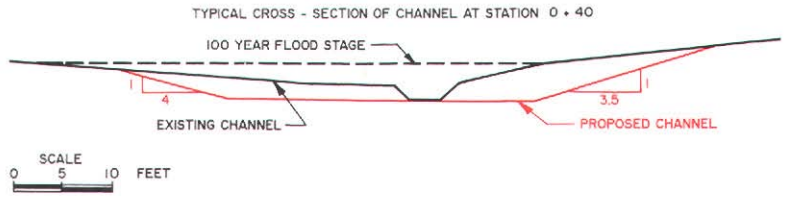
Source: SEWRPC.

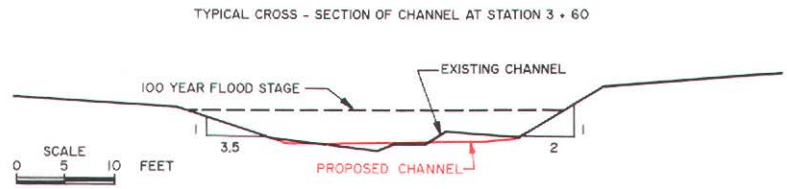
Figure A-2

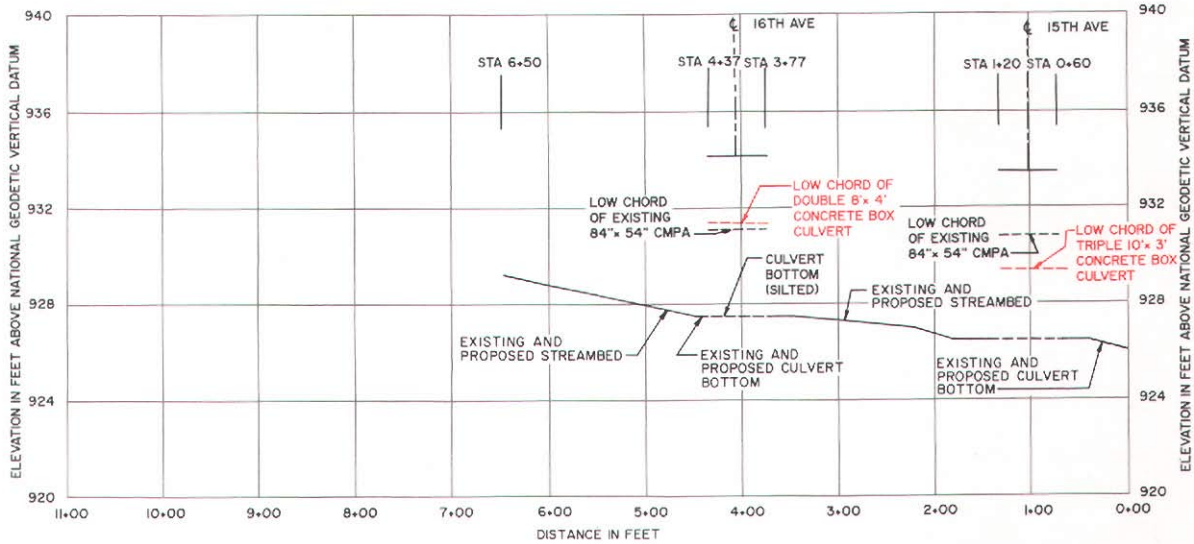
PLAN AND PROFILE OF PROPOSED CULVERT REPLACEMENT AND CHANNEL MODIFICATION OF A PORTION OF SILVERBROOK CREEK FROM 15TH AVENUE TO 16TH AVENUE

HYDROLOGIC UNIT E









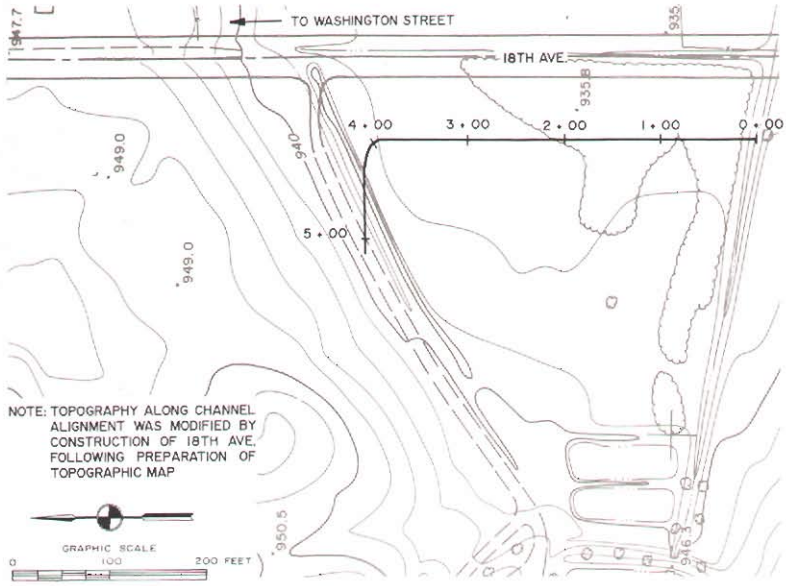
NOTE: Modified channel should be designed with a low flow channel to concentrate frequently occurring flows. Culverts should be designed to facilitate fish passage under low flow conditions.

Source: SEWRPC.

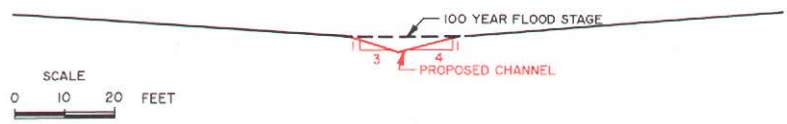
Figure A-3

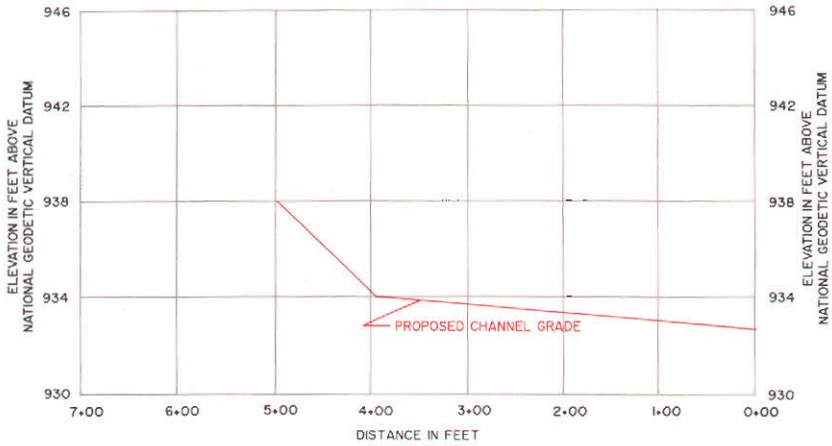
PLAN AND PROFILE OF PROPOSED CHANNEL ALONG WEST SIDE OF 18TH AVENUE 1,000 FEET SOUTH OF WASHINGTON STREET

HYDROLOGIC UNIT E



TYPICAL CROSS - SECTION OF PROPOSED CHANNEL LOOKING UPSTREAM





Source: SEWRPC.