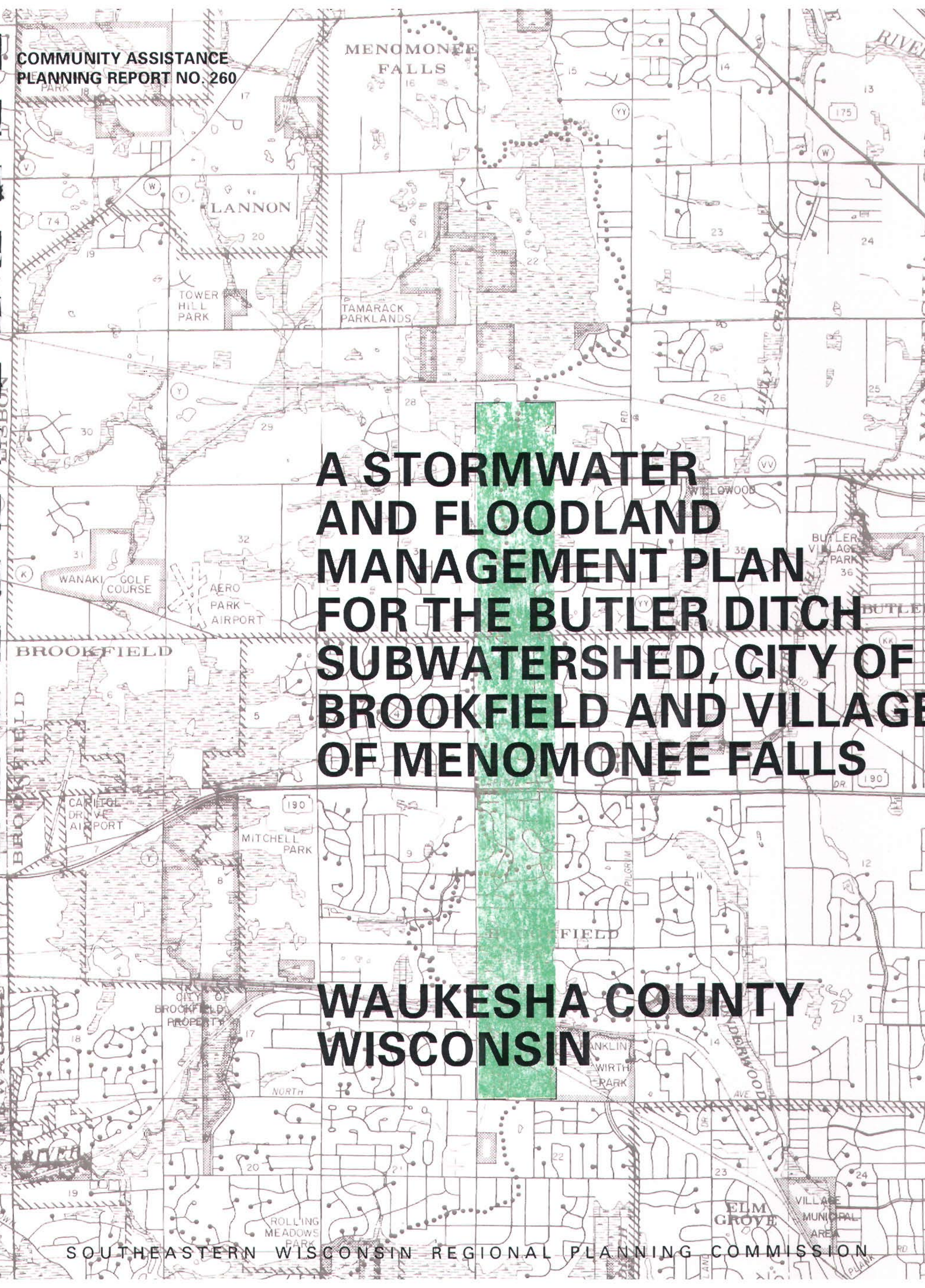
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 260

A STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE BUTLER DITCH SUBWATERSHED, CITY OF BROOKFIELD AND VILLAGE OF MENOMONEE FALLS

WAUKESHA COUNTY
WISCONSIN



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Special acknowledgement is due Ms. Carrie Bristoll-Groll, PE, City of Brookfield Project Engineer, and Mr. Jeffrey S. Nettesheim, PE, Village of Menomonee Falls Senior Utility Engineer, for their contributions to the preparation of this report.

COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 260

A STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE BUTLER DITCH SUBWATERSHED, CITY OF BROOKFIELD AND VILLAGE OF MENOMONEE FALLS WAUKESHA COUNTY, WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
and
Ruekert & Mielke, Inc.
in cooperation with the staffs of
the City of Brookfield and
the Village of Menomonee Falls

The preparation of this plan was funded in part by a local assistance grant from the Wisconsin Department of Natural Resources and a Community Development Block Grant for Federal disaster assistance administered by Waukesha County.

July 2004

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Chapter I

INTRODUCTION

This report presents the major findings and recommendations of a stormwater and floodland management planning program for the Butler Ditch subwatershed of the Menomonee River watershed in the City of Brookfield and the Village of Menomonee Falls (see Map 1). The report describes the existing stormwater management system and the existing stormwater management and flooding problems of the study area, and identifies the causes of these problems; describes existing and planned future land use conditions and identifies related stormwater management requirements; provides a set of objectives and supporting standards to guide the development of an effective stormwater and floodland management system for the area; presents alternative stormwater and floodland management system plans for the Butler Ditch subwatershed; provides a comparative evaluation of the technical, economic, and environmental features of these plans; recommends a cost-effective stormwater and floodland management plan for the subwatershed; and sets forth a plan implementation program.

STUDY BACKGROUND

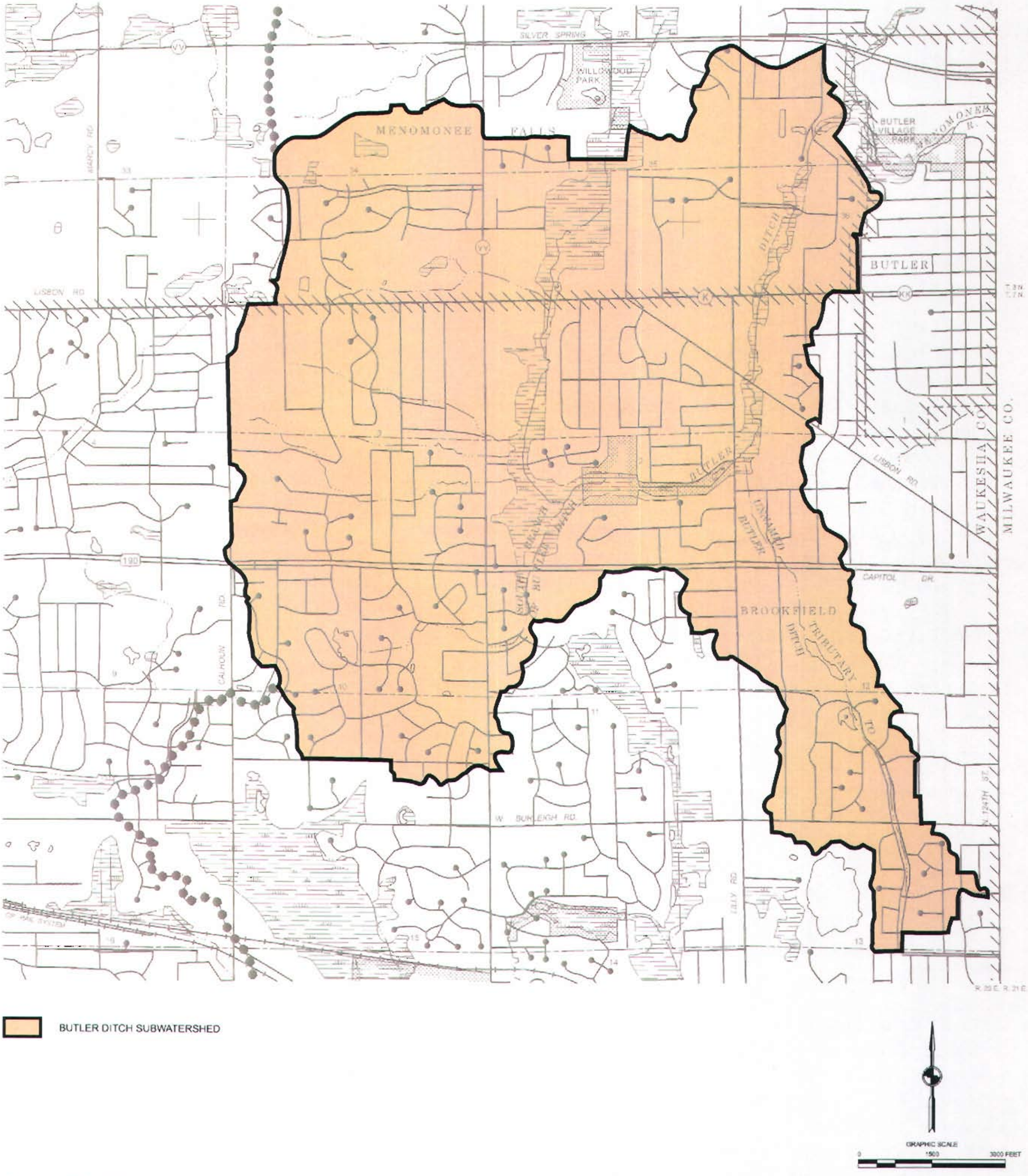
The City of Brookfield and the Village of Menomonee Falls are located in the northeastern portion of Waukesha County. The subcontinental divide between the Lake Michigan and Mississippi River basins traverses the City of Brookfield and the Village of Menomonee Falls from north to south. The Butler Ditch subwatershed is located within the Menomonee River watershed and drains to Lake Michigan. As shown on Map 1, approximately 4.0 square miles of the northeast portion of the City of Brookfield and 1.5 square miles of the southeast portion of the Village of Menomonee Falls are included in the Butler Ditch subwatershed.

To accommodate the projected increase in employment and to meet the demand for residential land, urban land use within the subwatersheds may be expected to increase from a total of about 4.1 square miles in 1995, to about 5.0 square miles by 2010—an increase of about 0.9 square mile, or about 22 percent, over the 1995 level. The planned year 2010 land use condition essentially represents the full development condition for the subwatershed.

In the absence of adequate planning, the conversion of land from rural to urban use may be expected to aggravate existing and create new stormwater management and floodland problems. In recognition of the need for a systematic plan to address existing problems and to avoid the creation of new problems, a joint resolution requesting that the Southeastern Wisconsin Regional Planning Commission assist the City of Brookfield and the Village of Menomonee Falls in the preparation of a stormwater and floodland management plan for the Butler Ditch subwatershed was adopted by the City on December 1, 1998, and by the Village on January 18, 1999. The planning work was jointly funded by the City and the Village with the aid of a Wisconsin Nonpoint Source Water Pollution Abatement Program local assistance grant from the Wisconsin Department of Natural Resources (WDNR) and a Community Assistance Block Grant for Federal disaster assistance administered by Waukesha County.

Map 1

BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS: 2003



Source: SEWRPC.

The purpose of this report is to present the resulting stormwater and floodland management plan. The plan seeks to promote the development of an effective stormwater and floodland management system, adequate to serve the City and the Village under full development conditions. To the extent practicable, the plan is intended to ameliorate existing stormwater management problems, to avoid the creation of new stormwater management problems as the area continues to develop, to mitigate the effects of nonpoint source pollution on surface water quality, and to help reduce flooding. More specifically, this report:

1. Describes the existing stormwater and floodland management system and the existing problems in the study area and identifies the causes of these problems;
2. Describes existing and planned land use conditions and identifies related stormwater and floodland management requirements;
3. Provides a set of objectives and supporting standards to guide the development of an effective stormwater and floodland management system;
4. Presents alternative stormwater and floodland management plans;
5. Provides a comparative evaluation of the technical, economic, and environmental features of the alternative plans;
6. Recommends a cost-effective stormwater and floodland management plan for the Butler Ditch subwatershed consisting of various structural and nonstructural measures; and
7. Identifies the responsibilities of, and actions required by, the various governmental units and agencies that will implement the recommended plan.

This report was prepared by the staff of the Southeastern Wisconsin Regional Planning Commission with assistance from Ruekert & Mielke, Inc., as a subcontractor to the Commission, and in cooperation with the staffs of the City of Brookfield, the Village of Menomonee Falls, and the WDNR. The recommended plan, as presented herein, is properly set within the context of broad flood control and water quality management plans for the Menomonee River watershed.[1] The findings and recommendations of urban nonpoint source pollution control studies conducted by the WDNR as part of the Menomonee River Priority Watersheds Program are also reflected in the alternative stormwater management plans and the recommended plan presented in this report.[2]

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[1] *See SEWRPC Planning Report No. 26,* A Comprehensive Plan for the Menomonee River Watershed, *Volume One,* Inventory Findings and Forecasts, *October 1976, and Volume Two,* Alternative Plans and Recommended Plan, *October 1976; SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978, Volume Two,* Alternative Plans, *February 1979, and Volume Three,* Recommended Plan, *June 1979; SEWRPC Community Assistance Planning Report No. 152 (CAPR No. 152),* A Stormwater Drainage and Flood Control System Plan for the Milwaukee Metropolitan Sewerage District, *December 1990; and SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995. The Menomonee River watershed plan has been formally adopted by the Wisconsin Department of Natural Resources and Waukesha County, as well as by the Regional Planning Commission. The regional water quality management plan has been adopted by the Wisconsin Department of Natural Resources, Waukesha County, and the Commission. In addition to the plans listed above, a floodland management planning effort to update the delineation and mapping of floodlands in the City of Brookfield was conducted by the City and the Commission concurrently with the preparation of the stormwater management plan for the Butler Ditch subwatershed.*

[2] *See* A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, *Wisconsin Department of Natural Resources and Wisconsin Department of Agriculture, Trade, and Consumer Protection in cooperation with the Ozaukee, Washington, and Waukesha County Land Conservation Departments and the Menomonee River Advisory Subcommittee, March 1992.*

DISTINCTIONS BETWEEN STORMWATER DRAINAGE, STORMWATER MANAGEMENT, AND FLOOD CONTROL

The distinctions between stormwater drainage, stormwater management, and flood control are not always clear. For the purposes of this report, flood control is defined as the prevention of damage from the overflow of natural streams and watercourses. Stormwater drainage is defined as the control of excess stormwater on the land surface before such water has entered stream channels. The term "stormwater management" encompasses stormwater drainage, nonpoint source pollution control measures, and measures to mitigate the impacts of increased stormwater runoff on the receiving riparian and aquatic environment in stream channels. This report focuses on stormwater management within the context of the broader floodland management plans cited above.

NEED FOR AND IMPORTANCE OF STORMWATER MANAGEMENT PLANNING

Stormwater management is one of the most important and costly requirements of sound urban development. Good stormwater management is essential to the provision of an attractive and efficient, as well as safe and healthful, environment for urban life.

Inadequate stormwater management can be costly and disruptive. Inadequate stormwater management can disrupt the safe and efficient movement of people and goods essential to the proper functioning of an urban area; undermine the structural stability of pavements, utilities, and buildings, requiring costly maintenance and reconstruction; and depreciate and destroy the market value of real property, with an attendant loss of tax base. Inadequate stormwater management can result in the excessive infiltration and flow of clear water into sanitary sewerage systems, with attendant surcharging of sanitary sewers, the backing of sanitary sewage into buildings, the bypassing of raw sewage to streams and watercourses through sanitary sewer system flow relief devices, and the attendant creation of serious hazards to public health. It can also damage the natural resource base through unacceptably high increases in the delivery of nonpoint source pollutants to streams and wetlands, increases in the frequency of erosive streamflows, modification or destruction of aquatic habitat, serious and costly soil erosion and sedimentation, and decreases in the amounts of groundwater recharge and stream baseflow.

Stormwater management planning and design requires knowledge and understanding of the complex relationships existing among the many interrelated natural and man-made features that together comprise the hydrologic-hydraulic system of the study area, and of how these relationships may change over time. Because of its important social, economic, and environmental impacts, stormwater management is a problem which requires sound resolution through careful application of the sciences of hydrology and hydraulics, as well as the arts of urban planning and engineering.[3]

BASIC CONCEPTS INVOLVED

The basic concept underlying urban stormwater management has evolved from the original concept which sought to remove excess surface water during and after a rainfall as quickly as possible through the provision of an

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[3] *Hydrology may be defined as the study of the physical behavior of the water resource from its occurrence as precipitation to its entry into streams and watercourses or its return to the atmosphere via evapotranspiration. The application of hydrology to the planning and design of urban stormwater management systems requires the collection and analyses or definitive information on precipitation, soils, and land uses, and on the volume and timing of that portion of precipitation which ultimately reaches the surface water system as runoff. Hydraulics may be defined as the study of the physical behavior of water as it flows within pipes and natural and artificial channels; under and over bridges, culverts, and dams; and through lakes and impoundments. The application of hydraulics to the planning and design of stormwater management systems requires the collection and analysis of definitive information on the configuration of the natural and artificial stormwater management systems of the study area.*

efficient, constructed drainage system, to the current concept which emphasizes storage and enhanced infiltration as well as conveyance of runoff while integrating constructed drainage facilities with the existing natural drainage system. The objectives of the current concept include reducing the peak rate of runoff and in some cases the total volume of runoff; reducing the transport of sediment and other water pollutants to receiving surface waters and wetlands; mitigating the adverse impacts of increased runoff and flow frequency on instream and riparian habitat; and protecting against increased downstream flooding.

The stormwater management system of an urban area may be conceived of as consisting of a major element operating infrequently and a minor element operating frequently. Both of these elements can, under certain conditions, utilize constructed or natural stormwater retention or detention storage, enhanced stormwater infiltration, and conveyance as potential design solutions. The benefits of stormwater storage may include a reduction in the high kinetic energy of surface runoff; a reduction in the peak rate of discharge; the provision of multiple-use opportunities for recreational and aesthetic purposes; and the entrapment of some pollutants. The benefits of enhanced stormwater infiltration may include a reduction in the total volume of runoff; the provision of groundwater recharge; and the maintenance of baseflow in streams. It is anticipated that the utilization of enhanced infiltration will be limited by the soil types present in the subwatershed.

For predominantly developed parts of urban communities—such as the established areas of the City of Brookfield and the Village of Menomonee Falls—the development of stormwater storage and nonpoint source pollution control measures may be constrained by the availability of open land on, or adjacent to, the drainage system, by relatively high costs, and by public concerns regarding safety and aesthetics. Nevertheless, successful efforts have been made to integrate such measures into the existing urban environment and they deserve careful consideration as a part of any sound stormwater management planning effort. In outlying, developing areas, the incorporation of stormwater storage facilities and nonpoint source pollution control measures may be more feasible owing to the availability of land and the opportunity to plan for such facilities as an integral part of the urban development process.

Facilities designed solely for the control of stormwater quantity, including storm sewers and dry detention basins which drain completely between storms, provide little or no reduction in nonpoint source pollutant loadings to receiving watercourses. However, when such facilities are integrated with nonpoint source pollution control measures such as source controls, wet detention basins, infiltration facilities, grass swales and waterways, regular street sweeping, and catch basin cleaning, a significant reduction in pollutant loadings may be achieved.

SCOPE OF THE STORMWATER AND FLOODLAND MANAGEMENT PLAN

The recommended stormwater and floodland management plan set forth in this report incorporates compatible multiple-use planning concepts and recognizes the constraints imposed by other community needs, such as park and open space, transportation, sanitary sewerage, and water supply. Stormwater and floodland management requirements under existing and planned full development land use conditions are evaluated. Floodland management recommendations for Butler Ditch have been made in the Menomonee River watershed study and refined under the drainage and flood control planning effort for the Milwaukee Metropolitan Sewerage District as noted above. Those recommendations provide a point of departure for the stormwater and floodland management plan set forth in this report. As shown on Map 1, the plan encompasses the entire 5.5-square-mile Butler Ditch subwatershed within the City of Brookfield and the Village of Menomonee Falls upstream of the confluence of Butler Ditch with the Menomonee River.

REVIEW OF PREVIOUS STUDIES

During preparation of the stormwater management plan, the findings and recommendations of previous studies related to stormwater and/or floodland management within the study area were reviewed. Those studies are listed below in chronological order and their salient findings and recommendations are summarized.

1. *A Comprehensive Plan for the Menomonee River Watershed*, SEWRPC Planning Report No. 26, October 1976.

   The recommended comprehensive plan for the Menomonee River watershed included a land use plan for the year 2000, a floodland management plan element, and a water quality management plan element. The floodland management plan element recommended floodproofing of 20 buildings along Butler Ditch in the City of Brookfield. That total included buildings that were outside the 100-year recurrence interval floodplain, but which could experience secondary basement flooding. The nonpoint source pollution control component of the water quality management plan called for low-cost control measures to be implemented through a combination of information and education programs and local ordinances. The recommended measures included construction erosion control, proper application of pesticides and fertilizers, proper material storage, control of pet waste, reevaluation of municipal street cleaning and de-icing operations, and consideration of the use of detention storage facilities to reduce the amounts of nonpoint source pollutants delivered to surface waters.

2. *A Stormwater Drainage and Flood Control System Plan for the Milwaukee Metropolitan Sewerage District*, SEWRPC Community Assistance Planning Report No. 152 (CAPR No. 152), December 1990

   On the basis of updated hydrologic and hydraulic data, this plan identified no direct flood hazard during events with recurrence intervals up to, and including, 100 years. Thus, the plan did not recommend structure floodproofing as was called for under the Menomonee River watershed study. The stormwater and floodland management recommendations for the Butler Ditch subwatershed were limited to minor deepening of the Butler Ditch channel from the storm sewer outfall at Dolphin Drive to W. Lisbon Road in order to provide an adequate outfall for the existing Dolphin Drive storm sewer.

3. *A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume Three, *Recommended Plan*, SEWRPC Planning Report No. 30, June 1979.

   For the Butler Ditch subwatershed, this plan recommended the implementation of control measures to reduce urban nonpoint source pollutant loadings by 25 percent, along with construction erosion control, and streambank erosion control.

4. *A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project*, Wisconsin Department of Natural Resources and Wisconsin Department of Agriculture, Trade, and Consumer Protection in cooperation with the Ozaukee, Washington, and Waukesha County Land Conservation Departments and the Menomonee River Advisory Subcommittee, March 1992.

   The adopted regional water quality management plan recommends that local agencies charged with responsibility for nonpoint source pollution control prepare refined and detailed local-level nonpoint source pollution control plans. Such plans are to identify the nonpoint source pollution control practices that should be applied to specific lands. Working with the individual county land conservation committees and local units of government involved, as well as the Commission, the Wisconsin Department of Natural Resources carried out the recommended detailed planning for nonpoint source water pollution abatement on a watershed-by-watershed basis. The Menomonee River priority watershed study is one of the detailed plans resulting from that program.

   The Menomonee River priority watershed study report includes an evaluation of surface water resources, water quality, and aquatic habitat conditions; development of water resource objectives; identification of nonpoint pollution sources and control needs; recommendations for an urban nonpoint source pollution control program; and a description of a program for implementation of the plan for the Menomonee River watershed.

The water resource-related objective established under the plan for Butler Ditch is to enhance the existing biological and recreational uses. In the context of urban nonpoint source pollution control, the proposed means of attaining those objectives include a reduction in the quantities of sediment delivered from uplands and stream banks; control of construction erosion; a reduction in runoff pollution from the areas of existing critical urban development, which include commercial and industrial land uses in the Butler Ditch subwatershed; and control of potential runoff pollution from areas of new urban development. Nonpoint source pollution control measures that were considered for the Butler Ditch subwatershed include source controls, maintenance of grassed swales in areas of low- and medium-density residential development, wet detention, and street sweeping.

5. *Menomonee River Phase 1 Watercourse System Management Plan,* prepared for the Milwaukee Metropolitan Sewerage District by Camp Dresser & McKee, August 2000.

   This plan updates SEWRPC CAPR No. 152. This report included determination of 100-year flood flows and stages in Butler Ditch under planned year 2020 land use and existing channel conditions. The plan identified no building flooding problems during a 100-year flood. It recommended the preservation of existing floodwater storage areas and consideration of the adequacy of the outlet for the Dolphin Drive storm sewer.

SUMMARY

The 5.5-square-mile Butler Ditch subwatershed is contained within the City of Brookfield and the Village of Menomonee Falls in northeastern Waukesha County. The subcontinental divide between the Lake Michigan and Mississippi River basins traverses the City and Village from north to south. The Butler Ditch subwatershed is located within the Menomonee River watershed and ultimately drains to Lake Michigan. As shown on Map 1, approximately 4.0 square miles of the northeast portion of the City of Brookfield and 1.4 square miles of the southeast portion of the Village of Menomonee Falls are included in the subwatershed.

The conversion of land in the Butler Ditch subwatershed from rural to urban use in the recent past, and the continuation of such conversion in the future may be expected to aggravate existing stormwater management and flooding problems and, in the absence of sound planning, create new problems. The need to resolve existing problems and to avoid the occurrence of new problems dictates the need to prepare a long-range stormwater and floodland management plan for the subwatershed.

The plan presented in this report seeks to promote the development of an effective stormwater and floodland management system for the study area under full development conditions, which are anticipated to be attained by the year 2010. Such a system will minimize inconvenience and damage attendant to poor drainage and protect and enhance surface water quality and aquatic habitat.

More specifically, this report describes the existing stormwater and floodland management system and the existing problems of the study area, and identifies the causes of these problems; describes existing and planned future land use conditions and identifies related stormwater and floodland management requirements; provides a set of objectives and supporting standards to guide the development of an effective stormwater and floodland management system for the area; presents alternative stormwater and floodland management system plans for the subwatershed; provides a comparative evaluation of the technical, economic, and environmental features of these plans; recommends a cost-effective plan for the subwatershed; and sets forth a plan implementation program.

The plan recognizes that good stormwater and floodland management is essential to the provision of an attractive and efficient, as well as safe and healthful, environment for urban life; and that inadequate stormwater drainage can be costly and disruptive, can create hazards to public health and safety, and can have adverse ecological and environmental impacts. Because of the technical complexity of the problem and the important social, economic, and environmental impacts involved, the plan recognizes that stormwater and floodland management planning must be based upon knowledge of the arts of urban planning and engineering and of the sciences of hydrology and hydraulics; an understanding of the social, economic, and environmental impacts involved; and information on the public attitudes toward stormwater and floodland management.

The basic concept underlying urban stormwater management has evolved from the original concept which sought to remove excess surface water during and after a rainfall as quickly as possible through the provision of an efficient, constructed drainage system, to the current concept which emphasizes storage and enhanced infiltration, as well as conveyance of runoff while integrating constructed drainage facilities with the existing natural drainage system. The objectives of the current concept include reducing the peak rate of runoff and in some cases the total volume of runoff; reducing the transport of sediment and other water pollutants to receiving surface waters and wetlands; mitigating the adverse impacts of increased runoff and flow frequency on instream and riparian habitat; and protecting against increased downstream flooding.

The plan presented herein regards the stormwater runoff system of the area as consisting of a major element operating infrequently and a minor element operating frequently, with both of these elements incorporating, to the extent practicable, the storage and infiltration, as well as conveyance of excess runoff. The recommended stormwater and floodland management plan set forth herein incorporates compatible multi-use planning concepts and recognizes the opportunities provided as well as the constraints imposed by other community needs, such as park and open space, transportation, and water supply.

Chapter II

INVENTORY AND ANALYSIS

INTRODUCTION

Information on certain pertinent natural and man-made features of the study area is essential to sound stormwater and floodland management planning. Accordingly, the collection and collation of definitive information on key hydrologic and hydraulic characteristics, on the existing stormwater management system, and on erosion and sedimentation characteristics constitute an important step in the stormwater and floodland management planning process. The resulting information is essential to the planning process, because sound alternative plans cannot be formulated and evaluated without an in-depth knowledge of the pertinent conditions in the planning area. This is particularly true for stormwater and floodland management, which must address the complex interaction of natural meteorologic events, key hydrologic and hydraulic characteristics of the planning area, and certain man-made physical systems.

This chapter presents data on 1) existing stormwater drainage and flooding problems; 2) surface water quality conditions in the subwatersheds; 3) sources of pollution related to stormwater management; 4) the anticipated type, density, and spatial distribution of land uses in the study area; 5) the impact of the anticipated changes in land use on the stormwater and floodland management needs of the study area; 6) natural resource features of the study area; and 7) biological conditions.

STORMWATER MANAGEMENT STUDY AREA

The study area for stormwater management planning consists of the entire Butler Ditch subwatershed, which is located within the City of Brookfield and the Village of Menomonee Falls as shown on Map 1 in Chapter I. The areal extent of the subwatershed is approximately 5.5 square miles, with about 4.0 square miles in the City of Brookfield and 1.5 square miles in the Village of Menomonee Falls.

LAND USE

This stormwater and floodland management plan is intended to identify the stormwater and floodland management needs of the Butler Ditch subwatershed under existing and planned land use conditions and to propose the best means of meeting those needs. Accordingly, a buildout land use pattern was developed for these subwatersheds, based upon the Waukesha County development plan which was prepared by the Regional Planning Commission under a separate planning effort.[1]

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[1] *SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

The land use plan identifies a recommended land use pattern for buildout land use conditions, which are expected to be achieved by the year 2010. This stormwater and floodland management plan is based upon buildout land use conditions.

The existing year 1995 land use pattern is shown on Map 2. The planned land use pattern is shown on Map 3. The areal extent of the various existing and planned land uses within the subwatersheds are set forth in Table 1. As indicated in Table 1, in 1995 urban land uses occupied 2,694 acres, or about 76.5 percent of the total area of the Butler Ditch subwatershed. About 558 acres of rural land, or about 15.8 percent of the subwatershed, may be expected to be converted from rural to urban uses over the plan design period. This conversion would increase the amount of land in urban use within the subwatershed by about 20.7 percent. Of the total area to be converted, about 339 acres, or 60.8 percent, would be converted to residential use, and about 219 acres, or 39.2 percent, to other urban uses, including commercial, industrial, governmental and institutional, and recreational.

Under planned ultimate land use conditions, rural land uses would be expected to account for about 273 acres, or about 7.7 percent of the total area of the subwatershed. Under planned land use conditions, almost all of the remaining rural open land would be contained in the primary environmental corridor along the main stem and the South Branch of Butler Ditch. An additional small area of rural land would be located in an isolated natural resource area in the northwestern portion of the subwatershed in the Village of Menomonee Falls.

LAND USE REGULATIONS

Pertinent land use regulations in the subwatershed include zoning and land subdivision control ordinances. Comprehensive zoning represents one of the most important tools available to local units of government for controlling the use of land in the public interest, and such zoning has important implications for stormwater management.

The zoning and subdivision control ordinances for the City of Brookfield and the Village of Menomonee Falls serve to regulate the type, location, and intensity of the various land uses, and the improvements provided for new urban development. These ordinances regulate aspects of development which influence both the amount and rate of stormwater runoff, and the quality of that runoff. For example, the size of lots and the placement and size of structures on them, as regulated by the zoning ordinances, affect the proportion of the land surface covered by impervious surfaces. Generally, as imperviousness increases, the rate and volume of stormwater runoff increase while the quality of the runoff decreases. The type and design of the stormwater drainage system, as regulated by the subdivision control ordinances, also affect the quantity and quality of stormwater runoff. For example, storm-sewered urban areas usually generate higher runoff rates and amounts, and a lower runoff quality, than do areas drained by vegetated open channels.

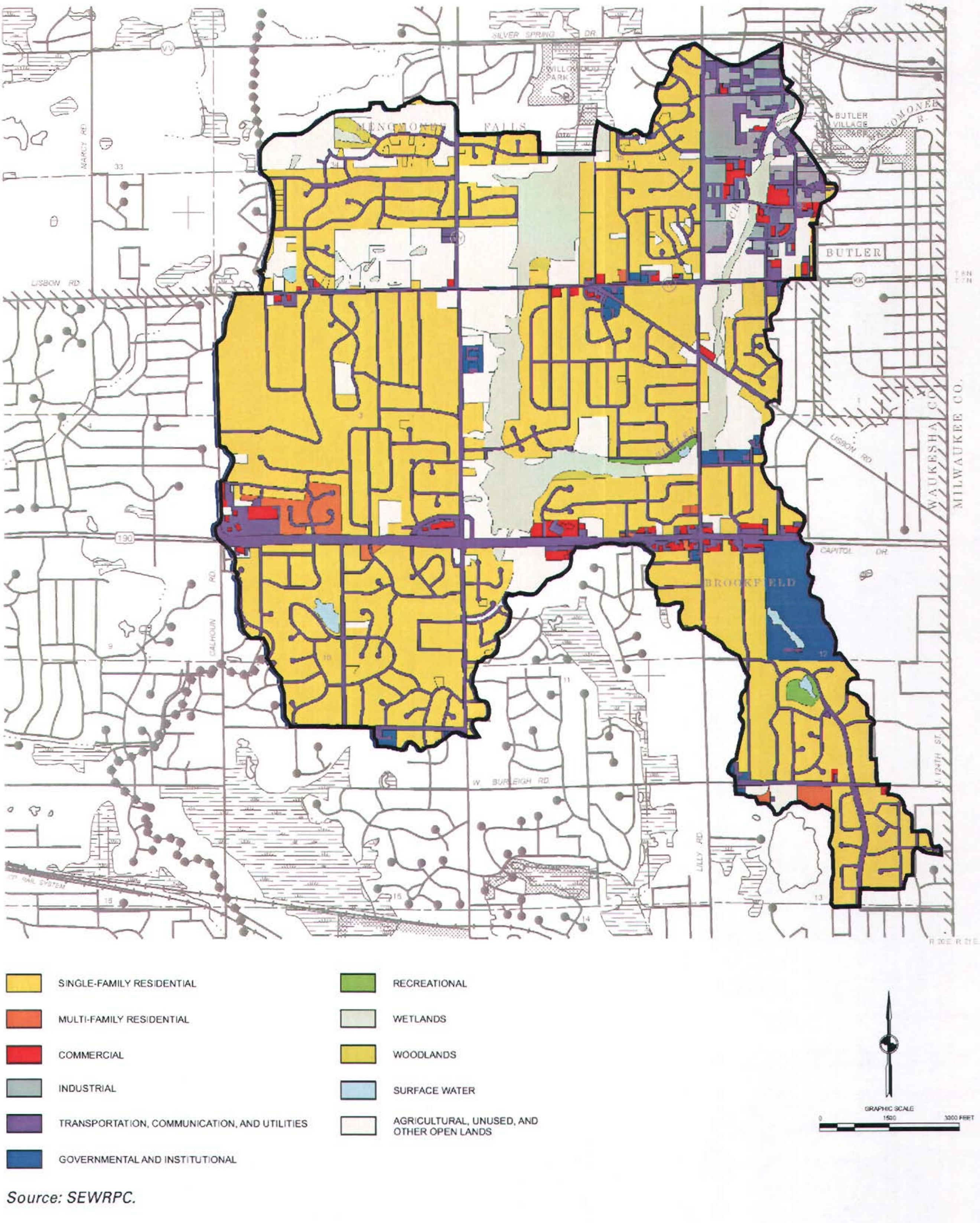
IMPACT OF CHANGING LAND USE ON SUBWATERSHED STORMWATER MANAGEMENT SYSTEMS

Land use and cover in the study area markedly influence the stormwater runoff process. Land cover differs from land use in that it describes a type of surface: roofed, paved, grassed, or wooded, for example; land use describes the function or activity served: residential, commercial, or recreational, for example. Table 2 lists the ranges of surface imperviousness for various land use and land cover conditions.

Increases in rates and volumes of runoff due to the conversion of land from rural to urban use can increase bank erosion and bed scour in receiving streams. In addition, increased imperviousness in areas of groundwater recharge may cause a reduction in stream base flow. Stormwater runoff from urban lands also carries different types and increased amounts of pollutants compared to runoff from rural lands.

Map 2

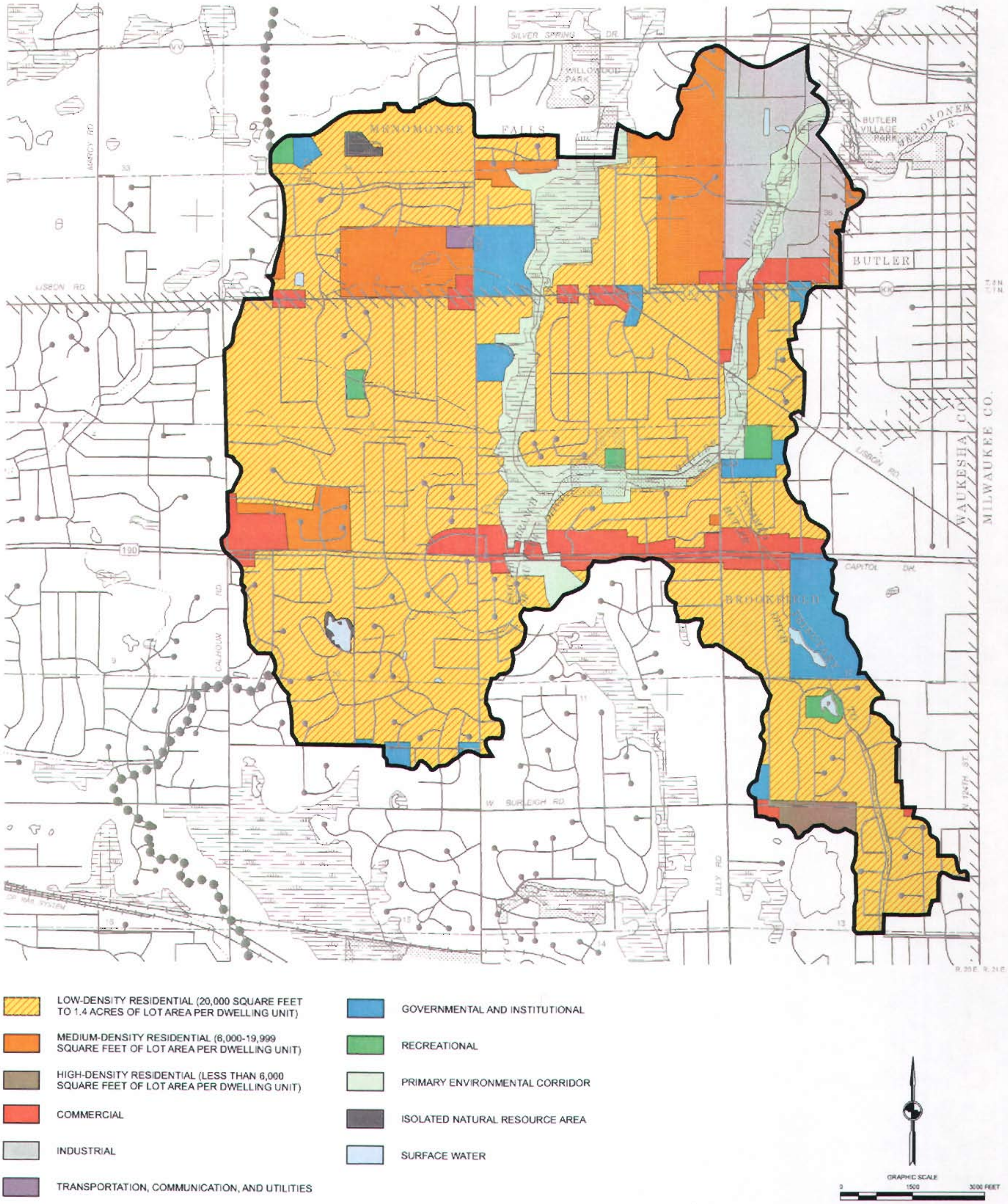
EXISTING LAND USE WITHIN THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS



Source: SEWRPC.

Map 3

RECOMMENDED LAND USE WITHIN THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS



Source: SEWRPC.

Table 1

EXISTING AND PROBABLE FUTURE LAND USE IN THE BUTLER DITCH SUBWATERSHED: 1995 AND BUILDOUT

Land Use Category	Existing 1995		Planned Increment		Buildout Total	
	Acres[a]	Percent of Total	Acres[a]	Percent Change	Acres[a]	Percent of Total
Urban						
Residential	2,363	67.1	339	14.4	2,702	76.7
Commercial	111	3.2	87	78.4	198	5.6
Industrial	102	2.9	66	64.7	168	4.8
Governmental and Institutional	106	3.0	42	40.0	148	4.2
Recreational	12	0.3	24	200.0	36	1.0
Subtotal	2,694	76.5	558	20.7	3,252	92.3
Rural						
Woodlands	13	0.4	0	0.0	13	0.4
Wetlands	213	6.0	0	0.0	213	6.0
Surface Water	12	0.3	0	0.0	12	0.3
Agricultural and Other Open Lands	593	16.8	-558	-94.0	35	1.0
Subtotal	831	23.5	-558	-67.2	273	7.7
Total	3,525	100.0	- -	- -	3,525	100.0

[a] *Areas include adjacent roads and/or parking lots.*

Source: SEWRPC.

Table 2

RANGE OF SURFACE IMPERVIOUSNESS FOR LAND USE AND LAND COVER CONDITIONS

Description	Range of Percent Imperviousness	Typical Corresponding Land Use/Cover Combinations
Rural	0-8	Agricultural lands, woodlands, wetlands, and unused lands
Low Imperviousness	9-20	Low-density residential with supporting urban uses and associated land cover
Low to Medium Imperviousness	21-33	Low- to medium-density residential with supporting urban uses and associated land cover
Medium Imperviousness	34-45	Medium-density residential with supporting urban uses and associated land cover
High Imperviousness	46-65	High-density residential with supporting urban uses and associated land cover
Very High Imperviousness	66-100	Commercial and industrial and associated land cover

Source: SEWRPC.

The stormwater and floodland management system of a watershed should serve to support the existing, and promote the planned, land use pattern of the watershed. Therefore, consideration of both the existing and probable land use pattern of the watershed is necessary for the development of effective alternative stormwater and floodland management plans and for the selection of a recommended plan.

CLIMATE

Air temperatures and the type, intensity, and duration of precipitation affect the extent of areas subject to inundation and the type and magnitude of stormwater and flooding problems within the subwatershed. The subwatershed has the typical continental-type climate, characterized primarily by a continuous progression of markedly different seasons and a wide range in monthly temperatures. The subwatershed lies in the path of both low pressure storm centers moving from the west and southwest and high pressure fair weather centers moving in a generally southeasterly direction. The confluence of these air masses results in frequent weather changes, particularly during spring and winter. These temporal weather changes consist of marked variations in temperature, precipitation, relative humidity, wind speed and direction, and cloud cover. The meteorologic events influence the rate and amount of stormwater runoff, the severity of storm drainage problems, and the required capacities of stormwater conveyance and storage facilities. Definitive, long-term meteorologic data are available for the Milwaukee National Weather Service (NWS) station, at General Mitchell International Airport (GMIA) in reasonable proximity to the Butler Ditch subwatershed.

Temperature and Seasonal Considerations

Table 3 presents average monthly air temperature data for the Milwaukee NWS GMIA station for the 30-year period from 1971 through 2000. The growing season in the Southeastern Wisconsin Region averages about 180 days and is defined as the number of days between the last 32°F temperature reading in the spring and the first such reading in fall. That frost in spring usually occurs in late April, whereas the first freeze in fall usually occurs during the latter half of October. Streams, ponds and lakes begin to freeze over in late November; ice breakup usually occurs in late March or early April. Ice jams at bridges and culverts in spring can be a source of localized flooding, which can be severe when combined with spring rainfall.

Precipitation

Precipitation within the subwatershed takes the form of rain, sleet, hail, and snow, ranging from gentle showers of trace quantities to brief, but intense and potentially destructive, thunderstorms or major rainfall-snowmelt events. These may cause property damage, inundation of poorly drained areas, stream flooding, street and basement flooding, and severe soil erosion and sedimentation. Average monthly and annual total precipitation and snowfall data from the Milwaukee NWS GMIA station for the period 1971 through 2000 are presented in Table 4. The average annual total precipitation based on the Milwaukee NWS station data is 34.81 inches, expressed as water equivalent, while the average annual snowfall and sleetfall measured as snow and sleet is 52.6 inches. Assuming that 10 inches of measured snowfall and sleetfall are equivalent to one inch of water, the average annual snowfall of 52.6 inches is equivalent to 5.26 inches of water and, therefore, only about 15 percent of the average annual total precipitation occurs as snowfall and sleet.

An important consideration in stormwater drainage is the seasonal nature of precipitation patterns. Based on historical observations, flooding in the Butler Ditch subwatershed is likely to occur at any time throughout the year except during winter. This is because the drainage area is relatively small and flood peaks are influenced by the effects of poorly drained soils and urban development. The relatively large proportions of poorly to very poorly drained soils, along with impervious surfaces in urban areas, inhibit infiltration. This increases surface runoff during even minor rainfall events. Because the dampening effects of infiltration, including leaf interception during summer months, are diminished in urban areas, the annual distribution of flood events in urbanized watersheds is similar to the annual distribution of significant rainfall events, and significant flood events may be expected to occur during spring, summer, and fall.

Extreme precipitation data for long-term meteorological data stations that are in the Southeastern Wisconsin Region and near the Butler Ditch subwatershed are presented in Table 5.

Snow Cover and Frost Depth

The likelihood of snow cover and the depth of snow on the ground are important precipitation-related factors that influence the planning, design, construction, and maintenance of stormwater management and flood control

Table 3

AVERAGE MONTHLY AIR TEMPERATURE AT MILWAUKEE: 1971 THROUGH 2000

Month	Average Daily Maximum (°F)	Average Daily Minimum (°F)	Mean (°F)
January	28.0	13.4	20.7
February	32.5	18.3	25.4
March	42.6	27.3	34.9
April	53.9	36.4	45.2
May	66.0	46.2	56.1
June	76.3	56.3	66.3
July	81.1	62.9	72.0
August	79.1	62.1	70.6
September	71.9	54.1	63.0
October	60.2	42.6	51.4
November	45.7	31.0	38.4
December	33.1	19.4	26.2
Annual	55.9	39.2	47.5

Source: National Weather Service, Midwest Regional Climate Center, and SEWRPC.

Table 4

AVERAGE MONTHLY TOTAL PRECIPITATION AND SNOWFALL AT MILWAUKEE: 1971 THROUGH 2000

Month	Average Total Precipitation (inches)	Average Snowfall (inches)
January	1.85	15.3
February	1.65	11.3
March	2.59	7.4
April	3.78	2.6
May	3.06	0.1
June	3.56	0.0
July	3.58	0.0
August	4.03	0.0
September	3.30	0.0
October	2.49	0.4
November	2.70	3.7
December	2.22	11.8
Annual	34.81	52.6

Source: National Weather Service, Midwest Regional Climate Center, and SEWRPC.

facilities. Snow cover in the Butler Ditch subwatershed is most likely during the months of December, January, and February, when at least a 50 percent probability exists of having one inch or more of snow cover. The amount of snow cover influences the severity of spring snowmelt-rainfall flood events, which usually occur during March.

The depth and duration of ground frost, or frozen ground, influences hydrologic processes, particularly such factors as the proportion of rainfall or snowmelt that will run off the land directly into storm sewerage systems and surface watercourses. The amount of snow cover is an important determinant of frost depth. Since the thermal conductivity of snow cover is less than one-fifth that of moist soil, heat loss from the soil to the colder atmosphere is greatly inhibited by the insulating snow cover. Frozen ground is likely to exist throughout the study area for approximately four months each winter season, from late November through March, with frost penetration to a depth ranging from six inches to more than four feet occurring in January, February, and the first half of March.

SOILS

Soil properties are an important factor influencing the rate and amount of stormwater runoff from land surfaces. The type of soil is also an important consideration in the evaluation of shallow groundwater aquifer recharge and stormwater retention, detention, and infiltration facilities. The soil characteristics, the slope, and vegetative cover of the land surface also affect the degree of soil erosion which occurs during runoff events.

In order to assess the significance of the diverse soils found in southeastern Wisconsin, the Southeastern Wisconsin Regional Planning Commission negotiated a cooperative agreement with the U.S. Soil Conservation Service in 1963 under which detailed operational soil surveys were completed for the entire Region. The results of the soil surveys have been published in SEWRPC Planning Report No. 8, *Soils of Southeastern Wisconsin*. The regional soil surveys have resulted in the mapping of the Region's soils in great detail. At the same time, the surveys have provided data on the physical, chemical, and biological properties of the soils, and, more importantly, have provided interpretations of the soil properties for planning, engineering, agricultural, and

Table 5

EXTREME PRECIPITATION EVENTS FOR SELECTED LONG-TERM STATIONS NEAR THE BUTLER DITCH SUBWATERSHED

Observation Station		Period of Precipitation Records	Total Precipitation (water equivalent, inches)							
			Maximum Annual		Minimum Annual		Maximum Monthly		Maximum Daily	
Name	County		Amount	Year	Amount	Year	Amount	Date	Amount	Date
Milwaukee	Milwaukee	1870-2001	50.36	1876	18.69	1901	10.03	June 1917	6.84[a]	August 6, 1986
Waukesha	Waukesha	1892-2001	44.73	2000	16.90	1901	11.41	July 1952	5.09	July 18, 1952

Observation Station		Period of Precipitation Records	Snowfall (inches)							
			Maximum Annual		Minimum Annual		Maximum Monthly		Maximum Daily	
Name	County		Amount	Year	Amount	Year	Amount	Date	Amount	Date
Milwaukee	Milwaukee	1870-2001	109.0[b]	1885-1886	11.0[b]	1884-1885	52.6	January 1918	20.3[c]	February 4-5, 1924
Waukesha	Waukesha	1892-2001	83.0[d]	1917-1918	9.1	1967-1968	56.0	January 1918	20.0[c]	January 5-6, 1918

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

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

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

[d] *Estimated from incomplete records.*

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

resource conservation purposes, and for underlying stormwater management purposes. Detailed soils maps of the study area are available for use in stormwater management planning.

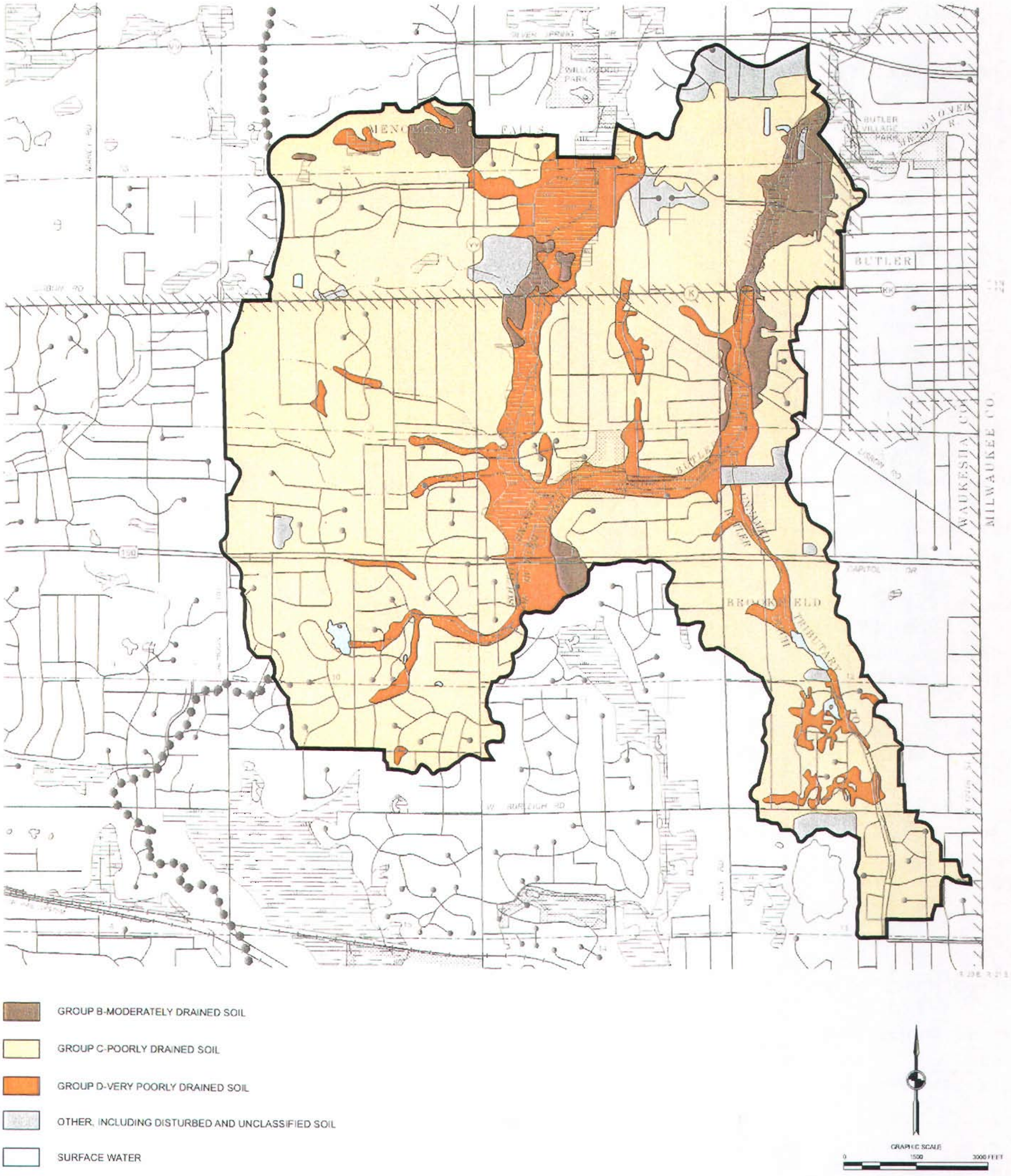
With respect to watershed hydrology, the most significant soil interpretation for stormwater management is the categorization of soils into hydrologic soil groups A, B, C, and D. In terms of runoff characteristics, these four hydrologic soil groups are defined as follows:

- Hydrologic Soil Group A: Very little runoff because of high infiltration capacity, high permeability, and good drainage.
- Hydrologic Soil Group B: Moderate amounts of runoff because of moderate infiltration capacity, moderate permeability, and good drainage.
- Hydrologic Soil Group C: Large amounts of runoff because of low infiltration capacity, low permeability, and poor drainage.
- Hydrologic Soil Group D: Very large amounts of runoff because of very low infiltration capacity, low permeability, and extremely poor drainage.

The spatial distribution of the hydrologic soil groups within the Butler Ditch subwatershed is shown on Map 4. Only groups B, C, and D occur in the study area, with the poorly to extremely poorly drained soils in groups C and D predominating.

Map 4

HYDROLOGIC SOIL GROUPS WITHIN BUTLER DITCH STUDY AREA



Source: SEWRPC.

BEDROCK

Bedrock is exposed in the Butler Ditch channel in both the headwaters and the downstream reach in the Village of Menomonee Falls. Thus, it is possible that bedrock could be encountered during construction of stormwater management facilities near the channel in those reaches.

STORMWATER AND FLOODLAND MANAGEMENT SYSTEM

The existing stormwater and floodland management system serving the study area consists of the streams and watercourses of the area together with certain constructed facilities. The performance of this system is influenced by, among other factors, study area topography and the location and extent of the tributary drainage areas, as well as by the characteristics of the streams and watercourses and related man-made drainage facilities.

Topography

Topography, or the relative elevation of the land surface in the study area, is one of the most important considerations in the planning and design of a stormwater management system. Surface topography of the land defines drainage areas, influences the rate and magnitude of surface water runoff and soil erosion, and determines both the uses to which the land can be put and related stormwater management needs.

Large-scale topographic maps for both communities in the watershed were prepared by Waukesha County and the Regional Planning Commission. The maps were prepared to Commission specifications at a scale of one inch equals 100 feet with contours at two-foot intervals. The City of Brookfield maps were prepared in 1998 and the Village of Menomonee Falls maps were prepared in 1987.[2]

The elevation of the Butler Ditch subwatershed ranges from a low of about 715 feet above National Geodetic Vertical Datum 1929 adjustment (NGVD29) in the northwest one-quarter of U.S. Public Land Survey Section 36, Township 8 North, Range 20 East, at the subwatershed outlet in the Village of Menomonee Falls to a high of about 942 feet NGVD29 in the southwest one-quarter of U.S. Public Land Survey Section 3, Township 7 North, Range 20 East, at the subcontinental divide. Land slopes in the Butler Ditch subwatershed range from a low of 0.5 percent to a high of 10 percent. In general, areas with slopes greater than 12 percent have severe limitations for urban residential development and, if developed, present serious potential drainage and erosion problems.

Hydrologic Units and Subbasins

For stormwater management planning purposes, each subwatershed was divided into smaller basic hydrologic units that were further divided into subbasins, as shown on Map 15 in Chapter V. The hydrologic units generally encompass the area draining to one of the streams tributary to Butler Ditch, or the area draining to a storm sewer outfall to the Ditch. The delineation of these areas permits a more accurate representation of the watershed hydrology in the computer models used to simulate stormwater runoff.

A number of considerations entered into the delineation of the subbasins. These included the configuration of the existing drainage system; locations of inlets to the storm sewers or culverts; locations of the discharge points of storm sewers or culverts to the major surface drainage channels; discharge points at confluences of drainage channels, tributaries, and the main stem of Butler Ditch; and at, or near, bridges and culverts along the main stem.

Streams, Drainage Channels, Storm Sewers, and Ponds

Perennial streams are watercourses which maintain a continuous flow throughout the year. Intermittent streams are those watercourses which do not sustain continuous flow during dry periods.

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[2] *Subsequent to preparation of the stormwater and floodland management analyses, a digital terrain model was developed for all of Waukesha County. Within the City of Brookfield, that model was developed from the data used for the 1998 large-scale topographic mapping program. Within the Village of Menomonee Falls, land surface elevation data were collected in 2000 as part of the program to create the digital terrain model.*

Butler Ditch is the only perennial stream in the subwatershed. The South Branch of Butler Ditch and the Unnamed Tributary to Butler Ditch are intermittent streams. The perennial and intermittent streams in the subwatershed receive runoff from storm sewers, culverts, roadside swales, drainageways, and drainage ditches. All known perennial and intermittent streams and ponds in the study area are shown on Map 5.

Constructed stormwater drainage facilities within the Butler Ditch subwatershed, defined as constructed channels or roadside swales, storm sewers and appurtenances, and ditch enclosures, as opposed to natural watercourses, have a combined service area of about 60 percent of the subwatershed area.

In general, the constructed stormwater drainage systems are maintained by the Public Works Departments of the City of Brookfield and the Village of Menomonee Falls. Waukesha County maintains Lisbon Road from W. Hampton Avenue to the west limits of the Butler Ditch subwatershed. Maintenance activities include sewer inspection; sewer, culvert, catch basin, and channel cleaning; and minor repair work on sewers, manholes, catch basins, and inlets.

Both the City of Brookfield and the Village of Menomonee Falls have adopted stormwater management ordinances that regulate stormwater runoff from new urban development and redevelopment.

The City ordinance requires that the quality of stormwater runoff be controlled as specified in the adopted City stormwater management plan. Unless specified otherwise in the City plan, the ordinance requires facilities to remove, on an average annual basis, 80 percent of the total suspended solids load based on no controls. The ordinance also requires that post-development peak rates of runoff for streams in the Menomonee River subwatershed be controlled as required under the Milwaukee Metropolitan Sewerage District's Chapter 13 "Surface Water and Storm Water" rule.

Stormwater management requirements for the Village of Menomonee Falls are specified in Chapter 38, "Environment," of the Village code of ordinances. The ordinance requires compliance with the two- and 100-year storm release rates specified under the Milwaukee Metropolitan Sewerage District Chapter 13, "Surface Water and Storm Water," rule.[3]

Wetlands

Wetlands are natural areas in which the groundwater table lies near, at, or above the surface of the ground, and which support certain types of vegetation. Wetlands are usually covered by organic soils, silts, and marl deposits. Wetlands provide valuable ecological habitats and stabilize streamflows by storing peak discharges and releasing water during low-flow conditions. Wetlands also have important recreational, educational, and aesthetic values.

A sound stormwater and floodland management plan should, to the extent practicable, utilize the stormwater storage capacity of any existing natural wetlands, while preserving the quality of the wetlands. Thus, wetland preservation is an integral part of this plan. Wetlands in the study area were identified in a special inventory conducted by the Commission using aerial photographic interpretation and field inspection supplemented by analysis of mapped soil data. The location and extent of wetlands in the subwatershed are shown on Map 2. Those areas should remain the same under buildout conditions.

Bridges, Culverts, and Other Structures

Bridges and culverts significantly influence the hydraulic behavior of a stream system. Constrictions caused by bridges and culverts can, during storm events, result in backwater effects, thereby creating a floodland storage area upstream of the structure that is larger than that which would exist in the absence of the bridge or culvert. Depending on the character of the upstream lands, the floodland area may be a valuable flood storage zone if open

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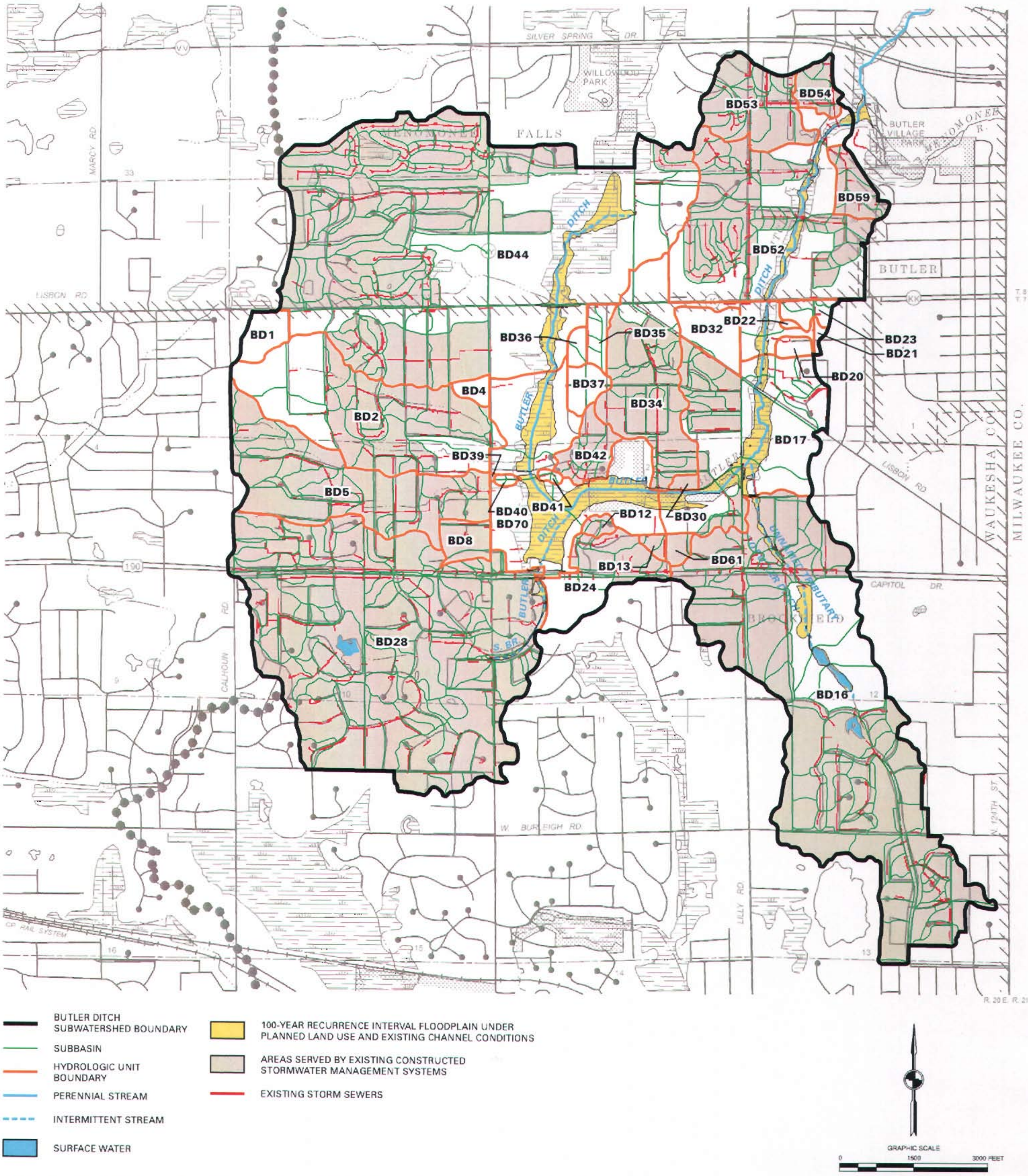
[3] *As noted in Chapters III and V of this report, the Village requires the use of larger 100-year design storm depths than does MMSD Chapter 13.*

Map 5

SELECTED CHARACTERISTICS OF THE SURFACE WATER DRAINAGE SYSTEM IN THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS: 2001



Source: City of Brookfield, Village of Menomonee Falls, Ruekert & Mielke, Inc., and SEWRPC.

lands are inundated or it may be a flooding problem area if structures and roads are flooded. Thus, if restrictive bridges or culverts do not contribute to the creation of an upstream flood and hazard and if the associated roadway meets established standards relative to the frequency of overtopping during floods, replacement with a larger structure may not be desirable. Such replacement could create new downstream flooding problems, or exacerbate existing problems, by reducing the available flood storage volume and increasing downstream flood flows and stages.

Table 6 provides information on the size and types of bridges and culverts along Butler Ditch and its tributaries.

Flood Discharges and Natural Floodlands

Floodlands in Wisconsin are regulated pursuant to Chapter NR 116 of the *Wisconsin Administrative Code*. The provisions of Chapter NR 116 require counties, cities, and villages to regulate activities within the area along a stream that is estimated to be inundated by runoff arising from a one in 100-year recurrence interval flood. Floodland regulations are set forth in local zoning ordinances. The Wisconsin Department of Natural Resources (WDNR) has oversight authority relative to the administration of the local floodland zoning ordinances.

As stated in Chapter I of this report, flood insurance studies were prepared for the City of Brookfield and the Village of Menomonee Falls, including Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch, by the Federal Emergency Management Agency as documented in the August 1986 *Flood Insurance Study for the City of Brookfield, Waukesha County, Wisconsin*, and the March 1978 *Flood Insurance Study for the Village of Menomonee Falls, Waukesha County, Wisconsin*. The Federal flood insurance study reports include flood insurance rate maps which show the expected elevations of the base 100-year flood and the attendant flood hazard areas.[4]

The flood flows developed for those studies were reviewed and updated for the floodland management element of this study. Chapter VI of this report presents refined estimates of the flood flows under planned land use and existing and planned channel conditions.

Stormwater Drainage and Flooding Problems

Stormwater drainage and flooding problems are described in detail in Chapter V of this report. The identified existing and potential drainage problems were considered in the evaluation of the existing stormwater drainage system and in the design of alternative stormwater and floodland management system plans. Those plans are thus intended to abate stormwater drainage and flooding problems during storms with recurrence intervals up to, and including, 100 years. Because the June 1997 and August 1998 storms described in Chapter V had recurrence intervals in excess of 100 years and because localized drainage system inadequacies, electrical power outages, and sanitary sewer infiltration contributed to flooding problems during those storms, the recommended measures would not completely eliminate all problems experienced during such storms. However, the measures would reduce the severity of the problems experienced even during storms with recurrence intervals greater than 100 years.

DESCRIPTION OF SOURCES OF WATER POLLUTION

The quality of the surface waters in the Butler Ditch subwatershed is an important concern of this study. In general , improper stormwater management may result in pollutant contributions to the streams and also in high flow velocities and volumes, which can cause erosion of streambanks and scour of the streambed; however, significant streambank erosion problems have not been observed in the Butler Ditch subwatershed. Deposition of sediment in streambeds may influence water quality conditions over a relatively long period of time. Erosion and the resulting sediment contributed to the stream systems can destroy important stream and riparian habitat and

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[4] *The FEMA flood insurance rate map for the Village was revised in October 1981.*

Table 6

STRUCTURE INFORMATION FOR BUTLER DITCH AND TRIBUTARIES

Structure Number	Structure Identification	U.S. Public Land Survey Section	Structure Type and Size[a]	Structure Length (feet)	Upstream Invert Elevation (feet NGVD29)	Downstream Invert Elevation (feet NGVD29)
Butler Ditch						
1604	Campbell Road	SE1/4, NW1/4, Sec 36 T8N, R20E	Three 9.7-foot-wide-by 6.6-foot-high CMPA	110	728.5	728.5
1608	Overview Drive	NW1/4, SW1/4, Sec 36 T8N, R20E	Three 9.7-foot-wide by 6.6 foot-high CMPA	70	740.0	739.6
1615	Hampton Road	NW1/4, NW1/4, Sec 1 T7N, R20E	26.0-foot-wide, two-span concrete bridge	58	742.7	742.7
1620	Lisbon Road	SW1/4, NW1/4, Sec 1 T7N, R20E	36.0-foot-wide concrete bridge	38	749.4	749.4
1625	Lilly Road	NE1/4, SE1/4, Sec 2 T7N, R20E	Three 7.5-foot-wide by 5.1-foot-high CMPA	44	751.4	751.1
1635	Shamrock Lane	NW1/4, SW1/4, Sec 2 T7N, R20E	42.0-foot-wide, two span concrete bridge	40	761.5	761.5
1645	Lisbon Road	NE1/4, NW1/4, Sec 2 T7N, R20E	Two 6.1-foot-wide by 3.4-foot-high CMPA	50	769.4	769.4
South Branch of Butler Ditch						
1690	Glenwood Executive Center Drive	SW1/4, SW1/4, Sec 2 T7N, R20E	24.0 foot-wide concrete bridge	63	761.7	761.1
1695	West Capitol Drive	NW1/4, NW1/4, Sec 11 T7N, R20E	Two 12.0-foot-wide by 4.0-foot-high concrete box culvert	150	760.4	760.1
Unnamed Tributary to Butler Ditch						
1650	School property enclosure	NW1/4, SW1/4, Sec 1 T7N, R20E	Two 3.0-foot-diameter CMP	320	754.1	752.3
1650A	Hope Street	NW1/4, SW1/4, Sec 1 T7N, R20E	Two 3.0-foot-diameter CMP	36	754.6	754.1
1655	Private drive	SW1/4, SW1/4, Sec 1 T7N, R20E	Two 3.0-foot-diameter CMP	22	760.1	759.3
1660	Private drive	SW1/4, SW1/4, Sec 1 T7N, R20E	Two 3.0-foot-diameter CMP	22	761.0	760.9
1670/ 1670A	N. 138th Street	SW1/4, SW1/4, Sec 1 T7N, R20E	Two 3.0-foot-diameter CMP	103	762.5	762.2
1670A/ 1670C	Parking lot enclosure	SW1/4, SW1/4, Sec 1 T7N, R20E	5.5-foot-diameter RCP and 5.0-foot-diameter RCP	126	762.6	762.5
1670C/ 1670E	West Capitol Drive	NW1/4, NW1/4, Sec 12 T7N, R20E	Two 4.0-foot-diameter RCP	500	763.2	762.5
1675	Private crossing	NW1/4, NW1/4, Sec 12 T7N, R20E	1.5-foot-diameter CMP	201	765.8	764.7
1680	Wisconsin Memorial Park pond outlet	SE1/4, NW1/4, Sec 12 T7N, R20E	4.2-foot-wide by 2.4-foot-high concrete box culvert	10	772.0	770.4
1685	Wisconsin Memorial Park Drive	SE1/4, NW1/4, Sec 12 T7N, R20E	Two 5.0-foot-diameter CMP	30	768.1	767.7

[a] CMP = Corrugated Metal Pipe; CMPA = Corrugated Metal Pipe Arch; RCP = Reinforced Concrete Pipe.

Source: SEWRPC.

aquatic life and can result in the discharge of pollutants, such as nutrients, pesticides, and metals, which are transported in the stream system attached to sediment particles. Stormwater runoff from urban lands, including lawns and pavements, can contain high concentrations of water pollutants, such as organic substances, nutrients, fecal coliform organisms, metals, and sediment. High pollutant concentrations and erosion and sedimentation in the streams of the subwatershed reduce their suitability, and the suitability of downstream waters, for recreational uses such as swimming, fishing, and boating; limit the ability of the waterbody to support desirable forms of fish and other aquatic life; adversely affect the aesthetics of the water resource; reduce the hydraulic capacity of drainage channels and streams; and result in the loss of, or damage to, public and private property.

There are eight Wisconsin Pollutant Discharge Elimination Systems (WPDES) industrial stormwater discharge permits for discharges to streams in the study area. There are four WPDES permits for potable water treatment and conditioning. Thus, there are relatively minor point source pollution contributions, and nonpoint sources of pollution account for almost all of the pollutant loadings to Butler Ditch. The nonpoint sources include urban and rural land stormwater runoff, construction site erosion, streambank erosion, atmospheric contributions, and industrial material leaks and spills. Pollutant loading estimates to Butler Ditch are presented in Chapter IV of this report.

Rural Land Runoff

Much of the remaining rural land in the subwatershed is natural, undisturbed woodlands and wetlands that contribute few pollutants to surface waters. No conversion of existing woodlands and wetlands is expected to take place. These natural areas will, thus, remain as important natural buffers to help reduce pollutant loadings to the streams.

Urban Land Runoff

Under buildout land use conditions, urban land uses are expected to cover about 90 percent of the subwatershed. Stormwater runoff from lawns, rooftops, streets and driveways, parking lots, and storage areas contributes sediment, nutrients, organic matter, oil and grease, bacteria, metals, and toxic organic substances to streams. Urban development generally increases stormwater flow rates and runoff volumes and the loadings of some pollutants. Stormwater runoff impacts are most severe in areas having large amounts of impervious areas directly connected to storm sewers or receiving waters. Stormwater pollutant concentrations and loadings vary considerably depending on the land use and land management activities.

Of particular concern is the potential for loadings of some priority pollutants. The priority pollutants are 126 substances identified by the U.S. Environmental Protection Agency as potentially being found in surface waters and which, in excessive concentrations, are toxic to humans or to fish and other aquatic life. Some of these priority pollutants may be deposited in the bottom sediments, potentially contaminating fish food supplies and having toxic effects on benthic organisms. Certain pollutants accumulate in the tissue of aquatic organisms. The Wisconsin Department of Natural Resources has issued fish consumption advisories for some urban streams because of accumulations of polychlorinated biphenyls (PCBs) in the tissue of fish. The U.S. Environmental Protection Agency, as part of the Nationwide Urban Runoff Program completed in 1983,[5] measured the concentration of priority pollutants in 121 urban runoff samples collected at 61 sites located throughout the United States. The Agency reported that 77 of the 126 priority pollutants were each detected in at least one of the urban runoff samples. Each of 17 of the priority pollutants listed in Table 7 were detected in more than 10 percent of the runoff samples. Five of the substances, all metals, were detected in more than 50 percent of the samples tested, with three of those metals, lead, zinc, and copper, detected in more than 90 percent of the samples. The

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[5] *U.S. Environmental Protection Agency,* Results of the Nationwide Urban Runoff Program, *Volume I,* Final Report, *December 1983.*

Table 7

PRIORITY POLLUTANTS DETECTED IN MORE THAN 10 PERCENT OF URBAN STORMWATER RUNOFF SAMPLES TESTED THROUGHOUT THE UNITED STATES: 1983

Priority Pollutant	Detection Level (percent)
1. Lead	94
2. Zinc	94
3. Copper	91
4. Chromium	58
5. Arsenic	52
6. Cadmium	48
7. Cyanide	23
8. α - Hexachlorocyclohexane	20
9. α - Endosulfan	19
10. Pentachlorophenol	19
11. Chlordane	17
12. Fluoranthene	16
13. γ - Hexachlorocyclohexane (Lindane)	15
14. Pyrene	15
15. Phenol	14
16. Phenanthrene	12
17. Dichloromethane (methylene chloride)	11

Source: U.S. Environmental Protection Agency.

metals lead, zinc, copper, and cadmium were also frequently detected at all of the sites monitored under a Nationwide Urban Runoff Program project conducted in Milwaukee County.[6]

Toxic organic substances were less prevalent than were metals in the runoff samples. All of the organic substances tested were identified in 20 percent or less of the samples tested.

The U.S. Environmental Protection Agency reported that acute and/or chronic water quality criteria recommended by the Agency for lead, zinc, copper and cadmium levels were exceeded in some of the urban runoff samples.[7] Exceeding the criteria does not necessarily indicate that an actual violation of the criteria would occur in receiving waters. However, urban runoff constitutes the majority of the flow in Butler Ditch during storm events. Thus, criteria violations could indeed occur in the stream during storm events if nonpoint source controls are not provided.

Table 8 presents a general list of selected toxic substances frequently detected in stormwater runoff from residential and industrial land. Pesticides were most frequently found in residential areas, while industrial land runoff more often contained other toxic organic substances. Metals were frequently found in both residential and industrial land runoff.

Potential sources of selected toxic substances in urban runoff are listed in Table 9. Studies have found that some substances, such as Lindane, dieldrin, polychlorinated biphenyls, and some metals, are contributed to urban waters during both wet weather and dry weather.[8] Automobile use contributes to loadings of several priority pollutants. Substances contributed by coal and wood combustion, plastics, and preserved wood may be difficult to control at their source.

Construction Site Erosion

Construction site erosion is a significant potential source of sediments to Butler Ditch. In the period from 1995 to achievement of buildout land use conditions in 2010, it is expected that 558 acres, or 15.8 percent of the subwatershed will be converted from rural to urban use.

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[6] *R. Bannerman, K. Baun, M. Bohn, P.E. Hughes, and D.A. Graczyk,* Evaluation of Urban Nonpoint Source Pollution Management in Milwaukee County, Wisconsin, *Volume I,* Urban Stormwater Characteristics, Sources, and Pollutant Management by Street Sweeping, *U.S. Environmental Protection Agency, PB 84-113164, 1983.*

[7] *U.S. Environmental Protection Agency,* Results of the Nationwide Urban Runoff Program, *Volume I,* Final Report, *December 1983.*

[8] *R. Pitt and J. McLean,* Toronto Area Watershed Management Strategy Study: Humber River Pilot Watershed Project, *Ontario Ministry of the Environment, Toronto, Ontario, 1986.*

Table 8

SELECTED TOXIC SUBSTANCES FREQUENTLY DETECTED IN RESIDENTIAL AND INDUSTRIAL LAND STORMWATER RUNOFF

Toxic Substance	Residential Land Runoff	Industrial Land Runoff
Haloginated Aliphatics		
1,2,-dichlorethane	- -	X
Methylene chloride	- -	X
Tetrachlorethylene	- -	X
Phthalate Esters		
Bis (2-Ethylene) phthalate	X	- -
Butylbenzyl phthalate	X	X
Diethyl phthalate	- -	X
Di-N-Butyl phthalate	X	X
Polycyclic Aromatic Hydrocarbons		
Phenanthrene	- -	X
Pyrene	- -	X
Chrysene	X	X
Fluoranthene	- -	X
Other Volatile Compounds		
Benzene	X	X
Chloroform	- -	X
Ethylbenzene	- -	X
N-Nitro-sodimethylamine	- -	X
Toluene	- -	X
Metals		
Chromium	- -	X
Copper	X	X
Lead	X	X
Zinc	X	X
Pesticides and Phenols		
Y – Hexachlorocyclohexane (Lindane)	X	- -
Chlordane	X	- -
Dieldrin	X	- -
Endosulfan sulfate	X	- -
Endrin	X	- -
Isophorone	X	- -
Methoxychlor	- -	X
Polychlorinated biphenyls	X	X
Pentachlorophenol	X	X
Phenol	X	- -
α - Hexachlorocyohexane	X	- -

Source: Wisconsin Department of Natural Resources.

Construction activities typically involve soil disturbance, the destruction of the vegetative cover, and changes in surface topography and drainage. In particular, the clearing and grading of construction sites subjects the soils to high erosion rates. Erosion rates from construction sites are typically 10 to 20 times higher than rates from agricultural land.[9] This excessive soil erosion frequently causes onsite construction problems, and the eroded

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[9] *S.J. Goldman, K. Jackson, and T.A. Bursztynsky,* Erosion and Sediment Control Handbook, *McGraw-Hill Book Company, 1986.*

Table 9

POTENTIAL SOURCES OF SELECTED TOXIC SUBSTANCES FOUND IN URBAN RUNOFF

Toxic Substances	Automobile Use	Pesticide Use	Industrial Use
Melogenated Aliphatics			
Methylene chloride	- -	Fumigant	Plastics, paint remover, solvents
Methyl chloride	Leaded gas	Fumigant	Refrigerant, solvent
Phthalate Esters			
Bis(2-ethyhexyl) phthalate	- -	- -	Plasticizer
Butylbenzyl phthalate	- -	- -	Plasticizer, printing inks, paper, stain, adhesive
Di-N-butyl phthalate	- -	Insecticide	- -
Polycyclic Aromatic Hydrocarbons			
Chrysene	Gasoline oil/grease	- -	Solvent
Phenanthrene	Gasoline	- -	Wood and coal combustion
Pyrene	Gasoline, soil, asphalt	Wood preservative	Wood and coal combustion
Other Volatile Compounds			
Benzene	Gasoline	- -	Solvent
Chloroform	Formed from salt, gasoline, asphalt	Insecticide	Solvent, chlorination
Toluene	Gasoline, asphalt	- -	Solvent
Metals			
Chromium	Metal corrosion	- -	Paint, metal corrosion, electroplating
Copper	Metal corrosion	Algicide	Paint, metal corrosion, electroplating
Lead	Gasoline, batteries	- -	Paint
Zinc	Metal corrosion, road salt, rubber	Wood preservative	Paint, metal corrosion
Pesticide and Phenols			
γ – Hexachlorocyclohexane (Lindane)	- -	Mosquito control, seed pretreatment	- -
Chlordane	- -	Termite control	- -
Dieldrin	- -	Insecticide	Wood processing
α – Endosulfan	- -	Insecticide	- -
α – Hexachlorocyclohexane	- -	Insecticide	- -
Pentachlorophenol	- -	Wood preservative	Paint
Polychlorinated biphenyls	- -	- -	Electrical, insulation, paper adhesives

Source: Wisconsin Department of Natural Resources.

sediment often causes sedimentation problems in downstream areas. The sediments are frequently deposited in storm sewers, culverts, drains, and waterways, decreasing their capacities and clogging them, sometimes causing drainage and flooding problems. Furthermore, erosion of the soil from the site is, in many cases, a loss of a valuable natural resource.

These high sediment contributions also contain nutrients which may increase algal growths, reduce water clarity, deplete oxygen supplies, lead to fish kills, and create odors. Ecological damages to nearby streams often include erosion of streambanks and destruction of streambank vegetation, covering of benthic fauna and fish spawning sites with sediment, filling of stream pools, and increased turbidity, which reduces instream photosynthesis and overall stream productivity.

With implementation of controls under 1) existing local construction erosion control ordinances, 2) the recently enacted Chapter NR 151 of the *Wisconsin Administrative Code*, and 3) the anticipated State of Wisconsin stormwater discharge permits which are to be issued to the City of Brookfield and the Village of Menomonee Falls,[10] the relative contribution of sediment from construction sites would be expected to diminish in the future.

Streambank Erosion

The energy of flowing water in a stream channel is dissipated along the stream length by turbulence, streambank and bed erosion, and sediment resuspension. In general, increased urbanization may be expected to result in increased stream flow rates and volumes, with potential increases in streambank erosion and bottom scour. Streambank erosion destroys aquatic habitat, spawning, and feeding areas; contributes to downstream water quality degradation by releasing sediments to the water; and provides material for subsequent sedimentation downstream, which, in turn, covers valuable benthic habitats, impedes navigation, and fills downstream stormwater storage basins, wetlands, ponds, and lakes. These effects may be mitigated by utilization of proper stormwater management practices.

In the early 1990s, the WDNR conducted surveys of streambank erosion in the Butler Ditch subwatershed under the Menomonee River priority watershed study. The stream surveys identified streambank erosion areas along Butler Ditch and estimated the following: the stream length affected; the height of the eroding streambank; the lateral recess, or erosion rate, of the bank; and the weight of sediment lost. Only about 50 linear feet of streambank were estimated to be eroding along Butler Ditch, as characterized in Chapter IV of this report. Commission staff observation of stream conditions during the 2001 field reconnaissance to assess biological conditions in the streams of the subwatershed verified that streambank erosion is not a widespread problem in the study area.

Atmospheric Contributions

Pollutants may also be contributed directly to surface waters through airborne emissions and subsequent dry fallout and washout. Atmospheric sources may be important contributions of sediment, nutrients, metals, and toxic organic substances. The total suspended particulate loading from the atmosphere in urban areas is up to 50 percent higher than in rural areas.[11] These particles also act as carriers for other pollutants.

Important nutrients contributed by the atmosphere are phosphorus and nitrogen. Windblown soil is the major source of phosphorus in dry fallout.[12] Particles containing phosphorus are also washed out by precipitation. Total phosphorus concentrations in rainwater are typically two to three times higher than the levels which can cause eutrophic conditions in lakes. Oxides of nitrogen may react with sodium, potassium, and other metals to form soluble nitrates which, when washed from the atmosphere, may contribute to the fertility of surface waters. Nutrient loadings from the atmosphere are usually highest in spring and summer, when nutrient contributions may have the most significant impact on aquatic plant growth.

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[10] *On February 11, 2000, the City and the Village applied to the WDNR for a stormwater discharge permit as part of a group of communities in the Menomonee River watershed. As of May 2003, the permit had not been issued.*

[11] *International Joint Commission,* The IJC Menomonee River Watershed Study, *Volume 8,* Atmospheric Chemistry of Lead and Phosphorus, *December 1979.*

[12] *U.S. Environmental Protection Agency,* Determination of Atmospheric Phosphorus Addition to Lake Michigan, *EPA-600/3-80-063, July 1980.*

Atmospheric loadings are also important sources of metals, primarily lead, zinc, and cadmium.[13] In the past, a major source of lead was from the exhaust of automobiles burning leaded gasoline. However, the use of unleaded gasoline has resulted in a corresponding decrease in dissolved lead concentrations in surface waters.[14] Lead, like most metals, has an affinity for very small particles.

Atmospheric sources also contribute to loadings of toxic organic substances such as polychlorinated biphenyls and polycyclic aromatic hydrocarbons (PAHs). PCBs, which are insoluble, are usually associated with extremely small particles, from 0.002 to 0.1 micron in diameter.[15] PCB loadings from the atmosphere are highest near industrial areas. Although production of PCBs is now banned, much of the present input of PCBs results from the low-temperature incineration of solid wastes that contain PCBs.[16] PAHs are released to the atmosphere as a by-product of man-made combustion processes.

Leaks and Spills of Industrial Materials

Leaks and spills of industrial materials may be directly discharged to waterways or the materials may be transported to the waterways via stormwater surface runoff and groundwater flow. These materials often contain toxic metals and organic substances which destroy streambank vegetation, contaminate bottom sediments, and harm fish and aquatic life. Contaminated bottom sediments may act as a residual source of the toxic substances, causing long-term effects which persist for years after the occurrence of the spill or leak. Industrial land uses only constituted about 2.9 percent of the total study area under 1995 conditions, and they are anticipated to constitute about 4.8 percent under planned buildout land use conditions. The 1995 regional water quality management plan update indicates that between 1978 and 1995 three spills occurred in the Butler Ditch subwatershed in the Village of Menomonee Falls. Thus, while leaks or spills could occur, the relatively small amount of industrial activity in the study area and historic observations indicate that such leaks or spills would not be prevalent.

EXISTING NONPOINT SOURCE POLLUTION CONTROL FACILITIES AND PROGRAMS WITHIN THE SUBWATERSHED

Under existing conditions, control of nonpoint source pollutants within the Butler Ditch subwatershed is accomplished through the filtering and infiltration effects of roadside drainage swales; through sweeping of streets twice a year; through catch basin cleaning; through stormwater management requirements for new development or redevelopment; and through enforcement of construction erosion control ordinances. In addition, as noted above, eight industrial stormwater discharge permits have been issued in the subwatershed.

DESCRIPTION AND ASSESSMENT OF EXISTING WATER QUALITY AND BIOLOGICAL CONDITIONS

Stormwater management planning efforts require the evaluation of existing water quality conditions and of the relationship of those conditions to existing biological communities.

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[13] *International Joint Commission,* The IJC Menomonee River Watershed Study, *Volume 6,* Dispersibility of Soils and Elemental Composition of Soils, Sediments, and Dust and Dirt from the Menomonee River Watershed, *December 1979.*

[14] *R.B. Alexander and R.A. Smith, "Trends in Lead Concentrations in Major U.S. Rivers and Their Relation to Historical Changes in Gasoline-Lead Consumption,"* Water Resources Bulletin, *Vol. 24, No. 3, pp. 557-568, June 1988.*

[15] *International Joint Commission,* The IJC Menomonee River Watershed Study, *Volume 9,* Atmospheric Chemistry of PCBs and PAHs, *March 1980.*

[16] *U.S. Environmental Protection Agency,* Toxic Substances in the Great Lakes, *EPA 905/9-80-005, June 1980.*

Based upon data from 1984, Butler Ditch is currently designated as only partially meeting both the standards for limited forage fish and full recreation water use objectives. The water quality of Butler Ditch varies from fair to poor, depending upon the indicators considered. From 1983 to 2003, the Wisconsin Department of Natural Resources and SEWRPC staff collected various instantaneous dissolved oxygen and temperature measurements, among others, for specific areas within Butler Ditch that were consistent with standards supporting a warmwater forage fish community. Small physical stream size, limited flow, and past channelization continue to limit the potential fishery. The amount, quality, and diversity of available instream fisheries and macroinvertebrate habitat are generally fair to poor within the Butler Ditch subwatershed. However, fishery data collected in the subwatershed in 2003 indicate an apparent improvement in abundance and diversity of species since the mid-1980s. Although Index of Biotic Integrity (IBI)[17] results continue to indicate an overall limited fishery, the improvements in the abundance and diversity of fishes over the past 20 years indicate that Butler Ditch is potentially capable of meeting the warmwater forage fish and partial recreation water use objectives. Between 2000 and 2010, urban land uses in the subwatershed are expected to increase, which could continue to limit the fishery in terms of hydrology, water quality, and habitat.

A detailed description and assessment of existing water quality and biological conditions in the streams of the subwatershed is provided in Chapter IV.

SUMMARY

An inventory of pertinent hydrologic and hydraulic characteristics of the 5.5-square-mile Butler Ditch subwatershed and related natural and man-made features is an essential step in the stormwater and floodland management planning process. Accordingly, this chapter presents data on 1) the hydrologic phenomena governing the magnitude and frequency of stormwater and flood flows; 2) existing stormwater drainage and flooding problems; 3) surface water quality conditions in the subwatersheds; 4) sources of pollution related to stormwater management; 5) the anticipated type, density, and spatial distribution of land uses in the study area; 6) the impact of the anticipated changes in land use on the stormwater and floodland management needs of the study area; 7) natural resource features of the study area; and 8) biological conditions.

Land use characteristics, including impervious area, the type of storm drainage system, the level and characteristics of human activity, and the type and amount of pollutants deposited on the land surface, greatly influence the quantity and quality of stormwater runoff. Urban land uses within the Butler Ditch subwatershed are expected to increase about 21.2 percent, from a total of 2,628 acres, or 74.6 percent of the subwatershed area in 1995, to about 3,186 acres, or 90.4 percent of the subwatershed area, under planned buildout land use conditions. The residential land use category is expected to experience the largest absolute increase, about 339 acres, to a total in the plan design year of about 2,702 acres, or 76.7 percent of the subwatershed area.

Changes from rural to urban land use affect the amount and quality of stormwater runoff. Increased rates and volumes of runoff result from the higher proportion of impervious areas, such as streets, parking lots, and rooftops. Thus, urban development can increase flood flows, stages, streambank erosion, and streambed scour in downstream watercourses. Such development can also increase the downstream surface-water pollutant loadings and may reduce stream base flows. Therefore, careful planning of urban stormwater management systems to meet sound water resource and related management objectives is essential.

Existing pertinent land use regulations include zoning and land division ordinances. These land use regulations represent important tools for the City of Brookfield and the Village of Menomonee Falls in directing the use of land in the public interest. Such zoning has important implications for stormwater management.

Climatological factors affecting stormwater management include air temperature and the type and amount of precipitation. Air temperature affects whether precipitation occurs as rainfall or snowfall, whether the ground is

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[17] *This index is described in Chapter IV of this report.*

frozen and, therefore, essentially impervious, and the rate of snowmelt and attendant runoff. The seasonal nature of precipitation patterns is an important consideration in stormwater drainage. Flooding along the streams in the study area is likely to occur at any time throughout the year except during winter because of the relatively small drainage areas and the impacts of urban development. The maximum monthly precipitation recorded at the National Weather Service station at General Mitchell International Airport in Milwaukee was 10.03 inches in June 1917 and the maximum 24-hour precipitation was 6.84 inches, recorded on August 6, 1986. The amount of snow cover influences the severity of snowmelt flood events and the extent and depth of frozen soils.

Soil properties influence the rate and amount of stormwater runoff from land surfaces. Most of the study area is covered by soils which generate moderate relatively large amounts of runoff.

Constructed stormwater drainage facilities serve about 60 percent of the subwatershed area. A system of open drainage channels and associated culverts serves the remainder.

Existing stormwater drainage and flooding problems are described in detail in Chapter V of this report.

Possible sources of water pollutants to Butler Ditch and its tributaries include stormwater runoff from urban and rural land, construction site erosion, streambank erosion, atmospheric contributions, and industrial material leaks and spills. Point sources of pollution are not significant relative to nonpoint sources.

Based upon data from 1984, Butler Ditch is currently designated as only partially meeting both the standards for limited forage fish and full recreation water use objectives. The water quality of Butler Ditch varies from fair to poor, depending upon the indicators considered. From 1983 to 2003, the Wisconsin Department of Natural Resources and SEWRPC staff collected various instantaneous dissolved oxygen and temperature measurements, among others, for specific areas within Butler Ditch that were consistent with standards supporting a warmwater forage fish community. Small physical stream size, limited flow, and past channelization continue to limit the potential fishery. The amount, quality, and diversity of available instream fisheries and macroinvertebrate habitat are generally fair to poor within the Butler Ditch subwatershed. However, fishery data collected in the Butler Ditch subwatershed in 2003 indicate an apparent improvement in abundance and diversity of species since the mid-1980s. Although IBI results continue to indicate an overall limited fishery, the improvements in the abundance and diversity of fishes over the past 20 years indicate that Butler Ditch is potentially capable of meeting the warmwater forage fish and partial recreation water use objectives. Between 2000 and 2010, urban land uses in the subwatershed are expected to increase, which could continue to limit the fishery in terms of hydrology, water quality, and habitat.

Chapter III

STORMWATER AND FLOODLAND MANAGEMENT OBJECTIVES, STANDARDS, AND DESIGN CRITERIA

INTRODUCTION

Planning may be defined as a rational process for formulating and meeting objectives. Consequently, the formulation of objectives is an essential task which must be undertaken before plans can be prepared. This chapter sets forth a set of stormwater and floodland management objectives and supporting standards for use in the design and evaluation of alternative system plans for the Butler Ditch subwatershed in the City of Brookfield and the Village of Menomonee Falls, and in the selection of a recommended plan from among those alternatives.

In addition, this chapter sets forth engineering design criteria and describes analytical procedures which were used in the preparation and evaluation of the alternative system plans. These criteria and procedures include the engineering techniques used to design the alternative plan elements; to test the physical feasibility of those elements; and to make necessary economic comparisons between the plan elements. This chapter thus documents the degree of detail and level of sophistication employed in the preparation of the recommended plan, and thereby is intended to provide a better understanding by all concerned of the plan and of the need for refinement of some aspects of the plan prior to and during implementation.

STORMWATER AND FLOODLAND MANAGEMENT OBJECTIVES AND STANDARDS

The following seven stormwater and floodland management objectives were formulated to guide the design, test, and evaluation of alternative plans and the selection of a recommended plan from among the alternatives considered:

1. The development of a stormwater and floodland management system which reduces the exposure of people to drainage-related inconvenience and to health and safety hazards and which reduces the exposure of real and personal property to damage through inundation resulting from flooding and inadequate stormwater drainage.

2. The development of a system which will effectively serve existing and planned future land uses and will promote implementation of the adopted land use plan set forth in the Waukesha County development plan and in the adopted City and Village local land use and zoning plans.[1]

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[1] *SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

3. 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 waterbodies.

4. The development of a system which will maintain or enhance existing terrestrial and aquatic biological communities, including fish and wildlife.

5. The development of a stormwater and floodland management system which will be flexible and readily adaptable to changing needs.

6. The development of a stormwater and floodland management system which will not pollute the groundwater aquifers serving the City and the Village.

7. The development of a stormwater and floodland management system which will efficiently and effectively meet all of the other stated objectives at the lowest practicable cost.

Complementing each of these objectives is a set of quantifiable standards which can be used to evaluate the relative or absolute ability of alternative plan designs to meet each objective. The objectives and standards are set forth in Table 10. Those objectives and standards were developed in close consultation with the City and Village public works and engineering staffs.

The planning standards fall into two groups—comparative and absolute. The comparative standards, by their very nature, can be applied only through a comparison of alternative plan proposals. The absolute standards can be applied individually to each alternative plan proposal since they are expressed in terms of maximum, minimum, or desirable values.

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS

The water use objectives for the surface waters of Wisconsin are set forth in Chapters NR 102 and NR 104 of the *Wisconsin Administrative Code*. Under these Chapters, Butler Ditch is designated to meet the standards for limited forage fish and full recreation water use objectives.[2] Based upon data from the year 1984,[3] this stream is currently designated as only partially meeting both the standards for limited forage fish and full recreation water use objectives and the fishable and swimmable goals for the waters of the United States as set forth in the Federal Clean Water Act. In the Wisconsin Department of Natural Resources (WDNR) stream classification report for Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch, as shown on Map 6, the watercourses are indicated as intermediate fish and aquatic life streams capable of supporting tolerant to very tolerant forage or rough fish and tolerant macroinvertebrates (see Description and Assessment of Existing Water Quality and Biological Conditions in Chapter II). The major recreational limitations noted in Butler Ditch are primarily related to its relatively small size, low flow, and past channelization that has resulted in the loss of important fish and aquatic life habitat.[4] The recommended water quality standards associated with these various water use objectives are set forth in Tables 11 and 12. Based upon recent year 2003 data from the WDNR, Butler

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[2] *Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, *PUBL-WR-244-92, March, 1992.*

[3] *Wisconsin Department of Natural Resources,* Stream Classification for Butler Ditch (South Branch Lilly Creek), Menomonee River Watershed, Milwaukee River Basin, Waukesha County, *September 1984.*

[4] Ibid.

Table 10

OBJECTIVES AND STANDARDS FOR STORMWATER AND FLOODLAND MANAGEMENT IN THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS

OBJECTIVE NO. 1

The development of a stormwater and floodland management system which reduces the exposure of people to drainage-related inconvenience and to health and safety hazards and which reduces the exposure of real and personal property to damage through inundation resulting from inadequate stormwater drainage.

STANDARDS

1. In order to prevent significant property damage and safety hazards, the major components of the stormwater management system and the floodland management system should be designed to accommodate runoff from a 100-year recurrence interval storm event.

2. In order to provide for an acceptable level of access to property and of traffic service, the minor components of the stormwater management system should be designed to accommodate runoff from a 10-year recurrence interval storm event.

3. In order to provide an acceptable level of access to property and of traffic service, the stormwater management system should be designed to provide two clear 10-foot lanes for moving traffic on existing arterial streets, and one clear 10-foot lane for moving traffic on existing collector and land access streets during storm events up to and including the 10-year recurrence interval event.

4. Flow of stormwater along and across the full pavement width of collector and land access streets shall be acceptable during storm events exceeding a 10-year recurrence interval when the streets are intended to constitute integral parts of the major stormwater drainage system.

5. Where practicable, ponding of runoff that could result in inflow to sanitary sewers should be eliminated or reduced to an acceptable level during storms with recurrence intervals up to, and including, 100 years.

6. Plan components shall be designed to comply with the requirements of Chapter NR 116 of the *Wisconsin Administrative Code.*

7. All new and replacement bridges and culverts over waterways shall be designed so as to accommodate, according to the categories listed below, the designated flood events without overtopping of the related roadway or railway track.

    a. Minor and collector streets used or intended to be used primarily for access to abutting properties: a 10-year recurrence interval flood discharge.

    b. Arterial streets and highways, other than freeways and expressways, used or intended to be used primarily to carry heavy volumes of through traffic: a 50-year recurrence interval flood discharge. Where practicable, the depth of overtopping of the arterial streets and highways along the main stem of Butler Ditch should be limited to no more than eight inches during the 100-year recurrence interval flood.

    c. Freeways and expressways: a 100-year recurrence interval flood discharge.

    d. Railways: a 100-year recurrence interval flood discharge.

8. Under planned land use and recommended drainage and channel conditions, two- through 100-year recurrence interval flood flows and stages along the main stem of Butler Ditch should be maintained at, or below, the corresponding flows and stages under existing land use and channel conditions at, and downstream from, municipal boundaries.

9. All new and replacement bridges and culverts along waterways shall be designed so as not to inhibit fish passage in areas which are supporting, or which are capable of supporting, valuable recreational sport and forage fish species.

Table 10 (continued)

OBJECTIVE NO. 2

The development of a stormwater and floodland management system which will effectively serve existing and planned future land uses and will promote implementation of the adopted land use plan set forth in the Waukesha County development plan and in the adopted City and Village local land use and zoning plans.

STANDARDS

1. Stormwater drainage systems should be designed assuming that the layout of collector and land access streets for proposed urban development and redevelopment will be carefully adjusted to the topography in order to minimize grading and drainage problems, to utilize to the fullest extent practicable the natural infiltration, drainage, and storage capabilities of the site, and to provide the most economical installation of a gravity flow drainage system. Generally, drainage systems should be designed to complement a street layout wherein collector streets follow valley lines and land access streets cross contour lines at right angles.

2. Stormwater drainage systems should be designed assuming that the layouts and grades of collector and land access streets can, during major storm events, serve as open runoff channels supplementary to the minor stormwater drainage system without flooding adjoining building sites. The stormwater drainage system design should avoid midblock sags in street grades, and street grades should generally parallel swale, channel, and storm sewer gradients.

3. Street elevations and grades, and appurtenant site elevations and grades, shall be set to provide overland gravity drainage to natural watercourses so that positive drainage may be effected without causing property damage during major storm events and in the event of failure of piped stormwater drainage facilities.

4. Stormwater management systems in all areas of planned new development shall utilize urban street cross-sections with curbs and gutters, inlets, and storm sewers. The existing cross-section shall be retained in areas of existing development where either rural or urban cross-sections are in place, including, where applicable, hybrid urban/rural sections where ditch enclosures have been constructed.[a]

5. The stormwater and floodland management system shall be designed to minimize the creation of new drainage or flooding problems, or the intensification of existing problems, at both upstream and downstream locations.

6. Stormwater and floodland management systems should utilize the existing storage capacity of wetlands and open spaces to the extent practicable.

OBJECTIVE NO. 3

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 waterbodies.

STANDARD

1. Stormwater management facilities should promote the achievement of recommended water use objectives and supporting water quality standards for lakes, streams, and wetlands, and should not degrade existing habitat conditions for fish and aquatic life. The applicable water use objectives for the streams concerned are shown on Map 7, and the water quality standards supporting these use objectives are presented in Tables 11 and 12.[b]

2. Stormwater management practices should promote the attainment of sediment quality criteria for toxic substances as set forth in Table 13.

OBJECTIVE NO. 4

The development of a stormwater and floodland management system which will maintain or enhance existing terrestrial and aquatic biological communities, including fish and wildlife.

STANDARDS

1. Stormwater and floodland management systems shall be designed to minimize disruption to primary and secondary environmental corridors, including the incorporated woodlands, wetlands, and wildlife habitat areas.

Table 10 (continued)

2. Stormwater and floodland management facilities should be designed to protect valuable and sensitive wetlands from the adverse impacts of stormwater runoff.

3. Stormwater and floodland management facilities shall be designed to control sedimentation in receiving streams and to prevent the loss of fish and aquatic life habitat through streambank erosion and streambed scour.

4. To the extent practicable, stormwater drainage and flood control facilities should be designed to avoid enclosure of tributary streams identified as having significant and valuable biological and recreational uses.

OBJECTIVE NO. 5

The development of a stormwater and floodland management system which will be flexible and readily adaptable to changing needs.

STANDARDS

1. Stormwater and floodland management facilities should be designed for staged, or phased, construction so as to limit the required investment in such facilities at any one time and to permit maximum flexibility to accommodate changes in urban development, in economic activity growth, in the objectives or standards, or in the technology of stormwater and floodland management.

2. Where practicable and advantageous to the achievement of the objectives of this plan, multipurpose stormwater storage facilities should be provided. Such facilities should serve two or more of the following functions: water quantity control, water quality control, active or passive recreation, and aesthetic enhancement.

OBJECTIVE NO. 6

The development of a stormwater management system which will not pollute the groundwater aquifers serving the City and the Village.[c]

STANDARD

1. Where practicable, wet detention basins and infiltration devices shall not be located within the boundary of a recharge area to a wellhead identified in a wellhead area protection plan; within 100 feet of a private well; 100 feet of a transient, noncommunity public water system;[d] or within 400 feet of a well serving a public water system other than a transient noncommunity system, unless more stringent requirements are imposed by local ordinances.

2. Where, of necessity, wet detention basins are located in areas where contamination of the groundwater is possible, the basins should be provided with an impermeable liner.

3. Stormwater discharges to infiltration devices should be pretreated to avoid groundwater contamination and to assure proper long-term functioning of the infiltration device.

OBJECTIVE NO. 7

The development of a stormwater and floodland management system which will efficiently and effectively meet all of the other stated objectives at the lowest practicable cost.

STANDARDS

1. The sum of stormwater and floodland management system capital investment and operation and maintenance costs should be minimized.

2. Maximum feasible use should be made of all existing stormwater and floodland 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 and floodland management needs generated by existing and proposed land use development and redevelopment.

Table 10 (continued)

3. To the maximum extent practicable, the location and alignment of new storm sewers and engineered channels and storage facilities should coincide with existing public rights-of-way to minimize land acquisition or easement costs.

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 downstream of the storage sites.

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[a] *Hybrid urban/rural sections with ditch enclosures consist of rural street cross-sections where the ditch bed has been raised and a storm sewer has been constructed along the side of the road, following the ditch alignment.*

[b] *The recommended objectives and standards are a revision of those set forth in the adopted areawide water quality management plan as documented in SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume Two,* Alternative Plans, *February 1979. Those objectives were revised based on the Wisconsin Department of Natural Resources' nonpoint source and stream appraisals set forth in* A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, *March 1992.*

Because no specific State-adopted objective is listed in Chapter NR 104 for Butler Ditch, it is classified as a warmwater sport fish stream under the Wisconsin Administrative Code.

[c] *The water supply for the City of Brookfield is provided by municipal wells developed in either the dolomite aquifer or the deep sandstone aquifer. The water supply for the portion of the Village of Menomonee Falls in the Menomonee River watershed, which includes Butler Ditch, comes from Lake Michigan.*

[d] *Chapter NR 809 of the Wisconsin Administrative Code, which sets forth rules regarding safe drinking water, defines a transient, noncommunity public water system as a system for the provision to the public of piped water for human consumption, if such system serves at least 25 people at least 60 days of the year. Examples of such systems include those serving taverns, motels, restaurants, churches, campgrounds, and parks.*

Source: SEWRPC.

Ditch was found to be potentially capable of supporting a warmwater forage fish community and partial recreational water use objectives (see Description and Assessment of Existing Water Quality and Biological Conditions in Chapter IV).[5]

Therefore, it is recommended that the water use objectives for Butler Ditch and its two main tributaries be upgraded to a classification of warm water forage fish and partial recreation water use objectives as shown on Map 7. This reclassification is primarily based upon observed improvements in the fishery resource within Butler Ditch from 1984 to the present. Nevertheless, despite the recommendation to upgrade the biological use classification to warmwater forage fish, low flow, historic channelization, and fish passage obstructions at culverts continue to limit the potential of this resource in fully meeting its recreational use potential.

There is no available data to directly assess the acute and chronic toxicity for substances related to water quality within the Butler Ditch watershed. However, limited metals data on the main stem of the Menomonee River from sites both upstream and downstream of the confluence with Butler Ditch suggest that metal concentrations in

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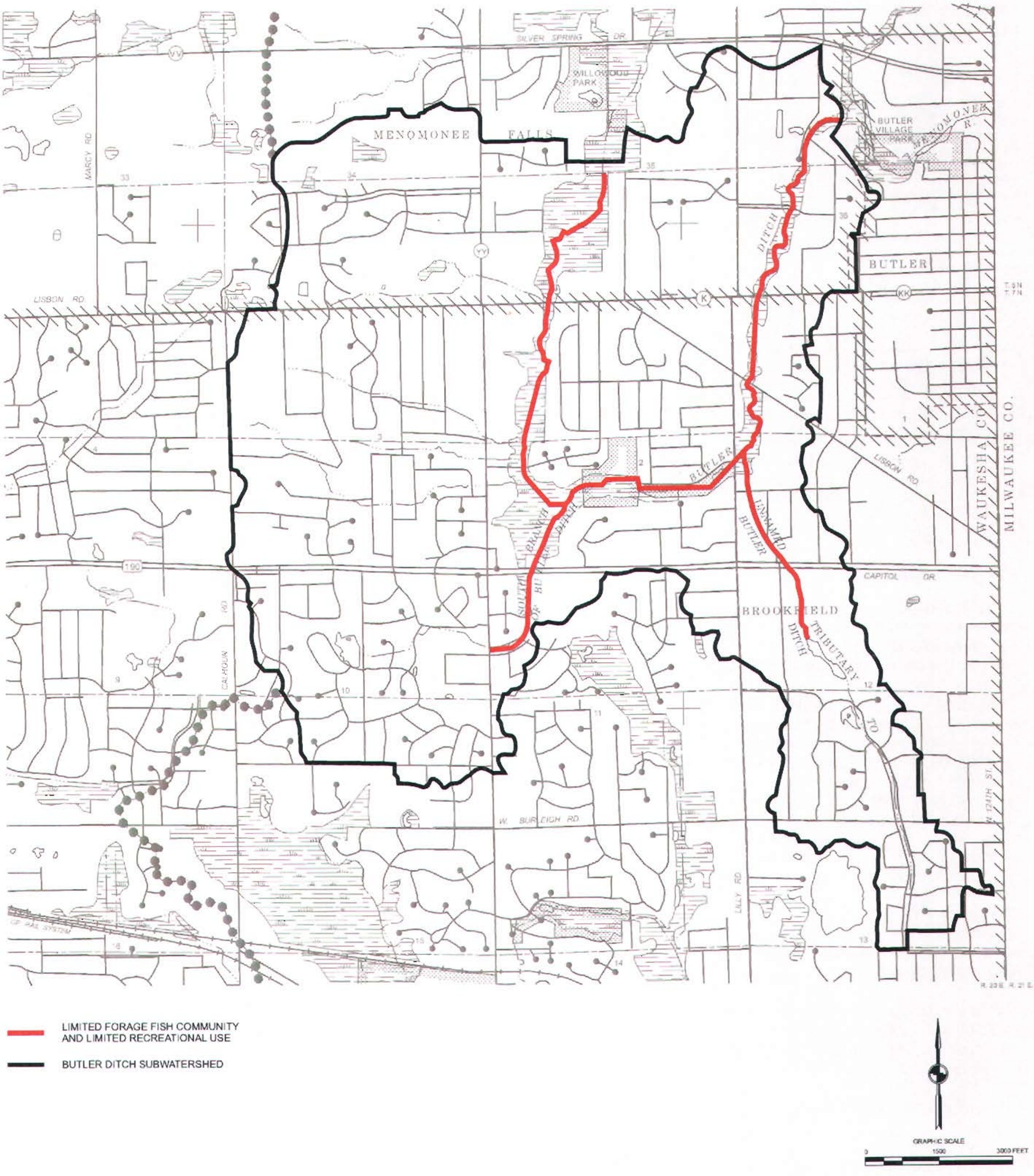
[5] *William G. Wawrzyn, Water Resource Biologist, WDNR-Southeast Region, personal communication with SEWRPC staff.*

Map 6

EXISTING POTENTIAL BIOLOGICAL AND RECREATIONAL USE CLASSIFICATION FOR THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS: 2003



Source: SEWRPC.

Table 11

APPLICABLE WATER USE OBJECTIVES AND WATER QUALITY STANDARDS AND GUIDELINES FOR LAKES AND STREAMS WITHIN THE SOUTHEASTERN WISCONSIN REGION

Water Quality Parameters	Combinations of Water Use Objectives Adopted for Wisconsin Inland Lakes and Streams[a,b]				
	Coldwater Community and Full Recreation Use	Warmwater Sportfish Community and Full Recreation Use	Warmwater Forage Fish Community and Limited Recreational Use	Limited Aquatic Life and Limited Recreational Use	Source
Temperature (°F)[c]	Background	89.0 maximum	89.0 maximum	- -	NR 102.04 (4)[d]
Dissolved Oxygen (mg/l)[c]	6.0 minimum 7.0 minimum during spawning	5.0 minimum	3.0 minimum	1.0 minimum	NR 102.04 (4) NR 104.02 (3)
pH Range (S.U.)	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	NR 102.04 (4)[e] NR 104.02 (3)
Fecal Coliform (MFFCC)	200 mean 400 maximum	200 mean 400 maximum	1,000 mean 2,000 maximum	1,000 mean 2,000 maximum	NR 102.04 (5) NR 104.06 (2)
Ammonia Nitrogen (mg/l)	- -	- -	3.0-6.0	- -	NR 104.02 (3)
Total Phosphorus (mg/l)	0.1 maximum for streams 0.02 maximum during spring turnover for lakes	0.1 maximum for streams 0.02 maximum during spring turnover for lakes	- -	- -	Regional water quality management plan[f]
Chloride (mg/l)	1,000 maximum	1,000 maximum	1,000 maximum	- -	Regional water quality management plan[g]

[a] *NR102.04(1) All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water, floating or submerged debris, oil, scum, or other material, and material producing color, odor, taste or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life.*

[b] *It is recognized that under both extremely high and extremely low flow conditions, instream water quality levels can be expected to violate the established water quality standards for short periods of time without significantly damaging the overall health of the stream. It is important to note the critical differences in the application of standards for regulatory versus planning purposes. For this purpose, the standards are often applied using a probabilistic approach, whereby the percent of time a given standard is violated is considered to allow assessment and resolution of water quality problems during high flow, as well as low flow conditions. This approach is considered appropriate for planning purposes, as opposed to regulation. The U.S. Environmental Protection Agency and the Wisconsin Department of Natural Resources, being regulatory agencies, utilize water quality standards as a basis for enforcement actions and compliance monitoring. This requires that the standards have a rigid basis in research findings and in field experience. The Southeastern Wisconsin Regional Planning Commission and others use water quality standards as criteria to measure the relative merits of alternative plans.*

[c] *Dissolved oxygen and temperature standards apply to continuous streams and the upper layers of stratified lakes and to the unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. However, trends in the period of anaerobic conditions in the hypolimnion of deep inland lakes should be considered important to the maintenance of their natural water quality.*

[d] *NR 102.04(4) There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the natural temperature shall not exceed 5°F for streams. There shall be no significant artificial increases in temperature where natural trout reproduction is to be maintained.*

[e] *The pH shall be within the stated range with no change greater than 0.5 unit outside the estimated natural seasonal maximum and minimum.*

[f] *U.S. Environmental Protection Agency,* Quality Criteria for Water, *EPA-440/9-76-023, 1976.*

[g] *J.E. McKee and M.W. Wolf,* Water Quality Criteria 2nd edition, *California State Water Quality Control Board, Sacramento, California, 1963.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 12

ACUTE AND CHRONIC TOXICITY CRITERIA FOR SUBSTANCES RELATED TO WATER QUALITY[a]

Substances[b]	Water Use Objectives					
	Acute Toxicity Criteria ATC (μg/l) at Various Hardness (mg$CaCO_3$/l) Levels[c]			Chronic Toxicity Criteria CTC (μg/l) at Various Hardness (mg$CaCO_3$/l) Levels		
	50	100	200	50	100	200
Cadmium						
All Surface Waters	- -	- -	- -	1.43	2.46	3.82[d]
Cold Water	1.97	4.36	9.65	- -	- -	- -
Warm Water Sportfish, Warm Water Forage and Limited Forage Fish	4.65	10.31	22.83	- -	- -	- -
Limited Aquatic Life	13.03	28.87	63.92	- -	- -	- -
Chromium (+3)						
All Surface Waters	1,022	1,803	3,181	- -	- -	- -
Cold Water	- -	- -	- -	48.86	86.21	152.1
Warm Water Sportfish	- -	- -	- -	74.88	132.1	233.1
All Other Surface Waters	- -	- -	- -	74.88	132.1	233.1
Copper	9.29	16.82	30.45	6.58	11.91	21.57
Lead	54.73	106.92	208.90	14.33	28.01	54.71
Nickel	642.7	1,361	2,434	71.50	151.5	270.8
Zinc	65.66	120.4	220.7	65.66	120.4	220.7

Substances[b]	Acute Toxicity Criteria ATC (μg/l) at Various pH (s.u.) Levels			Chronic Toxicity Criteria CTC (μg/l) at Various pH (s.u.) Levels		
	6.5	7.8	8.8	6.5	7.8	8.8
Pentachlorophenol						
All Surface Waters	5.25	19.40	53.01	- -	- -	- -
Cold Water	- -	- -	- -	4.43	14.81	40.48
All Other Surface Waters	- -	- -	- -	5.33	12.82	48.70

[a] *Values set forth in Chapter NR 105 of the* Wisconsin Administrative Code.

[b] *Values represent total recoverable form for each of these constituents and applicable to all surface waters unless otherwise stated.*

[c] *The ATC related to water quality are applicable to the following ranges in hardness concentration for each of the substances summarized below; 6-457 mg/l hardness for cadmium, 13-301 mg/l hardness for chromium (+3), 14-427 mg/l hardness for copper, 12-356 mg/l hardness for lead, 19-157 mg/l hardness for nickel, and 12-333 mg/l hardness for zinc.*

[d] *This CTC value is based upon a maximum hardness level of 175 mg/l.*

Source: Wisconsin Department of Natural Resources.

Butler Ditch were not likely to be exceeding acute or chronic levels of these constituents during the sampling period from 1985 to 1993.[6] There have been no subsequent indications within the watershed to suggest that the situation has changed.

SEDIMENT QUALITY STANDARDS

In addition to the contaminants indicated in Tables 11 and 12, contaminants can also potentially accumulate in stream sediments. Based on the potential for contaminants present in the sediments at a particular site to create

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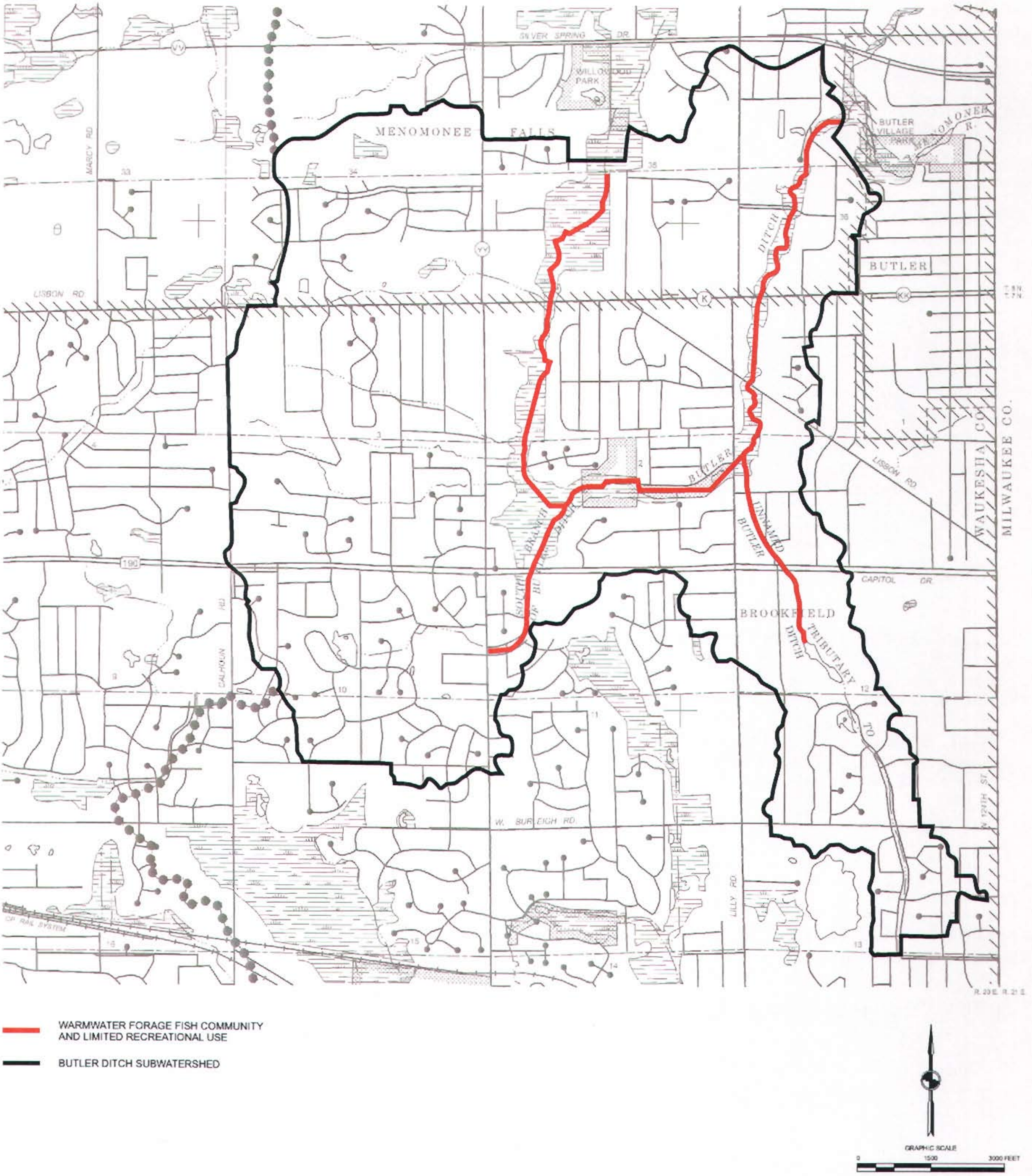
[6] *SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

Map 7

RECOMMENDED POTENTIAL BIOLOGICAL AND RECREATIONAL USE CLASSIFICATION FOR THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS: 2003



Source: SEWRPC.

biological impacts, the WDNR developed proposed assessment criteria.[7] Two levels of potential impact are proposed: the lowest effect level (LEL) and the severe effect level (SEL), which represent the 5th and 95th percentiles, respectively, of a database compiled and analyzed in a comprehensive reference study prepared by the Ontario Ministry of the Environment. These values were considered by the WDNR to be applicable within the State of Wisconsin. The lowest and severe effect levels for each parameter are shown in Table 13, however, it should be noted that the proposed LEL and SEL screening criteria in that table reflect updated values since completion of the aforementioned Wisconsin Department of Natural Resources draft document.[8] The WDNR is also currently developing consensus-based sediment quality guidelines in order to provide a reliable and accurate basis for predicting the presence or absence of toxicity for potential site assessments and establishing possible remedial action levels for protection of benthic macroinvertebrates.[9]

There is no available data to directly assess the sediment quality within the Butler Ditch watershed.

OVERRIDING CONSIDERATIONS

In the application of the stormwater and floodland management development objectives and standards to the preparation, test, and evaluation of system plans, several overriding considerations must be recognized. First, it must be recognized that any proposed stormwater and floodland management facilities must constitute integral parts of a total system. It is not possible to assure such system integration from application of the standards alone, since the standards cannot be used to determine the effect of individual facilities on the system as a whole, nor on the environment within which the system must operate. This requires the application of planning and engineering techniques developed for this purpose which can be used to quantitatively test the potential performance of proposed facilities as part of a total system. The use of mathematical simulation models facilitates such quantitative tests. Furthermore, by using these models, the configuration and capacity of the system can be adjusted to the existing and future runoff loadings. Second, it must be recognized that it is unlikely that any one plan proposal will fully meet all of the standards; and the extent to which each standard is met, exceeded, or violated must serve as the measure of the ability of each alternative plan proposal to achieve the objective which the given standard complements. Third, it must be recognized that certain objectives and standards may be in conflict and require resolution through compromise, such compromise being an essential part of any design effort.

ANALYTICAL PROCEDURES AND ENGINEERING DESIGN CRITERIA

Certain engineering criteria and procedures were used in designing alternative stormwater and floodland management plan elements, and in making the economic evaluations of those alternatives. While these criteria and procedures are widely accepted and firmly based in current engineering practice, it is, nevertheless, useful to briefly document them here. The criteria and procedures provide the means for quantitatively sizing and analyzing the performance of both the minor and major components of the total stormwater management system components considered in this plan. In addition, these criteria and procedures can serve as a basis for the more detailed design of system components. These criteria and procedures thus constitute a reference for use in facility design, and as such are intended to be applied uniformly and consistently in all phases of the implementation of the recommended stormwater and floodland management plan.

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[7] *Wisconsin Department of Natural Resources,* Inventory of Statewide Contaminated Sediment Sites and Development of a Prioritization System, *June 1994 (draft), Wisconsin Department of Natural Resources,* Consensus-Based Sediment Quality Guidelines; Recommendations for Use & Applications, *PUBL-WT-732-2002, 2002.*

[8] *D. Persaud, R. Jaagumagi, and A. Hayton,* Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, *ISBN 0-7729-9248-7, Ontario Ministry of the Environment, Ottawa, Ontario, 1993.*

[9] *Wisconsin Department of Natural Resources, PUBL WT-732-2002,* op. cit.

Table 13

SEDIMENT QUALITY GUIDELINES USED AS SCREENING CRITERIA TO EVALUATE CONTAMINATION IN SEDIMENTS[a]

Substance	Lowest Effect Level (LEL)[b] (mg / kg, dry weight)	Severe Effect Level (SEL)[c] (mg / kg, dry weight)
Metals		
Ag (Silver)	1.0	3.7
As (Arsenic)	6	33
Cd (Cadmium)	0.6	10
Cr (Chromium)	26	110
Cu (Copper)	16	110
Hg (Mercury)	0.2	2
Ni (Nickel)	16	75
Pb (Lead)	31	250
Zn (Zinc)	120	820
Organics-Polynuclear Aromatic Hydrocarbons (PAHs)		
Acenaphthene	0.016	0.500
Acenaphthylene	0.044	0.640
Anthracene	0.220	370
Benzo (a) anthracene	0.320	1,480
Benzo (k) fluoranthene	0.240	1,340
Benzo (g, h, i,) perylene	0.170	320
Benzo (a) pyrene	0.370	1,440
Chrysene	0.340	460
Dibenzo (a, h) anthracene	0.060	130
Fluoranthene	0.750	1,020
Fluorene	0.190	160
Indeno (1, 2, 3-cd) pyrene	0.200	320
2-methylnaphthalene	0.700	0.67
Naphthalene	0.16	2.1
Phenanthrene	0.560	950
Pyrene	0.490	850
PAH (Total)	4	10,000
Organics-Polychlorinated Biphenyls (PCBs)		
PCB Aroclor 1016	0.007	53
PCB Aroclor 1248	0.030	150
PCB Aroclor 1254	0.060	34
PCB Aroclor 1260	0.005	24
PCB (Total)	0.070	530
Pesticides		
Aldrin	0.002	8
Benzohexachloride (BHC)	0.003	12
a-BHC	0.006	10
b-BHC	0.005	21
y-BHC (Lindane)	0.003	1
Chlordane	0.007	6
DDT (Total)	0.007	12
op + pp DDT	0.008	71
pp DDD	0.008	6
pp DDE	0.005	19
Dieldrin	0.002	91
Endrin	0.003	130
Hexachlorobenzene (HCB)	0.020	24
Heptachlor epoxide	0.005	5
Mirex	0.007	130
Other		
Ammonia	75	- -
Oils and Grease	1,000	- -
CN (Cyanide)	0.1	- -

Table 13 Footnotes

[a] *These freshwater sediment screening guidelines are from the following references: D. Persaud, R. Jaagumagi, and A. Hayton,* Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. *ISBN 0-7729-9248-7, Ontario Ministry of the Environment, Ottawa, Ontario, 1993; U.S. Environmental Protection Agency,* Interim Sediment Criteria Values for Nonpolar Hydrophobic Organic Contaminants, *Office of Water Regulations and Standards, Criteria and Standards Division, SCD #17, 1988.*

[b] *Lowest Effects Levels (LELs) indicate concentrations at which adverse benthic impact may begin to occur (level tolerated by most benthic organisms). Water column species and wildlife are at a potential risk via biomagnification (food chain toxicity) if site-related sediment concentrations of PCBs, organochlorine pesticides, or mercury are at or above the LEL. It is also important to note that other known biomagnifiers (not included in this table) without screening numbers (i.e. dioxins, furans, other chlorinated organics, and selenium) warrant case-by-case evaluation.*

[c] *Severe Effects Levels (SELs) indicate contaminant concentrations at which severe impacts to the benthic community occurs in most cases studied. For nonpolar organics (PAHs, organochlorine pesticides, PCBs), the SEL is calculated from a site-specific total organic carbon (TOC) level. Since the table SEL is based on 100 percent organic carbon, the calculated site-specific number is lower.*

Source: Ontario Ministry of the Environment, Wisconsin Department of Natural Resources, and SEWRPC.

Analytical Procedures

Rainfall Intensity-Duration-Frequency Data

The rainfall intensity-duration-frequency relationships representative of the area are fundamental data for stormwater management planning and design. Such relationships facilitate determination of the total rainfall amount which may be expected to be reached or exceeded for a particular duration at a given recurrence interval. Under its comprehensive water resources planning program, the Southeastern Wisconsin Regional Planning Commission has developed a set of rainfall intensity-duration-frequency relationships.[10] The data collected by the National Weather Service in the City of Milwaukee are summarized in tabular form in Table 14 and in graphic form in Figure 1. Analyses conducted by the Commission staff indicate that these data are valid for use not only within the Milwaukee area, but anywhere in Southeastern Wisconsin.

Design Rainfall Frequency

To ensure that the stormwater system is able to effectively control the stormwater runoff in a cost-effective manner, storm events of specified recurrence intervals must be selected as a basis for the design and evaluation of both the minor and major drainage systems. The selection of these design storm events should be dictated by careful consideration of the frequency of inundation which can be accepted versus the cost of protection. This involves value judgments which should be made by the responsible local officials involved and applied consistently in both the public and private sectors.

The average frequency of rainfall used for design purposes determines the degree of protection afforded by the stormwater management system. This protection should be consistent with the damage to be prevented. In practice, however, the calculation of benefit-cost ratios is not deemed warranted for ordinary urban drainage facilities, and a design rainfall recurrence interval is selected on the basis of experienced engineering judgment and experience with the performance of stormwater management facilities in similar areas.

In this respect, it should be noted that the cost of storm sewers and other drainage facilities is not directly proportional to either the design storm frequency or the flow rates. A 10-year recurrence interval storm produces

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[10] *SEWRPC Technical Report No. 40 (TR No. 40),* Rainfall Frequency in the Southeastern Wisconsin Region, *Camp Dresser & McKee, University of Wisconsin-Madison, and SEWRPC, April 2000.*

Table 14

RECOMMENDED DESIGN RAINFALL DEPTHS FOR THE SOUTHEASTERN WISCONSIN REGION

	Recurrence Interval and Depths (inches)					
Storm Duration	2 Years[a]	5 Years[a]	10 Years[a]	25 Years	50 Years	100 Years
5 Minutes	0.40	0.48	0.54	0.62	0.68	0.74
10 Minutes	0.64	0.76	0.85	0.98	1.08	1.19
15 Minutes	0.83	0.98	1.07	1.21	1.31	1.41
30 Minutes	1.07	1.29	1.45	1.68	1.85	2.02
60 Minutes	1.31	1.60	1.84	2.20	2.50	2.82
2 Hours	1.54	1.93	2.23	2.73	3.16	3.64
3 Hours	1.68	2.07	2.40	2.93	3.39	3.89
6 Hours	1.95	2.40	2.79	3.44	4.03	4.70
12 Hours	2.24	2.74	3.17	3.89	4.53	5.25
24 Hours	2.57	3.14	3.62	4.41	5.11	5.88
48 Hours	3.04	3.71	4.20	4.94	5.53	6.13
72 Hours	3.29	3.94	4.40	5.09	5.63	6.17
5 Days	3.77	4.42	4.84	5.43	5.86	6.26
10 Days	4.68	5.42	5.89	6.55	7.03	7.46

[a] Factors presented in U.S. Weather Bureau TP-40 were applied to the SEWRPC 2000 annual series depths with recurrence intervals of two, five, and 10 years, converting those depths to the partial duration series amounts set forth in this table. The annual series depths were adjusted as follows:

Two-year: multiplied by 1.136; five-year: multiplied by 1.042; and 10-year multiplied by 1.010.

Source: Rodgers and Potter and SEWRPC.

approximately 15 percent greater rainfall intensities and about 25 percent greater runoff intensities than a five-year recurrence interval storm. This higher runoff rate requires sewer pipe diameters to be on the order of 10 percent larger. However, drainage systems are limited to commercially available pipe sizes which, in the most frequently used range of 15- to 66-inch diameter, have incremental diameter increases of 10 to 20 percent, corresponding incremental capacity increases of 27 to 58 percent, and corresponding average in-place cost increases of 15 to 23 percent. The incremental cost increases on a systemwide basis may be expected to be on the order of 15 percent, because only portions of any given system will require modified sizes due to the adoption of a 10-year design storm standard rather than a five-year standard.

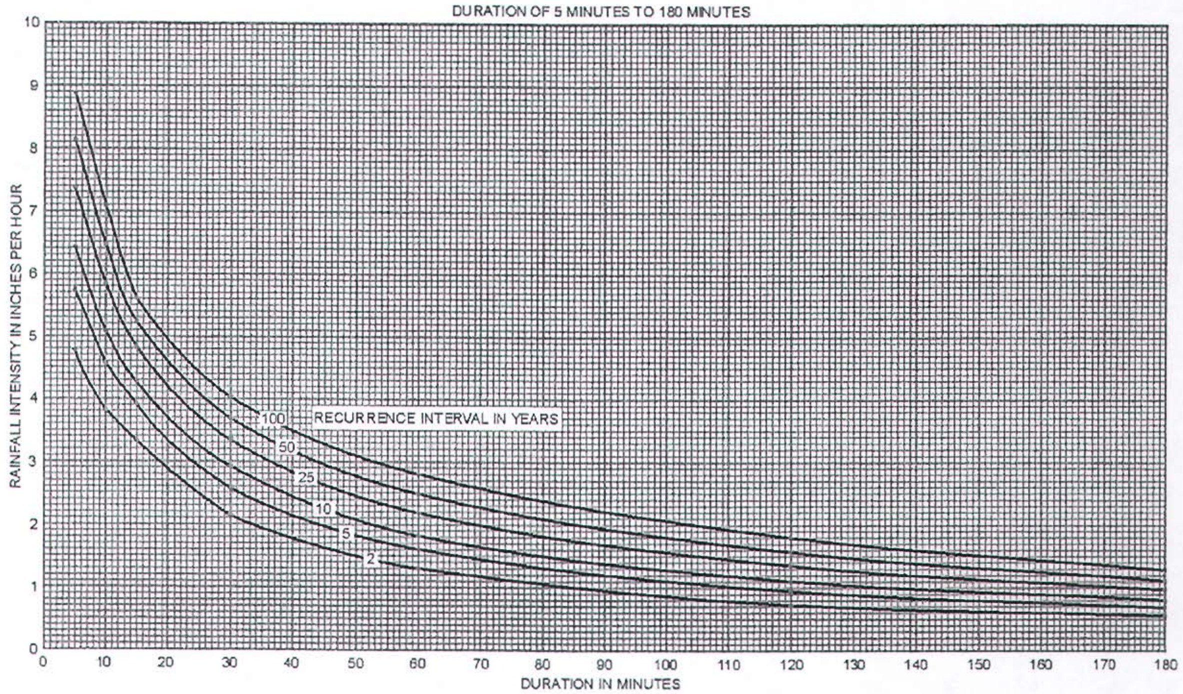
Another consideration in evaluating alternative design recurrence intervals for drainage facilities is the risk of exceeding capacity. A five-year recurrence interval event, which has a 20 percent chance of occurring in any given year, has a 50 percent chance of being exceeded in about 3.5 years, a period which may be unacceptable from a public relations point of view. In contrast, a 10-year recurrence interval event, has a 10 percent chance of occurring in any given year, has a 50 percent chance of being exceeded in about seven years, and a 100-year recurrence interval event, which has a 1 percent chance of occurring in any given year, has a 50 percent chance of being exceeded in about 69 years.

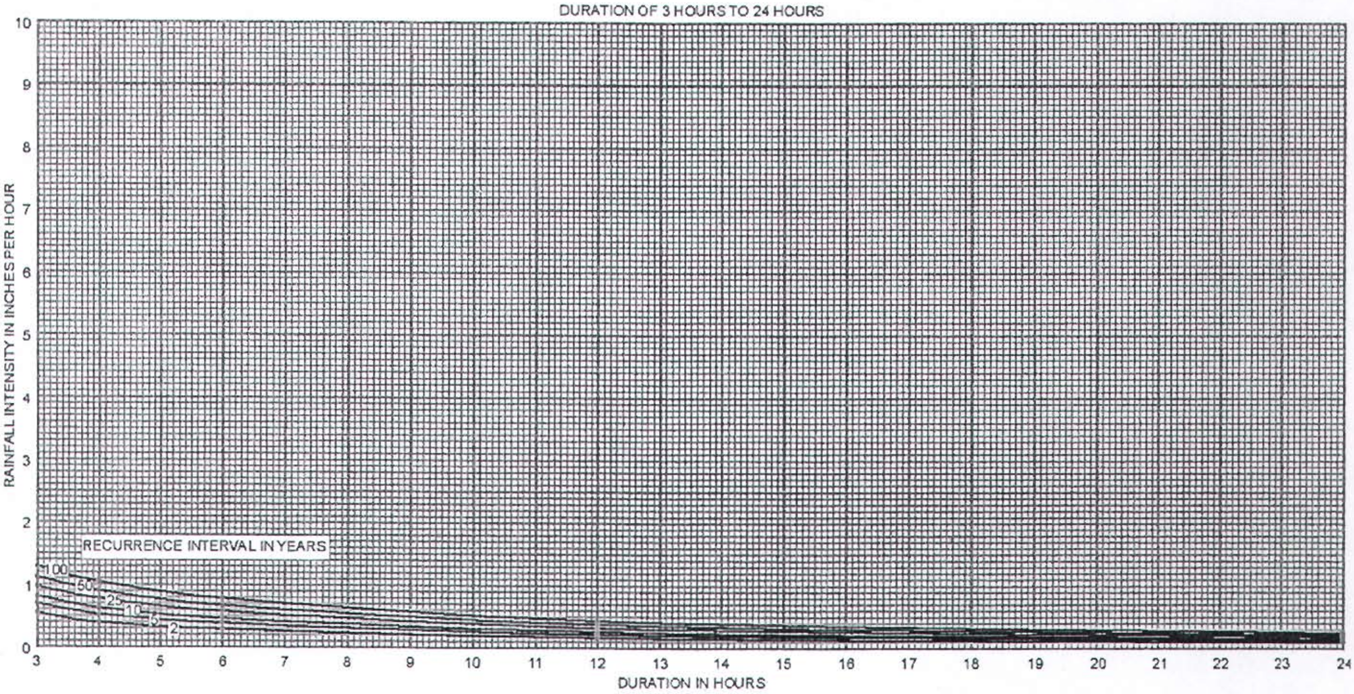
Based upon consideration of the costs and risks entailed, and consistent with the current policies of the City of Brookfield and the Village of Menomonee Falls, a 10-year recurrence interval storm was selected for use in the design of the elements of the minor stormwater management system for the study area.

When designing the minor urban stormwater management system, the designer should be aware that exceeding capacity does not cause incipient catastrophe. On the contrary, it means only that the minor drainage system capacity has been completely utilized and the unaccommodated portion of the stormwater flow will begin to cause

Figure 1

POINT RAINFALL INTENSITY-DURATION-FREQUENCY CURVES FOR MILWAUKEE, WISCONSIN[a]





[a]The curves are based on Milwaukee rainfall data for the 108-year period of 1891 to 1998.

Source: Rodgers & Potter and SEWRPC.

inconvenience and/or disruption of activities as it courses through the major system. In this respect, the minor system differs substantially from the major system.

A 100-year recurrence interval storm was selected for use in delineating areas of potential inundation along the major stormwater drainage system, and to size some elements of the system. This recurrence interval is used by the Regional Planning Commission in its flood control planning efforts, and by Federal and state agencies for floodland regulation. The 100-year recurrence interval event generally—with only certain unusual exceptions—approximates, in terms of the amount of land area inundated, the largest known flood levels that have actually occurred in the Region since its settlement by Europeans. Therefore, use of a 100-year recurrence interval event provides a conservatively safe level of protection against property damage and hazard to human health and safety from surcharge of the major, as opposed to the minor, stormwater management system.

The minor and major system design standards adopted for this plan are consistent with the City and Village standards of designing trunk storm sewers for storms with recurrence intervals from 10 to 25 years. Where hydraulic conditions dictate that the major system, consisting of a storm sewer or swale which conveys the runoff from a 10-year recurrence interval storm and the entire street cross section which conveys the runoff in excess of that from a 10-year storm, have inadequate combined capacity to convey the peak runoff from a 100 year storm without flooding adjacent buildings, the standards adopted for this plan would require that the design storm sewer or swale capacity be increased above that for a 10-year storm in order to obtain 100 year storm capacity of the major system. Therefore, the design capacity of storm sewer is flexible, subject to the satisfaction of the 100-year storm capacity criterion for the major system. In the most extreme application, a storm sewer would be sized to convey the 100-year recurrence interval storm. This would occur where the major system, other than the storm sewer, has zero capacity due to a mid block sag or an inadequate overland flow route.

Time Distribution of Design Rainfall

The hydrologic analyses conducted for this planning effort used design storms developed by distributing the total precipitation amounts determined from the Commission rainfall intensity-duration-frequency data according to the 90th percentile storm distribution developed for all storm durations under the study documented in SEWRPC TR No. 40. The temporal distribution is shown in Figure 2. A tabulation of the design storm distribution is set forth in Table 15.

Design storms of varying durations were analyzed to determine the critical durations for the production of peak flow rates and critical runoff volumes at key locations within the subwatershed. Generally, the critical storm duration for a given location along the drainage network increases with the amount of land area tributary to that point in the network. The presence of significant amounts of stormwater storage volume within the system also results in a longer critical storm duration. A third factor affecting the critical storm duration is the nature of the conveyance network in a given subbasin. If two subbasins have the same drainage areas, soil, and land cover characteristics, and similar drainage patterns, but one has a storm sewer conveyance system and the other has an open channel conveyance system, it is likely that the critical storm duration would be longer for the subbasin with the open channel system, since flow travel times in that system would be longer.

Specific Design Storm Characteristics for the Village of Menomonee Falls

The Village of Menomonee Falls has adopted design storm criteria that differ from those applied in the City of Brookfield and from those generally applied for consistency throughout the Butler Ditch subwatershed under this system plan. The Village has adopted a conservative approach requiring that 1) 24-hour design storm rainfall depths for various frequency events be taken from the isohyetal maps published by the Illinois State Water Survey[11] and 2) the total rainfall be distributed using the U.S. Natural Resources Conservation Service (formerly

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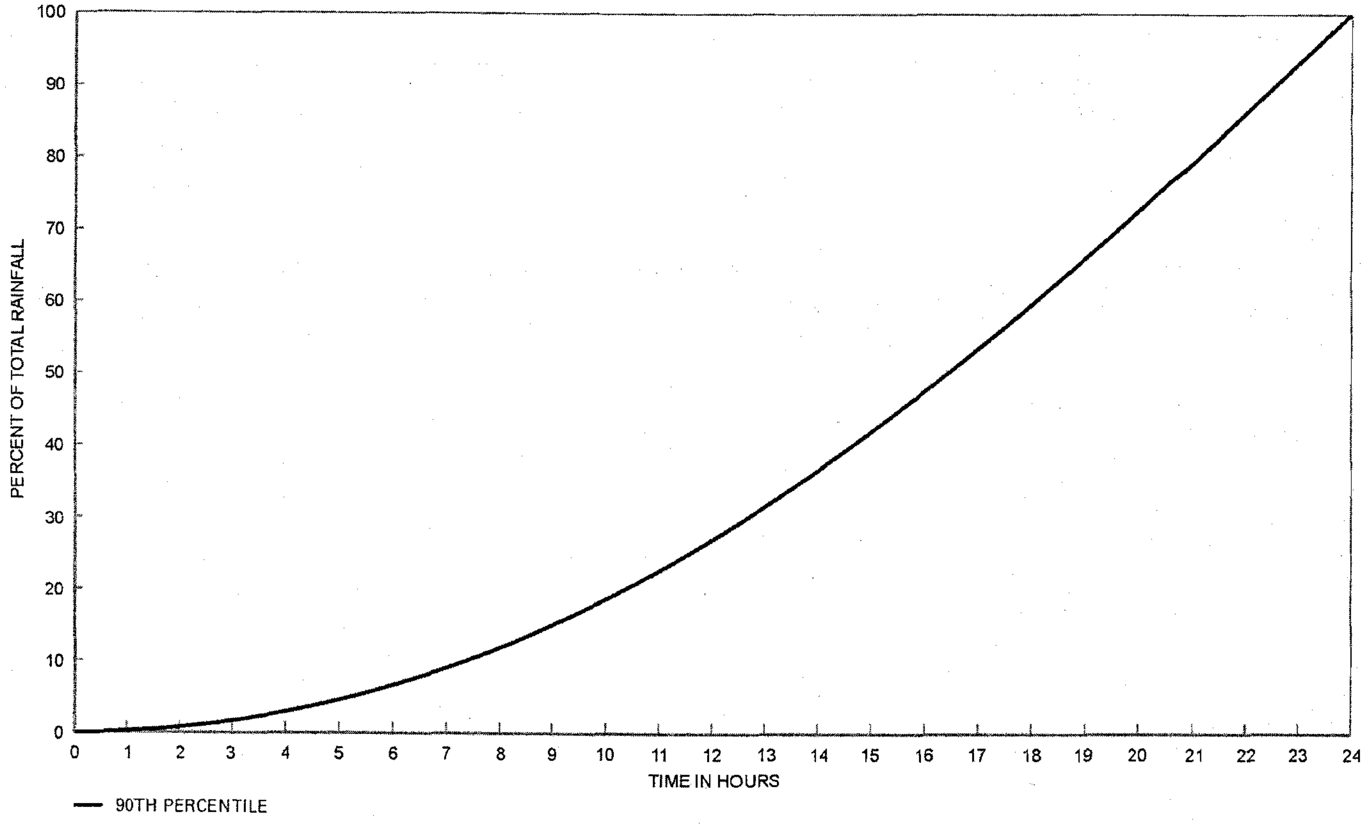
[11] *Floyd A. Huff, and James R. Angel,* Rainfall Frequency Atlas of the Midwest, *Illinois State Water Survey, Champaign, Bulletin 71, 1992.*

Figure 2

SMOOTHED 90TH PERCENTILE RAINFALL DISTRIBUTION



Source: Camp Dresser & McKee, Inc., and SEWRPC.

U.S. Soil Conservation Service) Type II distribution[12] or the SEWRPC 90th percentile distribution.[13] Under this system plan, the recommended stormwater management system in the Village of Menomonee Falls was sized using the SEWRPC 2000 rainfall depth-duration-frequency data and 90th percentile time distribution for the alternatives analyses set forth in Chapter V and the recommended plan components were then evaluated using the Village storm criteria in order to determine if any recommended components would require modification to convey and/or store runoff based on the Village criteria. That evaluation is set forth in Chapter VI.

Additional Hydrologic and Hydraulic Data

Data on the hydrologic and hydraulic characteristics of the study area were also available from the files of the Commission, including data on soils; topography; the drainage patterns of the natural streams and watercourses; the waterway openings of related bridges and culverts, and related flood hazard areas; wetlands; and areas with

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[12] *U.S. Soil Conservation Service, National Engineering Handbook Section 4 - Hydrology, March 1985.*

[13] *SEWRPC TR No. 40,* op. cit.

Table 15

SEWRPC RECOMMENDED 90TH PERCENTILE RAINFALL DISTRIBUTION

Percent of Total Storm Time	Cumulative Percent of Total Storm Rain
0	0.0
5	0.4
10	1.3
15	2.7
20	4.6
25	7.0
30	9.9
35	13.4
40	17.4
45	21.9
50	26.9
55	32.4
60	38.5
65	45.1
70	52.2
75	59.8
80	67.9
85	76.6
90	85.1
95	93.2
100	100.0

Source: Camp Dresser & McKee, Inc., and SEWRPC.

existing flood problems. Large-scale topographic maps prepared by Waukesha County and the Commission to Commission specifications as described in Chapter II of this report and Commission digital aerial orthophotographs prepared at a scale of one inch equals 400 feet were used in the analyses. The City and the Village have prepared digital communitywide stormwater infrastructure system maps. Those maps were used extensively in the analyses of the existing systems and in developing the alternative and recommended plans. Stormwater drainage system maps, construction plans, as-built surveys, development plans, and other pertinent information were obtained from the City, the Village, and by Ruekert & Mielke, Inc., field crews.

Simulation of Hydrologic, Hydraulic, and Nonpoint Source Pollutant Delivery Processes

Quantification of the stormwater flow rates and volumes and of nonpoint source pollutant loading rates under both existing and probable future land use conditions allows sound, rational decisions to be made concerning stormwater management. Such quantification aids in determining the type, location, and configuration of stormwater management facilities, and is essential to sizing facilities such as storm sewers, open channels, culverts and bridges, storage and pumping facilities, and nonpoint source pollution abatement measures. Rainfall-runoff modeling techniques were used under the study to quantify stormwater flow rate and volume in both the minor and major drainage systems and to quantify flood flows in the stream system.

1. The Visual SWMM Stormwater Management Model computer program, developed by CAiCE Software Corporation and the XP-SWMM program, developed by XP Software, Inc., were used for hydrologic and hydraulic analysis of the stormwater management systems of the subwatershed.[14] The models were used to develop, combine, and route flood hydrographs generated for each subbasin of the subwatershed. That process of combining and routing hydrographs yielded total runoff hydrographs at critical locations. The models enable the evaluation of a complex hydrologic/hydraulic network, accounting for the effects on flow hydrographs of routing through storm sewers, open channels, overland flow paths, and natural and man-made detention storage areas.

   Subbasin runoff hydrographs under existing and probable future conditions were developed using the U.S. Soil Conservation Service (SCS) dimensionless unit hydrograph method. Under this procedure, rainfall runoff is determined by subtracting interception, infiltration, and surface storage losses from the design storm amounts. Such losses are determined using a runoff curve number calculated from the land cover and hydrologic soil group distributions in a given subbasin.

   A unit hydrograph, representing one inch of runoff from a given subbasin for a given duration of rainfall excess, was developed for each subbasin by applying timing parameters characteristic of the

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[14] *The Visual SWMM and XP-SWMM programs are graphically based, enhanced versions of the U.S. Environmental Protection Agency (USEPA) Stormwater Management Model (SWMM).*

subbasin to the SCS standard dimensionless unit hydrograph. The subbasin flood hydrograph was generated by applying each time increment of rainfall excess to the unit hydrograph and then summing the individual hydrographs for each storm time increment, according to the principle of superposition.

Hydrograph routing through the network was accomplished using the full Saint Venant equations for one-dimensional, gradually varied unsteady flow. The hydraulics of the major and minor systems were explicitly modeled in cases where storm sewers were found to surcharge, dividing the total flow between an overland component flowing in a street or another flow path and the piped component in a storm sewer or culvert. Because the SWMM program models the hydraulics of the drainage network, it was applied to directly evaluate the hydraulic adequacy of the exiting stormwater management system and to perform the systems-level design of modifications or additions to the system.

2. The Hydrological Simulation Program-Fortran (HSPF)[15] was used for the development of flood discharges in Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch. The HSPF model simulates streamflow on a continuous basis using recorded climatological data as input. The continuous simulation was conducted at a 15-minute time interval for the period from 1940 through 1998. Flood discharges were developed by conducting discharge-frequency analyses of the simulated annual peak discharges generated by the hydrologic model. The flood frequency analyses applied the log Pearson Type III method, as recommended by the U.S. Water Resources Council[16] and as specified by the Wisconsin Department of Natural Resources. That approach for development of flood flows for the floodland management element of the plan is consistent with the methods used for the 1976 Menomonee River watershed study, the 1990 stormwater drainage and flood control system plan for the Milwaukee Metropolitan Sewerage District (MMSD), the 2000 MMSD Menomonee River watercourse system plan, and the ongoing floodplain delineation and mapping projects which the Regional Planning Commission is conducting for the City of Brookfield, the Milwaukee County Automated Mapping and Land Information Systems Steering Committee, and the MMSD.

3. The U.S. Army Corps of Engineers HEC-RAS "River Analysis System" model for gradually varied steady flow was used to determine flood stages along Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch. Flood profiles were developed using two- through 100-year recurrence interval flood flows for full development land use conditions, and existing stormwater drainage and channel conditions.

4. The Source Loading and Management Model (SLAMM) was used to determine nonpoint source pollutant loadings.[17] SLAMM was used to estimate pollutant contributions from various land use areas under both existing 1995 and planned land use conditions and to evaluate the effects of various pollution abatement measures. Average annual nonpoint source pollutant loadings of total solids, particulate solids, total phosphorus, copper, zinc, and cadmium were calculated by the SLAMM model using 1981 precipitation data from the National Weather Service station at General Mitchell International Airport. Those data are reasonably representative of a typical annual set of storms.

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[15] *U.S. Environmental Protection Agency, Environmental Research Laboratory,* Hydrological Simulation Program-Fortran, User's Manual for Release 10, *Athens, Georgia, September 1993.*

[16] *United States Water Resources Council, "Guidelines for Determining Flood Flow Frequency,"* Bulletin No. 17B of the Hydrology Committee, *Washington, D.C., revised September 1981.*

[17] *Robert Pitt and John Voorhees,* Source Loading and Management Model, *Version 6.2, 1994.*

Criteria and Assumptions

The criteria and assumptions set forth below were generally applied in the development of the stormwater management system plan. Many of the criteria may also apply at the project design level.

Street Cross-Sections, Site Grading, Inlets, and Parallel Roadside Culverts

An important secondary function of all streets and highways is the collection and conveyance of stormwater runoff. The planning of stormwater drainage systems should therefore be done simultaneously with the planning of the location, configuration, and gradients of the street system. At the systems planning level, recommendations concerning the approximate gradients of existing and proposed streets are provided. Pertinent details of the curbs and gutters, roadside swales, and street crowns are assumed based upon typical cross-sections and must be further addressed in subsequent project development engineering.

The location and size of inlets and culverts, as a part of the minor stormwater drainage system, are dictated by the allowable stormwater spread and depth of flow in streets, and attendant interference with the safe movement of pedestrian and vehicular traffic. The details of inlet locations and sizes are not determined at the systems level, but would be investigated during the detailed design of storm sewer systems.

Given the standards formulated under the study, only two assumptions concerning site grading, and one assumption concerning culverts and inlets, were required for the systems planning. It was assumed that all new urban development and redevelopment would be designed to facilitate good drainage, with slopes away from all sides of buildings to provide positive gravity drainage to streets or to drainage swales. It was also assumed that drainage swales along side lot or back lot lines or site boundaries would provide positive gravity drainage to streets.

With regard to inlets and parallel roadside culverts, such as driveway culverts, it was assumed that these system components would be designed to provide sufficient capacity to intake and pass all flow in the tributary gutters or swales from storms up to and including the 10-year recurrence interval event.

Roadside Swales

At the systems planning level, only recommendations relating to the general configuration, size, approximate depth, slope, and type of roadside swales are provided. More detailed engineering at the project development level will be needed to determine precise depth, location, and horizontal and vertical alignment of the swales, and the best response to constraints posed by structures and utilities.

In the systems planning, the Manning equation was used together with the cross-sectional area of flow to determine the required hydraulic capacity of swales. A Manning's "n" value corresponding to retardance level "D" in Figure 3 was assumed for well-constructed, properly maintained, frequently mowed, grass-lined roadside drainage swales, such as may be expected to exist adjacent to front yards in residential areas.

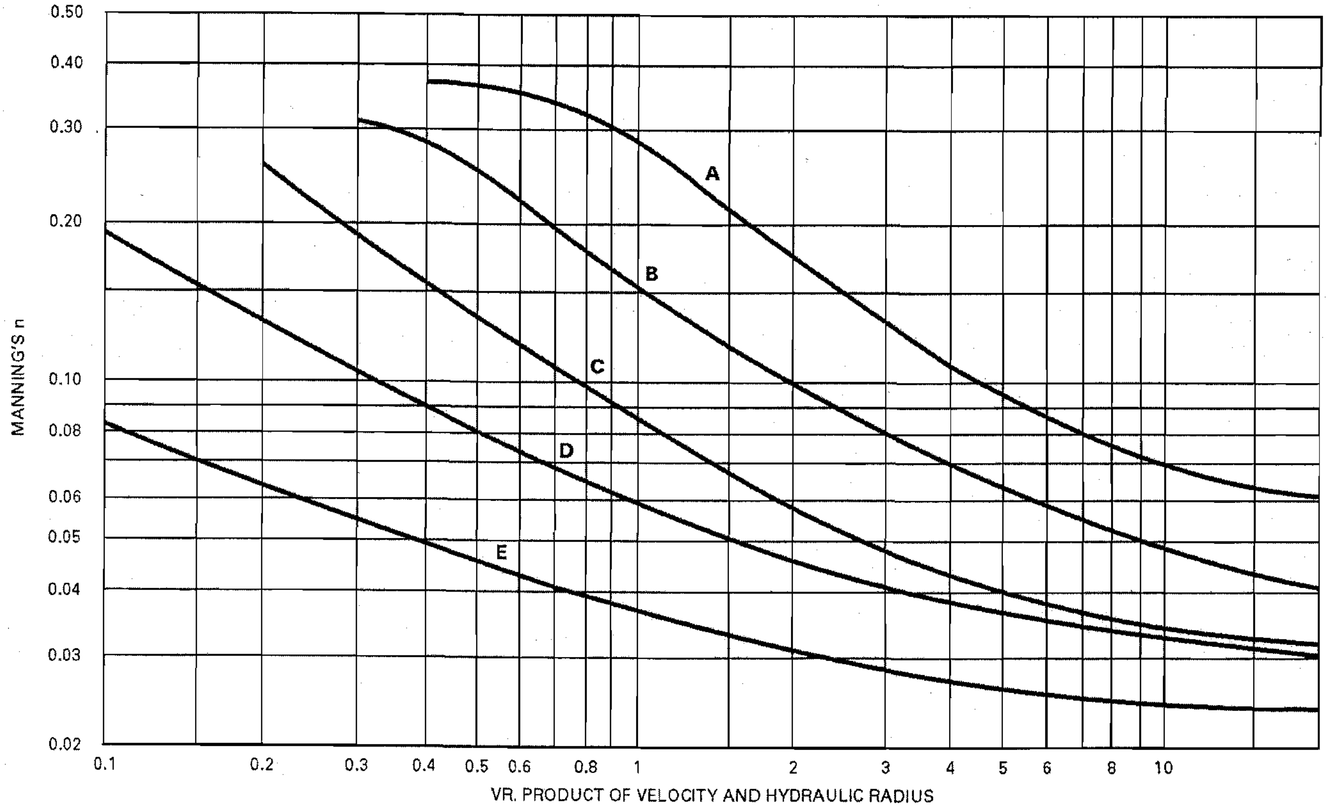
A Manning's "n" value corresponding to retardance level "C" in Figure 3 was assumed for properly constructed, less frequently maintained (one- to two-month mowing cycle), grass-lined roadside drainage swales commonly found in rural areas.

The following criteria and assumptions relating to the details of the grass-lined storm drainage swales and channels in and along street rights-of-way were used in the development of the stormwater management plan:

1. Swales were assumed generally to be located in public street rights-of-way and to follow the street alignments and gradients.
2. Swale cross-sections were assumed to be triangular with side slopes no steeper than one vertical on three horizontal. Where practicable and cost-effective, a trapezoidal cross-section was assumed with the bottom width selected to promote infiltration.

Figure 3

MANNING'S "n" FOR VEGETATION-LINED CHANNELS FOR VARIOUS RETARDANCE LEVELS



Source: U.S. Soil Conservation Service.

3. Swales were designed to accommodate the peak runoff expected from a minor—that is, a 10-year recurrence interval—storm when flowing full and without freeboard.

4. Swales were designed to provide a maximum flow velocity of five feet per second during the design storm event.

5. The minimum depth of swales below street shoulder was assumed to be one and one-half feet, while the maximum depth was assumed to be three feet.

Cross Culverts

Cross culverts, which are a common feature of open drainage systems, are used to convey stormwater under a street, highway, railroad, or embankment. At the systems planning level, recommendations concerning the location, size, and type of material of cross culverts are provided. More detailed engineering at the project development level will be needed to determine the precise depth, location, and horizontal and vertical alignment of the culverts and the best response to constraints posed by structures and utilities.

The hydraulic capacity of any culvert is affected by its cross-sectional area, shape, entrance geometry, length, slope, construction material, and depth of ponding at the inlet and outlet, details which must be addressed at the project development level. Culvert flows are classified as having either inlet or outlet control—that is, according to whether the discharge capacity is controlled by the inlet or outlet characteristics. Typical inlet control and outlet control culvert conditions are shown in Figure 4. Under inlet control conditions, the discharge capacity of a culvert is controlled at its entrance by the depth of headwater, the entrance shape and cross-sectional area, and the type of entrance edge. Under outlet control conditions, the discharge capacity of a culvert is influenced by the headwater depth, tailwater depth, entrance shape and cross-sectional area, and type of entrance edge, by the cross-sectional area, shape, slope, and length, and by the roughness of the culvert barrel.

In planning the system, required culvert sizes were determined by evaluating multiple constraints and selecting an appropriate size which appeared to best meet all requirements. The EXTRAN hydraulics routine of the SWMM program performs culvert hydraulic computations and was used to evaluate existing culverts and to size recommended new or replacement culverts.

For both annular corrugated metal pipe with a corrugation depth of 0.5 inch and helical corrugated metal pipe with a corrugation depth of one inch or less, a Manning's "n" value of 0.024 was assumed. For annular corrugated metal pipe with a corrugation depth of one inch, a Manning's "n" value of 0.027 was assumed. For annular corrugated metal pipe with a corrugation depth of more than one inch a Manning's "n" value of 0.032 was assumed. A Manning's "n" value of 0.013 was assumed for well-constructed, precast, concrete pipe culverts flowing full.

The following criteria and assumptions were used in the development of culvert sizes for the stormwater management system plan:

1. The culvert location should provide a direct exit, avoiding an abrupt change in direction at the outlet end and, preferably, at the inlet end.
2. The minimum culvert size used was 12 inches in diameter.
3. The culverts were assumed to be laid on a constant gradient.
4. Culvert inlets were assumed to be unblocked.

During the facility design phase subsequent to the adoption of the system plan, the following additional criteria should be considered:

1. Appropriate energy dissipation and/or erosion protection should be provided at culvert inlets and outlets. The type of protection will be dictated by site-specific hydraulic considerations.
2. In streams with an existing or potential valuable fishery, the bottoms of culverts should be designed to allow for the free passage of aquatic organisms for a variety of flow extremes. Typical culvert installations to permit fish passage are shown in Figure 5.

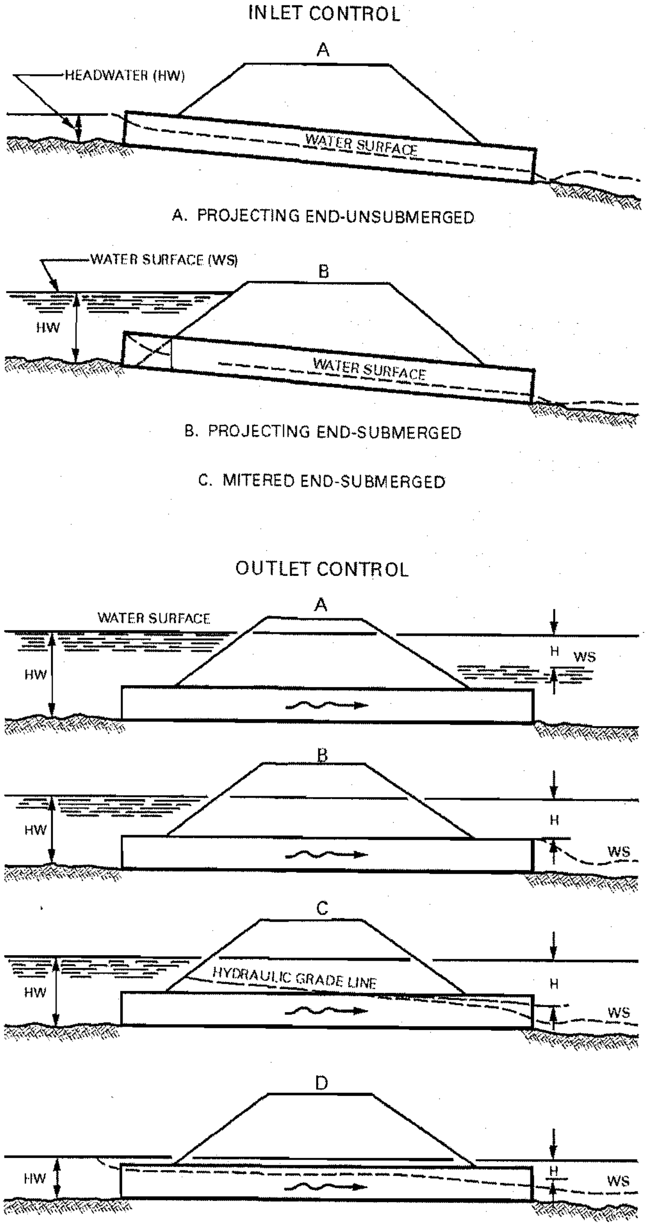
Open Drainage Channels

Open drainage channels in and along exclusive rights-of-way are a necessary and appropriate component of the total stormwater drainage system. In some areas of the stormwater management study area, open drainage channels, together with roadside swales, may serve as the sole component of the engineered stormwater drainage system which conveys surface runoff to the receiving natural stream system.

At the systems planning level, recommendations are provided with respect to the general location, cross-section bottom width and approximate bottom elevation depth, side slopes, gradient, and type of open drainage channels. More detailed engineering at the project development level will be needed to determine the precise location and horizontal and vertical alignment of the channels, the need for and type of channel lining, and the best response to constraints posed by structures, other utilities, and street layout.

Figure 4

CULVERT HYDRAULIC CONDITIONS



Source: American Iron & Steel Institute.

The EXTRAN hydraulics routine of the SWMM program performs open channel hydraulic computations and was used to evaluate existing channels and to size recommended new or modified channels. Careful consideration was given to allowable grades and depths of flow to prevent unacceptable velocities and damage to the facilities and adjacent land uses.

The following criteria relating to the details of the open drainage channels were used in the development of the stormwater management plan and/or can serve as guidelines in the facility design:[18]

1. All open drainage channels which are part of the major stormwater drainage system were designed to accommodate the peak runoff from a 100-year recurrence interval storm under planned land use and channel conditions.

2. Features to mitigate adverse impacts on fish and wildlife habitat should be considered in the design of channel modifications in streams with an existing or potential valuable fishery.

3. Manning's "n" values of 0.030 was used for modified existing or recommended new open channels which were assumed to be lined with turf or grasses, depending on anticipated vegetative growth and frequency of maintenance.

4. It was assumed that erosion control measures and energy dissipation would be provided on a case-by-case basis during the systems design phase.

Storm Sewers

At the systems planning level, only recommendations for the general configuration, size, approximate invert elevation, slope, and type of storm sewer facilities are provided. More detailed engineering at the facility design level will be needed to determine the precise invert elevation, location, and horizontal and vertical alignment of the sewer, the type of material used for the sewer, and the best response to constraints posed by structures and other utilities.

The EXTRAN hydraulics routine of the SWMM program performs storm sewer hydraulic computations and was used to evaluate existing storm sewers and to size recommended new or replacement storm sewers. Values for the

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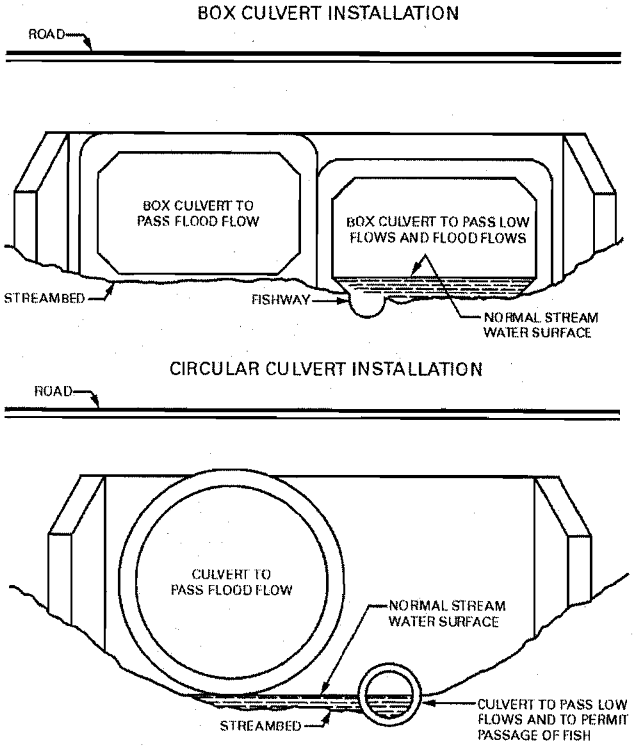
[18] *These criteria relate to small channels which function as part of the stormwater management system.*

Figure 5

TYPICAL CULVERT INSTALLATIONS TO PROVIDE FOR FISH PASSAGE



Source: SEWRPC.

Manning's roughness coefficient "n" vary with the type and conditions of the sewer, the depth of flow in the sewer, and the diameter of the sewer. A Manning's "n" value of 0.013 was assumed typical of well-constructed, precast, concrete pipe sewer lines. A Manning's "n" value of 0.024 was assumed for existing corrugated metal storm sewer lines.

The following criteria and assumption relating to the details of the storm sewers were used in the development of the stormwater management plan:

1. Storm sewers were assumed generally to be located in public street rights-of-way and to follow the street alignments and gradients.
2. All storm sewers were designed to accommodate the peak runoff expected from a minor—that is, a 10-year recurrence interval—storm when flowing full.
3. New storm sewers were assumed to be constructed of reinforced concrete pipe.
4. A minimum pipe diameter of 12 inches was assumed.
5. The minimum desirable velocity during the design storm event should be 2.5 feet per second.
6. Planned storm sewer outlet invert elevations should be above the channel bottom elevations of the receiving watercourses.
7. The minimum depth of cover over the top of the sewer should be three feet.
8. The minimum existing storm sewer diameter considered in the hydraulic model of the system was 18 inches, except in known problem areas where the storm sewers of smaller diameters were evaluated.

Stormwater Storage Facilities

Natural storage of stormwater is provided in surface depressions, vegetated areas, and pervious soils. Natural storage can be enhanced by preserving open areas, woodlands, wetlands, ponds, and areas with large infiltration capacities. These attributes can usually be incorporated into a stormwater management system at less cost than would be required for the incorporation of artificial storage facilities. Artificial storage facilities include constructed onsite swales, roadside swales, temporary storage facilities on parking lots and other open areas, and retention and detention basins.

Under this system planning effort, stormwater storage facilities were considered for the purposes of stormwater drainage, nonpoint source pollution control, peak flow reduction to control streambank erosion and streambed scour, or a combination of those functions. The three types of facilities considered include: 1) retention basins, 2) dry detention basins, and 3) wet detention basins. The term retention basin is used for a facility which stores runoff, but does not release the runoff during a storm. Runoff stored in such a facility is either pumped out, released after the storm through the operation of a gated outlet, or passively released through a combination of evaporation and infiltration. Such facilities may serve either a quantity or a quality control function, or both purposes. When a retention basin is designed to infiltrate runoff, it is also called an infiltration basin. The term dry detention basin is used to identify a stormwater storage facility which drains between storm events and has no permanent pond. Such facilities are primarily for the control of peak rates of runoff, rather than significant control of nonpoint source pollution. The term wet detention basin is used to identify a storage facility which has a permanent pond and generally provides control of nonpoint source pollution. Variations on wet and dry detention basins, which are designed to improve the pollutant removal efficiency of the basins, are extended dry and extended wet detention basins. In those types of basins, the amount of time for which runoff is detained is extended beyond that for a standard basin. Additional variations on the wet basin include constructed wetland basins, pond/wetland systems, and extended detention wetlands. At the systems planning level of detail, reference is only made to dry and wet detention basins.

Recommendations concerning the location, type, approximate size, and capacity of storage facilities and outlet flow constraints are provided in this report. More detailed engineering at the project development level will be needed to precisely locate, configure, and size storage facilities and to specify such details as the inlet and outlet control facilities. Modifications to the basic basin configurations for the purpose of enhancing removal of nonpoint source pollutants would also be addressed at the project design level. In planning the system, required quantity control storage volumes were calculated using the SWMM simulation model. Required wet detention basin sizes for nonpoint source pollution control were determined using the SLAMM program. The following criteria relating to storage facilities were used in the development of the stormwater management system plan:

1. Storage facilities were sized to control a range of storms depending on intended purposes. Storage facilities intended to serve as components of the minor drainage system were sized to control storms with recurrence intervals ranging from two to 10 years, under planned land use and channel system conditions. Storage facilities designed as components of the major drainage system were sized to control storms with recurrence intervals ranging from two to 100 years, under planned land use and channel system conditions. Storage systems planned for water quality purposes were designed based on a typical annual series of storms.

2. Where practical, storage facilities for stormwater drainage purposes were designed to limit the design outflow to no more than the capacity of the existing downstream conveyance and storage systems or to that dictated by the release rates specified in the Milwaukee Metropolitan Sewerage District Chapter 13, "Surface Water and Storm Water," rule.

3. Where modification to, or replacement of, the existing downstream conveyance and storage system is necessary, any proposed upland storage facilities that are required should be sized to minimize the costs of the combined storage and conveyance system.

4. The effects of storage facilities on the frequency, duration, and magnitude of downstream flooding under future conditions as compared to existing conditions were carefully examined. Routing through a storage facility significantly flattens the outflow hydrograph in comparison to the inflow hydrograph. Peak flows are reduced and the duration of peak, or near-peak, flows increased. When prolongation of near-peak flows causes those flows to coincide with near-peak flows of upstream or downstream tributaries, the storage facilities should be designed so as not to increase combined future downstream peak flows to an unacceptable level.

5. Storage depths on parking lots, truck stopping areas, and similar open spaces were assumed to not exceed six inches during the design flood event.

6. Storage facilities that include dams or earth embankments which detain runoff were assumed to include an emergency spillway to safely pass flows up to, and including, those resulting from a 100-year recurrence interval storm, with appropriate freeboard.

Urban Nonpoint Source Pollution Control Measures

Adequate control of urban nonpoint source pollution requires construction site erosion and sediment control and control of pollutants contained in runoff from developed land. Detailed criteria for construction site erosion and sediment control are given in the Wisconsin Department of Natural Resources, *Wisconsin Construction Site Best Management Practice Handbook* (latest revision April 1994). Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* establishes performance standards for post-construction control of the quality of runoff from new development and redevelopment and also establishes runoff infiltration standards for new development. The applicability of implementing infiltration practices and the infiltration requirements on a specific site must be determined based on site-specific investigations. Thus, this plan specifies no specific infiltration facilities; however, the following general criteria for nonpoint source control measures include factors to be considered in designing infiltration facilities.

1. Where feasible, to avoid short circuiting of flow and to maximize the efficiency of wet detention basins, the minimum basin length-to-width ratio was set at three to one, or baffles were assumed to be provided to increase the flow length.

2. The depths of wet detention basins were assumed to range between three and eight feet, with an average depth of five feet. A three-foot minimum depth is needed to minimize scour and resuspension of deposited sediments, and an eight-foot maximum depth will aid in reducing aquatic plant growth.

3. Pretreatment of storm runoff to infiltration devices should be provided to minimize clogging and reduce maintenance. Depending on the land uses tributary to the infiltration device, such pretreatment could typically consist of grass filter strips, grass infiltration swales, a sedimentation-flotation basin to trap oil and grease, and/or a wet detention basin.

4. The design of retention basins and other infiltration systems at the facilities level requires site-specific investigations to establish design parameters and to avoid groundwater contamination. Important considerations related to the assessment of the potential for groundwater contamination are the soil permeability, the depth to the water table, the depth to bedrock, and the existing and potential uses of the receiving groundwater.

Stormwater Management Facility Safety Design Criteria

Because of the detailed nature of the design of most safety measures for stormwater management facilities, such design is most appropriately accomplished at the final design stage rather than at the systems planning stage. The following criteria and assumptions relating to wet detention basins were considered in the development of the stormwater management system plan and may be used as guidelines in facilities design. Additional site- and case-specific measures should be incorporated in the detailed design.

1. For wet detention basins, a 10-foot-wide, essentially level terrace should be provided around the perimeter of the permanent pond above the permanent water level and another such terrace should be provided around the perimeter at a depth of about one foot below the water level.

2. Detention basin side slopes should be no steeper than one vertical on three horizontal and preferably flatter.

3. Removable safety cages or grates should be provided on the outlets of storage facilities and on entrances to large storm sewers which may pose a safety hazard. Such grates should be inspected monthly and after each storm totaling 1.5 inches or more of runoff in 24 hours. Maintenance to clear the grates should be performed as appropriate.

4. Signs should be posted at detention storage facilities indicating that they will occasionally store water, presenting a safety hazard.

ECONOMIC EVALUATION

It is customary to evaluate plans for water resource development projects on the basis of benefits and costs. This is particularly appropriate if the prospective development represents opportunities for investments to provide economic return to the public and if a comparison of alternative investments is desirable. In the case of stormwater management systems, however, it is assumed that such systems must be provided to fulfill a fundamental need of the community, and consequently, they do not compete with alternatives of investment in other economic sectors. Accordingly, it is assumed that the least costly alternative system that meets the stormwater management objectives set forth in this chapter will be the most desirable alternative economically.

The economic evaluations conducted under this stormwater management planning program include capital cost estimates and annual operation and maintenance cost estimates. Capital costs include construction contract costs plus engineering, inspection, and contract administration costs. Cost data for stormwater drainage and flood control measures are presented in Appendix A. Cost data for urban nonpoint source pollution control measures were obtained from SEWRPC Technical Report No. 31,[19] but were updated to reflect 2001 costs.

Unit cost tabulations are provided in Appendix A for site work, such as clearing, grubbing, and excavation; erosion protection, such as riprap and gabions; landscaping; and reinforced concrete. Unit costs of construction are also provided for circular reinforced concrete pipe storm sewers, circular corrugated metal pipes, concrete box culverts, reinforced concrete pipe arches, and horizontal elliptical pipes.

Tables A-1 through A-5 in Appendix A represent 2001 construction or operation and maintenance costs based on an Engineering News-Record, Construction Cost Index (CCI) of 7,360. When estimating total project costs, the costs obtained from those figures and tables should be adjusted using the CCI for the year of the estimate and, unless noted otherwise, increased by 35 percent to account for engineering, administration, and contingencies. Where applicable, the cost of land acquisition or easements should be added.

The cost data presented in Appendix A were obtained from bid tabulations for stormwater and floodland management projects within the Region and from past Regional Planning Commission studies. Cost data for the structural measures considered were adopted after comparison and evaluation of data from these sources.

The adopted base cost data are those that are considered the most applicable to the types of projects considered for the Butler Ditch stormwater and floodland management plan. The cost data presented in Appendix A were used in the economic evaluation of alternative systems plans, and are not intended to be used for project estimating purposes. Actual costs will vary from these estimates, reflecting site-specific conditions, local availability and supply of materials, and labor costs. Any necessary land acquisition costs were estimated utilizing real estate cost estimates provided by the City of Brookfield and the Village of Menomonee Falls.

SUMMARY

The process of formulating objectives and standards for stormwater and floodland management is an essential part of the planning process. To reflect the basic needs and values of the community, it is necessary that these objectives and standards be prepared within the context of, and be fully consistent with, proposed land use conditions and broad community development objectives.

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[19] *SEWRPC Technical Report No. 31,* Costs of Urban Nonpoint Source Water Pollution Control Measures, *June 1991.*

The following seven stormwater and floodland management objectives were formulated to guide the design, test, and evaluation of alternative stormwater management plans and the selection of a recommended plan from among the alternatives considered:

1. The development of a stormwater and floodland management system which reduces the exposure of people to drainage-related inconvenience and to health and safety hazards and which reduces the exposure of real and personal property to damage through inundation resulting from flooding and inadequate stormwater drainage.

2. The development of a system which will effectively serve existing and planned future land uses and will promote implementation of the adopted land use plan set forth in the Waukesha County development plan and in the adopted City and Village local land use and zoning plans.[20]

3. 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 waterbodies.

4. The development of a system which will maintain or enhance existing terrestrial and aquatic biological communities, including fish and wildlife.

5. The development of a stormwater and floodland management system which will be flexible and readily adaptable to changing needs.

6. The development of a stormwater and floodland management system which will not pollute the groundwater aquifers serving the City and the Village.

7. The development of a stormwater and floodland management system which will efficiently and effectively meet all of the other stated objectives at the lowest practicable cost.

Complementing each of the foregoing objectives is a set of quantifiable standards which can be used to evaluate the relative or absolute ability of alternative plan designs to meet the objective. The objectives and standards, which are set forth in Table 10, were developed in close consultation with the City and Village public works and engineering staffs.

In addition to presenting the objectives and standards established for the Butler Ditch subwatershed, this chapter presents the engineering design criteria and analytic procedures that were used to design and size the alternative plan elements and which will serve as a basis for the more detailed design of stormwater and floodland management system components. Criteria and procedures were developed for estimating stormwater flow rate and volume and for designing street cross-sections, swales, culverts, open channels, storm sewers, storage facilities, and urban nonpoint source pollution control measures. In addition, stormwater management facility safety design criteria are presented.

Consistent with existing City and Village policies, and with good engineering practice, a 10-year recurrence interval design storm was selected for the evaluation and design of the components of the minor, or convenience, stormwater management system. A 100-year recurrence interval storm was selected for use in evaluating the floodland management system and the major, or emergency, stormwater management system, in delineating areas of potential inundation along the stormwater drainage and stream system, and to size some elements of the system.

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[20] *SEWRPC Community Assistance Planning Report No. 209,* op. cit.

The hydrologic and hydraulic modeling of the subwatersheds under existing and full development conditions was accomplished with the VISUAL SWMM and XP-SWMM Stormwater Management Model computer programs, the USEPA HSPF continuous simulation program, and the U.S. Army Corps of Engineers HEC-RAS River Analysis System water surface profiles computer program. Estimation of nonpoint source pollution loads was accomplished using the Source Loading and Management Model (SLAMM).

The economic evaluations conducted under this stormwater management planning program include capital cost estimates and annual operation and maintenance cost estimates. Construction cost and operation and maintenance data which were used in the economic evaluation of alternative systems plans are presented in Appendix A.

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Chapter IV

WATER QUALITY MANAGEMENT PLAN ELEMENT

INTRODUCTION

This chapter presents a description and assessment of existing water quality and biological conditions and it describes and evaluates alternative water quality management plans designed to serve the Butler Ditch subwatershed under planned land use conditions.

The alternate nonpoint source pollution control plans are evaluated within the context of the Menomonee River watershed study;[1] the regional water quality management plan for Southeastern Wisconsin, as amended; [2] and the Menomonee River Priority Watershed Project nonpoint source control plan[3] and they incorporate the nonpoint source pollution control standards as set forth under Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code.*

The components of the alternative nonpoint source pollution control plans developed for the subwatersheds are described below and capital and operation and maintenance costs are provided.

The recommended stormwater drainage, nonpoint source pollution control, and floodland management measures are integrated into a recommended stormwater management plan for the subwatersheds as set forth in Chapter VI. The design of the recommended plan was based on 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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[1] *SEWRPC Planning Report No. 26,* A Comprehensive Plan for the Menomonee River Watershed, *Volume Two,* Alternative Plans and Recommended Plan, *October 1976.*

[2] *SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[3] *Wisconsin Departments of Natural Resources and Agriculture, Trade and Consumer Protection,* A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, *PUBL-WR-244-92, March 1992.*

DESCRIPTION AND ASSESSMENT OF EXISTING WATER QUALITY AND BIOLOGICAL CONDITIONS

Stormwater management planning efforts require the evaluation of existing water quality conditions and of the relationship of those conditions to existing biological communities. This section describes the existing water quality conditions in Butler Ditch based on the available data, which are limited. Field observations and measurements of stream properties were made by the Commission staff in the fall of 2001 and summer of 2002. Relatively extensive biological surveys were conducted in April and May of 2003 by the Wisconsin Department of Natural Resources (WDNR). Survey results summarized herein address the water quality, aquatic habitat conditions, and fishery resources. The information presented below is taken from the Commission and WDNR staff data collection efforts.

Effects of Urbanization

Increased land development or urbanization has been shown to cause changes in hydrologic, physical, water quality, and biological indicators.[4] These studies have examined the link between watershed urbanization and its impact on stream biodiversity and have revealed that a relatively small amount of urbanization has a potential negative effect on aquatic diversity.[5] These studies further indicate that as watersheds become highly urban, aquatic diversity becomes extremely degraded. Hence, hydrologic, physical, and water quality changes caused by watershed urbanization all stress the aquatic community and collectively diminish the quality and quantity of available habitat. As a result, these stressors generally cause a decline in biological diversity, a change in trophic structure, and a shift towards more pollutant tolerant organisms.

Impervious cover (IC) has begun to emerge as a key indicator linking the changes in watershed development and the potential severity of stream quality indicator response. These findings have been developed in a general watershed planning model, known as the impervious cover model (ICM). The ICM predicts that when watershed IC exceeds 10 percent most stream quality indicators decline and severe degradation is expected beyond 25 percent IC. However, it should be noted that these "thresholds" of 10 and 25 percent IC only reflect an expected transition of a composite of individual indicators in that range of IC and not a distinct breakpoint from one category to the next. It is also important to note that the ICM does not predict the precise score of individual stream quality indicators, but rather predicts the average behavior of a group of indicators over a range of IC.

As indicated in the land use section above, the Butler Ditch subwatershed currently contains approximately 75 percent urban lands and about 20 percent IC. Hence, the ICM indicates that the Butler Ditch subwatershed has been impacted by urbanization and may be near a "threshold" or expected transition from an impacted stream to one that could potentially become nonsupporting. The proportion of urban lands in the Butler Ditch subwatershed has remained relatively unchanged since 1985, when it was estimated to contain about 70 percent urban lands and 20 percent IC. This relatively stable condition of subwatershed development as well as the maintenance of a high quality floodplain corridor adjacent to Butler Ditch may be related to the apparent improvement in water quality and fisheries community in the Butler Ditch subwatershed during the time period from 1985 to 2003 (see water quality and fisheries sections below).

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[4] *Center for Watershed Protection,* Impacts of Impervious Cover on Aquatic Systems, *Watershed Protection Research Monograph No. 1, March 2003.*

[5] *P. Wood and P. Armitage, "Biological Effects of Fine Sediment in the Lotic Environment," Environmental Management, Volume 21(2), pages 203-217, 1997; D. Hart and C. Finelli, "Physical-Biological Coupling in Streams: the Pervasive Effects of Flow on Benthic Organisms,"* Annual Review of Ecology and Systematics, *Volume 30, pages 363-395, 1999.*

Hydrologic Characteristics

This section describes hydrologic characteristics of the Butler Ditch subwatershed that influence the physical, chemical and biological community of the system.

Stream Reaches

Based upon the analysis of discharge, bottom elevation, and bridge and culvert crossings, in combination with slope and sinuosity, specific sections of stream, defined as stream reaches, were developed, as set forth in Table 16. These properties are components of the Rosgen stream classification system which was applied to help categorize reaches of Butler Ditch and its tributaries as summarized below.[6]

Streambed Slope

The longitudinal streambed slope is an indicator of stream energy or power. The lower the slope, the lower the energy, and the slower the flow velocity. The slopes of Butler Ditch are indicative of lowland streams and do not generally exceed 0.5 percent or less, as shown in Table 16.

Sinuosity

Sinuosity is a measure of channel pattern and is defined as the ratio of channel length between two points on a channel to the straight-line distance between the same two points. Sinuosity or channel pattern can range from straight to a winding pattern, or "meandering." The more a stream meanders within a given distance, the more "sinuous" it is. Channels with sinuosities of 1.5 or greater are considered "meandering." Reaches of streams that have been straightened typically have low sinuosity or a number closer to one. Sinuosity is also related to slope. Streams with low slope values, such as Butler Ditch, should be associated with higher sinuosity or meandering patterns. Stream reaches within the Butler Ditch subwatershed have sinuosities that range from 1.0 to 1.4 as shown in Table 16. Those reaches include both channelized and nonchannelized segments. Past stream channelization has been identified by the WDNR staff to have resulted in the loss of important fish and aquatic life habitat within Butler Ditch.[7] Approximately 80 percent of Butler Ditch has been channelized. However, the most "natural" or sinuous reaches of the stream include Reaches 1 and 3 as shown in Table 16. These areas were also observed to contain some of the most diverse habitat in terms of pool and riffle habitats (see habitat discussion below).

Width and Depth

Width and depth characteristics of low flow and bankfull channel stages within Butler Ditch are shown in Figure 6. In an undisturbed stream ecosystem, channel width typically demonstrates an overall increase from upstream to downstream, however due to ditching, dredging and past channelization impacts, Butler Ditch displays a range in variability among all locations measured that obscures any obvious pattern in width and depth from upstream to downstream. Butler Ditch and its tributaries generally contain a very low width to depth ratio (i.e. values less than 12 according to the Rosgen Stream Classification) that indicates this stream is narrow compared to its depth as shown in Table 16 and Figure 6. Figure 6 also shows that the low flow width and depth characteristics do not change appreciably from upstream to downstream and indicate that Butler Ditch contains a relatively constant width and depth, which is consistent with a highly modified or channelized stream system. This narrow range in low flow width and depth is indicative that each of the reaches of Butler Ditch contains a paucity of deep and shallow areas typically referred to as pool and riffle habitats, which limits the amount of available habitat for aquatic organisms (see habitat section below).

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[6] *D.L. Rosgen, "A Classification of Natural Rivers,"* Catena, *Vol. 22, 1994, pp. 169-199.*

[7] *Wisconsin Department of Natural Resources, PUBL-WR-244-92,* op. cit.

Table 16

PHYSICAL CHARACTERISTICS AMONG STREAM REACHES WITHIN THE BUTLER DITCH WATERSHED: 2002

Reach	Location	River Mile	Entrenchment Ratio	Width/ Depth Ratio	Sinuosity	Slope	Dominant Channel Material
Main Channel-1	West side of Dolphin Drive about 800 feet south of Lancaster Avenue	3.99	3.1	8.2	1.42	0.0023	Bedrock, Sand
	Lisbon Road	3.4					
Main Channel-2	Lisbon Road	3.4	7.6	10.1	1.10	0.0021	Clay. silt
	Lilly Road	1.76					
Main Channel-3	Lilly Road	1.76	3.4	6.5	1.35	0.0016	Sand, silt
	Hampton Road	1.03					
Main Channel-4	Hampton Road	1.03	2.5	8.9	1.21	0.0053	Bedrock, cobble
	Confluence with the Menomonee River	0.0					
South Branch	Pilgrim Road	0.688	6.5	- -	1.14	0.0011	Sand, silt
	Confluence with Butler Ditch	0.0					
Unnamed Tributary	Wisconsin Memorial Park Cemetery	1.022	3.4	6.5	1.04	0.0035	Gravel, sand
	Confluence with Butler Ditch	0					

Source: SEWRPC.

Figure 6 also indicates a significant increase or transition in bankfull width and depth characteristics from Reach 2 to Reach 3. This shift seems to be related to increased discharge during storm events (see Figure 7 and habitat section below). Reaches 3 and 4 contained the greatest maximum and average low flow depths within the entire Butler Ditch system, which indicates these reaches contain higher quality pool habitat than the upstream areas of Reaches 1 and 2.

Substrates

Substrates were observed to change dramatically along reaches within Butler Ditch. The headwaters (Reach 1) are dominated by an exposed bedrock stream bottom, whereas Reach 2 is dominated by clay and silt. The substrates in Reach 3 are dominated by sand and silt. The most downstream segment of Butler Ditch (Reach 4) cuts once again into a bedrock outcrop and the channel substrates become dominated by bedrock and cobble.

Entrenchment

An important element of stream systems is the interrelationship of the stream to its valley and/or landform features. This interrelationship determines whether or not the river system is deeply incised or entrenched in the valley floor. Depending on the degree of entrenchment, the flat area adjacent to the channel may be an area of active flooding during events with recurrence intervals on the order of two to five years, or it may be outside of the area that would flood during such events. Under the second case, the flow during two- to five-year events would be contained within the entrenched channel. The entrenchment ratio is a quantitative expression of this feature and is a ratio of the width of the floodprone area to the bankfull surface width of the channel. A river is considered entrenched if the entrenchment ratio is less than 1.4, moderately entrenched if the ratio is between 1.4 and 2.2, and only slightly entrenched if the ratio is greater than 2.2.[8]

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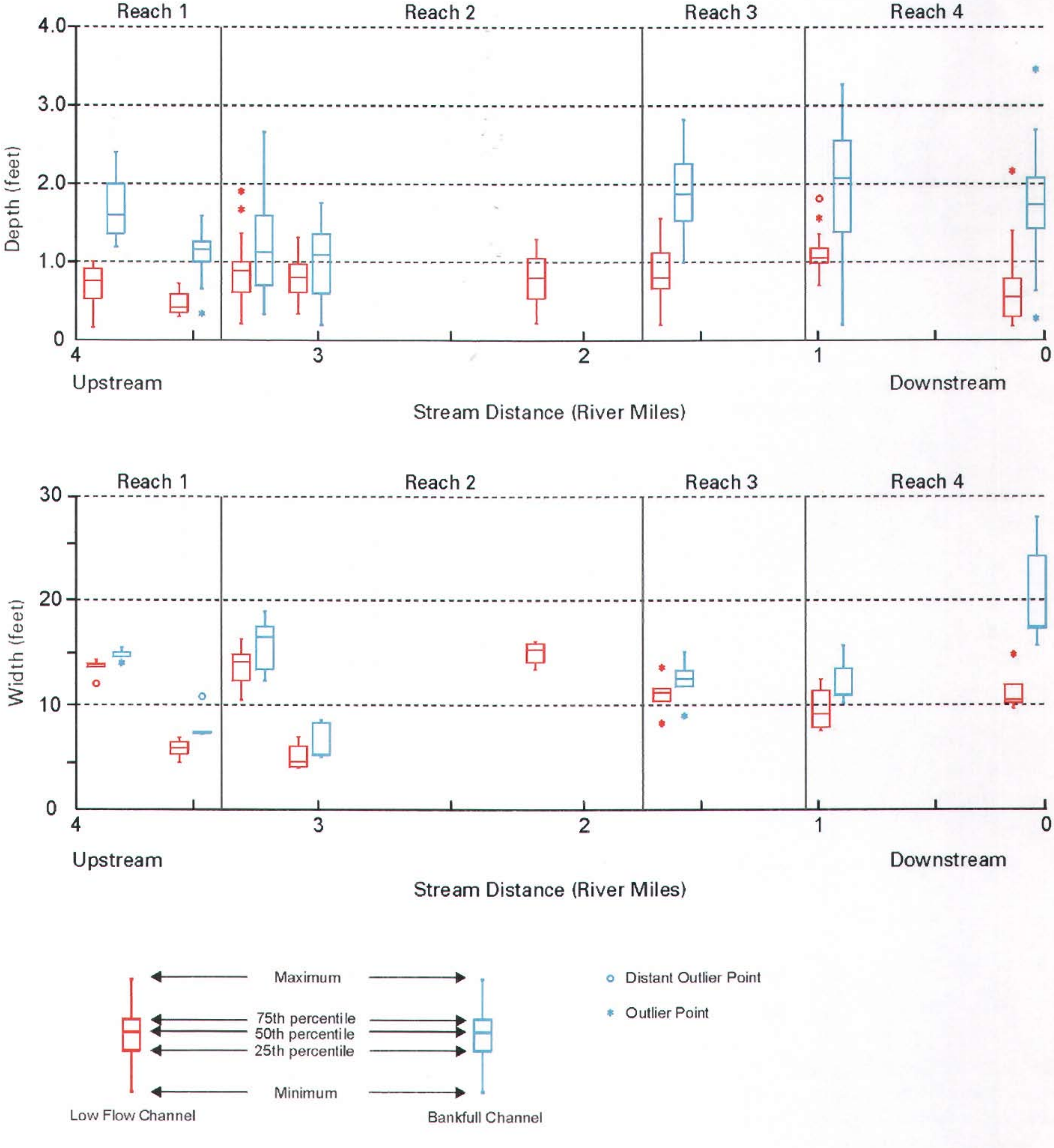
[8] *D.L. Rosgen,* op. cit.

Figure 6

DEPTH AND WIDTH CHARACTERISTICS OF THE LOW FLOW[a] AND BANKFULL[b] CHANNEL STAGES WITHIN BUTLER DITCH: SEPTEMBER 2001



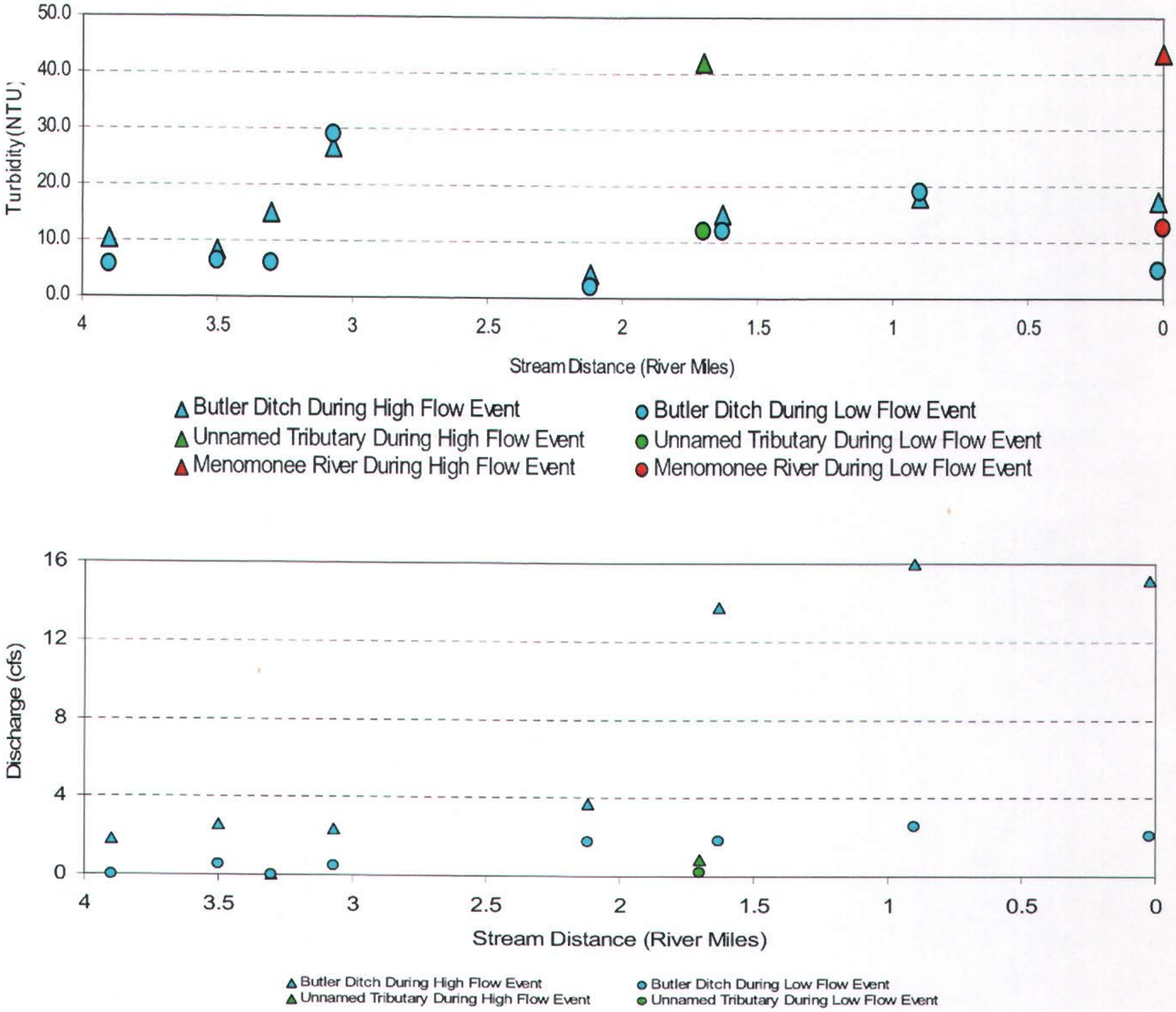
[a] *Low Flow is defined as the lowest discharge recorded during the time period between September 24-28, 2001.*

[b] *Bankfull channel is defined by the bankfull discharge, which occurs when water begins to leave the channel and spread out onto the floodplain.*

Source: SEWRPC.

Figure 7

TURBIDITY AND DISCHARGE CHARACTERISTICS WITHIN BUTLER DITCH DURING LOW FLOW AND HIGH FLOW EVENTS BETWEEN SEPTEMBER 24-28, 2001



Source: SEWRPC.

Table 16 indicates that none of the reaches of Butler Ditch are entrenched and, therefore, the stream has an active connection to the adjacent floodplain. These results are consistent with the observations of limited streambank erosion or failure within the Butler Ditch subwatershed, because water readily spills out into the broad floodplain adjacent to Butler Ditch.

Based only upon the hydrologic characteristics determined using the Rosgen classification system, Butler Ditch can be generally classified as very sensitive to disturbances within the drainage area, with a good recovery potential. These characteristics also suggest that the potential for streambank erosion within this stream system is moderate to very high, with streambank vegetation having a very high controlling influence on moderating this erosion potential. These features of Butler Ditch are also indicative of a low to moderate potential of suspended and bedload sediment supply emanating from channel derived sources and/or from adjacent stream slopes.

Water Quality Conditions

Historic

The water quality of Butler Ditch varies from poor to fair, depending upon the indicators considered. In 1984, the WDNR collected instantaneous dissolved oxygen and temperature measurements for one site at the downstream W. Lisbon Road crossing that indicated Butler Ditch could potentially support warm water forage fishery standards.[9] A dissolved oxygen concentration of 11.9 milligrams per liter (mg/l) and a water temperature of 8.6 degrees Celsius (°C) were measured (see water quality standards section in Chapter III). The well developed canopy cover throughout the upper portions of the subwatershed was thought to be a significant factor contributing to the low temperature conditions of the stream.

Existing

Based upon quality monitoring efforts by SEWRPC staff, water quality information on discharge, turbidity, dissolved oxygen and temperature during high and low flow events were taken at nine different locations from upstream to the confluence of Butler Ditch with the Menomonee River from September 24-28, 2001. These data were used to assess the current status of the Butler Ditch subwatershed. At the time that this study was prepared, no data on pH, total phosphorus, ammonia nitrogen, chloride, or fecal coliform concentrations existed for assessment of compliance with these water quality standards within Butler Ditch. However, since that time the WDNR has completed a baseline monitoring assessment of the Butler Ditch subwatershed.

Turbidity and discharge characteristics within Butler Ditch during low and high flow events are shown in Figure 7. Low flow discharge rates support the observed ephemeral nature of specific reaches of Butler Ditch. During one site visit in late summer of 2002, a portion of Reach 2 was observed to be completely waterless. The year 2002 was an exceptionally dry year, so it is unknown if this is a typical occurrence for this subwatershed. Nonetheless, the waterless section was observed between River Mile 2.66 and near the upstream W. Lisbon Road crossing at River Mile 3.40. Upstream and downstream from these points, Butler Ditch had measurable discharge rates during this same low flow period. Average low flow discharge rates upstream of the confluence with the Unnamed Tributary at Lilly Road at River Mile 1.76 were 0.49 cubic feet per second (cfs). Average low flow discharge rates downstream of the Unnamed Tributary were 2.16 cfs. High flow discharge rates averaged 1.92 cfs upstream of the confluence with the Unnamed Tributary and 15.01 cfs downstream of the Unnamed Tributary. Those observations indicate that the Unnamed Tributary at River Mile 1.76 is a major water source to Butler Ditch during the higher flow conditions.

Turbidity measurements were not significantly different between high flow and low flow events, however, turbidity measurements were variable between sample locations. The sample site at River Mile 3.07 recorded the maximum turbidity reading for both high and low flows at 26.55 Nephelometric turbidity units (NTU) and 28.85 NTU, respectively. The lowest turbidity readings were recorded at River Mile 2.12 just downstream of a wetland complex where the channel was more braided and undefined. Filtering and deposition of sediment in the grassy wetland in this reach appears to reduce sediment loads to downstream reaches. The turbidity readings for Butler Ditch during low flow conditions were generally at or below the turbidity observed in the Menomonee River. High flow measurements of turbidity in Butler Ditch were found to be well below high flow turbidity levels in the Menomonee River.

Dissolved oxygen and temperature levels within Butler Ditch during high flow and low flow events ranged from about 5 to 11 mg/l and 8 to 12°C, respectively. Dissolved oxygen concentrations were found to be highest near the headwaters of Butler Ditch in the Village of Menomonee Falls, during both high and low flow events. Dissolved oxygen concentrations dropped to their lowest levels at River Mile 2.12 near Lilly Heights Park during both high

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[9] *Wisconsin Department of Natural Resources,* Stream Classification for Butler Ditch (South Branch Lilly Creek), Menomonee River Watershed, Milwaukee River Basin, Waukesha County, *September 1984.*

and low flow events. Nonetheless, the dissolved oxygen concentration at that location was never lower than 5.3 mg/l. Overall temperature readings were not significantly different from upstream to downstream or during high flow and low flow stage events; however, a general trend of decreasing temperatures was observed from upstream to downstream, which may be indicative of spring water input within this stream system.

Aquatic Habitat

Historic

The aquatic habitat consists of those physical and biological characteristics of a surface water which determine its potential for supporting different communities of organisms. In 1984, Butler Ditch was determined to contain water quality classified as fair based upon the Stream System Habitat Evaluation procedure.[10] During this survey the WDNR observed that bank erosion was not limiting the water quality in Butler Ditch and the streambanks were generally stable and well vegetated with grasses and shrubs. The WDNR further concluded that low flow, insufficient water depth and the effects of past channelization were some of the factors limiting fish and aquatic life. The main factor responsible for limiting the potential biological use of Butler Ditch is the low flow conditions. It was observed that the stream segment upstream of W. Hampton Road does not have sufficient water depth to support a fishery year round. The reach of Butler Ditch downstream of W. Hampton Road to the confluence with the Menomonee River is deeper and supports a small population of tolerant to very tolerant fish year round.

Existing

The amount, quality, and diversity of available instream fisheries and macroinvertebrate habitat were generally observed to be poor to fair within the Butler Ditch subwatershed by SEWRPC staff in 2001. The proportion of pool and riffle habitats is highest in the downstream Reaches 3 and 4 of Butler Ditch compared to the rest of the stream. As indicated in the stream reach section above, width and depth characteristics were greatest in Reaches 3 and 4, which indicates these areas contain the highest diversity of habitat types, and therefore greatest potential for fisheries community development, compared to the rest of the stream. Reaches 3 and 4 also generally contained a moderate amount of instream cover for fish and macroinvertebrates in terms of undercut banks, woody debris, and large boulders in the channel. Woody debris is a significant habitat component within this portion of the stream system, most likely due to the extensive woody riparian buffers that exist throughout this area of the subwatershed. The presence and diversity of woody debris within the downstream reaches of the stream is excellent, however, woody debris has been observed to accumulate excessively causing debris jams in Reach 4. These debris jams can function much like a beaver dam, which can cause a significant disruption in sediment dynamics, cause localized flooding, and localized bank stability problems, and may inhibit movement of fishes to feeding and spawning areas.

Culverts tend to have a destabilizing influence on stream morphology that can create selective barriers to fish migration because swimming abilities vary substantially among species and size-classes of fish affecting their ability to traverse the altered hydraulic regime within the culverts.[11] Fish of all ages require freedom of movement to fulfill needs for feeding, growth, and spawning which generally cannot be found in only one particular area of a stream system. These movements may be upstream or downstream and occur over an extended period of time, especially in regard to feeding. In addition, before winter freeze-up, fish tend to move downstream to deeper pools for overwintering. Fry and juvenile fish also require access up and down the stream system while seeking rearing habitat for feeding and protection from predators. The recognition that fish populations are often adversely affected by culverts has resulted in numerous designs and guidelines that have been developed to allow for better

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[10] *Wisconsin Department of Natural Resources,* Stream Classification Guidelines for Wisconsin, *Technical Bulletin, 1982.*

[11] *Stream Enhancement Research Committee, "Stream Enhancement Guide," Province of British of Columbia and the British Columbia Ministry of Environment, Vancouver, 1980.*

fish passage and to help ensure a healthy sustainable fisheries community.[12] In addition to the woody debris jams, the WDNR noted a number of other potential physical and hydrological migratory barriers to fisheries movements particularly at culverts and bridges within Reaches 3 and 4.[13] These obstructions may be limiting the potential of the fishery within Butler Ditch.

Fishery Resources and Benthic Organisms

Review of the fishery data collected in the Butler Ditch subwatershed between 1984 and 2003 indicates an apparent increase of 11 species since the mid-1980s. In 1984, The WDNR collected four white suckers and two creek chubs, both tolerant species, during an extensive sampling effort at the downstream W. Lisbon Road crossing. Macroinvertebrate samples were also collected at this site and were dominated by few, tolerant species, resulting in a biotic index value indicative of low water quality. Benthic macroinvertebrates are bottom-dwelling organisms that are important sources of food for fish and also serve as an indicator of overall water quality conditions.[14] In comparison to the 1984 survey, in 2003 the WDNR staff captured 328 fish and 12 total species, at three sites downstream of the W. Lisbon Road crossing. The species included white sucker, creek chub, blacknose dace, black bullhead, bluntnose minnow, central mudminnow, common carp, common shiner, fathead minnow, green sunfish, stoneroller spp., and johnny darter. Hence, that preliminary electrofishing survey of the downstream portion of the Butler Ditch subwatershed indicates that the fishery in these portions have improved significantly from the historic survey in terms of overall fish abundance and diversity.

However, despite this marked improvement, application of the warmwater Index of Biotic Integrity (IBI), which is used to classify the fishery and environmental quality in this stream, indicates that the fishery within Butler Ditch is very poor.[15] The IBI consists of a series of fish community attributes that reflect basic structural and functional characteristics of biotic assemblages: species richness and composition, trophic and reproductive function, and individual abundance and condition.[16] Despite this very poor rating, this stream is considered to be one of the best quality urbanized warmwater streams within Southeastern Wisconsin.[17]

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[12] *B.G. Dane, "A Review and Resolution of Fish Passage Problems at Culvert Sites in British Columbia," Canada Fisheries and Marine Sciences Technical Report 810, 1978; Chris Katopodis, "Introduction to Fishway Design," Freshwater Institute Central and Arctic Region Department of Fisheries and Oceans, January, 1992.*

[13] *Personal communication, William G. Wawrzyn, Water Resource Biologist, WDNR-Southeast Region.*

[14] *William L. Hilsenhoff, "Rapid Field Assessment of Organic Pollution with Family-Level Biotic Index," University of Wisconsin, Madison, 1988.*

[15] *John Lyons, "Using the Index of Biotic Integrity (IBI) to Measure Environmental Quality in Warmwater Streams of Wisconsin," United States Department of Agriculture,* General Technical Report NC-149, *1992.*

[16] *John Lyons,* General Technical Report NC-149, op. cit. *The Wisconsin IBI described here consists of 10 basic metrics, plus two additional metrics (termed "correction factors") that affect the index only when they have extreme values. These 12 metrics are: Species Richness and Composition—total number of native species, darter species, sucker species, sunfish species, intolerant species, and percent (by number of individuals) that are tolerant species; Trophic and Reproductive Function—Percent that are omnivores, insectivores, top carnivores, and simple lithophilous spawners; and Fish Abundance and Condition—number of individuals (excluding tolerant species) per 300 meters sampled and percent with deformities, eroded fins, lesions, or tumors (DELT). The last two metrics are not normally included in the calculation of the IBI, but they can lower the overall IBI score if they have extreme values (very low number of individuals or high percent DELT fish).*

[17] *William G. Wawrzyn, Water Resource Biologist, WDNR-Southeast Region.*

Summary

Based upon data from 1984, Butler Ditch is currently designated as only partially meeting the standards for limited forage fish and full recreation water use objectives. The water quality of Butler Ditch varies from fair to poor, depending upon the indicators considered. From 1983 to 2003, the Wisconsin Department of Natural Resources and SEWRPC staff collected various instantaneous dissolved oxygen and temperature measurements, among others, for specific areas within Butler Ditch that were consistent with standards supporting a warmwater forage fish community. Small physical stream size, limited flow, and past channelization continue to limit the potential fishery. The amount, quality, and diversity of available instream fisheries and macroinvertebrate habitat are generally fair to poor within the subwatershed. However, fishery data collected in 2003 indicate an apparent improvement in the abundance and diversity of species since the mid-1980s. Although IBI results continue to indicate an overall limited fishery, the improvements in the abundance and diversity of fishes over the past 20 years indicate that Butler Ditch is potentially capable of meeting the warmwater forage fish and partial recreation water use objectives. Between 2000 and 2020, urban land uses in the subwatershed are expected to increase, which could continue to limit the fishery in terms of hydrology, water quality, and habitat.

Based upon the physical characteristics, Butler Ditch is considered very sensitive to disturbances within the subwatershed, with a fair to good recovery potential. These classifications also suggest that the potential for streambank erosion within this system is moderate to high, with streambank vegetation having a very high controlling influence on moderating this erosion potential. This was confirmed by the field survey which indicated that there were few sites where active streambank erosion was observed.

The amount, quality, and diversity of available instream fisheries and macroinvertebrate habitat are generally fair to poor within the Butler Ditch subwatershed. The subwatershed also generally contained a low amount of instream cover for fish and macroinvertebrates in terms of undercut banks, and woody debris, as well as large boulders. The presence and diversity of woody debris within the system is moderate in the downstream reaches of the subwatershed, however, woody debris has been observed to accumulate excessively causing debris jams. These debris jams function much like a beaver dam, which can cause a significant disruption in sediment dynamics, cause localized flooding, and localized bank stability problems. Debris jams as well as culverts within the stream system may inhibit movement of fishes to feeding and spawning areas.

WATER USE OBJECTIVES AND WATER QUALITY STANDARDS

The water use objectives and supporting water quality standards to be met by surface waters in the study area were set forth in Chapter III. The levels of control of nonpoint source pollutants determined to be needed to meet those objectives and standards provide the basis for selection of the recommended water quality management plan.

As noted in Chapter III, Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch are designated to meet the standards for limited forage fish and full recreation water use objectives. As noted above, based upon recent year 2003 data from the WDNR, Butler Ditch was found to be potentially capable of supporting a warmwater forage fish community and partial recreational water use objectives. Therefore, it is recommended that the water use objectives for Butler Ditch and its two main tributaries be upgraded to a classification of warm water forage fish and partial recreation water use objectives as shown on Map 7 in Chapter III of this report.

POLLUTANT LOADING ANALYSIS

Critical Land Uses within the Study Area

The 1992 priority watershed study identified commercial and industrial uses as critical land uses contributing to nonpoint source pollution in the study area. As set forth in Table 1 and shown graphically on Map 2 in Chapter II of this report, under 1995 land use conditions, about 75 percent of the Butler Ditch subwatershed was developed in urban land uses and about 6 percent of the subwatershed was in critical land uses. As set forth in Table 1 and shown graphically on Map 3, under planned land use conditions, it is anticipated that about 90 percent of the subwatershed would be developed in urban land uses and about 10 percent of the subwatershed would be in critical urban uses. In the interim period between 1995 and the present, much of the full buildout development has occurred in the subwatershed. The water quality management plan element focuses primarily on providing treatment of runoff from critical land uses under planned land use conditions, which represent full buildout of the subwatershed.

Quantification of Existing (1995) and Full Buildout Condition Loadings and Nonpoint Source Pollutants
As described in Chapter III, the Source Loading and Management Model (SLAMM) was used to estimate average annual loadings of particulate solids, total solids, total phosphorus, copper, zinc, and cadmium, under both existing (1995) and planned land use conditions with existing nonpoint pollution controls in the subwatershed. A comparison of estimated annual loadings is set forth in Table 17 and the subbasins used in the SLAMM analysis are shown on Map 8.

There are significant existing controls in the subwatershed, including 16 ponds that collect runoff from a total area of about 838 acres, or about 24 percent of the study area; grassed roadside swales with culverts or grassed swales with underlying storm sewer ditch enclosures that serve almost the entire study area; and a program of sweeping streets once in spring and once in fall in the City of Brookfield and approximately three times per year in the Village of Menomonee Falls. The effects of these controls were considered in the determination of the existing condition loadings. The SLAMM results indicate that the existing ponds are expected to be from about 45 to 65 percent effective in reducing nonpoint source pollutant loadings under existing land use conditions.

For the study area as a whole, under planned land use conditions, the annual loadings of sediment and phosphorus would be expected to increase by about 22 percent and 23 percent, respectively, relative to 1995 land use and control conditions. The annual loadings of copper, lead, zinc, and cadmium would be expected to increase by 25, 7, 15, and 72 percent, respectively, relative to 1995 land use and control conditions.

BASIS FOR THE SELECTION OF THE TARGETED LEVELS OF CONTROL OF NONPOINT SOURCE POLLUTION

The measures considered were directed toward reducing the pollutant loadings on the basis of two separate planning efforts and to meet the performance standards of Chapter NR 151.

Regional Water Quality Management Plan
The primary objective was to provide reductions in nonpoint source pollutant loadings to the levels set forth in the regional water quality management plan as amended. That level of control, when combined with the recommended level of control of point source loadings, was estimated to be adequate to achieve the water quality standards associated with the water use objectives described earlier. These recommendations were based upon analyses, including extensive instream water quality simulation modeling conducted to establish needed pollutant reductions on a major subwatershed basis, and were recommended to be refined by subsequent second level, more site-specific planning programs. For the Butler Ditch subwatershed, the recommended level of control was determined to be a reduction of about 25 percent of the nonpoint source loadings estimated under full buildout land use conditions, in addition to urban construction site erosion control and streambank erosion control.

The water quality modeling conducted to develop these recommendations included simulation of temperature, biochemical oxygen demand, dissolved oxygen, fecal coliform, ammonia nitrogen, and phosphorus.

Priority Watershed Study
In addition to the recommendations developed in the regional water quality management plan, nonpoint source pollutant reduction goals were established for the study area under the aforementioned priority watershed planning program. The latter nonpoint source pollutant reduction goals were established by the Wisconsin Department of Natural Resources (WDNR) staff, and considered primarily sediment, phosphorus, and lead, as an indicator for metal loadings. The pollutant reduction goals were established on the basis of Department staff

Table 17

ANNUAL NONPOINT SOURCE POLLUTANT LOADINGS TO BUTLER DITCH UNDER EXISTING (1995) AND PLANNED BUILDOUT LAND USE CONDITIONS WITH EXISTING CONTROLS[a]

		Particulate Solids (pounds)			Total Solids (pounds)			Total Phosphorus (pounds)			Copper (pounds)			Zinc (pounds)			Cadmium (pounds)		
Subbasin	Drainage Area (acres)[b]	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change
BD-1	17.06	2,705	2,705	0	7,683	7,683	0	6.00	6.00	0.00	7.00	7.00	0	4.000	4.00	0	2.31E-05	2.31E-05	0
BD-2	129.07	47,213	60,878	29	114,473	178,116	56	90.00	125.00	38.89	86.00	218.00	153	115.000	101.00	-12	4.49E-04	1.01E-03	125
BD-3	81.22	27,096	27,020	0	68,805	68,899	0	53.00	54.00	1.89	48.00	66.00	38	66.000	81.00	23	2.64E-04	2.65E-04	0
BD-4	8.08	1,278	1,278	0	3,631	3,631	0	3.00	3.00	0.00	7.00	3.00	0	2.000	2.00	0	1.09E-05	1.09E-05	0
BD-5	174.84	64,055	85,386	33	194,150	249,505	29	129.00	145.00	12.40	230.00	195.00	-15	89.000	137.00	54	5.84E-04	6.96E-04	20
BD-6	77.62	27,428	32,375	18	66,938	99,902	49	55.00	56.00	1.82	77.00	76.00	-1	37.000	52.00	41	2.47E-04	2.59E-04	5
BD-7	111.34	49,466	64,451	30	149,036	183,007	23	97.00	124.00	27.84	84.00	148.00	76	86.000	131.00	52	1.23E-03	1.58E-03	28
BD-8	19.14	7,179	7,179	0	19,649	19,649	0	15.00	15.00	0.00	15.00	15.00	0	19.000	19.00	0	1.09E-04	1.09E-04	0
BD-12	5.49	1,547	2,439	58	6,422	6,422	0	5.00	5.00	0.00	7.00	7.00	0	4.000	4.00	0	2.31E-05	2.31E-05	0
BD-13	4.42	1,825	1,825	0	5,034	5,034	0	4.00	4.00	0.00	3.00	5.00	0	3.000	3.00	0	1.70E-05	1.70E-05	0
BD-14	6.48	3,350	3,350	0	8,048	8,048	0	7.00	7.00	0.00	10.00	10.00	0	4.000	4.00	0	3.05E-05	3.05E-05	0
BD-15	18.40	9,610	10,383	8	27,096	28,011	3	21.00	21.00	0.00	20.00	19.00	0	19.000	22.00	16	1.89E-04	1.89E-04	0
BD-16	562.23	86,782	104,157	20	491,055	556,571	13	322.00	369.00	14.60	255.00	264.00	4	230.000	248.00	8	1.23E-03	1.85E-03	50
BD-17	3.82	604	1,043	73	1;718	1,718	0	1.00	1.00	0.00	1.00	1.00	0	9.00E-01	9.00E-01	0	5.13E-06	5.13E-06	0
BD-18	10.12	4,398	4,398	0	11,753	11,753	0	9.00	9.00	0.00	9.00	13.00	0	5.000	7.00	0	4.17E-05	4.17E-05	0
BD-19	14.79	6,980	6,820	-2	17,719	22,041	24	14.00	13.00	-7.14	13.00	16.00	-20	10.000	12.00	20	6.43E-05	1.21E-04	88
BD-20	6.59	3,913	3,804	-3	8,728	10,580	21	7.00	7.00	0.00	5.00	9.00	29	10.000	6.00	-40	3.81E-05	6.73E-05	77
BD-21	2.70	738	738	0	2,171	2,171	0	2.00	2.00	0.00	2.00	2.00	0	3.000	3.00	0	7.29E-06	7.29E-06	0
BD-22	1.22	455	428	-6	1,475	1,548	5	1.00	1.00	0.00	8.05E-01	1.00	0	9.90E-01	9.98E-01	1	2.72E-06	4.49E-06	65
BD-23	10.58	3,786	4,117	9	12,310	14,564	18	10.00	10.00	0.00	9.00	10.00	11	9.000	8.00	-11	4.55E-05	2.10E-04	362
BD-24	45.59	29,697	33,684	13	87,117	88,709	2	51.00	67.00	31.37	83.00	50.00	-40	44.000	57.00	30	3.48E-04	8.47E-04	143
BD-25	14.96	4,453	4,453	0	12,074	12,074	0	10.00	10.00	0.00	13.00	13.00	0	6.000	6.00	0	4.04E-05	4.04E-05	0
BD-27	10.29	3,220	3,614	12	8,850	10,067	14	7.00	8.00	14.29	6.00	8.00	33	8.000	10.00	25	2.79E-05	5.19E-05	86
BD-28	433.13	94,074	133,464	42	426,009	572,058	34	273.00	372.00	36.26	295.00	352.00	19	197.000	263.00	34	8.91E-04	1.35E-03	52
BD-29	33.58	10,781	10,781	0	27,880	27,880	0	22.00	22.00	0.00	31.00	31.00	0	15.000	15.00	0	9.76E-05	9.76E-05	0
BD-30	4.23	1,155	1,157	0	1,891	1,891	0	2.00	2.00	0.00	2.00	2.00	0	9.91E-01	9.91E-01	0	5.69E-06	5.69E-06	0
BD-31	3.95	1,082	1,080	0	1,796	1,796	0	1.00	1.00	0.00	2.00	2.00	0	9.47E-01	9.47E-01	0	5.42E-06	5.42E-06	0
BD-32	29.99	8,518	10,812	27	23,858	29,924	25	18.00	23.00	27.78	14.00	34.00	143	20.000	16.00	-20	8.05E-05	9.82E-05	22
BD-33	24.15	7,900	7,578	-4	20,747	24,874	20	16.00	20.00	25.00	14.00	29.00	107	19.000	14.00	-26	7.27E-05	8.91E-05	23
BD-34	130.15	45,119	45,528	1	147,196	119,768	-19	107.00	103.00	-3.74	121.00	146.00	21	72.000	70.00	-3	5.20E-04	5.53E-04	6
BD-35	12.97	4,314	4,460	3	12,379	12,899	4	9.00	10.00	11.11	9.00	9.00	0	13.000	13.00	0	6.13E-05	6.85E-05	12
BD-36	6.63	3,784	3,784	0	8,592	8,592	0	7.00	7.00	0.00	7.00	11.00	0	5.000	5.00	0	3.47E-05	3.47E-05	0
BD-37	7.91	2,165	2,165	0	6,203	6,203	0	5.00	5.00	0.00	7.00	7.00	0	3.000	3.00	0	1.96E-05	1.96E-05	0
BD-38	7.59	2,073	2,073	0	5,937	5,937	0	5.00	5.00	0.00	6.00	6.00	0	3.000	3.00	0	1.87E-05	1.87E-05	0
BD-39	0.21	55	55	0	156	156	0	1.21E-01	1.21E-01	0.00	1.66E-01	1.66E-01	0	8.17E-02	8.17E-02	0	4.90E-07	4.90E-07	0

Table 17 (continued)

Subbasin	Drainage Area (acres)[b]	Particulate Solids (pounds)			Total Solids (pounds)			Total Phosphorus (pounds)			Copper (pounds)			Zinc (pounds)			Cadmium (pounds)		
		Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change	Existing (1995) Land Use	Planned Buildout Land Use	Percent Change
BD-40	2.21	838	838	0	2,443	2,443	0	2.00	2.00	0.00	2.00	3.00	0	1.000	1.00	0	8.00E-06	8.00E-06	0
BD-41	2.45	941	941	0	2,721	2,721	0	2.00	2.00	0.00	2.00	3.00	0	1.000	1.00	0	9.05E-06	9.05E-06	0
BD-42	27.29	13,929	13,929	0	33,754	33,754	0	26.00	26.00	0.00	17.00	25.00	0	35.000	35.00	0	1.40E-04	1.40E-04	0
BD-43	1.73	472	469	-1	1,354	1,425	5	1.00	1.00	0.00	1.00	1.00	0	0.715	2.00	180	4.32E-06	5.02E-06	16
BD-44	155.10	53,904	75,807	41	172,422	223,050	29	114.00	175.00	53.51	180.00	211.00	17	127.000	146.00	15	3.48E-04	3.06E-03	779
BD-45	234.36	53,480	86,167	61	197,016	326,384	66	136.00	222.00	63.24	143.00	230.00	61	127.000	127.00	0	3.26E-04	8.92E-04	174
BD-47	20.33	3,248	7,326	126	9,236	22,326	142	7.00	11.00	57.14	8.00	18.00	125	5.000	11.00	120	2.78E-05	9.83E-05	254
BD-48	4.35	1,193	1,193	0	3,408	3,408	0	3.00	3.00	0.00	4.00	4.00	0	2.000	2.00	0	1.09E-05	1.09E-05	0
BD-49	9.43	1,496	1,496	0	4,245	4,245	0	3.00	3.00	0.00	8.00	4.00	0	2.000	2.00	0	1.28E-05	1.28E-05	0
BD-50	60.45	18,884	17,729	-6	51,291	58,722	14	40.00	38.00	-5.00	34.00	58.00	71	44.000	42.00	-5	1.70E-04	1.78E-04	5
BD-51	76.74	14,611	25,154	72	60,506	71,993	19	45.00	60.00	33.33	48.00	78.00	63	42.000	51.00	21	1.24E-03	2.69E-03	117
BD-52	51.89	22,346	17,739	-21	49,366	49,079	-1	42.00	47.00	11.90	63.00	54.00	-14	34.000	28.00	-18	2.55E-03	3.41E-03	34
BD-53	70.53	14,090	15,669	11	59,658	62,228	4	63.00	72.00	14.29	60.00	61.00	2	36.000	39.00	8	3.76E-03	7.45E-03	98
BD-54	18.70	11,028	11,825	7	23,168	22,240	-4	32.00	30.00	-6.25	46.00	49.00	7	16.000	13.00	-19	6.72E-03	5.15E-03	-23
BD-55	8.46	5,546	5,966	8	12,942	11,220	-13	14.00	16.00	14.29	15.00	21.00	17	8.000	8.00	0	1.90E-03	5.55E-03	192
BD-56	18.82	14,101	14,535	3	36,072	28,504	-21	29.00	35.00	20.69	33.00	70.00	84	21.000	22.00	5	2.39E-03	6.62E-03	177
BD-57	7.24	3,941	4,438	13	10,919	10,481	-4	10.00	11.00	10.00	9.00	14.00	40	7.000	7.00	0	8.27E-04	1.44E-03	74
BD-59	24.02	10,164	16,792	65	24,084	34,643	44	23.00	42.00	82.61	30.00	79.00	126	16.000	26.00	63	3.96E-03	7.17E-03	81
BD-60	5.35	1,466	1,466	0	4,190	4,190	0	3.00	3.00	0.00	4.00	4.00	0	2.000	2.00	0	1.33E-05	1.33E-05	0
BD-61	7.83	1,320	1,324	0	3,814	3,809	0	3.00	3.00	0.00	8.00	3.00	-25	3.000	5.00	67	1.13E-05	1.34E-05	19
Total	2,837.82	815,796	1,010,265	24	2,771,188	3,378,546	22	1,982.12	2,434.12	22.8	2,213.97	2,775.17	25	1,653.624	1,892.92	15	0.0313	0.0537	72

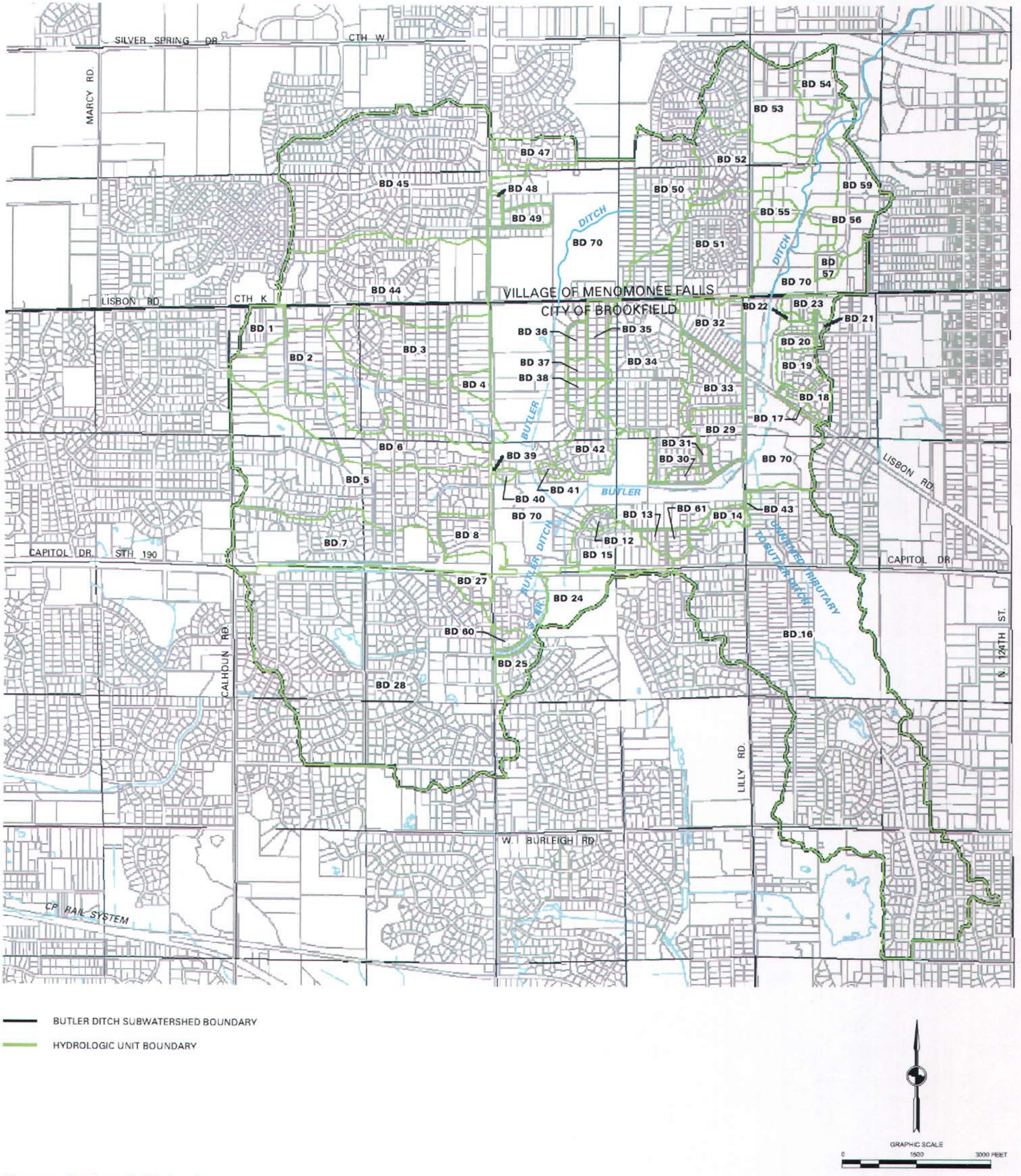
[a] *Existing controls consists of street sweeping once every 12 weeks in the Village of Menomonee Falls and about one every 18 weeks in the City of Brookfield, catch basin cleaning once every three years, and 16 wet detention basins. Assumes majority of new development will have curb and gutter per local convention.*

[b] *The SLAMM analyses were generally conducted for the planned urban areas with defined outlets to the stream system of the watershed. Those areas represent about 90 percent of the planned urban area. The remaining urban area generally consists of areas adjacent to, or in, the Butler Ditch floodplain/primary environmental corridor.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 8

BUTLER DITCH SUBWATERSHED SLAMM HYDROLOGIC UNITS



Source: *Ruekert & Mielke, Inc.*

judgment, and considered field observations, stormwater quality sampling, and estimates of the degree of improvement needed for the achievement of the desired recreation and aquatic life uses of the surface waters in the study area.

The priority watershed planning program recommended that sediment loadings be reduced under full buildout conditions to about 50 percent of the 1985 condition, that phosphorus loads be reduced from 50 to 70 percent, and that metals be reduced by about 42 percent in the Butler Ditch subwatershed.

Chapter NR 151

Chapter NR 151 requires that, by March 10, 2008, communities with stormwater discharge permits, such as the City of Brookfield and the Village of Menomonee Falls, achieve to the maximum extent practicable, a 20 percent reduction in total suspended solids in runoff to waters of the State as compared to no controls.[18] By March 10, 2013, Chapter NR 151 requires that communities with stormwater discharge permits achieve to the maximum extent practicable, a 40 percent reduction in total suspended solids in runoff as compared to no controls. Additional runoff control standards for new development and redevelopment are set forth in Chapter NR 151 as described in a subsequent section of this chapter.

Summary

Under the current planning process, consideration was given to achieving the levels of nonpoint source pollution control recommended under both planning efforts described above and under Chapter NR 151. However, experience indicates that the levels of pollutant reduction recommended under the enhancement objective set forth in the priority watershed planning program are not likely to be practically achievable in areas with the characteristics of the Butler Ditch subwatershed. The inability to achieve the recommended reductions is due to conditions in the watershed which constitute physical constraints on the locations of control measures. Such constraints include limitations on the provision of effective best management practices in areas of existing urban development where there may not be sufficient open lands to accommodate such practices.

EVALUATION OF STREAMBANK EROSION

The Menomonee River priority watershed study quantified the estimated contribution of sediment from streambank erosion as a percentage of the overall sediment loads in the Butler Ditch subwatershed. It was concluded that streambank erosion was not a significant sediment source (less than 1 percent of the total sediment load) in the Butler Ditch subwatershed. Inventories conducted under the priority watershed study identified one reach of eroding streambank in the Butler Ditch subwatershed. The site, which had a length of 50 feet, was classified in that study as being in Management Category II. Category II sites exhibit low to moderate lateral bank recession rates and contribute less than five tons of sediment a year to the stream.

The potential for streambank erosion in the streams of the study area was evaluated through both field observations by the Commission staff and the results of the hydrologic and hydraulic models developed under this stormwater management plan. The observation of the priority watershed study that streambank erosion is not, and is not anticipated to be, a major source of sediment in the subwatersheds was verified. It was found that, under planned land use conditions, streamflow velocities would generally be in the nonerosive range during more frequent floods with recurrence intervals of two years or less.[19]

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[18] *These pollutant reduction standards do not apply to industries that are required to obtain discharge permits under Subchapter II of NR 216.*

[19] *The more frequent floods are considered to be those which have the most impact on the configuration of a stream's low-flow channel.*

STATE OF WISCONSIN STORMWATER DISCHARGE PERMITTING PROGRAM

Both the City and the Village have participated in the submittal of a group application for a Wisconsin Pollutant Discharge Elimination Systems (WPDES) stormwater discharge permit as required under Chapter NR 216, "Storm Water Discharge Permits," of the *Wisconsin Administrative Code*. The group permit was submitted on February 11, 2000, by eight Menomonee River watershed communities, including the Cities of Brookfield, Greenfield, and Wauwatosa and the Villages of Butler, Elm Grove, Germantown, Menomonee Falls, and West Milwaukee. The permit to be issued by the WDNR will specify conditions intended to control nonpoint source pollution from all areas within the municipalities.[20] The recommendations of this plan would be expected to be an integral part of the permit requirements.

STATE OF WISCONSIN STORMWATER RUNOFF PERFORMANCE STANDARDS

On October 1, 2002, the State of Wisconsin promulgated runoff performance standards under Chapter NR 151 of the *Wisconsin Administrative Code*. The standards that are pertinent to this stormwater management plan apply to runoff from existing and new nonagricultural development, redevelopment sites, and construction sites.

The performance standards for new development apply to projects for which a notice of intent is submitted to the WDNR pursuant to Chapter NR 216, "Storm Water Discharge Permits," on or after October 1, 2004. The standards that most directly affect the development of alternative plans are:

- An 80 percent reduction in the average total suspended solids load, as compared to the load without controls, must be achieved for projects for which a notice of intent is submitted to the WDNR pursuant to Chapter NR 216, "Storm Water Discharge Permits," on or after October 1, 2004.[21]
- The peak rate of runoff from a two-year, 24-hour storm under post-development conditions must be controlled to the peak rate for the same storm under pre-development conditions.
- Infiltration of specified percentages of the pre-development runoff volume.

CONSTRUCTION EROSION CONTROL ORDINANCES

Both the City of Brookfield and the Village of Menomonee Falls have construction erosion control ordinances that require the provision of erosion control practices consistent with the WDNR *Construction Site Best Management Practices Handbook*. Strict application and enforcement of these ordinances would be expected to enable achievement of an 80 percent reduction in sediment transported from construction sites relative to uncontrolled conditions, as is required under Chapter NR 151. Strict adherence to the ordinance requirements is, therefore, an essential part of the nonpoint source control plan for the study area.

WINTER MANAGEMENT OF ROADWAYS

It is recommended that the City and Village investigate alternatives to the application of sand on roadways in the winter. Reductions in the amounts applied would be beneficial in reducing sediment loads to streams and in

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[20] *As of September 2004, the permit had not been issued by the WDNR.*

[21] *The corresponding requirement for redevelopment is the achievement of a 40 percent reduction in the total suspended solids load. For in-fill development less than five acres in extent that occurs before October 1, 2012, a 40 percent reduction in the total suspended solids load is also required. For in-fill development that occurs on or after October 1, 2012, an 80 percent reduction in the total suspended solids load is required. When individual sites are redeveloped, or when in-fill development occurs, it will be necessary to provide specific controls for those sites.*

reducing the accumulation of sediment in grass swales, at culverts, in storm sewers, and in ditch enclosures. It is also recommended that the communities investigate the feasibility of applying effective alternative snow and ice control agents that are less harmful to the environment than sodium and calcium chloride.

ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

Introduction

Alternative water quality management plans for the control of nonpoint source pollutants were developed and evaluated to achieve the water quality objectives presented in Chapter III. The alternative measures considered represent a refinement of the more generalized recommendations presented in the regional water quality management plan for the Southeastern Wisconsin Region. Furthermore, the measures considered are consistent with the nonpoint source control plan for the Menomonee River Priority Watershed, recognizing the constraints imposed by specific conditions in the study area. The water quality management measures considered are also coordinated and combined with the drainage recommendations so as to provide multiple water quantity and water quality benefits and to minimize costs. This section describes alternative water quality management plans, sets forth estimates of pollutant loadings to the surface waters under each of these alternatives, and presents the estimated cost of each alternative.

Each of the potentially available water quality management measures provide unique benefits with respect to the plan objectives. Yet, each measure also has limitations resulting from the physical constraints imposed by the watershed. The recommended water quality management plan was selected on the basis of the desired reduction in pollutant loadings, the cost-effectiveness of the measures, the availability of suitable sites, and compatibility with the stormwater drainage recommendations. Four general types of control measures could be expected to be effective and could potentially have application in the Butler Ditch subwatershed. These measures are: 1) wet detention basins; 2) maintenance of grassed swales in areas of suburban low- and medium-density urban development; 3) increased street sweeping in certain areas of critical land uses; and 4) construction site erosion control measures implemented as required by the City and Village construction erosion control ordinances. Items 2 and 4 above would be components of any nonpoint source control plan for the study area and they are discussed below following the description and evaluation of alternative plans.

Infiltration facilities, such as infiltration swales, trenches, and basins: rain gardens; and biofiltration facilities, remove waterborne pollutants by capturing surface water runoff and filtering it through the soil or other substrate material. Such facilities have been found to be effective in certain urban areas where the soils and drainage system are suitable and there are no significant sources of toxic pollutants which could contaminate underlying groundwater resources. Within the Butler Ditch subwatershed, however, large-scale implementation of infiltration facilities was not found to be a viable alternative because about 95 percent of the study area is covered by poorly drained or very poorly drained soils and because significant sanitary sewer backup problems have occurred in the study area, related in part to sanitary sewer inflow and infiltration.[22] Under these soil conditions, infiltration rates would be relatively low, the removal of pollutants through infiltration into the soil would be limited, and reductions in frequent storm runoff volumes would be somewhat limited.

Descriptions of Alternative Plans

The alternatives focus on practices that would control nonpoint source pollution from critical and noncritical existing land uses. Review of Maps 2 and 3 in Chapter II of this report, along with consideration of the land that has developed since 1995, emphasizes the relatively small amount of land available for future development as well as the general lack of available sites in the study area for the location of large-scale best management practices that would provide significant control of pollutants from critical land uses.

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[22] *When individual developments are designed, specific subsurface investigations will be needed to evaluate whether site conditions are such that the runoff infiltration requirements of Chapter NR 151 must be met.*

A common component of each alternative nonpoint source pollution control plan that was developed for the subwatersheds is the control of nonpoint source pollution from all remaining areas to be developed, or from areas of redevelopment, according to the standards of Chapter NR 151. Such control would be achieved through a combination of construction site erosion control measures and site-specific best management practices to reduce the washoff of pollutants.

Under the two alternative plans considered, common components of each plan included maintaining the existing 16 ponds in the subwatershed, constructing five wet detention facilities, and increasing the frequency of street sweeping to once every four weeks within the areas of critical land use having urban street cross-sections. Each of the proposed wet detention facilities would be constructed on undeveloped land having either a large tributary area of noncritical land use or a small tributary area of predominantly critical land use. The facilities are shown on Maps 9 and 10 and are described below:

- The first facility would be located east of Pilgrim Road along the west side of the Butler Ditch in the City of Brookfield in the northwest one-quarter of the northwest one-quarter of U.S. Public Land Survey Section 2, Township 7 North, Range 20 East. This facility would have a permanent pond volume of 3.5 acre-feet and a two-year storm surcharge volume of about 2.3 acre-feet.[23] This facility would serve existing primarily low-density residential development in Butler Ditch Hydrologic Unit 3 and would have a total tributary area of about 81 acres.

- The second facility is located east of Pilgrim Road and north of Susan Drive in the Village of Menomonee Falls in the southwest one-quarter of Section 35, Township 8 North, Range 20 East. This facility would have a permanent pond volume of 4.3 acre-feet and a two-year storm surcharge volume of about 1.4 acre-feet. This facility would serve existing predominantly low-density residential development in Butler Ditch Hydrologic Unit 45 and would have a total tributary drainage area of approximately 234 acres.

- The third facility would be located in the area west of Pilgrim Road and north of Lisbon Road in the Village of Menomonee Falls in the southeast one-quarter of Section 34. This facility would have a permanent pond volume of 1.0 acre-foot. This facility would serve approximately 20 acres of planned medium-density residential development

- The fourth facility would be located in the area east of Pilgrim Road and north of Lisbon Road in the Village of Menomonee Falls in the southwest one-quarter of Section 35. This facility would have a permanent pond volume of 2.1 acre-foot. This facility would serve approximately 28 acres of planned government and institutional land within Butler Ditch Hydrologic Unit 44.

- The fifth facility would also be located in the area east of Pilgrim Road and north of Lisbon Road in the Village of Menomonee Falls in the southwest one-quarter of Section 35. This facility would have a permanent pond volume of 0.8 acre-foot. This facility would serve approximately seven acres of planned government and institutional land within Butler Ditch Hydrologic Unit 44.

Of the five wet detention facilities, none would service a predominantly critical land use area, three of the facilities would serve predominantly low- to medium-density residential land use areas. The remaining two facilities would serve governmental and institutional land use, which, while not designated as a critical use under the priority watershed plan, would generate relatively high nonpoint source pollutant loads in the absence of controls.

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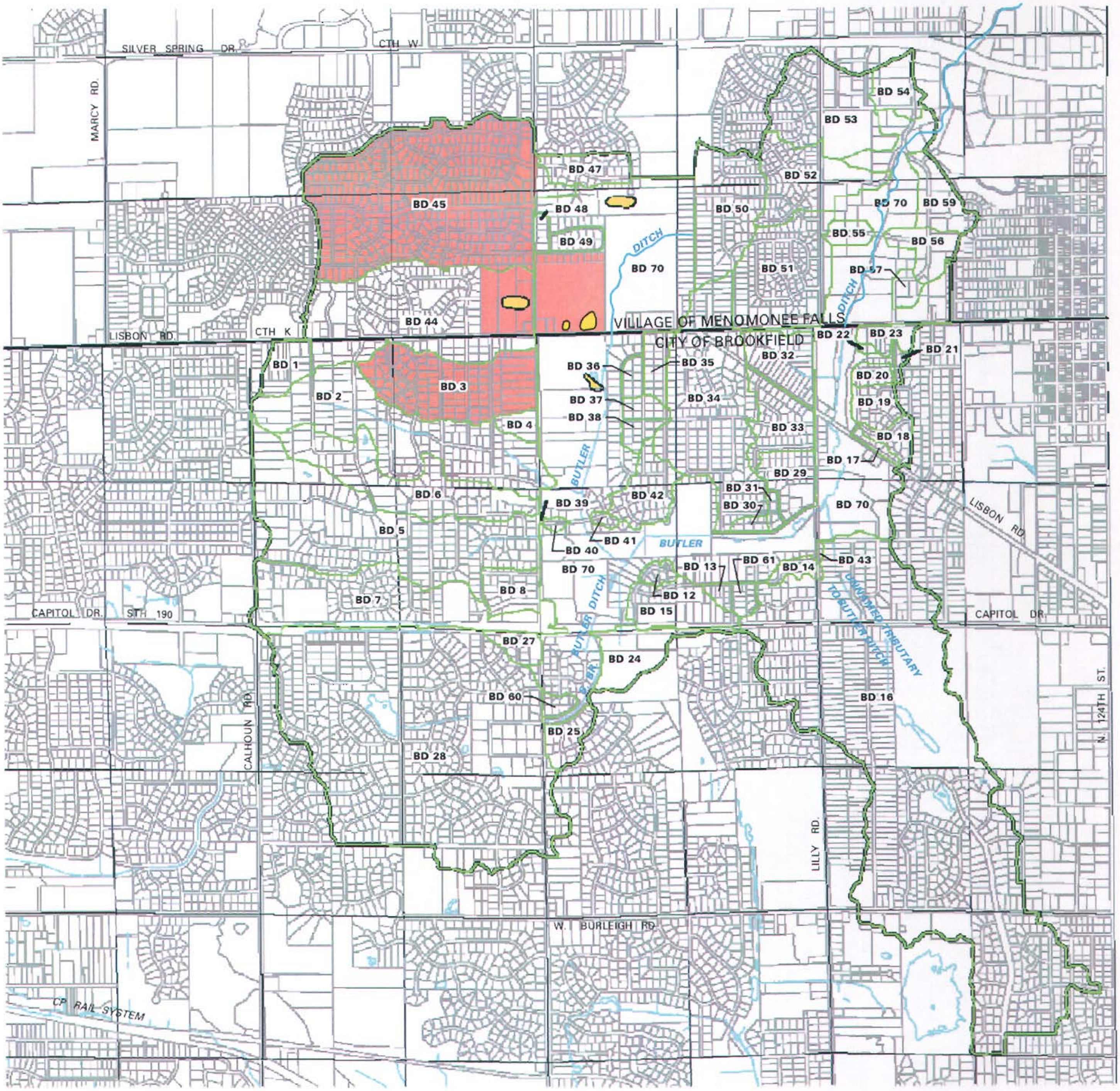
[23] *The two-year storage volume is listed for the detention basins that would serve existing development because the cost to provide the permanent pond volume plus the two-year volume could be eligible for State cost share funding for construction of those basins. Such cost share funding would not be available for the other basins that would serve planned development.*

Map 9

WATER QUALITY ALTERNATIVE PLAN NO. 1 -CONSTRUCT FIVE NEW WET DETENTION BASINS WITH INCREASED STREET SWEEPING IN CRITICAL AREAS



— BUTLER DITCH SUBWATERSHED BOUNDARY

— HYDROLOGIC UNIT BOUNDARY

▭ PROPOSED WET DETENTION BASINS

🟥 AREAS TRIBUTARY TO PROPOSED WET DETENTION BASINS

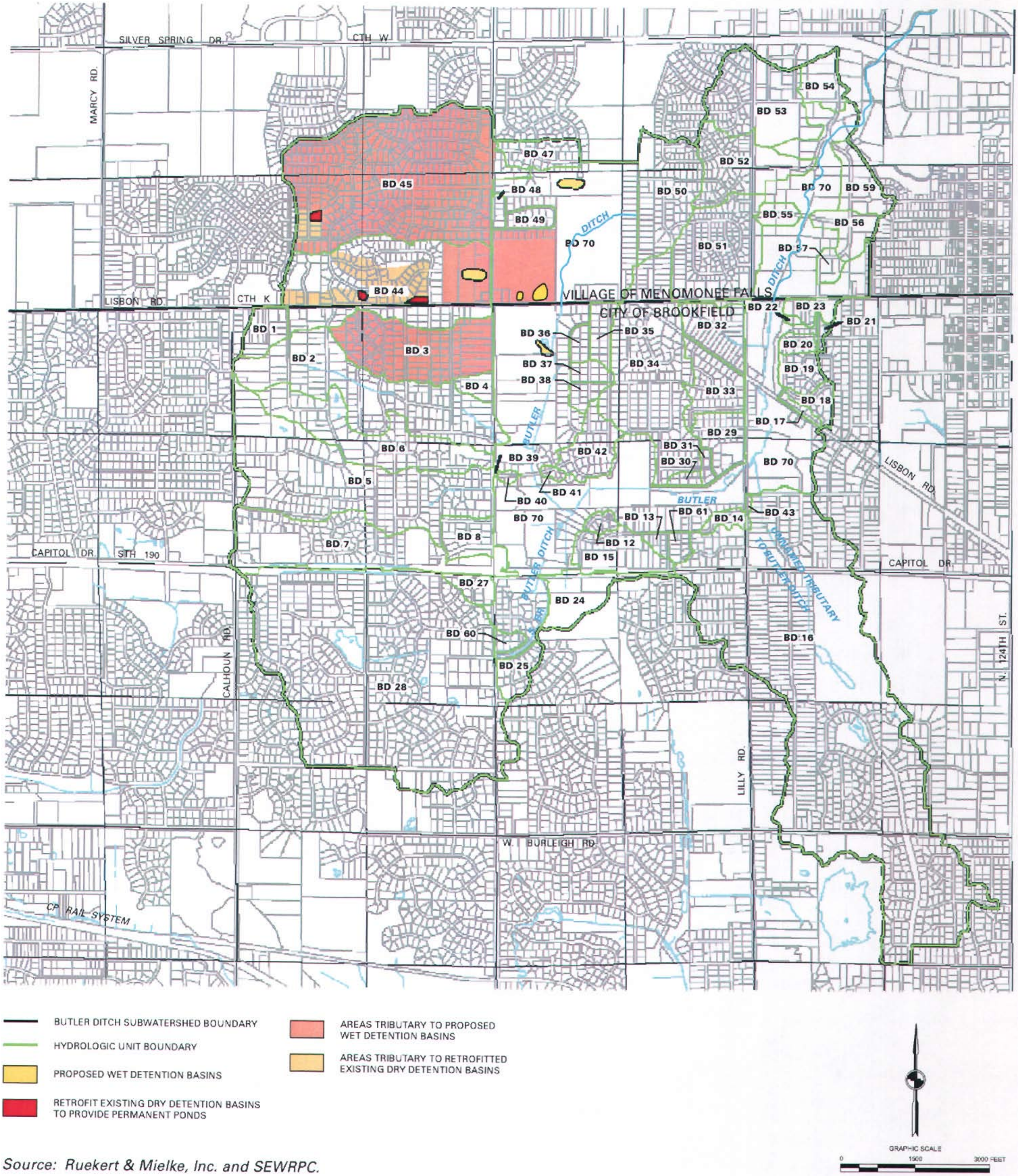
GRAPHIC SCALE

0 1500 3000 FEET

Source: Ruekert & Mielke, Inc. and SEWRPC.

Map 10

WATER QUALITY ALTERNATIVE PLAN NO. 2 - CONSTRUCT FIVE NEW WET DETENTION BASINS, RETROFIT THREE DRY DETENTION BASINS, AND INCREASE STREET SWEEPING IN CRITICAL AREAS



Source: Ruekert & Mielke, Inc. and SEWRPC.

An extensive analysis of different street sweeping schedules was performed. Pollutant loadings in each of the basins with critical land use was evaluated under street sweeping schedules of once every 12 weeks, once every eight weeks, once every four weeks and once every week. Based on the information set forth in Table 18, it was determined that sweeping the streets once every four weeks is the most cost-effective schedule. This schedule yields the smallest unit cost per pound of sediment removed and is therefore, part of each of the water quality management alternatives.

The possibility of constructing additional wet detention facilities in locations where they could effectively control runoff from critical land uses was investigated. It was determined there are no suitable undeveloped sites which would allow for the construction of a wet detention facility to effectively receive and treat runoff from existing critical land uses.

Several additional options that are available for the control of nonpoint source pollution from critical land use areas include: 1) reduced application of sand on streets in winter; and 2) public information and education efforts to promote good urban "housekeeping" practices that reduce nonpoint source pollution.

Water Quality Alternative Plan No. 1—Construct Five New Wet Detention Basins with Increased Street Sweeping in Critical Areas

As shown on Map 9, Alternative 1 includes the continued implementation of construction erosion control measures, maintenance of the existing 16 ponds, construction of five wet detention facilities with a permanent pond storage volume of approximately 11.7 acre-feet, and increasing the frequency of street sweeping from the current two to three times per year to once every four weeks in areas of critical land use between April 1 and October 31.

The increased street sweeping was limited to those areas of critical land uses that have urban street cross-sections with curb and gutter. Increased sweeping was not proposed for residential streets because most of those areas are served by roadside swales and little additional control of pollutants would be expected through sweeping of the low-density residential streets. The effectiveness of street sweeping would be greatest during spring and fall and would be greatly enhanced through the use of regenerative air sweepers. As seen in Table 19, implementation of this alternative plan would result in pollutant loading reductions relative to full buildout conditions (in the absence of further controls) to be approximately 3 percent for total solids, 12 percent for particulate solids, 6 percent for phosphorus, 11 percent for copper, 8 percent for zinc, and 26 percent for cadmium.

As set forth in Table 20, the present value cost of this alternative is $1,084,790 consisting of an estimated capital cost of $570,800 and an estimated operation and maintenance cost of $32,610.

Water Quality Alternative Plan No. 2—Construct Five New Wet Detention Basins, Retrofit Three Dry Detention Basins, and Increase Street Sweeping in Critical Areas

As shown on Map 10, Alternative No. 2 includes the retrofitting of three existing dry detention facilities in the Village of Menomonee Falls to provide a wet detention volume in addition to the measures previously set forth in Alternative No. 1.

One facility is located east of Grey Log Lane and southwest of Fair Oaks Court in the northeast one-quarter of the southwest one-quarter of Section 35, Township 8 North, Range 20 East. The existing dry detention facility would be reconfigured to provide a permanent pond volume of 0.11 acre-foot. A second facility is located north of Lisbon Road and west of Graysland Drive in the southwest one-quarter of the southeast one-quarter of Section 34, Township 8 North, Range 20 East. The existing dry detention facility would be expanded to provide a permanent pond volume of 0.01 acre-foot. The other facility is located west of Graysland Drive and south of Lone Oak Drive in the southwest one-quarter of the southeast one-quarter of U.S. Public Land Survey Section 34, Township 8 North, Range 20 East. The existing dry detention facility would be expanded to provide a permanent pond volume of 0.05 acre-foot. All three facilities are located in areas of predominantly low-density residential land uses.

Table 18

COST-EFFECTIVENESS OF STREET SWEEPING UNDER PLANNED BUILDOUT LAND USE CONDITIONS

Frequency of Street Cleaning (weeks)	Number of Times Streets Cleaned per Year[a]	Cost per Year[a] (dollars)	Percent Change in Buildout Load from Buildout Land Use Conditions with Current Street Sweeping Schedule	Percent Change in Buildout Load from 1995 Land Use Conditions with Current Street Sweeping Schedule
12	3	$ 5,569	0.0	4.2
8	4	7,426	-0.3	3.8
4	8	14,851	-1.2	2.9
1	30	55,692	-2.5	1.6

[a]Miles of Curb in Critical Land Use Areas (2020) = 56
Cost per Miles for Street Cleaning = $33.15
Cost to Clean Streets One Time = $1,856

Source: Ruekert & Mielke, Inc.

Table 19

ANNUAL TOTAL NONPOINT SOURCE LOADINGS TO BUTLER DITCH UNDER ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

			Alternative No. 1 Proposed Wet Detention Basins			Alternative No. 2 Retrofit Existing Dry Detention Basins		
Element	Existing (1995) Load with Existing Controls (pounds)	Full Buildout Load with Existing Controls (pounds)	Load (pounds)	Percent Change from Existing Conditions with Existing Controls	Percent Change from Full Buildout Conditions with Existing Controls	Load (pounds)	Percent Change from Existing Conditions with Existing Controls	Percent Change from Full Buildout Conditions with Existing Controls
Particulate Solids	815,796	1,010,265	886,986	9	-12	862,457	6	-15
Total Solids.............	2,771,188	3,378,546	3,261,265	18	-3	3,236,735	17	-4
Total Phosphorus....	1,982	2,434	2,298	16	-6	2,267	14	-7
Total Copper...........	2,214	2,775	2,458	11	-11	2,389	8	-14
Total Lead...............	1,353	1,448	1,246	-8	-14	1,211	-10	-16
Total Zinc................	1,448	1,893	1,748	21	-8	1,726	19	-9
Total Cadmium........	0.0313	0.0537	0.0397	27	-26	0.0390	25	-27

Source: Ruekert & Mielke, Inc., and SEWRPC.

As seen in Table 19, implementation of this alternative plan would result in pollutant loading reductions relative to full buildout conditions (in the absence of further controls) of 4 percent for total solids, 15 percent for particulate solids, 7 percent for phosphorus, 14 percent for copper, 9 percent for zinc, and 27 percent for cadmium.

As set forth in Table 20, the present value cost of this alternative is $1,114,760 consisting of an estimated capital cost of $600,770 and an estimated annual operations and maintenance cost of $32,610.

Evaluation of Water Quality Management Alternatives

The two alternative water quality management plans were evaluated with respect to pollutant removal effectiveness and cost.

Pollutant Removal Effectiveness

The alternative plans essentially provide the same degree of control of nonpoint source pollution. Only minor gains in the removal rates were realized under Alternative Plan No. 2.

Cost

The estimated capital, annual operation and maintenance, and equivalent annual costs of each alternative plan are presented in Table 20. The cost of Alternative No. 1 is slightly lower than that of Alternative No. 2.

Table 20

PRINCIPAL FEATURES AND COSTS OF ALTERNATIVE WATER QUALITY MANAGEMENT PLANS FOR THE BUTLER DITCH SUBWATERSHED IN THE VILLAGE OF MENOMONEE FALLS AND THE CITY OF BROOKFIELD

Alternative	Water Quality Control Costs			
	Description	Capital[a,b]	Annual Operation and Maintenance	Present Value Cost[c]
No. 1–Construct Five New Wet Detention Basins with Increased Street Sweeping in Critical Areas	Five new wet detention basins to provide a permanent pond volume of 11.7 acre-feet	$570,800	$17,710	$ 849,940[a]
	Street sweeping[d] (56 curb-miles)	N/A	14,900	234,850
	Total	$570,800	$32,160	$1,084,790
No. 2–Construct Five New Wet Detention Basins, Retrofit Three Dry Detention Basins, and Increase Street Sweeping in Critical Areas	Five new wet detention basins to provide a permanent pond volume of 11.7 acre-feet	$570,800	$17,710	$ 849,940[a]
	Street sweeping[d] (56 curb-miles)	N/A	14,900	234,850
	Retrofit three existing dry detention basins to provide a permanent pond volume of 0.17 acre-foot	29,970	0	29,970
	Total	$600,770	$32,610	$1,114,760

NOTE: Costs are based upon 2001 *Engineering News Record* Construction Cost Index = 7360.

[a] *Includes the estimated construction cost, engineering, and contingencies. Does not include land acquisition, easements, or legal costs.*

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

[c] *Includes cost for permanent pond, plus two-year storm control volume for two basins to serve existing development.*

[d] *Sweep every four weeks between April 1 and October 31.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Selection of the Preliminary Recommended Alternative Plan for Control of Nonpoint Source Pollution within the Study Area

Based on consideration of the level of reduction in pollutant loadings and equivalent cost, nonpoint source pollution control Alternative No. 1, Five New Wet Detention Basins with Increased Street Sweeping in Critical Areas, is selected as the preliminary recommended alternative. In addition to those components set forth above, the preliminary recommended alternative plan would also include the following measures which are consistent with the requirements of Chapter NR 151: 1) measures to control nonpoint source pollution from all remaining areas to be developed, or from areas of redevelopment, or in-fill development, through a combination of construction site erosion control measures and site-specific best management practices; 2) development and/or expansion of public education programs to encourage good urban "housekeeping" practices; 3) municipal programs for the collection and management of leaf and grass clippings; 4) controls on the application of lawn and garden fertilizers on municipally-controlled properties; 5) a program to detect and eliminate illicit discharges to storm sewers; 6) strict enforcement of the existing construction erosion control ordinances; and 7) reduced application of sand on streets in the winter and investigation of the feasibility of applying effective alternative snow and ice control agents that are less harmful to the environment than sodium and calcium chloride.

Public information and education programs are recommended to promote the acceptance and understanding of the proposed pollution abatement measures, the importance of water quality protection, and the establishment of good urban "housekeeping" practices. Urban housekeeping practices and source controls include restricted use of fertilizers and pesticides, improved pet waste and litter control, the reduced use of galvanized steel roof materials and gutters, proper disposal of motor vehicle fluids, increased leaf collection, and catch basin cleaning. Particular attention should be given to reducing pollutant loadings from high pollutant loading areas, such as industrial and commercial sites, parking lots, and material storage areas. To the extent practicable, rooftop and parking lot stormwater runoff should be diverted to pervious soil and vegetated areas, rather than being directly discharged to a storm sewer. Special spill control or containment facilities, such as earthen berms, may be used to reduce the discharge of such spilled substances as oil and grease into waterways. Material storage areas may be enclosed or periodically cleaned and diversion of stormwater away from these sites may further reduce pollutant loadings.

Other measures, such as the elimination of leaded gasoline and increased air pollution control, which may be implemented on a regional, state, or national level, may also be expected to reduce loadings of certain pollutants including metals. For example, the reduced use of leaded gasoline since 1974 has contributed to reduced dissolved lead levels in nearly two-thirds of the major rivers within the United States.[24]

COMPARISON OF NONPOINT SOURCE POLLUTION REDUCTIONS WITH THOSE CALLED FOR UNDER CHAPTER NR 151

As noted above, Chapter NR 151 requires that, by March 10, 2008, and March 10, 2013, communities with stormwater discharge permits, such as the City of Brookfield and the Village of Menomonee Falls, achieve reduction in total suspended solids in runoff of 20 and 40 percent, respectively, as compared to no controls. NR 151 notes that it is expected that the 20 percent reduction could be achieved through municipal street sweeping; regular catch basin cleaning; deicer management; and information and education programs to promote practices by individuals, organizations, and businesses to reduce nonpoint source pollution. Those activities are a recommended plan component under this stormwater management plan. NR 151 also notes that it is expected that the 40 percent reduction could be achieved through high efficiency street sweeping or structural best management practice retrofits, perhaps on privately-owned lands.

The estimated nonpoint source pollutant reductions set forth in Table 21 are expressed relative to both 1995 conditions with existing controls and buildout conditions with existing controls. As noted above, the loading reductions called for under Chapter NR 151 are relative to the condition with no controls. Because the existing condition nonpoint source pollution loads reflect the effects of the 16 ponds scattered throughout the watershed and of the existing system of roadside swales in many areas, the pollutant loading reductions achieved by those ponds and swales are not factored into the reductions attributed to the plan recommendations. If the quantifiable effects of the existing and recommended controls are considered along with the other nonquantifiable supplementary activities that NR 151 lists and this plan recommends, the 20 and 40 percent reduction levels called for under NR 151 should be achieved. The recommendations of this plan meet and exceed (through the provision of some wet detention facilities to serve existing development) the level of control envisioned under NR 151 as being needed to achieve a 20 percent reduction in sediment. If high efficiency street sweeping is

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[24] *R.B. Alexander and R.A. Smith, "Trends in Lead Concentration in Major US Rivers and Their Relation to Historical Changes in Gasoline Lead Consumption,"* Water Resources Bulletin, *Volume 24, No. 3, June 1988, pp. 557-569.*

Table 21

CHANGES IN NONPOINT SOURCE POLLUTANT LOADINGS

Pollutant	Changes in Nonpoint Source Pollutant Loadings under Planned Land Use Conditions			
	Regional Water Quality Management Plan (percent)	Priority Watershed Plan[a] (percent)	Preliminary Recommended Plan Relative to Buildout Conditions (percent)	Preliminary Recommended Plan Relative to 1995 Conditions (percent)
Sediment	25	50	-3	18
Phosphorus	25	50-70	-6	16
Copper	- -[b]	50[c]	-11	11
Zinc	- -[b]	50[c]	-8	21
Cadmium	- -[b]	- -[d]	-26	27

[a] Reduction relative to 1985 conditions.

[b] No specific analyses were conducted to establish a level of reduction for metals in the regional water quality management plan.

[c] Approximate reduction. Actual Reduction to meet acute effluent toxicity standards should be determined on a case by case basis.

[d] No level of reduction established.

Source: Ruekert & Mielke, Inc., and SEWRPC.

phased in between 2008 and 2013, the plan should meet the level of control envisioned under NR 151 to achieve a 40 percent reduction in sediment. Thus, it is concluded that, to the maximum extent practicable, this plan meets the standards for 20 percent and 40 percent control as set forth under NR 151.

COMPARISON OF NONPOINT SOURCE POLLUTION REDUCTIONS WITH THOSE RECOMMENDED UNDER THE REGIONAL WATER QUALITY MANAGEMENT PLAN AND THE PRIORITY WATERSHED STUDY

Table 21 sets forth a comparison of the preliminary recommended plan minimum loading reductions with the reductions recommended under the regional water quality management plan and under the priority watershed study. The preliminary recommended five wet detention basins and the accelerated street sweeping program, if fully implemented, would reduce nonpoint source pollutant loadings to the streams in the study area under full buildout land use conditions by a minimum 3 to 26 percent relative to the loadings under full buildout conditions without the recommended controls. Relative to 1995 land use and nonpoint source pollution control conditions, full implementation of the preliminary recommended control measures would limit increases in sediment, phosphorus, copper, zinc, and cadmium loads to 18, 16, 11, 21, and 27 percent, respectively.

The minimum loading reductions anticipated if the preliminary recommended plan were implemented fall short of the recommendations of both the regional water quality management plan and the priority watershed study. However, when the level of control provided by the existing wet detention basins is considered along with; the additional recommended measures, including control of the quality of runoff from areas of new development and redevelopment; construction erosion control; reduced application of sand on streets; public information and education efforts; sound household land management practices; and industrial onsite nonpoint source pollution control measures, the estimated reductions would be considered consistent with the regional water quality management plan goals and closer to the priority watershed plan goals.

INTEGRATION OF THE PRELIMINARY RECOMMENDED STORMWATER DRAINAGE AND WATER QUALITY MANAGEMENT PLANS INTO A PRELIMINARY RECOMMENDED STORMWATER MANAGEMENT PLAN

The preliminary recommended water quality management plan is compatible with the preliminary recommended stormwater drainage and floodland management plan elements as set forth in Chapter V. The wet detention basins, which are the major structural components of the water quality management plan, could be easily integrated into the preliminary recommended stormwater and floodland management plan. The construction erosion control and street sweeping components are essentially independent of the drainage and floodland measures and are readily implementable under the preliminary recommended stormwater and floodland management plan.

SUMMARY

Based upon data from 1984, Butler Ditch is currently designated as only partially meeting both the standards for limited forage fish and full recreation water use objectives. The water quality of Butler Ditch varies from fair to poor, depending upon the indicators considered. From 1983 to 2003, the Wisconsin Department of Natural Resources and SEWRPC staff collected various instantaneous dissolved oxygen and temperature measurements, among others, for specific areas within Butler Ditch that were consistent with standards supporting a warmwater forage fish community. Small physical stream size, limited flow, and past channelization continue to limit the potential fishery. The amount, quality, and diversity of available instream fisheries and macroinvertebrate habitat are generally fair to poor within the Butler Ditch subwatershed. However, fishery data collected in the Butler Ditch subwatershed in 2003 indicate an apparent improvement in abundance and diversity of species since the mid-1980s. Although IBI results continue to indicate an overall limited fishery, the improvements in the abundance and diversity of fishes over the past 20 years indicate that Butler Ditch is potentially capable of meeting the warmwater forage fish and partial recreation water use objectives. Between 2000 and 2020, urban land uses in the subwatershed are expected to increase, which could continue to limit the fishery in terms of hydrology, water quality, and habitat.

The preliminary recommended water quality management plan calls for:

- Five proposed wet detention basins,
- Increased street sweeping in industrial and commercial areas with conversion to high efficiency sweepers by 2013,
- Measures to control nonpoint source pollution from all remaining areas to be developed, or from areas of redevelopment, or in-fill development, through a combination of construction site erosion control measures and site-specific best management practices,
- Development and/or expansion of public education programs to encourage good urban "house-keeping" practices,
- Municipal programs for the collection and management of leaf and grass clippings,
- Controls on the application of lawn and garden fertilizers on municipally-controlled properties,
- A program to detect and eliminate illicit discharges to storm sewers,
- Strict enforcement of the existing construction erosion control ordinances, and

- Reduced application of sand on streets in the winter and investigation of the feasibility of applying effective alternative snow and ice control agents that are less harmful to the environment than sodium and calcium chloride.

As set forth in Table 20, the estimated capital cost of the preliminary recommended water quality management plan element is $570,800. The estimated annual operation and maintenance cost increase is $32,610.

It is concluded that, to the maximum extent practicable, this plan meets the standards for 20 percent and 40 percent control as set forth under NR 151, and the plan is considered to be consistent with the regional water quality management plan goals.

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Chapter V

ALTERNATIVE AND PRELIMINARY RECOMMENDED STORMWATER MANAGEMENT PLANS

INTRODUCTION

This chapter presents the findings of an inventory and evaluation of the existing stormwater and floodland management system serving the Butler Ditch subwatershed in the City of Brookfield and Village of Menomonee Falls. This chapter also describes and evaluates alternative stormwater and floodland management approaches/ systems designed to serve the subwatershed under full development conditions A 10-year recurrence interval rainfall event was used to evaluate the minor drainage system components; a 50-year recurrence interval rainfall event was used to evaluate the adequacy of culverts under arterial streets; and a 100-year recurrence interval event was used to evaluate the major system components. The floodland management plan element was developed considering the 100-year recurrence interval floodplain.

Based upon an evaluation of alternatives, recommended stormwater and floodland management approaches were identified. In the evaluation of the alternatives, current regulatory policies relative to activities in and along streams and wetlands were also considered.

Each alternative considered is described and estimates of attendant capital and annual operation and maintenance costs are provided. The alternative stormwater management plans are evaluated based on: the relative ability to reduce stormwater management problems; relative capital and annual operation and maintenance costs; ability to incorporate the recommended nonpoint source pollution control measures; and practicability of implementation. The alternatives recommended for inclusion in the final plan are identified by hydrologic unit.

The recommended stormwater drainage, nonpoint source pollution control, and floodland management measures are integrated into a recommended stormwater management plan for the subwatersheds as set forth in Chapter VI. The design of the recommended plan was based on 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.

EVALUATION OF THE EXISTING STORMWATER AND FLOODLAND MANAGEMENT SYSTEM IN THE SUBWATERSHED

Introduction

In order to evaluate the performance of the existing stormwater management system, the components of that system must be definitively described. Digital stormwater infrastructure system maps that were prepared under a separate planning effort provided the necessary definitive descriptions and enable the hydraulic capacities of the existing conveyance and storage facilities to be evaluated under the selected design storms under both existing and planned land use conditions. Components, which were found to have inadequate capacity, were then addressed in the design of alternative stormwater management system plans.

The evaluation of the existing stormwater management system was based on the storm sewers, storage facilities, open channels, roadside swales, and culverts which may be components of both the minor and major stormwater management systems. In the evaluation it was assumed that backyard and sideyard drainage swales and storm sewer 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 waters and storage facilities of the minor system. As noted in Chapter III, the CAiCE Visual SWMM and the XP-SWMM models were used to evaluate the stormwater drainage system tributary to the streams in the subwatershed and also to evaluate the impacts of alternative measures on flows in those streams.

The magnitude of existing flooding problems due to overflow from Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch was characterized based on historical observation and computer simulation of flood profiles. Consistent with standard engineering practice and State and Federal floodplain management policies, flooding conditions were evaluated during floods with recurrence intervals up to, and including, 100 years. The U.S. Environmental Protection Agency HSPF continuous simulation model was used for the floodland management analyses and the delineation of the 100-year floodplain limits.

Physical Characteristics

The 5.5-square-mile study area was divided into 31 hydrologic units for stormwater management analysis. Those hydrologic units were further divided into subbasins. The existing stormwater management system within the planning area in the City of Brookfield and Village of Menomonee Falls consists of a combination of roadside swales and open channels with associated culverts; "ditch enclosures" consisting of roadside swales with underlying storm sewers; roadway curbs and gutters, storm sewer inlets, storm sewers; and wet and dry detention basins together with the streams to which the outlets of the engineered and constructed system components discharge.

Hydraulic Capacities of Stormwater Conveyance Systems and Comparison with Anticipated Storm Flows

Peak rates and critical volumes of stormwater runoff, as determined by the hydrologic and hydraulic characteristics of each subbasin, were estimated using the SWMM computer simulation models. Where the capacities of conveyance facilities are expected to be exceeded during the design storm, surface ponding, flooding, and surcharging of upstream or downstream drainage facilities may be expected to occur.

Identified Stormwater Drainage Problem Areas

Maps 11 through 13 show the general locations of existing, or potential future, stormwater management and flooding problems within the study area as identified by historic observations of the Village and City staffs and by computer simulations.[1] The hydrologic and hydraulic analyses conducted for this study verified the existence of the most significant problems shown on Maps 11 and 12 and identified additional system components that have inadequate hydraulic capacity under existing and/or planned land use conditions.

Flooding of streets and buildings, primarily basements, was reported in the study area as a result of the June 20-21, 1997 and the August 6, 1998 storms. Several types of structural flooding occurred. A major source of basement flooding was surcharging of sanitary sewers and the resultant backups into basements. Another source of basement flooding was sump pump failure due to electrical power outages. Those two problems are interrelated. If sump pumps cannot operate and the volume of clearwater collected by a building foundation drain

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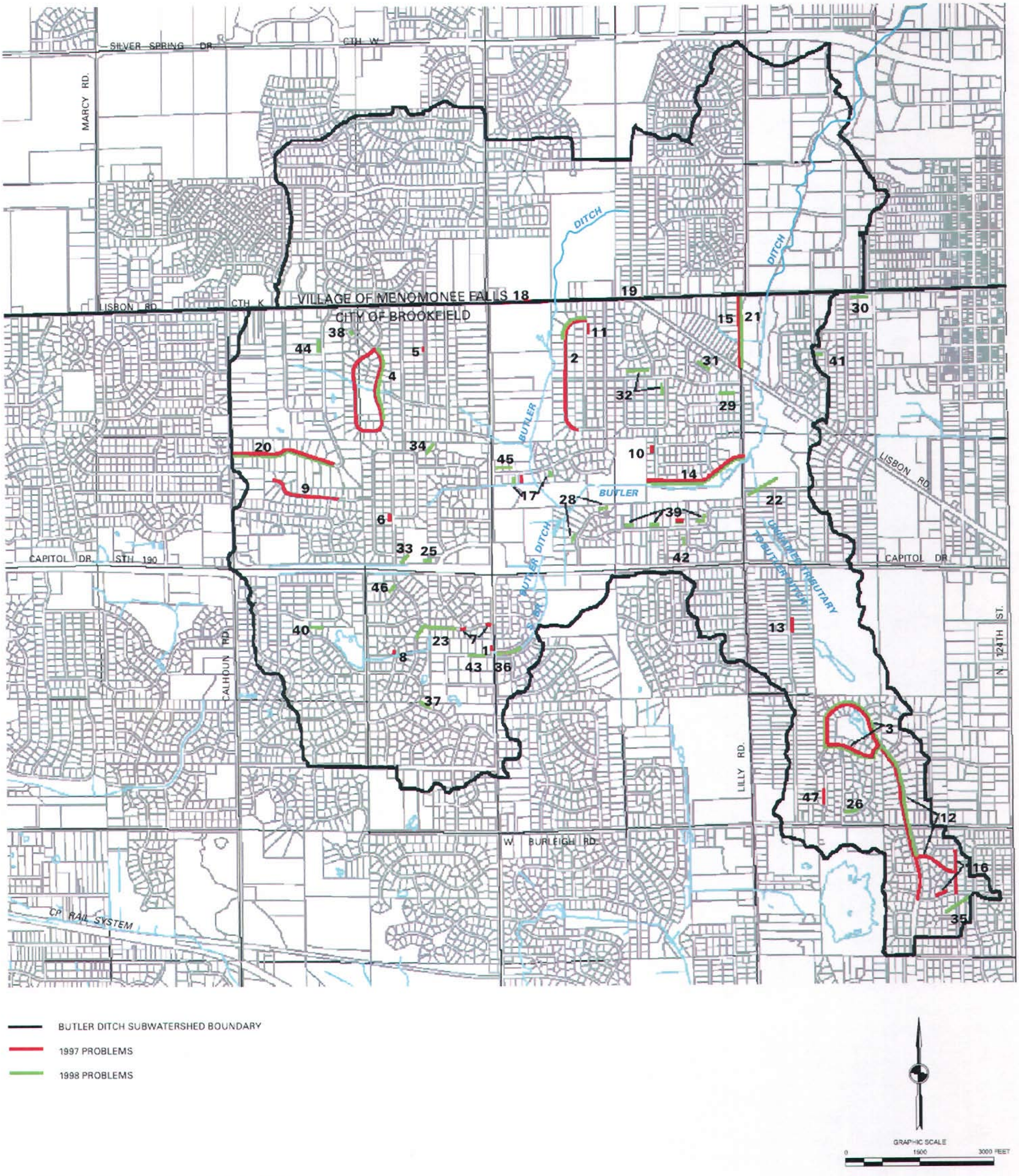
[1] *Different problem area identification categories are shown for each community, because different approaches were applied to collect and categorize the data.*

Map 11

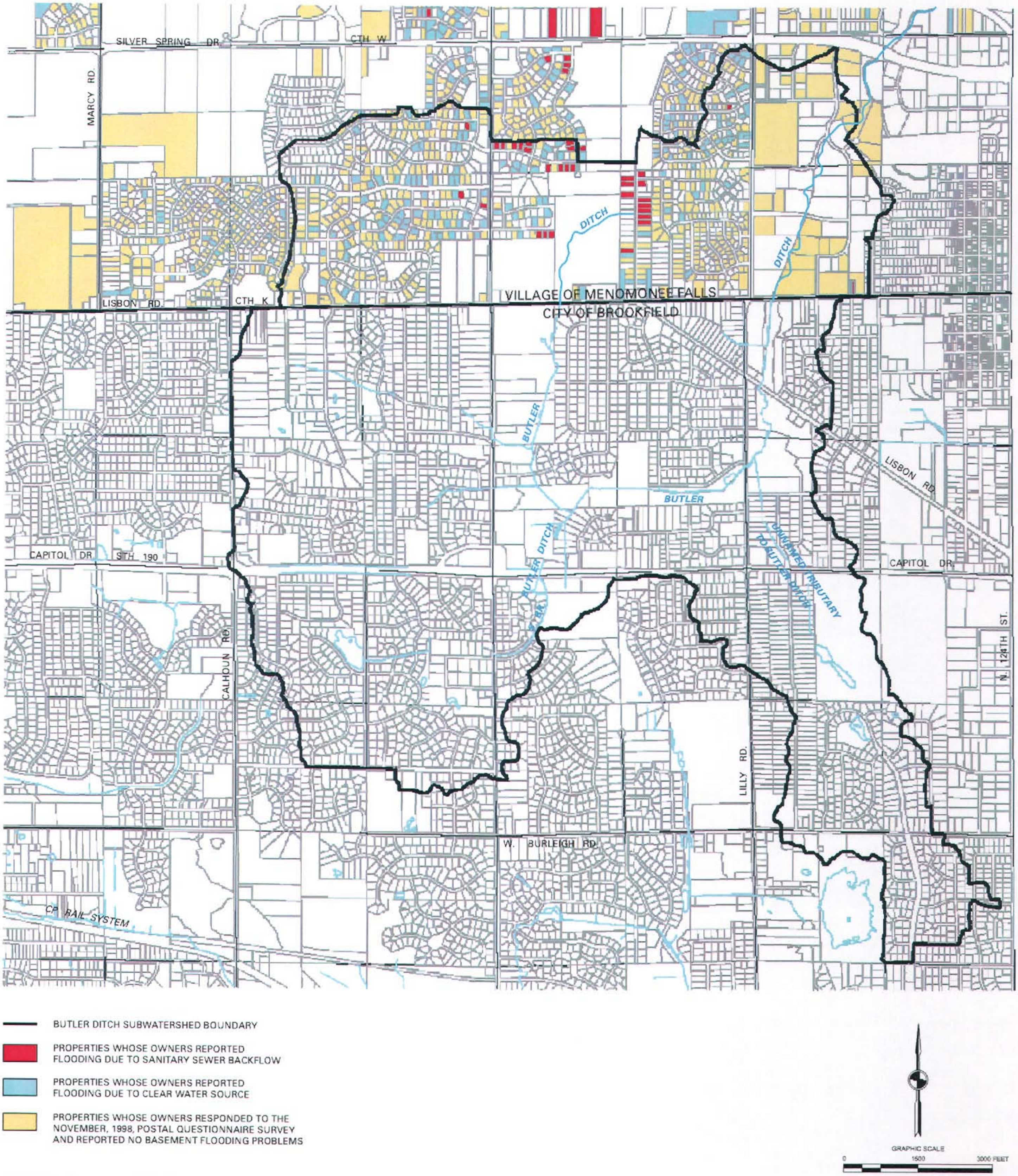
JUNE 1997 AND AUGUST 1998 STORMWATER DRAINAGE OR FLOODING PROBLEMS REPORTED IN THE CITY OF BROOKFIELD



Source: City of Brookfield and SEWRPC.

Map 12

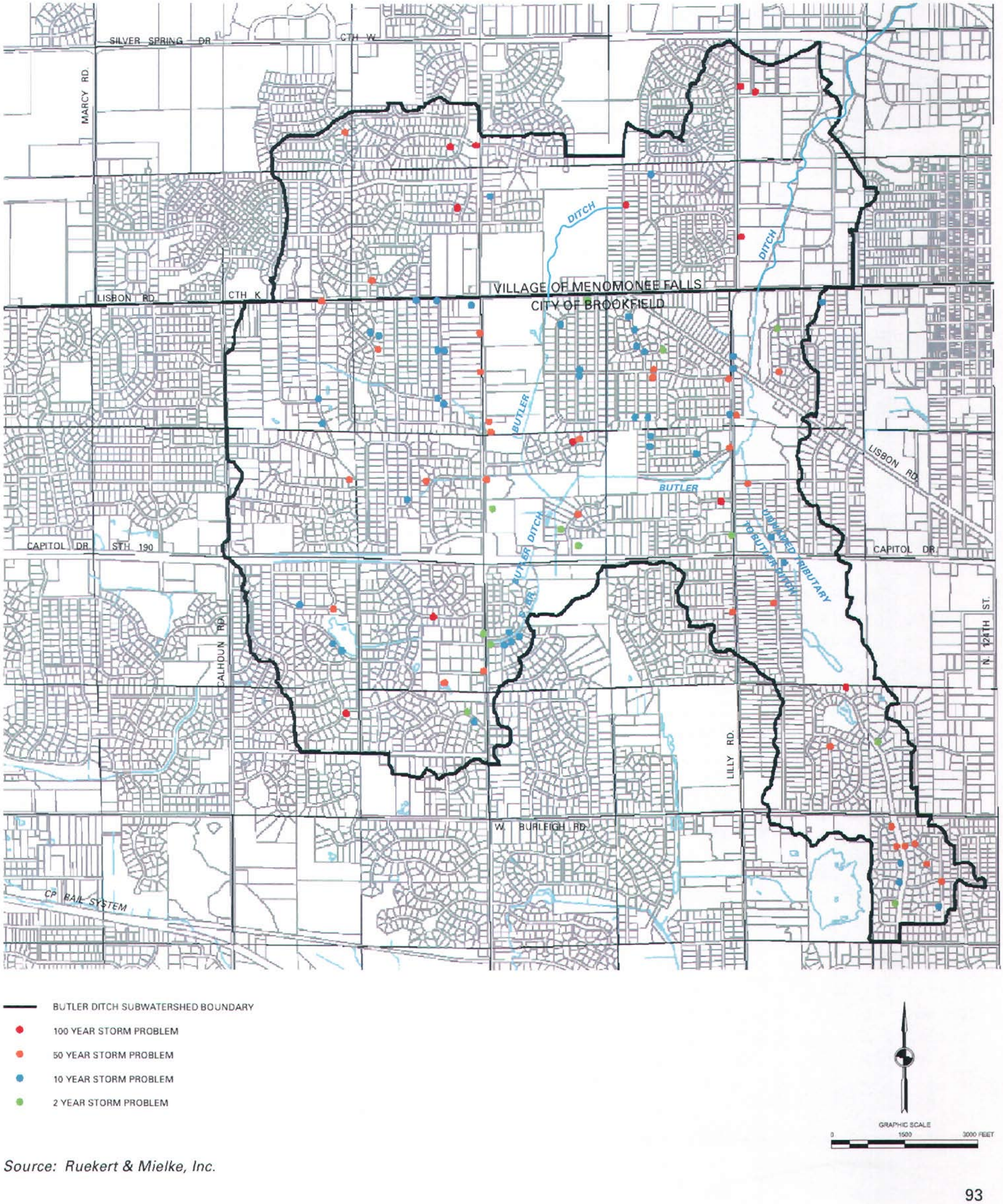
JUNE 1997 AND AUGUST 1998 STORMWATER DRAINAGE AND FLOODING PROBLEMS REPORTED IN THE VILLAGE OF MENOMONEE FALLS



Source: Ruekert & Mielke, Inc.

Map 13

BUTLER DITCH SUBWATERSHED STORMWATER DRAINAGE PROBLEM AREAS IDENTIFIED USING SWMM



Source: Ruekert & Mielke, Inc.

system exceeds the capacity of the sump crock, water will overflow from the crock into the basement. That clearwater may then flow into the basement floor drain, which is connected to the sanitary sewer. Excessive flows of such clearwater into the sanitary sewers can quickly exceed the capacity of those relatively small-diameter sewers, leading to surcharging and backup of a combination of sanitary sewage and clearwater into basements connected to the surcharged sewers. Additional sources of clearwater inflow to sanitary sewers include: flooding of basements due to surface runoff; excessive amounts of water collecting in streets or roadside swales and entering sanitary sewer manholes through unsealed lids and frames; sanitary sewer manhole covers which were disturbed; and missing caps on sanitary sewer lateral cleanouts located in roadside swales. It is also likely that increased infiltration of clearwater occurred as a result of saturation of the ground surrounding sanitary sewers and sewer laterals.

This stormwater management plan does not directly address the issue of sanitary sewer backup, however, an important component of a strategy to alleviate such backup is the reduction of stormwater drainage and flooding problems. The reduction of such problems eliminates or reduces the magnitude of certain sources of inflow to sanitary sewers. Those inflow sources addressed by this plan include flooding of basements with clearwater and excessive accumulation and ponding of stormwater runoff in streets and roadside swales.

In identifying problems in the existing system, consideration was given to the potential impact of excessive amounts of runoff. In some cases, problems would not be anticipated, even though the capacity of the system component would be exceeded. Examples of this include inundated areas that are or would be in open space use and in which no buildings, transportation facilities, or other damage-prone improvements would be affected; and areas where Standard 3 of Objective 1 relating to acceptable levels of street flooding during a 10-year recurrence level event was satisfied.

Problem areas associated with the existing stormwater management system were identified based on the hydrologic and hydraulic models results, applying the interpretations of the objectives and standards that were developed by the staffs of the City, the Village, and the Commission in June 2001 and are set forth in Appendix B.

The problem areas identified were reviewed by the Village and City staffs for concurrence with information on historic flooding and system surcharging.

Description of the Storms of June 20-21, 1997, and August 6, 1998

The heavy rainfall of June 20-21, 1997, caused severe stormwater drainage and flooding problems in Milwaukee, Ozaukee, Washington, and Waukesha Counties. The estimated 26-hour storm total rainfall over the Butler Ditch subwatershed ranged from six to seven inches.[2] Those rainfall amounts have recurrence intervals in the 100- to 200-year range.

The heavy rainfall of August 6, 1998, caused severe stormwater drainage and flooding problems in Milwaukee and Waukesha Counties. The estimated 24-hour storm total rainfall over the Butler Ditch subwatershed was from six to seven inches in the Village of Menomonee Falls (recurrence intervals from 110 to 240 years) and from seven to nine inches in the City of Brookfield (recurrence intervals from 240 to 930 years).[3]

Flooding and Stormwater Drainage Problems Resulting from the Storms of June 20-21, 1997 and August 6, 1998

The major stormwater drainage and/or flooding problem areas reported in the portions of the City of Brookfield in the study area were similar in June 1997 and August 1998; however, the 1998 flooding was much more extensive, due to the concentration of heavier rainfalls over the subwatershed.

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[2] *SEWRPC Technical Report No. 40,* Rainfall Frequency in the Southeastern Wisconsin Region, *April 2000.*

[3] Ibid.

Descriptions of the stormwater drainage and/or flooding problems experienced in the City of Brookfield during the 1997 and 1998 storms are presented in Appendix C. The problem area numbers are shown on Map 11. The problem descriptions were developed based on review of City records and conversations with City staff and residents.

A questionnaire survey[4] was conducted by the Village of Menomonee Falls soon after the August 1998 storm. The results of the survey are set forth on Map 12. The questionnaire related to both the June 1997 and August 1998 events and it asked whether flooding was caused by clearwater infiltration, inflow into the basement, the backflow of sanitary sewage into the basement, or a combination of clearwater infiltration and inflow and backflow of sanitary sewage. If basement flooding was caused by clearwater infiltration and inflow, the respondents were asked to indicate the source of the infiltration and inflow and whether or not electric power failure had been experienced.

ALTERNATIVE STORMWATER AND FLOODLAND MANAGEMENT APPROACHES

Introduction

To abate existing, as well as future, stormwater management and flooding problems, several approaches were considered. These approaches were first evaluated on a conceptual basis, considering the technical feasibility, applicability, advantages, and disadvantages of each approach. Elements of the most feasible approaches were then incorporated into systems-level alternative stormwater and floodland management plans for the planning area.

Alternative Stormwater and Floodland Management Approaches

Alternative approaches to stormwater and floodland management that were considered include conventional conveyance, centralized detention, decentralized or onsite detention, "natural" systems, and nonstructural measures. Because the study area is almost fully developed, the character of the stormwater management system has largely been established. Thus, opportunities to significantly alter that system are somewhat limited. However, the existing system does include components characteristic of most of the alternative approaches listed below. A description of those approaches is set forth in the Lilly Creek stormwater management and flood control plan prepared by the Regional Planning Commission for the Village of Menomonee Falls[5] and the Dousman Ditch and Underwood Creek stormwater and floodland management plan prepared by the Commission for the City of Brookfield and the Village of Elm Grove.[6]

FLOODLAND MANAGEMENT ELEMENT

Flooding-Related Problems

As indicated on Maps 11 and 12, as described in Appendix C, and as observed by the City and Village staffs, reported problems related to overflow from Butler Ditch during the large floods of June 1997 and/or August 1998 include:

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[4] *"Stormwater Management System Plan" in the Village of Menomonee Falls, Chapter 3, Ruekert & Mielke, Inc., February 2001.*

[5] *SEWRPC Community Assistance Planning Report No. 190,* A Stormwater Management and Flood Control Plan for the Lilly Creek Subwatershed, Village of Menomonee Falls, Waukesha County, Wisconsin, *February 1993.*

[6] *SEWRPC Community Assistance Planning Report No. 236,* A Stormwater and Floodland Management Plan for the Dousman Ditch and Underwood Creek Subwatersheds in the City of Brookfield and the Village of Elm Grove, Waukesha County, Wisconsin, *February 2000.*

- Yard flooding primarily in the reach from W. Lisbon Road to Shamrock Lane,
- Unspecific flooding along Lilly Heights Road,
- Overtopping of W. Lisbon Road at its upstream crossing of Butler Ditch,
- Overtopping of Lilly Road at Butler Ditch,
- Overtopping of W. Hampton Road at Butler Ditch,
- Overtopping of Hope Street at the Unnamed Tributary to Butler Ditch,
- Unspecific flooding at two properties on Fiebrantz Drive along the Unnamed Tributary, and
- Flooding of the west side of the Brookfield School Administration Center (on August 6, 1998).

In addition, residents along the upper reach of Butler Ditch in the Village of Menomonee Falls and along the reach between W. Lisbon Road and Shamrock Lane in the City of Brookfield have reported the need for multiple sump pumps and/or frequent sump pump operation to maintain dry basement conditions. Instances of basement flooding as a result of sump pump failure and/or loss of power have been reported at two houses on Senate St. along the wetland adjacent to Butler Ditch in Brookfield and at numerous houses along the wetland adjacent to the upper reaches of Butler Ditch in Menomonee Falls.

Results of Floodland Analyses

The limits of the 100-year floodplain along Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch are shown on Map 14. No inhabited buildings were identified as being in the 100-year floodplain under planned land use and existing channel and drainage conditions.

Evaluation of Reported Flooding-Related Problems

There are no documented reports of direct overland flooding of inhabited buildings along Butler Ditch, the South Branch, or the Unnamed Tributary. However, along Butler Ditch between W. Lisbon Road and Shamrock Lane in Brookfield, overland yard flooding has occurred to a degree that residents perceived a possible direct flooding threat to their houses. The 100-year floodplain limits shown on Map 14 do approach several houses, but none of those houses would be expected to be directly flooded.

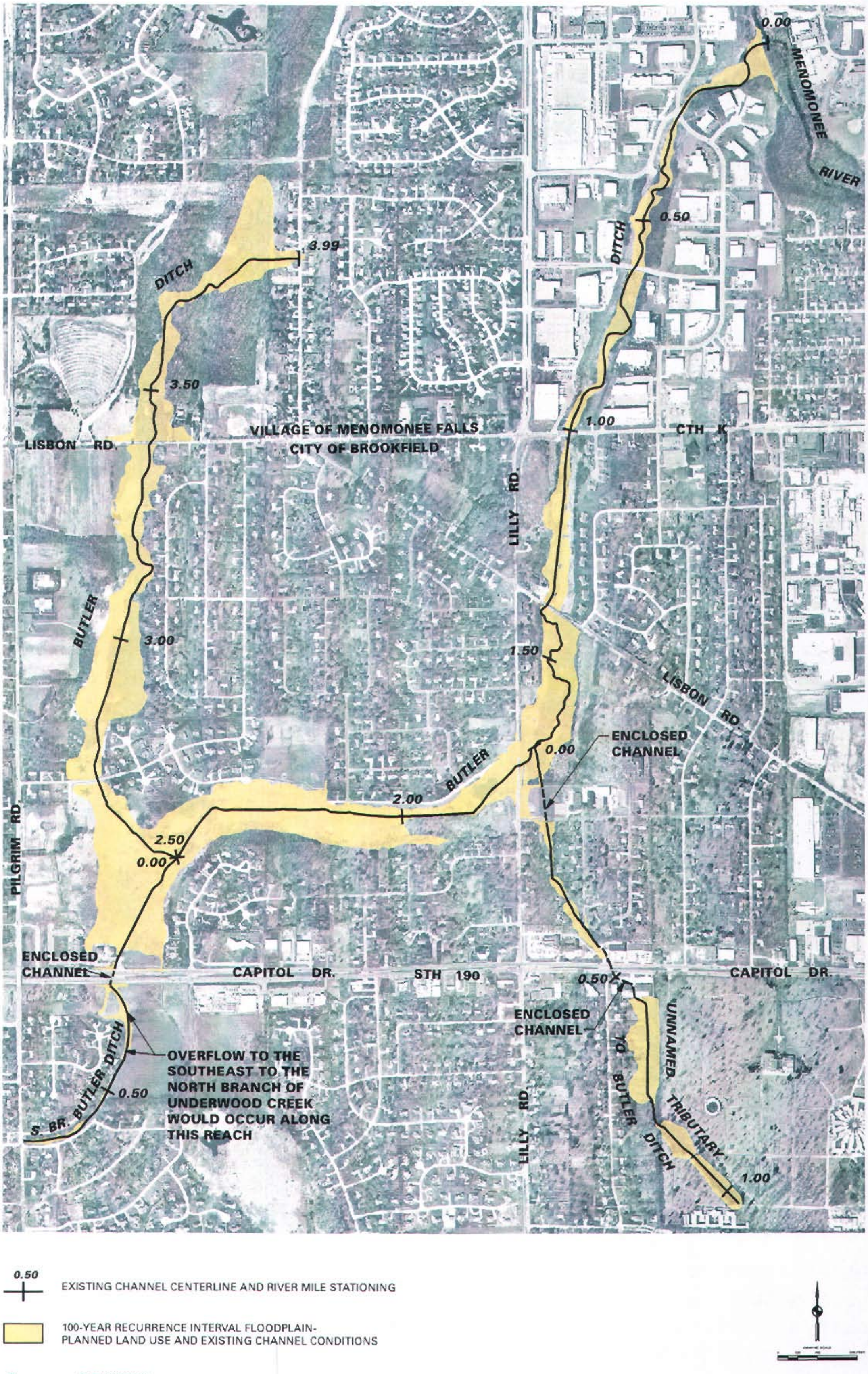
Many of the problems are related to the impacts of high groundwater on basements. When houses are located at low elevations relative to a wetland, as is the case of many of the houses along Butler Ditch in Brookfield and Menomonee Falls, there is the potential for groundwater levels to impact basements even under normal stream flow conditions. Those negative impacts are aggravated when the ground becomes saturated at higher elevations during floods. An inventory of the approximate basement floor elevations of the eight lowest houses in Brookfield adjacent to the wetland along Butler Ditch between W. Lisbon Road and Shamrock Lane and the six lowest houses in Menomonee Falls adjacent to the wetland along Butler Ditch upstream of W. Lisbon Road, indicates that the basement floors of those houses are about one to five feet below the level of the adjacent wetland and/or the low flow water level in Butler Ditch. Because groundwater levels in the wetland are generally near the ground surface, it is likely that the groundwater levels adjacent to those low houses are at, or several feet above, the basement floors, even under normal conditions.

Approaches Proposed by Citizens of Brookfield to Alleviate Yard Flooding and Wet Basement Conditions Along Butler Ditch

Table 22 provides an evaluation of suggested approaches to alleviating yard flooding and wet basement problems along Butler Ditch. Based on a comparison of the advantages and disadvantages, it is concluded that dredging the channel would have overriding negative consequences and it may be difficult to obtain a Wisconsin Department

Map 14

100-YEAR RECURRENCE INTERVAL FLOODPLAIN LIMITS ALONG BUTLER DITCH, THE SOUTH BRANCH OF BUTLER DITCH, AND THE UNNAMED TRIBUTARY TO BUTLER DITCH



Source: SEWRPC.

Table 22

EVALUATION OF CITIZEN-PROPOSED APPROACHES TO REDUCE YARD FLOODING/WET BASEMENT CONDITIONS ALONG BUTLER DITCH SOUTH OF W. LISBON ROAD IN THE CITY OF BROOKFIELD

Proposal	Advantages	Disadvantages	Evaluation
Dredge Channel	10-foot fall in streambed from W. Lisbon Road to South Branch Butler Ditch	Would increase downstream flood flows and stages in the absence of significant compensatory floodwater storage Unlikely to be permitted by WDNR (Chapter 30) given nature of problem addressed Would involve excavation in wetland Could lower groundwater levels draining wetland	Not recommended due to overriding negative environmental impacts and probable inability to obtain WDNR permit
Flatten West Bank	None	Little effect on flood stages No appreciable effect on groundwater levels Could require compensatory floodwater storage Unlikely to be permitted by WDNR (Chapter 30) given nature of problem addressed Would involve excavation in wetland	Not recommended due to ineffectiveness and probable difficulties in obtaining WDNR permit
Construct Berm or Place Fill in Yards	Could provide more usable land during small events Might provide some compensatory floodwater storage in Glendale Avenue abandoned right-of-way Could avoid floodway, but would not gain much usable land	Probably only viable at a few lots No appreciable effect on groundwater levels Would require compensatory floodwater storage Berm would require interior drainage (backwater gate, pump) Would have to stay out of wetland	Could be done at the initiative of individual property owners if regulatory requirements are met
Upstream Detention Basins	May improve situation, but more likely to simply avoid flow and stage increases	Will be provided for new development under local and MMSD regulations	Recommended for new development

Source: SEWRPC.

of Natural Resources permit for such action. Flattening the west bank of the channel would have similar, although less extensive, negative impacts as dredging and it would have little effect on flood stages and no appreciable effect on groundwater levels. Construction of berms on individual lots or placement of fill on lots would not affect groundwater levels, but could limit flooding of yards. That option could be pursued by individual property owners, subject to meeting regulatory requirements. The fourth option, providing upstream detention basins, is recommended under this plan.

Floodland Management Recommendations

Consistent with established Federal, State, and local regulations and with the standards adopted by the City and Village under this planning effort, the floodland management plan element is intended to avoid direct overland flooding of buildings, or to mitigate the effects of such flooding, during floods with recurrence intervals up to, and including, 100 years. Thus, because direct overland flooding of buildings would not be expected to occur during a 100-year flood under planned land use and existing channel and drainage conditions, no flood control measures are recommended under this plan.

The recommended floodland management plan, calls for the continued application by the two communities of floodplain zoning regulations along Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch. It is recommended that both the City of Brookfield and the Village of Menomonee Falls revise their floodplain zoning ordinances to recognize the 100-year flood profile and the floodplain and floodway limits as determined under this planning effort and set forth on Map 14. It is also recommended that both communities include ordinance revisions designed to maintain existing floodwater storage capacities.[7]

ALTERNATIVE STORMWATER MANAGEMENT PLANS

Introduction

The alternative plans address problems with the existing stormwater management system and include determination of the facilities required to serve planned new development in the Village of Menomonee Falls immediately north of W. Lisbon Road on either side of Pilgrim Road. Alternative measures for control of nonpoint source pollution are set forth in Chapter IV. Where those measures are directly related to alternative stormwater management measures, they were considered in formulation of the alternative plans.

Utilizing the alternative stormwater management measures listed above, the following general alternative stormwater management approaches were developed for the resolution of problems throughout the subwatershed: 1) culvert, roadside swale, and storm sewer conveyance, and 2) detention storage with culvert, roadside swale, and storm sewer conveyance. Each alternative stormwater management approach included the proposed preservation of environmental corridors and of the wetlands and floodplains contained within those corridors. The main components of each approach would supplement the existing system of storm sewers, culverts, roadside swales, and detention storage facilities.

In order to compare and evaluate the alternative stormwater management plans, the planning area subwatersheds were divided into 31 hydrologic units as depicted on Map 15. The hydrologic units were further divided into subbasins as shown on Map 15. There were 16 hydrologic units evaluated that did not exhibit flooding problems and, therefore, no system upgrades are proposed. A description of individual components together with estimated costs are presented for each hydrologic unit with flooding problems identified in the analysis of the stormwater management systems.

Stormwater Drainage System Costs

The estimated costs presented for each hydrologic unit reflect only the stormwater drainage plan element and do not include costs for nonpoint source pollution abatement measures. Costs for the entire stormwater management system plan, including those for nonpoint source pollution abatement measures, are presented in the overall recommended stormwater management plan as described in Chapter VI. The estimated costs include construction, engineering and contingencies. The estimate costs do not include land acquisition costs or legal fees.

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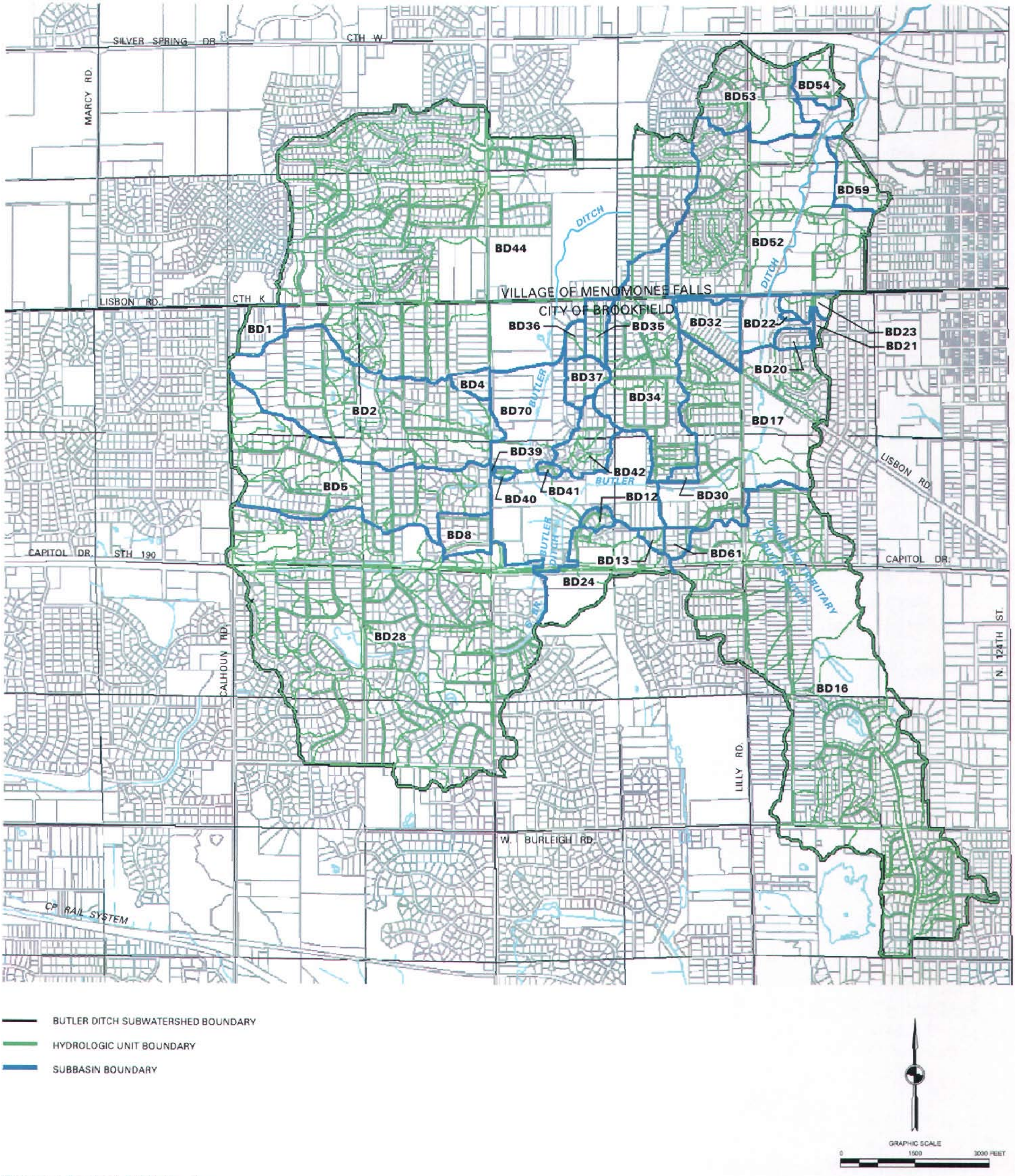
[7] *As of September 2004, the City of Brookfield was in the process of updating their floodplain zoning maps and ordinance as recommended under this plan.*

Map 15

BUTLER DITCH SUBWATERSHED SWMM HYDROLOGIC UNITS AND SUBBASINS



Source: Ruekert & Mielke, Inc.

Detention Storage for New Development

The City of Brookfield and the Village of Menomonee Falls both have stormwater management ordinances which require runoff from new development to be controlled to meet the requirements of the Milwaukee Metropolitan Sewerage District Chapter 13, "Surface Water and Storm Water" rule. The Chapter 13 rule requires that runoff from new development that increases the impervious area on a site by 0.5 acre or more be controlled to avoid adverse impacts on downstream two- through 100-year recurrence interval flood flows and stages. The following means of demonstrating that level of control are provided for under Chapter 13:

- Through preparation of a watershed or subwatershed stormwater management plan or a local stormwater management plan for several sites,
- By controlling runoff from an individual new development to achieve release rates of 0.15 cfs per acre for a two-year storm and 0.5 cfs per acre for a 100-year storm, or
- By controlling runoff from an individual new development so that it is distributed over the critical time period (as defined in the MMSD Chapter 13 rule) so that increases in the regional flood and streambank erosion rates are avoided.

The Village of Menomonee Falls has a set of guidelines that require new development to control the post–development two- and 100-year storm peak outflows from the site according to the release rate criteria set forth in MMSD Chapter 13, "Surface Water and Storm Water." However the Village requires use of a larger design storm rainfall depth than does Chapter 13.[8]

For the stormwater and floodland management alternatives analysis set forth in this chapter, the MMSD release rate criteria as established under MMSD Chapter 13 were applied to size detention facilities to serve new development in the Village of Menomonee Falls immediately north of W. Lisbon Road on either side of Pilgrim Road.[9]

Alternative Stormwater Drainage Plans for Each Hydrologic Unit

The following sections describe each hydrologic unit, as well as the components of the alternative plans for each hydrologic unit.

HYDROLOGIC UNIT BD-2

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-2 is an approximately 207-acre area located entirely within the City of Brookfield in the west-central portion of the Butler Ditch subwatershed in U.S. Public Land Survey Section 3. The hydrologic unit is generally located east of Calhoun Road, south of Lisbon Road, north of Capitol Drive, and east of Pilgrim Road.

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[8] *As noted in Chapter III of this report, the Village requires that runoff hydrographs be computed using rainfall depths from the isohyetal maps in* Rainfall Frequency Atlas of the Midwest, *Midwest Climate Center Bulletin 71, 1992 and that the rainfall be distributed according to the U.S. Natural Resources Conservation Service Type II distribution or the SEWRPC 90th percentile distribution. The MMSD Chapter 13 rule calls for the use of the most recent SEWRPC regional rainfall data, rather than Bulletin 71 data. The SEWRPC regional data are set forth in SEWRPC TR No. 40, as described in Chapter III of this report. Because the Village approach is more conservative than required under the MMSD Chapter 13 rule, it is allowed under that rule.*

[9] *The effects of applying the larger design storm used by the Village are described in Chapter, VI, "Recommended Stormwater and Floodland Management Plans."*

Approximately 97 percent of the hydrologic unit was developed in low-density residential uses under 1995 land use conditions. The remaining 3 percent of the hydrologic unit was comprised of open lands. Under full buildout land use conditions, the residential land use in the unit would remain the same and the open land would be converted to recreational use.

Conveyance features within the unit are roadside swales, ditch enclosures, and storm sewers. The flow of stormwater within the unit is generally from northwest to southeast.

Conveyance system improvements are proposed to alleviate possible building flooding at the northeast end of Pilgrim Hollow Court, northeast of the intersection of Meadow View Drive and Meadow View East, and at the intersection of N. 158th Street and Elderlawn Parkway. In conjunction with the conveyance system improvements proposed to resolve the building flooding at Meadow View East, an expansion of an existing natural depression is also proposed in order to offset the increased flows from the proposed upstream improvements. Additional system improvements are proposed to resolve ponding in Three Meadows Drive south of Elderlawn Parkway and at Pilgrim Road just north of Brentwood Drive where the 50-year storm capacity criterion for an arterial street is not currently met.

Alternative Stormwater Drainage Plan for Hydrologic Unit BD-2

The identified localized problems can be readily solved through increasing the hydraulic capacity of the inadequate pipes and the minor expansion of an existing natural depression. Thus, the development of alternative plans is not considered to be necessary and a stormwater conveyance with detention storage plan was developed.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-2

The preliminary recommended system is shown on Maps 16 through 19 and plan components are described in Table 23. As set forth in Table 23, the estimated capital cost of this plan is $236,930 and the estimated operation and maintenance cost increase is $150.

HYDROLOGIC UNIT BD-4

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-4 is an approximately eight-acre area located entirely within the City of Brookfield in the northeast one-quarter of U.S. Public Land Survey Section 3. It is generally located west of Pilgrim Road approximately one-quarter mile south of Lisbon Road.

Under 1995 land use conditions, the hydrologic unit was fully developed in low-density residential uses. The land use is anticipated to be unchanged under buildout conditions.

Conveyance features within the unit consist of roadside swales and ditch enclosures. Flow of stormwater within the unit is generally from west to east.

Major system inadequacies analyzed occur at Pilgrim Road where excess stormwater would surcharge and flow over the road during the 50-year recurrence interval storm event.

Alternative Stormwater Drainage Plans for Hydrologic Unit BD-4

Two alternative plans were developed for the alleviation of drainage problems during 50- and 100-year storm events. Both alternatives involve upgrading the hydraulic capacity of selected conveyance features.

Alternative Plan No. BD-4a1—Stormwater Conveyance

The alternative plan components are shown graphically on Map 20 and they are described in Table 24.

The total capital cost of this alternative is estimated to be $4,640. The present value cost is also estimated to be $4,640, since implementation of this alternative would not result in an increase in annual operation and maintenance costs.

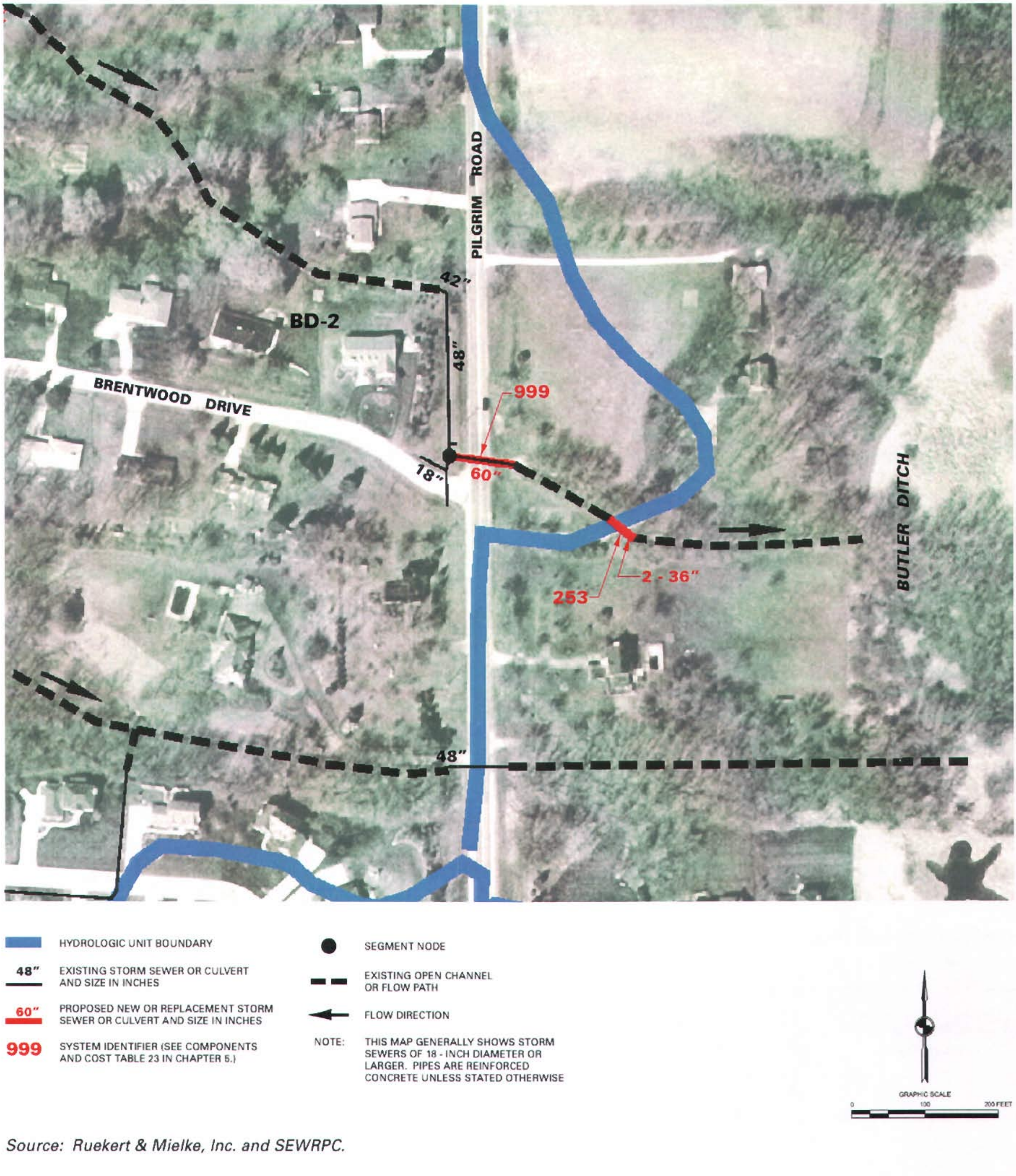
Map 16

INDEX MAP FOR HYDROLOGIC UNIT BD-2

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 17

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-2 STORMWATER CONVEYANCE WITH DETENTION STORAGE



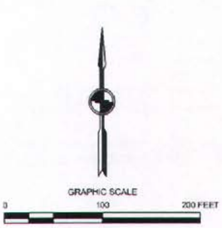
Source: Ruekert & Mielke, Inc. and SEWRPC.

Map 18

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-2 STORMWATER CONVEYANCE WITH DETENTION STORAGE

36″ ▬	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
36″ x 59″ RCPA ▬	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
24″ ////	PROPOSED NEW PARALLEL STORM SEWER OR CULVERT AND SIZE IN INCHES
9009	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 23 IN CHAPTER 5.)
●	SEGMENT NODE

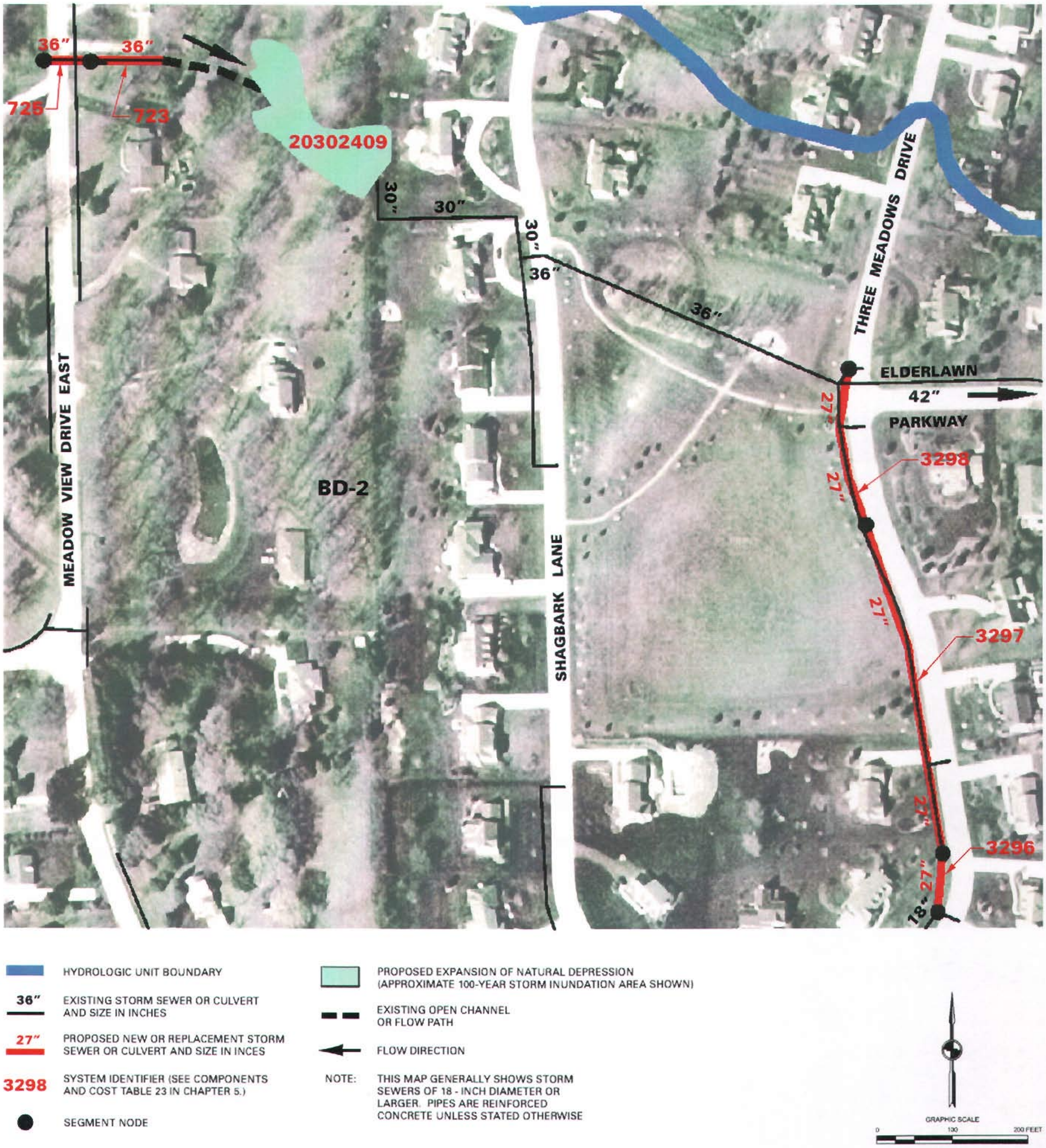
▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
←	FLOW DIRECTION
RCPA	REINFORCED CONCRETE PIPE ARCH
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 19

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-2 STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 23

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-2 STORMWATER CONVEYANCE WITH DETENTION STORAGE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
City of Brookfield	1. 253–Replace 22 feet of dual 24-inch CMPs east of Pilgrim Road with dual 36-inch RCPs	$ 4,970	$ 0
	2. 999–Replace 90 feet of 48-inch RCP crossing Pilgrim Road north of Brentwood Drive with 60-inch RCP	25,200	0
	3. 9016–Install 206 feet of new 24-inch RCP parallel to the existing 42-inch RCP east of the intersection of N. 158th Street and Elderlawn Parkway	16,070	130
	4. 9015–Install 36 feet of new 24-inch RCP parallel to the existing 42-inch RCP crossing N. 158th Street north of Elderlawn Parkway	3,600	20
	5. 20302409–Expand the existing 0.27 acre-foot runoff storage area 200 feet west of Shagbark Lane and 1,400 feet south of Lisbon Road to 0.86 acre-foot. Replace catch basin with headwall	34,300	0
	6. 723–Replace 116 feet of 30-inch RCP east of Meadow View Drive East and north of Meadow View Drive with 36-inch RCP	13,110	0
	7. 725–Replace 42 feet of 24-inch RCP crossing Meadow View Drive East north of Meadow View Drive with 36-inch RCP	6,300	0
	8. 3298–Replace 159 feet of 24-inch RCP in Three Meadows Drive south of Elderlawn Parkway with 27-inch RCP	19,080	0
	9. 3297–Replace 477.5 feet of 24-inch RCP in Three Meadows Drive south of Elderlawn Parkway with 27-inch RCP	57,300	0
	10. 3296–Replace 78.5 feet of 24-inch RCP in Three Meadows Drive north of Shagbark Lane with 27-inch RCP	9,420	0
	11. 3303–Replace 180 feet of 36-inch RCP east of Pilgrim Hollow Court and north of Laura Lane with 36-inch-high by 59-inch-wide RCPA	26,100	0
	12. 9009–Replace 84 feet of 36-inch RCP crossing Pilgrim Hollow Court north of Laura Lane with 36-inch-high by 59-inch-wide RCPA	21,480	0
	Total	$236,930	$150

NOTE: The following abbreviations have been used in this table:
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

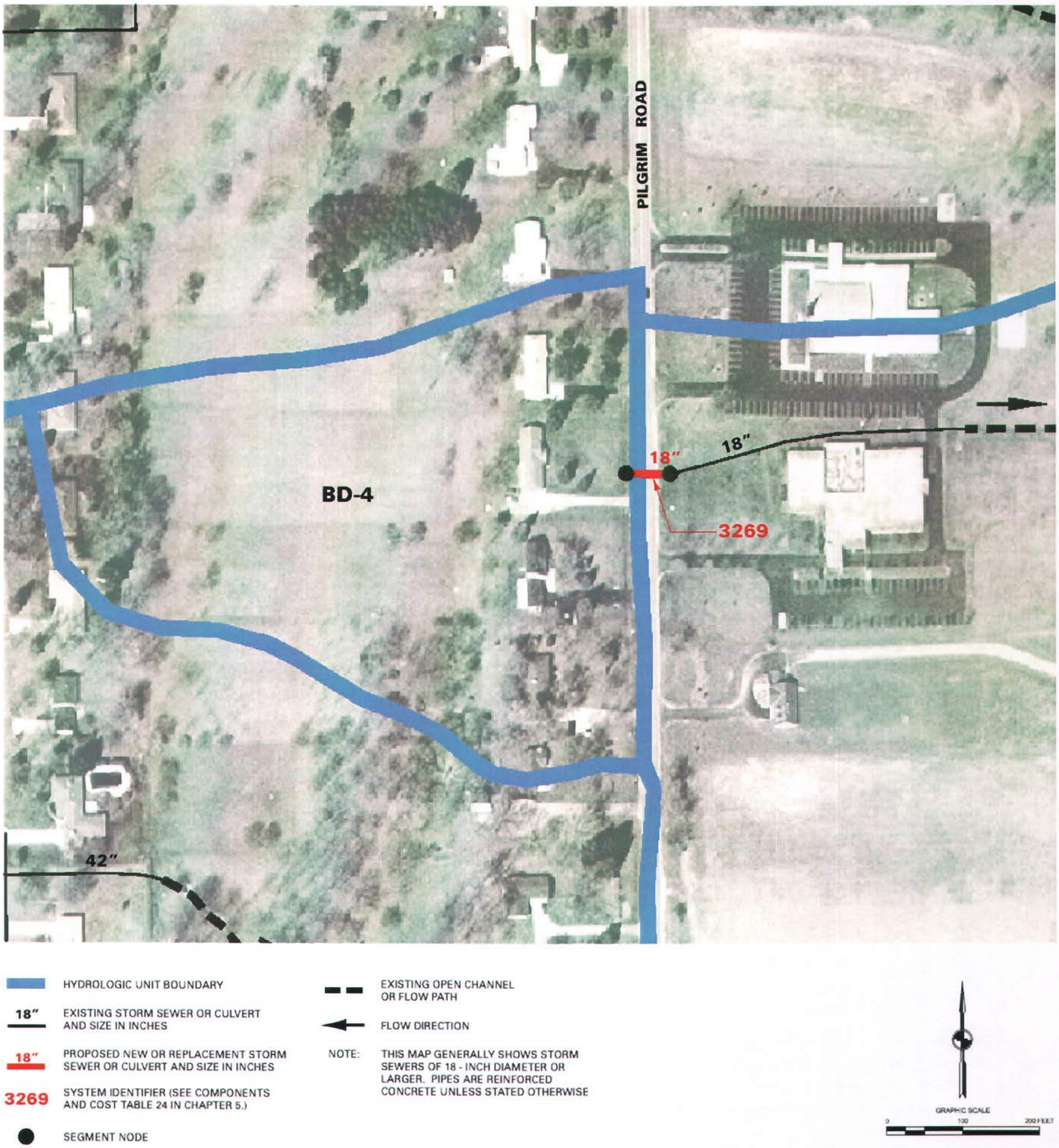
[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 20

ALTERNATIVE PLAN NO. BD-4A1
STORMWATER CONVEYANCE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 24

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-4a1 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 3269–Replace 58 feet of 18-inch CMP crossing Pilgrim Road approximately 1,600 feet south of Lisbon Road with 18-inch RCP at a reduced slope	$4,640	$0
	Total	$4,640	$0

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs do not include easements or land acquisition unless specifically noted.*

[d] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Alternative Plan No. BD-4a2—Increased Stormwater Conveyance

The alternative plan components are shown graphically on Map 21 and they are described in Table 25.

The total capital cost of this alternative is estimated to be $31,200. The present value cost is also estimated to be $31,200 since implementation of this alternative would not result in an increase in annual operation and maintenance costs.

Evaluation of Alternative Stormwater Drainage for Hydrologic Unit BD-4

The foregoing information provides a basis for a comparative evaluation between the two alternative plans. The principle criteria for the comparative evaluation were cost and implementability.

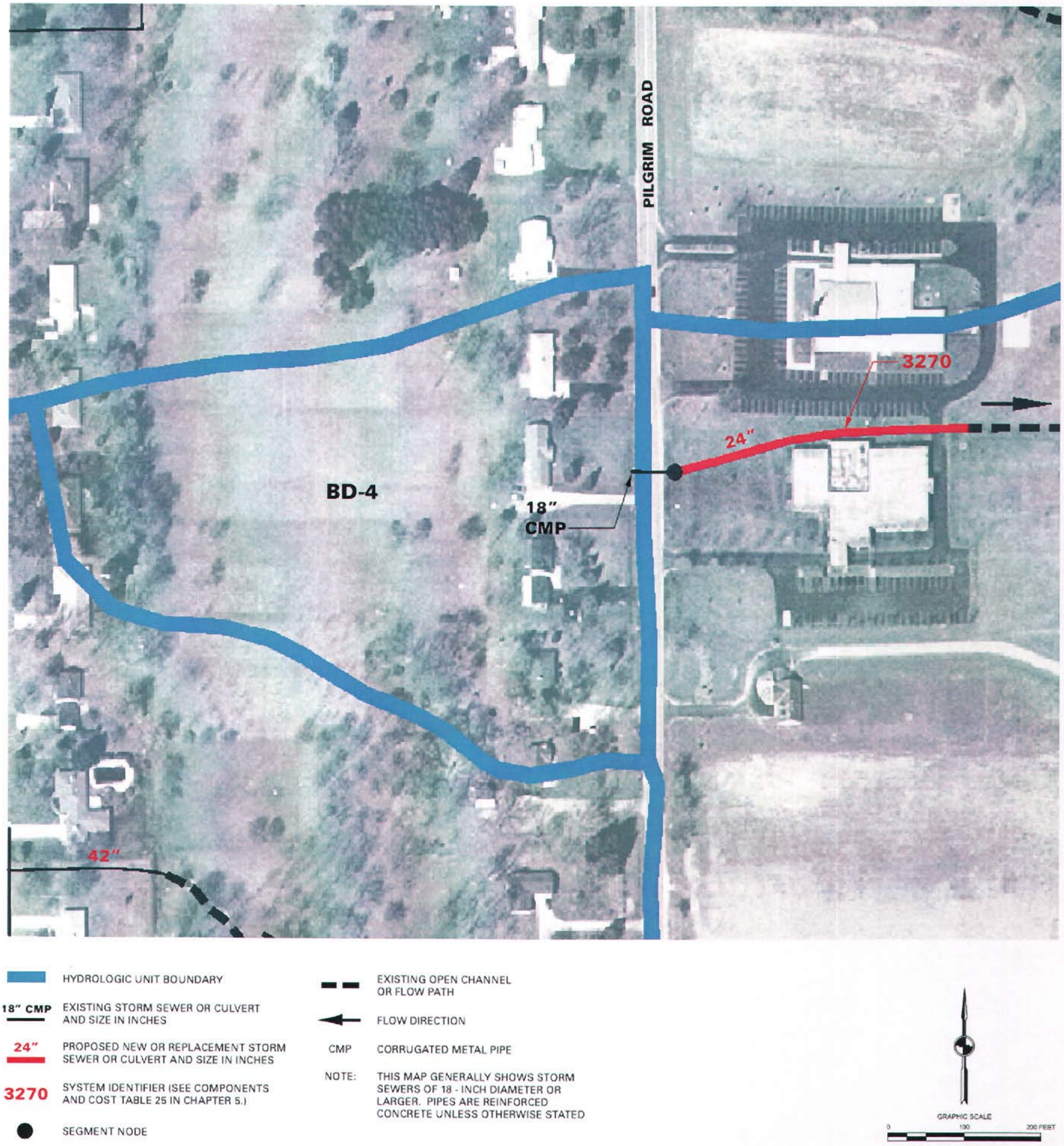
Alternative Plan No. BD-4a1 is the least costly of the two alternatives. The full implementation of Alternative Plan No. BD-4a2 is likely to be more difficult than the full implementation of Alternative Plan No. BD-4a1 due to the requirement of having to acquire drainage easements in order to accommodate the installation of the proposed improvements.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-4

Based upon cost and implementability, Alternative Plan No. BD-4a1 is selected as the preliminary recommended plan.

Map 21

ALTERNATIVE PLAN NO. BD-4A2
INCREASED STORMWATER CONVEYANCE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 25

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-4a2 INCREASED STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 3270–Replace 400 feet of 18-inch CMP east of Pilgrim Road approximately 1,600 feet south of Lisbon Road with 24-inch RCP at an increased slope	$31,200	$0
	Total	$31,200	$0

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs do not include easements or land acquisition unless specifically noted.*

[d] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

HYDROLOGIC UNIT BD-5

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-5 is an approximately 175-acre area located entirely within the City of Brookfield in the west-central portion of the Butler Ditch subwatershed in U.S. Public Land Survey Section 3. The hydrologic unit is located between Calhoun Road and Pilgrim Road north of Capitol Drive (STH 190).

Approximately 99 percent of the hydrologic unit was developed in urban land use under 1995 land use conditions, including 93 percent in low-density residential uses and 6 percent in medium-density residential uses. The remaining 1 percent was in open lands. Under full buildout land use conditions, it is anticipated that the remaining open lands would be converted to low-density residential use.

Conveyance features within the hydrologic unit are comprised of roadside swales, ditch enclosures, and storm sewers. The flow of stormwater within the unit is generally from the west and northwest to the east.

Major system inadequacies were identified through a combination of problems reported to, and/or observed by, City staff and analysis of the stormwater management systems within the hydrologic unit. Possible flooding of two houses on Willow Ridge Lane approximately 300 to 500 feet east of N. 163rd Street during the 100-year recurrence interval storm event may occur as a result of surcharged stormwater from the existing storm sewer systems to the north flowing towards and along the affected structures. Within the Peppercorn Circle area, surcharged stormwater from the existing storm sewer system to the southwest was analyzed to flow overland through a minor swale possibly impacting two residences.

The analyses identified possible minor system inadequacies at 1) N. 160th Street approximately 150 feet north of Spruce Lane, 2) at the intersection of Brook Lane and Laura Lane, and 3) at the intersection of Brook Lane and

Pilgrim Road. In each area, the minor system inadequacy could result in ponding within the road cross-section or road overtopping during the 10-year recurrence interval storm event.

Alternative Stormwater Management Plans for Hydrologic Unit BD-5

Two alternative plans were developed to alleviate the drainage problems with storm events having a 10- to 100-year recurrence interval. The difference between the two plans is the means of resolving the residential structural flooding north of Willow Ridge Lane. Both plans involve increasing the conveyance capacity of the existing systems, since the lack of open land within the hydrologic unit precludes the option of providing detention.

Alternative Plan No. BD-5a1—Stormwater Conveyance in Backyard Easement

Under this alternative plan, the storm sewers located in the drainage easements north of Willow Ridge Lane and west of 163rd Street and southwest of Peppercorn Circle between N. 160th Street and Brook Lane, and also along Brook Lane, would be upgraded to alleviate structure flooding during the 100-year storm event. The remaining systems are sized to alleviate the problems associated with the 10-year storm. The alternative plan components are shown graphically on Map 22 and they are described in Table 26.

The total present value cost of this alternative is estimated to be $262,190. This is based upon an estimated capital cost of $262,190 with no estimated annual operations and maintenance cost increase.

Alternative Plan No. BD-5a2—Stormwater Conveyance in Right-of-Way

This alternative is the same as Alternative No. BD-5a1, except for the means of resolving the structural flooding north of Willow Ridge Lane. The alternative plan components are shown graphically on Map 23 and they are described in Table 27.

The total present value cost of this alternative is estimated to be $257,230. This is based on an estimated capital cost of $256,280 and an estimated annual operation and maintenance cost increase of $60.

Evaluation of Alternative Stormwater Drainage Plans for Hydrologic Unit BD-5

The foregoing information provides the basis for the comparative evaluation of the two alternative plans. The principal criteria for the evaluation are cost and implementability.

The two alternative plans have essentially the same estimated costs. Implementation of Alternative Plan No. BD-5a2 would be more difficult than the implementation of Alternative Plan No. BD-5a1 due to the requirement of acquiring a drainage easement between two residential structures north of Willow Ridge Lane.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-5

Based upon implementatability, Alternative Plan No. BD-5a1—Stormwater Conveyance in Backyard Easement, is selected as the preliminary recommended plan.

HYDROLOGIC UNIT BD-8

Description and Evaluation of the Stormwater Management System

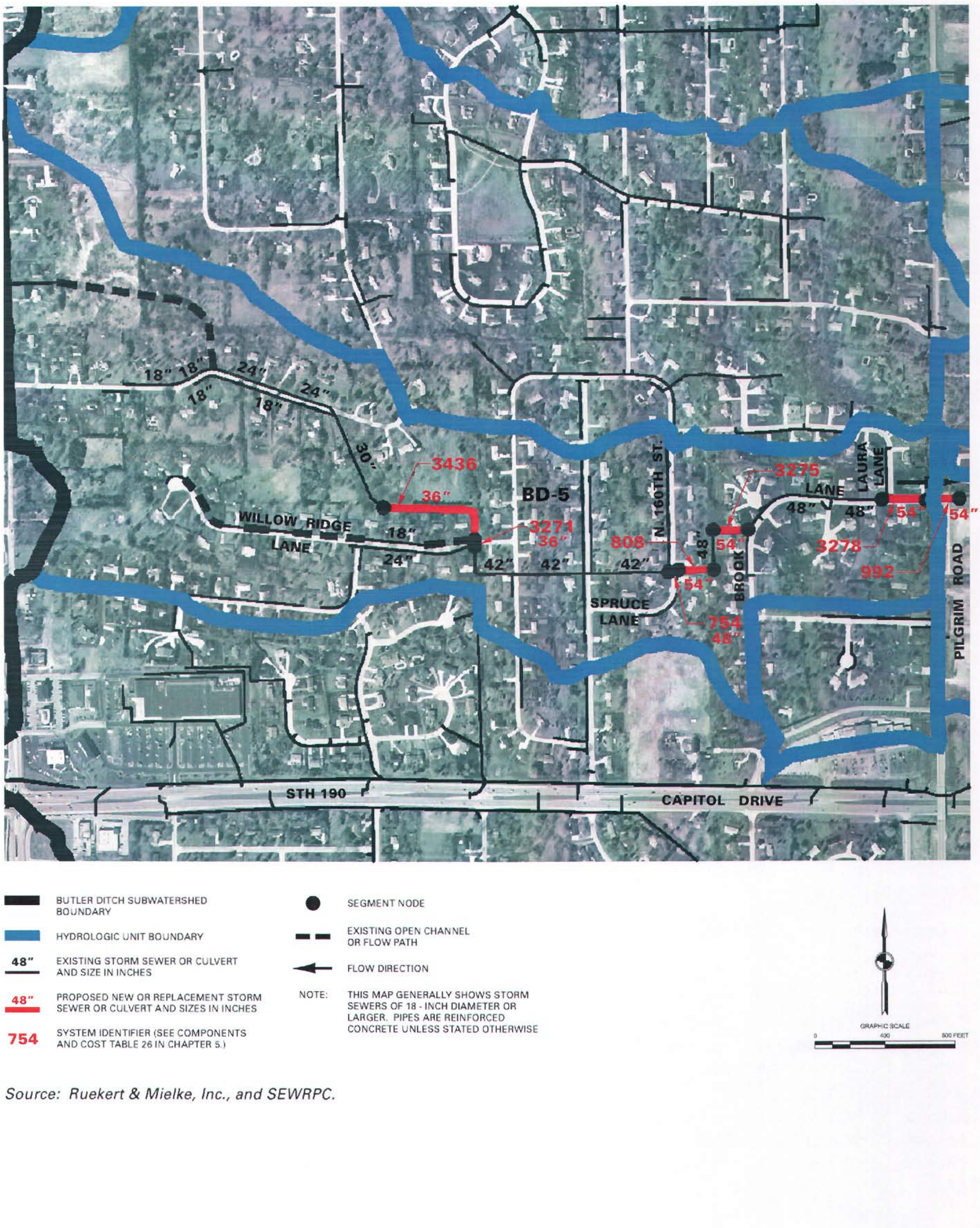
Hydrologic Unit BD-8 is an approximately 19.1-acre area located entirely within the City of Brookfield in the southeast one-quarter of U.S. Public Land Survey Section 3. The unit is generally bordered by Brook Lane on the west, Fieldbrook Drive on the north, and Pilgrim Road on the east.

The entire hydrologic unit was developed in urban land uses under 1995 land use conditions. The urban land uses included 24 percent commercial uses and 76 percent low-density residential uses. The land use distribution is anticipated to remain essentially unchanged under buildout conditions.

The stormwater drainage system in the unit consists of roadside swales and ditch enclosures.

Map 22

ALTERNATIVE PLAN NO. BD-5A1
STORMWATER CONVEYANCE IN BACKYARD EASEMENT



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 26

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-5a1 STORMWATER CONVEYANCE IN BACKYARD EASEMENT

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 992–Replace 130 feet of 48-inch and 60-inch RCP crossing Pilgrim Road north of Brook Lane with 54-inch RCP	$ 35,100	$0
	2. 3278–Replace 234 feet of 48-inch RCP along Brook Lane from Laura Lane to Pilgrim Road with 54-inch RCP	63,180	0
	3. 3275–Replace 208 feet of 48-inch RCP west of Brook Lane and southwest of Peppercorn Circle with 54-inch RCP	39,940	0
	4. 808–Replace 200 feet of 48-inch RCP east of N. 160th Street and west of Brook Lane with 54-inch RCP	38,400	0
	5. 754–Replace 44 feet of 42-inch RCP crossing N. 160th Street north of Spruce Lane with 48-inch RCP	9,240	0
	6. 3271–Replace 38 feet of 30-inch RCP crossing Willow Ridge Lane west of N. 163rd Street with 36-inch RCP	5,700	0
	7. 3436–Replace 625 feet of 30-inch RCP north of Willow Ridge Lane and west of N. 163rd Street with 36-inch RCP	70,630	0
	Total	$262,190	$0

NOTE: The following abbreviations have been used in this table:

RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs do not include easements or land acquisition unless specifically noted.*

[d] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

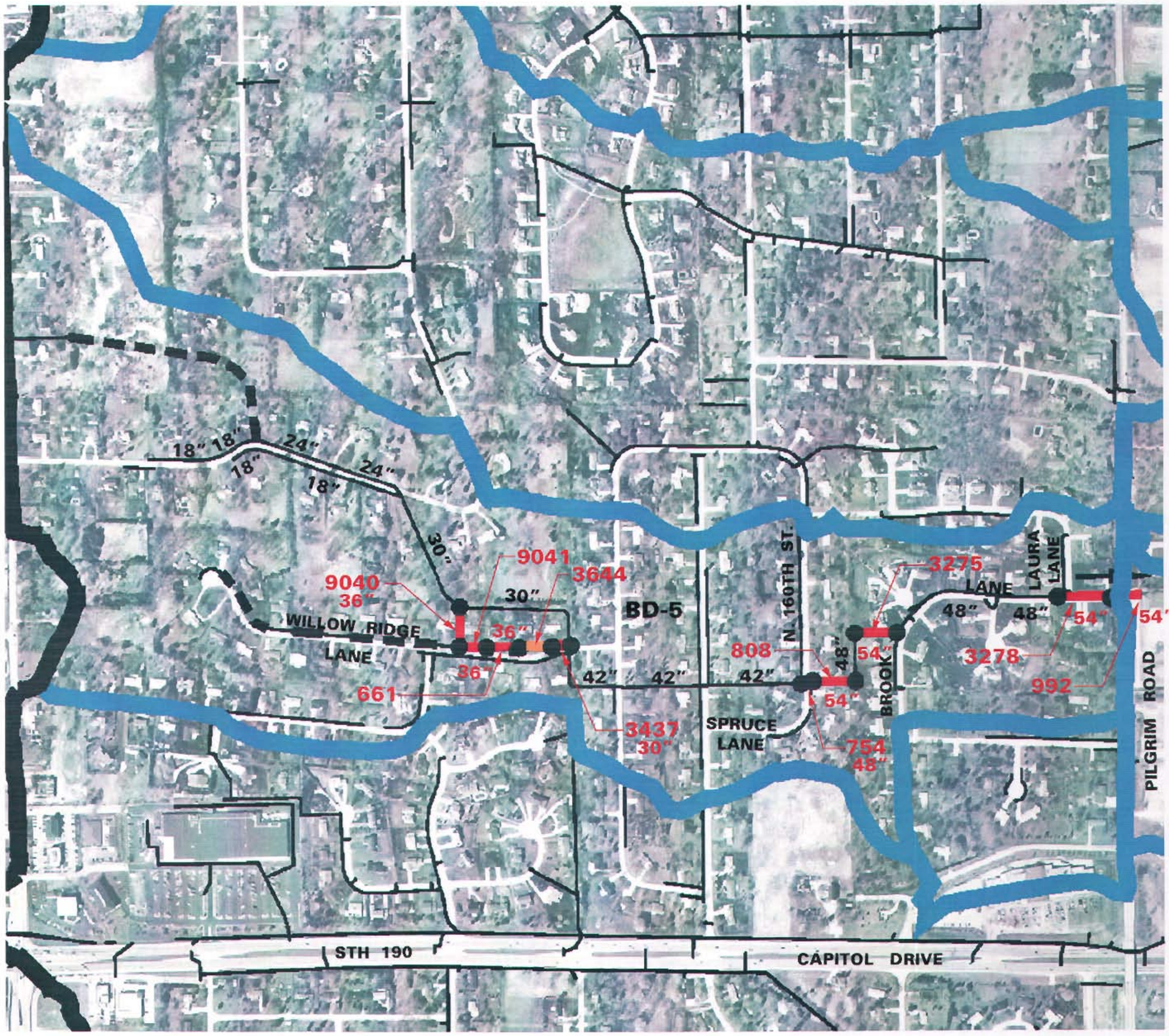
Minor system inadequacies were identified at the crossing at Pilgrim Road south of Fieldbrook Drive. Analyses indicate that the existing 21-inch-diameter corrugated metal pipe surcharges during the two- through 100-year recurrence interval storm events resulting in the overtopping of Pilgrim Road.

Alternative Stormwater Drainage Plan for Hydrologic Unit BD-8

The identified localized problems can be readily solved through the provision of increased hydraulic capacity. Thus, the development of alternative plans is not considered necessary and a stormwater conveyance plan was developed.

Map 23

ALTERNATIVE PLAN NO. BD-5A2
STORMWATER CONVEYANCE IN RIGHT-OF-WAY



■ BUTLER DITCH SUBWATERSHED BOUNDARY

■ HYDROLOGIC UNIT BOUNDARY

42" EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES

36" PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES

992 SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 27 IN CHAPTER 5.)

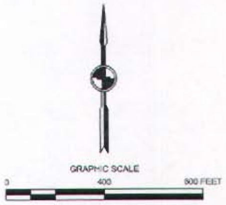
● SEGMENT NODE

▬ ▬ PROPOSED REGRADED OPEN CHANNEL

▬ ▬ EXISTING OPEN CHANNEL OR FLOW PATH

◄— FLOW DIRECTION

NOTE: THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 27

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-5a2 STORMWATER CONVEYANCE IN BACKYARD EASEMENT

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 992–Replace 130 feet of 48-inch and 60-inch RCP crossing Pilgrim Road north of Brook Lane with 54-inch RCP	$ 35,100	$ 0
	2. 3278–Replace 234 feet of 48-inch RCP north of Brook Lane from Laura Lane to Pilgrim Road with 54-inch RCP	63,180	0
	3. 3275–Replace 208 feet of 48-inch RCP west of Brook Lane and southwest of Peppercorn Circle with 54-inch RCP	39,940	0
	4. 808–Replace 200 feet of 48-inch RCP east of N. 160th Street and west of Brook Lane with 54-inch RCP	38,400	0
	5. 754–Replace 44 feet of 42-inch RCP crossing N. 160th Street north of Spruce Lane with 48-inch RCP	9,240	0
	6. 3437–Replace 44 feet of 18-inch RCP north of Willow Ridge Lane and west of N. 163rd Street with 30-inch RCP and headwall	5,280	0
	7. 3644–Regrade 250 feet of swale north of Willow Ridge Lane and west of N. 163rd Street to have a 2.5-foot depth, a bottom width of two feet, and side slopes of one vertical on four horizontal	7,970	0
	8. 661–Replace 109 feet of 18-inch RCP north of Willow Ridge Lane and east of N. 166th Street with 36-inch RCP	16,350	0
	9. 9041–Replace 131 feet of 18-inch RCP north of Willow Ridge Lane and east of N. 166th Street with 36-inch RCP	19,350	0
	10. 9040–Install 190 feet of new 36-inch RCP along side of lot north of Willow Ridge Lane and east of N. 166th Street extended	21,470	60
	Total	$256,280	$60

NOTE: The following abbreviations have been used in this table:

RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs do not include easements or land acquisition unless specifically noted.*

[d] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-8
The preliminary recommended system is described in Table 28. The components of that system are shown on Map 24. As set forth in Table 28, the total capital cost for this recommended replacement is $11,700. No increase in annual operation and maintenance costs would be expected.

HYDROLOGIC UNIT BD-12

Description and Evaluation of the Stormwater Management System
Hydrologic Unit BD-12 is an approximately five-acre area located entirely within the City of Brookfield in the southwest one-quarter of U.S. Public Land Survey Section 2. The unit is located around the northern terminus of Clare Bridge Lane north of Woodland Place.

Under 1995 land use conditions, all of the hydrologic unit was comprised of low-density residential uses. It is anticipated that the distribution of land uses would be unchanged under full buildout land use conditions.

The stormwater drainage system in the hydrologic unit is comprised of storm sewers. Flow within the unit is generally from the southeast to the northwest.

The major drainage system does not have adequate capacity to avoid impacting the sanitary sewer system during the 50- and 100-year recurrence interval storms.

Alternative Stormwater Drainage Plan for Hydrologic Unit BD-12
The identified localized problems can readily be solved through the provision of increases in hydraulic capacity. Thus, the development of alternative plans is not considered to be necessary and a culvert and storm sewer conveyance plan was developed.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-12
The preliminary recommended system is shown on Map 25 and plan components are described in Table 29. As set forth in Table 29, the total capital cost is estimated to be $14,880. No increase in annual operation and maintenance costs would be expected.

HYDROLOGIC UNIT BD-16

Description and Evaluation of the Stormwater Management System
Hydrologic Unit BD-16 is an approximately 563-acre area located entirely within the City of Brookfield in the northern one-half of U.S. Public Land Survey Section 13, the western one-half of Section 12, the northeast one-quarter of Section 11, and the southwest one-quarter of Section 1. The unit is generally located north of Center Street, east of Lilly Road, south of Hope Street, and west of N. 124th Street.

Under 1995 land use conditions, about 95 percent of the hydrologic unit was developed in urban land uses, including 73 percent low-density residential, 2 percent high-density residential, 5 percent commercial, 2 percent recreational, and 13 percent governmental and institutional.[10] The remaining 5 percent of the unit was in open space and surface water. Under full buildout land use conditions, the entire unit would be in urban uses. The unit would then consist of 73 percent low-density residential, 8 percent commercial, 4 percent high-density residential, 2 percent recreational, and 13 percent governmental and institutional.

The stormwater drainage system consists primarily of a system of roadside swales, culverts, ditch enclosures, and detention basins/ponds. A wet detention basin in Lamplighter Park receives runoff from roughly half of the hydrologic unit area. The Unnamed Tributary to Butler Ditch begins in two interconnected ponds near the south

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[10] *About 90 percent of the governmental and institutional category is cemetery.*

Table 28

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-8 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 827–Replace 78 feet of 21-inch CMP crossing Pilgrim Road south of Fieldbrook Drive with 36-inch RCP	$11,700	$0
	Total	$11,700	$0

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs do not include easements or land acquisition unless specifically noted.*

[d] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

end of the Wisconsin Memorial Park Cemetery and flows to the north, discharging to Butler Ditch north of W. Hope Street and east of Lilly Road. The Unnamed Tributary is enclosed in storm sewers and culverts in the vicinity of W. Capitol Drive and also near W. Hope Street.

Both clearwater flooding and sanitary sewer backup problems were reported to the City as a result of the June 1997 and the August 1998 storms. The hydrologic and hydraulic analyses conducted for this plan yielded results consistent with the experienced problems. The analyses identified inadequate hydraulic capacity at the pipes crossing Burlawn Parkway at Upper Wembley Circle, crossing Cardinal Drive at Burlawn Parkway, and crossing N. 138th Street at Woodside Road. In 1997 and 1998, problems were observed along Burlawn Parkway, along Princeton Road from Winthrop Court to Hampstead Drive, along Hampstead Drive from Princeton Road to Burlawn Parkway, in the area surrounding Lamplighter Park, and along Fiebrantz Drive about 1,200 feet south of Capitol Drive. Flooding resulted from inadequate capacity of the conveyance system at Applegate Lane south of Commons Drive and at Fiebrantz Drive, 1,200 feet south of Capitol Drive. Inadequate capacity was also found at Ranch Road and Lilly Road requiring a 50-year alternative because Lilly Road is an arterial.

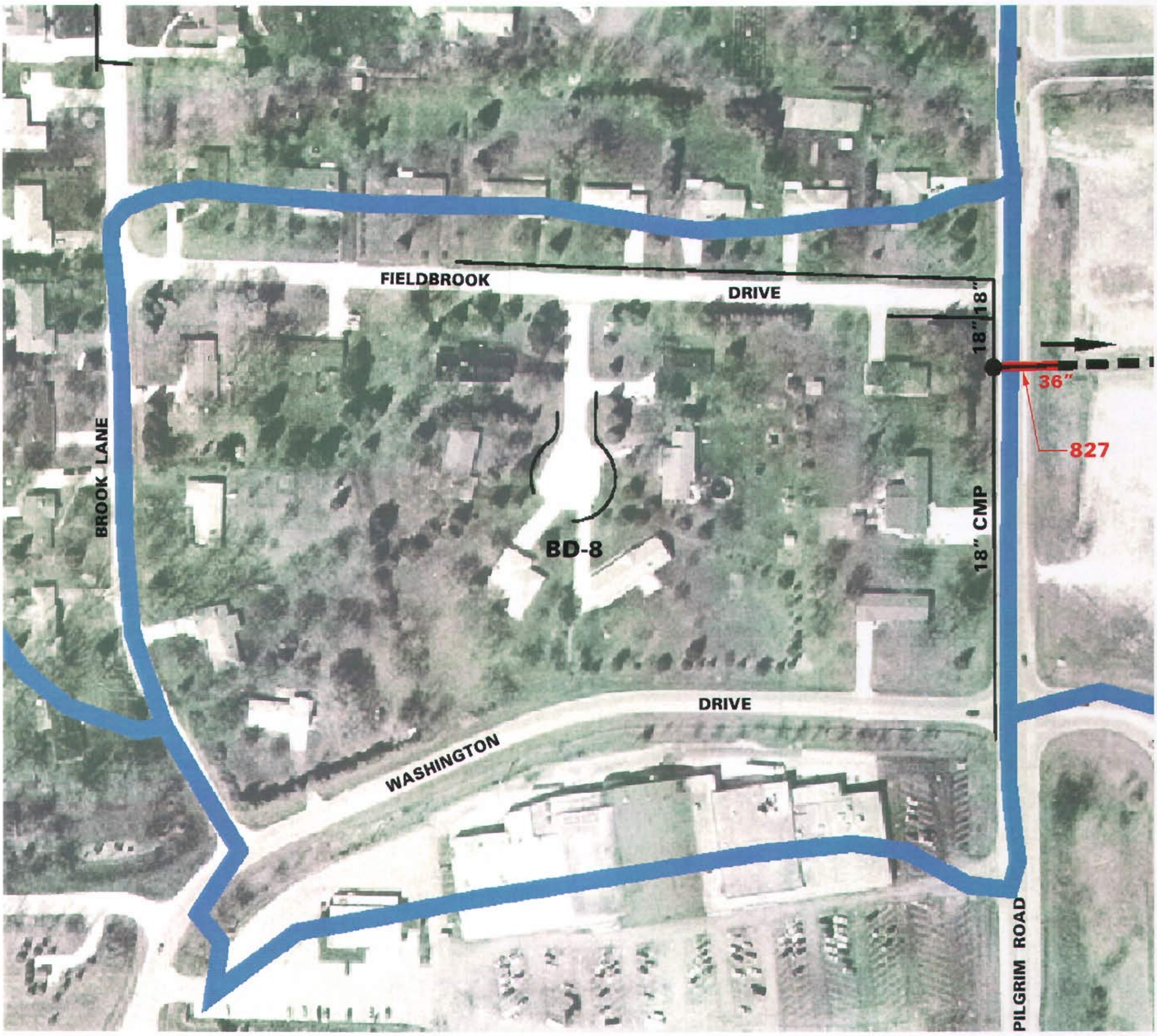
The City has recently completed upgrades to both the storm sewer and sanitary sewer systems in this hydrologic unit that are intended to alleviate sanitary sewer backup problems and stormwater drainage problems. The stormwater system upgrades are based on the recommendations of this plan.

Alternative Stormwater Drainage Plans for Hydrologic Unit BD-16

The identified stormwater management problems can readily be solved through a combination of increased detention storage and increased hydraulic capacity within the existing system. Significant increases in flood flows to Butler Ditch would not be expected as a result of the proposed improvements. Due to the lack of open space, development of multiple alternative plans is not considered to be necessary and a stormwater conveyance with detention storage alternative was developed as described below.

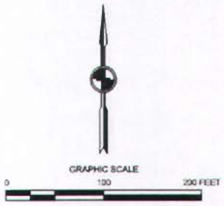
Map 24

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-8 STORMWATER CONVEYANCE



🟦	HYDROLOGIC UNIT BOUNDARY
18"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
36"	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
827	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 28 IN CHAPTER 5.)
●	SEGMENT NODE

▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
←	FLOW DIRECTION
CMP	CORRUGATED METAL PIPE
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 25

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-12 STORMWATER CONVEYANCE

Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 29

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-12 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 237–Replace 190 feet of 15-inch RCP from Claire Bridge Lane to the outfall at Butler Ditch with 18-inch RCP	$11,780	$0
	2. 236–Replace 31 feet of 15-inch RCP crossing Claire Bridge Lane north of Woodland Place with 18-inch RCP	3,100	0
	Total	$14,880	$0

NOTE: The following abbreviations have been used in this table:

RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs do not include easements or land acquisition unless specifically noted.*

[d] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

The recommended plan from Addendum No. 1 to a previous study of the Burlawn Parkway Drainage Area that was completed for the City by Graef, Anhalt, Schloemer, and Associates (GAS) was incorporated in the plan formulation. The plan calls for an additional two feet of depth for storage in the Lamplighter Park Pond along with a revised outlet structure. A new storm sewer system through the Wisconsin Memorial Park Cemetery was also proposed.

The proposed measures address identified drainage problems in the major and minor systems. The alternatives for those problems will also help alleviate sanitary sewer backup problems. Yard and basement flooding problems due to localized grading conditions are not addressed by the proposed measures.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-16

The preliminary recommended system is shown on Maps 26 through 29 and plan components are described in Table 30. As set forth in Table 30, the estimated total capital cost of this plan is $1,597,760 and the estimated annual operation and maintenance cost increase is $770.

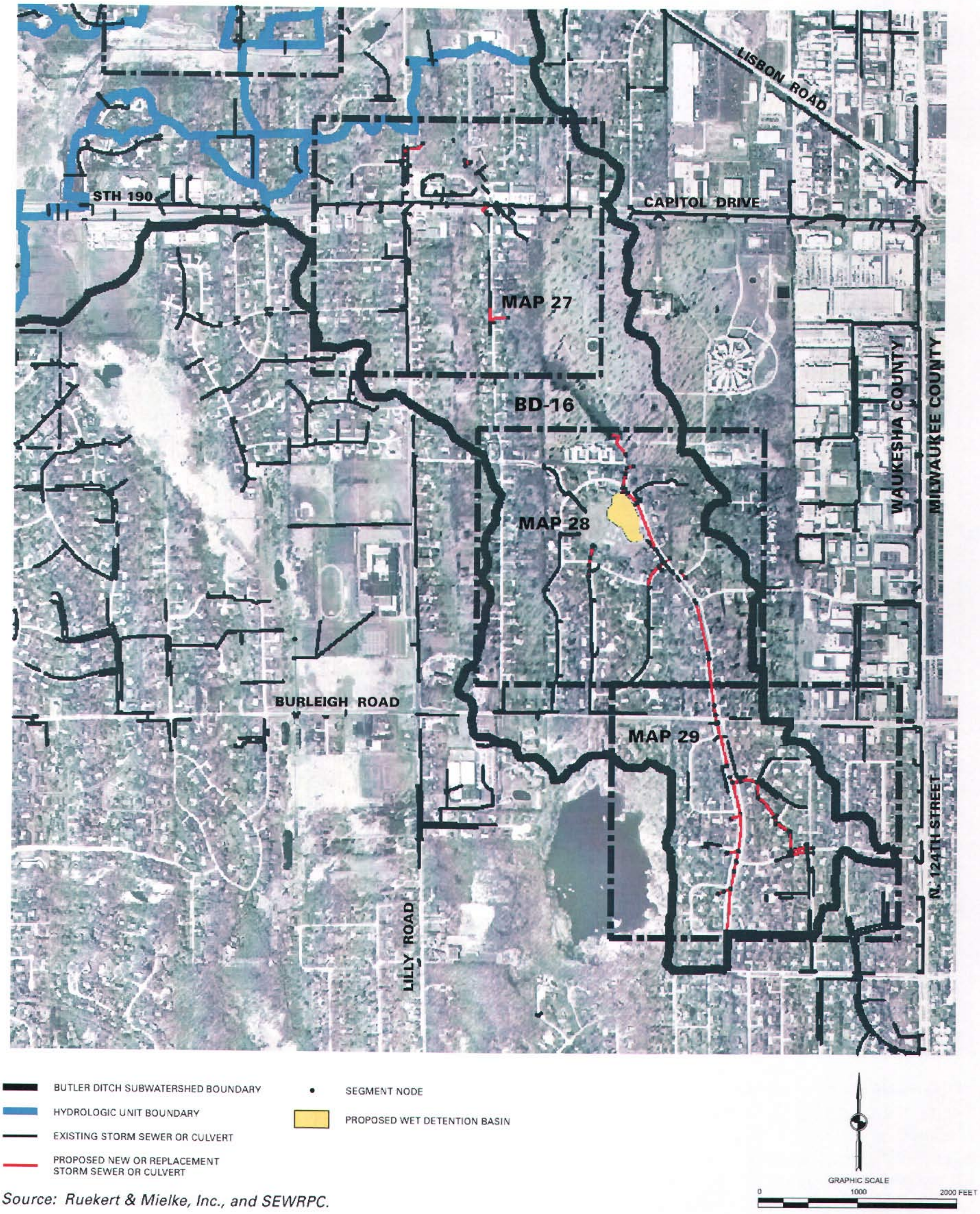
HYDROLOGIC UNIT BD-17

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-17 is an approximately 206-acre area located entirely within the City of Brookfield in U.S. Public Land Survey Sections 1 and 2 in the east-central portion of the Butler Ditch subwatershed. The unit is generally located west of N. 135th Street, north of Capitol Drive, east of N. 144th Street, and south of Hampton Road (CTH K).

Map 26

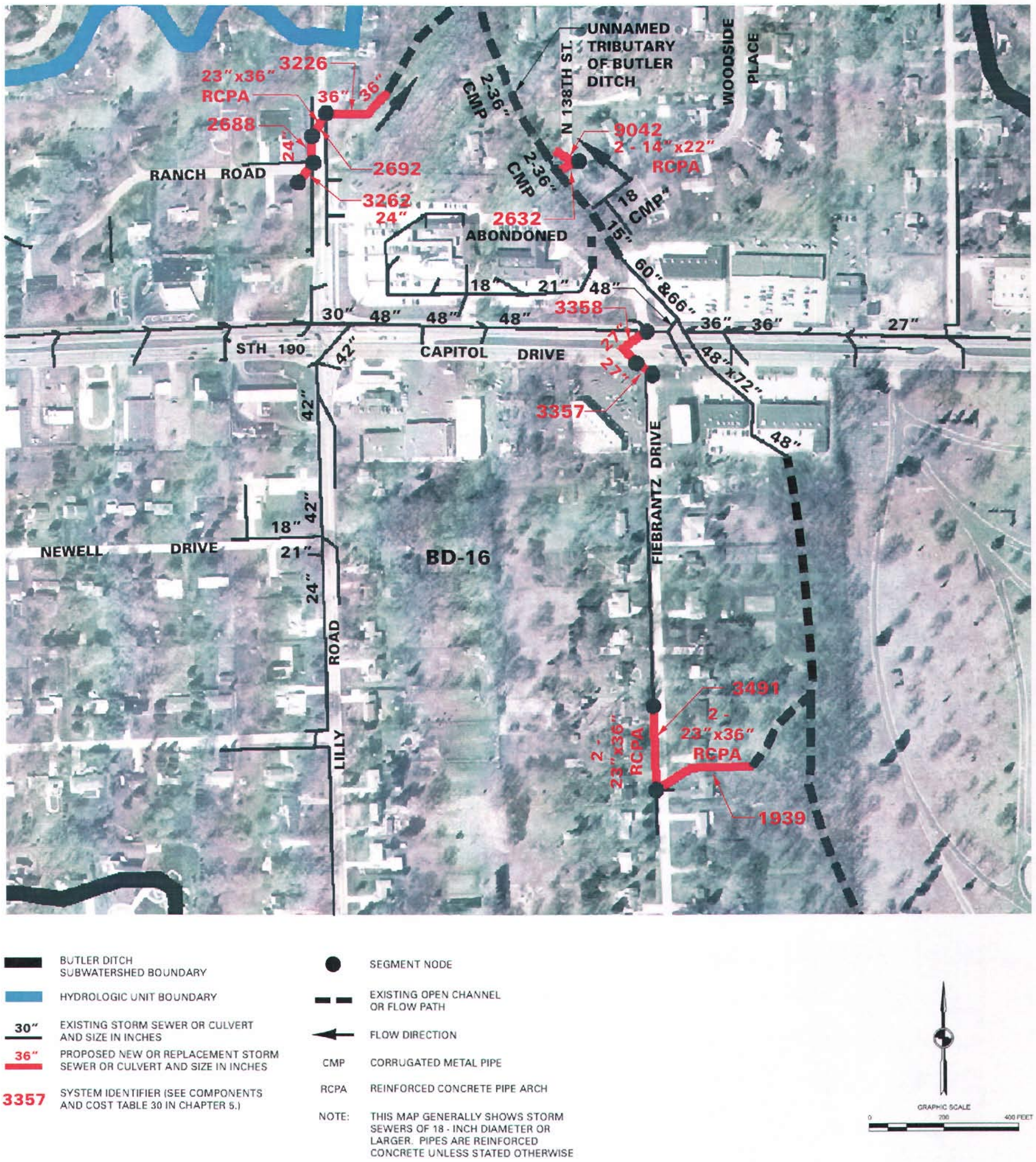
INDEX MAP FOR HYDROLOGIC UNIT BD-16



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 27

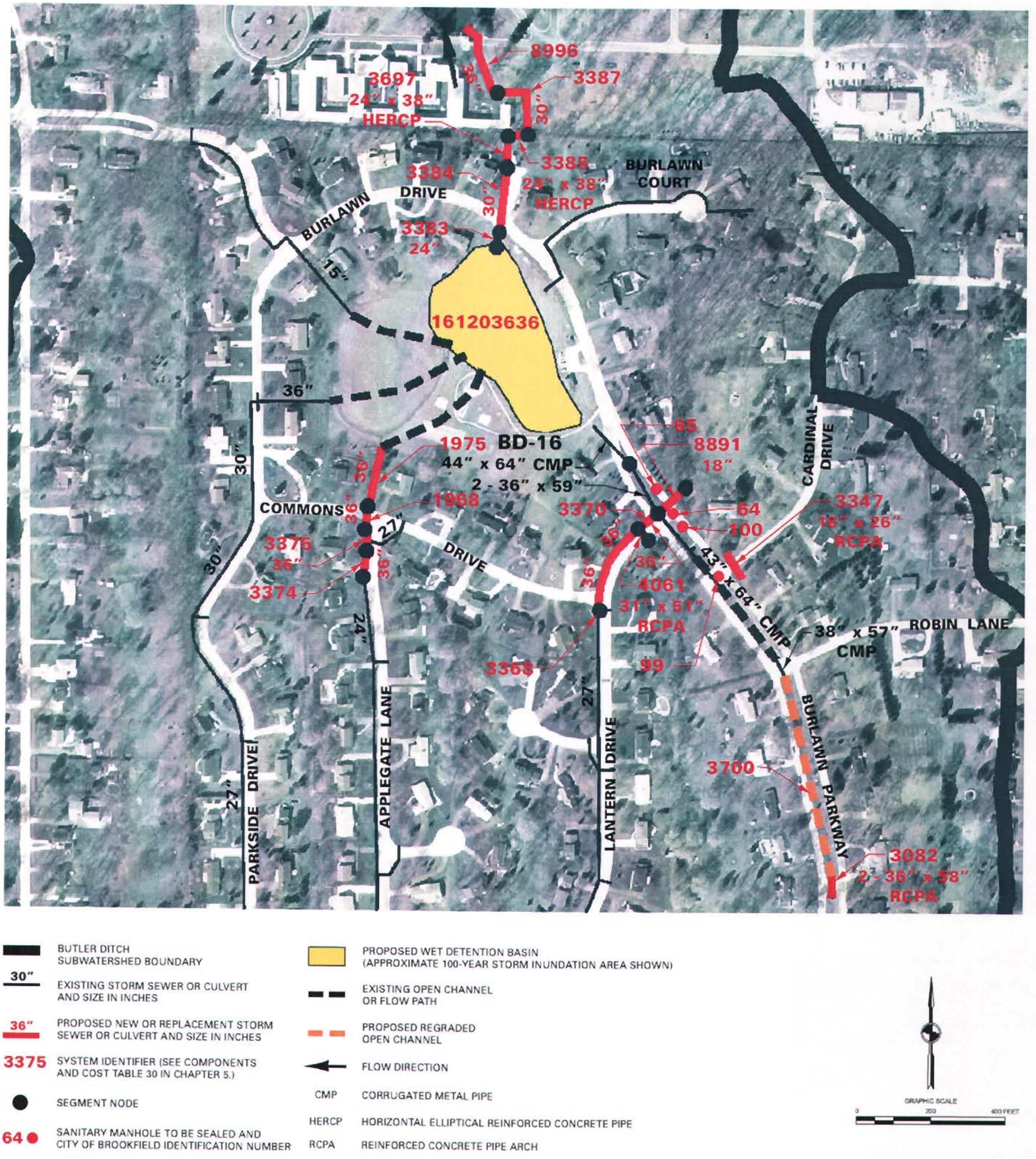
PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-16 STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 28

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-16 STORMWATER CONVEYANCE WITH DETENTION STORAGE

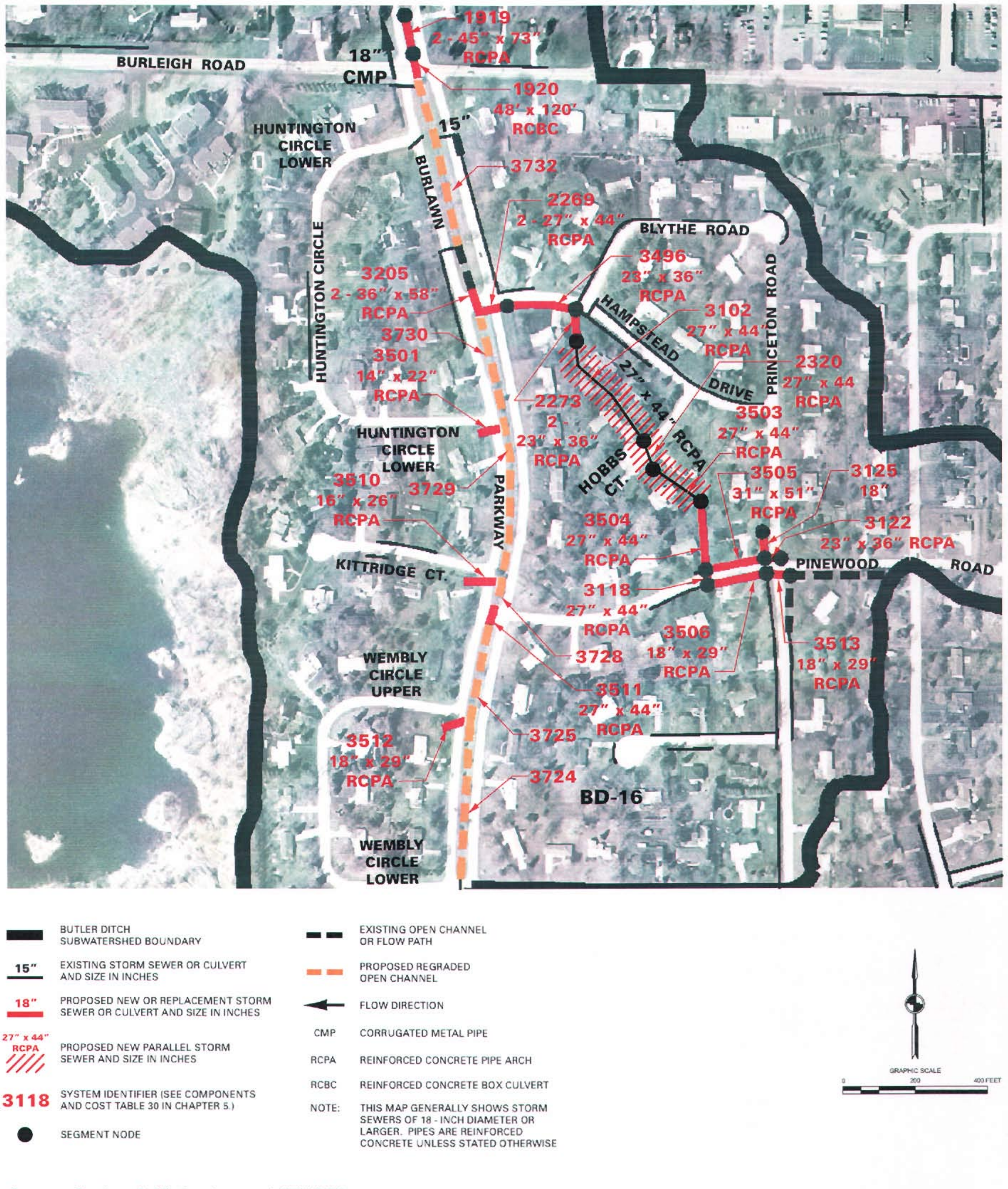


NOTE: THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 29

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-16 STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 30

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-16 STORMWATER CONVEYANCE WITH DETENTION STORAGE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 3226–Replace 192 feet of 24-inch RCP through the side yard of two houses 160 feet north of Ranch Road along Lilly Road with 36-inch RCP	$ 24,190	$ 0
	2. 2692–Replace 38 feet of 24-inch RCP crossing Lilly Road north of Ranch Road with 23-inch-high by 36-inch-wide RCPA	6,090	0
	3. 2688–Replace 65 feet of 21-inch RCP along Lilly Road north of Ranch Road with 24-inch RCP	6,500	0
	4. 3262–Replace 40 feet of 13-inch-high by 17-inch-wide CMPA crossing Ranch Road at Lilly Road with 24-inch RCP	4,000	0
	5. 9042–Install 34 feet of new dual 14-inch-high by 22-inch-wide RCPA culverts crossing N. 138th Street north of 4065 N. 138th Street driveway culverts	5,240	20
	6. 2632–Abandon 34 feet of 18-inch CMP culvert crossing N. 138th Street south of the 4065 N. 138th Street driveway culverts	0	0
	7. 3358–Replace 122 feet of 21-inch RCP crossing Capitol Drive west of Fiebrantz Drive with 27-inch RCP	14,640	0
	8. 3357–Replace 28 feet of 18-inch RCP crossing Capitol Drive at Fiebrantz Drive with 27-inch RCP	3,360	0
	9. 1939–Replace 46 feet of 18-inch RCP in the side yard of two houses 1,200 feet south of Capitol Drive along Fiebrantz Drive with 250 feet of dual 23-inch-high by 36-inch-wide RCPA	80,090	280
	10. 3491–Replace 140 feet of 15-inch RCP along Fiebrantz Drive beginning 1,000 feet south of Capitol Drive with 23-inch-high by 36-inch-wide RCPA	22,430	0
	11. 8996–Install 196 feet of new 36-inch RCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1	22,150	60
	12. 3387–Replace 137 feet of three-feet-high by 3.33-feet-wide reinforced concrete box in Wisconsin Memorial Park Cemetery east of the Mausoleum with 30-inch RCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	12,610	60
	13. 3385–Replace 30 feet of 24-inch RCP in Wisconsin Memorial Park Cemetery along the southeast corner of the Mausoleum with 24-inch-high by 38-inch-wide HERCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	2,760	0

Table 30 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield (continued)	14. 3697–Install 68 feet of new 24-inch-high by 38-inch-wide HERCP in the existing swale south of Wisconsin Memorial Park Cemetery and south of the Mausoleum as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	$ 6,260	$ 40
	15. 3384–Replace 196 feet of 24-inch RCP north of and crossing Burlawn Parkway with 30-inch RCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	18,040	0
	16. 3383–Replace eight feet of 24-inch RCP outlet for Lamplighter Park Pond with 24-inch RCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	630	0
	17. Seal sanitary sewer manhole numbers 64, 65, 99, and 100 in Burlawn Parkway near Lantern and Cardinal Drives[e]	5,000	0
	18. 161203636–Lower water surface elevation of the Lamplighter Park detention basin by two feet and add new outlet structure as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	582,980	0
	19. 1975–Replace 182 feet of 27-inch RCP north of Commons Drive outletting into Lamplighter Park detention basin with 36-inch RCP	20,570	0
	20. 1968–Replace 28 feet of 27-inch RCP crossing Commons Drive at Applegate Lane with 36-inch RCP with a revised grade	4,200	0
	21. 3375–Replace 50 feet of 27-inch RCP along Applegate Lane south of Commons Drive with 36-inch RCP with a revised grade	7,500	0
	22. 3374–Replace 87 feet of 27-inch RCP along Applegate Lane south of Commons Drive with 36-inch RCP	13,050	0
	23. 8891–Install 50 feet of new 18-inch RCP crossing Burlawn Parkway at Lantern Drive at existing low area	4,000	30
	24. 3370–Replace 68 feet of 27-inch RCP crossing Burlawn Parkway at Lantern Drive with 36-inch RCP	10,880	0
	25. 3368–Replace 260 feet of 27-inch RCP along Lantern Drive at Burlawn Parkway with 36-inch RCP	41,600	0
	26. 4061–Replace 39 feet of 12-inch RCP crossing Lantern Drive at Burlawn Parkway with 31-inch-high by 51-inch-wide RCPA	9,440	0
	27. 3347–Replace 40 feet of 12-inch CMP culvert crossing Cardinal Drive at Burlawn Parkway with 16-inch-high by 26-inch-wide RCPA culvert	3,360	0

Table 30 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a] Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield (continued)	28. 3700–Regrade 550 feet of swale to have a bottom width of eight feet, a depth of three feet, and side slopes of one vertical on four horizontal in Burlawn Parkway	$ 10,330	$ 0
	29. 3082–Replace 44 feet of 43-inch-high by 64-inch-wide CMPA culvert in Burlawn Parkway 640 feet north of Burleigh Road with dual 36-inch-high by 58-inch-wide RCPA culverts	16,900	10
	30. 1919–Replace 104 feet of 47-inch-high by 71-inch-wide CMPA along Burlawn Parkway at Burleigh Road with dual 45-inch-high by 73-inch-wide RCPA	73,610	30
	31. 1920–Replace 90 feet of dual 33-inch-high by 49-inch-wide CMPA culverts in Burlawn Parkway crossing Burleigh Road with a four-foot-high by 10-foot-wide concrete box culvert	90,000	0
	32. 3732–Regrade 435 feet of existing swale to a bottom width of six feet, a depth of two feet, and side slopes of one vertical on four horizontal in Burlawn Parkway	9,620	0
	33. 3205–Replace 44 feet of 29-inch-high by 42-inch-wide CMPA culvert in Burlawn Parkway at Hampstead Drive with dual 36-inch-high by 58-inch-wide RCPA	16,900	10
	34. 3730–Regrade 320 feet of existing swale to a new grade along Burlawn Parkway south of Hampstead Drive	23,540	0
	35. 3729–Regrade 440 feet of existing swale to a new grade along Burlawn Parkway south of Lower Huntington Circle	57,250	0
	36. 3728–Regrade 70 feet of existing swale to a new grade along Burlawn Parkway south of Kittridge Court	1,980	0
	37. 3511–Replace 44 feet of 18-inch CMP culvert in Burlawn Parkway at Pinewood Road with 27-inch-high by 44-inch RCPA culvert	5,550	0
	38. 3725–Regrade 275 feet of existing swale to a bottom width of five feet, depth of two feet, and side slopes of 5 to 1 in Burlawn Parkway south of Pinewood Road	5,870	0
	39. 3724–Regrade 438 feet of existing swale to a bottom width of five feet, depth of two feet, and side slopes of 5 to 1 in Burlawn Parkway south of Upper Wembley Circle	9,340	0
	40. 3512–Replace 40 feet of 15-inch CMP culvert crossing Burlawn Parkway at Upper Wembley Court with a 18-inch-high by 29-inch-wide RCPA culvert	3,680	0
	41. 3510–Replace 40 feet of 15-inch CMP culvert crossing Burlawn Parkway at Kittridge Court with a 16-inch-high by 26-inch-wide RCPA culvert	3,360	0

Table 30 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield (continued)	42. 3501–Replace 40 feet of 15-inch CMP culvert crossing Burlawn Parkway at Lower Huntington Circle with 14-inch-high by 22-inch-wide RCPA culvert	$ 3,080	$ 0
	43. 2269–Replace 58 feet of dual 18-inch-high by 29-inch-wide RCPA crossing Burlawn Parkway at Hampstead Drive with dual 27-inch-high by 44-inch-wide RCPA and reset grade	22,080	0
	44. 3496–Replace 203 feet of dual 20-inch-high by 28-inch-wide CMPA along Hampstead Drive east of Burlawn Parkway with dual 23-inch-high by 36-inch-wide RCPA	65,030	0
	45. 2273–Replace 82 feet of dual 18-inch-high by 29-inch-wide RCPA through a side yard at Hampstead Drive and Blythe Court with dual 23-inch-high by 36-inch-wide RCPA[f]	15,090	0
	46. 3102–Install 361 feet of new 27-inch-high by 44-inch-wide RCPA parallel to the existing pipe through backyards northwest of Hobbs Court and south of Hampstead Drive[f]	40,800	110
	47. 2320–Relay existing 57-foot-long, 27-inch-high by 44-inch-wide RCPA and install a new parallel pipe of the same size under Hobbs Court[f]	11,950	20
	48. 3503–Relay existing 178-foot long, 27-inch-high by 44-inch-wide RCPA and install a new parallel pipe of the same size southeast of Hobbs Court and west of Princeton Road[f]	20,120	50
	49. 3504–Replace 178 feet of 29-inch-high by 42-inch-wide CMPA along backyards north of Pinewood Road with dual 27-inch-high by 44-inch-wide RCPA[f]	40,230	0
	50. 3118–Replace 43 feet of 29-inch-high by 42-inch-wide CMPA crossing Pinewood Road west of Princeton Road with 27-inch-high by 44-inch-wide RCPA	8,190	0
	51. 3506–Replace 166 feet of 21-inch RCP along the south side of Pinewood Road west of Princeton Road with 18-inch-high by 29-inch-wide RCPA and provide positive slope on pipe	20,130	0
	52. 3513–Replace 40 feet of 15-inch RCP crossing Princeton Road along the south side of Pinewood Road with 18-inch-high by 29-inch-wide RCPA and provide positive slope on pipe	4,860	0
	53. 3505–Replace 165 feet of 24-inch RCP along the north side of Pinewood Road west of Princeton Road with dual 31-inch-high by 51-inch-wide RCPA and provide positive slope on pipe	73,050	50

Table 30 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield (continued)	54. 3122–Replace 48 feet of 18-inch CMPA crossing Princeton Road along the north side of Pinewood Road with 23-inch-high by 36-inch-wide RCPA with headwall and reset grade	$ 7,690	$ 0
	55. 3125–Replace 12 feet of 12-inch RCP along the west side of Princeton Road on the north side of Pinewood Road with 18-inch RCP and reset grade	960	0
	Total	$1,597,760	$770

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
CMPA = Corrugated metal pipe arch
HERCP = Horizontal elliptical reinforced concrete pipe
RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs do not include easements or land acquisition unless specifically noted.*

[d] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[e] *This work has been completed by the City of Brookfield.*

[f] *These proposed replacement pipes could be moved to the public right-of-way along Princeton Road and Hampstead Drive and the existing pipes could be maintained to handle local runoff. The feasibility of moving the pipes, and perhaps reducing their size, since some runoff could be conveyed in the existing pipes, could be investigated during the engineering design phase.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Approximately 74 percent of the hydrologic unit was developed in urban land uses under 1995 land use conditions, including 66 percent in low-density residential uses, 5 percent in government and institutional uses, and 3 percent in recreational uses. The remaining 26 percent of the unit was comprised of open lands. About one-half of the open lands were wetlands and woodlands. Under full buildout land use conditions, 89 percent of the unit would be in urban land uses, including 72 percent in low-density residential uses, 3 percent in high-density residential uses, 5 percent in government and institutional uses, and 9 percent in recreational uses. The remaining 11 percent would primarily be wetlands. There would be no loss of wetlands between 1995 and attainment of full buildout.

Conveyance features within the hydrologic unit are comprised of roadside swales, ditch enclosures, and storm sewers. Conveyance system improvements are proposed to alleviate the overtopping of Lilly Road at Regis Street during the 50-year recurrence interval storm event.

Alternative Stormwater Drainage Plans for Hydrologic Unit BD-17

The identified localized problems can be readily solved through increasing the hydraulic capacity of the inadequate pipes and roadside swales. Therefore, the development of alternative plans is not considered to be necessary and a stormwater conveyance plan was developed.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-17

The preliminary recommended system is shown on Map 30 and plan components are described in Table 31. As set forth in Table 31, the estimated capital cost of this plan is $33,320 and the estimated annual operation and maintenance cost increase is $50.

HYDROLOGIC UNIT BD-20

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-20 is an approximately seven-acre area located entirely within the City of Brookfield in the northwest one-quarter of U.S. Public Land Survey Section 1. The unit is generally located east of the Butler Ditch, along Turtle Creek Drive and Courtland Avenue.

Under 1995 land use conditions, 98 percent of the hydrologic unit was developed in low-density residential uses and 2 percent of the unit was comprised of open space. Under full buildout conditions, all of the unit would be developed in low-density residential uses.

The stormwater drainage system within the hydrologic unit consists of roadside swales and storm sewers.

Analysis of the existing stormwater drainage system indicated that the minor system at the corner of Courtland Avenue and Turtle Creek Drive is inadequate to convey the flow from a two-year storm event without ponding in the street.

Alternative Stormwater Drainage Plan for Hydrologic Unit BD-20

The identified localized problems can readily be solved through increasing the hydraulic capacity of the inadequate pipe. Thus, the development of multiple alternative plans is not considered to be necessary and a stormwater conveyance plan was developed.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-20

The preliminary recommended system is described in Table 32 and system components are shown on Map 31. As set forth in Table 32, the total capital cost for this recommended replacement is $29,920. No increase in annual operation and maintenance costs would be expected.

HYDROLOGIC UNIT BD-28

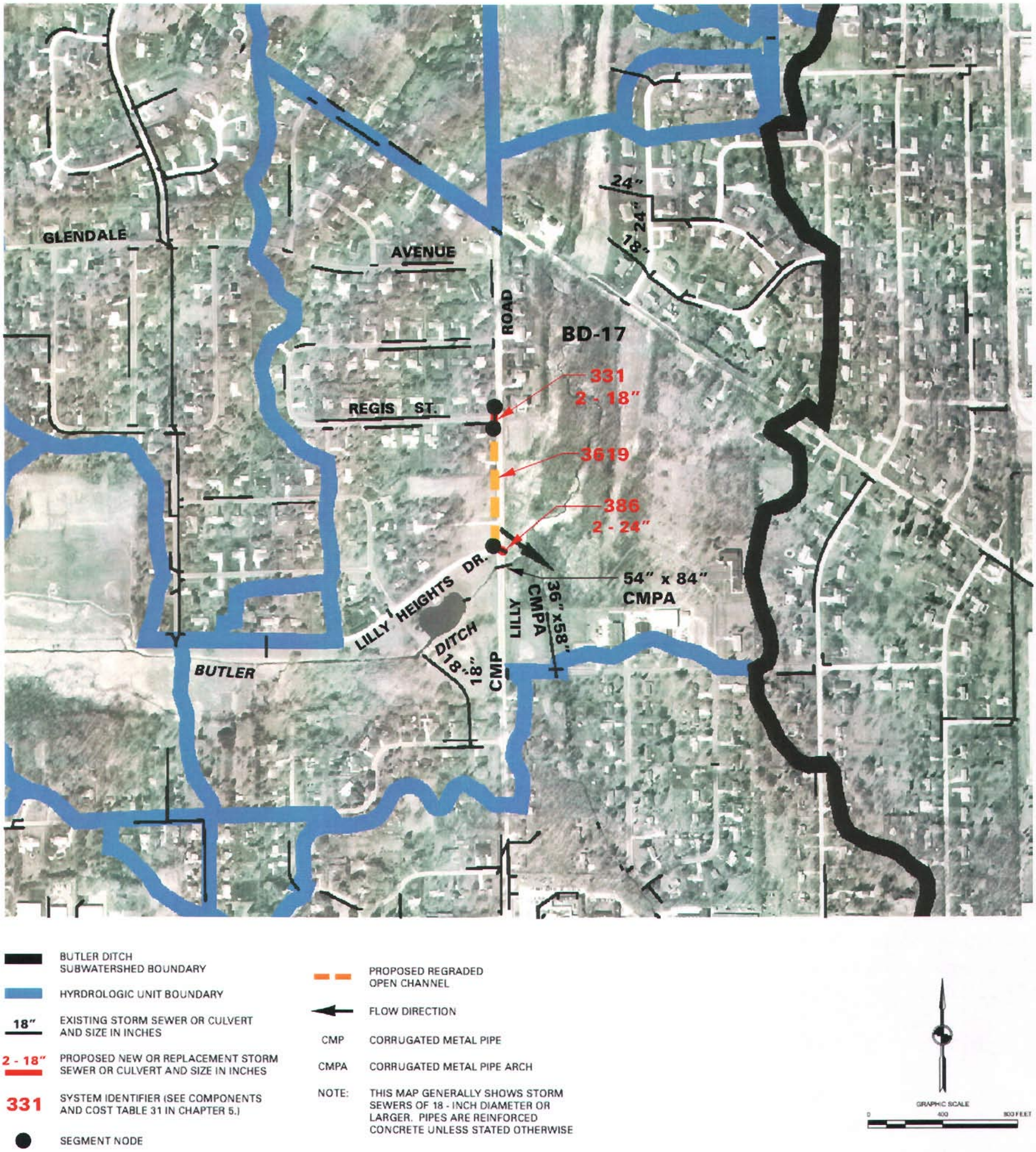
Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-28 is an approximately 575-acre area located entirely within the City of Brookfield primarily in U.S. Public Land Survey Section 10 in the southwestern corner of the subwatershed. Most of the unit is located south of Capitol Drive, east of Calhoun Road, north of Burleigh Road, and west of Pilgrim Road. The South Branch of Butler Ditch flows from south to north through the extreme northeastern portion of the unit.

Under 1995 land use conditions, about 94 percent of the hydrologic unit was in urban land uses, including about 76 percent low-density residential, 6 percent high-density residential, 10 percent commercial, and 2 percent government/institutional. The remaining 6 percent of the unit was divided equally between open space and surface water. Under full buildout land use conditions, about 97 percent of the unit would be in urban uses, with the additional 3 percent relative to 1995 representing an increase in the amount of low-density residential area. The distribution of the remaining uses would remain essentially the same.

Map 30

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-17 STORMWATER CONVEYANCE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 31

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-17 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 386–Replace 40 feet of 24-inch CMP crossing Lilly Road north of Lilly Heights Drive with dual 24-inch RCP	$ 7,360	$20
	2. 3619–Regrade 670 feet of existing swale east of Lilly Road between Regis Street and Lilly Heights Drive to have a depth of two feet, a bottom width of three feet and sides slopes of one vertical on four horizontal	19,180	0
	3. 331–Replace 44 feet of 18-inch CMP crossing Regis Street west of Lilly Road with dual 18-inch RCP with headwalls	6,780	30
	Total	$33,320	$50

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

The stormwater drainage system consists primarily of a system of roadside swales, culverts, and ditch enclosures that convey the flow to the South Branch of Butler Ditch. There is one pond located in the hydrologic unit at Arrowhead Park.

Ditch enclosure capacity was identified as inadequate along Douglas Drive, west of Anders Lane, and along Woodview Drive at the intersection with N. 167th Street. Inadequate hydraulic capacity was also identified in a storm sewer system outlet crossing Shoreline Drive 450 feet north of Mary Cliff Lane; the culverts crossing Over Hill Drive, Cumberland Trail, and Shadybrook Place along Lone Elm Drive; and the culvert crossing at the east end of Saint Therese Boulevard. Structure flooding was identified in the backyard overland flow route east of Cherry Hill Drive and south of Tarrytown Road. Flooding problems, duplicated by the analysis, were reported to the City as a result of the June 1997 and the August 1998 storms at the overland flow route from the ditch enclosure outlet in Woodview Drive to Arrowhead Lake, south of Brookhill Drive, east of Shadybrook Place, west of Pilgrim Road, and on Vernon Drive near Shetland Lane. Inadequate capacity was also identified near Heather Hill Drive and Vernon Drive along Pilgrim Road requiring a 50-year storm capacity design due to the classification of Pilgrim Road as an arterial.

Table 32

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-20 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 190–Replace 228 feet of 18-inch RCP west of Courtland Avenue with 31-inch-high by 51-inch-wide RCPA	$29,920	$0
	Total	$29,920	$0

NOTE: The following abbreviations have been used in this table:

RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

The proposed measures address identified drainage problems in the minor and major systems during storms with recurrence intervals up to and including the 100-year event. The alternatives for those problems will also help alleviate sanitary sewer backup problems. Yard and basement flooding problems due to local yard grading conditions are not addressed by the proposed measures.

Alternative Stormwater Drainage Plans for Hydrologic Unit BD-28

The three alternative plans that were considered for this hydrologic unit are listed below.

Alternative Plan No. BD-28a1—Stormwater Conveyance with Upstream and Downstream Detention Storage

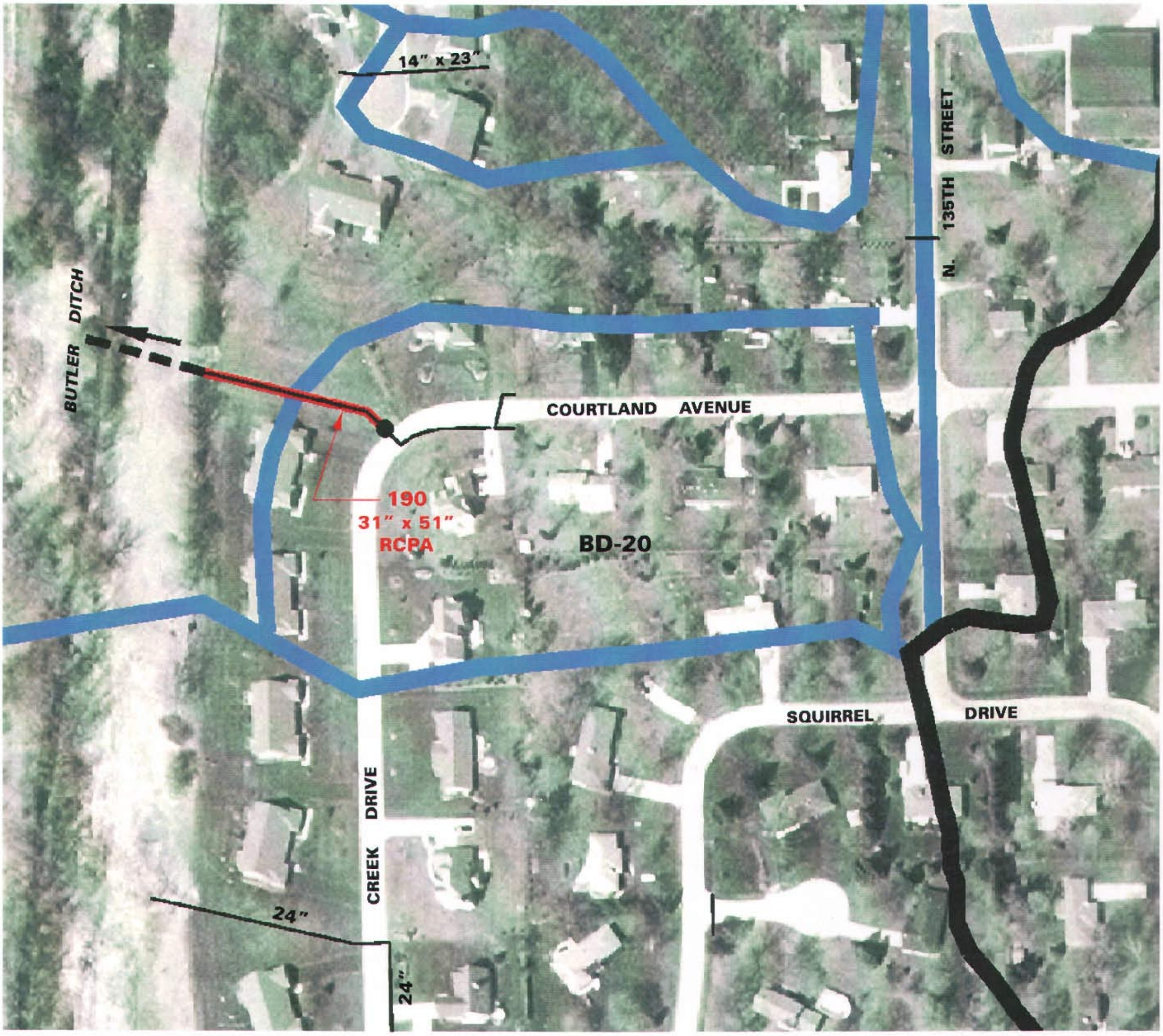
The components of this alternative plan are shown on Maps 32 through 38 and are described in Table 33. As set forth in Table 33, the total present value cost of this plan is estimated to be $789,190. This is based upon an estimated capital cost of $609,660 and an estimated annual operation and maintenance cost of $11,390.

Alternative Plan No. BD-28a2—Stormwater Conveyance with Limited Downstream Detention Storage

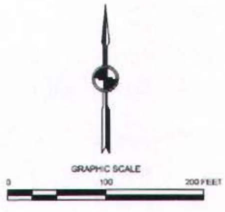
This alternative plan is the same as Alternative Plan No. BD-28a1, except that Items 18 and 22 from Table 33 are eliminated and the following additional components are recommended to be installed: 1) 672 feet of new 36-inch reinforced concrete pipe south of Brookhill Drive parallel to the existing conveyance system in the backyards; 2) 206 feet of new 36-inch reinforced concrete pipe south of Brookhill Drive parallel to the existing backyard conveyance system; 3) 200 feet of new 36-inch reinforced concrete pipe south of Brookhill Drive parallel to the existing backyard conveyance system; 4) 250 feet of new 36-inch reinforced concrete pipe south of Brookhill Drive parallel to the existing backyard conveyance system; and 5) 50 feet of new 36-inch reinforced concrete pipe under Pilgrim Road north of Vernon Drive parallel to the existing conveyance system. An easement, if one does not already exist, should be obtained along the length of the storm sewer pipes in backyards.

Map 31

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-20 STORMWATER CONVEYANCE



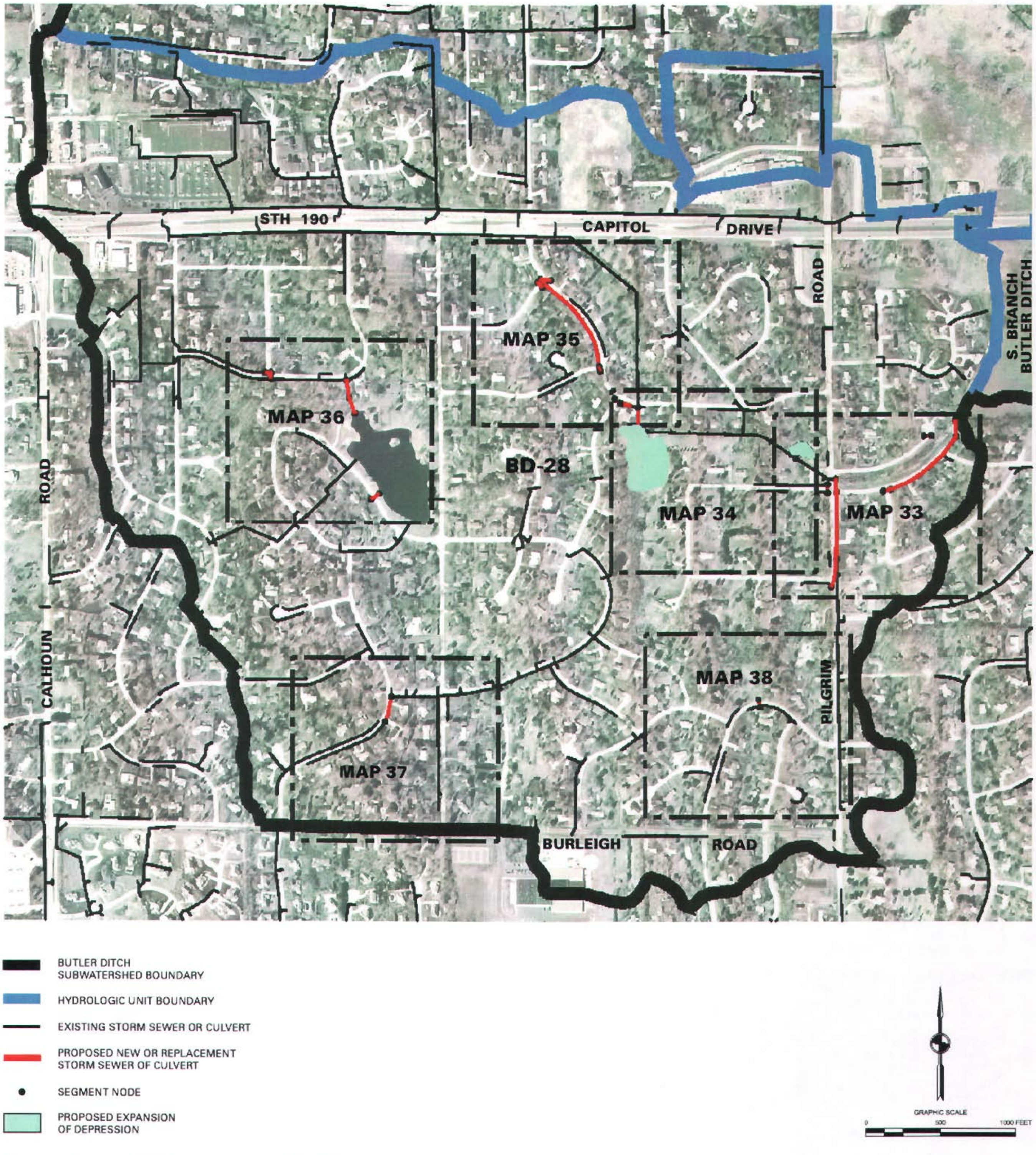
▬	BUTLER DITCH SUBWATERSHED BOUNDARY	●	SEGMENT NODE
▬	HYDROLOGIC UNIT BOUNDARY	▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
24"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES	←	FLOW DIRECTION
31" x 51" RCPA	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES	RCPA	REINFORCED CONCRETE PIPE ARCH
190	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 32 IN CHAPTER 5.)	NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 32

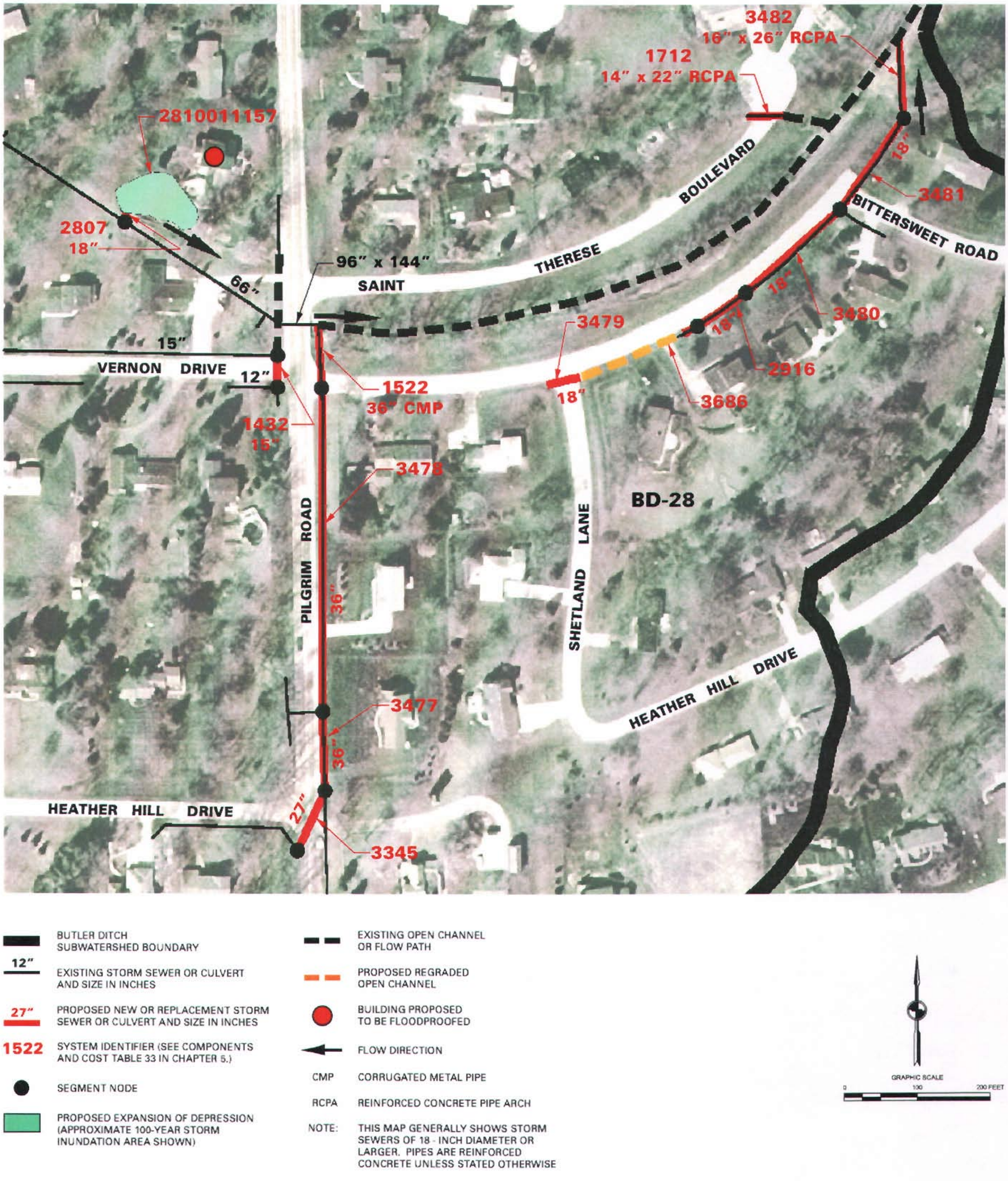
INDEX MAP FOR HYDROLOGIC UNIT BD-28 STORMWATER CONVEYANCE WITH UPSTREAM AND DOWNSTREAM DETENTION STORAGE ALTERNATIVE PLAN



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 33

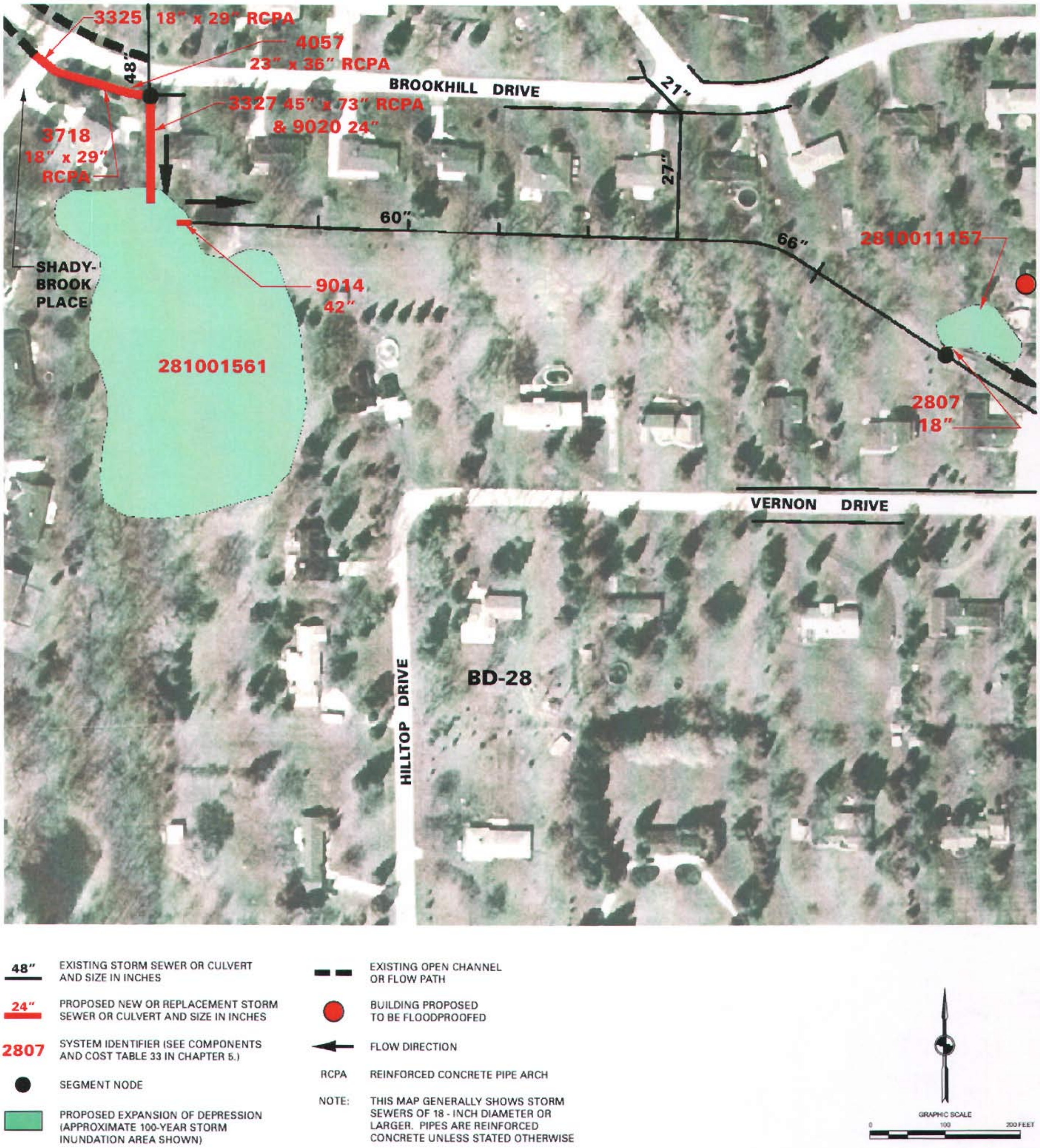
ALTERNATIVE PLAN NO. BD-28A1
STORMWATER CONVEYANCE WITH UPSTREAM AND DOWNSTREAM DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 34

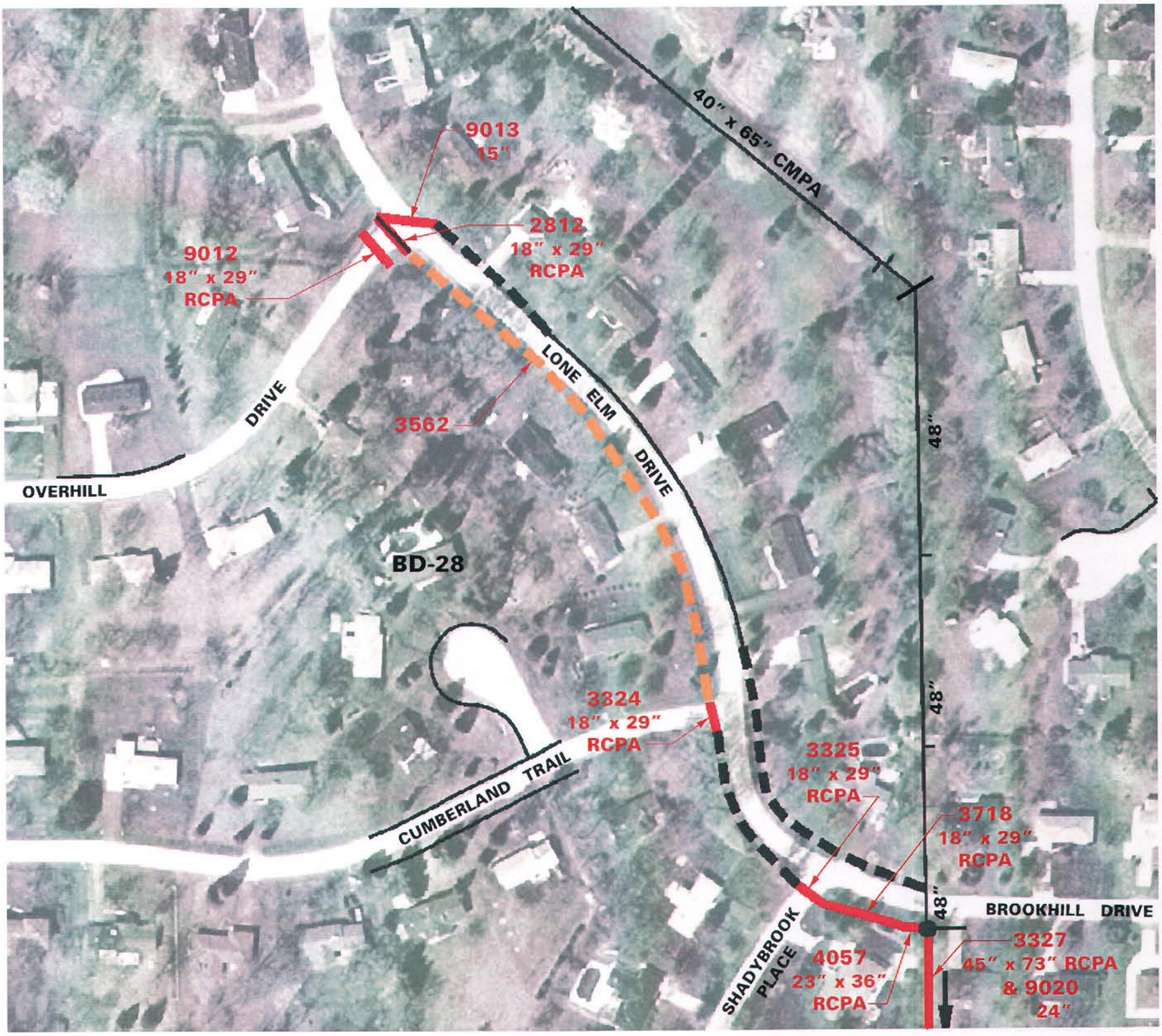
ALTERNATIVE PLAN NO. BD-28A1
STORMWATER CONVEYANCE WITH UPSTREAM AND DOWNSTREAM DETENTION STORAGE



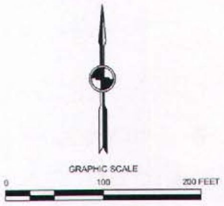
Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 35

ALTERNATIVE PLAN NO. BD-28A1
STORMWATER CONVEYANCE WITH UPSTREAM AND DOWNSTREAM DETENTION STORAGE



48"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
24"	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
9012	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 33 IN CHAPTER 5.)
●	SEGMENT NODE
▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
▬ ▬	PROPOSED REGRADED OPEN CHANNEL
←	FLOW DIRECTION
CMPA	CORRUGATED METAL PIPE ARCH
RCPA	REINFORCED CONCRETE PIPE ARCH
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



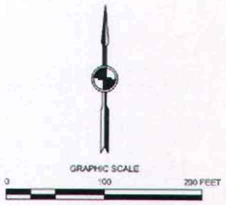
Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 36

ALTERNATIVE PLAN NO. BD-28A1
STORMWATER CONVEYANCE WITH UPSTREAM AND DOWNSTREAM DETENTION STORAGE

18"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
24"	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
1263	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 33 IN CHAPTER 5.)
●	SEGMENT NODE
▬ ▬	PROPOSED REGRADED OPEN CHANNEL
←	FLOW DIRECTION

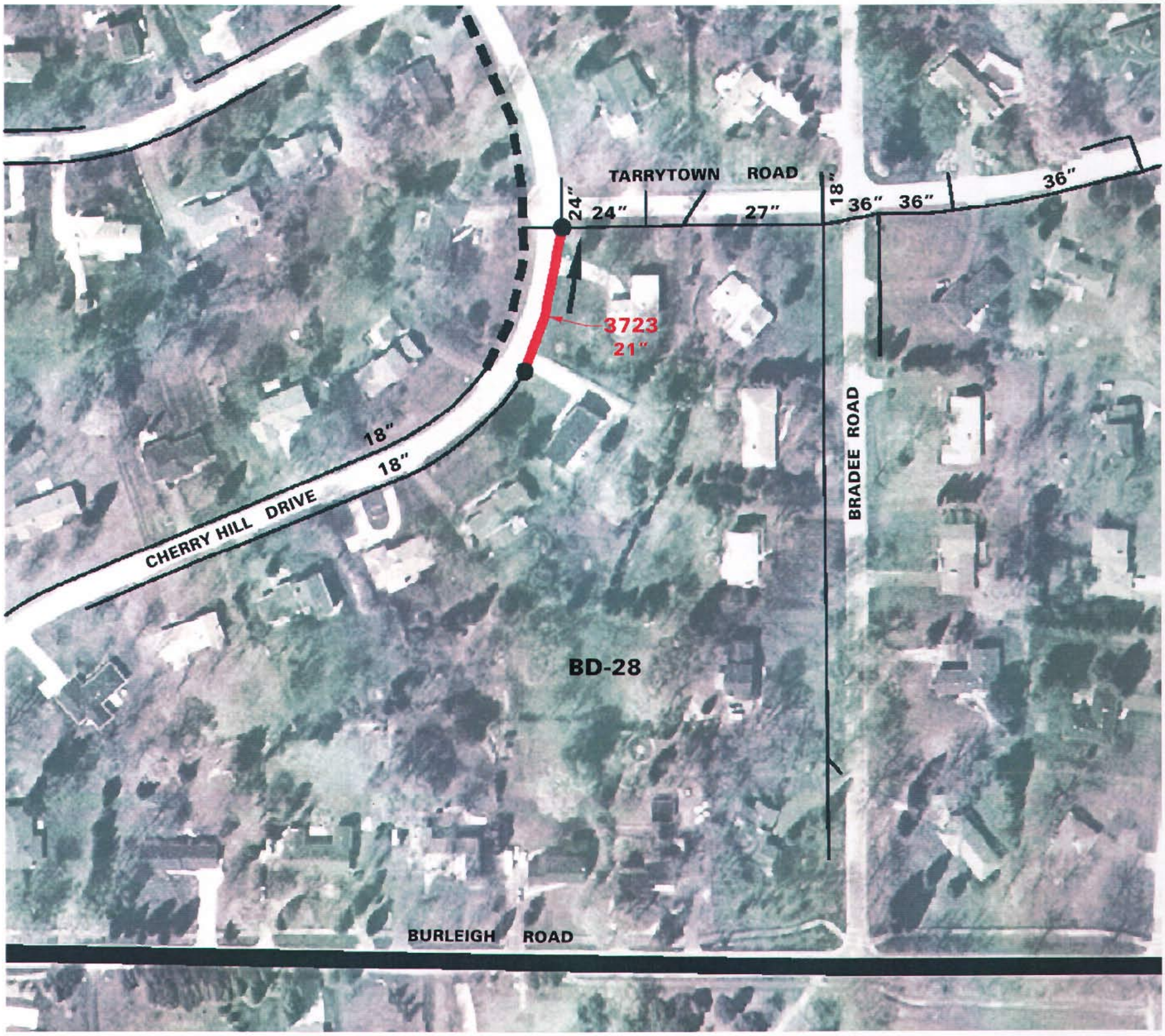
RCPA	REINFORCED CONCRETE PIPE ARCH
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



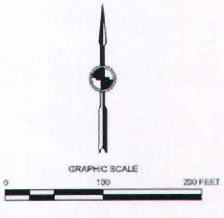
Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 37

ALTERNATIVE PLAN NO. BD-28A1
STORMWATER CONVEYANCE WITH UPSTREAM AND DOWNSTREAM DETENTION STORAGE



▬	BUTLER DITCH SUBWATERSHED BOUNDARY
18"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
21"	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
3723	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 33 IN CHAPTER 5.)
●	SEGMENT NODE
▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
←	FLOW DIRECTION
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE

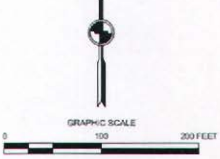


Source: *Ruekert & Mielke, Inc., and SEWRPC.*

Map 38

ALTERNATIVE PLAN NO. BD-28A1
STORMWATER CONVEYANCE WITH UPSTREAM AND DOWNSTREAM DETENTION STORAGE

18"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
18" x 29" RCPA	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
2906	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 33 IN CHAPTER 5.)
●	SEGMENT NODE
▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
←	FLOW DIRECTION
RCPA	REINFORCED CONCRETE PIPE ARCH
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 33

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-28a1 STORMWATER CONVEYANCE WITH UPSTREAM AND DOWNSTREAM DETENTION STORAGE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 3723–Enclose 160 feet of existing ditch along Cherry Hill Drive with new 21-inch RCP connecting the existing storm sewer system on the south side of Tarrytown Road	$ 14,400	$ 100
	2. 2906–Replace 32 feet of 18-inch RCP crossing Douglas Drive west of Anders Lane with 18-inch-high by 29-inch-wide RCPA	3,880	0
	3. 1263–Replace 42 feet of 18-inch RCP crossing N. 167th Street at Woodview Drive with 24-inch RCP	4,200	0
	4. 1265–Replace 37 feet of 18-inch RCP crossing Woodview Drive at N. 167th Street with 24-inch RCP	3,700	0
	5. 1254–Replace 160 feet of 36-inch RCP south of Woodview Drive and north of Arrowhead Lake Park with 42-inch RCP	20,960	0
	6. 8894–Regrade 90 feet of ditch to create a more defined channel from the outfall of the 36-inch RCP called for under Item 5 above (No. 1254) to Arrowhead Lake with a depth of one foot, a bottom width of two feet, and side slopes of one vertical on five horizontal	1,250	0
	7. 3456–Replace 74 feet of 24-inch RCP crossing Shoreline Drive discharging to Arrowhead Lake with 27-inch-high by 44-inch-wide RCPA	15,500	0
	8. 2812–Replace 50 feet of 18-inch-high by 24-inch-wide CMPA crossing Over Hill Drive at Lone Elm Drive with 18-inch-high by 29-inch-wide RCPA	4,600	0
	9. 9012–Install 50 feet of new 18-inch-high by 29-inch-wide RCPA under Over Hill Drive at Lone Elm Drive parallel with the replacement pipe called for under Item 8 above (No. 2812)	4,600	30
	10. 9013–Install 40 feet of new 15-inch RCP under Lone Elm Drive at Over Hill Drive to create a bypass	2,680	20
	11. 3562–Regrade 640 feet of ditch to lower inverts with a bottom width of five feet, side slopes of 7H:1V and 8H:1V, and a depth of 1.25 feet	13,420	0
	12. 3324–Replace 44 feet of 18-inch-high by 24-inch-wide CMP crossing Cumberland Trail at Lone Elm Drive with an 18-inch-high by 29-inch-wide RCPA	4,050	0
	13. 3325–Replace 44 feet of 18-inch-high by 24-inch-wide CMP under Shadybrook Place at Lone Elm Drive with an 18-inch-high by 29-inch-wide RCPA	4,050	0
	14. 3718–Install 80 feet of new 18-inch-high by 29-inch-wide RCPA on the south side of Brookhill Drive east of Shadybrook Place in place of the existing swale and regrade area to provide cover	11,000	50

Table 33 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield (continued)	15. 4057–Replace 20 feet of 18-inch-high by 24-inch-wide CMPA south of Brookhill Drive and east of Shadybrook Place with 23-inch-high by 36-inch-wide RCPA. Connect to RCPA to be installed per Item 14 above (No. 3718)	$ 3,200	$ 0
	16. 3327–Replace 170 feet of 48-inch RCP south of Brookhill Drive and east of Shadybrook Place with 45-inch-high by 73-inch-wide RCPA	42,670	0
	17. 9020–Install 170 feet of new 24-inch RCP south of Brookhill Drive, east of Shadybrook Place, and parallel with the RCPA to be installed per Item 16 above (No. 3327)	13,260	110
	18. 281001561 and 9014–Enhance existing natural depression from 0.29 acre-feet to approximately 13.6 acre-feet of storage and install 10 feet of 42-inch RCP as an outlet structure connected to the existing 60-inch RCP conveyance system east of Shadybrook Place and south of Brookhill Drive	277,720	11,070
	19. 2810011157–Lower existing inlet grate by about one foot and regrade approximately 0.1 acre to provide adequate drainage to inlet at low area west of Pilgrim Road and north of Vernon Drive	3,820	0
	20. 2807–Install an additional inlet and 15 feet of new 18-inch RCP at low area west of Pilgrim Road and north of Vernon Drive	1,200	10
	21. Floodproof structure north of Vernon Drive along Pilgrim Road	12,560	0
	22. 1432–Replace 42 feet of 12-inch RCP crossing Vernon Drive at Pilgrim Road with 15-inch RCP	2,940	0
	23. 3345–Replace 78 feet of 24-inch RCP crossing Pilgrim Road at Vernon Drive with 27-inch RCP	8,580	0
	24. 3477–Replace 110 feet of 30-inch RCP along the east side of Pilgrim Road with 36-inch RCP	16,500	0
	25. 3478–Replace 423 feet of 30-inch RCP along the east side of Pilgrim Road with 36-inch RCP	63,450	0
	26. 1522–Replace 60 feet of 30-inch CMP crossing Vernon Drive along the east side of Pilgrim Road with 36-inch CMP	5,060	0
	27. 3479–Replace 48 feet of 15-inch CMP crossing Shetland Lane at Vernon Drive with 18-inch RCP	3,660	0
	28. 3686–Regrade 120 feet of existing ditch to have a bottom width of two feet, one vertical on four horizontal sides slopes, a depth of one foot	1,440	0
	29. 2916–Replace 111 feet of 12-inch RCP along Vernon Drive between Shetland Lane and Bittersweet Road with 18-inch RCP	8,880	0

Table 33 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield (continued)	30. 3480–Replace 173 feet of 15-inch RCP along Vernon Drive between Shetland Lane and Bittersweet Road with 18-inch RCP	$ 13,840	$ 0
	31. 3481–Replace 147 feet of 15-inch RCP along Vernon Drive crossing Bittersweet Road with 18-inch RCP	11,320	0
	32. 3482–Replace 103 feet of 15-inch RCP north of Vernon Drive with 16-inch-high by 26-inch-wide RCPA	7,420	0
	33. 1712–Replace 50 feet of 12-inch RCP crossing Saint Therese Boulevard with 14-inch-high by 22-inch-wide RCPA	3,850	0
	Total	$609,660	$11,390

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
CMPA = Corrugated metal pipe arch
RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

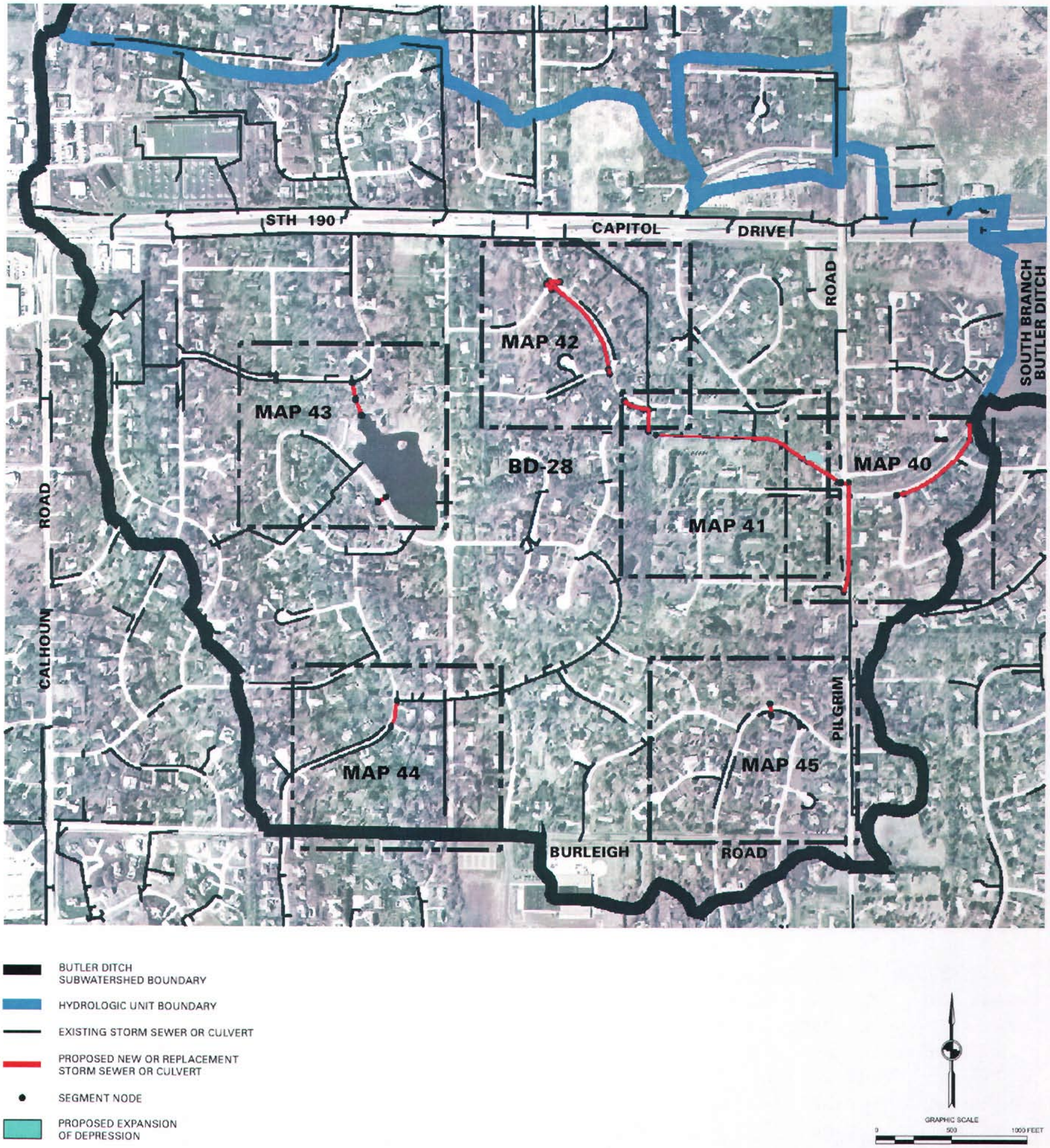
The components of this plan are shown on Maps 39 through 45 and are described in Table 34. The total present value cost of this alternative is $497,760 consisting of an estimated capital cost of $486,570 and an estimated annual operation and maintenance cost of $710.

Alternative Plan No. BD-28a3—Stormwater Conveyance with Maximum Downstream Detention Storage

This alternative plan is the same as Alternative Plan No. BD-28a1, except that Items 18, 19, 20, 21, and 22 from Table 33 are eliminated and the following additional components are recommended: 1) installation of 672 feet of 36-inch reinforced concrete pipe south of Brookhill Drive parallel to the existing pipes in the backyards; 2) installation of 206 feet of 36-inch reinforced concrete pipe south of Brookhill Drive parallel to the existing pipes in the backyards; 3) installation of 45 feet of 36-inch reinforced concrete pipe south of Brookhill Drive parallel to the existing pipes in the backyards; 4) removal of 155 feet of the 66-inch reinforced concrete pipe south of Brookhill Drive for pond construction; 5) purchase and removal of the house located northwest of the intersection of Saint Therese Boulevard and Pilgrim Road; 6) construction of a detention basin with a maximum storage volume of 9.4 acre-feet during a 100-year storm northwest of the intersection of St. Theresa Boulevard and Pilgrim Road; 7) installation of 160 feet of 45-inch-high by 73-inch-wide reinforced concrete arch pipe west of Pilgrim Road and north of Vernon Drive as the outlet to the proposed detention basin; 8) removal of the 15-foot-long, 18-inch reinforced concrete pipe located west of Pilgrim Road and north of Vernon Drive and replacement

Map 39

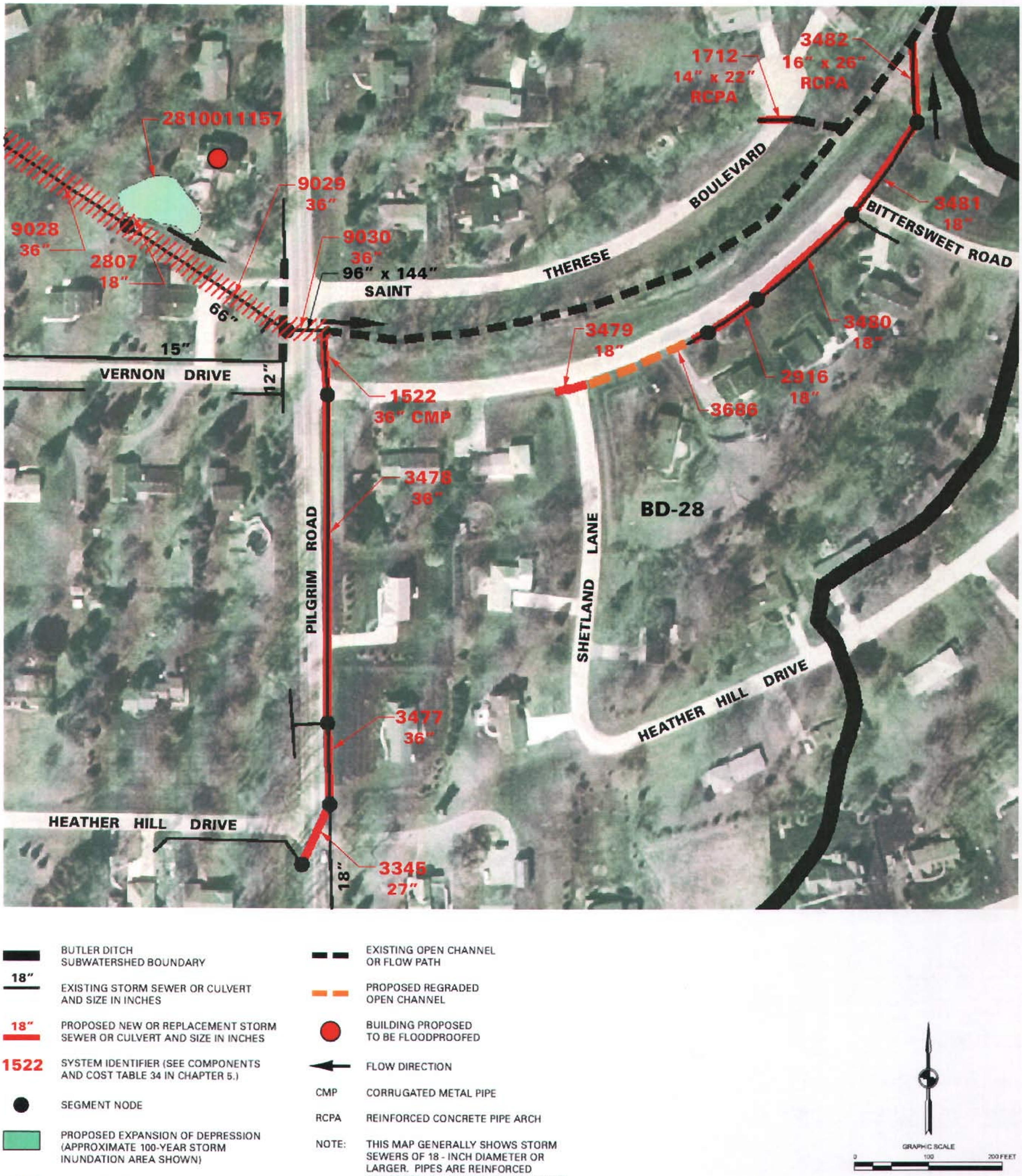
INDEX MAP FOR HYDROLOGIC UNIT BD-28
STORMWATER CONVEYANCE WITH LIMITED DOWNSTREAM DETENTION STORAGE ALTERNATIVE PLAN



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 40

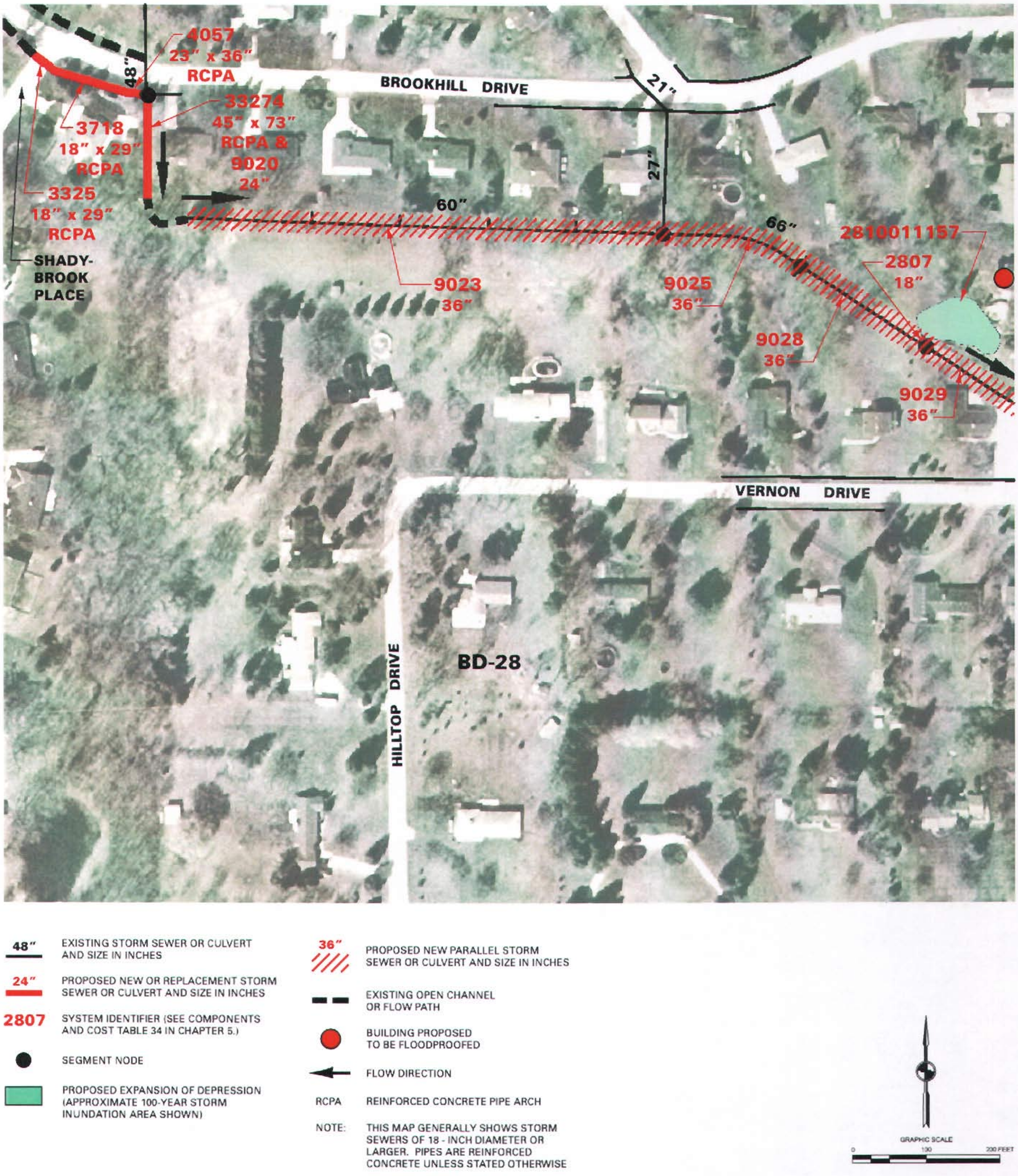
ALTERNATIVE PLAN NO. BD-28A2
STORMWATER CONVEYANCE WITH LIMITED DOWNSTREAM DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 41

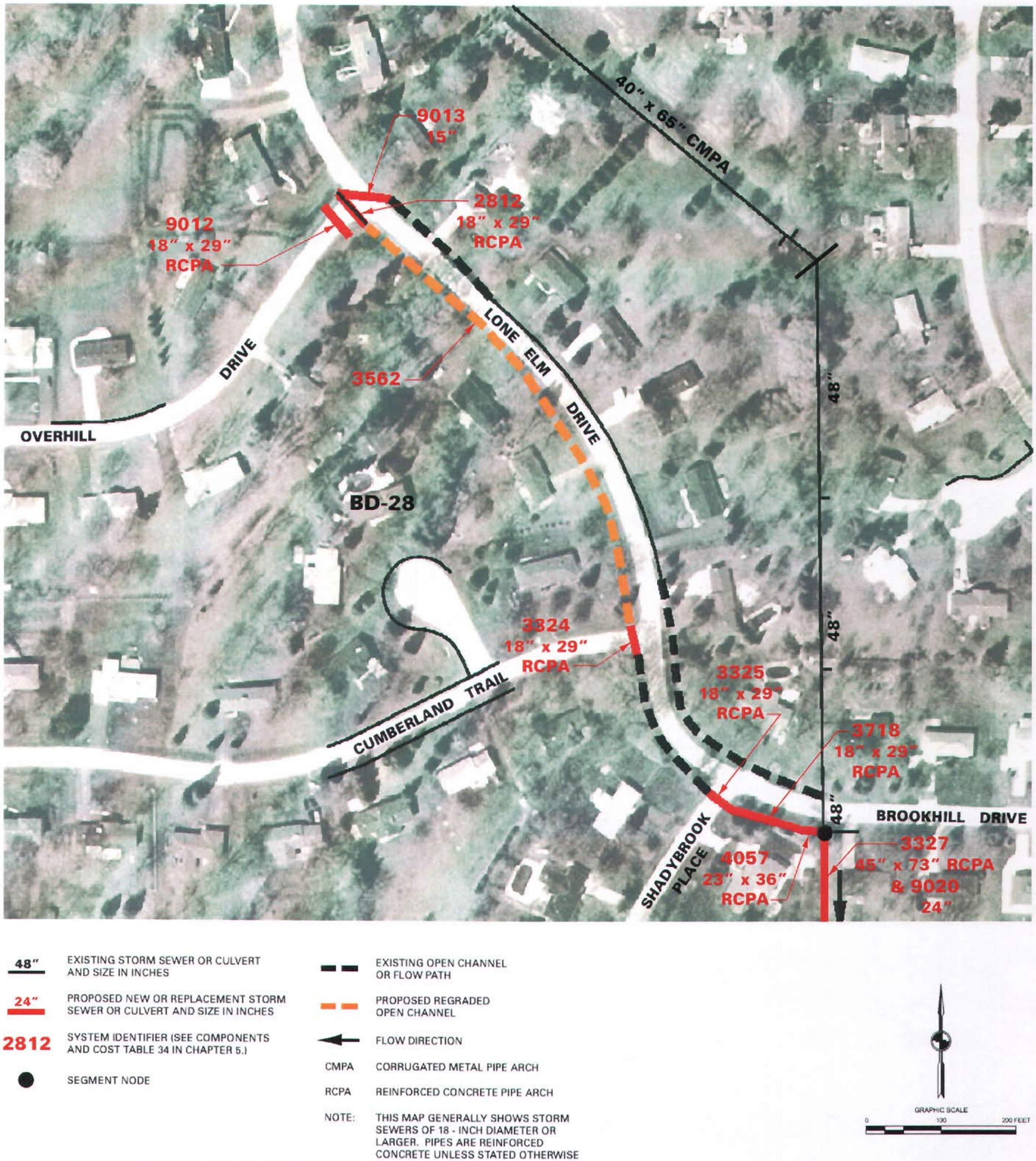
ALTERNATIVE PLAN NO. BD-28A2
STORMWATER CONVEYANCE WITH LIMITED DOWNSTREAM DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 42

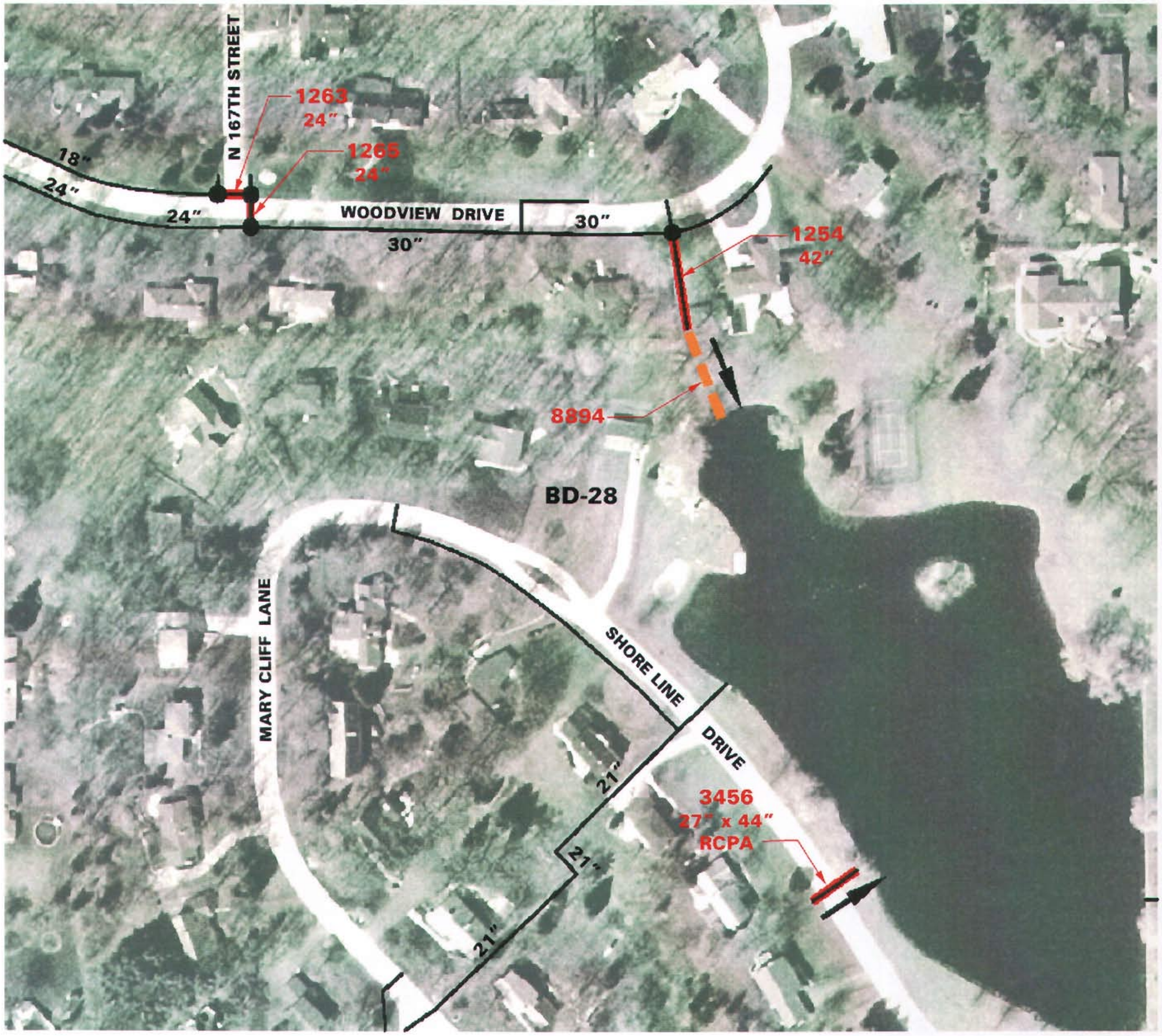
ALTERNATIVE PLAN NO. BD-28A2
STORMWATER CONVEYANCE WITH LIMITED DOWNSTREAM DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 43

ALTERNATIVE PLAN NO. BD-28A2 STORMWATER CONVEYANCE WITH LIMITED DOWNSTREAM DETENTION STORAGE



21″	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
24″	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCES
1254	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 34 IN CHAPTER 5.)
●	SEGMENT NODE
▬ ▬	PROPOSED REGRADED OPEN CHANNEL
←	FLOW DIRECTION

RCPA	REINFORCED CONCRETE PIPE ARCH
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE

GRAPHIC SCALE
0 100 200 FEET

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 44

ALTERNATIVE PLAN NO. BD-28A2
STORMWATER CONVEYANCE WITH LIMITED DOWNSTREAM DETENTION STORAGE

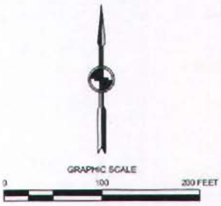
Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 45

ALTERNATIVE PLAN NO. BD-28A2
STORMWATER CONVEYANCE WITH LIMITED DOWNSTREAM DETENTION STORAGE

18"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
18" x 29" RCPA	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
2906	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 34 IN CHAPTER 5.)
●	SEGMENT NODE
▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
←	FLOW DIRECTION

RCPA	REINFORCED CONCRETE PIPE ARCH
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 34

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-28a2 STORMWATER CONVEYANCE WITH LIMITED DOWNSTREAM DETENTION STORAGE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. Same as Items 1 through 17 in Table 33 for Alternative Plan No. BD-28a1	$167,420	$310
	2. 9023–Install 672 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	75,940	190
	3. 9025–Install 206 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	23,280	60
	4. 9028–Install 200 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	22,600	60
	5. 9029–Install 250 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	28,250	70
	6. 9030–Install 50 feet of new 36-inch RCP under Pilgrim Road north of Vernon Drive parallel to the existing pipe	7,500	10
	7. Same as Items 19 through 21 and 23 through 33 in Table 33 for Alternative Plan No. BD-28a1	161,580	10
	Total	$486,570	$710

NOTE: The following abbreviations have been used in this table:

RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

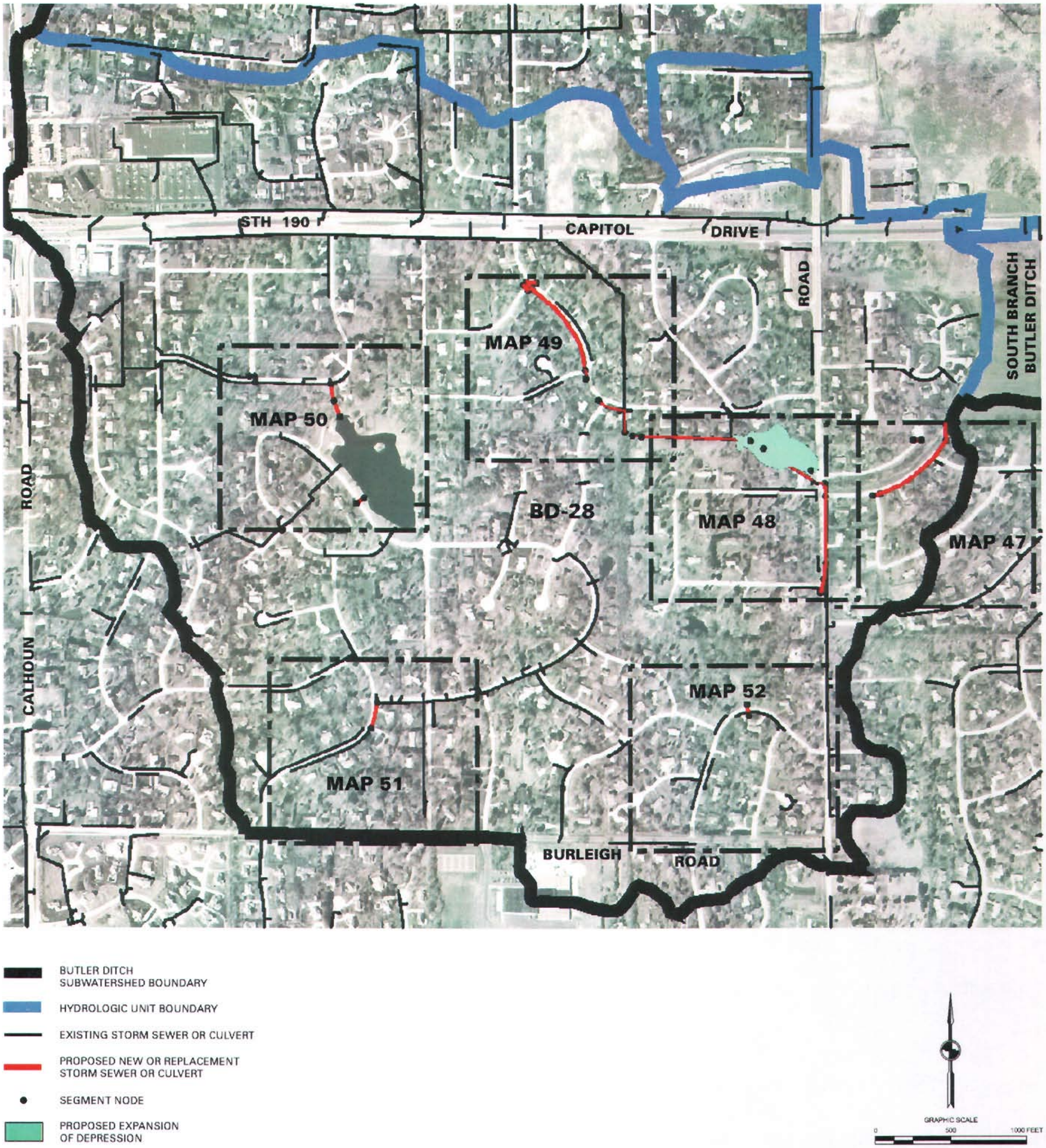
Source: Ruekert & Mielke, Inc., and SEWRPC.

with a weir for the proposed pond having a depth of two feet, a bottom width of 10 feet, and 10 feet horizontal to one foot vertical side slopes; 9) removal of 250 feet of 66-inch reinforced concrete pipe west of Pilgrim Road and north of Vernon Drive and replacement with 120 feet of swale having a depth of one foot, a bottom width of two feet, and side slopes of four feet horizontal to one foot vertical; and 10) installation of 50 feet of 36-inch reinforced concrete pipe under Pilgrim Road north of Vernon Drive parallel to the existing pipe.

The components of this plan are shown on Maps 46 through 52 and are described in Table 35. The total present value cost of this plan is estimated to be $1,125,470. This is based upon an estimated capital cost of $959,340 and an estimated annual operation and maintenance cost of $10,540.

Map 46

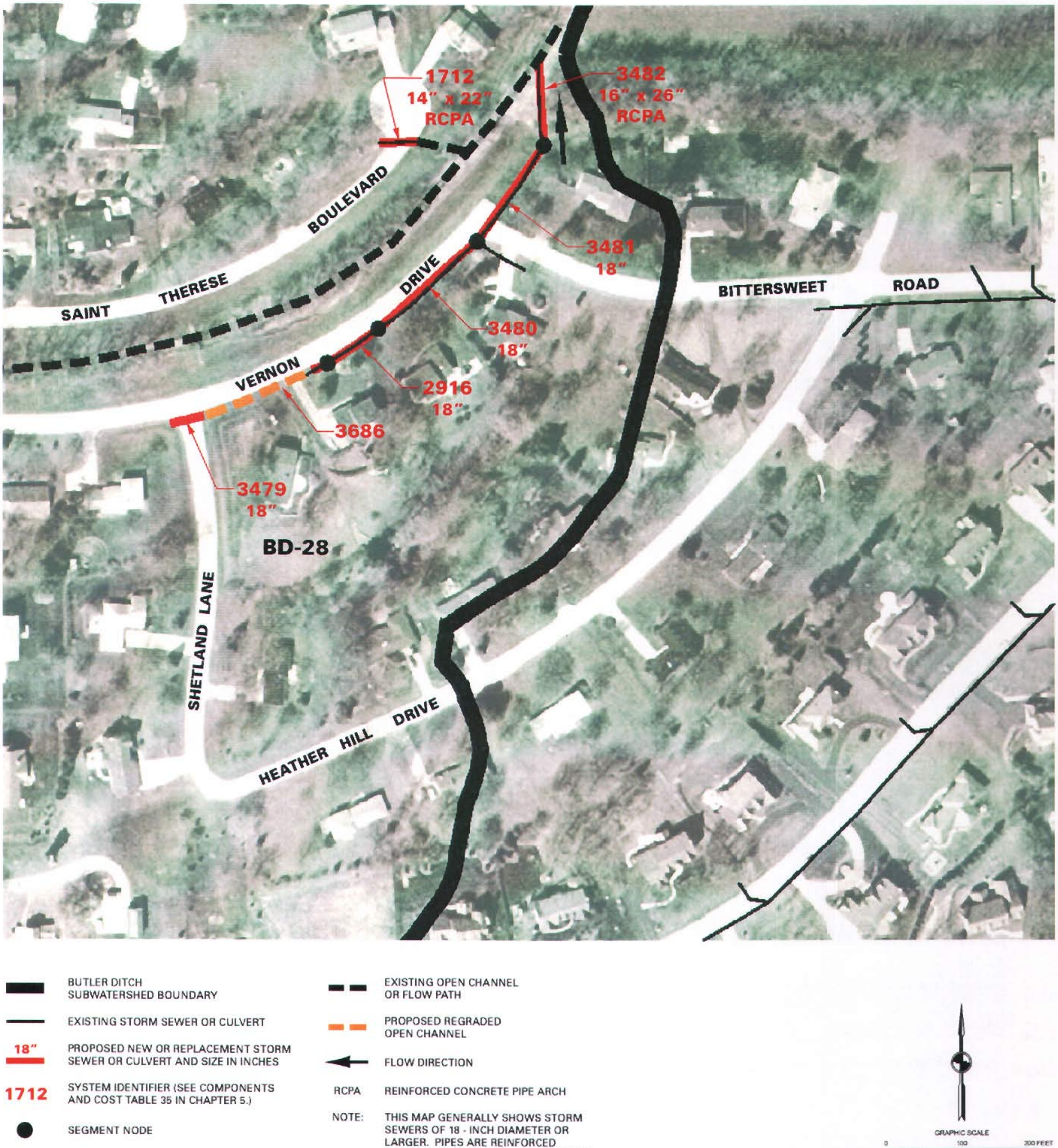
INDEX MAP FOR HYDROLOGIC UNIT BD-28 STORMWATER CONVEYANCE WITH MAXIMUM DOWNSTREAM DETENTION STORAGE ALTERNATIVE PLAN



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 47

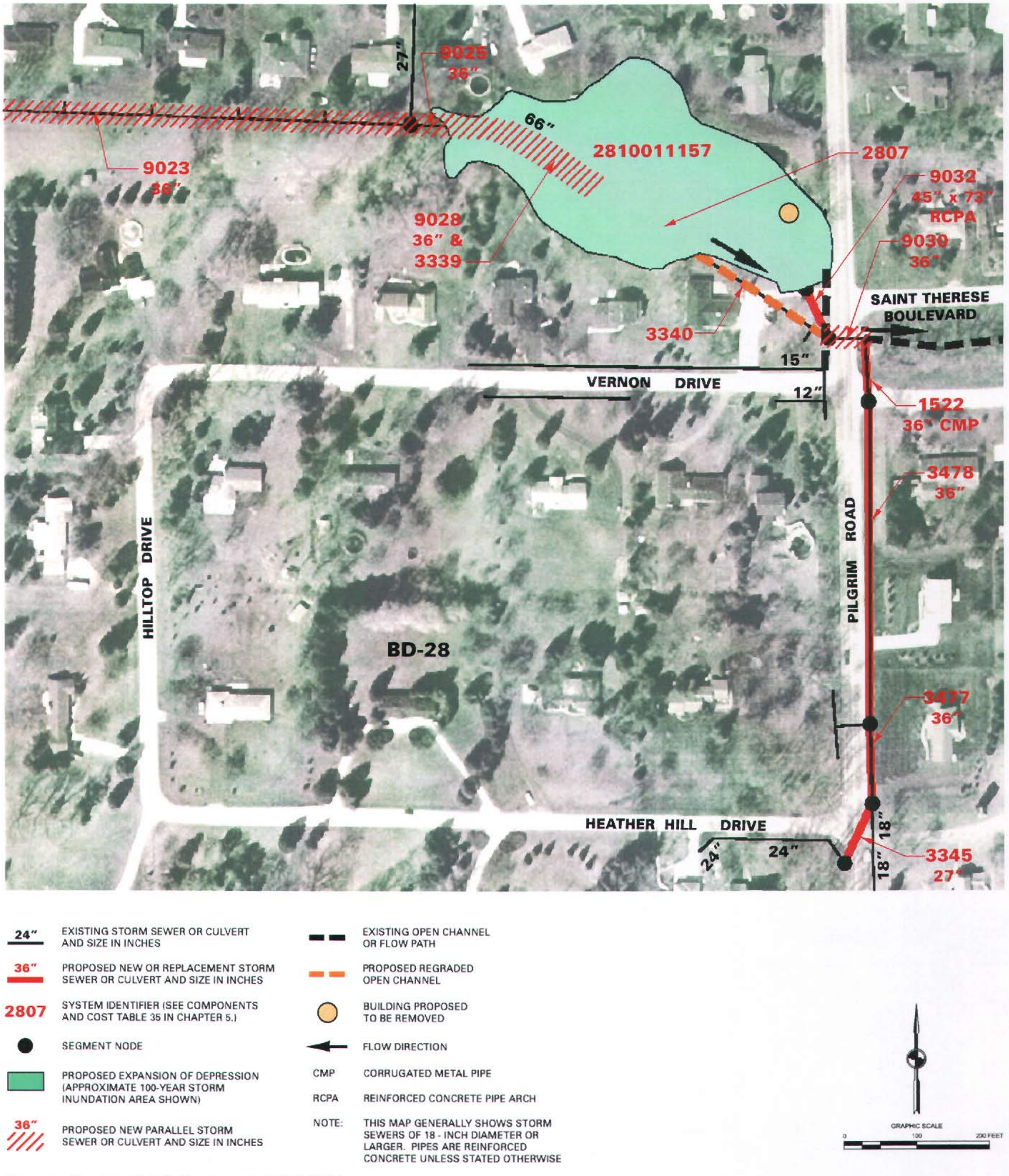
ALTERNATIVE PLAN NO. BD-28A3
STORMWATER CONVEYANCE WITH MAXIMUM DOWNSTREAM DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 48

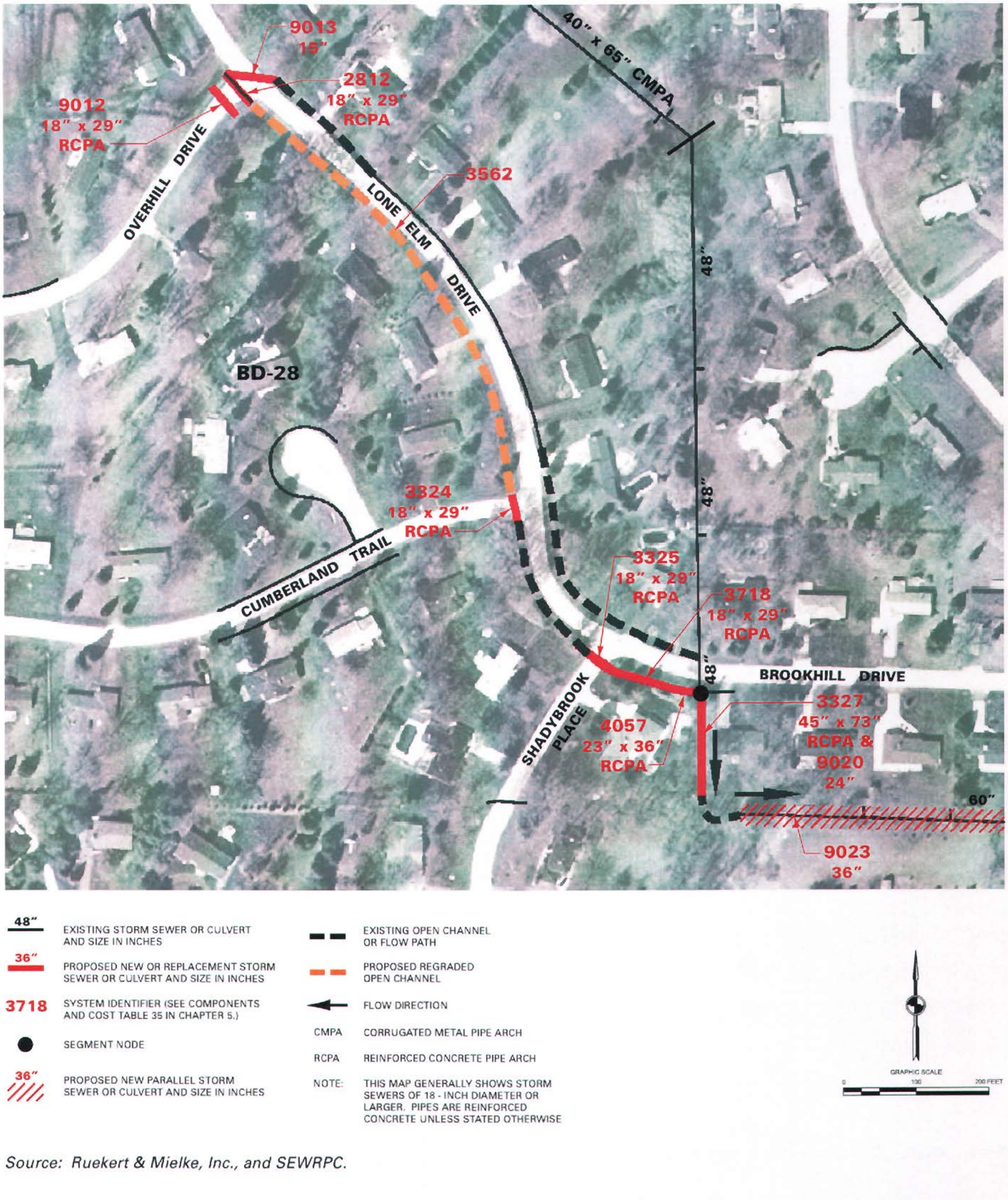
ALTERNATIVE PLAN NO. BD-28A3
STORMWATER CONVEYANCE WITH MAXIMUM DOWNSTREAM DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 49

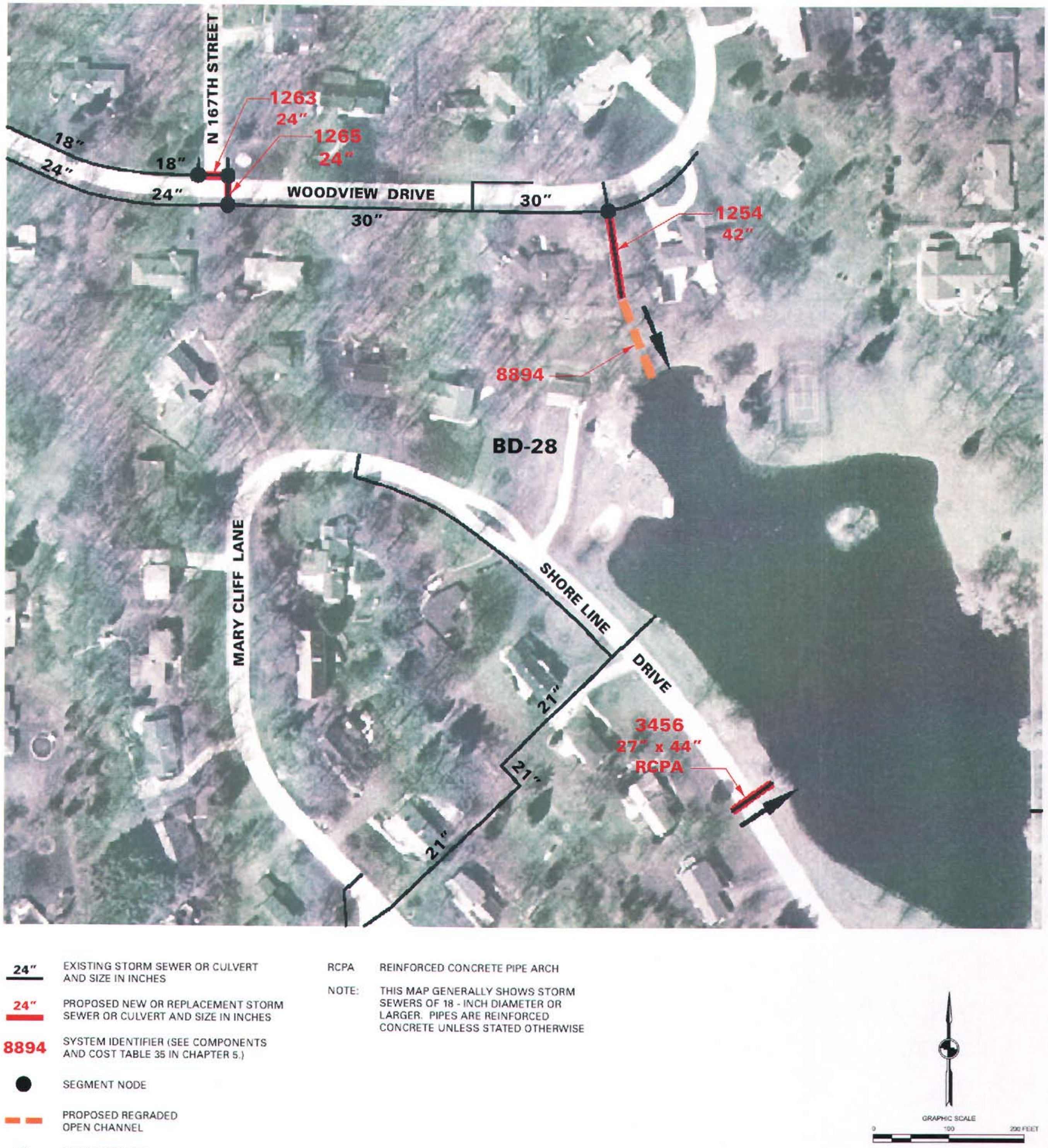
ALTERNATIVE PLAN NO. BD-28A3
STORMWATER CONVEYANCE WITH MAXIMUM DOWNSTREAM DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 50

ALTERNATIVE PLAN NO. BD-28A3
STORMWATER CONVEYANCE WITH MAXIMUM DOWNSTREAM DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 51

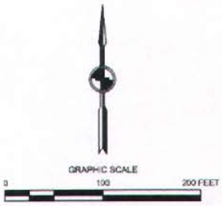
ALTERNATIVE PLAN NO. BD-28A3
STORMWATER CONVEYANCE WITH MAXIMUM DOWNSTREAM DETENTION STORAGE

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 52

ALTERNATIVE PLAN NO. BD-28A3
STORMWATER CONVEYANCE WITH MAXIMUM DOWNSTREAM DETENTION STORAGE

18"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
18" x 29" RCPA	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
2906	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 35 IN CHAPTER 5.)
●	SEGMENT NODE
▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
←	FLOW DIRECTION
RCPA	REINFORCED CONCRETE PIPE ARCH
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



Source: *Ruekert & Mielke, Inc., and SEWRPC.*

Table 35

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-28a3 STORMWATER CONVEYANCE WITH MAXIMUM DOWNSTREAM DETENTION STORAGE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. Same as Items 1 through 17 in Table 33 for Alternative Plan No. BD-28a1	$167,420	$310
	2. 9023–Install 672 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	75,940	190
	3. 9025–Install 206 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	23,280	60
	4. 3339–Remove 155 feet of 66-inch RCP south of Brookhill Drive for detention basin construction	22,170	0
	5. 9028–Install 45 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	5,090	10
	6. 2810011157–Purchase and remove existing house northwest of the intersection of St. Theresa Boulevard and Pilgrim Road	145,400	0
	7. 2810011157–Construct a detention basin with a 100-year storm volume of 9.4 acre-feet	289,380	9,830
	8. 9032–Install 160 feet of new 45-inch-high by 73-inch-wide RCPA west of Pilgrim Road north of Vernon Drive as the outlet from the detention basin called for under Item 7 above	40,160	50
	9. 2807–Remove 15 feet of 18-inch RCP located west of Pilgrim Road and north of Vernon Drive and replace with a weir having a depth of two feet, a bottom width of 10 feet and 10H:1V side slopes	1,610	0
	10. 3340–Remove 250 feet of 66-inch RCP located west of Pilgrim Road and north of Vernon Drive and replace with a 120-foot-long swale with a depth of one foot, a bottom width of two feet and one vertical on four horizontal side slopes for an emergency overflow path	37,390	80
	11. 9030–Install 50 feet of new 36-inch RCP crossing Pilgrim Road north of Vernon Drive parallel to the existing crossing	7,500	10
	12. Same as Items 23 through 33 in Table 33 for Alternative Plan No. BD-28a1	144,400	0
	Total	$959,340	$10,540

NOTE: The following abbreviations have been used in this table:
RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Evaluation of Alternative Stormwater Drainage Plans for Hydrologic Unit BD-28

The foregoing information provides a basis for a comparative evaluation of the three alternative plans. The principal criteria for the comparative evaluation were cost and implementability. The alternatives all have similar levels of protection.

Alternative Plan No. BD-28a1 is the intermediate alternative in terms of cost, but would be difficult to implement, because, although a portion of the detention basin proposed to be located southeast of the intersection of Brookhill Drive and Shadybrook Place is on City parkland, construction of the basin would require that easements or land be acquired from several private property owners. Alternative Plan No. BD-28a2 is the least expensive alternative, but requires disruption of many backyards due to the installation of the parallel storm sewer system. Alternative Plan No. BD-28a3 is the most expensive alternative and it would be difficult to implement due to the required acquisition of easements or land for the detention basin and acquisition of a house that was recently purchased by a private owner.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-28

Based on cost and ease of construction, Alternative Plan No. BD-28a2—Stormwater Conveyance with Limited Downstream Detention Storage, is selected as the preliminary recommended plan.

HYDROLOGIC UNIT BD-34

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-34 is an approximately 130-acre area located in the central portion of the Butler Ditch subwatershed. About 90 percent of the unit is located within the City of Brookfield, north of Capitol Drive and west of Lilly Road. The remaining 10 percent is located within the Village of Menomonee Falls north of Hampton Avenue and west of Stone Drive.

Under 1995 land use conditions, about 98 percent of the hydrologic unit was in urban land uses including approximately 94 percent in low-density residential uses, 3 percent in government and institutional uses, and 1 percent in commercial uses. The remaining 2 percent of the unit was comprised of open lands. Under full buildout land use conditions, the entire unit would be in urban land uses with the open lands under 1995 conditions being converted to commercial uses.

Conveyance features within the hydrologic unit are predominantly comprised of roadside swales, culverts, and ditch enclosures. The flow of stormwater is generally from north to south with the unit outlet located just south of Lilly Heights Road.

Inadequate minor system capacity was indicated within the conveyance systems located along N. 145th Street from Cameron Drive Upper to Cameron Court; at N. 146th Street, north of Marcella Lane; at the intersection of Marcella Lane and N. 145th Street; at the intersection of Mildale Street and N. 145th Street; and N. 145th Street between Mildale Street and Sunrise Avenue. The identified minor system problems were generally due to road overtopping during the 10-year storm event. During the 100-year storm event, the major system deficiencies included ponding on the roadway and over sanitary sewer manholes.

Inadequate major system capacity was found at the intersection of N. 145th Street and Glendale Lane. The analysis of the system indicated impounded stormwater on both sides of N. 145th Street could encroach upon or directly flood three houses.

Alternative Stormwater Management Plans for Hydrologic Unit BD-34

Two alternative plans were developed to alleviate the drainage problems associated with storms having recurrence intervals ranging from 10 to 100 years. These plans included a plan based solely upon increasing the conveyance capacity of the stormwater drainage system and a plan based upon both increased conveyance and detention storage.

Alternative Plan No. BD-34a1—Stormwater Conveyance with Detention Storage

The alternative plan components are shown graphically on Maps 53 through 55 and they are described in Table 36.

The total present value cost of this alternative is estimated to be $1,639,000. This is based upon an estimated capital cost of $1,420,380 and an estimated annual operations and maintenance cost increase of $13,870.

Alternative Plan No. BD-34a2—Stormwater Conveyance

The alternative plan components are shown graphically on Maps 56 through 58 and they are described in Table 37.

The total present value cost of this alternative is estimated to be $1,292,410. This is based upon an estimated capital cost of $1,291,310 and an estimated annual operations and maintenance cost increase of $70.

Evaluation of Alternative Stormwater Drainage Plans for Hydrologic Unit BD-34

The foregoing information provides the basis for the comparative evaluation of the two alternative plans. The principal criteria for the comparative evaluation are cost and implementability.

Alternative Plan No. BD-34a2 is the less costly of the two alternatives. Full implementation of Alternative Plan No. BD-34a1 would be more difficult than the implementation of Alternative Plan No. BD-34a2 due to the need to acquire three houses.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-34

Based upon cost and implementability, Alternative Plan No. BD-34a2—Stormwater Conveyance, is selected as the preliminary recommended plan.

HYDROLOGIC UNIT BD-35

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-35 is an approximately 13-acre area located entirely within the City of Brookfield in the northwest one-quarter of U.S. Public Land Survey Section 2. The unit is located south of Lisbon Road and generally between N. 148th Street and N. 149th Street.

Under 1995 land use conditions, the hydrologic unit was fully developed in urban land uses including 82 percent low-density residential uses and 18 percent commercial uses. The distribution of land uses will remain the same under buildout conditions.

The stormwater drainage system within the hydrologic unit consists of ditch enclosures and roadside swales. The flow of stormwater within the unit is generally from south to north.

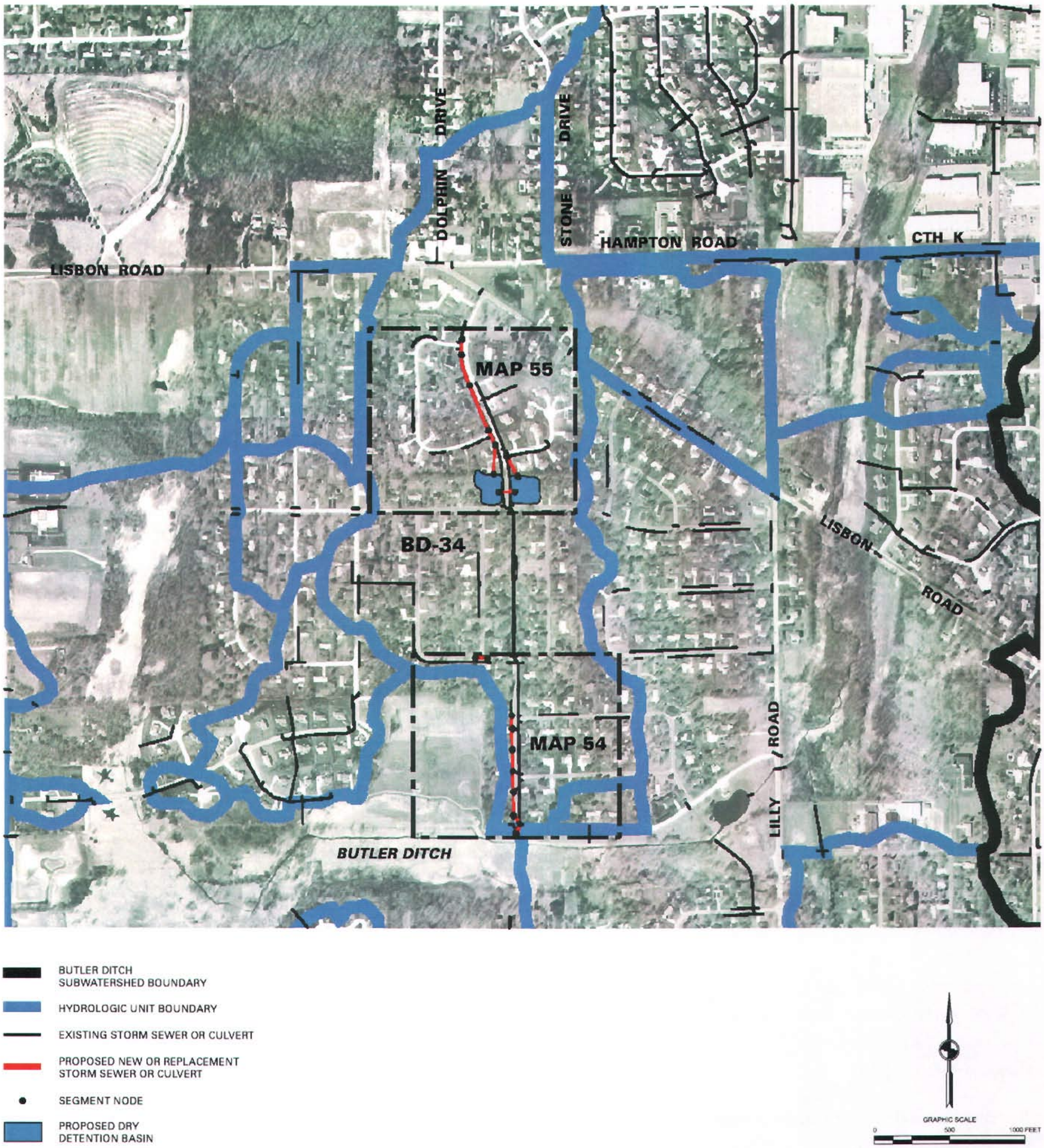
Minor system inadequacies were identified at the intersection of N. 149th Street and Lisbon Road during the analysis of the existing stormwater management system. The runoff generated for the hydrologic unit during all storm events analyzed may surcharge the existing system resulting in the overtopping of N. 149th Street and Lisbon Road.

Alternative and Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-35

The identified localized problems can readily be solved through increasing the hydraulic capacity of the inadequate conveyance features. Thus, the development of alternative plans is not considered to be necessary and a stormwater conveyance plan was developed.

Map 53

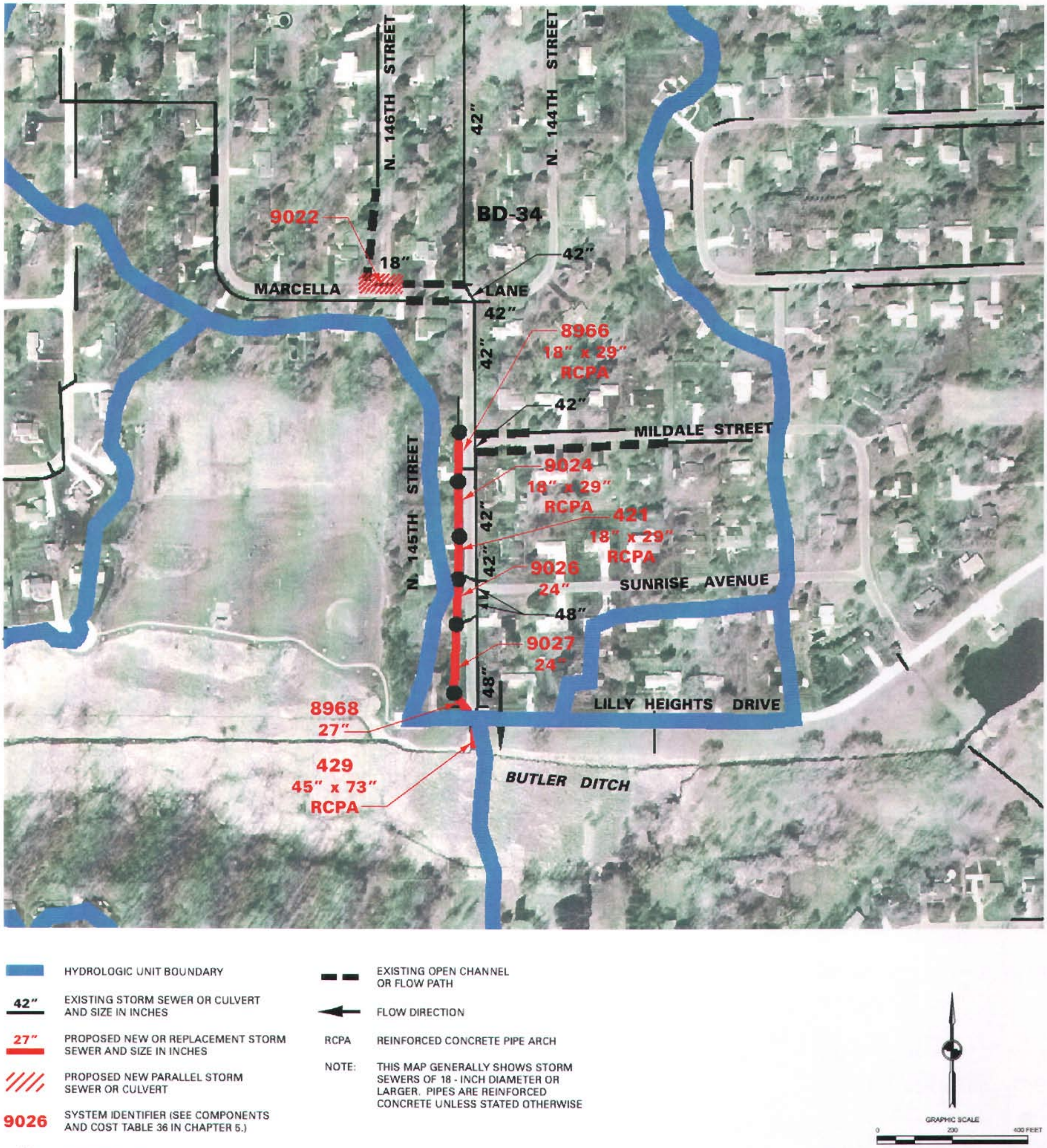
INDEX MAP FOR HYDROLOGIC UNIT BD-34
STORMWATER CONVEYANCE WITH DETENTION STORAGE ALTERNATIVE PLAN



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 54

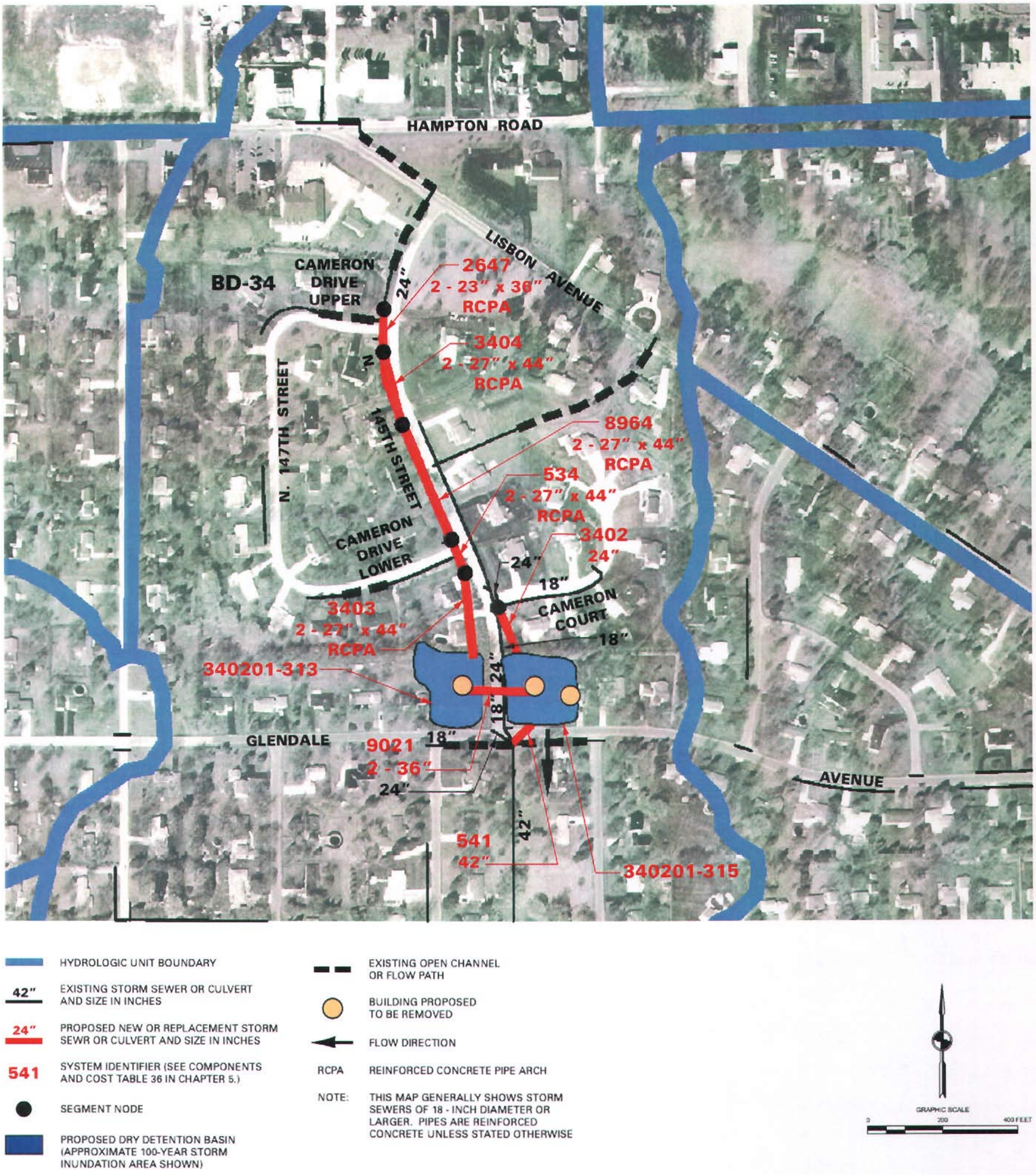
ALTERNATIVE PLAN NO. BD-34A1
STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 55

ALTERNATIVE PLAN NO. BD-34A1
STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 36

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-34a1 STORMWATER CONVEYANCE WITH DETENTION STORAGE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield	1. 429–Replace 17 feet of 48-inch RCP south of the intersection of Lilly Heights Road and N. 145th Street with 45-inch-high by 73-inch-wide RCPA	$ 4,270	$ 0
	2. 8968–Replace 49.6 feet of 12-inch RCP crossing Lilly Heights Drive west of N. 145th Street with 27-inch RCP	5,460	0
	3. 9027–Install 218 feet of new 24-inch RCP west of N. 145th Street and north of Lilly Heights Drive	21,800	140
	4. 9026–Install 130 feet of 24-inch RCP west of N. 145th Street and south of Sunrise Avenue	13,000	80
	5. 421–Replace 85.6 feet of 12-inch RCP northwest of the intersection of N. 145th Street and Sunrise Avenue with 18-inch-high by 29-inch-wide RCPA	10,380	0
	6. 9024–Install 190 feet of new 18-inch-high by 29-inch-wide RCPA between Mildale Street and Sunrise Avenue west of N. 145th Street	23,040	120
	7. 8966–Replace 74.6 feet of 12-inch RCP west of the intersection of N. 145th Street and Mildale Street with 18-inch-high by 29-inch-wide RCPA	9,050	0
	8. 541–Install 85 feet of new 42-inch RCP crossing Glendale Avenue east of N. 145th Street	12,330	20
	9. 340201315–Remove two houses east of N. 145th Street and north of Glendale Avenue	298,800	0
	10. 340201315–Remove 234 feet of 18-inch RCP and 24 feet of 12-inch RCP and construct a 2.9 acre-foot dry detention facility east of N. 145th Street and north of Glendale Avenue	212,280	6,920
	11. 340201313–Remove one house west of N. 145th Street and north of Glendale Avenue	171,300	0
	12. 340201313–Remove 240 feet of 24-inch RCP and 24 feet of 12-inch RCP and construct a 2.2 acre-foot dry detention facility west of N. 145th Street and north of Glendale Avenue	155,510	6,200
	13. 9021–Install 102 feet of new dual 36-inch RCP culverts crossing N. 145th Street north of Glendale Avenue	25,700	60
	14. Raise road grade about 0.75 foot along both 400 feet of Glendale Road and 200 feet of N. 145th Street to provide for the construction of two dry detention facilities	77,280	0
	15. 3402–Replace 128 feet of 18-inch RCP between Cameron Court and Glendale Avenue east of N. 145th Street with 24-inch RCP	12,800	0

Table 36 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,c]	Annual Operation and Maintenance[d]
City of Brookfield (continued)	16. 3403–Replace 290 feet of 24-inch RCP between Cameron Drive and Glendale Avenue west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	$ 110,390	$ 80
	17. 534–Replace 52 feet of 24-inch RCP crossing Cameron Drive Lower west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	19,790	20
	18. 8964–Replace 333 feet of 24-inch RCP between Cameron Drive Upper and Cameron Drive Lower west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	126,740	100
	19. 3404–Replace 237 feet of 24-inch RCP between Cameron Drive Upper and Cameron Drive Lower west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	90,210	70
	20. 2647–Replace 54 feet of 24-inch RCP crossing Cameron Drive Upper west of N. 145th Street with dual 23-inch-high by 36-inch-wide RCPA	17,300	30
	21. 9022–Install 44 feet of new 15-inch RCP parallel to the existing culvert under N. 146th Street at Marcella Lane	2,950	30
	Total	$1,420,380	$13,870

NOTE: The following abbreviations have been used in this table:

RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-35

The preliminary recommended system is shown graphically on Map 59 and the system components are described in Table 38. The total capital cost is estimated to be $19,340. No increase in annual operation and maintenance costs would be expected.

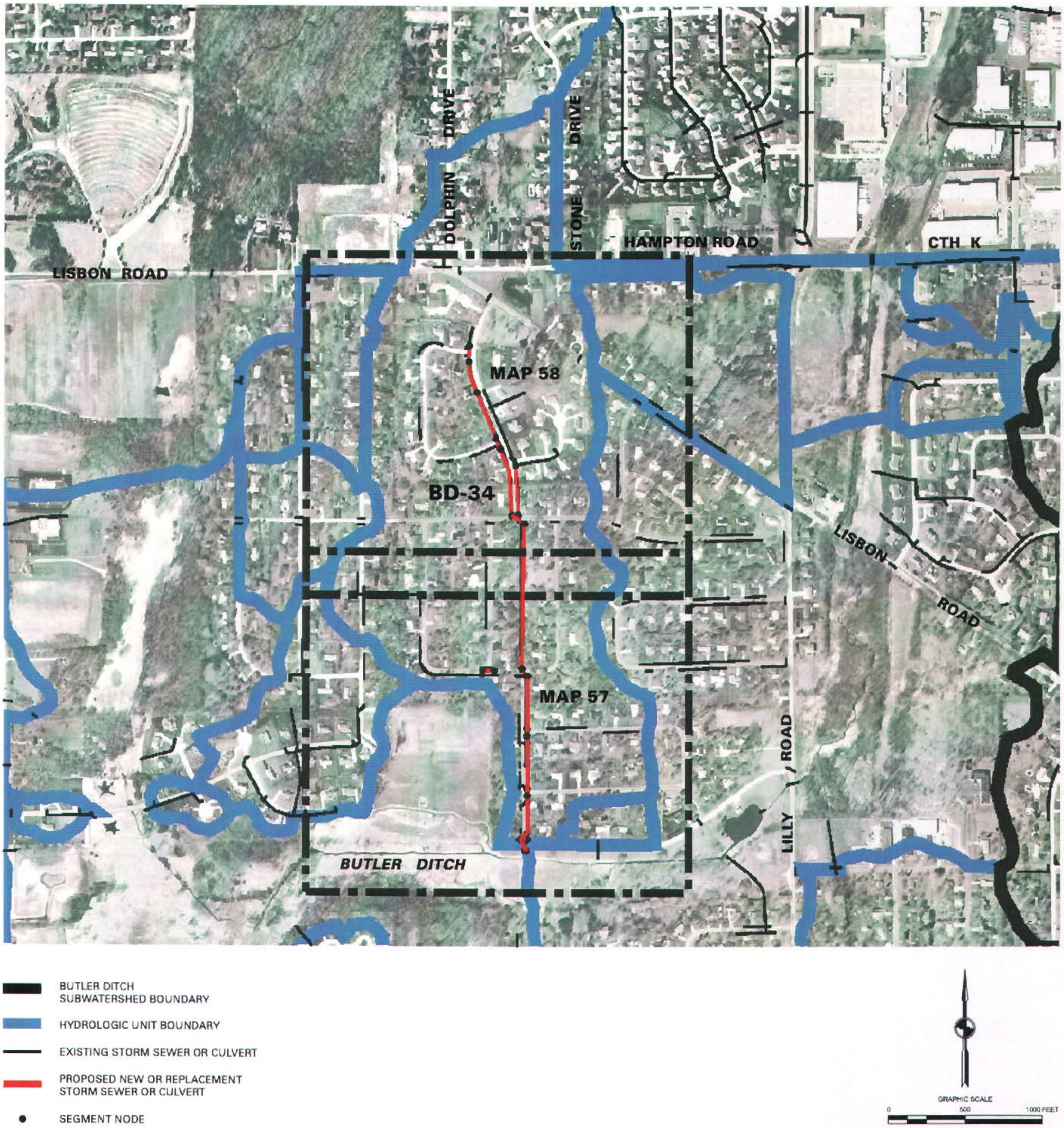
HYDROLOGIC UNIT BD-36

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-36 is an approximately seven-acre area located entirely within the City of Brookfield in the northwest one-quarter of U.S. Public Land Survey Section 2. The unit is located south of Senate Street between N. 149th and N. 150th Streets.

Map 56

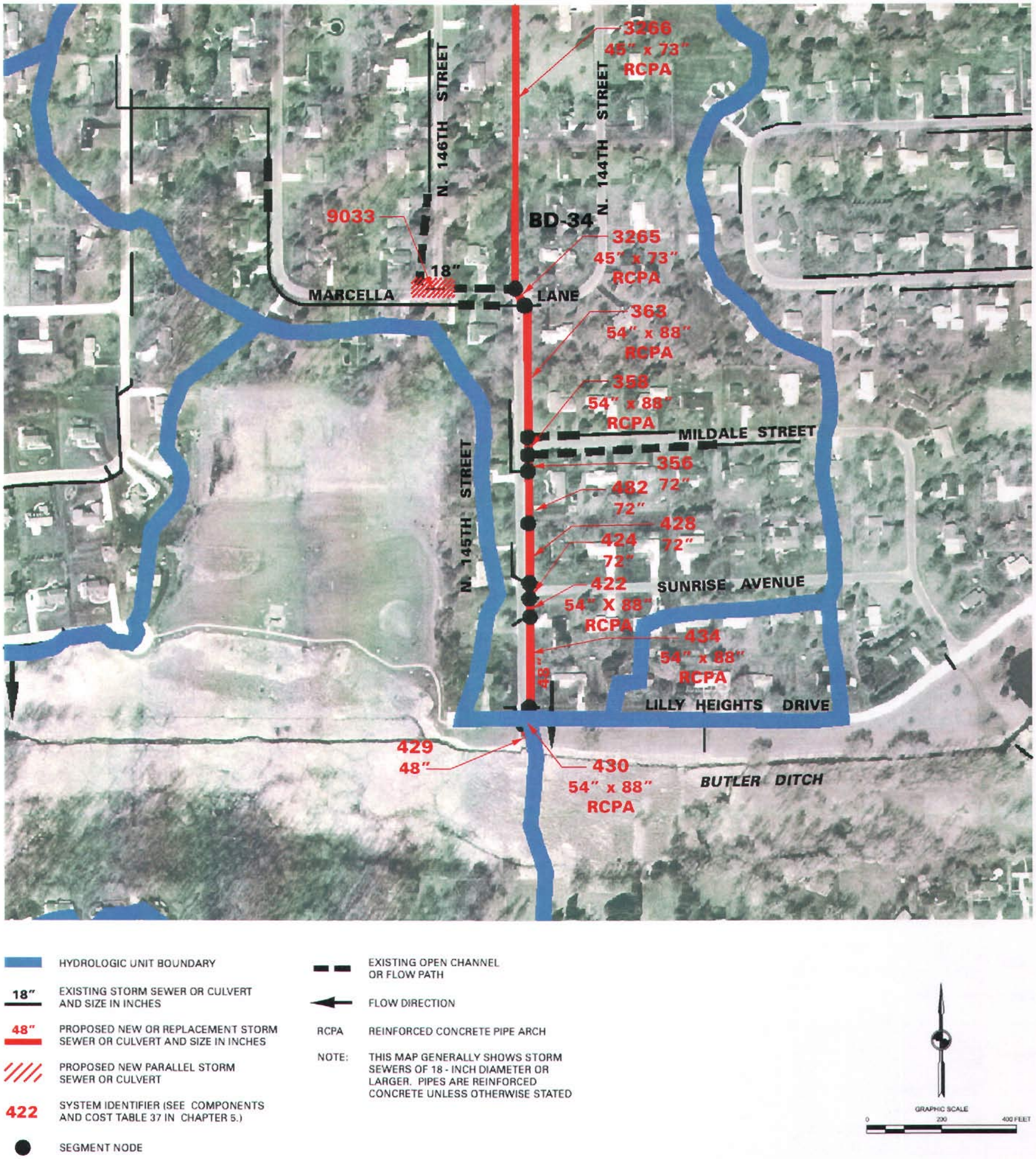
INDEX MAP FOR HYDROLOGIC UNIT BD-34 STORMWATER CONVEYANCE ALTERNATIVE PLAN



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 57

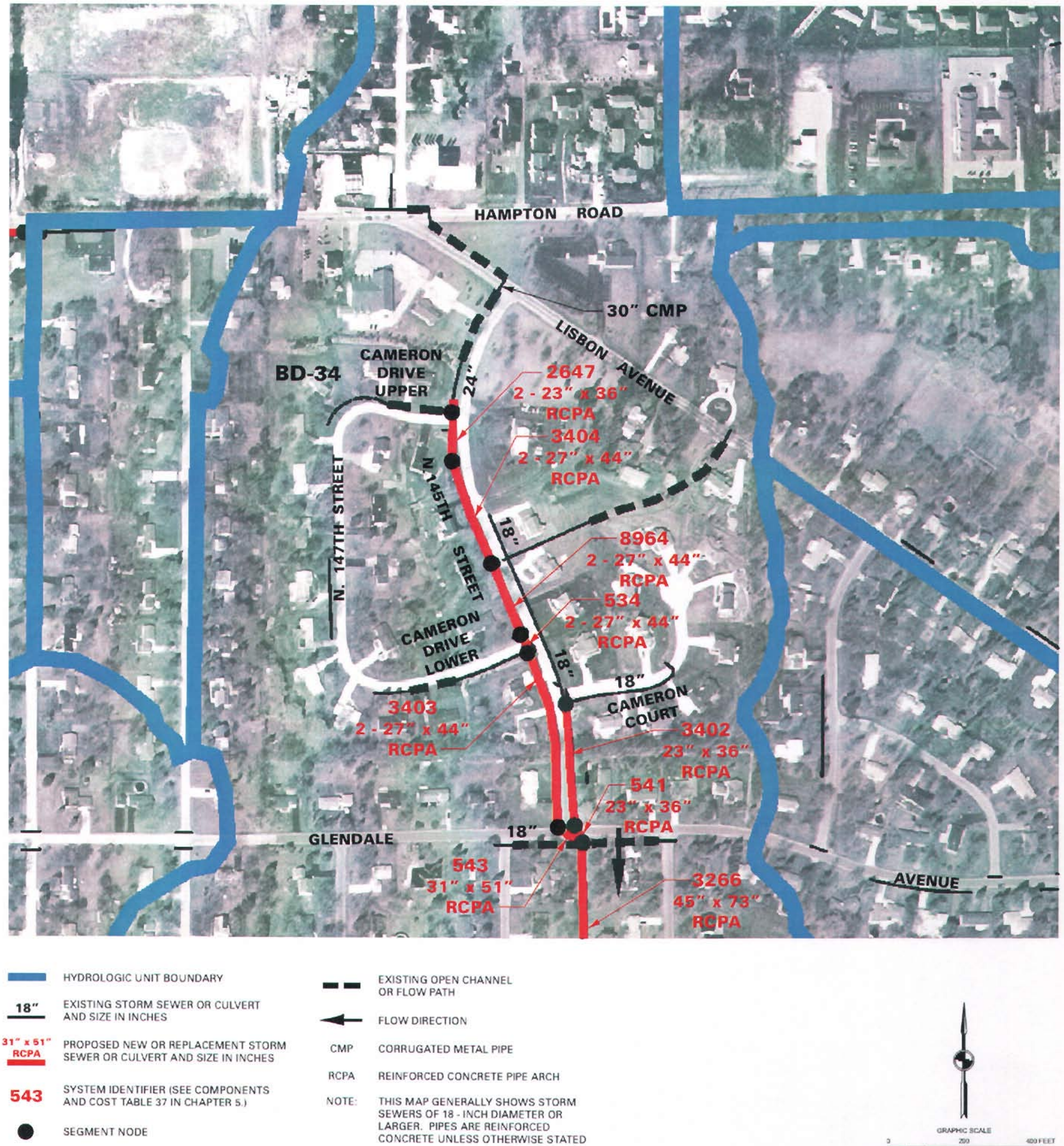
ALTERNATIVE PLAN NO. BD-34A2
STORMWATER CONVEYANCE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 58

ALTERNATIVE PLAN NO. BD-34A2
STORMWATER CONVEYANCE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 37

COMPONENTS AND COSTS OF ALTERNATIVE PLAN NO. BD-34a2 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
City of Brookfield	1. 429–Relay 17 feet of 48-inch RCP south of the intersection of Lilly Heights Road and N. 145th Street and install 17 feet of new 48-inch RCP	$ 4,930	$10
	2. 430–Replace 50 feet of 48-inch RCP crossing Lilly Heights Drive east of N. 145th Street with 54-inch-high by 88-inch-wide RCPA	24,450	0
	3. 434–Replace 240 feet of 48-inch RCP east of N. 145th Street and north of Lilly Heights Drive with 54-inch-high by 88-inch-wide RCPA	122,990	0
	4. 422–Replace 48 feet of 48-inch RCP east of N. 145th Street and south of Sunrise Avenue with 54-inch-high by 88-inch-wide RCPA	24,470	0
	5. 424–Replace 48 feet of 48-inch RCP crossing Sunrise Avenue east of N. 145th Street with 72-inch RCP	18,130	0
	6. 428–Replace 162 feet of 42-inch RCP east of N. 145th Street and north of Sunrise Avenue with 72-inch RCP	61,480	0
	7. 482–Replace 138 feet of 42-inch RCP east of N. 145th Street and south of Mildale Street with 72-inch RCP	52,400	0
	8. 356–Replace 46 feet of 42-inch RCP east of N. 145th Street and south of Mildale Street with 72-inch RCP	17,560	0
	9. 358–Replace 46 feet of 42-inch RCP crossing Mildale Street east of N. 145th Street with 54-inch-high by 88-inch-wide RCPA	23,500	0
	10. 363–Replace 349 feet of 42-inch RCP east of N. 145th Street and north of Mildale Street with 54-inch-high by 88-inch-wide RCPA	179,280	0
	11. 3265–Replace 53 feet of 42-inch RCP crossing Marcella Lane east of N. 145th Street with 45-inch-high by 73-inch-wide RCPA	18,680	0
	12. 3266–Replace 949 feet of 42-inch RCP between Glendale Avenue and Marcella Lane with 45-inch-high by 73-inch-wide RCPA	238,270	0
	13. 541–Replace 48 feet of 18-inch RCP crossing Glendale Avenue east of N. 145th Street with 23-inch-high by 36-inch-wide RCPA	7,690	0
	14. 543–Replace 72 feet of 24-inch RCP crossing Glendale Avenue west of N. 145th Street with 31-inch-high by 51-inch-wide RCPA	15,940	0
	15. 3402–Replace 314 feet of 18-inch RCP between Cameron Court and Glendale Avenue east of N. 145th Street with 23-inch-high by 36-inch-wide RCPA	50,210	0

Table 37 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
City of Brookfield (continued)	16. 3403–Replace 458 feet of 24-inch RCP between Cameron Drive Lower and Glendale Avenue west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	$ 174,330	$ 0
	17. 534–Replace 52 feet of 24-inch RCP crossing Cameron Drive Lower west of N. 145th Street with dual 27-inch-wide by 44-inch-wide RCPA	19,790	0
	18. 8964–Replace 333 feet of 24-inch RCP between Cameron Drive Upper and Cameron Drive Lower west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	126,750	0
	19. 3404–Replace 237 feet of 24-inch RCP between Cameron Drive Upper and Cameron Drive Lower west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	90,210	0
	20. 2647–Replace 54 feet of 24-inch RCP crossing Cameron Drive Upper west of N. 145th Street with dual 23-inch-high by 36-inch-wide RCPA	17,300	30
	21. 9033–Install 44 feet of new 15-inch RCP parallel culvert under N. 146th Street at Marcella Lane	2,950	30
	Total	$1,291,310	$70

NOTE: The following abbreviations have been used in this table:

RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

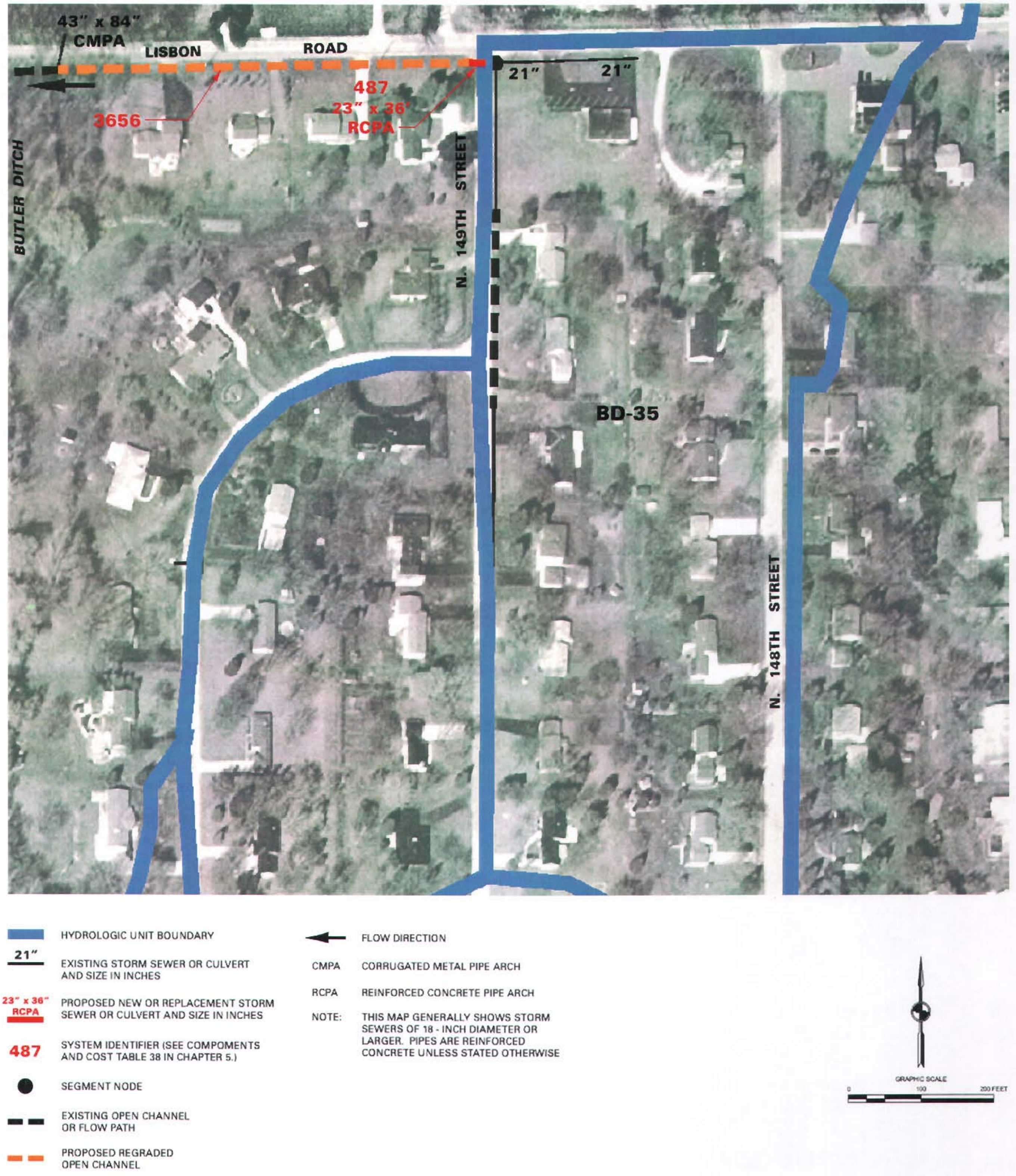
Under 1995 land use conditions, the hydrologic unit was fully developed in low-density residential uses. The land use distribution is anticipated to be the same under buildout conditions.

The stormwater management system within this hydrologic unit consists of mainly roadside swales and a small section of ditch enclosure. The flow of stormwater within the unit generally follows an east to west pattern.

The analyses indicated inadequate minor system capacity at the crossing of N. 150th Street, resulting in road overtopping.

Map 59

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-35 STORMWATER CONVEYANCE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 38

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-35 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
City of Brookfield	1. 3656–Regrade 450 feet of swale south of Lisbon Road from N. 149th Street to Butler Ditch to have a depth of two feet, a bottom width of three feet, and one vertical on four horizontal side slopes	$12,940	$0
	2. 487–Replace 40 feet of 18-inch CMP crossing N. 149th Street south of Lisbon Road with 23-inch-high by 36-inch-wide RCPA	6,400	0
	Total	$19,340	$0

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Alternative Stormwater Drainage Plan for Hydrologic Unit BD-36

The identified localized problems can readily be solved through increasing the hydraulic capacity of the inadequate pipes. Thus, the development of alternative plans is not considered to be necessary and a stormwater conveyance plan was developed.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-36

The preliminary recommended system is described in Table 39 and system components are shown on Map 60. As set forth in Table 39, the total estimated capital cost of this plan is $5,000. No increase in annual operation and maintenance costs would be expected.

HYDROLOGIC UNIT BD-37

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-37 is an approximately 16-acre area located entirely within the City of Brookfield in the northwestern portion of U.S. Public Land Survey Section 2. The unit is generally located between N. 148th and N. 150th Streets, with Glendale Avenue bisecting the unit from west to east.

Under 1995 land use conditions, the hydrologic unit was fully developed in low-density residential uses. The land use distribution is anticipated to be the same under buildout conditions.

Table 39

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-36 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
City of Brookfield	1. 498–Replace 44 feet of 15-inch CMP crossing N. 159th Street south of Senate Street with 18-inch RCP. Lower upstream invert by 0.4 foot[e]	$5,000	$0
	Total	$5,000	$0

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

[e] *The storm sewer inlets and leads associated with this pipe will also have to be reconstructed.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

The stormwater drainage system within the hydrologic unit consists of roadside swales and culvert crossings. The stormwater within the unit generally flows in an east to west pattern.

Minor system inadequacies were identified at the crossing of N. 149th Street.

Alternative Stormwater Drainage Plan for Hydrologic Unit BD-37

The identified localized problems can readily be solved through increasing the hydraulic capacity of the inadequate pipes. Thus, the development of alternative plans is not considered to be necessary and a culvert conveyance plan was developed.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-37

The preliminary recommended system is shown on Map 61 and plan components are described in Table 40. As set forth in that table, the estimated capital cost of this plan is $3,860. No increase in annual operation and maintenance costs would be expected.

HYDROLOGIC UNIT BD-42

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-42 is an approximately 27-acre area located entirely within the City of Brookfield in the northwestern and southwestern portions of U.S. Public Land Survey Section 2. BD-42 is generally located south of Glendale Avenue and north of Dublin Court between N. 147th and 150th Streets.

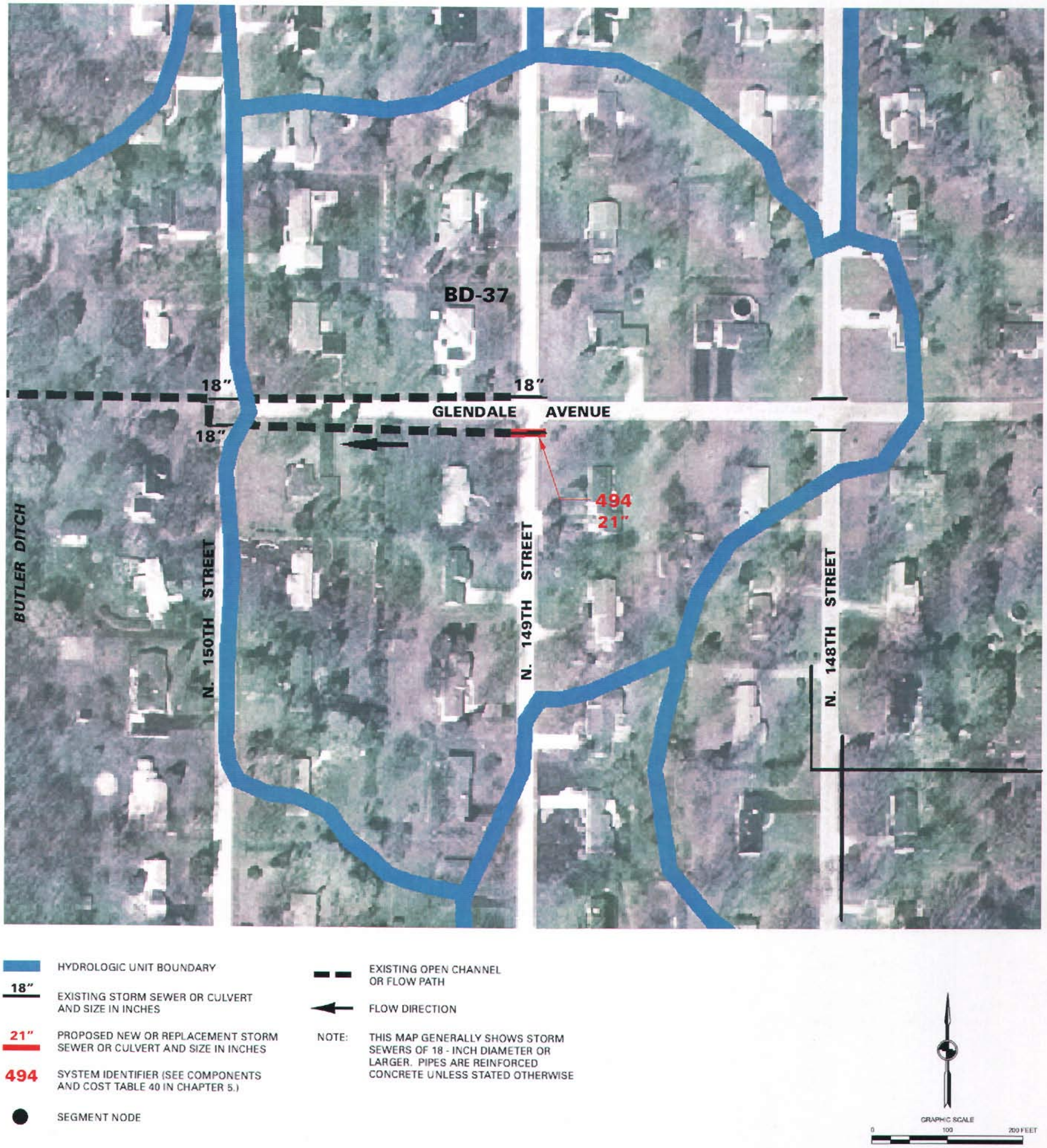
Map 60

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-36 STORMWATER CONVEYANCE

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 61

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-37 STORMWATER CONVEYANCE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 40

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-37 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
City of Brookfield	1. 494–Replace 46 feet of 18-inch RCP under N. 149th Street south of Glendale Avenue with 21-inch RCP	$3,860	$0
	Total	$3,860	$0

NOTE: The following abbreviations have been used in this table:

RCP = Reinforced concrete pipe

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Under 1995 land use conditions, the hydrologic unit was fully developed in low-density residential uses. The land use distribution is anticipated to be the same under buildout conditions.

The stormwater drainage system within the hydrologic unit consists of storm sewers, ditch enclosures, and roadside swales. The flow of stormwater within the unit is generally from north to south.

Major system inadequacies were identified in the region of Shamrock Lane. During the 50- and 100-year storms, excess stormwater may pond over the sanitary sewer manholes at the midblock sag in Shamrock Lane resulting in possible sanitary sewer backups.

Alternative Stormwater Management Plans for Hydrologic Unit BD-42

Two alternative plans were developed to alleviate the identified problems. These include a conveyance alternative and an alternative calling for sealing a sanitary sewer manhole.

Alternative Plan No. BD-42a1—Stormwater Conveyance

The alternative plan components are shown graphically on Map 62 and they are described in Table 41.

The total present value cost of this alternative is estimated to be $99,990. No increase in annual operation and maintenance costs would be expected.

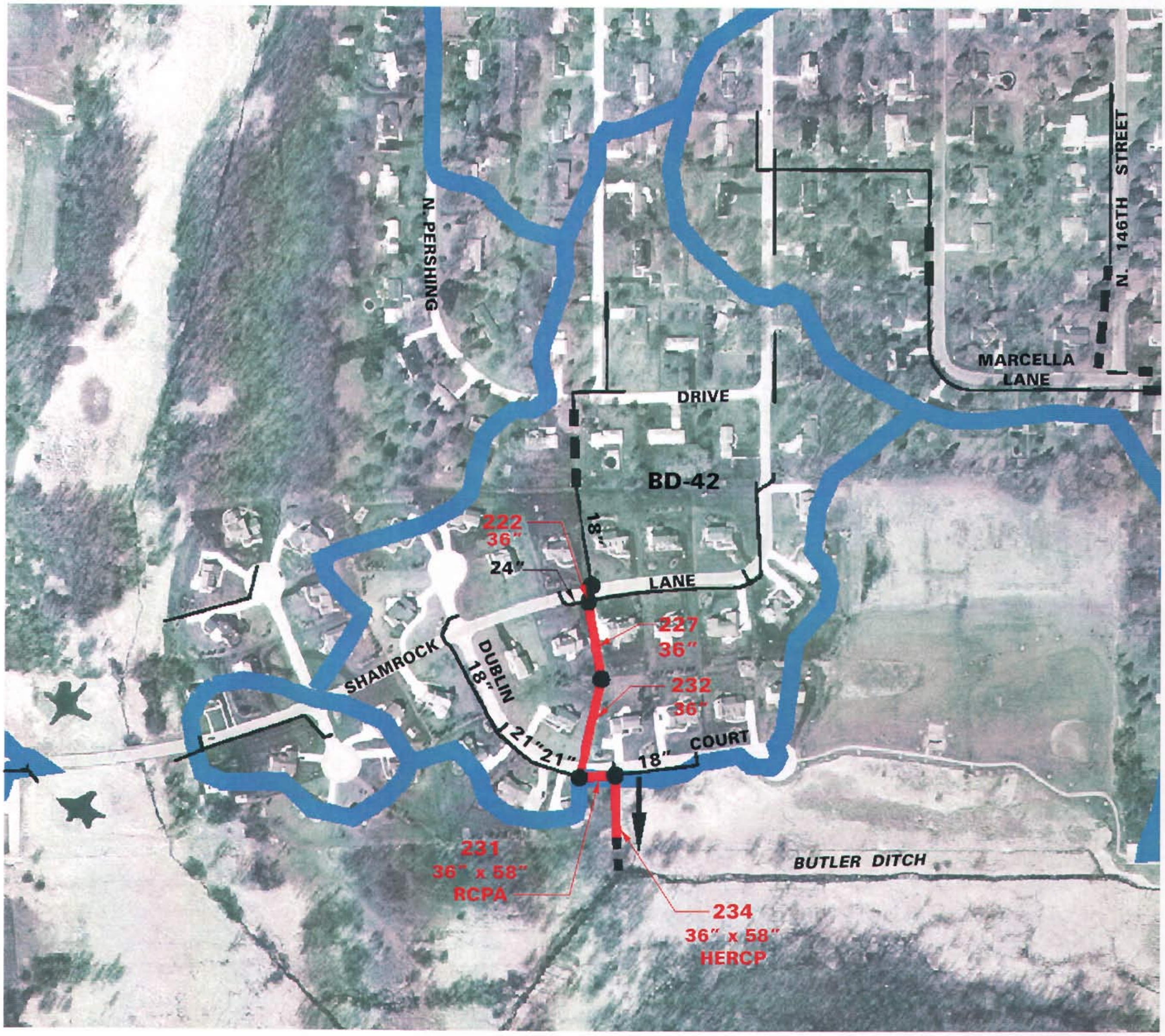
Alternative Plan No. BD-42a2—Seal Sanitary Sewer Manhole

This alternative plan calls for sealing the lowest sanitary sewer manhole located in the midblock sag in Shamrock Lane east of Dublin Court.

The total present value cost of this alternative is estimated to be $1,250. No increase in annual operation and maintenance costs would be expected.

Map 62

ALTERNATIVE NO. BD-42A1
STORMWATER CONVEYANCE



▬	HYDROLOGIC UNIT BOUNDARY	▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
18"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES	←	FLOW DIRECTION
36"	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES	HERCP	HORIZONTAL ELLIPTICAL REINFORCED CONCRETE PIPE
222	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 41 IN CHAPTER 5.)	RCPA	REINFORCED CONCRETE PIPE ARCH
●	SEGMENT NODE	NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE

Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 41

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-42 STORMWATER CONVEYANCE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
City of Brookfield	1. 234–Replace 157 feet of 29-inch-high by 45-inch-wide HERCP from Dublin Court to Butler Ditch with 36-inch-high by 58-inch-wide RCPA	$22,770	$0
	2. 231–Replace 86 feet of 29-inch-high by 45-inch-wide HERCP south of Dublin Court and north of Butler Ditch with 36-inch-high by 58-inch-wide RCPA	22,020	0
	3. 232–Replace 247 feet of 30-inch RCP between Shamrock Lane and Dublin Court with 36-inch RCP	27,880	0
	4. 227–Replace 188 feet of 30-inch RCP between Shamrock Lane and Dublin Court with 36-inch RCP	21,240	0
	5. 222–Replace 38 feet of 24-inch RCP crossing Shamrock Lane east of Dublin Court with 36-inch RCP	6,080	0
	Total	$99,990	$0

NOTE: The following abbreviations have been used in this table:

HERCP = Horizontal elliptical reinforced concrete pipe
RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Evaluation of Alternative Stormwater Management Plans for Hydrologic Unit BD-42

The foregoing information provides the basis for the comparative evaluation of the two alternative plans. Capital cost is the principal criterion for the comparative evaluation , and Alternative Plan No. BD-42a2 would cost much less than the conveyance alternative.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-42

Based upon cost, Alternative Plan No. BD-42a2—Seal Sanitary Sewer Manhole, is selected as the preliminary recommended plan.

HYDROLOGIC UNIT BD-44

Description and Evaluation of the Stormwater Management System

Hydrologic Unit BD-44 is an approximately 776-acre area located in U.S. Public Land Survey Section 34 and the western two-thirds of Section 35, Township 8 North, Range 20 East, and the northern one-third of U.S. Public

Land Survey Section 3, Township 7 North, Range 20 East. The unit is located predominantly north of W. Lisbon Road between Lilly and Calhoun Roads. About 80 percent of the unit is located within the Village of Menomonee Falls and about 20 percent is within the City of Brookfield.

Approximately 56 percent of the hydrologic unit was developed in urban land uses under 1995 conditions, including 54 percent low-density residential, 1 percent commercial, and 1 percent governmental and institutional. The remaining 44 percent of the unit was comprised of open land, surface water, wetlands, and woodlands. Under full buildout conditions, about 91 percent of the hydrologic unit would be in urban uses, including 66 percent low-density residential, 17 percent high-density residential, 6 percent governmental and institutional, and 2 percent commercial.

The stormwater drainage system within the Village of Menomonee Falls consists primarily of engineered storm sewer systems with inlets, leads, and storm sewers. There is a mix of natural storage areas and dry and wet detention basins throughout this unit that have been incorporated into the storm sewer systems. The stormwater drainage system within the City of Brookfield consists primarily of culverts and ditch enclosures.

Improvements to the stormwater conveyance system in the Village of Menomonee Falls are recommended to alleviate overtopping of Chase Avenue and Stone Drive in the 10-year storm event and avert possible flooding of two houses along Dolphin Drive during a 100-year storm. In addition, the natural depression on Dolphin Drive located approximately 200 feet north of Lancaster Drive must be preserved or replaced if the area develops.

In the City of Brookfield, improvements are required along W. Lisbon Road to avoid overtopping during a 50-year storm. The intersections of N. 159th Street, N. 158th Street, and Pilgrim Road with Lisbon Road could overtop during storms with recurrence intervals ranging from 10 through 100 years. The standards adopted for this planning effort call for a 50-year storm capacity at arterial highways such as W. Lisbon Road (CTH K). At the intersection of Shagbark Lane and Three Meadows Drive, there is the potential for flooding of two houses and ponding on the roadway during storms with recurrence intervals ranging from 10 through 100 years. Also, the ponding on the roadway may contribute to sanitary sewer inflow at manholes, possibly resulting in basement backups. The 10-year overtopping standard for collector streets would not be met at N. 158th Street approximately 1,000 feet south of W. Lisbon Road. Pilgrim Road also overtops in the 50- and 100-year events approximately 800 feet south of W. Lisbon Road. That road is also an arterial with a 50-year capacity standard.

Alternative Stormwater Drainage Plan for Hydrologic Unit BD-44

The identified stormwater management problems can readily be addressed and future problems can be avoided through maintenance of the mix of natural storage areas and dry and wet detention basins throughout this hydrologic unit, the provision of detention storage for new development, and the provision of increased hydraulic capacity within certain components of the existing conveyance system. A stormwater conveyance with detention storage alternative was developed for this hydrologic unit.

Culverts and/or storm sewer systems under Pilgrim Road within the Village of Menomonee Falls have also been assumed to be extended to 100 foot lengths as is anticipated following the proposed widening of Pilgrim Road.

The plan includes the systems-level design of a proposed skeletal stormwater management system for two areas of proposed future development along Pilgrim Road just north of Lisbon Road in the southeast one-quarter of U.S. Public Land Survey Section 34 and the southwest one-quarter of Section 35, Township 8 North, Range 20 East in the Village of Menomonee Falls. The development site on the west side of Pilgrim Road is an area of planned medium-density residential development. The site on the east side of Pilgrim Road is planned to be governmental and institutional. The detention basins for each site were sized based upon both the stormwater detention policy of the Village of Menomonee Falls and the requirements of the Milwaukee Metropolitan

Sewerage District (MMSD) Chapter 13 rule, "Surface Water and Storm Water.[11] The capital cost and operation and maintenance for the systems to serve new development are presented in Table 42.

The plan calls for the preservation of the existing natural storage area located north of the intersection of Dolphin and Lancaster Drives. The portion of that storage area located north of the existing residential lots is owned by the Village of Menomonee Falls.

The proposed measures address identified existing drainage problems in the major and minor systems. The alternatives for those problems will also help alleviate sanitary sewer backup problems. Yard and basement flooding problems due to local yard grading conditions are not addressed by the proposed measures.

Preliminary Recommended Stormwater Drainage Plan for Hydrologic Unit BD-44

Preliminary recommended stormwater management systems to serve existing and planned development are shown graphically on Maps 63 through 71 and plan components are described in Table 42. As set forth in that table, the total capital cost of this plan for the City of Brookfield is $256,830. No increase in annual operation and maintenance costs would be expected. The total capital cost of this plan for measures associated with existing development in the Village of Menomonee Falls is $14,490 with an annual operation and maintenance cost increase of $10. The total capital cost for measures associated with planned new development in the Village is estimated to be $600,970, with an annual operation and maintenance cost of $6,790. The total capital cost for measures in the Village is estimated to be $615,460, with an annual operation and maintenance cost increase of $6,810. The preliminary recommended measures have an estimated total capital cost of $872,290, with an estimated increase of $6,800 in annual maintenance and operation costs.

INTEGRATION OF THE PRELIMINARY RECOMMENDED STORMWATER DRAINAGE AND WATER QUALITY MANAGEMENT PLANS INTO A PRELIMINARY RECOMMENDED STORMWATER MANAGEMENT PLAN

The preliminary recommended water quality management plan set forth in Chapter IV is compatible with the preliminary recommended stormwater drainage and floodland management plans described above. The wet detention basins, which are the major structural components of the water quality management plan, could be easily integrated into the preliminary recommended stormwater and floodland management plan. The construction erosion control and street sweeping components are essentially independent of the drainage and floodland measures and are readily implementable under the preliminary recommended stormwater and floodland management plan.

The recommended stormwater and floodland management plan, which combines the water quality, floodland, and stormwater drainage plan elements is described in the next chapter.

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[11] *The alternatives for each site show possible layouts for each development and give a systems-level indication of the stormwater management requirements for the site, including the necessary detention storage facilities.*

Table 42

COMPONENTS AND COSTS OF PRELIMINARY RECOMMENDED PLAN FOR SUBBASIN BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
City of Brookfield	1. 1003–Replace 40 feet of 42-inch RCP under Pilgrim Road south of Lisbon Road with 40-inch-high by 65-inch-wide RCPA	$ 11,910	$ 0
	2. 978–Relay 260 feet of 36-inch RCP in drainage easement east of N. 158th Street and south of Lisbon Road to provide increased cover and slope	29,380	0
	3. 981–Relay 175 feet of 36-inch RCP in drainage easement east of N. 158th Street south of Lisbon Road to provide increase cover and slope	19,780	0
	4. 3313–Replace 236 feet of 36-inch RCP under N. 158th Street and in a drainage easement east of N. 158th Street and south of Lisbon Road with 45-inch-high by 73-inch-wide RCPA	59,240	0
	5. 961–Replace 220 feet of 24-inch RCP in drainage easement west of N. 161st Street and east of Three Meadows Drive with 30-inch RCP	20,240	0
	6. 3309–Replace 258 feet of 24-inch RCP under Three Meadows Drive and in the drainage easement east of Three Meadows Drive and southeast of Shagbark Court with 36-inch RCP	29,150	0
	7. 3310–Replace 161 feet of 24-inch RCP under Shagbark Court and southwest of Three Meadows Drive with 36-inch RCP	25,760	0
	8. 2711–Replace 165 feet of 18-inch RCP under Three Meadows Drive northwest of Shagbark Court with 30-inch RCP	23,100	0
	9. 3317–Replace 121 feet of 15-inch CMP crossing Pilgrim Road south of Lisbon Road with 23-inch-high by 36-inch-wide RCPA	12,830	0
	10. 3627–Regrade 800 feet of swale south of Lisbon Road between N. 158th Street and Pilgrim Road to provide an increased slope	16,680	0
	11. 3316–Replace 44 feet of 13-inch-high by 17-inch-wide CMPA crossing N. 158th Street south of Lisbon Road with 21-inch RCP	3,700	0
	12. 3288–Install 55 feet of new 24-inch RCP under Meadow View East south of Lisbon Road	5,060	0
	Subtotal for City of Brookfield	$256,830	$ 0
Village of Menomonee Falls	13. 3864–Install 13 feet of 54-inch RCP to extend the existing culvert under Pilgrim Road at Fair Oak Parkway to provide a total length of 100 feet when Pilgrim Road is reconstructed	$ 3,110	$ 10
	14. 3869–Relay 45 feet of 18-inch CMP crossing Chase Avenue north of Susan Drive to provide positive slope	2,860	0

Table 42 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
Village of Menomonee Falls (continued)	15. 3804–Replace 42 feet of 20-inch-high by 28-inch-wide CMPA crossing Dolphin Drive approximately 600 feet south of Lancaster Avenue with a 27-inch-high by 44-inch-wide RCPA	$ 5,290	$ 0
	16. 8948–Replace 42 feet of 13-inch-high by 17-inch-wide CMPA under Stone Drive south of Lancaster Drive with 14-inch-high by 22-wide RCPA	3,230	0
	Subtotal for Existing Development in Menomonee Falls	$ 14,490	$ 10
	17. 3913b–Construct 40 feet of swale west of Pilgrim Road north of Drive "E" to have a two-foot depth, a three-foot bottom width and one vertical on four horizontal side slopes	$ 1,370	$ 20
	18. POND–Construct a detention basin with a 9.6 acre-foot surcharge storage volume during a 100-year storm. West of Pilgrim Road north of Drive "E"	238,200[e,f]	3,180[e,f]
	19. MPOND–Realign 100 feet of road-sidewalk to drain to proposed detention basin	5,000	50
	20. L-POND–Install 80 feet of new 18-inch RCP from Drive "E" to the proposed detention basin west of Pilgrim Road	6,400	50
	21. K-POND–Install 180 feet of new 12-inch RCP from Court "D" to the proposed detention basin west of Pilgrim Road	12,000	110
	22. I-POND–Install 300 feet of new 24-inch RCP from Street "B" to the proposed detention basin west of Pilgrim Road	30,000	190
	23. JI–Install 225 feet of new 12-inch RCP in Street "B" south of Court "D"	15,750	140
	24. AJ–Install 300 feet of new 12-inch RCP in Drive "C" and Street "B"	21,000	190
	25. G/HI–Install 165 feet of new 24-inch RCP in Street "B" north of Drive "E"	16,500	100
	26. FG/H–Install 420 feet of new 21-inch RCP in Street "B" north of Drive "F"	37,800	260
	27. EF–Install 270 feet of new 18-inch RCP in Drive "F" east of Street "A"	21,600	170
	28. DE–Install 105 feet of new 12-inch RCP in Street "A" north of Drive "F"	7,350	70
	29. CG/H–Install 290 feet of new 12-inch RCP in Drive "E" between Street "A" and Street "B"	20,300	180
	30. BC–Install 220 feet of new 12-inch RCP in Street "A" north of Drive "E"	15,400	140
	31. EE–Install 280 feet of new 18-inch RCP and a 10-foot-long berm at the inlet structure north of Lisbon Road to maintain existing flow to Drive "F"	23,400	170

Table 42 (continued)

Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
		Capital[b,d]	Annual Operation and Maintenance[c]
Village of Menomonee Falls (continued)	32. SW BASIN–Construct a detention basin with a 1.0 acre-foot surcharge storage volume during a 100-year storm east of Pilgrim Road and north of W. Lisbon Road	$ 18,400[e,f]	$ 240[e,f]
	33. SE BASIN– Construct a detention basin with a 4.4 acre-foot surcharge storage volume during a 100-year storm east of Pilgrim Road and north of W. Lisbon Road	109,900[e,f]	1,530[e,f]
	Subtotal for Planned New Development	$600,970	$6,790
	Subtotal for Village of Menomonee Falls	$615,460	$6,810
	Total	$872,290	$6,810

NOTE: The following abbreviations have been used in this table:

CMP = Corrugated metal pipe
CMPA = Corrugated metal pipe arch
RCP = Reinforced concrete pipe
RCPA = Reinforced concrete pipe arch

[a] *Costs based upon 2001* Engineering News-Record *Construction Cost Index = 7360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Costs do not include easements or land acquisition unless specifically noted.*

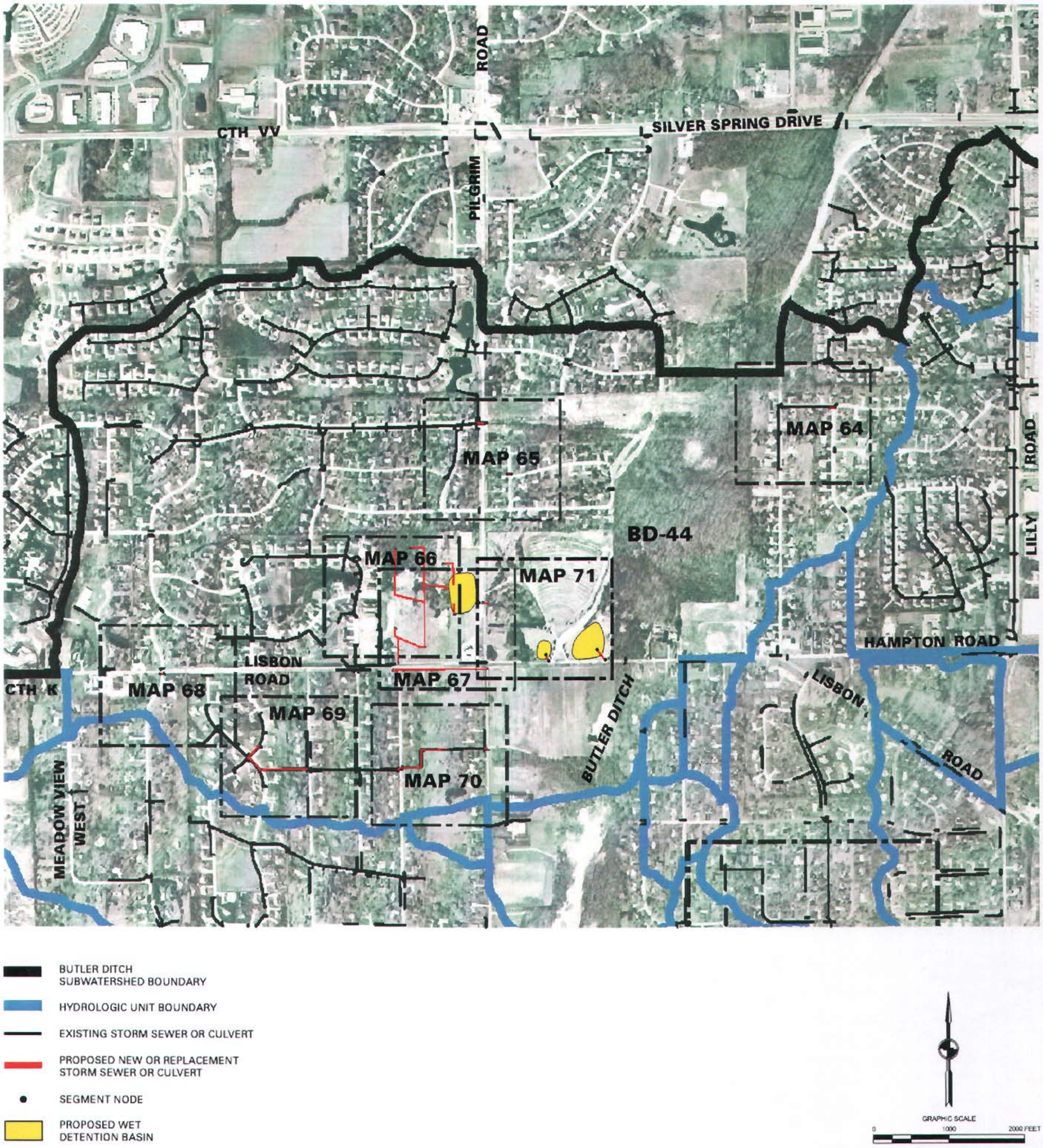
[e] *Cost includes detention basin outlets: 3913A for POND, SW OUTLET for SW BASIN, and SE OUTLET for SE BASIN.*

[f] *Incremental cost for water quantity control.*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 63

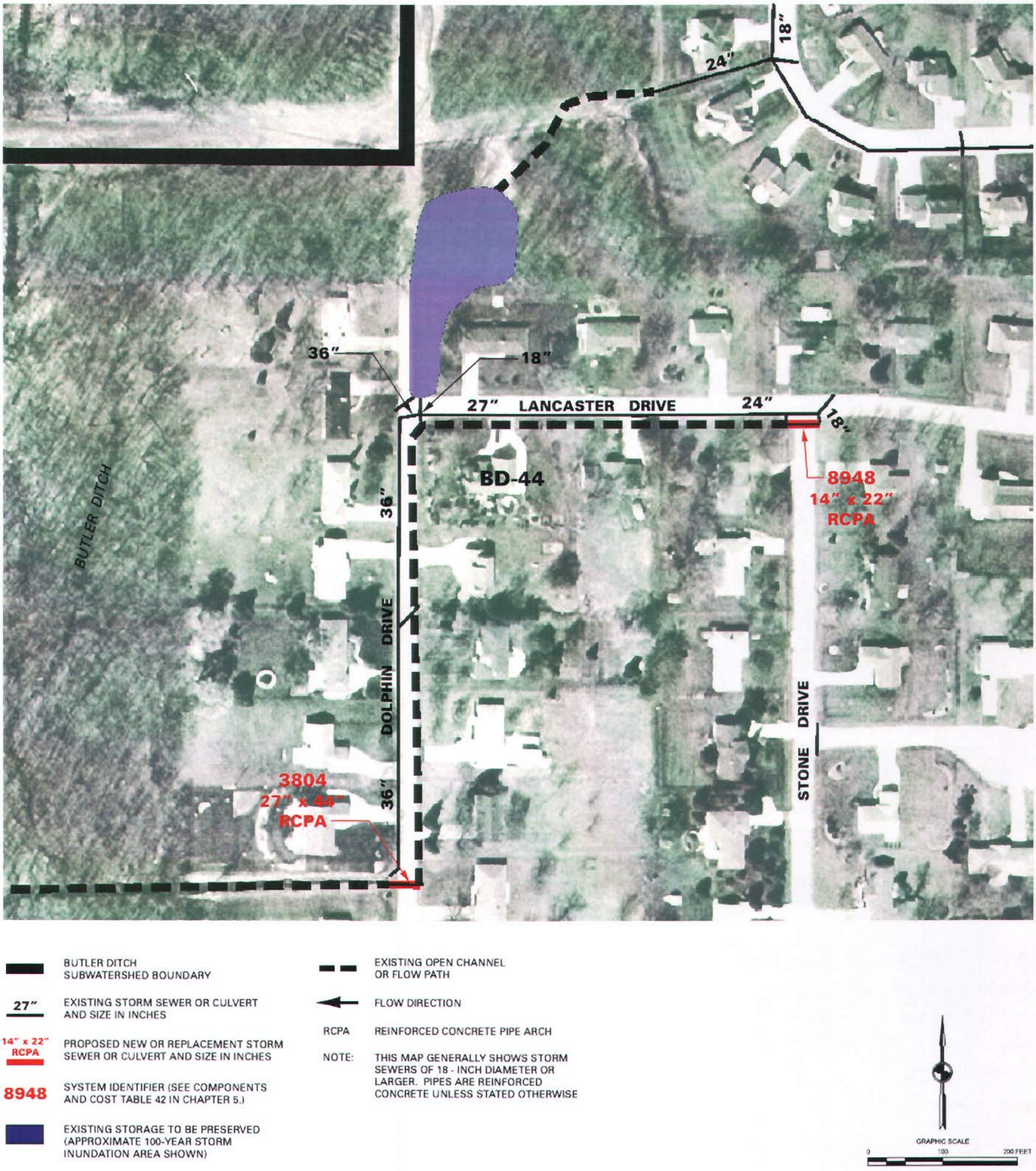
INDEX MAP FOR HYDROLOGIC UNIT BD-44



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 64

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE

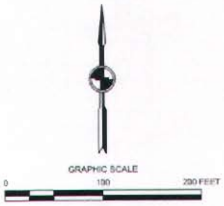


Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 65

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE

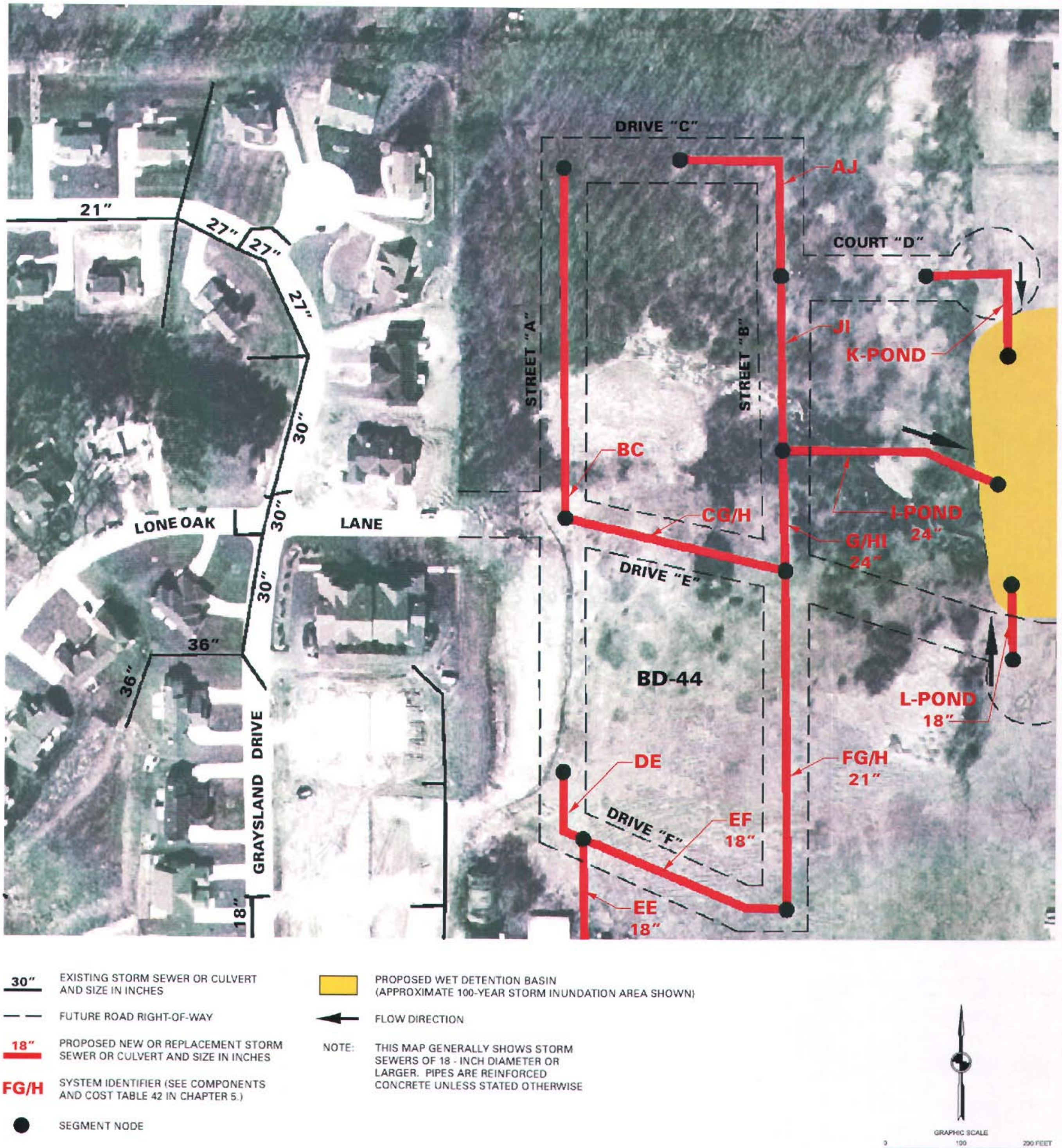
24"	EXISTING STORM SEWER OR CULVERT AND SIZE IN INCHES
54"	PROPOSED NEW OR REPLACEMENT STORM SEWER OR CULVERT AND SIZE IN INCHES
3869	SYSTEM IDENTIFIER (SEE COMPONENTS AND COST TABLE 42 IN CHAPTER 5.)
●	SEGMENT NODE
▬ ▬	EXISTING OPEN CHANNEL OR FLOW PATH
←	FLOW DIRECTION
CMP	CORRUGATED METAL PIPE
RCPA	REINFORCED CONCRETE PIPE ARCH
NOTE:	THIS MAP GENERALLY SHOWS STORM SEWERS OF 18 - INCH DIAMETER OR LARGER. PIPES ARE REINFORCED CONCRETE UNLESS STATED OTHERWISE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 66

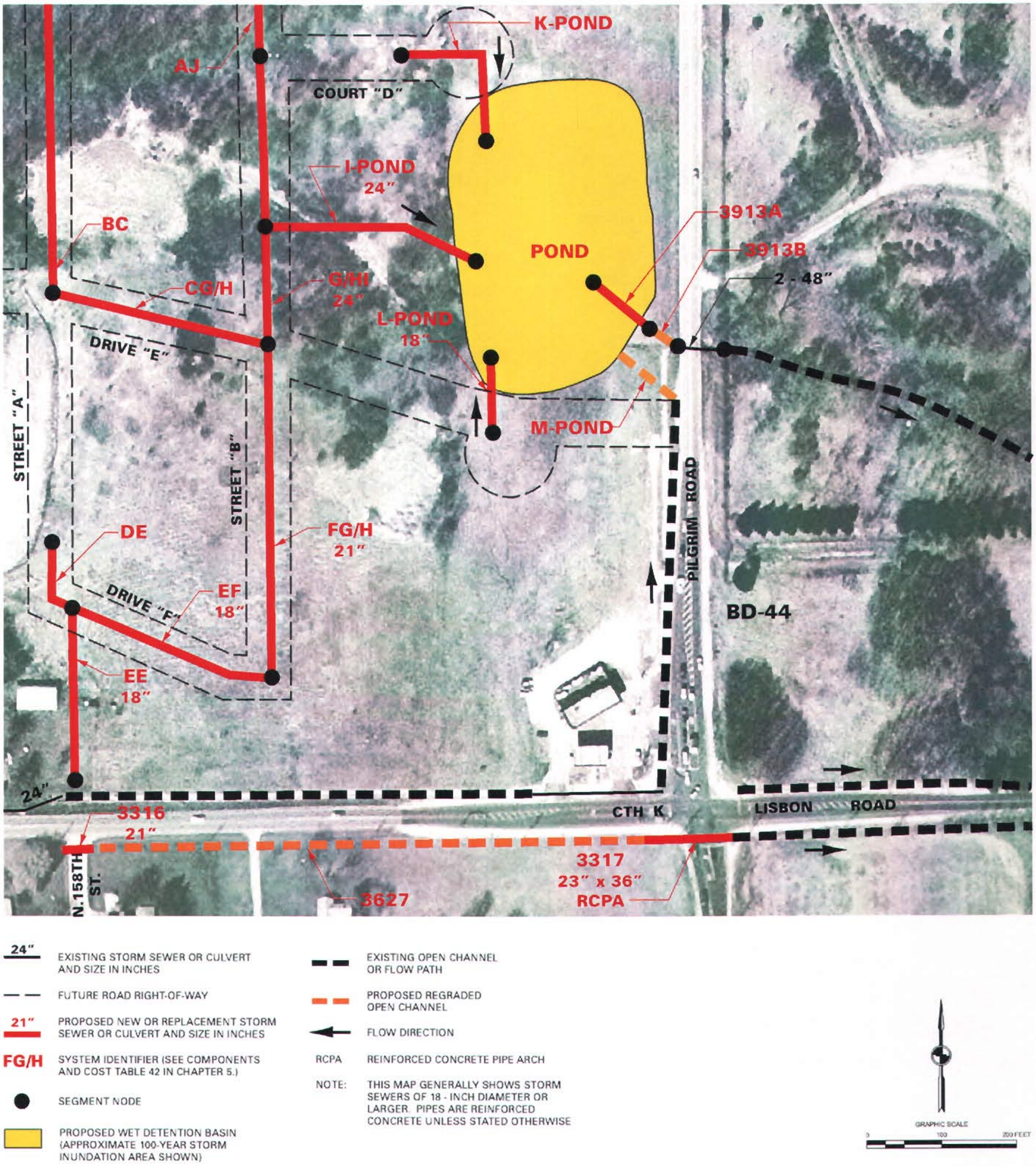
PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 67

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

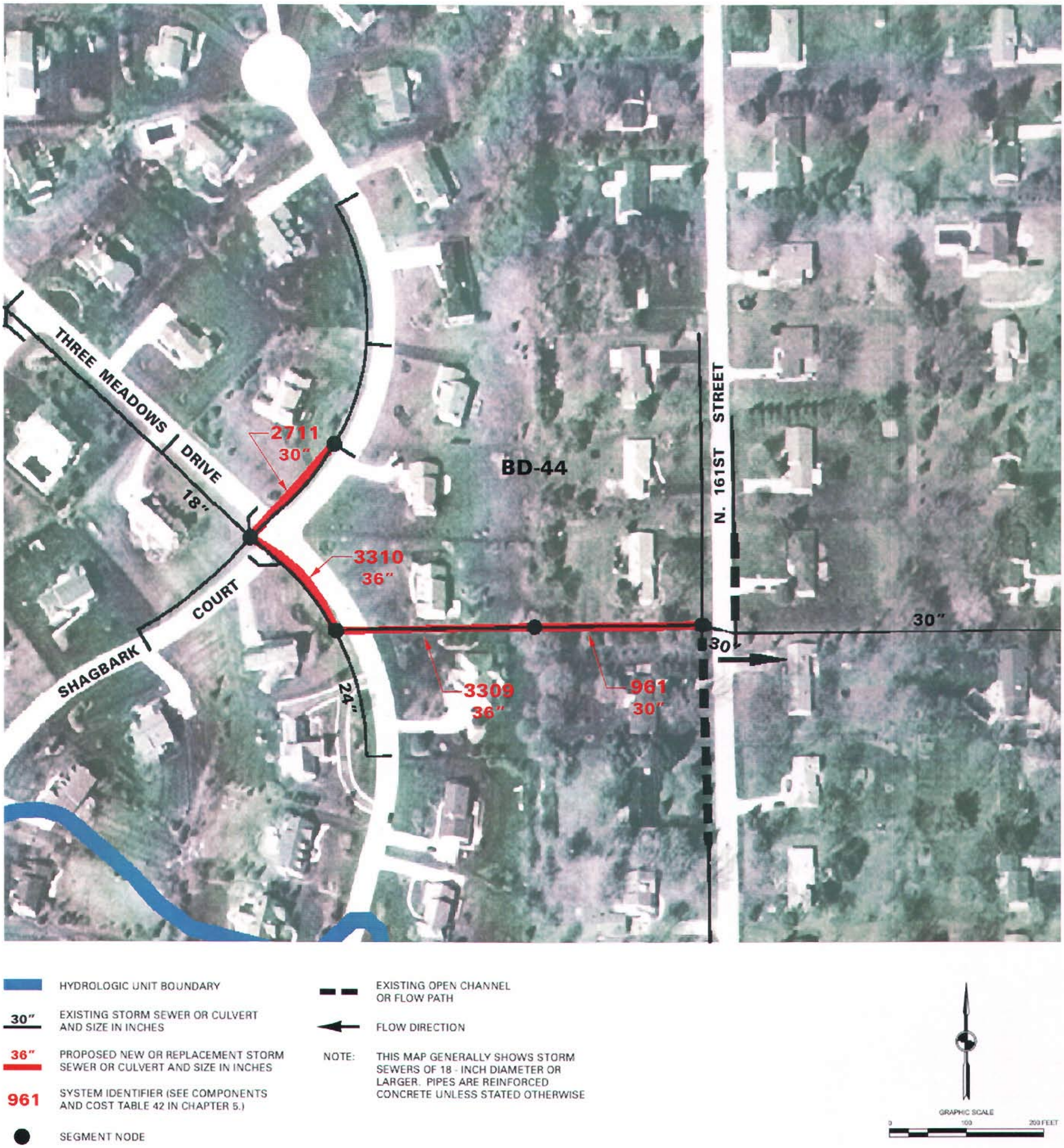
Map 68

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE

Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 69

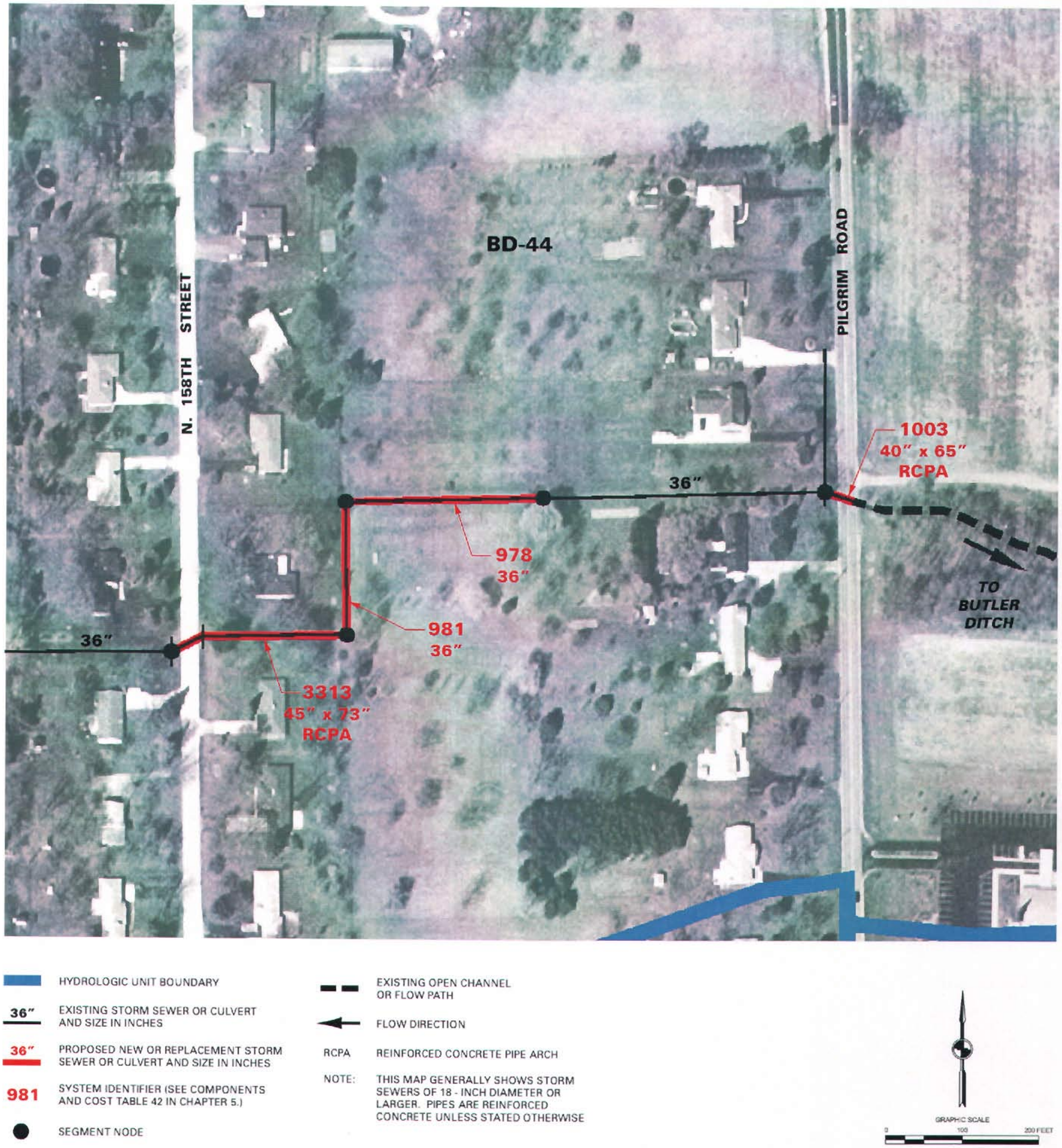
PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 70

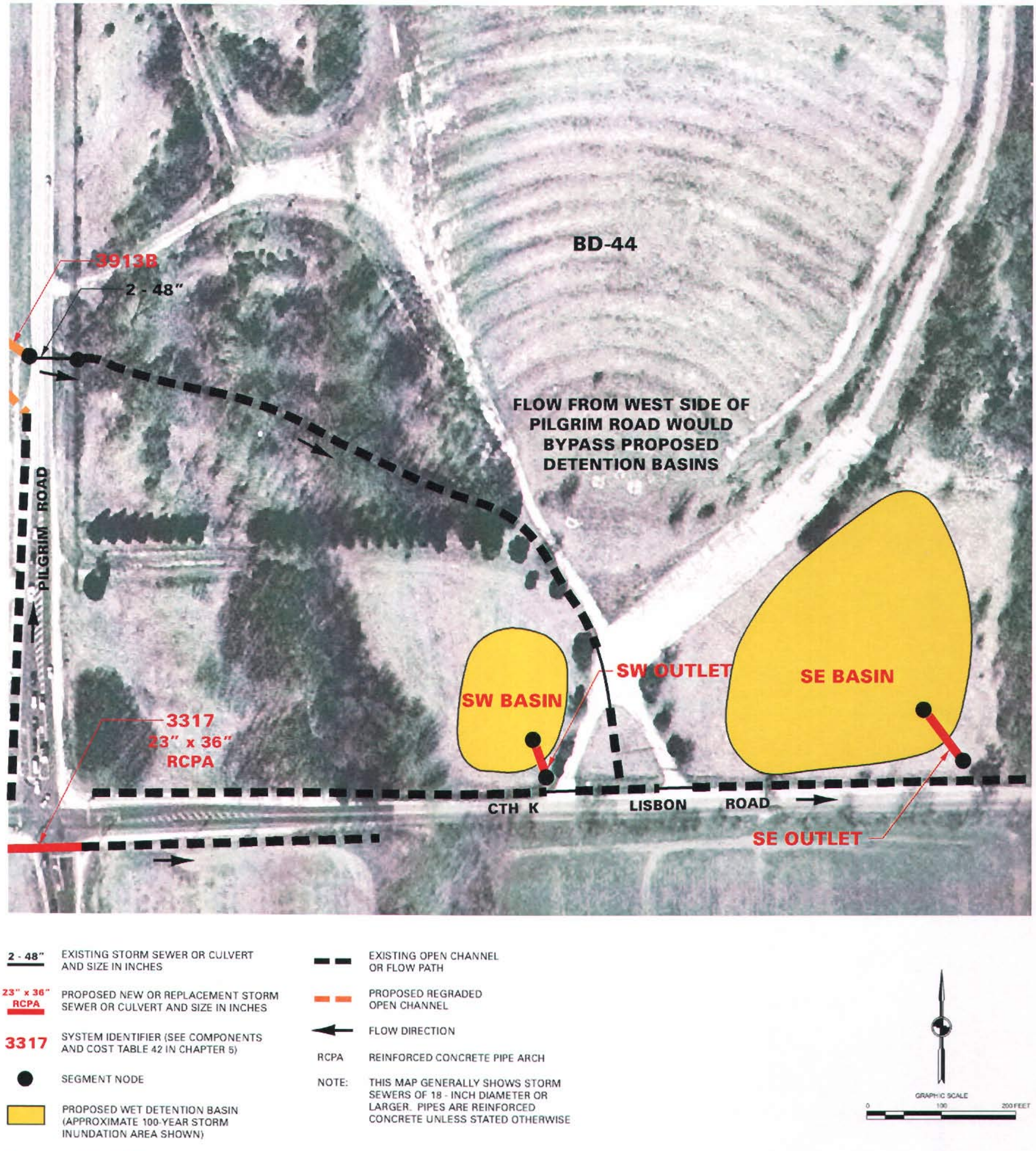
PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: Ruekert & Mielke, Inc., and SEWRPC.

Map 71

PRELIMINARY RECOMMENDED PLAN FOR HYDROLOGIC UNIT BD-44 STORMWATER CONVEYANCE WITH DETENTION STORAGE



Source: SEWRPC.

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Chapter VI

RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN

INTRODUCTION

The recommended stormwater and floodland management plan for the Butler Ditch subwatershed consists of three elements: a water quality management element, a stormwater drainage element, and a floodland management element. Preliminary recommendations for those three plan elements were presented in Chapters IV and V of this report. This chapter describes the comprehensive recommended plan that combines the three plan elements. This chapter also presents auxiliary plan recommendations regarding preservation of natural resources and open spaces, revisions to the City and Village floodplain maps, and maintenance of stormwater management facilities; and provides estimates of the cost of the recommended plan.

RECOMMENDED STORMWATER MANAGEMENT PLAN

The components of the recommended stormwater management plan and their estimated capital and annual operation and maintenance costs are summarized in Tables 43 and 44. The plan combines the preliminary recommended water quality management plan element described in Chapter IV and the preliminary recommended stormwater drainage plan element described in Chapter V. The recommended stormwater drainage plan is summarized in graphic form on the Chapter V maps listed in Table 45. The recommended water quality management plan element is shown on Map 72. Detailed descriptions of the recommended stormwater management plan components for each of the hydrologic units in the study area are provided in Chapters IV and V.

The recommended stormwater management plan calls for the following: 1) the provision of new or replacement culverts and storm sewers at potential problem areas throughout the study area; 2) limited swale modification; 3) the provision of three dual-purpose wet detention basins to provide water quality and quantity control for runoff from planned new development in the Village of Menomonee Falls on either side of Pilgrim Road just north of W. Lisbon Road; 4) the provision of detention storage for scattered new development and redevelopment in the City of Brookfield, according to the requirements of Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* and Chapter 13, "Surface Water and Storm Water," of the Milwaukee Metropolitan Sewerage District rules; 5) the construction of two wet detention basins to serve areas of existing urban land use in Brookfield and Menomonee Falls; 6) floodproofing of one house located along Pilgrim Road between Brookhill and Vernon Drives; 7) sealing several sanitary sewer manholes in Brookfield; 8) increased sweeping of about 56 curb-miles of streets in critical land use areas in both Brookfield and Menomonee Falls; and 9) auxiliary measures to reduce nonpoint source pollution loads delivered to the streams of the subwatershed.

Table 43

COMPONENTS AND COSTS OF THE RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a] Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance with Detention Storage		
BD-2	City of Brookfield	1. 253–Replace 22 feet of dual 24-inch CMPs east of Pilgrim Road with dual 36-inch RCPs	$ 4,970	$ 0
		2. 999–Replace 90 feet of 48-inch RCP crossing Pilgrim Road north of Brentwood Drive with 60-inch RCP	25,200	0
		3. 9016–Install 206 feet of new 24-inch RCP parallel to the existing 42-inch RCP east of the intersection of N. 158th Street and Elderlawn Parkway	16,070	130
		4. 9015–Install 36 feet of new 24-inch RCP parallel to the existing 42-inch RCP crossing N. 158th Street north of Elderlawn Parkway	3,600	20
		5. 20302409–Expand the existing 0.27 acre-foot runoff storage area 200 feet west of Shagbark Lane and 1,400 feet south of Lisbon Road to 0.86 acre-foot. Replace catch basin with headwall	34,300	0
		6. 723–Replace 116 feet of 30-inch RCP east of Meadow View Drive East and north of Meadow View Drive with 36-inch RCP	13,110	0
		7. 725–Replace 42 feet of 24-inch RCP crossing Meadow View Drive East north of Meadow View Drive with 36-inch RCP	6,300	0
		8. 3298–Replace 159 feet of 24-inch RCP in Three Meadows Drive south of Elderlawn Parkway with 27-inch RCP	19,080	0
		9. 3297–Replace 477.5 feet of 24-inch RCP in Three Meadows Drive south of Elderlawn Parkway with 27-inch RCP	57,300	0
		10. 3296–Replace 78.5 feet of 24-inch RCP in Three Meadows Drive north of Shagbark Lane with 27-inch RCP	9,420	0
		11. 3303–Replace 180 feet of 36-inch RCP east of Pilgrim Hollow Court and north of Laura Lane with 36-inch-high by 59-inch-wide RCPA	26,100	0
		12. 9009–Replace 84 feet of 36-inch RCP crossing Pilgrim Hollow Court north of Laura Lane with 36-inch-high by 59-inch-wide RCPA	21,480	0
		Subtotal BD-2	$ 236,930	$ 150
		Stormwater Conveyance with Detention Storage		
BD-16	City of Brookfield	1. 3226–Replace 192 feet of 24-inch RCP through the side yard of two houses 160 feet north of Ranch Road along Lilly Road with 36-inch RCP	$ 24,190	$ 0
		2. 2692–Replace 38 feet of 24-inch RCP crossing Lilly Road north of Ranch Road with 23-inch-high by 36-inch-wide RCPA	6,090	0
		3. 2688–Replace 65 feet of 21-inch RCP along Lilly Road north of Ranch Road with 24-inch RCP	6,500	0
		4. 3262–Replace 40 feet of 13-inch-high by 17-inch-wide CMPA crossing Ranch Road at Lilly Road with 24-inch RCP	4,000	0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance with Detention Storage (continued)		
BD-16 (continued)	City of Brookfield	5. 9042–Install 34 feet of new dual 14-inch-high by 22-inch-wide RCPA culverts crossing N. 138th Street north of 4065 N. 138th Street driveway culverts	$ 5,240	$ 20
		6. 2632–Abandon 34 feet of 18-inch CMP culvert crossing N. 138th Street south of the 4065 N. 138th Street driveway culverts	0	0
		7. 3358–Replace 122 feet of 21-inch RCP crossing Capitol Drive west of Fiebrantz Drive with 27-inch RCP	14,640	0
		8. 3357–Replace 28 feet of 18-inch RCP crossing Capitol Drive at Fiebrantz Drive with 27-inch RCP	3,360	0
		9. 1939–Replace 46 feet of 18-inch RCP in the side yard of two houses 1,200 feet south of Capitol Drive along Fiebrantz Drive with 250 feet of dual 23-inch-high by 36-inch-wide RCPA	80,090	280
		10. 3491–Replace 140 feet of 15-inch RCP along Fiebrantz Drive beginning 1,000 feet south of Capitol Drive with 23-inch-high by 36-inch-wide RCPA	22,430	0
		11. 8996–Install 196 feet of new 36-inch RCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1	22,150	60
		12. 3387–Replace 137 feet of three-feet-high by 3.33-feet-wide reinforced concrete box in Wisconsin Memorial Park Cemetery east of the Mausoleum with 30-inch RCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	12,610	60
		13. 3385–Replace 30 feet of 24-inch RCP in Wisconsin Memorial Park Cemetery along the southeast corner of the Mausoleum with 24-inch-high by 38-inch-wide HERCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	2,760	0
		14. 3697–Install 68 feet of new 24-inch-high by 38-inch-wide HERCP in the existing swale south of Wisconsin Memorial Park Cemetery and south of the Mausoleum as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	6,260	40
		15. 3384–Replace 196 feet of 24-inch RCP north of and crossing Burlawn Parkway with 30-inch RCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	18,040	0
		16. 3383–Replace eight feet of 24-inch RCP outlet for Lamplighter Park Pond with 24-inch RCP as recommended in the Burlawn Parkway Drainage Study Addendum Number 1[e]	630	0
		17. Seal sanitary sewer manhole numbers 64, 65, 99, and 100 in Burlawn Parkway near Lantern and Cardinal Drives[e]	5,000	0
		18. 161203636–Lower water surface elevation of the Lamplighter Park detention basin by two feet and add new outlet structure as recommended in the Burlawn Parkway Drainage Study Addendum Number 1	582,980	0
		19. 1975–Replace 182 feet of 27-inch RCP north of Commons Drive outletting into Lamplighter Park detention basin with 36-inch RCP	20,570	0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance with Detention Storage (continued)		
BD-16 (continued)	City of Brookfield	20. 1968–Replace 28 feet of 27-inch RCP crossing Commons Drive at Applegate Lane with 36-inch RCP with a revised grade	$ 4,200	$ 0
		21. 3375–Replace 50 feet of 27-inch RCP along Applegate Lane south of Commons Drive with 36-inch RCP with a revised grade	7,500	0
		22. 3374–Replace 87 feet of 27-inch RCP along Applegate Lane south of Commons Drive with 36-inch RCP	13,050	0
		23. 8891–Install 50 feet of new 18-inch RCP crossing Burlawn Parkway at Lantern Drive at existing low area	4,000	30
		24. 3370–Replace 68 feet of 27-inch RCP crossing Burlawn Parkway at Lantern Drive with 36-inch RCP	10,880	0
		25. 3368–Replace 260 feet of 27-inch RCP along Lantern Drive at Burlawn Parkway with 36-inch RCP	41,600	0
		26. 4061–Replace 39 feet of 12-inch RCP crossing Lantern Drive at Burlawn Parkway with 31-inch-high by 51-inch-wide RCPA	9,440	0
		27. 3347–Replace 40 feet of 12-inch CMP culvert crossing Cardinal Drive at Burlawn Parkway with 16-inch-high by 26-inch-wide RCPA culvert	3,360	0
		28. 3700–Regrade 550 feet of swale to have a bottom width of eight feet, a depth of three feet, and side slopes of one vertical on four horizontal in Burlawn Parkway	10,330	0
		29. 3082–Replace 44 feet of 43-inch-high by 64-inch-wide CMPA culvert in Burlawn Parkway 640 feet north of Burleigh Road with dual 36-inch-high by 58-inch-wide RCPA culverts	16,900	10
		30. 1919–Replace 104 feet of 47-inch-high by 71-inch-wide CMPA along Burlawn Parkway at Burleigh Road with dual 45-inch-high by 73-inch-wide RCPA	73,610	30
		31. 1920–Replace 90 feet of dual 33-inch-high by 49-inch-wide CMPA culverts in Burlawn Parkway crossing Burleigh Road with a four-foot-high by 10-foot-wide concrete box culvert	90,000	0
		32. 3732–Regrade 435 feet of existing swale to a bottom width of six feet, a depth of two feet, and side slopes of one vertical on four horizontal in Burlawn Parkway	9,620	0
		33. 3205–Replace 44 feet of 29-inch-high by 42-inch-wide CMPA culvert in Burlawn Parkway at Hampstead Drive with dual 36-inch-high by 58-inch-wide RCPA	16,900	10
		34. 3730–Regrade 320 feet of existing swale to a new grade along Burlawn Parkway south of Hampstead Drive	23,540	0
		35. 3729–Regrade 440 feet of existing swale to a new grade along Burlawn Parkway south of Lower Huntington Circle	57,250	0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance with Detention Storage (continued)		
BD-16 (continued)	City of Brookfield	36. 3728–Regrade 70 feet of existing swale to a new grade along Burlawn Parkway south of Kittridge Court	$ 1,980	$ 0
		37. 3511–Replace 44 feet of 18-inch CMP culvert in Burlawn Parkway at Pinewood Road with 27-inch-high by 44-inch-wide RCPA culvert	5,550	0
		38. 3725–Regrade 275 feet of existing swale to a bottom width of five feet, depth of two feet, and side slopes of one vertical on five horizontal in Burlawn Parkway south of Pinewood Road	5,870	0
		39. 3724–Regrade 438 feet of existing swale to a bottom width of five feet, depth of two feet, and side slopes of one vertical on five horizontal in Burlawn Parkway south of Upper Wembley Circle	9,340	0
		40. 3512–Replace 40 feet of 15-inch CMP culvert crossing Burlawn Parkway at Upper Wembley Court with a 18-inch-high by 29-inch-wide RCPA culvert	3,680	0
		41. 3510–Replace 40 feet of 15-inch CMP culvert crossing Burlawn Parkway at Kittridge Court with a 16-inch-high by 26-inch-wide RCPA culvert	3,360	0
		42. 3501–Replace 40 feet of 15-inch CMP culvert crossing Burlawn Parkway at Lower Huntington Circle with 14-inch-high by 22-inch-wide RCPA culvert	3,080	0
		43. 2269–Replace 58 feet of dual 18-inch-high by 29-inch-wide RCPA crossing Burlawn Parkway at Hampstead Road with dual 27-inch-high by 44-inch-wide RCPA and reset grade	22,080	0
		44. 3496–Replace 203 feet of dual 20-inch-high by 28-inch-wide CMPA along Hampstead Road east of Burlawn Parkway with dual 23-inch-high by 36-inch-wide RCPA	65,030	0
		45. 2273–Replace 82 feet of dual 18-inch-high by 29-inch-wide RCPA through a side yard at Hampstead Road and Blythe Court with dual 23-inch-high by 36-inch-wide RCPA[f]	15,090	0
		46. 3102–Install 361 feet of new 27-inch-high by 44-inch-wide RCPA parallel to the existing pipe through backyards northwest of Hobbs Court and south of Hampstead Road[f]	40,800	110
		47. 2320–Relay existing 57-foot-long, 27-inch-high by 44-inch-wide RCPA and install a new parallel pipe of the same size under Hobbs Court[f]	11,950	20
		48. 3503–Relay existing 178-foot long, 27-inch-high by 44-inch-wide RCPA and install a new parallel pipe of the same size southeast of Hobbs Court and west of Princeton Road[f]	20,120	50
		49. 3504–Replace 178 feet of 29-inch-high by 42-inch-wide CMPA along backyards north of Pinewood Road with dual 27-inch-high by 44-inch-wide RCPA[f]	40,230	0
		50. 3118–Replace 43 feet of 29-inch-high by 42-inch-wide CMPA crossing Pinewood Road west of Princeton Road with 27-inch-high by 44-inch-wide RCPA	8,190	0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance with Detention Storage (continued)		
BD-16 (continued)	City of Brookfield	51. 3506–Replace 166 feet of 21-inch RCP along the south side of Pinewood Road west of Princeton Road with 18-inch-high by 29-inch-wide RCPA and provide positive slope on pipe	$ 20,130	$ 0
		52. 3513–Replace 40 feet of 15-inch RCP crossing Princeton Road along the south side of Pinewood Road with 18-inch-high by 29-inch-wide RCPA and provide positive slope on pipe	4,860	0
		53. 3505–Replace 165 feet of 24-inch RCP along the north side of Pinewood Road west of Princeton Road with dual 31-inch-high by 51-inch-wide RCPA and provide positive slope on pipe	73,050	50
		54. 3122–Replace 48 feet of 18-inch CMPA crossing Princeton Road along the north side of Pinewood Road with 23-inch-high by 36-inch-wide RCPA with headwall and reset grade	7,690	0
		55. 3125–Replace 12 feet of 12-inch RCP along the west side of Princeton Road on the north side of Pinewood Road with 18-inch RCP and reset grade	960	0
		Subtotal BD-16	$1,597,760	$ 770
BD-44	City of Brookfield	1. 1003–Replace 40 feet of 42-inch RCP under Pilgrim Road south of Lisbon Road with 40-inch-high by 65-inch-wide RCPA	$ 11,910	$ 0
		2. 978–Relay 260 feet of 36-inch RCP in drainage easement east of N. 158th Street and south of Lisbon Road to provide increased cover and slope	29,380	0
		3. 981–Relay 175 feet of 36-inch RCP in drainage easement east of N. 158th Street south of Lisbon Road to provide increase cover and slope	19,780	0
		4. 3313–Replace 236 feet of 36-inch RCP under N. 158th Street and in a drainage easement east of N. 158th Street and south of Lisbon Road with 45-inch-high by 73-inch-wide RCPA	59,240	0
		5. 961–Replace 220 feet of 24-inch RCP in drainage easement west of N. 161st Street and east of Three Meadows Drive with 30-inch RCP	20,240	0
		6. 3309–Replace 258 feet of 24-inch RCP under Three Meadows Drive and in the drainage easement east of Three Meadows Drive and southeast of Shagbark Court with 36-inch RCP	29,150	0
		7. 3310–Replace 161 feet of 24-inch RCP under Shagbark Court and southwest of Three Meadows Drive with 36-inch RCP	25,760	0
		8. 2711–Replace 165 feet of 18-inch RCP under Three Meadows Drive northwest of Shagbark Court with 30-inch RCP	23,100	0
		9. 3317–Replace 121 feet of 15-inch CMP crossing Pilgrim Road south of Lisbon Road with 23-inch-high by 36-inch-wide RCPA	12,830	0
		10. 3627–Regrade 800 feet of swale south of Lisbon Road between N. 158th Street and Pilgrim Road to provide increased slope	16,680	0

Table 43 (continued)

			Estimated Cost[a]	
Hydrologic Unit	Location of Component	Project and Component Designation and Description	Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance with Detention Storage (continued)		
BD-44 (continued)	City of Brookfield	11. 3316–Replace 44 feet of 13-inch-high by 17-inch-wide CMPA crossing N. 158th Street south of Lisbon Road with 21-inch RCP	$ 3,700	$ 0
		12. 3288–Install 55 feet of new 24-inch RCP under Meadow View East south of Lisbon Road	5,060	0
		Subtotal for City of Brookfield	$ 256,830	$ 0
	Village of Menomonee Falls	13. 3864–Install 13 feet of 54-inch RCP to extend the existing culvert under Pilgrim Road at Fair Oak Parkway to provide a total length of 100 feet when Pilgrim Road is reconstructed	$ 3,110	$ 10
		14. 3869–Relay 45 feet of 18-inch CMP crossing Chase Avenue north of Susan Drive to provide positive slope	2,860	0
		15. 3804–Replace 42 feet of 20-inch-high by 28-inch-wide CMPA crossing Dolphin Drive approximately 600 feet south of Lancaster Avenue with a 27-inch-high by 44-inch-wide RCPA	5,290	0
		16. 8948–Replace 42 feet of 13-inch-high by 17-inch-wide CMPA under Stone Drive south of Lancaster Drive with 14-inch-high by 22-wide RCPA	3,230	0
		Subtotal for Existing Development in Village of Menomonee Falls	$ 14,490	$ 10
		17. 3913b–Construct 40 feet of swale west of Pilgrim Road north of Drive "E" to have a two-foot depth, a three-foot bottom width and one vertical on four horizontal side slopes	$ 1,370	$ 20
		18. POND–Construct a detention basin with a 9.6 acre-foot surcharge storage volume during a 100-year storm. West of Pilgrim Road north of Drive "E"	238,200[f,g]	3,180[f,g]
		19. MPOND–Realign 100 feet of roadside swale to drain to proposed detention basin	5,000	50
		20. L-POND–Install 80 feet of new 18-inch RCP from Drive "E" to the proposed detention basin west of Pilgrim Road	6,400	50
		21. K-POND–Install 180 feet of new 12-inch RCP from Court "D" to the proposed detention basin west of Pilgrim Road	12,600	110
		22. I-POND–Install 300 feet of new 24-inch RCP from Street "B" to the proposed detention basin west of Pilgrim Road	30,000	190
		23. JI–Install 225 feet of new 12-inch RCP in Street "B" south of Court "D"	15,750	140
		24. AJ–Install 300 feet of new 12-inch RCP in Drive "C" and Street "B"	21,000	190
		25. G/HI–Install 165 feet of new 24-inch RCP in Street "B" north of Drive "E"	16,500	100
		26. FG/H–Install 420 feet of new 21-inch RCP in Street "B" north of Drive "F"	37,800	260
		27. EF–Install 270 feet of new 18-inch RCP in Drive "F" east of Street "A"	21,600	170
		28. DE–Install 105 feet of new 12-inch RCP in Street "A" north of Drive "F"	7,350	70

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance with Detention Storage (continued)		
BD-44 (continued)	Village of Menomonee Falls	29. CG/H–Install 290 feet of new 12-inch RCP in Drive "E" between Street "A" and Street "B"	$ 20,300	$ 180
		30. BC–Install 220 feet of new 12-inch RCP in Street "A" north of Drive "E"	15,400	140
		31. EE–Install 280 feet of new 18-inch RCP and a 10-foot-long berm at the inlet structure north of Lisbon Road to maintain existing flow to Drive "F"	23,400	170
		32. SW BASIN–Construct a detention basin with a 1.0 acre-foot surcharge storage volume during a 100-year storm. East of Pilgrim Road and north of W. Lisbon Road	18,400[g,h]	240[g,h]
		33. SE BASIN–Construct a detention basin with a 4.4 acre-foot surcharge storage volume during a 100-year storm. East of Pilgrim Road and north of W. Lisbon Road	109,900[g,h]	1,530[g,h]
		Subtotal for Planned New Development	$ 600,970	$ 6,790
		Subtotal for Village of Menomonee Falls	$ 615,460	$ 6,800
		Total	$ 872,290	$ 6,800
		Stormwater Conveyance		
BD-4	City of Brookfield	1. 3269–Replace 58 feet of 18-inch CMP crossing Pilgrim Road approximately 1,600 feet south of Lisbon Road with 18-inch RCP at a reduced slope	$ 4,640	$ 0
		Subtotal BD-4	$ 4,640	$ 0
BD-8	City of Brookfield	1. 827–Replace 78 feet of 21-inch CMP crossing Pilgrim Road south of Fieldbrook Drive with 36-inch RCP	$ 11,700	$ 0
		Subtotal BD-8	$ 11,700	$ 0
		Stormwater Conveyance (continued)		
BD-12	City of Brookfield	1. 237–Replace 190 feet of 15-inch RCP from Clare Bridge Lane to the outfall at Butler Ditch with 18-inch RCP	$ 11,780	$ 0
		2. 236–Replace 31 feet of 15-inch RCP crossing Clare Bridge Lane north of Woodland Place with 18-inch RCP	3,100	0
		Subtotal BD-12	$ 14,880	$ 0
BD-17	City of Brookfield	1. 386–Replace 40 feet of 24-inch CMP crossing Lilly Road north of Lilly Heights Drive with dual 24-inch RCP	$ 7,360	$ 20
		2. 3619–Regrade 670 feet of existing swale east of Lilly Road between Regis Street and Lilly Heights Drive to have a depth of two feet, a bottom width of three feet and sides slopes of one vertical on four horizontal	19,180	0
		3. 331–Replace 44 feet of 18-inch CMP crossing Regis Street west of Lilly Road with dual 18-inch RCP with headwalls	6,780	30
		Subtotal BD-17	$ 33,320	$ 50
BD-20	City of Brookfield	1. 190–Replace 228 feet of 18-inch RCP west of Courtland Avenue with 31-inch-high by 51-inch-wide RCPA	$ 29,920	$ 0
		Subtotal BD-20	$ 29,920	$ 0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance (continued)		
BD-34	City of Brookfield	1. 429–Relay 17 feet of 48-inch RCP south of the intersection of Lilly Heights Road and N. 145th Street and install 17 feet of new 48-inch RCP	$ 4,930	$ 10
		2. 430–Replace 50 feet of 48-inch RCP crossing Lilly Heights Drive east of N. 145th Street with 54-inch-high by 88-inch-wide RCPA	24,450	0
		3. 434–Replace 240 feet of 48-inch RCP east of N. 145th Street and north of Lilly Heights Drive with 54-inch-high by 88-inch-wide RCPA	122,990	0
		4. 422–Replace 48 feet of 48-inch RCP east of N. 145th Street and south of Sunrise Avenue with 54-inch-high by 88-inch-wide RCPA	24,470	0
		5. 424–Replace 48 feet of 48-inch RCP crossing Sunrise Avenue east of N. 145th Street with 72-inch RCP	18,130	0
		6. 428–Replace 162 feet of 42-inch RCP east of N. 145th Street and north of Sunrise Avenue with 72-inch RCP	61,480	0
		7. 482–Replace 138 feet of 42-inch RCP east of N. 145th Street and south of Mildale Street with 72-inch RCP	52,400	0
		8. 356–Replace 46 feet of 42-inch RCP east of N. 145th Street and south of Mildale Street with 72-inch RCP	17,560	0
		9. 358–Replace 46 feet of 42-inch RCP crossing Mildale Street east of N. 145th Street with 54-inch-high by 88-inch-wide RCPA	23,500	0
		10. 363–Replace 349 feet of 42-inch RCP east of N. 145th Street and north of Mildale Street with 54-inch-high by 88-inch-wide RCPA	179,280	0
		11. 3265–Replace 53 feet of 42-inch RCP crossing Marcella Lane east of N. 145th Street with 45-inch-high by 73-inch-wide RCPA	18,680	0
		12. 3266–Replace 949 feet of 42-inch RCP between Glendale Avenue and Marcella Lane with 45-inch-high by 73-inch-wide RCPA	238,270	0
		13. 541–Replace 48 feet of 18-inch RCP crossing Glendale Avenue east of N. 145th Street with 23-inch-high by 36-inch-wide RCPA	7,690	0
		14. 543–Replace 72 feet of 24-inch RCP crossing Glendale Avenue west of N. 145th Street with 31-inch-high by 51-inch-wide RCPA	15,940	0
		15. 3402–Replace 314 feet of 18-inch RCP between Cameron Court and Glendale Avenue east of N. 145th Street with 23-inch-high by 36-inch-wide RCPA	50,210	0
		16. 3403–Replace 458 feet of 24-inch RCP between Cameron Drive Lower and Glendale Avenue west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	174,330	0
		17. 534–Replace 52 feet of 24-inch RCP crossing Cameron Drive Lower west of N. 145th Street with dual 27-inch-wide by 44-inch-wide RCPA	19,790	0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a] Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance (continued)		
BD-34 (continued)	City of Brookfield	18. 8964–Replace 333 feet of 24-inch RCP between Cameron Drive Upper and Cameron Drive Lower west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	126,750	0
		19. 3404–Replace 237 feet of 24-inch RCP between Cameron Drive Upper and Cameron Drive Lower west of N. 145th Street with dual 27-inch-high by 44-inch-wide RCPA	90,210	0
		20. 2647–Replace 54 feet of 24-inch RCP crossing Cameron Drive Upper west of N. 145th Street with dual 23-inch-high by 36-inch-wide RCPA	17,300	30
		21. 9033–Install 44 feet of new 15-inch RCP parallel culvert under N. 146th Street at Marcella Lane	2,950	30
		Subtotal BD-34	$1,291,310	$ 70
BD-35	City of Brookfield	1. 3656–Regrade 450 feet of swale south of Lisbon Road from N. 149th Street to Butler Ditch to have a depth of two feet, a bottom width of three feet, and one vertical on four horizontal side slopes	$ 12,940	$ 0
		2. 487–Replace 40 feet of 18-inch CMP crossing N. 149th Street south of Lisbon Road with 23-inch-high by 36-inch-wide RCPA	6,400	0
		Subtotal BD-35	$ 19,340	$ 0
BD-36	City of Brookfield	1. 498–Replace 44 feet of 15-inch CMP crossing N. 159th Street south of Senate Street with 18-inch RCP. Lower upstream invert by 0.4 foot[e]	$ 5,000	$ 0
		Subtotal BD-36	$ 5,000	$ 0
		Stormwater Conveyance (continued)		
BD-37	City of Brookfield	1. 494–Replace 46 feet of 18-inch RCP under N. 149th Street south of Glendale Avenue with 21-inch RCP	$ 3,860	$ 0
		Subtotal BD-37	$ 3,860	$ 0
		Stormwater Conveyance in Backyard Easement		
BD-5	City of Brookfield	1. 992–Replace 130 feet of 48-inch and 60-inch RCP crossing Pilgrim Road north of Brook Lane with 54-inch RCP	$ 35,100	$ 0
		2. 3278–Replace 234 feet of 48-inch RCP along Brook Lane from Laura Lane to Pilgrim Road with 54-inch RCP	63,180	0
		3. 3275–Replace 208 feet of 48-inch RCP west of Brook Lane and southwest of Peppercorn Circle with 54-inch RCP	39,940	0
		4. 808–Replace 200 feet of 48-inch RCP east of N. 160th Street and west of Brook Lane with 54-inch RCP	38,400	0
		5. 754–Replace 44 feet of 42-inch RCP crossing N. 160th Street north of Spruce Lane with 48-inch RCP	9,240	0
		6. 3271–Replace 38 feet of 30-inch RCP crossing Willow Ridge Lane west of N. 163rd Street with 36-inch RCP	5,700	0
		7. 3436–Replace 625 feet of 30-inch RCP north of Willow Ridge Lane and west of N. 163rd Street with 36-inch RCP	70,630	0
		Subtotal BD-5	$ 262,190	$ 0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
		Stormwater Conveyance with Limited Downstream Detention Storage		
BD-28	City of Brookfield	1. 3723–Enclose 160 feet of existing ditch along Cherry Hill Drive with new 21-inch RCP connecting the existing storm sewer system on the south side of Tarrytown Road	$ 14,400	$ 100
		2. 2906–Replace 32 feet of 18-inch RCP crossing Douglas Drive west of Anders Lane with 18-inch-high by 29-inch-wide RCPA	3,880	0
		3. 1263–Replace 42 feet of 18-inch RCP crossing N. 167th Street at Woodview Drive with 24-inch RCP	4,200	0
		4. 1265–Replace 37 feet of 18-inch RCP crossing Woodview Drive at N. 167th Street with 24-inch RCP	3,700	0
		5. 1254–Replace 160 feet of 36-inch RCP south of Woodview Drive and north of Arrowhead Lake Park with 42-inch RCP	20,960	0
		6. 8894–Regrade 90 feet of ditch to create a more defined channel from the outfall of the 42-inch RCP called for under Item 5 above (No. 1254) to Arrowhead Lake with a depth of one foot, a bottom width of two feet, and side slopes of one vertical on five horizontal	1,250	0
		7. 3456–Replace 74 feet of 24-inch RCP crossing Shoreline Drive discharging to Arrowhead Lake with 27-inch-high by 44-inch-wide RCPA	15,500	0
		8. 2812–Replace 50 feet of 18-inch-high by 24-inch-wide CMPA crossing Over Hill Drive at Lone Elm Drive with 18-inch-high by 29-inch-wide RCPA	4,600	0
		9. 9012–Install 50 feet of new 18-inch-high by 29-inch-wide RCPA under Over Hill Drive at Lone Elm Drive parallel with the replacement pipe called for under Item 8 above (No. 2812)	4,600	30
		10. 9013–Install 40 feet of new 15-inch RCP under Lone Elm Drive at Over Hill Drive to create a bypass	2,680	20
		11. 3562–Regrade 640 feet of ditch to lower inverts with a bottom width of five feet, side slopes of one vertical on seven horizontal and one vertical on eight horizontal, and a depth of 1.25 feet	13,420	0
		12. 3324–Replace 44 feet of 18-inch-high by 24-inch-wide CMP crossing Cumberland Trail at Lone Elm Drive with an 18-inch-high by 29-inch-wide RCPA	4,050	0
		13. 3325–Replace 44 feet of 18-inch-high by 24-inch-wide CMP under Shadybrook Place at Lone Elm Drive with an 18-inch-high by 29-inch-wide RCPA	4,050	0
		14. 3718–Install 80 feet of new 18-inch-high by 29-inch-wide RCPA on the south side of Brookhill Drive east of Shadybrook Place in place of the existing swale and regrade area to provide cover	11,000	50
		15. 4057–Replace 20 feet of 18-inch-high by 24-inch-wide CMPA south of Brookhill Drive and east of Shadybrook Place with 23-inch-high by 36-inch-wide RCPA. Connect to RCPA to be installed per Item 14 above (No. 3718)	3,200	0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
Stormwater Conveyance with Limited Downstream Detention Storage (continued)				
BD-28 (continued)	City of Brookfield	16. 3327–Replace 170 feet of 48-inch RCP south of Brookhill Drive and east of Shadybrook Place with 45-inch-high by 73-inch-wide RCPA	$ 42,670	$ 0
		17. 9020–Install 170 feet of new 24-inch RCP south of Brookhill Drive, east of Shadybrook Place, and parallel with the RCPA to be installed per Item 16 above (No. 3327)	13,260	110
		18. 9023–Install 672 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	75,940	190
		19. 9025–Install 206 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	23,280	60
		20. 9028–Install 200 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	22,600	60
		21. 9029–Install 250 feet of new 36-inch RCP south of Brookhill Drive parallel to the existing pipes in the backyards	28,250	70
		22. 9030–Install 50 feet of new 36-inch RCP under Pilgrim Road north of Vernon Drive parallel to the existing pipe	7,500	10
		23. 2810011157–Lower existing inlet grate by about one foot and regrade approximately 0.1 acre to provide adequate drainage to inlet at low area west of Pilgrim Road and north of Vernon Drive	3,820	0
		24. 2807–Install an additional inlet and 15 feet of new 18-inch RCP at low area west of Pilgrim Road and north of Vernon Drive	1,200	10
		25. Floodproof structure north of Vernon Drive along Pilgrim Road	12,560	0
		26. 3345–Replace 78 feet of 24-inch RCP crossing Pilgrim Road at Vernon Drive with 27-inch RCP	8,580	0
		27. 3477–Replace 110 feet of 30-inch RCP along the east side of Pilgrim Road with 36-inch RCP	16,500	0
		28. 3478–Replace 423 feet of 30-inch RCP along the east side of Pilgrim Road with 36-inch RCP	63,450	0
		29. 1522–Replace 60 feet of 30-inch CMP crossing Vernon Drive along the east side of Pilgrim Road with 36-inch CMP	5,060	0
		30. 3479–Replace 48 feet of 15-inch CMP crossing Shetland Lane at Vernon Drive with 18-inch RCP	3,660	0
		31. 3686–Regrade 120 feet of existing ditch to have a bottom width of two feet, one vertical on four horizontal sides slopes, a depth of one foot	1,440	0
		32. 2916–Replace 111 feet of 12-inch RCP along Vernon Drive between Shetland Lane and Bittersweet Road with 18-inch RCP	8,880	0
		33. 3480–Replace 173 feet of 15-inch RCP along Vernon Drive between Shetland Lane and Bittersweet Road with 18-inch RCP	13,840	0

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
Stormwater Conveyance with Limited Downstream Detention Storage (continued)				
BD-28 (continued)	City of Brookfield	34. 3481–Replace 147 feet of 15-inch RCP along Vernon Drive crossing Bittersweet Road with 18-inch RCP	$ 11,320	$ 0
		35. 3482–Replace 103 feet of 15-inch RCP north of Vernon Drive with 16-inch-high by 26-inch-wide RCPA	7,420	0
		36. 1712–Replace 50 feet of 12-inch RCP crossing Saint Therese Boulevard with 14-inch-high by 22-inch-wide RCPA	3,850	0
		Subtotal BD-28	$ 486,570	$ 710
Seal Sanitary Sewer Manhole				
BD-42	City of Brookfield	1. Seal lowest sanitary sewer manhole in the midblock sag in Shamrock Lane east of Dublin Court	$ 1,250	$ 0
		Subtotal BD-42	$ 1,250	$ 0
- -	- -	Subtotal Stormwater Drainage Plan Element	$4,871,050	$ 8,550
Water Quality Management Plan Element				
Five Wet Detention Basin with Increased Street Sweeping in Critical Areas				
- -	City of Brookfield Village of Menomonee Falls	1. Street sweeping (56 curb-miles)[i]	$ 0	$14,900
- -	City of Brookfield Village of Menomonee Falls	2. Site-specific controls for new development or redevelopment	- -[j]	- -[j]
- -	City of Brookfield Village of Menomonee Falls	3. Development or expansion of public education programs and resultant improved urban "housekeeping" practices	- -[j]	- -[j]
- -	City of Brookfield Village of Menomonee Falls	4. Municipal programs for collection and management of leaf and grass clippings	- -[j]	- -[j]
- -	City of Brookfield Village of Menomonee Falls	5. Controls on application of fertilizer on municipality controlled properties	- -[j]	- -[j]
- -	City of Brookfield Village of Menomonee Falls	6. Program to detect and eliminate illicit discharges to storm sewers	- -[j]	- -[j]
- -	City of Brookfield Village of Menomonee Falls	7. Strict enforcement of construction erosion control ordinances	- -[j]	- -[j]
- -	City of Brookfield Village of Menomonee Falls	8. Reduction of application of streets and investigation of alternative snow and ice control agents	- -[j]	- -[j]
- -	City of Brookfield	9. Construct wet detention basin to serve existing development southeast of intersection of Pilgrim and Lisbon Roads Permanent pond volume = 3.5 acre-feet	209,890	5,890
- -	Village of Menomonee Falls	10. Construct wet detention basin to serve existing development east of Pilgrim Road and north of Susan Drive Permanent pond volume = 4.3 acre-feet	205,690	4,870
- -	Village of Menomonee Falls	11. Construct wet detention basin to serve planned development west of Pilgrim Road Permanent pond volume = 1.0 acre-foot	46,100	2,150

Table 43 (continued)

Hydrologic Unit	Location of Component	Project and Component Designation and Description	Estimated Cost[a]	
			Capital[b,c]	Annual Operation and Maintenance[d]
Five Wet Detention Basin with Increased Street Sweeping in Critical Areas (continued)				
- -	Village of Menomonee Falls	12. Construct wet detention basin to serve planned development east of Pilgrim Road Permanent pond volume = 2.1 acre-feet	42,300	2,110
- -	Village of Menomonee Falls	13. Construct wet detention basin to serve planned development east of Pilgrim Road Permanent pond volume = 0.8 acre-foot	66,800	2,690
- -	- -	Subtotal Water Quality Management Plan Element	$ 570,780	$32,610
- -	- -	Total for Stormwater Management Plan	$5,441,830	$41,160

[a] *Costs based upon* 2001 Engineering News-Record *Construction Cost Index = 7,360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Costs do not include easements or land acquisition unless specifically noted.*

[d] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[e] *This work has been completed by the City of Brookfield.*

[f] *These proposed replacement pipes could be moved to the public right-of-way along Princeton Road and Hampstead Drive and the existing pipes could be maintained to handle local runoff. The feasibility of moving the pipes, and perhaps reducing their size, since some runoff could be conveyed in the existing pipes, could be investigated during the engineering design phase.*

[g] *Incremental cost for water quantity control.*

[h] *Cost includes detention basin outlets: 3913A for POND, SW OUTLET for SW BASIN, and SE OUTLET for SE BASIN.*

[i] *Sweep every four weeks between April 1 and October 31.*

[j] *No specific costs estimated.*

Source: SEWRPC.

Full implementation of the recommended stormwater drainage measures would provide a minor stormwater drainage system adequate to convey and/or store runoff from storms with recurrence intervals up to, and including 10 years and to generally provide an acceptable level of traffic service and access to property during such storms. Implementation of the recommended drainage measures would also avoid direct flooding of inhabited buildings during storms with recurrence intervals up to, and including 100 years. The recommended measures would help to mitigate, but not eliminate, flooding of basements due to sanitary sewer backup. Other measures directed toward reduction of infiltration and inflow to sanitary sewers would be required to fully alleviate sanitary sewer backup problems.

Additional Measures for the Control of Nonpoint Source Pollution

In addition to the control of runoff from areas of planned development that would be provided by the recommended wet detention basins, the recommended plan calls for the control of nonpoint source pollution from all remaining areas to be developed, or from areas of redevelopment and in-fill development. Such control would be achieved through 1) construction site erosion control measures and 2) site-specific best management practices to reduce the washoff of pollutants, consistent with the performance standards of Chapter NR 151 of the *Wisconsin Administrative Code*.

Table 44

RECOMMENDED BUTLER DITCH STORM WATER MANAGEMENT PLAN COST SUMMARY

Recommended Plan	City of Brookfield[a]		Village of Menomonee Falls[a]		Private Sector[a]		Estimated Cost[a]	
	Estimated Capital Cost[b]	Estimated Annual Operation and Maintenance Cost Increase[c]	Estimated Capital Cost[b]	Estimated Annual Operation and Maintenance Cost Increase[c]	Estimated Capital Cost[b]	Estimated Annual Operation and Maintenance Cost Increase[c]	Estimated Total Capital Cost[b]	Estimated Total Annual Operation and Maintenance Cost Increase[c]
BD-2–Stormwater Conveyance with Detention Storage	$ 236,930	$ 150	- -	- -	- -	- -	$ 236,930	$ 150
BD-4a1–Stormwater Conveyance	4,640	0	- -	- -	- -	- -	4,640	0
BD-5a1–Stormwater Conveyance in Backyard Easement	262,190	0	- -	- -	- -	- -	262,190	0
BD-8–Stormwater Conveyance	11,700	0	- -	- -	- -	- -	11,700	0
BD-12–Stormwater Conveyance	14,880	0	- -	- -	- -	- -	14,880	0
BD-16–Stormwater Conveyance with Detention Storage	1,597,760	770	- -	- -	- -	- -	1,597,760	770
BD-17–Stormwater Conveyance	33,320	50	- -	- -	- -	- -	33,320	50
BD-20–Stormwater Conveyance	29,920	0	- -	- -	- -	- -	29,920	0
BD-28a2–Stormwater Conveyance with Limited Downstream Detention Storage	486,570	710	- -	- -	- -	- -	486,570	710
BD-34a2–Stormwater Conveyance	1,291,310	70	- -	- -	- -	- -	1,291,310	70
BD-35–Stormwater Conveyance	19,340	0	- -	- -	- -	- -	19,340	0
BD-36–Stormwater Conveyance	5,000	0	- -	- -	- -	- -	5,000	0
BD-37–Stormwater Conveyance	3,860	0	- -	- -	- -	- -	3,860	0
BD-42–Seal Sanitary Sewer Manhole	1,250	0	- -	- -	- -	- -	99,990	0
BD-44–Stormwater Conveyance with Detention Storage	256,830	0	$ 14,490	$ 1,850	$600,970	$ 4,950[d]	872,290	6,800
Subtotal for Stormwater Quantity	$4,255,590	$ 1,750	$ 14,490	$ 1,850	$600,970	$ 4,950[d]	$4,871,050	$ 8,550
Alternative 1–Construct Five New Wet Detention Basins with Increased Street Sweeping in Critical Areas	$ 209,890[e]	$13,340	$205,690[e]	$12,320	$155,200	$ 6,950	$ 570,780	$32,610
Subtotal for Stormwater Quality	$ 209,890[e]	$13,340	$205,690[e]	$12,320	$155,200	$ 6,950	$ 570,780	$32,610
Total for Butler Ditch Subwatershed	$4,465,480	$15,090	$220,180	$14,170	$756,170	$11,900	$5,441,830	$41,160

[a] *Costs based upon* 2001 Engineering News-Record *Construction Cost Index = 7,360.*

[b] *Includes 35 percent for engineering, administration, and contingencies.*

[c] *Operation and maintenance costs are listed as $0 when an existing component is replaced with a component having similar operation and maintenance costs.*

[d] *Annual operation and maintenance costs for detention basins to serve planned development would be borne by homeowners associations or property owners according to Village policy.*

[e] *Includes cost to provide control of two-year storm for basins serving existing development. (Should be eligible for WDNR cost-sharing.)*

Source: Ruekert & Mielke, Inc., and SEWRPC.

Table 45

MAPS IN CHAPTER V WHICH DEPICT THE RECOMMENDED STORMWATER DRAINAGE PLAN ELEMENT

Hydrologic Unit	Map Numbers
BD-2	16 through 19
BD-4	20
BD-5	22
BD-8	24
BD-12	25
BD-16	26 through 29
BD-17	30
BD-20	31
BD-28	39 through 45
BD-34	56 through 58
BD-35	59
BD-36	60
BD-37	61
BD-44	63 through 71

Source: SEWRPC.

The plan also calls for 1) maintenance of the existing 16 ponds in the study area; 2) increasing the frequency of street sweeping in industrial and commercial areas with urban street cross-sections and curb and gutter to once every four weeks between April 1 and October 31, and conversion to high-efficiency sweepers by 2013; and 3) the following measures which are consistent with the requirements of Chapter NR 151:

- Development and/or expansion of public education programs to encourage good urban "housekeeping" practices,
- Municipal programs for the collection and management of leaf and grass clippings,
- Controls on the application of lawn and garden fertilizers on municipally controlled properties,
- A program to detect and eliminate illicit discharges to storm sewers,
- Strict enforcement of the existing construction erosion control ordinances, and
- Reduced application of sand on streets in the winter and investigation of the feasibility of applying effective alternative snow and ice control agents that are less harmful to the environment than sodium and calcium chloride.

As described in Chapter IV, it is concluded that, to the maximum extent practicable, this plan meets the standards for 20 percent and 40 percent control as set forth under NR 151, and the plan is considered to be consistent with the regional water quality management plan goals.

Stormwater Management Plan Costs

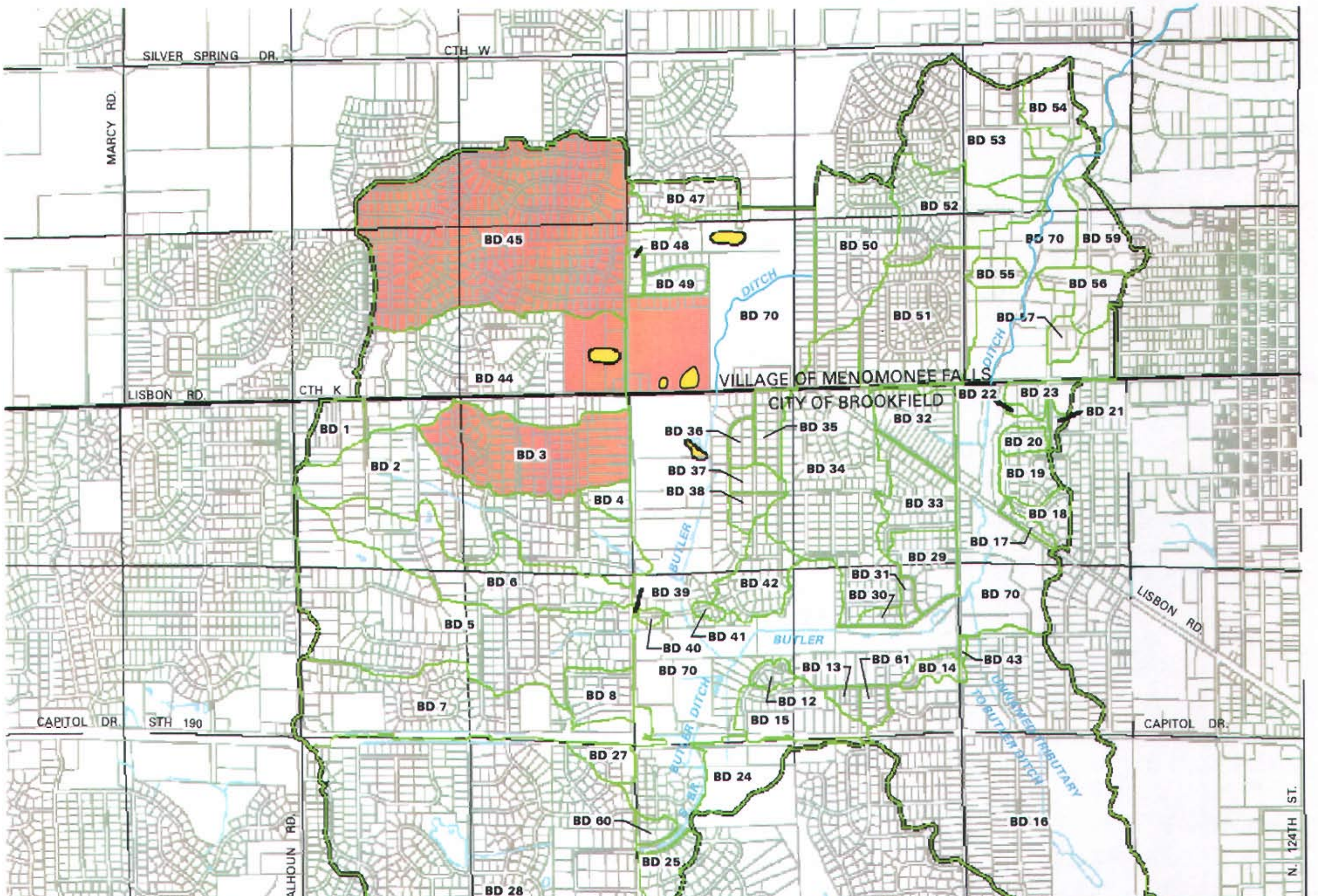
As set forth in Table 43, the estimated capital cost of the recommended water quality management plan element is $571,000 and the estimated capital cost of the recommended stormwater drainage plan element is $4,871,000. Thus, the estimated capital cost of the recommended stormwater management plan is $5,442,000. The estimated annual operation and maintenance cost increase is $32,610 for the recommended water quality management plan element and $8,550 for the recommended stormwater drainage plan element. Thus, the total estimated annual operation and maintenance cost increase is $41,160. As previously mentioned, the capital costs include construction, engineering and contingencies. They do not include land acquisition or legal fees, unless specifically noted.

RECOMMENDED FLOODLAND MANAGEMENT PLAN

Consistent with established Federal, State, and local regulations and with the standards adopted by the City and Village under this planning effort, the floodland management plan element is intended to avoid direct overland flooding of buildings, or to mitigate the effects of such flooding, during floods with recurrence intervals up to, and including, 100 years. Thus, because direct overland flooding of buildings would not be expected to occur during a 100-year flood under planned land use and existing channel and drainage conditions, no flood control measures are recommended under this plan.

Map 72

RECOMMENDED WATER QUALITY MANAGEMENT PLAN
FIVE NEW WET DETENTION BASINS WITH INCREASED STREET SWEEPING IN CRITICAL AREAS



Source: Ruekert & Mielke, Inc. and SEWRPC.

100-Year Recurrence Interval Flood Flows and Floodplain Delineations

Tables 46, 47, and 48 present estimated 100-year recurrence interval flood flows at selected locations along Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch, respectively. It was found that the proposed development between 1995 and attainment of buildout conditions was not significant enough to produce increases in flood flows between 1995 land use and existing channel conditions and buildout land use and existing channel and drainage conditions.[1]

The planned land use and existing channel and drainage condition flood flows for Butler Ditch, the South Branch, and the Unnamed Tributary were used to compute flood profiles for delineation of the 100-year floodplain and floodway limits that are recommended to be adopted by the City and the Village (Map 14 in Chapter V). The floodplain delineations were accomplished using one-inch-equals-100-feet scale, two-foot contour interval topographic maps prepared to Regional Planning Commission standards.

Under the requirements of Chapter NR 116, "Wisconsin's Floodplain Management Program," of the *Wisconsin Administrative Code*, the effects on flood flows of planned facilities, such as detention basins, that may be constructed in the future cannot be considered in delineating a regulatory floodplain until the facilities are constructed. If the recommended detention basins are constructed, the City and Village could evaluate their effect on flood flows and revise the 100-year flood profiles and floodplain maps if the changes were large enough.

Comparison to the Federal Flood Insurance Study

The hydrologic and hydraulic analyses performed under this planning effort for the determination of 100-year recurrence interval flood stages along Butler Ditch refine the corresponding analyses performed under the 1978 Federal Emergency Management Agency (FEMA) flood insurance study (FIS) for the Village of Menomonee Falls and the 1986 FEMA FIS for the City of Brookfield.

As may be seen from an examination of Tables 46 through 48, the Commission flood flows developed for planned land use and existing channel conditions are somewhat lower than the FIS flood flows for each stream. The differences are due to a better accounting for the existing wetland/floodplain storage and extension of the simulation modeling period of record.

Recommendation

It is recommended that both the City of Brookfield and the Village of Menomonee Falls revise their floodplain zoning ordinances to recognize the 100-year flood profile and floodplain and floodway limits as determined under this planning effort. It is also recommended that both communities include ordinance revisions designed to maintain existing floodwater storage capacities.[2]

EVALUATION OF EFFECTS OF IMPLEMENTATION OF THE RECOMMENDED STORMWATER MANAGEMENT PLAN ON FLOOD FLOWS IN BUTLER DITCH

Because the SWMM model represents both the existing and recommended stormwater management systems and the stream system of the subwatershed in detail, it was applied to evaluate the effects on flood flows of implementing the recommended stormwater management plan. The main flow comparison locations, from upstream to downstream, are:

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[1] *Flows were computed with the USEPA HSPF continuous simulation model and the USCOE HEC-FFA flood frequency analysis program. Given the level of detail of the HSPF model, the planned land use changes between 1995 and buildout were not sufficient to result in a significant change in flood flows.*

[2] *The Commission staff has computed updated flood profiles throughout the City of Brookfield under a map updating program undertaken by the City. The City and Commission staffs are also developing zoning ordinance revisions to preserve floodwater storage capacity.*

Table 46

COMPARISON OF 100-YEAR RECURRENCE INTERVAL FLOOD FLOWS FOR BUTLER DITCH

Location	River Mile	1995 and Buildout Land Use and Existing Channel Conditions (cfs)[a]	Federal Flood Insurance Study (cfs)
About 50 Feet Downstream of Dolphin Drive (Village of Menomonee Falls)	3.99	53	- -[b]
About 1,500 Feet Upstream of Lisbon Road (Village of Menomonee Falls)	3.71	212	- -[b]
At Lisbon Road (corporate limits)	3.40	212	820[c]
About 100 Feet Downstream of Lisbon Road (City of Brookfield)	3.38	415	820[c]
At Confluence with the South Branch of Butler Ditch (City of Brookfield)	2.50	617	1,213[c]
At Lilly Road (City of Brookfield)	1.76	617	1,213[c]
Just Downstream of Confluence with the Unnamed Tributary to Butler Ditch (City of Brookfield)	1.63	718	1,213[c]
At Lisbon Road (City of Brookfield)	1.35	718	1,213[c]
At Hampton Road (corporate limits)	1.02	808	1,213[c]
Above Confluence with the Menomonee River (Village of Menomonee Falls)	0.02	808	1,213[d]

[a] *Based upon simulated record from 1940 through 1998.*

[b] *No floodplain delineation made or flood flows computed under Federal Emergency Management Agency (FEMA) Flood Insurance Study.*

[c] *Flow based upon 1986 FEMA* Federal Flood Insurance Study – City of Brookfield, Wisconsin.

[d] *Flow based upon 1978 FEMA* Federal Flood Insurance Study – Village of Menomonee Falls, Wisconsin.

Source: SEWRPC.

Table 47

COMPARISON OF 100-YEAR RECURRENCE INTERVAL FLOOD FLOWS FOR THE SOUTH BRANCH OF BUTLER DITCH IN THE CITY OF BROOKFIELD

Location	River Mile	1995 and Buildout Land Use and Existing Channel Conditions (cfs)[a]	1986 Federal Flood Insurance Study for the City of Brookfield (cfs)
Just Downstream of Pilgrim Road	0.69	398	- -[b]
About 300 Feet Upstream of Capitol Drive	0.35	245	- -[b]
At W. Capitol Drive (STH 190)	0.27	245	455
About 50 Feet Downstream of Capitol Drive	0.24	382	455
At Confluence with Butler Ditch	0.00	382	455

[a] *Based upon simulated record from 1940 through 1998.*

[b] *Approximate delineation under FEMA* Flood Insurance Study – City of Brookfield, Wisconsin, *therefore, no flood flows were published in the Flood Insurance Study.*

Source: SEWRPC.

Table 48

100-YEAR RECURRENCE INTERVAL FLOOD FLOWS FOR UNNAMED TRIBUTARY TO THE BUTLER DITCH IN THE CITY OF BROOKFIELD

Location	River Mile	1995 and Buildout Land Use and Existing Channel and Drainage Conditions (cfs)[a,b]
At Wisconsin Memorial Park Pond	1.02	52
About 1000 Feet Upstream of Capitol Drive	0.70	103
At W. Capitol Drive (STH 190)	0.51	103
At Hope Street	0.15	103
Above Confluence with Butler Ditch	0.06	103

[a] *Based upon simulated record from 1940 through 1998.*

[b] *Approximate delineation under FEMA Flood Insurance Study, therefore, no flood flows were published in the Flood Insurance Study.*

Source: SEWRPC.

- The upstream crossing of W. Lisbon Road where Butler Ditch flows from Menomonee Falls into Brookfield,
- The crossing of W. Hampton Road where Butler Ditch flows from Brookfield back into Menomonee Falls, and
- The mouth of Butler Ditch at the Menomonee River.

Flood flows were evaluated in the context of the following criteria:

- The MMSD Chapter 13 "Surface Water and Storm Water" rule calls for new development in areas subject to the rule to cause no increase "in the regional flood (100-year) and stream bank erosion rates (two-year flood)."
- The plan objectives set forth in Chapter III call for two- through 100-year flood flows and stages along the main stem of Butler Ditch to be maintained at, or below, the corresponding flows and stages under existing land use and channel conditions at, and downstream from, municipal boundaries.

The following three conditions were evaluated:

- 1995 land use, existing channel and stormwater management conditions,
- Buildout land use, existing channel and stormwater management conditions, and
- Buildout land use, existing channel and recommended stormwater management conditions.

Peak 100- and two-year recurrence interval flood flow comparisons are set forth in Tables 49 and 50, respectively. Those comparisons enable quantification of the effects on peak flood flows of 1) planned land use changes after 1995 and 2) implementation of the recommended stormwater management measures. Each of columns 1 through 3 in Tables 49 and 50, builds off the other. That is, column 1 indicates the change in peak flow anticipated to result from conversion of land to urban uses in the time period from 1995 to the achievement of buildout

Table 49

RELATIVE 100-YEAR STORM FLOW COMPARISON ALONG THE MAIN STEM OF BUTLER DITCH

	100-Year Storm[a]		
	Buildout Land Use, Existing Channel and Stormwater Management Conditions[b]	Buildout Land Use, Existing Channel, and Recommended Stormwater Management Conditions[c]	
Location	(1) Change in Peak Flow Relative to 1995 Land Use and Existing Channel and Stormwater Management Conditions (percent)	(2) Change in Peak Flow Relative to Buildout Land Use, Existing Channel and Stormwater Management Conditions[b] (percent)	(3) Change in Peak Flow Relative to 1995 Land Use and Existing Channel and Stormwater Management Conditions (percent)
Upstream W. Lisbon Road Crossing (flow from Menomonee Falls to Brookfield)	1.9	-5.8	-4.0
Lilly Road Crossing in Brookfield...............	-1.0	2.4	1.4
W. Hampton Road Crossing (flow from Brookfield to Menomonee Falls)	2.7	0.9	3.6
Mouth at Menomonee River......................	2.8	0.9	3.7

[a] *Flows determined based on a critical storm duration analysis.*

[b] *For buildout land use with existing channel and stormwater management conditions, it is assumed that there are no controls on runoff from new urban development and redevelopment. Determining flood flows under that condition enables the need for controls to be evaluated through comparison with existing land use, channel, and stormwater management conditions. If a need for controls is established, analyses are then made to determine whether to apply 1) specific controls established through the systems planning process, or 2) controls that meet the requirements of the MMSD Chapter 13 rule.*

[c] *Those measures include specifically recommended stormwater conveyance and detention facilities. The effects of detention facilities provided for new development or redevelopment in Brookfield to meet MMSD Chapter 13 requirements are not included.*

Source: SEWRPC.

conditions as expected in 2010. Column 2 indicates the additional effects on peak flows resulting from implementation of the recommended stormwater management measures. Finally, column 3 represents the overall change in 1995 condition peak flows that would result from the combination of planned land use changes and implementation of the recommended stormwater management measures.

Evaluation of 100-Year Recurrence Interval Flows Relative to the Requirements of MMSD Chapter 13

As seen from column 1 of Table 49, anticipated land use changes alone during the time period from 1995 through achievement of full buildout conditions around 2010 would be expected to raise the peak 100-year flood flow by about 1.9 percent at W. Lisbon Road where flow passes from Menomonee Falls to Brookfield, by 2.7 percent at W. Hampton Road where flow passes from Brookfield to Menomonee Falls, and by about 2.8 percent at the mouth at the Menomonee River. Important conclusions that can be drawn from that comparison are 1) that changes in land use in the portion of the Village of Menomonee Falls downstream from W. Hampton Road would have an insignificant effect on the peak flood flow at the mouth and 2) that land use changes in the City of Brookfield, in the absence of runoff controls on new development or redevelopment, would have a more substantial effect on peak flows entering the Menomonee River.[3,4]

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[3] *The projected changes in flow due to development and/or redevelopment would not be expected to occur assuming continued application of the current City stormwater management ordinance, which calls for runoff controls that meet the requirements of the MMSD Chapter 13 rule. The analyses made for this stormwater and floodland management plan are intended to evaluate whether such controls should be continued or whether specific controls established through the systems planning process can be substituted. (See page 218 for footnote 4.)*

Table 50

RELATIVE TWO-YEAR STORM FLOW COMPARISON ALONG THE MAIN STEM OF BUTLER DITCH

	Two-Year Storm[a]		
	Buildout Land Use, Existing Channel and Stormwater Management Conditions[b]	Buildout Land Use, Existing Channel, and Recommended Stormwater Management Conditions[c]	
Location	(1) Change in Peak Flow Relative to 1995 Land Use and Existing Channel and Stormwater Management Conditions (percent)	(2) Change in Peak Flow Relative to Buildout Land Use, Existing Channel and Stormwater Management Conditions[b] (percent)	(3) Change in Peak Flow Relative to 1995 Land Use and Existing Channel and Stormwater Management Conditions (percent)
Upstream W. Lisbon Road Crossing (flow from Menomonee Falls to Brookfield)	12.7	-15.2	-4.4
Lilly Road Crossing in Brookfield................	1.6	-0.8	0.8
W. Hampton Road Crossing (flow from Brookfield to Menomonee Falls)	4.1	2.9	7.1
Mouth at Menomonee River.......................	3.6	3.0	6.7

[a] *Flows determined based on a critical storm duration analysis.*

[b] *For buildout land use with existing channel and stormwater management conditions, it is assumed that there are no controls on runoff from new urban development and redevelopment. Determining flood flows under that condition enables the need for controls to be evaluated through comparison with existing land use, channel, and stormwater management conditions. If a need for controls is established, analyses are then made to determine whether to apply 1) specific controls established through the systems planning process, or 2) controls that meet the requirements of the MMSD Chapter 13 rule.*

[c] *Those measures include specifically recommended stormwater conveyance and detention facilities. The effects of detention facilities provided for new development or redevelopment in Brookfield to meet MMSD Chapter 13 requirements are not included.*

Source: SEWRPC.

As set forth in column 2 of Table 49, implementation of the recommended stormwater management measures under buildout land use conditions would be expected to decrease the peak 100-year storm flood flow in Butler Ditch by about 5.8 percent where flow passes from Menomonee Falls to Brookfield[5] and to increase the peak flow by about 0.9 percent at the downstream location where flow passes from Brookfield to Menomonee Falls and also at the mouth at the Menomonee River. The key conclusion from these comparisons is that in the absence of controls on runoff from new development and redevelopment, implementation of the recommended stormwater management measures in the City of Brookfield would have the theoretical net result of increasing the peak flow by 0.9 percent at the downstream boundary with Menomonee Falls and at the confluence of Butler Ditch and the

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[4] *It should be noted that increases in 100- or two-year peak flood flows relative to the 1995 land use conditions applied under this plan are greater than increases relative to land use conditions when the MMSD Chapter 13 rule took effect on January 1, 2002. It would be reasonable for MMSD to evaluate changes relative to that 2002 date, since communities should not be retroactively penalized for development activity prior to promulgation of the rules.*

[5] *The stormwater detention facilities recommended under this plan for the Village of Menomonee Falls upstream of the City of Brookfield were sized based on application of MMSD Chapter 13 two- and 100-year storm release rates. This was practical because there are two large-scale areas of potential development in the Village that could be served with centralized facilities that could readily be analyzed. In the City of Brookfield, potential new development would be more scattered and, thus, less amenable to direct analysis.*

Menomonee River.[6] A change of 0.9 percent is considered to be insignificant and comparison of flood flow hydrographs at the mouth of Butler Ditch shows that the hydrograph timing under planned land use and recommended plan conditions would essentially be the same as under 1995 conditions. Therefore, it can reasonably be concluded that implementation of the recommended stormwater measures would have no significant adverse impact on Menomonee River flood flows and stages at, and downstream from, its confluence with Butler Ditch. Thus, with the previous characterization of the impact of land use changes in the City of Brookfield in mind, mitigation of the effects of those impacts becomes the focus of a plan to avoid increasing flows on the Menomonee River. It is recommended that such mitigation be accomplished by continuing to require that new development and redevelopment in Brookfield be provided with runoff controls consistent with MMSD Chapter 13.

Evaluation of 100-Year Recurrence Interval Flows Relative to the "No Increase" Standard at Municipal Boundaries

Column 3 of Table 49 indicates that implementation of the recommended stormwater management measures in the portion of the subwatershed in Menomonee Falls upstream of W. Lisbon Road would reduce the 100-year flood flow passing to Brookfield, relative to 1995 conditions, by 4.0 percent at the upstream boundary between the two communities. Thus, the objective of not increasing the 100-year flood flow under buildout conditions relative to 1995 conditions is met at that location. As described above, the comparison in Table 49 also demonstrates that the implementation of the recommended stormwater management measures in the portion of the subwatershed in Menomonee Falls and Brookfield upstream of W. Hampton Road would result in an insignificant increase in the peak 100-year flow passing from Brookfield to Menomonee Falls at W. Hampton Road.

Comparison of the relative change in flood flows set forth in Table 49 indicates that the change in flow at W. Hampton Road (3.6 percent) is largely attributable to land use changes in Brookfield. The recommendation to continue requiring runoff controls consistent with MMSD Chapter 13 for new development and redevelopment in the City of Brookfield should reduce the peak 100-year flow in Butler Ditch and avoid a significant increase in the peak flow at the crossing from Brookfield to Menomonee Falls, relative to 1995 conditions.

Evaluation of Two-Year Recurrence Interval Flows Relative to the Requirements of MMSD Chapter 13

As seen from column 1 of Table 50, anticipated land use changes alone during the time period from 1995 through achievement of full buildout conditions would be expected to raise the peak two-year storm flood flow by about 12.7 percent at W. Lisbon Road where flow passes from Menomonee Falls to Brookfield, by 4.1 percent at W. Hampton Road where flow passes from Brookfield to Menomonee Falls, and by about 3.6 percent at the mouth at the Menomonee River. Important conclusions that can be drawn from that comparison are 1) that changes in land use in the portion of the Village of Menomonee Falls downstream from W. Hampton Road would not be expected to increase the peak flood flow at the mouth since the increase relative to 1995 is less at the mouth than at W. Hampton Road and 2) that land use changes in the City of Brookfield and in the Village of Menomonee Falls upstream of Brookfield, in the absence of runoff controls on new development or redevelopment, would have a more substantial effect on peak flows.

As set forth in column 2 of Table 50, implementation of the recommended stormwater management measures under buildout land use conditions would be expected to decrease the peak two-year storm flood flow in Butler Ditch by about 15.2 percent where flow passes from Menomonee Falls to Brookfield, increase the peak flow by about 2.9 percent at the downstream location where flow passes from Brookfield to Menomonee Falls, and increase the flow by about 3.0 percent at the mouth at the Menomonee River. The key conclusion from these comparisons is that implementation of the recommended stormwater management measures in the City of Brookfield would have the theoretical net result of increasing the peak flow by 3 percent at the downstream boundary with Menomonee Falls and at the confluence of Butler Ditch. The approximately 3 percent increase in flood flows at the crossing from Brookfield to Menomonee Falls and at the mouth, respectively, are small changes

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[6] *There would be no change in the increase in the peak flow in the downstream portion of Menomonee Falls because no stormwater management measures are recommended for that area.*

that would not be expected to have significant negative impacts on streambank erosion and streambed scour, which are primarily influenced by relatively frequent flood events. That conclusion is based on the meandering nature of the channel and the fact that much of the streambed in the Menomonee Falls reach is in bedrock. Thus, with the previous characterization of the impact of land use changes in the City of Brookfield on two-year storm flows in mind, mitigation of the effects of those impacts becomes the focus of a plan to avoid increasing flows on the Menomonee River.[7] The recommendation set forth above that new development and redevelopment in Brookfield be provided with runoff controls as required under MMSD Chapter 13 is applicable to limiting increases in the peak two-year flows in Butler Ditch at the mouth, relative to 1995 conditions.

Evaluation of Two-Year Recurrence Interval Flows Relative to the "No Increase" Standard at Municipal Boundaries

Column 3 of Table 50 indicates that implementation of the recommended stormwater management measures in the portion of the subwatershed in Menomonee Falls upstream of W. Lisbon Road would reduce the two-year flood flow passing to Brookfield, relative to 1995 conditions, by 4.4 percent at the upstream boundary between the two communities. Thus, the objective of not increasing the two-year flood flow under buildout conditions relative to 1995 conditions is met at that location. As described above, the comparison in Table 50 also demonstrates that implementation of the recommended stormwater management measures in the portion of the subwatershed in Menomonee Falls and Brookfield upstream of W. Hampton Road would result in relatively small changes in peak two-year flood flows that would not be expected to have significant negative impacts on streambank erosion and streambed scour in the channel in Brookfield in the vicinity of W. Hampton Road and in Menomonee Falls downstream of W. Hampton Road.

Comparison of the relative changes in flood flows set forth in columns 1 and 2 of Table 50 indicates that most of the 7.1-percent change in flow at the W. Hampton Road crossing is attributable to land use changes in Brookfield. Thus, the recommendation set forth above that new development and redevelopment in Brookfield be provided with runoff controls as required under MMSD Chapter 13 is applicable to limiting increases in the peak two-year flood flows in Butler Ditch at the crossing from Brookfield to Menomonee Falls, relative to 1995 conditions.

EFFECT ON THE RECOMMENDED STORMWATER MANAGEMENT PLAN OF APPLYING THE VILLAGE OF MENOMONEE FALLS DESIGN STORM CRITERION

As noted in Chapter III of this report, the Village of Menomonee Falls has adopted design storm criteria that differ from those applied in the City of Brookfield and from those generally applied for consistency throughout the Butler Ditch subwatershed under this system plan. The Village has adopted a conservative approach requiring that 1) 24-hour design storm rainfall depths for various frequency events be taken from the isohyetal maps published by the Illinois State Water Survey[8] and 2) the total rainfall be distributed using either the U.S. Natural Resources Conservation Service (NRCS, formerly U.S. Soil Conservation Service) Type II distribution,[9] or the SEWRPC 90th percentile distribution. As presented in Chapter V, alternative and recommended stormwater management systems in the Village of Menomonee Falls were sized using the SEWRPC 2000 rainfall depth-duration-frequency data and time distribution. The recommended system in Menomonee Falls was then evaluated using the Village storm criteria (with the NRCS Type II distribution) in order to determine if any recommended components would require modification to convey and/or store runoff based on the Village criteria.

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[7] *The increases in peak two-year flow due to land use changes in the Village of Menomonee Falls upstream of Brookfield would be mitigated by implementation of the recommended stormwater management measures. Thus, additional controls on flow are not required in the Village.*

[8] *Floyd A. Huff, and James R. Angel,* Rainfall Frequency Atlas of the Midwest, *Illinois State Water Survey, Champaign, Bulletin 71, 1992.*

[9] *U.S. Soil Conservation Service, National Engineering Handbook Section 4 - Hydrology, March 1985.*

Hydrologic Unit BD-44 is the only hydrologic unit for which modified or new stormwater drainage facilities are recommended. The stormwater drainage system in that unit was evaluated using the Village design storm criteria and it was found that the recommended facilities as sized using the SEWRPC 2000 design storm were adequate except for the three detention basins proposed to serve planned development on either side of Pilgrim Road just north of W. Lisbon Road. As noted by in Table 43, if those three detention basins were to be sized according to the Village criterion, the total cost of the recommended stormwater management plan would be increased by about $63,000. The 100-year storm maximum storage volume of the basin on the west side of Pilgrim Road would increase from 9.6 acre-feet to 10.8 acre-feet and the 100-year volumes for the basins on the east side of Pilgrim Road would increase from 1.0 to 1.1 acre-feet and from 4.4 to 5.3 acre-feet.

TOTAL COST OF THE RECOMMENDED PLAN

The total capital cost of the recommended stormwater and floodland management plan as set forth in Table 43 is estimated to be $5.44 million, based on application of SEWRPC 2000 design storm criteria throughout the subwatershed and $5.50 million, based on application of SEWRPC 2000 design storm criteria in Brookfield and Village design storm criteria in Menomonee Falls. The annual operation and maintenance cost increase relative to existing conditions is estimated to be $41,160. The costs of the plan are apportioned between the City of Brookfield, the Village of Menomonee Falls, and the private sector in Chapter VII, "Plan Implementation."

AUXILIARY PLAN RECOMMENDATIONS

Natural Resources and Open Space Preservation

The adopted park and open space plan for the City of Brookfield, the Waukesha County development plan, and the adopted regional land use plan provide for the preservation of the primary environmental corridor lands within the City, the Village, and environs, including associated floodlands and wetlands in essentially natural, open uses.[10] The protection of floodlands and wetlands from the intrusion of 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.

Maintenance of Stormwater Management Facilities

The effectiveness of the stormwater management conveyance and detention facilities can be sustained only if proper operation, repair, and maintenance procedures are carefully followed. Important maintenance procedures include the periodic repair of storm sewers, clearing sewer obstructions, maintenance of open channel vegetation lining, clearing debris and sediment from open channels, maintenance of detention facilities inlets and outlets, maintenance of detention basin vegetative cover, and periodic removal of sediment accumulated in detention basins. These maintenance activities are recommended to be carried out on a continuing basis to maximize the effectiveness of the stormwater management facilities and measures along with protecting the capital investment in the facilities.

SUMMARY

Description of the Recommended Plan

The recommended stormwater management plan for the Butler Ditch subwatershed consists of two major elements: a water quality management element and a stormwater drainage element.

The components of the recommended stormwater management plan, including the water quality and stormwater drainage elements, and their estimated capital and annual operation and maintenance costs are summarized in Table 43. The recommended water quality management plan is summarized in graphic form on Map 72. The recommended stormwater drainage and water quality management plan calls for 1) the provision of new or

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[10] *SEWRPC Community Assistance Planning Report No. 108, 2nd Edition,* A Park and Open Space Plan for the City of Brookfield, Waukesha County, Wisconsin, *March 2001.*

replacement culverts and storm sewers at potential problem areas throughout the study area; 2) limited swale modification; 3) detention storage in Hydrologic Units BD-2, BD-16, and BD-28 in the City of Brookfield; 4) maintenance of existing constructed and natural detention storage in Hydrologic Unit BD-44 in the Village of Menomonee Falls; 5) three new wet detention storage basins to serve planned development in BD-44 in the Village of Menomonee Falls; 6) the provision of runoff controls as required under MMSD Chapter 13 for new development and redevelopment in Brookfield; 7) floodproofing of one house in Unit BD-28 in Brookfield; 8) sealing several sanitary sewer manholes in Brookfield; 9) increased sweeping of about 56 curb-miles of street in critical land use areas; 10) two new wet detention basins to serve existing development; 11) strict enforcement of the existing construction site erosion control ordinances; 12) site-specific best management practices, consistent with the requirements of proposed Chapter NR 151 of the *Wisconsin Administrative Code*, to reduce the washoff of pollutants from new development, redevelopment, or in-fill sites; 13) maintenance of the existing ponds in the study area; 14) municipal programs for the collection and management of leaf and grass clippings; 15) controls on the application of lawn and garden fertilizers on municipally controlled properties; 16) institution of programs to detect and eliminate illicit discharges to storm sewers; 17) reduced application of sand on streets in the winter and investigation of the feasibility of applying effective alternative snow and ice control agents that are less harmful to the environment than sodium and calcium chloride; and 18) public information and education efforts to promote good urban "housekeeping" practices that reduce nonpoint source pollution.

The estimated capital cost of the recommended water quality management plan element is $0.57 million and the estimated capital cost of the recommended stormwater drainage plan element is $4.87 million. Thus, the estimated capital cost of the recommended stormwater management plan is $5.44 million.

It is concluded that, to the maximum extent practicable, this plan meets the standards for 20 percent and 40 percent control as set forth under NR 151, and the plan is considered to be consistent with the regional water quality management plan goals.

Full implementation of the recommended stormwater drainage measures would provide a minor stormwater drainage system adequate to convey and/or store runoff from storms with recurrence intervals up to, and including, 10 years and to generally provide an acceptable level of traffic service and access to property during such storms. Implementation of the preliminary recommended drainage measures would also avoid direct flooding of inhabited buildings during storms with recurrence intervals up to and including 100 years. The recommended measures would help to mitigate, but not eliminate, flooding of basements due to sanitary sewer backup. Other measures directed toward reduction of infiltration and inflow to sanitary sewers would be required to fully alleviate sanitary sewer backup problems.

Chapter VII

PLAN IMPLEMENTATION

INTRODUCTION

The recommended stormwater and floodland management plan described in this report is designed to attain, to the maximum extent practicable, the stormwater and floodland management objectives and standards set forth in Chapter III. 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 the plan by the City of Brookfield and the Village of Menomonee Falls, 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 and Village officials and staff, Wisconsin Department of Natural Resources staff, developers, and concerned citizens in undertaking the substantial investments and series of actions needed to implement the plan.

The first section of this chapter describes the relationship of land development and redevelopment to the effectiveness of stormwater and floodland management measures. The second section addresses the importance of more detailed engineering design to implementation of the plan. The specific actions required to implement the plan are presented in the third section of this chapter. The fourth section sets forth an apportionment of costs between the City, the Village, and the private sector and presents a preliminary plan implementation schedule. Regulatory considerations and the need for periodic reevaluation and updating of the plan are addressed in the fifth and sixth sections of this chapter, respectively.

RELATION TO FUTURE LAND USE DEVELOPMENT

Coordination with land use development and redevelopment is fundamental to successful implementation of a sound stormwater and floodland management plan. Planned buildout land use conditions in the study area, as presented in Chapter II of this report, have almost been achieved. The estimated rates and volumes of runoff and nonpoint source pollutant loadings which were used in the development of the alternatives set forth here were determined based on the buildout land use condition. Although buildout land use conditions have been attained in almost all of the study area, in limited areas the effectiveness of the recommended stormwater and floodland management measures will depend upon the degree to which future land use development and redevelopment and the plan properly complement each other.

It should be noted that under planned buildout conditions, about 8 percent of the study area would remain in open space uses, including environmental corridors and other open space lands. This system plan identifies those areas in the subwatershed that should be preserved in open, natural uses. Such preservation would provide major economies in stormwater and floodland management, thus maximizing the use of natural stormwater conveyance and storage and allowing such conveyance and storage to be incorporated in the plan. If the preservation of these areas is greatly compromised, 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 and floodland management plan presented in this report is intended to serve as a guide to the future design and construction of stormwater management facilities. Detailed engineering design should begin as the systems-planning phase is completed. The detailed engineering design should examine in greater depth and detail potential 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 recommendations presented in this report.

Chapter III of this report presented the engineering design criteria and analytic procedures used in the preparation and evaluation of the alternative stormwater and floodland management 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 and the flooding characteristics of the streams in the subwatershed. These criteria and procedures should also serve as a basis for the more detailed design of 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 function as envisioned in the plan. Accordingly, Table 51 presents the design criteria and analytic procedures recommended to be followed in the detailed engineering design of the recommended plan components. Criteria and procedures presented in the table are for estimating rates of runoff, calculating hydraulic capacities of conveyance components, designing street cross-sections and related site grading, locating and designing storm sewer inlets, designing storm sewers, designing roadside swales, open channels, and culverts, designing detention facilities, and designing water quality control facilities. In this respect, it is recognized that over time new procedures may be developed and become available for use in the design of stormwater and floodland management components. Before adoption, such techniques should, however, be carefully reviewed 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 and floodland management plan, as documented herein, by the Brookfield City-Wide Flooding Task Force; the Board of Public Works, Plan Commission, and Common Council of the City; and the Board of Trustees of the Village of Menomonee Falls. In addition, the plan should be endorsed by the Wisconsin Department of Natural Resources (WDNR).

Upon such adoption, the plan becomes the official guide to making of stormwater and floodland management decisions by City and Village officials. Such formal adoption serves to signify agreement with, and official support of, the recommendations contained in the plan and enables the City and Village staffs 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 and the Village.

Implementation Procedures

It is recommended that the plan be implemented by using the existing City and Village procedures for land subdivision plat approval; capital improvement programming; and public works construction, operation, and maintenance. Funding for capital improvements and operation and maintenance can be obtained through the creation of a stormwater utility, the property tax levy, special assessments, issuance of general obligation bonds, reserve funds, private developer contributions, and grants from the State of Wisconsin and/or the Federal government.

Table 51

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

Design Function	Recommended Criteria and Procedures
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. The effects of refinements to the plan recommendations should be analyzed using the base SWMM stormwater management models developed for this system plan
Conveyance and On-Line Storage Components, Including Storm Sewers, Culverts, and Stream Channels	The sizes of recommended conveyance facilities are set forth in Table 43 of Chapter VI of this report. Design criteria for such facilities are provided in Chapter III of this report. Stormwater conveyance facilities should be designed using the base SWMM models developed for this system plan. The SWMM models may be supplemented as necessary by the use of appropriate culvert nomographs or the application of standard procedures for computation of hydraulic capacities of pipes. The floodland management system should be analyzed using the HSPF continuous simulation hydrologic model and the HEC-RAS hydraulic models developed for this system plan
Site Grading	Slopes away from all buildings, as well as the slopes of interior drainage swales, should be at 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 part of the minor stormwater drainage system. At locations where storm sewers function as 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
Storage Facilities	The recommended storage facilities are listed in Table 43. The effects of storage facilities on the frequency and magnitude of downstream flows under planned conditions as compared to existing conditions should be carefully examined using the SWMM model developed for this system plan. Evaluation of the effects of storage facilities on flood flows in the Menomonee River downstream of its confluence with Butler Ditch would have to be made using the HSPF continuous simulation hydrologic model developed for the Butler Ditch subwatershed under this system plan along with the HSPF model for the entire Menomonee River watershed. The watershed model to be used is the model as developed by MMSD under its Phase 1 and 2 watercourse system planning program and subsequently refined by the Regional Planning Commission staff under the Milwaukee County Automated Mapping and Land Information System/MMSD/SEWRPC floodland mapping program.
Water Quality Control Measures	The following references provide criteria for the design of water quality control measures: 1. SEWRPC Technical Report No 31, *Costs of Urban Nonpoint Source Water Pollution Control Measures*, June 1991 2. Schueler, Thomas R., *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Metropolitan Washington Council of Governments, July 1987

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

Source: SEWRPC.

In reviewing subdivision plats and land development or redevelopment proposals, the City and Village Plan Commissions should determine the compatibility of the plats or the proposals with the land use recommendations set forth in the adopted regional land use plan, described in detail in Chapter II of this report, and used in preparation of the stormwater management plan. Any proposed departures from those recommendations should be carefully considered in light of the stormwater and/or floodland management needs of the proposed development or redevelopment and the impacts on upstream and downstream areas. Implementation of the plan through the City and Village zoning maps and ordinances would be another means of ensuring that land use development takes place in accordance with the assumptions underlying the stormwater and floodland management plan.

Stormwater facility maintenance is an important part of plan implementation. It is recommended that the public works programs of the City and Village continue to provide for the maintenance, as well as the construction, of the stormwater management facilities, including periodic inspection of conveyance and detention facilities; timely repair of facilities; cleaning of storm sewers, culverts, open channels, and detention facility inlets and outlets; repair of erosion along open channels; and periodic removal of accumulated sediment from conveyance, retention, and detention facilities.

Financing

Several means of financing stormwater management components are available to local government agencies that are not available to the private sector. Although these means offer flexibility, certain constraints and limitations are imposed on these financing methods by State law; in some cases approval by the electorate is required. 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 to securing public support and approvals.

Financing of the construction, operation, and maintenance of stormwater and floodland management facilities may be accomplished through the establishment of a stormwater utility; tax incremental financing districts; local property taxes; reserve funds; general obligation bonds; private developer contributions, including paying fees to be applied toward construction of regional stormwater management facilities in lieu of providing onsite facilities; and State or Federal grants or loans. Appendix K of the Dousman Ditch and Underwood Creek stormwater and floodland management plan[1] provides a brief description of the possible features and functions of a stormwater utility.

It is recommended that the City and Village study public financing options, considering each of the financing methods listed in the following section of this report.

Possible Funding through State Programs

Under the targeted Runoff Management Grant program (see Chapter NR 153 of the *Wisconsin Administrative Code*), local units of government and lake districts and associations are eligible to receive up to 70 percent of State cost-share dollars provided that there is a 30 percent local match. Potential projects could include installing practices that ensure compliance with the State nonpoint source performance standards as set forth in Chapter NR 151, improving 303(d) waters, protecting outstanding water resources, complying with a notice of discharge from animal feeding operations, and addressing water quality concerns for a waterbody of national or statewide importance. The City and Village may not be eligible for this program, or may only have limited eligibility, since they will be permitted under the State stormwater discharge permit program.

The Urban Nonpoint Source Water Pollution Abatement and Storm Water Management Grants Program, which is set forth in Chapter NR 155 of the *Wisconsin Administrative Code,* assists municipalities in designated urban areas[2] with designing and implementing urban nonpoint source best management practices. For projects covered

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[1] *SEWRPC Community Assistance Planning Report No. 236,* A Stormwater and Floodland Management Plan for the Dousman Ditch and Underwood Creek Subwatersheds in the City of Brookfield and Village of Elm Grove, Waukesha County, Wisconsin, *February 2000.*

[2] *Defined as an area having population density of greater than 1,000 people per square mile.*

under agreements signed after October 29, 1999, the program will fund up to 50 percent of construction costs of best management practices. Eligible projects could include detention basins, streambank stabilization, and shoreline stabilization.

On the basis of current State cost-sharing policy, it is estimated that a maximum of $208,000 in State nonpoint source grant funds could be provided for components of the water quality management plan.

In addition to funds provided by the WDNR, it is also possible that the cost of certain recommended components of the stormwater drainage system may be shared between the City or Village and the Wisconsin Department of Transportation as a part of future highway construction or reconstruction projects. Funding may also be available through the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant (HMG) or Public Assistance Grant programs or the U.S. Department of Housing and Urban Development Community Development Block Grant program, but all such funds are only available in fixed amounts following a Presidential disaster declaration. Because the division of costs for such measures is presently unknown, this plan assigns all such costs to the City or Village.

SCHEDULE FOR FINANCING AND IMPLEMENTATION OF THE PLAN

Apportionment of Costs Between the City of Brookfield, the Village of Menomonee Falls, and the Private Sector

With the exception of the costs of floodproofing, the costs of the plan were assumed to be borne by the public sector. Floodproofing costs are usually borne by the individual building owner; however, if the City provided financial assistance to the owner, it would be more the likely that floodproofing measures would be implemented. If it were found that floodproofing, which was only recommended at one house, was not feasible and acquisition and removal of the structure was necessary, the cost of acquisition and removal would be a public sector cost. Tables 52 and 53 provide possible allocations of costs between the City, the Village, and the private sector.

The recommended individual stormwater drainage and water quality management projects are generally intended to solve problems due to stormwater runoff from the community in which the project would be constructed. In addition, in most cases, all of the tributary runoff to the problem areas is from the same community as the problem location. Thus, stormwater drainage and water quality management capital and operation and maintenance costs were assigned to the municipality in which the project would be located.

As set forth in Table 52, the total capital cost of the recommended plan is estimated to be $5.44 million. The local public sector share of the capital costs is estimated to be $4.68 million and the private-sector share is estimated to be $0.76 million. As set forth in Table 53, of that public sector share, $4.46 million is assigned to the City of Brookfield and $0.22 million is assigned to the Village of Menomonee Falls. The estimated annual operation and maintenance cost assigned to the City is $15,090, the annual operation and maintenance cost assigned to the Village is $14,170, and the annual operation and maintenance cost assigned to the private sector is $11,900.

Prioritization of Capital Improvements

A preliminary prioritization of the recommended capital improvements is given in Table 54. 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 system of which it is a part.

The projects are classified as of high, intermediate, or low priority. The high-priority projects are those that address the most significant existing problems, including direct flooding of structures and ponding of stormwater in areas where such ponding could cause inflow to sanitary sewers and resultant backups into basements. The intermediate-priority projects are predominantly those that are required to upgrade the minor system to meet the plan standards and which are of somewhat greater extent than the low-priority projects, but which do not relate to the prevention of direct flooding of buildings. The low-priority projects are those that are required to upgrade the minor system to meet the plan standards and to address localized problems.

Table 52

ASSIGNMENT OF LOCAL PUBLIC-SECTOR AND PRIVATE-SECTOR CAPITAL COSTS OF THE RECOMMENDED PLAN FOR THE BUTLER DITCH SUBWATERSHED

Plan Element	Capital Cost[a]		
	Local Public Sector	Private Sector	Total
Stormwater Drainage	$4,270,000	$601,000	$4,871,000
Water Quality Management	416,000[b]	155,000	571,000
Total	$4,686,000	$756,000	$5,442,000

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 2001 with* Engineering News-Record *Construction Cost Index = 7,360.*

[b] *State of Wisconsin nonpoint source grant program funds may be available for up to $208,000 of this amount. That cost assumes 50 percent State cost-sharing for construction of wet detention basins to serve existing development.*

Source: SEWRPC.

Table 53

APPORTIONMENT OF TOTAL CITY OF BROOKFIELD AND VILLAGE OF MENOMONEE FALLS COSTS FOR THE RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE BUTLER DITCH SUBWATERSHED

Plan Element	City of Brookfield		Village of Menomonee Falls		Local Total	
	Capital Cost[a]	Annual Operation and Maintenance	Capital Cost[a]	Annual Operation and Maintenance	Capital Cost[a]	Annual Operation and Maintenance
Stormwater Drainage	$4,255,590	$ 1,750	$ 14,490	$ 1,850	$4,270,080	$ 3,600
Water Quality Management	209,890	13,340	205,690	12,320[b]	415,580	25,660
Total	$4,465,480	$15,090	$220,180	$14,170[b]	$4,685,660[c]	$29,260

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 2001 with* Engineering News-Record *Construction Cost Index = 7,360.*

[b] *Annual operation and maintenance cost of $11,900 would be borne by homeowners association or property owners according to Village policy.*

[c] *Up to $208,000 in WDNR cost-share funds could be provided as described in a footnote to Table 52.*

Source: SEWRPC.

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 and floodland management considerations. Such factors include budgetary constraints, the need to implement other projects in the City and Village capital improvements programs, and variations in future development and redevelopment patterns as determined by the urban land market.

Critical Implementation Sequences

In general, projects which call for upgrading the existing stormwater conveyance system should proceed from downstream to upstream to insure that the downstream portions of the system are not overloaded when the hydraulic capacities of the upstream portions are increased. Also, in the context of a project, detention storage facilities should be constructed prior to conveyance facilities. The water quality and floodland management plan elements is described below.

Table 54

PRIORITIZATION OF RECOMMENDED PROJECTS FOR THE BUTLER DITCH SUBWATERSHED

Project Description	Location of Component	Hydrologic Unit (H.U.)	Plan Components As Listed In Table 43	Capital Cost[a]			
				City of Brookfield	Village of Menomonee Falls	Private Sector	Total
			High-Priority Projects				
Stormwater Drainage/Water Quality Management							
1. Vicinity of Meadowview Drive–Stormwater Conveyance with Detention Storage	City of Brookfield	BD-2	H.U. BD-2 Items 1 through 12	$ 236,930	$ 0	$ 0	$ 236,930
2. Vicinity of Willow Ridge Lane–Stormwater Conveyance	City of Brookfield	BD-5	H.U. BD-5 Items 1 through 7	262,190	0	0	262,190
3. Lamplighter Lane–Stormwater Conveyance with Detention Storage	City of Brookfield	BD-16	H.U. BD-6 Items 1 through 55	1,597,760	0	0	1,597,760
4. Arrowhead Lake-Brookhill Drive Area–Stormwater Conveyance with Detention Storage	City of Brookfield	BD-28	H.U. BD-28 Items 1 through 36	486,570	0	0	486,570
5. Vicinity of 145th Street	City of Brookfield	BD-34	H.U. BD-34 Items 1 through 21	1,291,310	0	0	1,291,310
6. Shamrock Lane/ Dublin Court	City of Brookfield	BD-42	H.U. BD-42 Item 1	1,250	0	0	1,250
7. Three Meadows Drive/ Shagbark Lane	City of Brookfield	BD-44	H.U. BD-44 Items 1 through 8	218,560	0	0	218,560
8. Fair Oak Parkway	Village of Menomonee Falls	BD-44	H.U. BD-44 Item 13	0	3,110	0	3,110
9. Dolphin/Stone Drives	Village of Menomonee Falls	BD-44	H.U. BD-44 Items 15 and 16	0	8,520	0	8,520
			Medium-Priority Projects				
10. Detention Basins to Serve Existing Development	Village of Menomonee Falls	- -	Water Quality Management Plan Element Items 9 through 11	$ 209,890	$205,690	$ 0	$ 415,580
11. Measures for Planned Development West of Pilgrim Road	Village of Menomonee Falls	BD-44	H.U. BD-44 Items 17 through 31 and Water Quality Item 12	0	0	518,770	518,770
12. Measures for Planned Development East of Pilgrim Road	Village of Menomonee Falls	BD-44	H.U. BD-44 Items 32 and 33 and Water Quality Items 13 and 14	0	0	237,400	237,400
13. Additional Water Quality Measures	City of Brookfield Village of Menomonee Falls	- -	Water Quality Items 1 through 8	0[b]	0[b]	0	0[b]
14. Clare Bridge Lane	City of Brookfield	BD-12	H.U. BD-12 Items 1 and 2	14,880	0	0	14,880
15. Courtland Avenue	City of Brookfield	BD-20	H.U. 20 Item 1	29,920	0	0	29,920
16. 158th Street/Pilgrim Road Area	City of Brookfield	BD-44	H.U. BD-44 Items 9 through 12	38,270	0	0	38,270
			Low-Priority Projects				
17. Pilgrim Road/Lisbon Road Area	City of Brookfield	BD-4	H.U. BD-4 Item 1	$ 4,640	$ 0	$ 0	$ 4,640
18. Fieldbrook Drive	City of Brookfield	BD-8	H.U. BD-8 Item 1	11,700	0	0	11,700
19. Lilly Heights Drive Area	City of Brookfield	BD-17	H.U. BD-17 Items 1 through 3	33,320	0	0	33,320
20. 149th Street/Lisbon Road Area	City of Brookfield	BD-35	H.U. BD-35 Items 1 and 2	19,340	0	0	19,340
21. 159th Street/Senate Street Area	City of Brookfield	BD-36	H.U. BD-36 Item 1	5,000	0	0	3,860
22. Glendale Avenue	City of Brookfield	BD-37	H.U. BD-37 Item 1	3,860	0	0	5,000
23. Chase Avenue	Village of Menomonee Falls	BD-44	H.U. BD-44 Item 14	0	2,860	0	2,860
Total	- -	- -	- -	$4,465,480	$220,180	$756,170	$5,441,830

[a] *Includes 35 percent for engineering, administration, and contingencies. Costs are for year 2001 with* Engineering News-Record *Construction Cost Index = 7,360.*

[b] *Annual operation and maintenance cost of $7,450 per community for street sweeping.*

Source: SEWRPC.

REGULATORY CONSIDERATIONS

Implementation of some of the measures recommended in this system plan may require the prior approval of certain regulatory agencies other than the City and Village, including the Wisconsin Department of Natural Resources, and the U.S. Army Corps of Engineers. The regulatory process involved is complex, therefore, the City and Village should seek legal counsel prior to proceeding with any stormwater and floodland management measures that involve the construction or modification 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 disturbance of wetlands.

Federal regulatory authority relating to the disturbance of wetlands 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.

State regulatory authority relates to the construction or modification of artificial waterways, canals, or ponds connecting to, or located within 500 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, the removal of material from navigable waterways, and also to activities affecting the water quality of wetlands. This authority is contained in sections 30.12, 30.195, 30.20, and 144.025 of the *Wisconsin Statutes*. The administering agency is the Wisconsin Department of Natural Resources.

Chapters of the *Wisconsin Administrative Code* which are pertinent to activities called for under the recommended plan include Chapter NR 103, "Water Quality Standards for Wetlands"; Chapter NR 116, "Wisconsin's Floodplain Management Program"; and Chapter NR 117, "Wisconsin's City and Village Shoreland-Wetland Protection Program."

As a result of the detailed hydrologic and hydraulic modeling conducted under the planning effort, updated, or new, 100-year recurrence interval flood profiles were computed for Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch in the City of Brookfield and the Village of Menomonee Falls. Those profiles and the substantiating analyses used in their development can be submitted by the City and the Village to the WDNR and FEMA with a request to revise the City and Village floodplain boundary maps.[3]

PROPOSED FACILITIES ON CURRENT PRIVATE SITES

Table 55 lists the private properties, aside from those that are planned to be developed, on which recommended stormwater management facilities are to be located.

PLAN REEVALUATION AND UPDATING

The recommended plan components should be reevaluated at 10-year intervals, considering the degree to which the recommendations have been implemented and incorporating any changes in the available rainfall-duration-frequency data and in the state-of-the-art of stormwater and floodland management. 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 conditions and stormwater management needs.

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[3] *The currently adopted 100-year recurrence interval flood profiles are based on the FEMA FIS prepared in 1986 for the City and 1978 for the Village. Those profiles must be used for zoning and regulatory purposes until the 100-year flood profiles determined under this stormwater and floodland management plan are formally approved by the State of Wisconsin and FEMA and adopted by the City and the Village.*

Table 55

RECOMMENDED STORMWATER MANAGEMENT FACILITIES ON PRIVATE PROPERTY[a,b]

Hydrologic Unit	Community	Recommended Plan Map Number	Recommended Component	Tax Key Number for Property
BD-2	City of Brookfield	17	253	1014-999
BD-2	City of Brookfield	19	20302409	1018-993, 1017-173
BD-28	City of Brookfield	40	2810011157	1045-001, possibly 1045-001-001
BD-28	City of Brookfield	43	8894	1046-235
BD-70	City of Brookfield	72	Wet basin southeast of intersection of Pilgrim and Lisbon Roads	1014-997

[a] *Does not include facilities to serve areas of planned new development.*

[b] *The wet basin proposed to be located east of Pilgrim Road and north of Susan Drive is located on Village property.*

Source: SEWRPC.

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Chapter VIII

SUMMARY

DESCRIPTION OF THE RECOMMENDED PLAN

The recommended stormwater and floodland management plan for the Butler Ditch subwatershed consists of three elements: a water quality management element, a stormwater drainage element, and a floodland management element. The recommended stormwater drainage plan components are shown on the maps that are listed in Table 45 in Chapter VI. The recommended water quality management plan element is shown graphically on Map 72 in Chapter VI. The recommended 100-year recurrence interval floodplain and floodway boundaries are shown on Map 14 in Chapter V. An overall summary of recommended plan components is shown on Map 73.

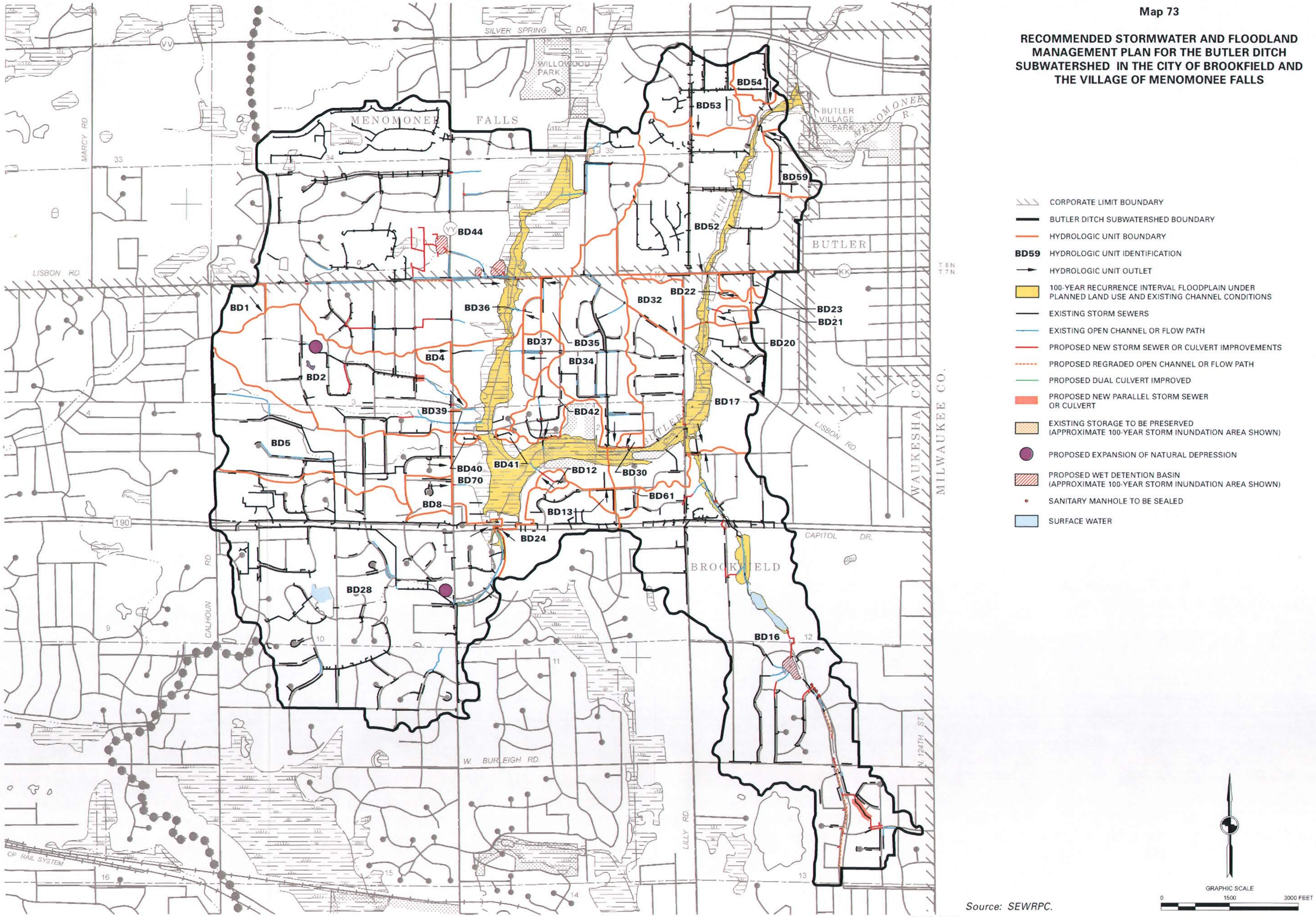
Stormwater Management Plan Element

The components of the recommended stormwater management plan, including the water quality and stormwater drainage elements, and their estimated capital and annual operation and maintenance costs are summarized in Table 43. The recommended stormwater management plan calls for 1) the provision of new or replacement culverts and storm sewers at potential problem areas throughout the study area; 2) limited swale modification; 3) detention storage in Hydrologic Units BD-2, BD-16, and BD-28 in the City of Brookfield; 4) maintenance of existing constructed and natural detention storage in Hydrologic Unit BD-44 in the Village of Menomonee Falls; 5) three new wet detention storage basins to serve planned development in BD-44 in the Village of Menomonee Falls; 6) the provision of runoff controls as required under MMSD Chapter 13 for new development and redevelopment in Brookfield; 7) floodproofing of one house in Unit BD-28 in Brookfield; 8) sealing several sanitary sewer manholes in Brookfield; 9) increased sweeping of about 56 curb-miles of street in critical land use areas; 10) two new wet detention basins to serve existing development; 11) strict enforcement of the existing construction site erosion control ordinances; 12) site-specific best management practices, consistent with the requirements of proposed Chapter NR 151 of the *Wisconsin Administrative Code*, to reduce the washoff of pollutants from new development, redevelopment, or in-fill sites; 13) maintenance of the existing ponds in the study area; 14) municipal programs for the collection and management of leaf and grass clippings; 15) controls on the application of lawn and garden fertilizers on municipally controlled properties; 16) institution of programs to detect and eliminate illicit discharges to storm sewers; 17) reduced application of sand on streets in the winter and investigation of the feasibility of applying effective alternative snow and ice control agents that are less harmful to the environment than sodium and calcium chloride; and 18) public information and education efforts to promote good urban "housekeeping" practices that reduce nonpoint source pollution.

The recommended wet detention basins and accelerated street sweeping, if fully implemented, would reduce nonpoint source pollutant loadings to the streams in the study area under full buildout land use conditions by a minimum 3 to 26 percent relative to the loadings under full buildout conditions without the recommended controls. Relative to 1995 land use and nonpoint source pollution control conditions, full implementation of the

Map 73

RECOMMENDED STORMWATER AND FLOODLAND MANAGEMENT PLAN FOR THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS



Source: SEWRPC.

recommended wet detention basins and accelerated street sweeping would limit increases in sediment, phosphorus, copper, zinc, and cadmium loads to 18, 16, 11, 21, and 27 percent, respectively. Implementation of the additional measures recommended to control runoff (Items 11 through 18 as listed above) would be expected to further reduce the loadings. As described in Chapter IV of this report, it is concluded that, to the maximum extent practicable, this plan meets the standards for 20 percent and 40 percent control of total suspended solids as set forth under NR 151.

Full implementation of the recommended stormwater drainage measures would provide a minor stormwater drainage system adequate to convey and/or store runoff from storms with recurrence intervals up to, and including, 10 years and to generally provide an acceptable level of traffic service and access to property during such storms. Implementation of the preliminary recommended drainage measures would also avoid direct flooding of inhabited buildings during storms with recurrence intervals up to and including 100 years. The recommended measures would help to mitigate, but not eliminate, flooding of basements due to sanitary sewer backup. Other measures directed toward reduction of infiltration and inflow to sanitary sewers would be required to fully alleviate sanitary sewer backup problems.

As described in Chapter VI of this report and demonstrated in Table 49, implementation of the recommended stormwater management measures in the portion of the subwatershed in Menomonee Falls upstream of W. Lisbon Road would meet the objective of not increasing the 100-year flood flow, relative to 1995 conditions, passing to Brookfield at the upstream boundary between the two communities. It is also demonstrated that implementation of the recommended stormwater management measures in the portion of the subwatershed in Menomonee Falls and Brookfield upstream of W. Hampton Road would result in an insignificant increase in the peak 100-year flows in Butler Ditch, relative to 1995 conditions, passing to Menomonee Falls at the downstream boundary between the two communities and at the mouth. Thus, it was concluded that land use changes in Brookfield are the overriding factor in producing changes in flows at the downstream boundary between Brookfield and Menomonee Falls and at the mouth. In order to mitigate the effects of changed land use on the peak 100-year flow in Butler Ditch at those locations, it is recommended that the City of Brookfield continue to require that new development and redevelopment in Brookfield be provided with runoff controls as currently specified under the City stormwater management ordinance and MMSD Chapter 13. As described in Chapter VI, that recommendation would also serve to mitigate increases in peak two-year flood flows.

Floodland Management Plan Element

The recommended floodland management plan, calls for the continued application by the two communities of floodplain zoning regulations along Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch. It is recommended that both the City of Brookfield and the Village of Menomonee Falls revise their floodplain zoning ordinances to recognize the 100-year flood profile and the floodplain and floodway limits as determined under this planning effort and set forth on Map 14. It is also recommended that both communities include ordinance revisions designed to maintain existing floodwater storage capacities.[1]

Full implementation of the recommended floodland management plan would avoid structure flood damages due to direct overland flooding along Butler Ditch, the South Branch of Butler Ditch, and the Unnamed Tributary to Butler Ditch for floods up to and including the 100-year recurrence interval flood event under buildout land use and channel conditions. Damages due to street flooding would not be eliminated by implementation of this plan in the absence of other measures directed toward reduction of infiltration and inflow to sanitary sewers.

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[1] *The Commission staff has computed updated flood profiles throughout the City of Brookfield under a map updating program undertaken by the City. In 2004, SEWRPC prepared the necessary study documentation and the City submitted the revised floodplain information for review and approval by the Wisconsin Department of Natural Resources and the Federal Emergency Management Agency. The City and Commission staffs are also developing zoning ordinance revisions to preserve floodwater storage capacity.*

TOTAL COST OF THE RECOMMENDED PLAN

The total capital cost of the recommended stormwater and floodland management plan as set forth in Table 43 is estimated to be $5.44 million. The annual operation and maintenance cost increase relative to existing conditions is estimated to be $41,160. The City of Brookfield share of the estimated plan capital costs would be $4.46 million, the Village of Menomonee Falls share would be $0.22 million, and the private sector share would be $0.76 million. The City share of the estimated annual operation and maintenance costs would be $15,090, the Village share would be $14,170, and the private sector share would be $11,900.

APPENDICES

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Appendix A

COST DATA FOR STORMWATER MANAGEMENT MEASURES FOR THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS

Table A-1

UNIT COSTS FOR REINFORCED CONCRETE PIPE STORM SEWERS

Pipe Diameter (inches)	Unit Cost[a,b] (per lineal foot)	
	Construction of New Storm Sewers in Developing Areas	Replacement of Existing Storm Sewers in Urbanized Areas
12	50	60
15	50	60
18	60	70
21	70	80
24	70	80
27	80	90
30	90	100
36	110	120
42	130	150
48	160	170
54	180	200
60	210	230

[a] *ENR CCI = 7,360 (2001). Does not include easements, engineering, administration, and contingencies. Annual operation and maintenance costs equal $1,500 per mile for diameters greater than or equal to 36 inches and $3,300 per mile for diameters less than 36 inches.*

[b] *These costs are applicable for pipe invert depths of up to 12 feet. For depths greater than 12 feet, site-specific cost adjustments should be made.*

Source: SEWRPC.

Table A-2

UNIT COSTS FOR CORRUGATED METAL PIPE[a]

Pipe Diameter (inches)	Unit Cost[a] (per lineal foot)	
	Excluding Pavement Replacement	Including Pavement Replacement
12	29	38
15	34	41
18	38	47
21	42	53
24	48	60
27	56	67
30	62	76
36	76	92
42	93	111
48	113	140
54	138	163
60	167	192
72	226	263

[a] *ENR CCI = 7,360 (2001). Does not include easements, engineering, administration, and contingencies.*

Source: SEWRPC.

Table A-3

UNIT COSTS FOR CONCRETE BOX CULVERTS

Culvert Size (feet)	Unit Cost[a,b] (per lineal foot)
4 x 2	$ 210
5 x 3	290
7 x 3	510
8 x 4	610
8 x 6	660
8 x 8	740
10 x 3	580
10 x 4	720
10x 6	800
10 x 8	950
10 x 10	1,070
12 x 6	1,050
12 x 8	1,090
12 x 10	1,340
12 x 12	1,460
16 x 6	980

[a] *ENR CCI = 7,360 (2001).*

[b] *Add $35 per lineal foot of pipe to account for road reconstruction.*

Source: SEWRPC.

Table A-4

UNIT COSTS FOR REINFORCED CONCRETE PIPE ARCH (RCPA) AND HORIZONTAL ELLIPTICAL (HE) STORM SEWERS

Pipe Size, Span x Rise (inches)		Unit Cost[a] (per lineal foot)	
RCPA	HE	Replacement of Existing Storm Sewers in Urbanized Areas	Construction of New Storm Sewers in Developing Areas
22 x 14	23 x 14	$ 88	$ 78
29 x 18	30 x 19	102	90
36 x 23	38 x 24	131	119
44 x 27	45 x 29	155	141
51 x 31	53 x 34	179	164
58 x 36	60 x 38	204	189
65 x 40	68 x 43	239	221
73 x 45	76 x 48	281	262
- -	83 x 53	364	340
88 x 54	91 x 58	399	380

[a] *ENR CCI = 7,360 (2001).*

Source: SEWRPC.

Table A-5

MISCELLANEOUS UNIT COSTS

Component	Unit Cost[a]
Clearing and Grubbing	$5,800 per acre
Excavation	$4.00 to $30 per cubic yard[b]
Concrete	$260 per cubic yard
Riprap	$65 per cubic yard
Gabions	$165 per cubic yard
Landscaping	$5,600 per acre

[a] *ENR CCI = 7,360 (2001). Annual channel maintenance cost = $3,300 per mile.*

[b] *Cost dependent on haul distance to disposal site, disposal site tipping fees, and whether excavated material includes toxic substances requiring special disposal methods.*

Source: SEWRPC.

Appendix B

INTERPRETATIONS OF STORMWATER MANAGEMENT OBJECTIVES AND STANDARDS FOR THE BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD AND THE VILLAGE OF MENOMONEE FALLS[1]

OBJECTIVE NO. 1 The development of a stormwater management system which reduces the exposure of people to drainage related inconveniences and to health and safety hazards and which reduces the exposure of real and personal property to damage through inundation resulting from inadequate stormwater drainage.

Interpretation: Should the flow or ponding of excess stormwater be perceived or interpreted by the public as a health, safety or property hazard, a corrective measure is required.

Standard 1: In order to prevent significant property damage and safety hazards, the major components of the stormwater management system ... should be designed to accommodate runoff from a 100-year recurrence interval rainfall event."

Standard 4: Flow of stormwater along or across the full pavement width of collector and land access streets shall be acceptable during storm events exceeding a 10-year recurrence interval rainfall when the streets are intended to constitute integral parts of the major stormwater management system.

Interpretation: Should the flow of stormwater during any storm event recurrence interval up to, and including, 100 years, impact any structure, a corrective measure is required.

Standard 2: In order to provide for an acceptable level of access to property and of traffic service, the minor components of the stormwater management system should be designed to accommodate runoff from a 10-year recurrence interval storm event.

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[1] *The Objectives and Standards are set forth in Chapter III.*

Standard 3:

In order to provide for an acceptable level of access to property and of traffic service, the stormwater management system should be designed to provide two clear 10-foot lanes for moving traffic on existing arterial streets, and one clear 10-foot lane for moving traffic on existing collector and land access streets during storm events up to, and including, the 10-year recurrence interval storm."

Interpretation:

a. Should the depth of stormwater flow along a collector or land access street with an urban curb and gutter cross-section exceed 0.35 foot during the 10-year recurrence interval rainfall event, a corrective measure is required.

b. Should stormwater flow, along a collector or land access street with a rural road ditch cross-section, encroach upon the centerline during the 10-year recurrence interval rainfall event, a corrective measure is required.

c. Should the depth of stormwater flow along an arterial street with an urban curb and gutter cross-section exceed 0.13 foot during the 10-year recurrence interval rainfall event, a corrective measure is required.

d. Should stormwater flow along an arterial street with a rural road ditch cross-section encroach upon the edge of pavement during the 10-year recurrence interval rainfall event, a corrective measure is required.

e. Should stormwater flow across an arterial, collector or land access street during the 10-year recurrence interval rainfall event, a corrective measure is required.

f. Should ponding occur on or within the cross-section of an arterial, collector or land access street during the 10-year recurrence interval rainfall event, a corrective measure is required.

Standard 5:

Where practicable, ponding of runoff that could result in inflow to sanitary sewers should be eliminated or reduced to an acceptable level during storms with recurrence intervals up to, and including, 100 years."

Interpretation: Should the flow of stormwater during a storm event up to the 100-year storm interval exceed the rim grade of the sanitary sewer system, a corrective action is required.

Appendix C

DRAINAGE AND FLOODING PROBLEM DESCRIPTIONS JUNE 20-21, 1997 AND AUGUST 6, 1998 BUTLER DITCH SUBWATERSHED IN THE CITY OF BROOKFIELD (T7N, R20E)[1]

1. NE Section 10. Low house north of 66-inch diameter RCP storm sewer that discharges to the South Branch of Butler Ditch upstream of the Pilgrim Road bridge. Garage and lower level (garage and basement) flooding in 1997. 36-inch depth of flooding in garage on August 6, 1998. Pilgrim Road was overtopped on August 6, 1998. This problem is related to Problems No. 7 and 23 also.

2. NW Section 2. Butler Ditch floodplain between N. 150th Street and Pilgrim Road. This is primarily a flooding, rather than drainage problem. Back yard flooding. Two basements on Senate St. have been flooded due to sump pump failure. Ridgefield subdivision in the Village of Menomonee Falls also contributes runoff to this location. In April 1973, several feet of water accumulated in two basements, one on Senate St and one on N. 150th St. At one residence on Senate St. the August 6, 1998, flood inundation area approached the back door and it was claimed that saturated ground threatened the basement wall.

3. SW Section 12. Lamplighter Park-Commons Drive area. This is a stormwater drainage problem that should be alleviated by implementation of the measures recommended in the April 2000 Addendum No. 1 to the November 1998 *Storm Water Drainage Analysis for Burlawn Parkway Drainage Area*, both of which were prepared by Graef, Anhalt, Schloemer & Associates, Inc. Those recommendations are incorporated in this plan and they have largely been implemented by the City. Three houses along Commons Drive reported unspecified problems on June 21, 1997. Three houses along Commons Drive and one on Old Lantern Drive reported unspecified problems on August 6, 1998. On August 6, 1998, prior to construction of mitigative measures, flooding occurred up to the entrance of one residence. Also see Problems 12, 16, 26, and 35.

4. NE & NW Section 3. Shagbark Lane/Three Meadows Drive area. Unspecified problem reported at one property on Shagbark Lane on June 21, 1997. One house on Three Meadows Drive is lower than the roadway. Up to six houses near the west end of the Three Meadows subdivision have experienced flooding. According to the City Highway Department, no defined overland flow path existed, causing water to run toward houses. Following the 1997 storm, the City graded a swale over the storm sewer to convey water surcharging or bypassing the storm sewer. An additional inlet was also installed along Three Meadows

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[1] *Problem numbers correspond to the numbered areas on Map 11.*

Drive to intercept additional flow on the roadway. No problems were reported in that area after the work was completed.

5. NE Section 3. Unspecified problem reported at one property on N. 159th St. on June 21, 1997. It may be located along the west-east 30-inch RCP storm sewer alignment and also along the overland flow path.

6. SE Section 3. Problem reported at one property on N. 162nd St. on June 21, 1997. Roof drain is connected to storm sewer. When storm sewer surcharges, water backs up at the building wall and enters the basement.

7. NE Section 10. Unspecified problems reported on June 21, 1997 at two properties on Brookhill Drive. Drainage concerns were reported at one property on Brook Lane after the August 6, 1998 storm. One of the houses on Brookhill Drive experienced overland flow into the basement in 1997, 1998, and 2000.

8. NE Section 10. One property on Stonebrook Court reported an unspecified problem on June 21, 1997.

9. SW Section 3. One property on Willow Ridge Lane reported an unspecified problem on June 21, 1997. Culvert/swale/ditch enclosure system. At the eastern end of Ridge View Drive, major system overflow would occur to the southeast toward Willow Ridge Lane.

10. SE Section 2. One property on N. 145th Street reported an unspecified problem on June 21, 1997. East side of Lilly Heights Park. Ditch enclosure system.

11. NW Section 2. One property on N. 149th Street reported an unspecified problem on June 21, 1997. Located near Senate St. Culvert/swale/ditch enclosure system.

12. SE Section 12, NE Section 13. Numerous problems with flooding and sanitary sewer backup along Burlawn Parkway and Hampstead Drive reported on June 21, 1997 and August 6, 1998. Flooding around Lamplighter Park. Overland flow between two houses south of Wisconsin Memorial Park in 1998. Sanitary sewer manholes are located in the median ditch along Burlawn Parkway.

13. NW Section 12. Flooding reported at two properties along Fiebrantz Drive on June 21, 1997 and August 6, 1998. Runoff flows between houses along the east side of Lilly Road and along Fiebrantz. Some flooding on west side of Fiebrantz due to elevation of roadway, but most significant flooding occurs on the east side near the Unnamed Tributary to Butler Ditch. This area is the collection point for local runoff from the area that is generally south of W. Capitol Drive, north of Keefe Avenue, and east of Lilly Road. Culvert/swale/ditch enclosure system.

14. SE Section 2. One property on Lilly Heights Drive reported problems on June 21, 1997 and August 6, 1998. Considerable flooding along Lilly Heights Road in 1998.

15. and 21. NE Section 2. One property on N. Lilly Road reported unspecified problem on June 21, 1997.

16. and 35. NE Section 13. Sanitary sewer backup problems were reported at six houses along Pinewood and Princeton Roads on June 21, 1997 and August 6, 1998. May be related to Problems 3, 12, 26, and 35. Pinewood/Princeton intersection and area to the north is a low spot.

17. and 45. SW Section 2. Yard flooding reported in the vicinity of Shamrock Lane on June 21, 1997 and August 6, 1998. Near Butler Ditch floodplain. Sara Street was flooded in 1998. Extreme southern end of Sara Street is close to Butler Ditch floodplain. The outfall from the new Conservancy subdivision has been realigned with the receiving ditch to avoid discharging into a backyard along Shamrock Lane.

18. NW Section 2. Overland flooding reported along Lisbon Road between Pilgrim Road and 149th Street on June 21, 1997.

19. NE Section 2. Lisbon Road at Hampton Avenue. Intersection blocked off on June 21, 1997.

20. SW Section 3. Unspecified problems reported at two properties along Ridge View Drive on June 21, 1997. In 1998, a plugged culvert was reported at one property along Ridge View and a soil washout was reported at another. City crews ditched to the east and restored the washout area. Culvert/swale/ditch enclosure system.

21. See Problem 15 above.

22. SE Section 1. Hope Street was overtopped by about one to 1.5 foot on August 6, 1998. The Brookfield School Administration Center received direct overland flooding on its west side. The Unnamed Tributary to Butler Ditch affects flooding in this reach. Tributary flood stages are influenced by Butler Ditch in this area.

23. NE Section 10. On August 6, 1998, storm sewer grates popped off in the vicinity of Brookhill Drive. There is a long storm sewer along back yard easements in this area.

24. - -[2]

25. and 33. SE Section 3. Sanitary sewer backup reported at three houses on N. 162nd Street near W. Capitol Drive on August 6, 1998.

26. SW Section 12. (See Problems 3, 12, 16, and 35.) Flooding was reported at one property on Applegate Lane on August 6, 1998. Storm sewer drainage system that discharges to the pond in Lamplighter Park.

27. - -[3]

28. SW Section 2. Sanitary sewer backup problems reported at two houses on Clare Bridge Lane on August 6, 1998. Mid-block sag along Clare Bridge north of Woodland Place. Culvert/swale/ditch enclosure system.

29. NE Section 2. Unspecified problem reported at one property on W. Glendale Avenue on August 6, 1998. Culvert/swale/ditch enclosure system.

30. NW Section 1. Unspecified problem reported at one property on W. Hampton Road on August 6, 1998. Road and land grades are generally flat in this area.

31. NE Section 2. Sanitary sewer backup reported at one house on W. Lisbon Road on August 6, 1998. Culvert/swale/ditch enclosure system.

32. NE Section 2. Sanitary sewer backup reported at one house on N. 144th Street and one house on N. 145th Street on August 6, 1998. Mid-block sag at 145th and Glendale. The City problem report states that a cross culvert was plugged on August 6, 1998. That may have contributed to the problem. Extensive storm sewer system that discharges to Butler Ditch. City staff indicates that large storm sewer in this area has functioned adequately during past large storms.

33. SE Section 3. See Problem 25.

34. SE Section 3. Unspecified problem reported on August 6, 1998.

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[2] *There is no Problem Number 24.*

[3] *There is no Problem Number 27.*

35. NE Section 13. See Problem 16.

36. NW 11. Unspecified problem reported at one property on St. Therese Boulevard on August 6, 1998. Located along the South Branch of Butler Ditch. Pilgrim Road was overtopped near this location on August 6, 1998.

37. NE & SE Section 10. Water in back yard reported at one property on Tarrytown Road and unspecified problem reported at another property on Tarrytown Road on August 6, 1998. Storm sewer drainage system.

38. NW Section 3. Flooding reported at one property on Twin Oaks Ct. on August 6, 1998.

39. SE Section 2. Yard flooding and sinkholes reported at or near four properties on Woodland Place on August 6, 1998. A City ditch improvement project was subsequently constructed along Woodland Place.

40. NW Section 10. Flooding reported at one property on Woodview Drive on August 6, 1998. Extensive culvert/swale/ditch enclosure system that discharges to Arrowhead Lake. Even before the June 21, 1997 storm, the City staff reported stormwater drainage problems in the Arrowhead Lake area.

41. NW Section 1. City replaced culvert at Squirrel Drive in 1998.

42. SE Section 2. Problem with water in ditch caused by frequent sump pump operation in the vicinity of N. 143rd Street at Ranch Road. City regraded ditch.

43. NE Section 10. See Problems 1, 7, and 23. Unspecified problem reported at one property on Vernon Drive in 1998. Culvert/swale/ditch enclosure system.

44. NW Section 3. Problem with ditch reported at one property on Meadowview East in 1998. Problem area is located at low spot where flow from the west collects and is conveyed under Meadowview East in a long 30-inch diameter concrete culvert.

45. SW Section 2. Shamrock Lane outfall at Pilgrim Road. See Problem 17.

46. NE Section 10. Lower-level garages and basement flood at two properties on Lone Elm Dr. City subsequently implemented a project to keep runoff in the right-of-way and away from the buildings.

47. SW Section 12. Parkside Drive. Local runoff collects in depression between Fiebrantz and Parkside. Local drainage issue. Properties along Burleigh pump from depression into Burleigh St. ditch.