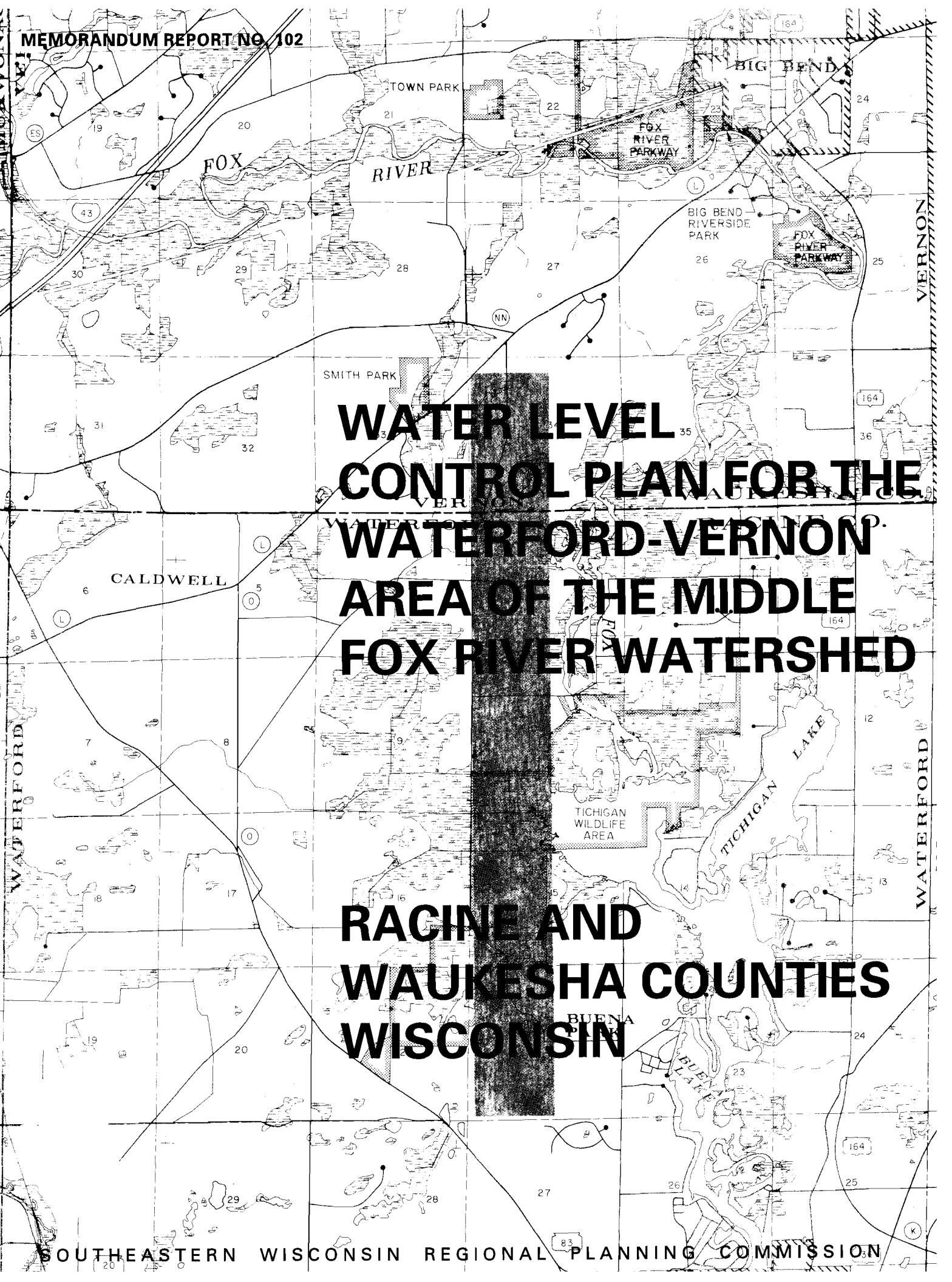
MEMORANDUM REPORT NO. 102



WATER LEVEL CONTROL PLAN FOR THE WATERFORD-VERNON AREA OF THE MIDDLE FOX RIVER WATERSHED

RACINE AND WAUKESHA COUNTIES WISCONSIN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgement is due Ronald J. Printz, SEWRPC Principal Engineer, for his contribution to this report.

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RACINE AND WAUKESHA COUNTIES, WISCONSIN

Prepared by the

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Chapter I

INTRODUCTION

In accordance with the terms of the agreement entered into on February 16, 1994, between the Town of Vernon, the Village of Big Bend, Waukesha County, and the Regional Planning Commission, the Commission staff undertook a study of water level-related problems along the Fox River between IH-43 in the Town of Vernon, Waukesha County, and the dam located in the Village of Waterford, Racine County. This memorandum report documents the findings and recommendations of that study. It is intended that this report serve as an update and refinement to the comprehensive plan for the Fox River watershed,[1] as that plan relates to flooding and drainage along the project reach.

BACKGROUND

The problems related to water levels in the reach of the Fox River between IH-43 and the Waterford dam include seasonal impairments to navigation due to limited depth and accumulated sediments during low water periods, as well as obstructions caused by fallen trees, and to flooding and drainage problems during high water periods. High water levels along the study reach of the Fox River between IH-43 and the Waterford impoundment have been a problem for a number of years. Most affected are farmers operating along this reach who have experienced flooding and poor drainage on fields located along the River. Also affected is a privately-owned golf course which has experienced similar problems. In addition, flooding of lands included in the Village of Big Bend Riverside Park have periodically limited use of portions of the park. Reported problems related to flooding worsened in 1969, when an existing mill race at the dam located in the Village

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[1]SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume One, Inventory Findings and Forecasts, and Volume Two, Alternative Plans and Recommended Plan; and SEWRPC Community Assistance Planning Report No. 5, Drainage and Water Level Control Plan for the Waterford-Rochester-Wind Lake Area of the Lower Fox River Watershed.

of Waterford was closed. That dam consisted of two fixed spillways located along either side of the Fox River island, along with a 33-foot-wide side channel located along the west side of the River. Water levels within the upstream impoundment could be regulated by raising or lowering a series of wooden sluice gates located within the mill race. With the closure of the mill race, the ability to effectively regulate water levels in the impoundment, as well as to provide for the timely drainage of upstream flood waters, was eliminated. It was also at this time that problems due to siltation along the River appeared to increase.

In 1974, the Commission Fox River Watershed Committee requested that the staff of the Regional Planning Commission study the issue and develop a plan for controlling water levels along the Fox River. That plan is documented in SEWRPC Community Assistance Planning Report No. 5 which was adopted by the Commission as an amendment to the comprehensive plan for the Fox River watershed on June 5, 1975. A brief description of that plan and the status of its implementation is warranted in order to relate that plan and its implementation status to the current study.

Component 1--The installation of two 20-foot radial gates in the west dam structure of the waterford dam and Component 2--Upstream water level sensors and an automated gate operation system.

This component of the 1975 plan was recommended to provide for more stable water levels in the Impoundment, to improve navigation, and to reduce flooding and drainage problems. The proposed radial gates would have a greater hydraulic capacity than the former mill race, thus allowing for a more rapid drawdown of the Impoundment than previously. It was specifically noted in the plan that the installation of the gates would not have a significant impact on flood levels upstream of the Impoundment, but that they would allow for the more rapid removal of floodwater from the reach, thus reducing the duration of flooding and of damage problems. Reconstruction of the west dam structure was completed in 1977. That reconstruction included installation of the recommended radial gates and an automated operating system which included upstream water level sensors and transmitting devices. The two fixed spillways flanking the new gates were intended to be set at elevation 773.4 feet above National Geodetic Vertical Datum

(NGVD) of 1929, the same as the original spillway. At the time the dam was rebuilt, the contractor constructed the spillway at elevation 772.9 feet NGVD due to use of improper survey benchmark data. In the Spring of 1978, this situation was rectified when the County installed an angle iron riser on the dam to raise the crest to elevation 773.4 feet NGVD.

Problems related to the operation of the automated dam control system resulted in its use being discontinued in the early 1980s. These problems were, in part, related to the interruptions in the operation caused by lightning. The interruptions in operation resulted in the Impoundment being lowered below the recommended minimum operating level, causing problems for, and complaints by, the Impoundment users. The operational problems presumably were associated with the design and technology used, and perhaps with failure to develop a program--or algorithm--for the automated operation of the gates on the basis of a sufficient period of experience. It is unclear if attempts were made to rectify the problems by installation of surge protectors or other devices. However, the operation of the gates has been carried out manually by Racine County personnel since that time. The operators of the dam have indicated that through daily inspection the elevation of the Impoundment can be regulated to within about 0.2 foot of the spillway elevation of 773.4 NGVD.

Component 3--Channel clearing and maintenance aimed at removal of fallen trees and accumulated sediment along that reach of the stream between CTH L and IH 43 in the Town of Vernon.

This component of the 1975 plan was recommended to improve navigation capabilities and to reduce the flooding and drainage problems associated with high water levels. This component was not implemented.

Component 4--Dredging in selected shallow areas along the shoreline of the Waterford Impoundment.

This component of the 1975 plan was recommended to improve shoreline access and navigation. However, it would also provide increased flexibility in the operation of the Waterford dam. This component was partially implemented by private property owners who have carried out relatively small dredging projects. During 1994, 12 property owners on the southeast side of Tichigan

Lake carried out a dredging project involving 15,000 cubic yards of sediment material removal.

In the interval since the installation of floodgates at the Waterford dam, farmers and other upstream property owners have continued to voice complaints about frequent flooding of riparian lands and problems with siltation and streambank erosion. In addition, there has been an observed problem with navigation in the upper reaches of the Impoundment and the upstream river system during low water periods as a result of the siltation which has occurred, as well as the numerous trees which have fallen into the channel. Along the reach of the River upstream of the Village of Big Bend boating is limited mainly to canoes and personal water craft--jet skis--which can operate in shallow water. Water depths during periods of dry-weather flow average between one and three feet. Passage of small, motorized fishing boats is difficult even at slow speeds due to shallow depths and the presence of fallen trees which require boaters to maneuver around them and into areas of shallower water. Downstream of the Village of Big Bend water levels during dry-weather flow conditions become influenced by the Waterford Dam, with average water depths being between three and five feet. Numerous sandbars and fallen trees still present a hazard along this reach. At the inlet to the Waterford Impoundment, the channel again becomes very shallow, with an average water depth of about two feet.

In the Spring of 1993, flooding of more than the usually perceived severity occurred along much of the Fox River in Wisconsin. Based on streamflow records at the U.S. Geological Survey gages at Waukesha and Wilmot, however, that event had a recurrence interval of only about 15 years. As a result of this flood, a series of meetings were held between landowners, local officials, representatives of State and local agencies, and the Regional Planning Commission. The intent of these meetings was to determine a course of action for resolving the problems associated not only with frequent flooding, but also with increased siltation along the reach of the stream concerned. As a result of those meetings, the Chairman of the Town of Vernon requested that the Regional Planning Commission update and refine its earlier study in order to better define the location and extent of the recommended sediment removal within the reach of the stream concerned, as well as to evaluate the impact of the existing Waterford dam on upstream flood problems. Upon further discussion, it was agreed that funding for this study would be provided by the Town of Vernon, the Village of Big Bend,

Waukesha County, and the Regional Planning Commission. A formal agreement between the concerned parties was drafted on January 12, 1994, and fully executed on February 16, 1994.

STUDY AREA

As shown on Map 1, the study area consists of the 18.0-mile-long reach of the Fox River between the Village of Waterford dam in Racine County and the IH-43 crossing located in the Town of Vernon in Waukesha County. Within this reach the River is characterized by a very shallow, meandering channel between IH-43 and Bridge Drive in the Town of Waterford. Downstream of Bridge Drive the River enters a four-mile-long impoundment created by the dam at Waterford. The tributary drainage area for the study reach ranges from about 312 square miles at IH-43 to about 364 square miles at the Waterford dam. Most problems related with flooding and subsurface drainage are located upstream of the impoundment.

The Fox River within the study reach has a very flat gradient, with a total drop in the channel bottom of only 5.4 feet along the 18.0-mile reach between IH-43 and the base of the floodgates at the Waterford dam. More significant is the fact that more than half of this drop--3.6 feet--occurs between IH-43 and Center Drive, a distance of about four miles. Thus, less than two feet of drop exists between Center Drive and the Waterford dam, a distance of almost 14 miles. A profile of the river bottom is shown in Appendix A. This lack of slope, coupled with the winding nature of the channel, results in a very slow-moving water body. The low channel velocities make conditions ideal for the deposition of sediment, as is evidenced by the wide, shallow channel with the nearly continuous occurrence of sandbars and mudflats upstream of the impoundment. Streambank erosion is also prevalent, providing a source of sediment as well as resulting in trees being undermined and falling into the channel. These trees not only create a hazard to navigation, but also serve to further trap sediment. Selected photographic views of the channel are provided in Figure 1.

SCOPE OF STUDY

The purpose of this study is to update and refine the analyses set forth in SEWRPC Community Assistance Planning Report No. 5, as those analyses pertain to

MAP 1

FOX RIVER WATER LEVEL STUDY AREA

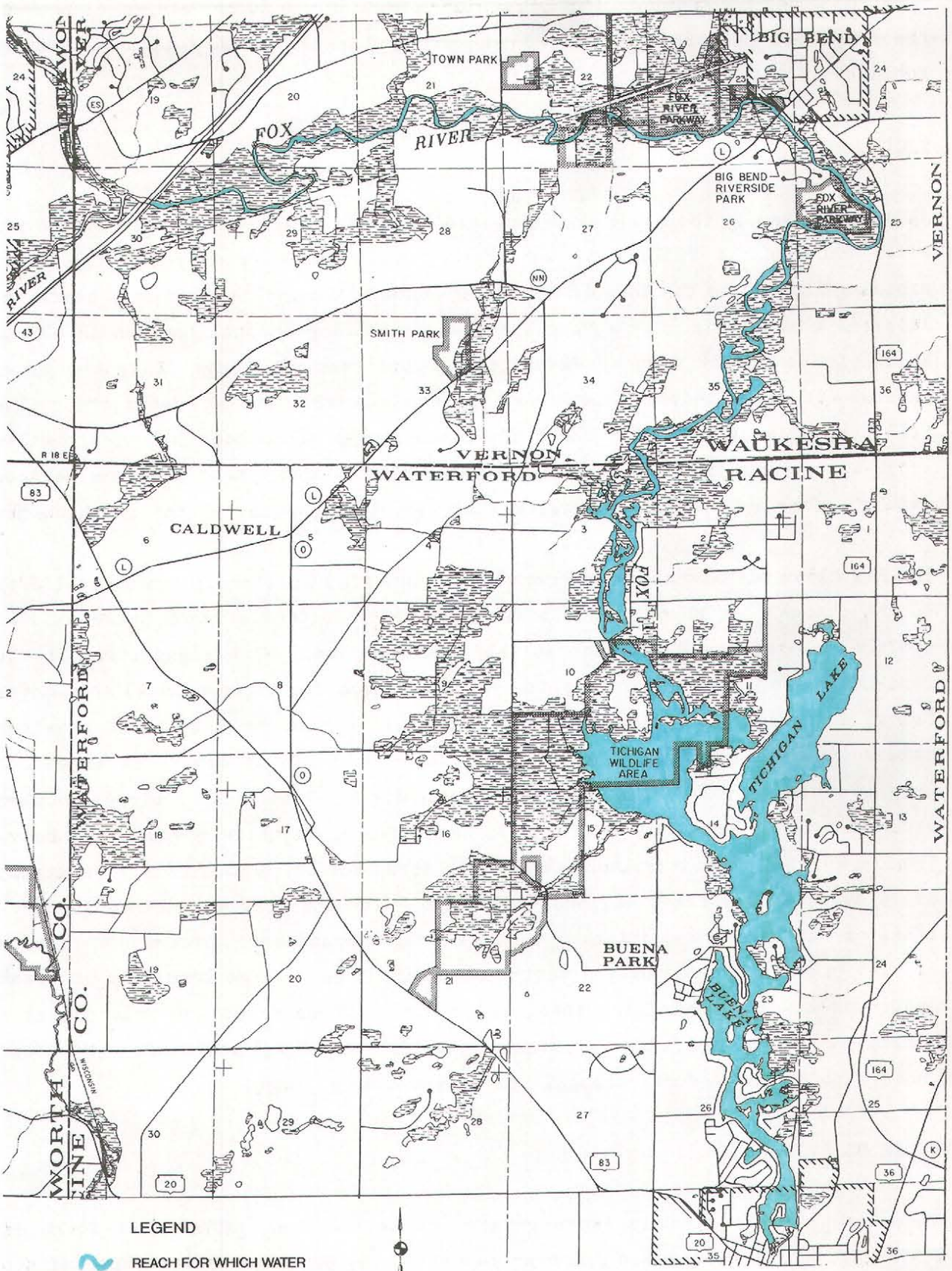


FIGURE 1

VIEWS OF THE FOX RIVER CHANNEL
BETWEEN IH-43 AND THE WATERFORD IMPOUNDMENT

Fox River Upstream From Center Drive

Fox River Downstream From Center Drive

Source: SEWRPC

FIGURE 1 (continued)

Fox River Upstream of Village of Big Bend

Fox River Upstream From CTH L

Source: SEWRPC

FIGURE 1 (continued)

Fox River Upstream From Racine-Waukesha County Line

Fox River Upstream From Bridge Drive

Source: SEWRPC

control of water levels along that reach of the Fox River between IH-43 and the Waterford dam. Specific work elements of this study include the following:

1. Evaluate the impact of the existing dam at Waterford and the current operating procedure of that dam on upstream flood levels.

2. Collect field-surveyed channel cross sections and determine the extent of sediment deposition and scour which has occurred over the last twenty years.

3. Collect samples of the channel sediments and evaluate the quality of those sediments.

4. Utilize recent large-scale topographic mapping and land use data, together with testimony from area residents to determine the nature and extent of the flooding, drainage, and navigation problems.

5. Prepare, test, and evaluate alternative water level control measures.

6. Select a final recommended plan which will represent a refinement of the previously recommended plan.

This study is to be carried out within the context of the adopted comprehensive plan for the entire Fox River watershed, and the recommended solution should be consistent with that plan.

Chapter II

DATA COLLECTION AND ANALYTICAL METHODS

DATA COLLECTION

As reported earlier, reports from landowners and local officials indicate that the degree of sedimentation in the study reach has increased since the previous plan was prepared almost twenty years ago. An inventory of Commission files indicated that the most recent information pertaining to the Fox River channel were field-surveyed cross sections obtained as part of the Federal flood insurance study prepared for Waukesha County and published in 1983. Since a decade has elapsed since that study was prepared, and since field inspections and testimony of local officials and citizens indicated that there has been sediment and streambank erosion occurring, it was deemed necessary to obtain new stream cross-section data for use in defining and documenting the existing problems and in evaluating alternative measures for the abatement of those problems. In addition, any plan involving removal of channel sediments will require that an assessment first be made of the quality of those sediments. The level of pollutants in the sediment would be a significant determinant of the methods used in, and the cost of, removal and disposal. Therefore, a preliminary analysis of river sediment quality was also undertaken as part of this study.

Channel Cross Section Survey

This section of the report summarizes the results of the channel cross-section field survey conducted as part of this study. A more detailed description of these surveys is given in the SEWRPC Staff Memorandum included as Appendix B.

Based upon review of available channel data in Commission files, as well as field inventories conducted on May 10 and 12, 1994, a total of 18 locations were selected for surveys of the channel cross sections. These surveys were obtained in June 1994, by the firm of Ayres & Associates, Inc. under contract to the Commission. The locations of the surveyed cross sections are shown in Appendix B.

Of the 18 cross sections surveyed, 16 corresponded with sections used in previous hydraulic analyses. The remaining two represented new sections within the

Waterford Impoundment. These surveys reveal that some shifting of the streambed has taken place through a combination of scour and deposition. On average, however, the bottom elevation of the low-flow portion of the channel has not changed appreciably over the past 15 years. Of the 16 sections for which comparisons could be made, five showed higher low-flow channel bed elevations; six showed lower elevations; and five showed little or no change. It is important to note that, although the elevation of the low-flow channel has not increased significantly, the total cross-sectional area of the channel has been reduced due to deposition along the banks of the channel. The streambed profile shown in Appendix A is based upon the surveys conducted under this study.

River Sediment Quality Survey

This section of the report summarizes the results of the surveys of sediment quality which were conducted as part of this study. A more detailed description of this survey is given in the SEWRPC Staff Memorandum included as Appendix B.

An initial survey of sediment within the channel was conducted by Commission staff on May 10 and 12, 1994. Grab samples of sediment were collected at 19 locations along the 14-mile-long reach between IH-43 and the Waterford Impoundment. These locations generally corresponded to the location of the cross section surveys. A preliminary analysis of these samples was performed at the Commission offices. As a result of this screening, a total of seven sites were located for more detailed sample collection and laboratory analysis. Samples were collected by Commission staff on August 25, 1994, and delivered within 24 hours to Swanson Environmental, Inc. for analysis. The locations of the sediment collection sites are shown in Appendix B.

Testing was conducted using standard methods for those contaminants set forth under Section NR 347.06 of the Wisconsin Administrative Code, and included selected metals, nutrients, poly-aromatic hydrocarbons (PAHs), biocides, and poly-chlorinated byphenyls (PCBs). The results of the testing indicate "clean" sediments with little detectable contamination. Biocide concentrations were reported as "not detectable" at all seven sampling sites. Detectable metal concentrations varied from site to site, but none appeared to be a cause for concern. PAH concentrations were generally "not detectable" for most of the individual PAH analytes tested for. Trace levels of certain PAH analytes were

detected at six of the sites, although their concentrations would not appear to be a cause for concern at this time.

Based upon the results of these surveys, it was assumed for cost-estimating purposes that the sediments were clean and, if dredged, could be disposed of by conventional means, including land spreading. It should be recognized, however, that these results provide only an initial screening, and that further sampling and analyses may be required by the Wisconsin Department of Natural Resources should a dredging plan for the River be pursued.

ANALYTICAL METHODS

Development of Flows and Stages

The existing Fox River channel within the study reach has a very limited capacity, with overland flooding beginning to occur at discharges ranging from about 150 to 300 cubic feet per second (cfs), depending upon the location along the channel considered. For comparative purposes, the estimated average daily flow of the Fox River through this reach is about 300 cfs. Thus, for some reaches water levels are at or near flood stage for much of the year.

The focus of this study was on frequent flooding, which occurs on a nearly annual basis. Any effort to control flooding from larger, less-frequent flood events would require extensive and costly channel enlargement or diking measures to contain the flows. Such measures would serve to reduce the floodwater storage capacity of the watershed, thus increasing downstream flood problems.

Since most frequently reported flood problems are related to agricultural damages, and since the planting and harvesting period occurs between May and November, the development of a design discharge should be based upon the flows which may be expected to occur during that period. Streamflow records are available for a 31-year period for the stream gage located on the Fox River at Waukesha, which is operated by the U.S. Geological Survey under a cooperative agreement with Waukesha County and the Southeastern Wisconsin Regional Planning Commission. For each of these 31 years, the highest daily flow occurring during the period from May through November was determined. Based on these 31 years of record, the average high daily flow rate at Waukesha was estimated to be about 440 cfs. This corresponds to a flow of about 720 cfs along the study reach.

Therefore, a design discharge of 720 cfs was used in the evaluation of alternative flood control measures. Such a discharge may be expected to occur about once every two years during the growing season. By comparison, the 10- and 100-year recurrence interval flood discharges along the study reach are estimated to be about 2,050 cfs and 3,330 cfs, respectively. This latter flow is used by regulatory agencies for floodland management purposes and is also considered herein in order to assess the conformance of the selected alternative with the floodland management recommendation previously set forth in the Fox River watershed plan and with appropriate State and Federal regulations.

Flood stages for existing channel conditions, as well as for the alternative plan conditions considered, were computed using the U.S. Army Corps of Engineers HEC-2 hydraulic model. Channel cross sections used in the model were updated to incorporate the field-surveyed data collected under this study. The river crossing data at Bridge Drive was also updated as this structure was replaced in 1982. Information for the new bridge was obtained from the Wisconsin Department of Transportation. Finally, the coefficients used to estimate friction loss along the channel were modified for certain reaches to reflect the obstruction to flow caused by the numerous trees and sand bars which were noted in the field inventory.

According to the staff of the Racine County Public Works Division--the operators of the Waterford Dam--current operating procedure for the dam is to visually check the water level in the impoundment on a daily basis. The control gates on the dam are either opened or closed to maintain the water level as close as possible to the spillway elevation of 773.4 feet NGVD-29. The operators generally inspect the dam at least once per day and generally control the level to within 0.2 foot of the spillway elevation. At water levels below the spillway elevation, complaints from recreational users of the Impoundment are generally experienced. Therefore, with the exception of those alternative plans evaluated which involve varying water levels for the impoundment, it was assumed that the level of the impoundment would be kept at 773.4 feet NGVD-29.

Assessment of Damages

Flood damages to agricultural lands were assessed in a manner similar to that used in the 1975 study. An evaluation of those lands identified as suffering flooding or subsurface drainage problems was made based upon meetings with local

farm operators and review of the extent of the floodplain for various storm events, as well as review of soil survey maps. Based upon this evaluation, it was determined that those croplands located within an elevation of up to five feet above the normal water level would be adversely affected by prolonged periods of high water. These lands would be expected to be impacted by either direct flooding or by impaired drainage conditions. While some of the problems related to impaired drainage may be due to damaged or blocked drain tiles, most reports from the farmers indicate that lands currently under production have adequate drainage except for those periods when water levels on the River are high. Thus, it may be concluded that most tile systems are functioning adequately.

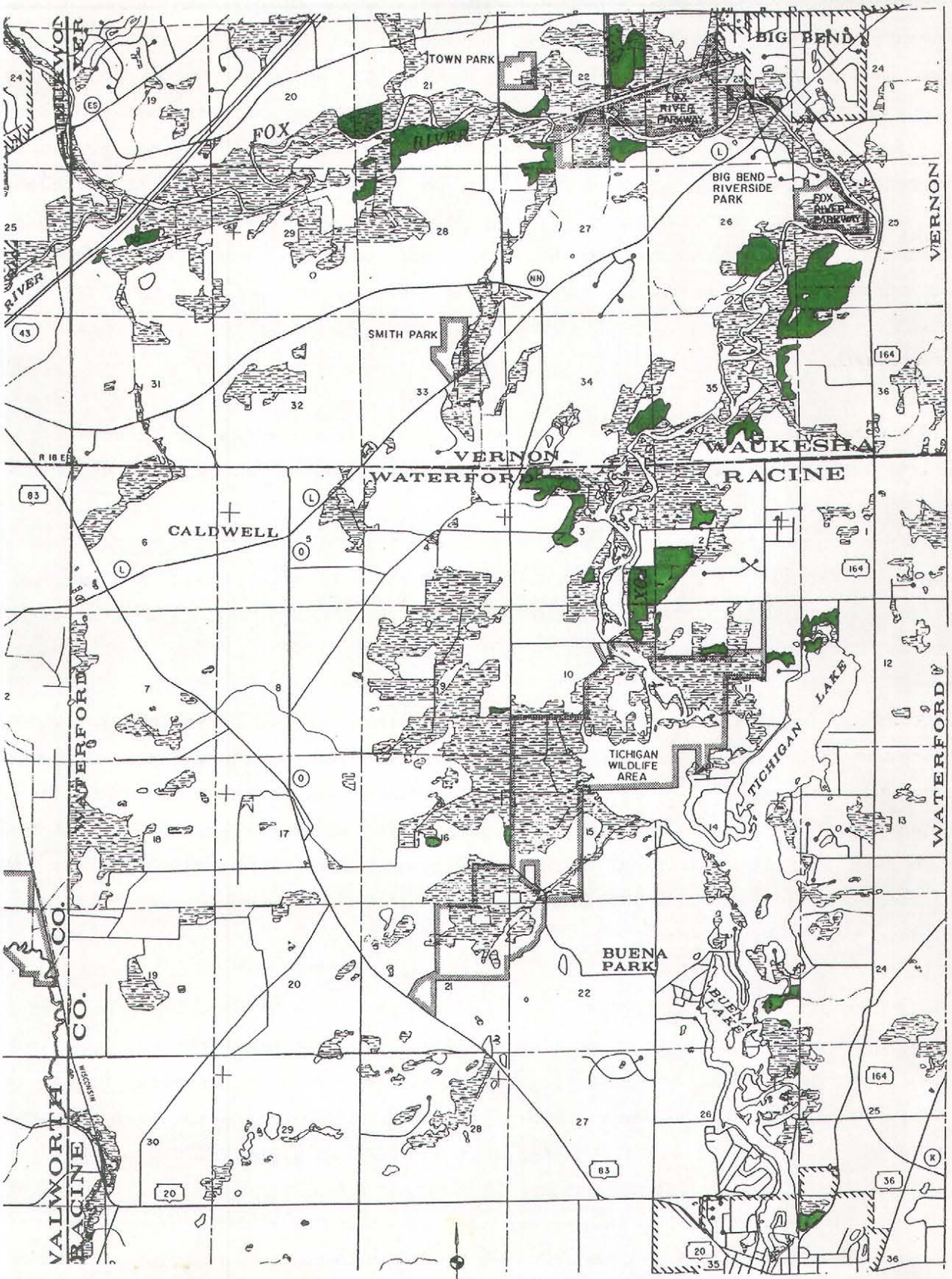
An estimate of the normal water level was obtained from the channel cross-section survey conducted under this study. Racine and Waukesha County one inch equals 200 feet scale, two-foot contour interval topographic maps were then used to delineate the area having a surface elevation within five feet of that water level. Finally, the Commission's 1990 land use inventory data were used to identify agricultural lands located within the delineated area. The location of these lands are shown on Map 2.

A total of 335 acres of land in the Town of Vernon and 370 acres in the Town of Waterford were identified as being adversely affected by high water levels. Of these lands, about 602 acres are used, or have recently been used, for crop production, about 100 acres are used for pasture, and the remaining three acres are used for recreational--golf course--purposes. High water problems within the Village of Big Bend are related primarily to flooding and impaired drainage within two Village parks.

A review of streamflow records for the Fox River at Waukesha indicates that prolonged periods of high streamflow usually occur from March through June, but have occurred also in late summer. Since planting of crops generally occurs in May, the agricultural damages assessed under this study were based on the assumption that planting has taken place and that the crops will suffer a total loss, either through direct overland flooding or through prolonged saturation of the root system. Damages related to the Edgewood Golf Course in the Town of Vernon were based on an estimate of lost revenue due to the inability to utilize that portion of the course likely to be flooded.

MAP 2

AGRICULTURAL LANDS AFFECTED BY HIGH WATER LEVELS OR IMPAIRED DRAINAGE ALONG THE FOX RIVER



LEGEND

AGRICULTURAL LANDS SUBJECT TO HIGH WATER DAMAGES

Source: SEWRPC.

Based upon estimates of the frequency of agricultural and recreational damages in a typical year, the total annual flood damages were estimated at about $41,500--$38,300 for cropland, $1,200 for pasture, and $2,000 for golf course land--for the riparian lands located in the Town of Vernon and Village of Big Bend; and about $42,200--$40,400 for cropland and $1,800 for pasture--for the riparian lands located in the Town of Waterford.

In addition to these direct agricultural and recreational damages, there are other indirect damages attendant to the high water problems in the Village of Big Bend and the Towns of Vernon and Waterford which should be considered when evaluating alternative water level control measures. These indirect damages include the loss of user days at the Village of Big Bend Riverside Park; lack of adequate outlets for stormwater drainage systems; closure of roads and increased travel times and costs; and in some cases, the negative impacts on the viability of farming for individual farmers most severely impacted. Such losses, while potentially significant, are not generally quantified. In addition, the problems associated with restricted navigation during low water periods were not specifically quantified in terms of monetary damages.

Chapter III

IMPACTS OF INCREASED SEDIMENTATION AND CHANGING LAND USE ON THE STUDY AREA

SEDIMENTATION

As was discussed in Chapter II, new field-surveyed cross sections of the river channel were obtained under this study for use in assessing the degree of sedimentation that has taken place within the study reach over the past 20 years. From those surveys, and from a series of field inspections, it was found that the bottom elevation of the channel generally has not changed significantly from that recorded in the previous survey conducted as part of the Waukesha County Federal flood insurance study published in 1983. The sedimentation that has taken place, moreover, has taken place along the outer edges of the channel. Therefore, even though the minimum depth of the channel generally has not decreased, the overall cross sectional area of the channel has.

Hydraulic analyses were conducted under this study for comparative purposes, utilizing both the previously available cross sections, as well as the more recent survey data. Under the design discharge of 720 cubic feet per second, an increase of up to 0.3 foot in the water level resulted from use of the new survey data. Smaller increases were noted under the less frequent 10-and 100-year recurrence interval flood events.

From these analyses, it appears that increased sedimentation along the River has reduced the hydraulic capacity of the channel. The effect of that reduction is most noticeable under smaller, more-frequent runoff events. The duration of any given flooding event would also expect to be greater under current channel conditions for these more-frequent events.

LAND USE

One of the issues raised concerning the water level problems along the Fox River within the study area has been the impact of increased urbanization on those problems. Additional upstream development has the potential to increase the

volume and the peak rate of stormwater runoff due to increases in impervious areas, and to add to the sedimentation problems through contributions from construction site erosion. It has been suggested that the use of upstream detention storage facilities on new development could prevent or significantly reduce these problems.

As shown in Table 1, a significant amount of urban development has occurred within the watershed since 1963, with additional development expected in the future. From 1963 to 1990, the amount of land in urban use within the watershed upstream of the Village of Waterford increased by about 87 percent, from about 49 square miles to about 92 square miles. More than half of that increase--about 54 percent--occurred in that portion of the watershed downstream of the City of Waukesha. Between 1990 and the year 2010, land devoted to urban use within the watershed upstream of Waterford may be expected to increase further by about 15 percent, to 106 square miles. Of that increase, about 20 percent may be expected to occur within that portion of the watershed downstream of the City of Waukesha.

Hydrologic and hydraulic analyses of the Fox River watershed were conducted by the Commission under its comprehensive planning effort for the watershed.[2] Table 2 presents the estimated discharges under both 10- and 100-year recurrence interval flood events for several locations along the Fox River, as determined under the Commission watershed study. Discharges are listed for both combination rainfall-snowmelt events and for rainfall events. Analyses conducted under the comprehensive watershed study indicated that major flood events in the headwater reaches of the watershed above the City of Waukesha were more likely to occur as a result of heavy rainfall, while major floods downstream of Waukesha were most likely to occur as a result of a combination of snowmelt, saturated or frozen ground conditions, and rainfall. Assuming a strictly rainfall event, major flood discharges in the City of Waukesha may be expected to increase about 7 percent between 1963 and 1990 land use conditions, and by an additional 5 percent between 1990 and anticipated year 2000 land use conditions. Within the study area, these increases are only 1 percent and 2 percent, respectively. This can be attributed in part to the ameliorating effect on flows of the Vernon Marsh area and to the fact that much of the urban residential development which has occurred was of a

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[2]Loc cit, SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, February 1970.

Table 1

CHANGES IN LAND USE WITHIN THE FOX RIVER WATERSHED

Land Use Class	Fox River at Waukesha[a]								Fox River at Waterford[b]							
	1963		1970		1990		2010		1963		1970		1990		2010	
	Area (sq. miles)	Percent	Area (sq. miles)	Percent	Area (sq. miles)	Percent	Area (sq. miles)	Percent	Area (sq. miles)	Percent	Area (sq. miles)	Percent	Area (sq. miles)	Percent	Area (sq. miles)	Percent
Urban	33.9	22.6	42.7	28.5	53.7	35.8	64.4	43.0	49.2	13.5	62.5	17.2	92.1	25.3	105.5	29.0
Rural	116.0	77.4	107.2	71.5	96.2	64.2	85.5	57.0	315.0	86.5	301.7	82.8	272.1	74.7	258.7	71.0
Total	149.9	100.0	149.9	100.0	149.9	100.0	149.9	100.0	364.2	100.0	364.2	100.0	364.2	100.0	364.2	100.0

[a] Area tributary to Fox River at STH 59.

[b] Area tributary to Fox River at Waterford dam.

Source: SEWRPC

Table 2

COMPARISON OF FLOOD DISCHARGES FOR THE FOX RIVER[a],[b]

Location	Spring Snowmelt-Rainfall Event									
	10-Year Recurrence Interval					100-Year Recurrence Interval				
	1963 Land Use	1990 Land Use	Percent Increase	Year 2000[c] Planned Land Use	Percent Increase	1963 Land Use	1990 Land Use	Percent Increase	Year 2000[c] Planned Land Use	Percent Increase
Prairie Avenue-Waukesha	1,310	1,310	0	1,320	1	2,000	2,000	0	2,010	1
CTH ES-Town of Vernon	1,460	1,470	1	1,480	1	2,340	2,360	1	2,370	1
STH 24-Big Bend	2,000	2,000	0	2,000	0	3,300	3,300	0	3,300	0
STH 20-Waterford	2,050	2,050	0	2,050	0	3,330	3,300	0	3,330	0
	Rainfall Event									
Prairie Avenue-Waukesha	1,530	1,640	7	1,720	12	2,870	3,080	7	3,220	12
CTH ES-Town of Vernon	700	710	1	720	2	1,370	1,390	1	1,400	2
STH 24-Big Bend	760	770	1	780	3	1,570	1,600	2	1,620	3
STH 20-Waterford	1,020	1,040	2	1,060	4	1,660	1,700	2	1,725	4

[a] Discharges are in cubic feet per second.

[b] Existing channel conditions.

[c] Year 2000 discharges are based upon planned 1990 land use conditions as projected in the comprehensive plan for the Fox River watershed in 1970. That earlier land use plan is very similar to a more recent year 2000 plan.

Source: SEWRPC.

relatively low density and would not result in significant increases in runoffs or in sediment once the development site is developed and stabilizes, compared to some agricultural uses. A similar increase in the total volume of runoff during these events, however, may be expected. The increases based upon a combination of snowmelt and rainfall are even less, with total increases of only about 1 percent expected between 1963 and planned year 2000 land use conditions. This relatively insignificant increase can be attributed to the fact that frozen or saturated ground conditions are likely to exist during these type of events, with very little infiltration likely to occur. Therefore, increases in impervious area due to urbanization would have little effect in increasing runoff under those conditions.

As noted earlier, the capacity of the Fox River through the study area is small enough that flooding occurs not only during major events, but usually even on an annual basis. Analyses made as part of the regional water quality planning effort were reviewed as they relate to annual runoff volumes.[3] Those analyses show that, between 1975 and planned year 2000 land use conditions, the volume of annual runoff for the Fox River at Waukesha may be expected to increase by about 25 percent. Within that same period, the increase for the Fox River at Waterford is expected to be about 17 percent. As with the major flood events, the increase in runoff volume between 1975 and planned year 2000 land use conditions during the spring would be less than the increase in the annual average runoff volume, with the increase at Waukesha being about 14 percent, and the increase at Waterford being about 10 percent. Again, this can be attributed to the fact that less infiltration is likely to occur due to higher soil moisture conditions during that period.

Based upon these observations, it may be concluded that increased urbanization within the Fox River watershed will have only a slight impact on the magnitude of peak flood flows and stages within the study area. Therefore, it is not likely that flooding will spread to significant areas previously unaffected. The impact of urbanization is more likely to be noticed in the volume of the streamflow and the resulting duration in which the River flows will remain high,

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[3]SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin--2000, Volume One, Inventory Findings, Volume Two, Alternative Plans, Volume Three, Recommended Plan, June 1979

particularly following smaller, more-frequent rainfall events. Those longer periods of high flow in the River may be expected to result in significant impacts on agricultural uses of the lands since limitations on the planting, growing, and harvesting may be extended. The increased duration of high flows may also be expected to result in streambank erosion. That erosion, in turn, will produce more sedimentation within the channel, thus further reducing the hydraulic capacity of the River.

It is important to note that the use of stormwater detention facilities can be helpful in reducing the peak rates of discharge associated with new development but will not significantly reduce the volume of runoff. Also, these basins are typically designed to release stored stormwater within a 24-hour period of a rainfall event. Since the problems which exist within the study area are generally associated with prolonged periods of flooding and standing water, rather than short-period peak-flow problems generally associated with urban streams, the use of a system of small, onsite detention basins is unlikely to be effective in resolving these problems.

It is also important to note that the sediment loading resulting from construction site erosion associated with land development and from agricultural land runoff be controlled. Such loadings result in sediment buildup within the channel, negatively affecting navigation and reducing the channel's hydraulic capacity. At the present time, within the watershed area upstream of Waterford, the Cities of Brookfield, Muskego, New Berlin, and Waukesha; the Villages of Big Bend, North Prairie, and Sussex; and the Towns of Lisbon and Vernon have adopted construction erosion control ordinance requirements. Waukesha County has also adopted erosion control requirements covering all developments within the incorporated areas of the County, with the exception of one- and two-family buildings. Those structures are covered under the Wisconsin Department of Industry, Labor and Human Relations (DILHR) regulations. Thus, with proper enforcement within the counties and communities which have adopted such ordinance provisions, the impacts of sediment loadings from construction sites will be minimized.

It would be desirable for the other communities in the watershed to also adopt and enforce construction erosion control ordinance provisions. It would also be desirable to reduce the sediment and other nonpoint sources of pollution from

agricultural lands in the areas tributary to the subject stream reach. The regional water quality management plan recommended, for water quality purposes, a reduction in rural nonpoint sources of from 25 to 75 percent, depending upon the location with the tributary watershed. Such reduction would require the preparation of plans for, and the application of good soil and water conservation practices on, the farm fields concerned.

Chapter IV

ALTERNATIVE WATER LEVEL AND FLOOD CONTROL SYSTEM PLANS

A total of eight alternative water level control plans were considered under this study. Each alternative plan is briefly described in this chapter. The estimated costs of the alternative plans are set forth in Table 3. Ratios of plan benefits versus costs are also presented to demonstrate the economic feasibility of each alternative. Values of one or more indicate a positive return on investment of public monies, and, therefore, that the project is economically justified. An evaluation of all the alternatives is also presented at the end of this chapter. Unit cost values used in determining the cost of each alternative plan are listed in Appendix C. The potential for adverse environmental impacts for each alternative plan is set forth in Table 4.

ALTERNATIVE 1 - NO ACTION

One alternative course of action with respect to high water-related problems along the Fox River in the Towns of Vernon and Waterford is to do nothing--that is, to recognize the inevitability of high water levels and flooding, and to decide not to mount a collective, coordinated effort to abate the attendant problems and damages. If nothing is done with respect to the drainage and water level control problems of the Fox River within the study reach, annual monetary damages of about $84,000 may be expected to continue to be incurred in the area.

ALTERNATIVE 2 - LOWER SPILLWAY ELEVATION ON WEST DAM TO ORIGINAL LEVEL

As noted in Chapter I of this report, the spillway of the west dam structure at Waterford was raised about 0.5 foot in 1978, thus bringing the elevation of that spillway about equal to that of the east dam structure--773.4 feet above National Geodetic Vertical Datum of 1929 (NGVD). The west dam spillway elevation of 773.4 feet NGVD is also equal to the elevation of the original crest of the dam which was replaced in 1977. Since the addition of the 0.5 foot of height to the spillway, there has been the perception that upstream flooding and drainage problems have worsened.

Table 3

COST ESTIMATES FOR ALTERNATIVE DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLANS FOR THE FOX RIVER-TOWNS OF VERNON AND WATERFORD

Alternative Plan	Capital Cost[a]	Annual Costs				Benefit-Cost analysis			
		Amortized Capital[b]	Operation and Maintenance	Other	Total	Annual Benefits	Annual Benefits Minus Annual Costs	Benefit-Cost Ratio	Economic Ratio Greater Than One
1. No Action	$ 0	$ 0	$ 0	$ 83,700	$ 83,700	$ 0	$-83,700	--	No
2. Lower Spillway Elevation on West Dam to Original Level	438,000	27,800	0	0	27,800	3,500	-24,300	0.13	No
3. Draw Down Water Level in Impoundment During Winter and Early Spring	0	0	0	0	0	--[c]	--[c]	--	--
4. Removal of Waterford Dam[d]	--	--	--	--	--	--	--	--	--
5. Minor Channel Clearing and Maintenance	310,000	19,700	6,000	0	25,700	4,400[e]	-21,300	0.17	No
6. Moderate Channel Dredging	717,000	45,500	6,000	0	51,500	5,700[e]	-45,800	0.11	No
7. Major Channel Dredging	4,076,000	258,500	6,000	0	264,500	11,000[e]	-253,500	0.04	No
8. Purchase of Flood-prone Lands	1,269,000	80,500	0	0	80,500	81,700	1,200	1.01	Yes

[a]Costs are in 1994 dollars.

[b]Cost is based on an interest rate of 6 percent and a project life of 50 years.

[c]No specific benefits were computed since conditions during the growing season would not be changed. There would be some unquantified benefits associated with improved early planting conditions and potentially reduced shoreline ice damage.

[d]This alternative was not evaluated in detail. Therefore, no costs were computed.

[e]Values shown do not include benefits due to the potential increase in boating and other recreational use due to increased navigability.

Source: SEWRPC

Table 4

POTENTIAL FOR ADVERSE ENVIRONMENTAL IMPACT OF ALTERNATIVE DRAINAGE AND WATER LEVEL CONTROL PLANS FOR THE FOX RIVER--TOWNS OF VERNON AND WATERFORD

Alternative Plan	Potential Environmental Impact[1]					
	Aquatic Habitat Loss	Wetland Loss or Degradation	Fishery Degradation	Increased Streambank Erosion/ Sedimentation	Increased Upstream/ Downstream Flooding	Weighted Overall Impact
1. No Action	N	N	N	N	N	N
2. Lower Spillway Elevation on West Dam to Original Level	M	M	M	N	N	L
3. Draw Down Water Level in Impoundment During Winter and Early Spring	N	L	L	N	N	N
4. Removal of Waterford Dam	H	H	H	N	L	M
5. Minor Channel Clearing and Maintenance	L	N	N	N	N	N
6. Moderate Channel Dredging	L	L	L	L	L	L
7. Major Channel Dredging	M	L	M	L	L	L
8. Purchase of Flood-prone Lands	N	N	N	N	N	N

[1] Degree of potential impact is as follows: N-Negligible, L-Low, M-Moderate, H-High

Source: SEWRPC

Under this alternative plan, the metal plates added to the two spillways along the west dam structure would be removed, thus bringing the spillway elevation down to elevation 772.9 feet NGVD. It is assumed the control gates at the dam would be operated so as to maintain the water level in the Impoundment equal to the lower spillway elevation.

Permanent lowering of the water level would impair boating activities on the Impoundment, mainly within shallow bays and along the shoreline, as well as in upstream reaches during low flow periods. Alleviation of this problem will require dredging about 50 acres within the Impoundment by about 0.5 foot.

Table 5 lists water levels for the design flood along the Fox River upstream of the Waterford dam under existing and alternative plan conditions. As shown in this table, lowering of the spillway by 0.5 foot would have no significant impact on flood elevations upstream of the Racine-Waukesha County line, with the exception of a small reduction in the duration of the flooding. Therefore, no significant reduction in flood damages would be expected within the Town of Vernon and Village of Big Bend. Some reduction in both the extent and the duration of flooding would be realized within the Town of Waterford.

The estimated capital cost of this alternative is about $438,000. There would be no increase in annual operation and maintenance costs. Utilizing an annual interest rate of 6 percent and a project life of 50 years, the annual cost of this alternative would be about $27,800. Annual benefits due to reduction of flooding are estimated at about $3,500, yielding a benefit-cost ratio of 0.13.

ALTERNATIVE 3 - DRAW DOWN WATER LEVEL IN WATERFORD IMPOUNDMENT DURING WINTER AND EARLY SPRING

Under this alternative plan, the control gates of the Waterford dam would be opened beginning December 1st. The water level of the Impoundment would be lowered to elevation 772.6 feet NGVD, which corresponds to the minimum allowable elevation set by the State of Wisconsin. At that point, the control gates would be operated so as to maintain this lower level as closely as possible until May 1st, at which time the gates would be closed and the water level brought back up to elevation 773.4 feet NGVD.

Table 5

COMPARISON OF FLOOD STAGES UNDER THE DESIGN EVENT[a]
FOX RIVER - VERNON AND WATERFORD

Location	River Mile[b]	Existing Condition	Alternative 2 - Lower Spillway Elevation		Alternative 3 - Winter Drawdown		Alternative 4 - Removal of Waterford Dam		Alternative 5 - Minor Channel Clearing and Maintenance		Alternative 6 - Moderate Channel Dredging		Alternative 7 - Major Channel Dredging	
		Stage (feet NGVD-29)	Stage (feet NGVD-29)	Difference (feet)	Stage (feet NGVD-29)	Difference (feet)	Stage (feet NGVD-29)	Difference (feet)	Stage (feet NGVD-29)	Difference (feet)	Stage (feet NGVD-29)	Difference (feet)	Stage (feet NGVD-29)	Difference (feet)
Upstream from Waterford Dam	0.00	773.4	772.9	-0.5	772.6	-0.8	769.6	-3.8	773.4	0	773.4	0	773.4	0
Bridge Drive (upstream side)	4.887	773.9	773.6	-0.3	773.5	-0.4	773.1	-0.8	773.9	0	773.9	0	773.8	-0.1
Racine-Waukesha County Line	6.472	774.5	774.4	-0.1	774.4	-0.1	774.3	-0.2	774.5	0	774.5	0	774.5	0
--	8.177	775.7	775.7	0	775.7	0	775.7	0	775.7	0	775.7	0	775.5	-0.2
At Edgewood Golf Course	8.824	776.1	776.1	0	776.1	0	776.0	-0.1	776.0	-0.1	776.0	-0.1	775.8	-0.3
--	0.915	776.3	776.3	0	776.2	-0.1	776.2	-0.1	776.2	-0.1	776.2	-0.1	776.0	-0.3
CTH L (upstream side)	11.452	776.7	776.7	0	776.7	0	776.7	0	776.7	0	776.6	-0.1	776.4	-0.3
--	12.905	777.8	777.8	0	777.8	0	777.8	0	777.3	-0.5	777.0	-0.8	776.8	-1.0
Center Drive (upstream side)	13.824	778.1	778.1	0	778.1	0	778.1	0	777.6	-0.5	777.4	-0.7	777.1	-1.0
--	15.047	778.5	778.5	0	778.5	0	778.5	0	778.1	-0.4	778.0	-0.5	777.7	-0.8
--	16.945	778.8	778.8	0	778.8	0	778.8	0	778.5	-0.3	778.5	-0.3	778.3	-0.5
IH 43 (downstream side)	17.974	779.2	779.2	0	779.2	0	779.2	0	779.0	-0.2	779.0	-0.2	778.9	-0.3

[a]Based on a discharge of 720 cubic feet per second representing the average high daily discharge during the growing season (May-November).

[b]Measured from the Waterford Dam - west structure.

Source: SEWRPC

As shown in Table 5, this lowering of the water level of the Impoundment would not have a significant impact on water levels within the Town of Vernon and Village of Big Bend during flooding conditions. Since the proposed water level drawdown would not occur during the planting and growing season, no specific reduction in damages was estimated. The drawdown could, however, produce some benefits by accelerating the passage of early spring rain-snowmelt runoff, thus allowing farmers the opportunity to work fields earlier. Also, property owners along the impoundment have expressed concerns over winter ice damage to the shoreline. Reduction of the water level could help to reduce those damages.

No costs have been assigned to this alternative as there would be no significant additional structural or operating costs over those which currently exist.

Consideration was also given under this alternative to leaving the control gates completely opened from December 1 to May 1, thus allowing water levels within the Impoundment to be controlled strictly by the flow in the River. This alternative was not pursued for two reasons. The first reason is that flow rates in the Fox River during early spring are generally much higher than at other times of the year. Due to the hydraulics of the dam with the gates open, it is likely that the water level in the Impoundment would be near the 772.6 feet NGVD elevation at that time in any case. The second reason for not lowering the water levels further is that many of the fish within the Waterford Impoundment-Tichigan Lake area utilize the many adjacent wetlands for spring spawning. For example, northern pike typically begin spawning as early as mid-March. A lower drawdown of the Impoundment would lower water levels in these wetlands, thus impeding the ability of some fish--particularly larger game fish--to utilize these spawning areas. Additional adverse impacts to the fishery could occur during the winter months as fish within the Impoundment would be forced to move to deeper water within Tichigan Lake, thus increasing competition for available food. Although there is the potential for these same problems to occur with the recommended draw-down level, it is assumed that these impacts were accounted for in the establishment of the State-mandated minimum water level for the Impoundment. It is recommended, however, that State fish managers be consulted on this matter before this alternative is implemented.

ALTERNATIVE 4 - REMOVAL OF WATERFORD DAM

An alternative plan calling for the complete removal of the dam at Waterford was considered under the 1975 Commission study. It was noted at that time that the benefits achieved through removal of the dam would be far less than the costs involved. These costs relate not only to the direct cost of removing the dam, but also to the resulting reduction in property values for landowners along the Waterford Impoundment and Tichigan Lake, and the loss of revenue from recreational uses, including boating, fishing, and waterfowl hunting. This measure would also have an adverse impact on valuable fish and migratory waterfowl habitat within this area. For these reasons, this alternative was not considered feasible under this study. For comparison purposes, an analysis was made of the impact that such a measure would have on flood stages along the Fox River. As shown in Table 5, complete removal of the dam would have a similar impact on flood levels upstream of the Waterford Impoundment as the winter drawdown outlined in Alternative 3 above.

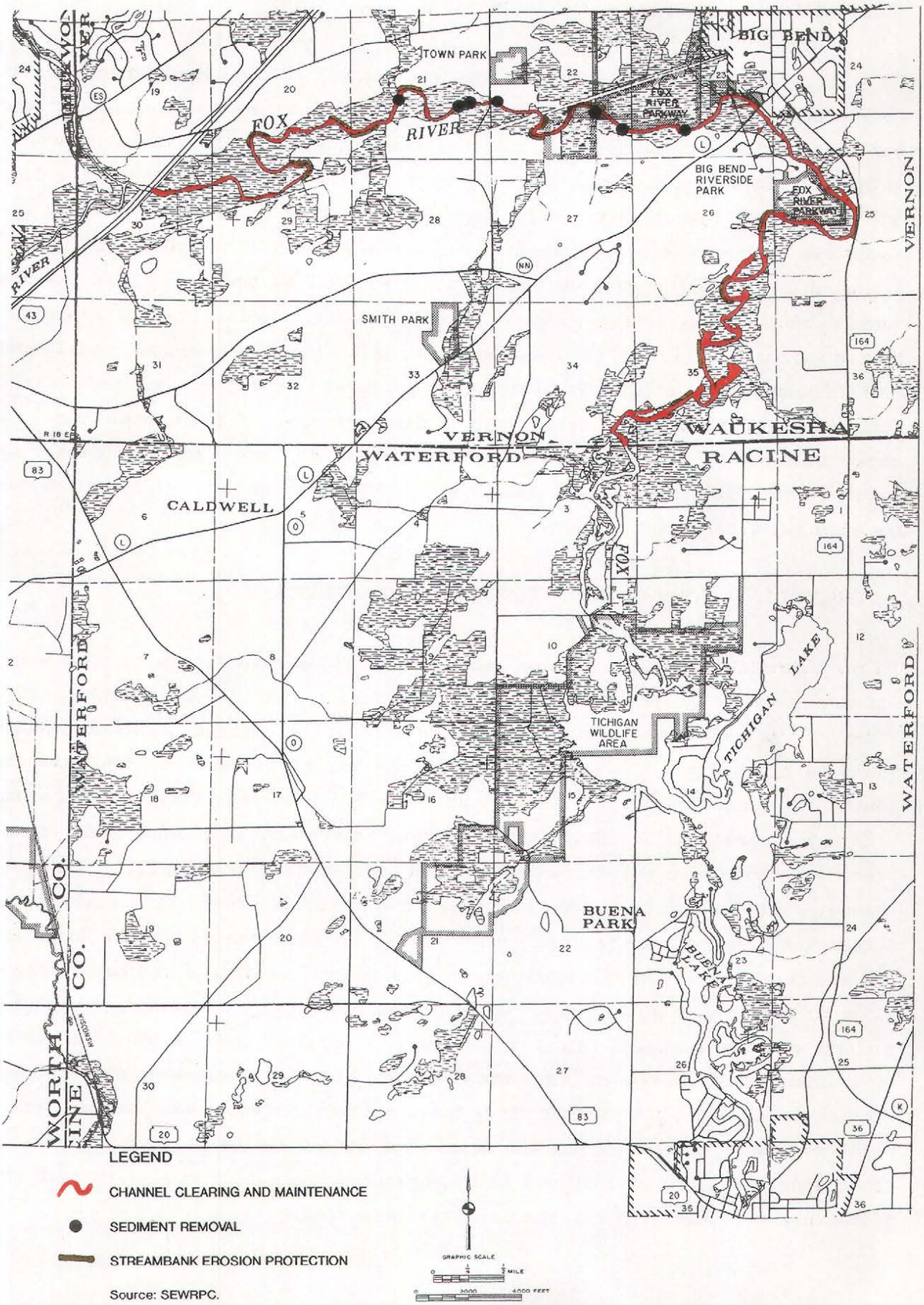
ALTERNATIVE 5 - MINOR CHANNEL CLEARING AND MAINTENANCE

This alternative plan is shown on Map 3 and is similar in nature to that which was recommended for the Town of Vernon area under the 1975 Commission study. Under this alternative, a program of regular channel clearing and maintenance would be pursued for the entire reach of the Fox River between IH-43 and the Racine-Waukesha County line. Within this reach, trees and other debris, along with any accumulated sediment, would be removed from the channel. Also, those trees located along the streambanks which are in danger of falling into the channel would be cut down. It is recommended that, as trees are cut along the streambank, the stumps be left intact so as to help stabilize the bank and prevent further erosion. In addition to tree removal, selected sandbars located along the River within this reach would be removed through dredging and the main channel would be deepened in selected areas. A total of about 6,400 cubic yards of sediment would be removed from the channel. Finally, streambank erosion protection measures would be placed along those reaches currently exhibiting erosion problems, mostly located along the outside of stream meanders. For purposes of estimating costs, it was assumed that protection would be provided through the placement of riprap or other stabilization measures.

MAP 3

ALTERNATIVE 5

MINOR CHANNEL CLEARING AND MAINTENANCE



Under this alternative, some improvement in navigability would be realized along those reaches where obstructions would be removed. Although the aim of this alternative is to improve navigability along the River, some benefits in flood damage reduction would also be realized. The impact of this alternative on flood stages is shown in Table 5. Under this alternative, stage reductions within the Town of Vernon and Village of Big Bend of up to 0.5 foot may be expected under the design flood. No reduction in flood stage would be realized within the Town of Waterford.

The estimated capital cost of this alternative is about $310,000, with annual operation and maintenance costs of about $6,000. Utilizing an annual interest rate of 6 percent and a project life of 50 years, the annual cost of this alternative would be about $25,700. Annual benefits due to reduction of flooding is estimated at about $4,400, yielding a benefit-cost ratio of 0.17. Additional benefits may be derived from increased recreational activity along the River resulting from improvements to navigability. Since any attempt to assign a value to such benefits would be highly subjective, it has not been included in the benefit-cost analysis.

ALTERNATIVE 6 - MODERATE CHANNEL DREDGING

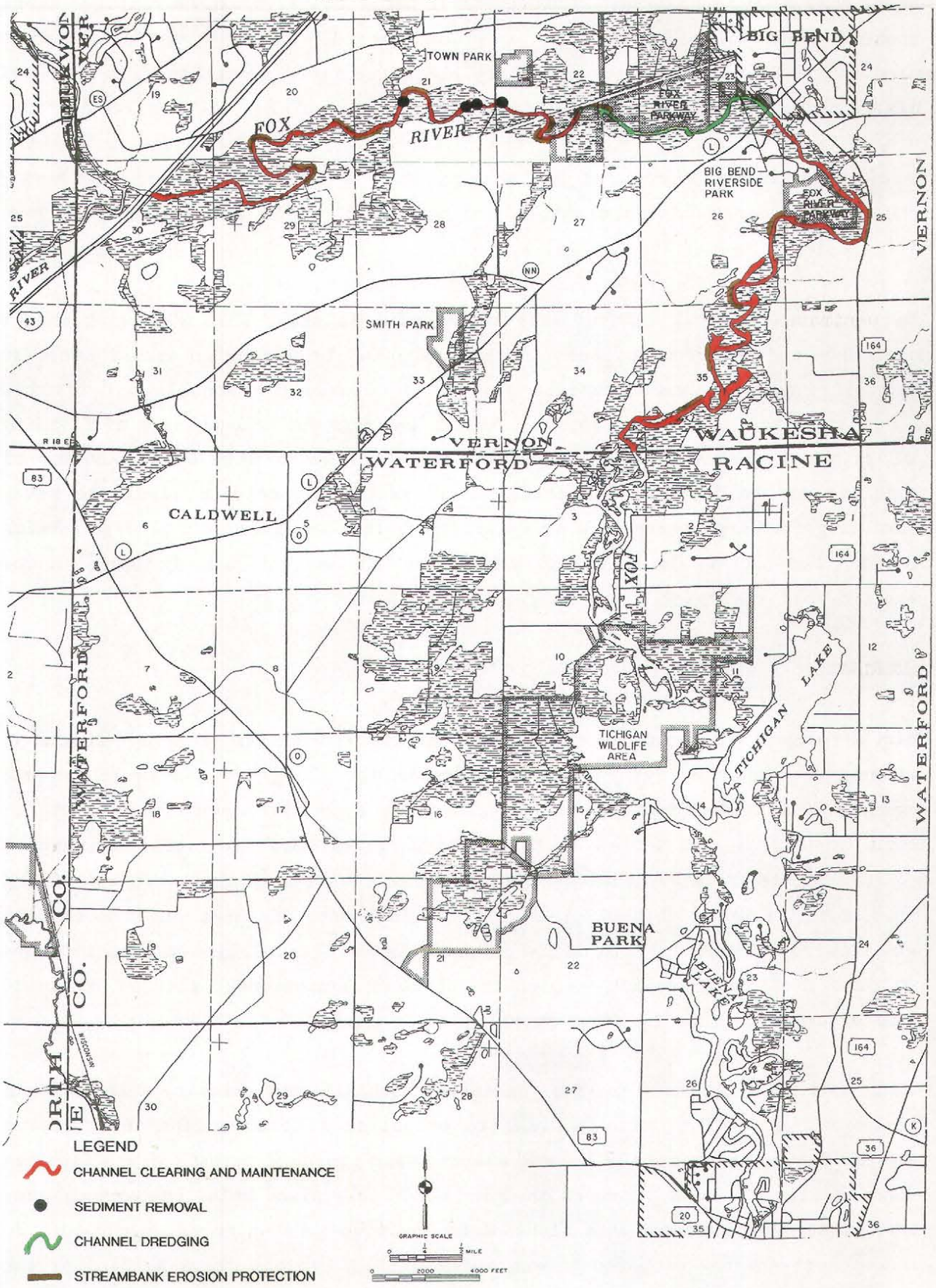
This alternative plan is the same as Alternative 5, with the exception that more extensive channel dredging would be carried out along a 1.7-mile-long reach extending upstream from a point located about 0.25 mile downstream of CTH L. Field inspection and review of the field-surveyed cross sections indicates a greater degree of sedimentation--due in part to severe streambank erosion--along that reach. Regular channel clearing and maintenance measures would be carried out along the remaining 9.8 miles of river between the Racine-Waukesha County line and IH-43. Streambank erosion protection measures would also be provided. This alternative plan is shown on Map 4.

Along that reach proposed for more extensive dredging, the existing channel would be lowered up to 0.9 foot in order to establish a positive channel gradient between Center Drive and CTH L. The existing and proposed streambed profiles are shown on Figure 2. The proposed dredging would take place below the normal water line, extending downward at a slope of one on five--one on three on the outside of meanders--to the proposed invert elevation. A typical cross section of the

MAP 4

ALTERNATIVE 6

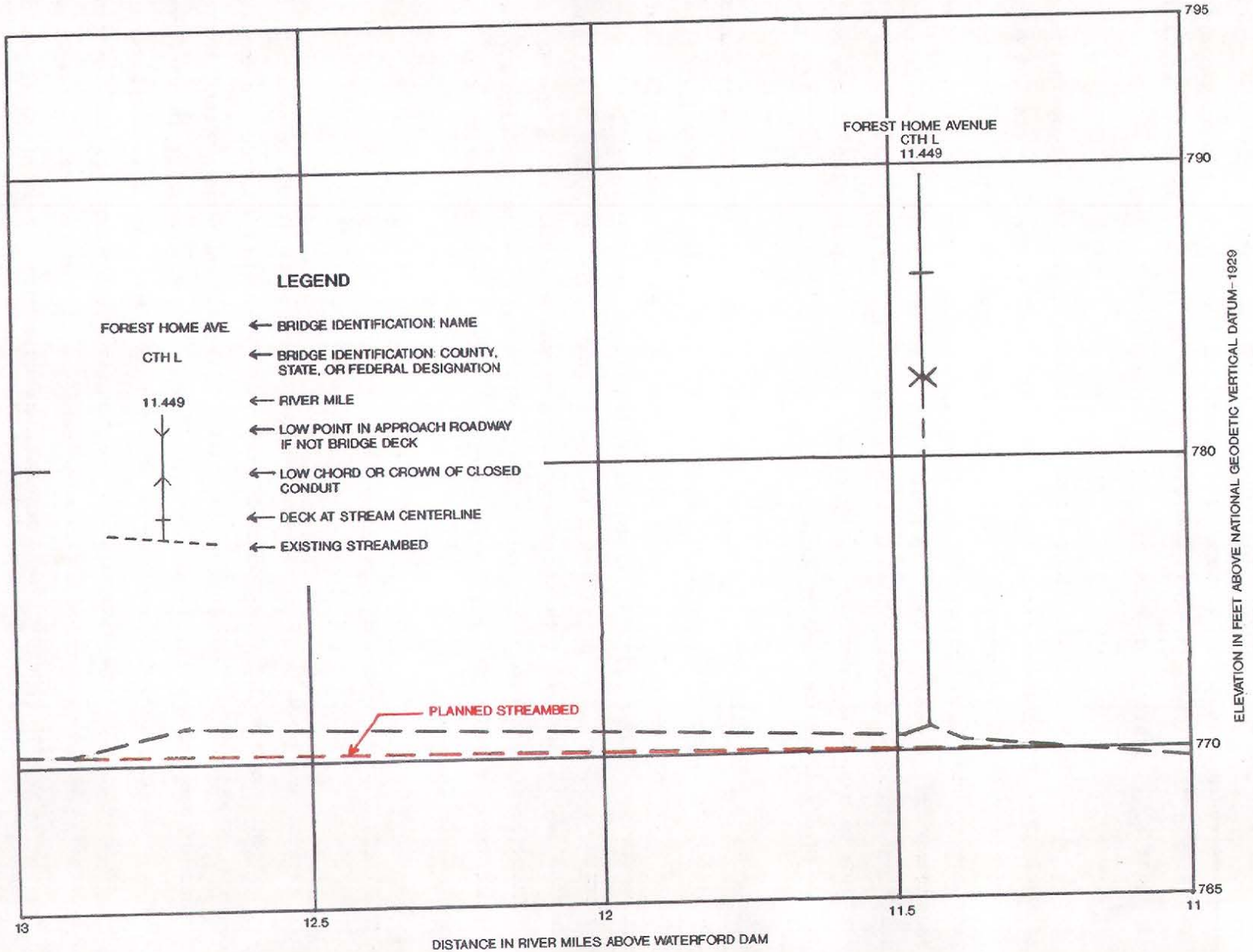
MODERATE CHANNEL DREDGING



Source: SEWRPC.

FIGURE 2

PROFILE OF PROPOSED CHANNEL DREDGING UNDER ALTERNETIVE 6 – MODERATE CHANNEL DREDGING



Source: SEWRPC.

existing and proposed channel through this reach is shown on Figure 3. This dredging would result in the removal of about 39,000 cubic yards of sediment. In addition, several small sandbars would be removed from the channel, resulting in about 3,500 cubic yards more of sediment removed.

As with Alternative 5, this alternative is aimed at improving the navigability of the River. Improvements in navigability would occur along those reaches where obstructions would be removed, with a greater degree of navigability being provided in the reach where more significant dredging would take place. Some benefits in flood damage reduction would also be realized. As shown in Table 5, stage reductions within the Town of Vernon and Village of Big Bend of up to 0.8 foot may be expected under the design flood. No reduction in flood stage would be realized within the Town of Waterford.

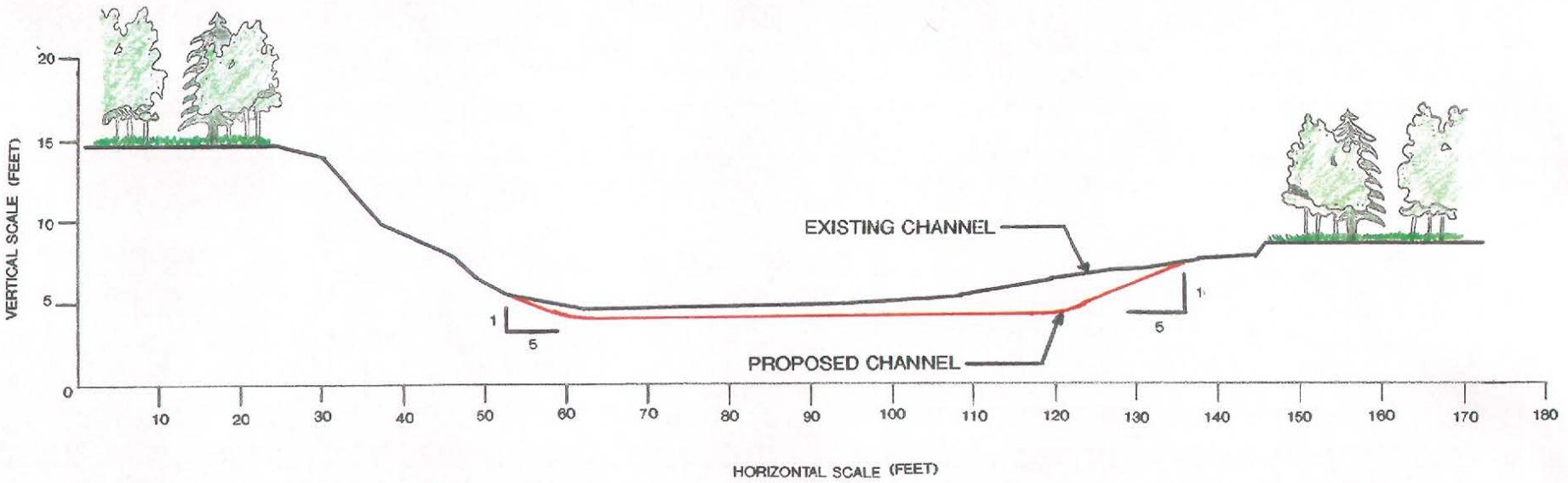
The estimated capital cost of this alternative is about $717,000, with annual operation and maintenance costs of about $6,000. Utilizing an annual interest rate of 6 percent and a project life of 50 years, the annual cost of this alternative would be about $51,500. Annual benefits due to reduction of flooding are estimated at about $5,700, yielding a benefit-cost ratio of 0.11. Additional benefits may be derived from increased recreational activity along the River, resulting from improvements to navigability. Since any attempt to assign a value to such benefits would be highly subjective, it has not been included in the benefit-cost analysis.

ALTERNATIVE 7 - MAJOR CHANNEL DREDGING

This alternative plan is shown on Map 5, and consists of dredging about 11.6 miles of the Fox River in the Towns of Vernon and Waterford in order to remove accumulated sediment. Dredging in the Town of Waterford would extend for a distance of about 2.4 miles downstream from Bridge Drive. Dredging in the Town of Vernon would extend for a distance of 9.2 miles upstream from the Racine-Waukesha County line. Regular channel clearing and maintenance as outlined in Alternative 5 would be carried out for the remaining 2.3-mile reach upstream to IH-43. Also, as with Alternative 5, streambank erosion protection measures would be provided.

FIGURE 5

EXISTING AND PROPOSED CROSS SECTIONS OF THE FOX RIVER CHANNEL UNDER ALTERNATIVE PLAN 6 – MODERATE CHANNEL DREDGING

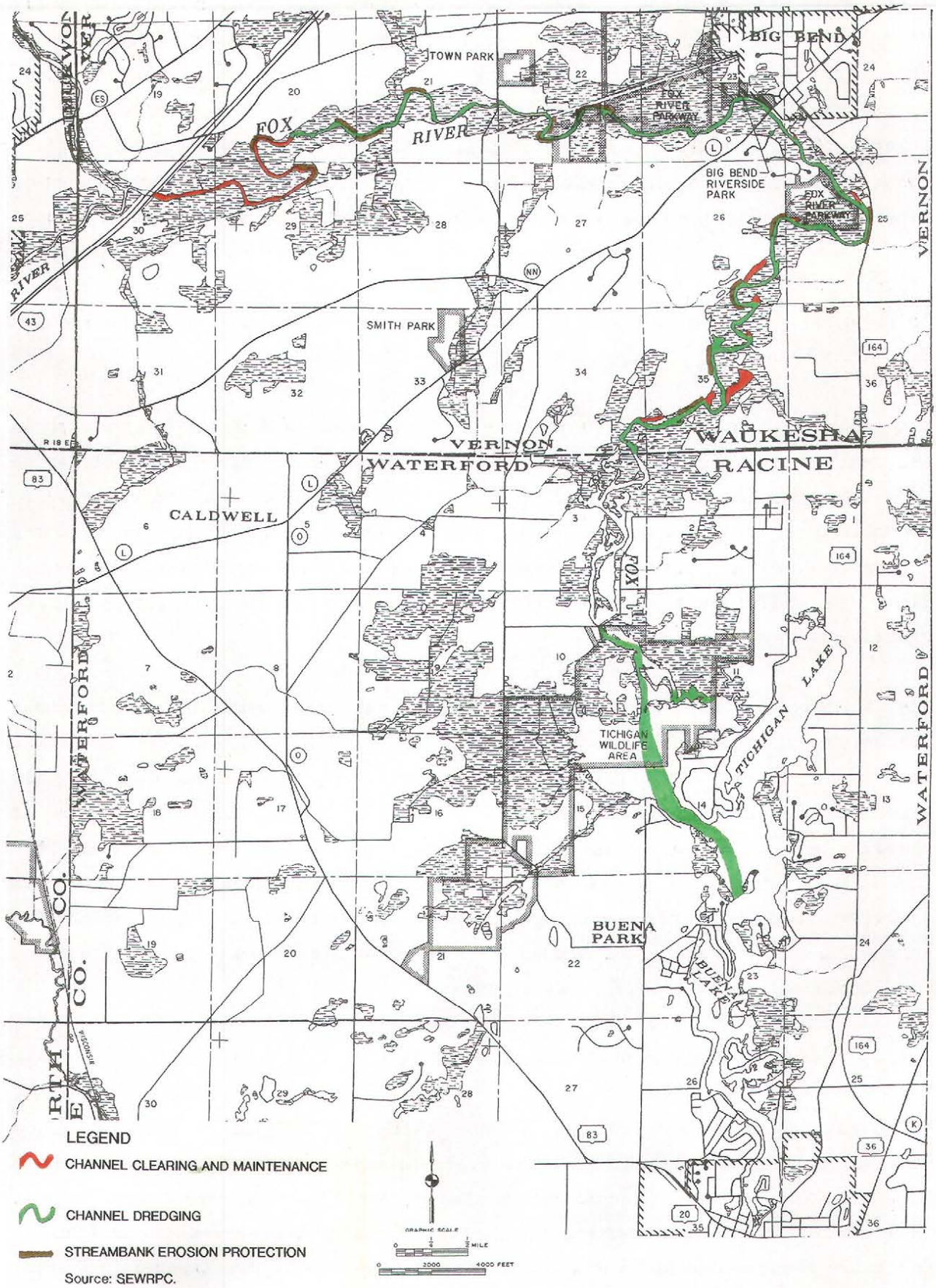


Source: SEWRPC.

MAP 5

ALTERNATIVE 7

MAJOR CHANNEL DREDGING



The purpose of the channel dredging is to both increase the hydraulic capacity of the River and improve navigation. During field investigations conducted under this study it was found that, due to the extensive sedimentation along the sides of the channel, sufficient water depths for boating are often confined to the relatively narrow thalweg of the channel. Under this alternative, the dredging would occur below the normal water line by excavating to the elevations shown on Figure 4. Excavation would extend downward from the normal water edge at a slope of one on five--one on three on the outside of meanders--to the proposed elevation. A typical cross section of the existing and proposed channel is shown on Figure 5. A total of about 349,000 cubic yards of sediment would be removed from the channel.

The impact of this alternative on flood stages is shown in Table 5. Under this alternative, stage reductions within the Town of Vernon of up to 1.0 foot may be expected under the design flood. Only a slight reduction in flood stage would be noticed in the Town of Waterford. That is due in part to the fact that the Waterford dam has a greater influence on flood stages downstream of the County line. In addition to a reduction in flood stage, the navigability would be greatly enhanced.

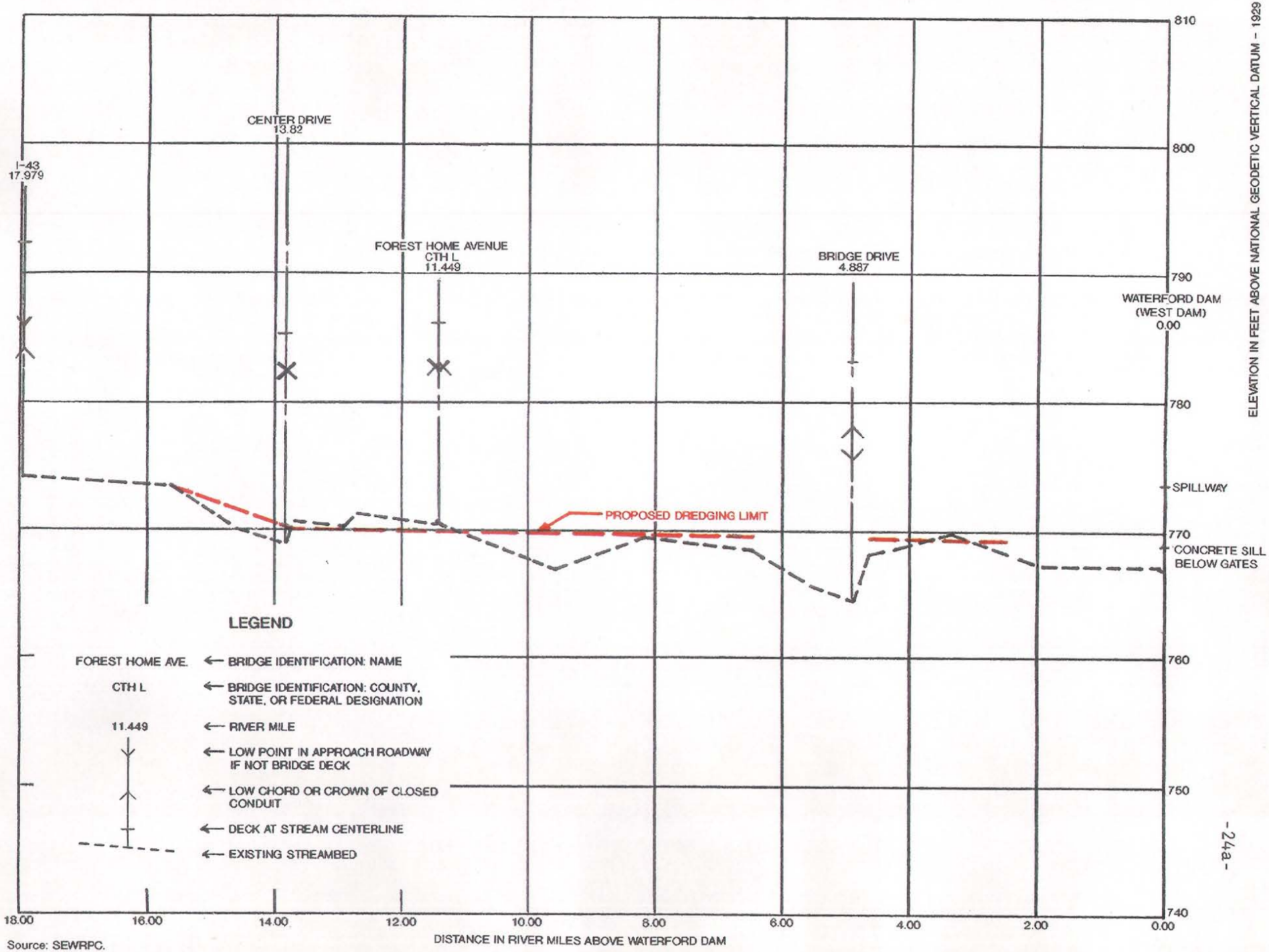
The estimated capital cost of this alternative is about $4,076,000, with annual operation and maintenance costs of about $6,000. Utilizing an annual interest rate of 6 percent and a project life of 50 years, the annual cost of this alternative would be about $264,500. Annual benefits due to reduction of flooding are estimated at about $11,000, yielding a benefit-cost ratio of less than 0.1. Additional benefits may be derived from increased recreational activity along the River, resulting from improvements to navigability. Since any attempt to assign a value to such benefits would be highly subjective, it has not been included in the benefit-cost analysis.

ALTERNATIVE 8 - PURCHASE OF FLOOD-PRONE LANDS

Under this alternative plan, those lands which are subject to frequent flood problems, and those agricultural lands experiencing poor drainage due to high water levels, would be purchased and placed in public open space use. These lands would become part of the Fox River Parkway recreational corridor as initially recommended under the Commission's adopted Fox River watershed plan,

FIGURE 4

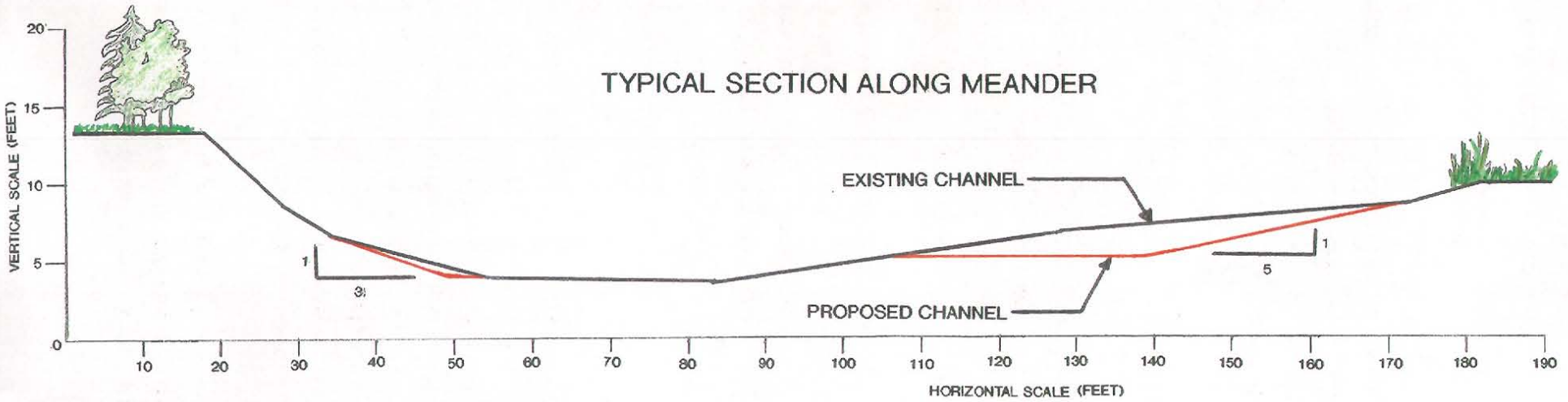
PROFILE OF PROPOSED CHANNEL DREDGING UNDER ALTERNATIVE 7 – MAJOR CHANNEL DREDGING

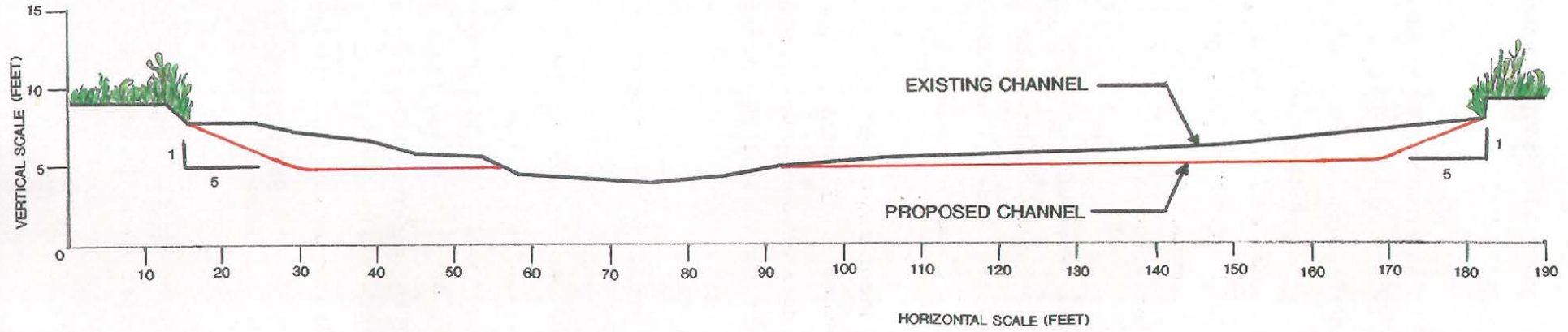


Source: SEWRPC.

FIGURE 5

EXISTING AND PROPOSED CROSS SECTIONS OF THE FOX RIVER CHANNEL UNDER ALTERNATIVE PLAN 7 - MAJOR CHANNEL DREDGING





Source: SEWRPC.

and under the adopted park and open space plans for both Racine and Waukesha Counties.

This alternative would entail the purchase of up to 332 acres of land within the Town of Vernon and up to 370 acres in the Town of Waterford. It is assumed that the Edgewood Golf Course lands would remain in private ownership. This alternative would essentially eliminate damages on those lands subject to frequent flooding and poor drainage. Periodic flooding of low-lying land at the Edgewood Golf Course could be expected to continue since this alternative would do nothing to reduce flood stages. Also, no improvement to navigation along the River would be realized.

As an alternative to outright purchase of these lands, it may also be possible to purchase conservation easements. Under such an arrangement, the individual property owners would agree to leave the affected lands in open space use. For cost-analysis purposes, it was assumed that the lands would be purchased.

The estimated cost of this alternative is about $1,269,000. Utilizing an annual interest rate of 6 percent and a project life of 50 years, the annual cost of this alternative would be about $80,500. Annual benefits due to the elimination of flood damages is estimated at about $81,700, yielding a benefit-cost ratio of 1.01.

EVALUATION OF ALTERNATIVES

None of the alternative plans considered under this study would fully eliminate damages due to the frequent flooding and poor drainage conditions along the Fox River within the study area. However, Alternative Plan 8 which would provide for the purchase of most of the flood-prone lands, would eliminate about 98 percent of the damages. Alternative Plan 8 is also the only alternative plan considered which has a benefit-cost ratio equal to or greater than one. The "no action" alternative, while offering the lowest cost, does nothing to alleviate the flood problem and does not represent a sound approach to flood control.

Alternative Plan 2, which calls for a lowering of the spillway at the Waterford dam, would provide some relief from frequent flooding and drainage problems along agricultural lands in the Town of Waterford. This alternative would not, however,

reduce those problems within the Town of Vernon. There would also be no benefits in improved navigability along the River. This alternative has a significant cost--$438,000--associated with the need to dredge selected areas of the Impoundment to maintain current navigability conditions with the lower water level.

Alternative Plan 3, which involves lowering the water level in the Impoundment during the winter and early spring would not solve problems related to flooding and poor drainage during the growing season, nor would it serve to improve navigability along the River. It could, however, provide some modest benefit by improving drainage from fields, allowing farmers to begin working them in a timely manner. In addition, this alternative would provide some relief to property owners along the Waterford Impoundment and Tichigan Lake by reducing the amount of ice related damage to shorelines and dockage. Also, this alternative plan could be implemented at no additional cost to local agencies since it would be carried out as part of the regular daily operation of the Waterford dam. Since the water level in the Impoundment during early spring would be about 0.8 foot lower than under current operating procedures, there may be some adverse impact on fish spawning activities due to a reduction in the ability of some species to access adjacent wetland areas for that purpose.

As previously noted, Alternative Plan 4, which consists of removing the Waterford dam completely, would not be a viable alternative. The costs related to reduction in shoreline property values, loss of recreational activities, and adverse impacts on fish and waterfowl far outweigh any benefits derived from such a measure.

Alternative Plans 5 and 6 are very similar in nature and would both provide some relief from high water and drainage problems within the Town of Vernon and Village of Big Bend. No such relief would be realized within the Town of Waterford. These alternatives would also serve to improve navigability along the River through the removal of trees and other obstructions, as well as through selected removal of accumulated sediment. Also, implementation of the streambank erosion measures would help to reduce the amount of future sedimentation within the River and the downstream Impoundment. Since the hydraulic capacity of the channel would be increased due to the proposed dredging, there is the potential that some sediments which would normally settle out along those reaches would now be conveyed further downstream to reaches for which no dredging is proposed. The

potential for this problem is greater for Alternative Plan 6, since the dredging called for under Alternative Plan 5 is very limited, occurring along reaches generally less than 200 feet in length. These alternatives have a significant capital cost, $310,000 and $717,000 for Alternative Plans 5 and 6, respectively, of which $199,000 is associated with the streambank erosion control measures which should be carried out in any case for water quality purposes.

Alternative Plan 7 would provide the greatest relief to high water and drainage problems within the Town of Vernon and Village of Big Bend, although its impact on more frequent flooding would not be much greater than Alternatives 5 and 6. Navigation along the River and the northern end of the Waterford Impoundment would be greatly enhanced. Since the proposed dredging would increase the hydraulic capacity of the River, there is the potential that sediment conveyed from upstream reaches which would normally settle out along the improved reach would be conveyed further downstream, thus increasing the sediment load in the Waterford Impoundment. This alternative also has the highest capital cost of all the plans considered.

Alternative Plan 8, which consists of purchasing those lands which are subject to frequent flooding and/or drainage problems due to high water levels, has the highest benefit-cost ratio of all of the plans considered. In addition to significantly reducing frequently occurring problems, this plan is consistent with the Commission's adopted Fox River watershed plan and the adopted Racine and Waukesha Counties park and open space plans. Those plans all recommend the public acquisition of primary environmental corridor lands--including a large portion of floodlands--for use in the development of a Fox River Parkway recreational corridor. This alternative would not serve to enhance the navigability of the River, nor would it reduce problems with streambank erosion.

Chapter V

RECOMMENDED PLAN AND IMPLEMENTATION

This chapter sets forth a recommended water level control plan for that reach of the Fox River between IH-43 and the Waterford dam. Also included is a description of plan implementation actions as well as potential funding sources for such implementation.

The selection of the recommended plan has been based upon consideration of the level of implementation of the plan recommendations set forth in the 1975 water level control plan,[4] as well as the costs, benefits, and other non-monetary consideration of the eight alternative plans considered in this updated plan. As noted in Chapter I, the recommended plan components of the 1975 plan and the implementation status of each may be summarized as follows:

Component 1--Installation of Gates on the Waterford Dam: Implemented
Component 2--Upstream Water Level Sensors and Automated Dam Gate operation: Partially implemented, with current frequent manual operation of motorized gates to approximate operation of intended automated system
Component 3--Channel Dredging and Clearing: Not implemented
Component 4--Dredging in Selected Shallow Areas of the Impoundment: Partially implemented

RECOMMENDED PLAN

Based upon consideration of the previous plan recommendations, and the status of implementation of those recommendations, and upon an evaluation of the eight alternative plans considered under this study, it is recommended that problems related to water levels and sedimentation along the Fox River in the Village of Big Bend and the Towns of Vernon and Waterford be addressed through a combination of Alternative Plan 3, calling for a winter drawdown of the water level in the Waterford Impoundment; Alternative Plan 5, calling for a program of channel clearing and dredging along that reach within the Town of Vernon; and Alternative

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[4]Loc cit, SEWRPC Community Assistance Planning Report No. 5.

Plan 8, calling for the purchase of flood-prone lands. In addition, two auxiliary plan recommendations are made--one providing for establishment of boating regulations for the subject study reach and one providing for the dredging of selected shallow areas in the Waterford Impoundment as set forth in the initial plan. The recommended plan is shown graphically on Map 6. The costs associated with the plan are set forth in Table 6. The individual plan elements are described below.

Waterford Dam Operation

It is recommended that the water level in the Waterford Impoundment be lowered by about 0.8 foot during the winter and early spring to the State-mandated minimum elevation of 772.6 feet NGVD. This would be accomplished by opening the control gates at the dam on December 1 and lowering the water level to the winter level. The gates would then be manipulated throughout the winter and early spring so as to maintain this level as nearly as possible. The control gates would then be closed in late April so as to ensure that the water level is brought back up to the existing spillway elevation by May 1, in order for sufficient depths to be available for boating purposes. In this regard, it should be recognized that at typical low flow conditions during late April and early May, it will take about two days to bring the level of the Impoundment up to elevation 773.4 NGVD. During drought conditions, if they were to occur, this time could be as much as one week and during wet weather periods, this time will be considerably shorter than two days. Thus, the timing of the spring gate closure operation should be made using judgement and consideration of weather conditions. It is recommended that, prior to implementation of this plan element, State fishery managers be consulted regarding the impact of such a drawdown on spawning activities.

Implementation of this recommendation should help to reduce ice-related damages along the shoreline of the Impoundment. It should also help to reduce the time needed for the removal of early spring rain-snowmelt runoff events within the study area, thus allowing farmers an earlier opportunity to work the fields.

There would be no additional cost associated with this recommended plan element since daily monitoring and control of the gates at the Waterford dam is already being carried out by Racine County personnel.

MAP 6

RECOMMENDED WATER LEVEL CONTROL PLAN FOR THE VERNON AND WATERFORD AREA OF THE MIDDLE FOX RIVER

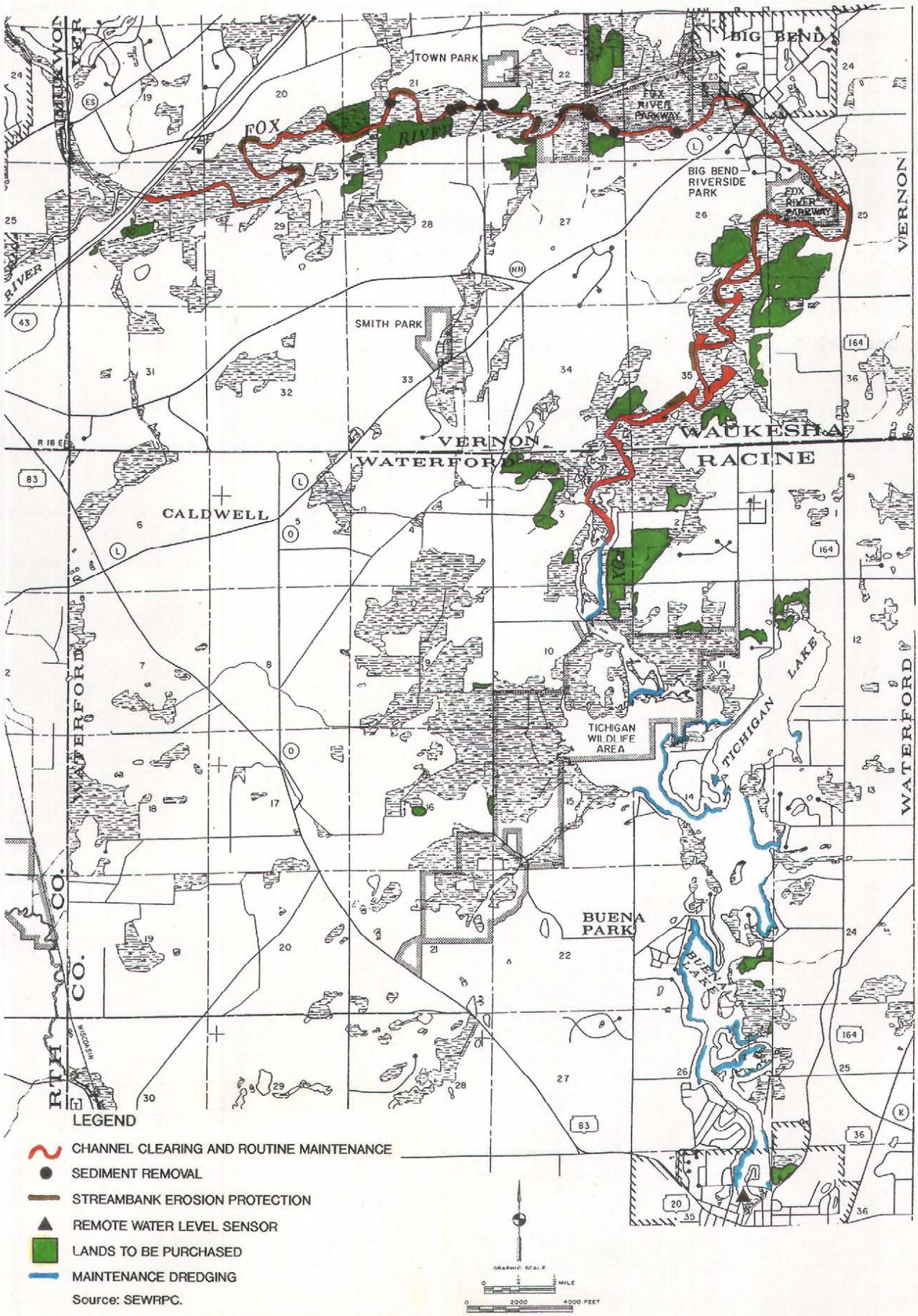

Table 6

COST ESTIMATES FOR THE RECOMMENDED WATER LEVEL CONTROL PLAN FOR THE VERNON AND WATERFORD AREA OF THE MIDDLE FOX RIVER

Plan Element	Estimated Capital Cost[a]	Estimated Annual Operation and Maintenance Cost[a]
Waterford Dam Drawdown	$ 0	$ 0
Waterford Dam Automation	40,000	3,000
Channel Clearing and Maintenance	111,000	6,000
Streambank Erosion Protection	199,000	0
Navigation and Maintenance Dredging	605,000	0
Establishment of Boating Restrictions	3,000	500
Purchase of Flood-prone Land	1,269,000	0
Total	$2,227,000	$ 7,500

[a] Expressed in 1994 dollars.

Source: SEWRPC

Degree of Water Level Monitoring and Dam Automation

Based on discussions with local officials, it is apparent that there has been a lack of communication in the past between Racine County staff charged with operation of the Waterford dam and upstream communities. Due to the lag time required for the flood wave to pass from these upstream communities to the Waterford Impoundment, flooding of upstream reaches occurs before operators notice a rise in water level and open the control gates at the dam. To account for that situation, the 1975 plan included a recommendation for the installation of an automated river monitoring and control system for operation of the gates at the dam. That system included a water level monitor located at CTH L in the Village of Big Bend which would transmit a signal to open the control gates when the water level at CTH L reached a predetermined level.

As noted earlier in this report, technical problems with the operation of that system led to its use being discontinued shortly after it was installed. Operation of the gates since that time has been based solely upon observation of the water level in the Impoundment and have been done using the motorized operation on a frequent basis--about once per day--in order to limit the elevation in the Impoundment and maintain a minimum elevation during the boating season of 773.4 NGVD. As noted earlier, the operators of the dam indicate that this operating procedure can be used to effectively maintain the levels in the Impoundment to about 0.2 foot of elevation 773.4 NGVD. Two options have been considered for improved operation of the Waterford dam gates. The first would provide for a new water level sensor and automation system. The second option would provide for improved manual operation.

Under the first option, new automatic equipment would be installed. Changes in technology in the river sensing equipment over the past 15 years have resulted in simpler and more dependable systems being available. Systems are available which can transmit signals to a central processing unit either over existing telephone lines with surge protection, or through the use of low-power radio signals. It is estimated that a new automated system consisting of water level monitors installed at CTH L, Center Drive, and within the Impoundment; a means of transmitting the signal; and a central processing unit located at the dam would have a cost ranging from about $35,000 to $45,000. This option would also entail an annual cost of about $3,000 for system inspection and maintenance.

These cost estimates assume that the existing motor drives on the control gates are operable and could be connected directly to the central processing unit.

Under the second option, a system would be established which would provide for the dam operators to be kept apprised of upstream conditions. This could be accomplished by a system of river watchers who would be responsible for notifying the operators when water levels along the upper reaches approach flood stage. These river watchers could consist of either volunteers who live along the River at specified control locations, or Town and Village personnel. Staff gages would be installed along the upstream sides of the bridges located at CTH L in the Village of Big Bend and at Center Drive in the Town of Vernon. When the water level of the river reaches a pre-determined elevation, as indicated on the staff gage, the person responsible for monitoring the level would notify the dam operator. The total estimated capital cost of carrying out this option is estimated at about $1,500, and consists of the installation and calibration of the two staff gages. Operation and maintenance costs would be negligible.

Under both options the initial control elevations at the two upstream monitoring sites would initially be set at 775.0 feet NGVD at CTH L, and 775.5 feet NGVD at Center Drive. These elevations represent an initial setting and may require adjustment based upon actual experience.

As shown in Chapter IV of this report, hydraulic analyses conducted under this study indicate that water levels along the Fox River in the Town of Vernon and Village of Big Bend are not significantly influenced by changes in the water level in the Waterford Impoundment, particularly during periods of high streamflow. While the actual high water levels are not expected to be impacted in the Vernon-Big Bend area, there would be some limited reduction in the duration of the flood events. It is also noted that the effectiveness of either of the operational mode options to reduce high water levels in areas upstream of the Impoundment is limited by the fact that the water level cannot be drawn down below about elevation 773.4 NGVD during the boating season. Thus, even if high water level elevations occur upstream, there is only limited capacity for adjustment available at the dam. There may be some increase in flexibility provided for water level adjustments if the dredging in the Impoundment is fully carried out. However, due to the cost and the need for private property owners to fund most of that project, it is unlikely that plan component will be fully

implemented in the near future. The most significant impacts are generally confined to that reach within the Town of Waterford located immediately upstream from the Impoundment. The timing of peak discharges along that reach, however, corresponds very closely with those in the Impoundment.

Another important consideration which would justify the need for automation of the control gates is the need to maintain a constant water level in the Impoundment during the winter and early spring drawdown and during dry-weather periods during the rest of the year. Maintaining the water level as close as possible to a specific elevation requires continual adjustment of the control gates. This could best be served by some system of automation, thereby freeing County staff from the need to constantly monitor water levels.

Based upon these considerations, it is recommended that Racine County and Waukesha County consider installing an automated system of gate controls as noted under the first option described above. Until such time as that option is implemented, the second option should be carried out.

Establishment of Navigability by Channel Clearing and Dredging

Boating activities on the Fox River, particularly upstream of the Village of Big Bend, are severely restricted due to an accumulation of trees, sediment, and other debris within the channel. Therefore, it is recommended that navigability along the River be established through the removal of the numerous trees and other debris from the channel within the Towns of Vernon and Waterford between IH-43 and the Waterford Impoundment. Any accumulated sediment associated with these debris would also be removed. Also, selected accumulations of sediment totaling about 6,400 cubic yards would be removed from the channel as shown on Map 6. These accumulations currently restrict the passage of small motor boats through this reach. Their removal, however, would not result in the use of this reach for high-speed boating activity. Finally, it is recommended that a total of about 12,700 feet of streambank be protected from erosion through the installation of riprap or other suitable methods. Once the navigability of the channel is established, it is recommended that a routine schedule of clearing and maintenance be carried out.

It should be noted that activities calling for the removal of material from the bed of a navigable waterway such as the Fox River will require that a permit be

obtained under Chapter 30 of the Wisconsin State Statutes. The permit application will require that sufficient detail be provided so that an assessment can be made of the potential environmental impacts of the project, such as loss of aquatic habitat, wetland losses, or increases in flooding. Cross sections of the existing and proposed channel should be included. The Department of Natural Resources may require that additional testing of sediments be made as part of the review process.

The total capital cost of carrying out this recommended plan element is estimated to be about $310,000. The estimated annual operation and maintenance cost would be about $6,000. It should be noted that, of the $310,000 capital cost, about $199,000 represents costs for streambank erosion protection. Those measures may be funded by the State of Wisconsin by up to 70 percent under the Chapter NR 120 nonpoint source pollution abatement program.

Purchase of Flood-prone Lands

As shown in the benefit-cost analyses presented in Chapter IV of this report, the only cost-effective plan with regard to reducing damages related to frequent flooding and impaired drainage conditions would be the purchase of those lands affected by such conditions. Therefore, it is recommended that those lands identified as incurring damages on a regular basis, as shown on Map 6, be acquired as they become available on the open market. The lands purchased under this plan would become part of the Fox River Parkway recreational corridor which is recommended under the Fox River watershed plan and the Racine and Waukesha County park and open space plans.

A total of 702 acres--332 acres in the Town of Vernon and 370 acres in the Town of Waterford--would be purchased under this plan element. It is assumed that an additional three acres of land at the Edgewood Golf Course would remain in private ownership. Such land would be purchased, however, should the owner wish to sell it.

The total capital cost of carrying out this recommended plan element is estimated to be about $1,269,000. No specific operation and maintenance costs have been assigned since it is assumed these costs would be borne as part of the recreational and educational uses of the lands. As an alternative to outright

purchase of land, consideration could also be given to obtaining conservation easements from the property owners concerned.

Since it is the intent of this recommendation that the identified lands be purchased only upon their being placed on the market, agricultural and recreational damages associated with these lands are expected to continue in the interim. Some reduction in the level of those damages can be expected from implementation of the other recommended plan elements, however.

Establishment of Boating Restrictions Along the River

During interviews with property owners along the River, concerns were raised that the wake caused by motorized, recreational watercraft--specifically jet skis--was causing increased streambank erosion problems and causing user conflicts. The use of these watercraft within the relatively close confines of the River, coupled with the reduced visibility created by the numerous meanders in the channel, also creates a hazard to more passive users of the River, such as canoeists and fishermen.

In order to address these concerns, it is recommended that a task force be established comprised of representatives of the Village of Big Bend, the Towns of Vernon and Waterford, Waukesha and Racine Counties, Wisconsin Department of Natural Resources, and selected user groups. The Regional Planning Commission would assist and staff the task force if requested. The purpose of this task force would be to develop a water use plan for the Fox River upstream of the Waterford Impoundment. This plan would include consideration of establishing a navigation channel along the River. In addition, consideration should be given to modifying regulations, such as establishing speed limits, motor size limitations, and no wake areas, as well as determining locations for signage and buoys to properly communicate those policies. Establishment of these regulations would need to be incorporated into local ordinances. While it is recognized that enforcement of such policies will be difficult due to the relative seclusion of the River, it is believed that it could have some benefits in reducing the potential for increased erosion and boating accidents and in providing for a broad-based, passive water use recreation area. Maintaining lower speeds may also reduce the risk of boats getting grounded along the shallow channel.

Restricting use of the River to non-motorized watercraft only, while possibly being easier to enforce, would hamper fishing and hunting possibilities. People living along, or immediately upstream from, the Waterford Impoundment, as well as those who normally use the boat launch in the Village of Waterford, would be required to trailer their boats to upstream launches in the Village of Big Bend or at CTH ES in order to access the upstream reaches.

The total capital cost of carrying out this recommended plan element is estimated to be about $3,000 and would consist of placing appropriate signage and marker buoys along the channel. In addition, there would be some nominal cost associated with enforcement of the ordinance requirements and replacement and modification of the markers and signage once implemented.

Dredging of Selected Shallow Areas in the Impoundment

It is recommended that dredging be undertaken along some of the shoreline and in shallow bays within the Waterford Impoundment and Tichigan Lake, and in the Fox River immediately upstream from the Impoundment. Dredging within the Impoundment and Tichigan Lake would be mainly along areas of existing development. A total of about 58 acres would be dredged by up to 1.0 foot. A total of about 56,000 cubic yards of material would be removed. A similar dredging proposal was recommended in the 1975 plan and is intended to avoid both existing navigational problems in these shallow areas as well as to allow for more flexibility in the operational limits of the water level in the Impoundment. As with the recommended dredging along the Fox River in the Town of Vernon, this proposed dredging will require that a permit be obtained under Chapter 30 of the Wisconsin State Statutes. Sufficient detail regarding the dredging will be needed in the permit application so that an assessment can be made of the potential environmental impacts of the project, such as loss of aquatic habitat, wetland losses, or increases in flooding. Cross sections of the existing and proposed channel should be included. The Department of Natural Resources may require that additional testing of sediments be made as part of the review process. The total capital cost of this recommended plan element is estimated to be about $605,000.

Auxiliary Plan Recommendations

It is recommended that local agencies charged with responsibility for nonpoint source pollution control prepare detailed local-level nonpoint source pollution control plans to identify the practices to be applied to specific lands. In this

regard, it is recommended that Waukesha County and the communities noted in Chapter III continue to enforce their construction site erosion control ordinances. It is also recommended that the remaining communities within the watershed adopt and enforce such ordinances.

It is recommended that the Middle Fox River subwatershed--which includes the study reach--be included in the Wisconsin Nonpoint source Priority Watershed Pollution Abatement Program in order to make State cost-sharing funds and related programs available for nonpoint source pollution control measures, such as the streambank protection measures included in this plan. The current priority ranking of watersheds for inclusion in that program places the Fox River watershed in the high category, indicating that inclusion in the program will be possible in the near future when existing planning projects are completed, or additional funds and staff become available within the Department of Natural Resources and its sister agencies.

Impact of the Recommended Plan on the Regulatory Floodplain

Only two of the recommended plan elements may be expected to have significant impacts on the flows and stages associated with the regulatory--100-year recurrence interval--floodplain. Those elements are the proposed drawdown of the Waterford Impoundment during winter and early spring, and the proposed channel clearing and sediment removal.

Lowering of the water level of the Waterford Impoundment by up to 0.8 foot would provide about 1,500 acre-feet of additional storage volume in the event of a 100-year recurrence interval flood occurring during the drawdown period. This represents only about 2 percent of the total runoff volume associated with a 100-year recurrence interval flood event. This relatively small amount of added storage would not be expected to provide any significant reduction in downstream flood flows and stages.

Hydraulic analyses carried out under this study indicate that the proposed channel clearing and sediment removal may be expected to reduce the 100-year recurrence interval flood elevation by up to 0.3 foot within the Town of Vernon. No change in flood elevations is expected within the Town of Waterford as elevations along that reach are controlled by the Waterford Dam. This stage decrease would reduce the floodplain storage volume by less than 2 percent. This

relatively small decrease in storage is not expected to have a significant impact on downstream flood flows and attendant stages.

Based upon the foregoing statements, it may be concluded that the recommended water level control plan would not have a significant impact on the regulatory floodplain of the Fox River. Also, the recommended plan would be in conformance with the Fox River watershed plan as that plan recommends that all available floodplain storage--with the exception of certain urban reaches--be maintained within the watershed.

Potential Environmental Impacts of Recommended Plan

Implementation of those plan elements which will require State permits, or which will utilize State or Federal funding, will require that an assessment be made of any potential adverse environmental impacts. This section is intended to provide a preliminary assessment of such potential impacts for each element of the recommended plan. A more detailed assessment may be required prior to implementation of certain elements, such as those involving dredging. Such detailed assessments may include an inventory of existing aquatic habitat, including determination of critical habitats or sensitive areas.

The recommended winter and early spring water level drawdown in the Waterford Impoundment may be expected to impact the existing aquatic habitat. This seasonal drawdown has the potential to affect spawning activities of some fish due to the inability to access some wetland areas. The proposed drawdown would be about 0.8 foot below the normal water level in the Impoundment. It is believed that the recommended plan would minimize that impact by limiting the drawdown to the minimum water level established by the Wisconsin Department of Natural Resources, it being assumed that the impact on the fishery was accounted for by the Department in the establishment of that level. Prior to implementation of this plan element, it is recommended that the Wisconsin Department of Natural Resources be consulted regarding the potential impact. In addition, the actual drawdown procedures can be refined during the implementation period to reflect ongoing surveillance and acquired experience.

The recommended water level monitoring and dam automation should not have any adverse environmental impacts.

The recommended channel clearing activities along the Fox River would have an impact on the existing environment. Removal of trees and other debris from the channel would result in some loss of habitat for fish and other aquatic life. These trees provide shade and protection from predators. The effect of the channel clearing can be lessened by removing only those trees which impede navigation on the river or provide a significant obstruction to flow. It is recommended that the implementing agencies work with the staff of the Wisconsin Department of Natural Resources in identifying those trees which should be removed and those which should be left in place.

Recommended channel dredging within the Town of Vernon is limited to removal of areas of sediment deposits along seven relatively short reaches, generally 200 feet or less in length. At these locations flows are impeded and passage of even small motor boats is difficult during certain seasons of the year. A total of about 6,400 cubic yards of sediment would be removed. No submergent or emergent vegetation was observed within the channel at these locations. All seven of the dredging sites are located adjacent to wetlands. Since the dredging would take place over very short reaches, and would involve the removal of relatively small amounts of material, normal water levels along the river should not be affected. Thus, the dredging should not result in draining of adjacent wetlands.

The proposed streambank stabilization measures should serve to improve the environment by reducing the sediment loads to the River and Impoundment and reducing the loss of riparian vegetation. Those areas identified on Map 6 for stabilization measures were selected based upon field observation of existing erosion problems, as well as the potential for such problems due to the presence of high erosive forces in the River. A more detailed site specific assessment of each of these areas should be conducted to determine the need for stabilization measures and the type of measure to be employed. Soils along some reaches may be unsuitable for structural measures such as riprap or gabions. In those locations, the establishment of deep-rooted vegetation may be more appropriate.

The recommended purchase of flood-prone lands, or of conservation easements on those lands, would have positive environmental benefits. By discontinuing farming activities on these lands, the lands could be returned to natural grasslands or wetlands which would provide additional wildlife habitat. An attendant reduction in nutrient and sediment loadings to the Fox River should be realized.

The recommendation for the establishment of boating restrictions along the Fox River would also have positive environmental benefits. By instituting low speed or no-wake zones along the channel, problems with streambank erosion due to wave action from high speed boating would be reduced. This would result in lower sediment loads in the River.

The recommended dredging along the shoreline of the Waterford Impoundment and Tichigan Lake, and along the Fox River in the Town of Waterford, would involve the removal of up to one foot of sediment over about 58 acres. A total of about 56,000 cubic yards of material would be removed. Dredging at the inlet to the Impoundment and upstream of Bridge Drive would occur below the normal water, away from stands of emergent vegetation. No submergent vegetation was noted along these reaches. The proposed shoreline dredging within the Impoundment and Tichigan Lake would also begin at the normal water line and extend about 50 to 75 feet from the shore. Nearly all of the shoreline along which dredging is proposed has been developed. An assessment of aquatic habitat along the shoreline areas to be dredged should be made prior to implementation of this plan element. Water levels within the Impoundment and along the Fox River in the Town of Waterford are controlled by the Waterford dam. Therefore, the proposed dredging would not affect existing normal water levels, and thus, would not result in draining of adjacent wetlands. The type of dredging proposed has been permitted by the Wisconsin Department of Natural Resources in the recent past.

Implementation and enforcement of construction site erosion control ordinances within the watershed will have a positive environmental benefit in that it will serve to reduce sediment loads to the Fox River and its tributaries.

Regulatory Requirements Affecting
Replacement of Agricultural Drainage Systems

During the course of this study, questions arose regarding the repair and replacement of agricultural drainage systems. As noted in Chapter I, most of the existing systems appear to be functioning properly, at least along those areas which are currently in production. However, some drainage systems, particularly those in areas not currently in production, are in need of repair. Of particular concern was the regulatory requirements concerning lands which are considered wetlands. Those requirements are rather involved, with regulatory and oversight responsibilities assigned to local, State, and Federal authorities. This section

is intended to provide a brief overview of the factors involved regarding wetland disturbances. A more comprehensive discussion of this matter may be found in SEWRPC Memorandum Report No. 79, An Agricultural Drainage and Urban Stormwater Management Plan for Racine County Farm Drainage District No. 1, Village of Waterford and Towns of Norway and Waterford, Racine County, Wisconsin.

Much of the land located adjacent to the Fox River in the Towns of Vernon and Waterford, including land which has historically been used for agricultural purposes, is considered wetland. In Southeastern Wisconsin, the primary sources of wetland mapping include the Wisconsin Wetland Inventory maps compiled on Commission 1980 aerial photography at a scale of one inch equals 2000 feet and the Commission 1990 land use inventory maps compiled at a scale of one inch equals 400 feet. The U.S. Natural Resources Conservation Service (NRCS)--formerly the U.S. Soil Conservation Service--has also prepared wetland maps on one inch equals 660 feet scale and one inch equals 1,000 feet scale aerial photographs. Wetland areas shown on the NRCS maps are generally more extensive due to the use of a broader definition of wetlands.

Repair or replacement of drain tiles on land which is not identified as a wetland generally would not require a permit. One possible exception would be cleaning the outlets of drain tiles or ditches which discharge below the ordinary high water mark of the Fox River. Such activity may require a permit under Chapter 30 of the Wisconsin State Statutes.

Regulation of shoreland-wetlands is administered by the counties under Chapter NR 115 of the Wisconsin Administrative Code and by cities and villages under Chapter NR 117. The Wisconsin Department of Natural Resources maintains oversight responsibilities to ensure that local governments are properly enforcing the code. Under the code, maintenance and repair of existing drainage systems is generally allowed. Within lands which have reverted to wetland due to lack of maintenance, repair may be permitted provided that the land is still being cultivated.

Regulation of all wetland areas, regardless of shoreland designation, is administered jointly by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers under Section 404 of the Federal Clean Water Act. Permitting responsibilities rest with the Corps, with oversight by the EPA. As

part of the permitting process, the Wisconsin Department of Natural Resources must also issue a water quality certification for the project. The certification process follows the procedures which are outlined in Chapter NR 103 of the Wisconsin Administrative Code. Requirements for receiving certification include demonstrating that the project is either wetland dependent or that no other practicable alternative exists. Even if the project meets one of those requirements, certification may be denied if it is found to have an adverse environmental impact. Activities which would result in the draining of a designated wetland generally would not be permitted. It may be permissible, however, to replace a drain tile through a wetland to service upland areas, provided that that portion of the tile line extending through the wetland is sealed to prevent infiltration.

One additional area of concern involves lands which currently do not show up on either the Wisconsin Wetland Inventory maps or the Commission's land use inventory maps, but are designated on the NRCS maps as Prior Converted Cropland. These are areas which originally were wetlands but were converted for agricultural use through draining, regrading, or filling prior to December 23, 1985. These lands are flooded for no more than 14 consecutive days during the growing season. If the land has not been in production for a period of five consecutive years, and it reverts to a wetland, it would be regulated by the Corps under Section 404.

PLAN IMPLEMENTATION

The following plan implementation recommendations are provided in regard to the lead agencies for each of the plan elements. It should be noted that funding of the plan is intended to be provided largely through existing State and Federal programs as discussed in the next section of this report.

It is recommended that the water level control plan elements set forth above be implemented through the combined efforts of the Village of Big Bend, the Towns of Vernon and Waterford, and Racine and Waukesha Counties. More specifically, it is recommended that Racine County, as owner and operator of the Waterford dam, implement the proposed water level drawdown in the Waterford Impoundment during the winter and early spring. It is also recommended that Racine County investigate further the economics of an automated dam operation in the context of the operation of all of its dams.

It is recommended that the Village of Big Bend and the Town of Vernon install staff gages at the bridges at CTH L and Center Drive, and provide for Village and Town personnel to monitor water levels on the River during runoff events. Those personnel would be responsible for notifying the Waterford dam operators when water levels at the gages indicate that the River is at flood stage. This operation would be discontinued once a new automation system for the dam is installed.

It is recommended that the proposed channel dredging along the inlet to the Waterford Impoundment and in the reach upstream of Bridge Drive be carried out by the Town of Waterford, with the local cost which cannot be obtained from State or Federal sources, being shared between the Town and Racine County.

It is recommended that the creation of the navigation channel through the cleaning and dredging of the Fox River channel between IH-43 and the Waterford Impoundment, including the removal of trees and other debris; the selected removal of accumulated sediment; and the installation of streambank stabilization measures, be carried out by Racine and Waukesha Counties and the Towns of Vernon and Waterford, with the local cost, which cannot be obtained from State or Federal sources, being shared between the respective Towns and Counties. It is further recommended that the Towns of Vernon and Waterford be responsible for carrying out programs of routine channel clearing and maintenance along their respective river reaches.

It is recommended that the Village of Big Bend, the Towns of Vernon and Waterford, Waukesha and Racine Counties, the Wisconsin Department of Natural Resources, and SEWRPC establish a water use task force to develop recommendations for the establishment of a navigation channel and the adoption of boating regulations along the Fox River upstream of the Waterford Impoundment--specifically, the reach upstream of Bridge Drive. Following incorporation of those regulations into local zoning ordinances, appropriately marked signage and buoys notifying boaters of the recommended policies should be posted along the channel at regular intervals.

It is recommended that the proposed dredging in the Impoundment and Tichigan Lake, and in the Fox River immediately upstream of Bridge Drive,be carried out by the Town of Waterford and the local property owners.

It is recommended that all those communities which have adopted construction site erosion control ordinances continue to enforce those ordinances. It is further recommended that the remaining communities within the Fox River watershed also adopt and enforce construction site erosion control ordinances. It is also recommended that the Wisconsin Department of Natural Resources include the Middle Fox River subwatershed in the Wisconsin Nonpoint Source Priority Watershed Pollution Abatement Program.

Finally, it is recommended that Racine County and Waukesha County be the lead agencies in purchasing or acquiring conservation easements over the 370 acres of land in Racine County and the 332 acres of land in Waukesha County identified as being affected by frequent flooding and impaired drainage due to high water levels. It is expected that this purchase would be partially funded by State and Federal grants. Those lands would then be incorporated into the Fox River recreation corridor within the respective counties.

A summary of the plan costs and attendant implementing agencies is presented in Table 7.

The decision to assign a portion of the cost of the recommended channel cleaning and sediment removal to Racine and Waukesha Counties is based on the fact that these measures are intended primarily to improve the navigability of the Fox River, as opposed to solely alleviating local flooding problems. Since the Fox River represents a resource of Regional significance, and since the improvement in navigability would benefit users from outside the respective townships, it is believed that the proposed cost sharing is appropriate.

FUNDING SOURCES

In carrying out the recommended water level control plan, the concerned local units of government should be aware of possible sources of financial aid, particularly from State and Federal agencies. Listed below are several known sources of potential funding for the recommended plan elements.

Potential sources of funding for the establishment of a navigation channel element and potentially portions of the dredging in the Impoundment element of the recommended plan include:

Table 7

RECOMMENDED PLAN IMPLEMENTATION AND FUNDING

Plan Element	Lead Implementing Agency	Estimated Capital Cost[a]	Potential Funding Sources
Waterford Dam Drawdown	Racine County	$ 0	--
Waterford Dam Automation	Racine County, Waukesha County	$ 40,000	--
Channel Clearing	Town of Vernon, Waukesha County; Town of Waterford, Racine County	$ 111,000	• Chapter NR 7 Recreational Boating Facilities Fund • Conservation Corps Programs (Americorps Program)
Streambank Erosion Protection	Town of Vernon, Waukesha County	$ 199,000	• Chapter NR 120 Wisconsin Nonpoint Source Pollution Abatement Program • Chapter NR 191 Lake Management Protection Grant Program[b] • Americorps Program
Navigation Dredging and Maintenance Dredging	Riparian Property Owners,[c] Town of Waterford, Racine County	$ 605,000	• Chapter NR 7 Recreational Boating Facilities Fund[d]
Establishment of Navigation Channel and Boating Restrictions	Village of Big Bend, Town of Vernon, Town of Waterford, Waukesha County	$ 3,000	• Chapter NR 7 Recreational Boating Facilities Fund • Chapter NR 191 Lake Management Protection Grant Program
Purchase of Flood-prone Land	Racine County, Waukesha County	$1,269,000	• Chapter NR 50/51 Stewardship Program • Chapter NR 191 Lake Management Protection Grant Program

[a] Expressed in 1994 dollars.
[b] Subject to adoption of currently proposed Administrative Code revision.

[c] Maintenance dredging along the shoreline within the Waterford Impoundment and Tichigan Lake would be the responsibility of the adjacent property owners. Dredging within the Fox River at the inlet to the Impoundment and upstream of Bridge Drive would be the responsibility of the Town of Waterford and Racine County as that dredging is aimed at maintaining the navigability of the River.

[d] Funds under this program may be available for the proposed dredging at the inlet to the Impoundment and upstream of Bridge Drive as that dredging is aimed at creating or establishing access to the Impoundment from the upstream areas.

Source: SEWRPC

1. Chapter NR 7 Recreational Boating Facilities Fund administered by the Wisconsin Waterways Commission and the Wisconsin Department of Natural Resources (DNR) can provide up to 50 percent of the cost of establishing a navigational access linking public access sites to recreational water bodies. Buoyage and signage required to demarcate such a navigation lane is also cost-sharable under this fund. Communities operating a DNR-approved water patrol may qualify for an additional 10 percent State share.

2. Chapter NR 191 Lake Management Protection Grant Program administered by the DNR provides a 50 percent cost share up to a $100,000 State share for ordinance development relating to lake protection (e.g. boating ordinance aimed at reducing streambank erosion).

3. Conservation Corps programs, such as the Americorps Program, are Federal or State-funded programs which provide volunteer labor to assist in construction of environmental-related projects, such as river restoration. A host agency would be required to provide construction materials and equipment, as well as housing for the volunteers.

Potential sources of funding for the placement of streambank erosion protection measures element of the recommended plan include:

1. Chapter NR 120 Wisconsin Nonpoint Source Pollution Abatement Program (Priority Watershed Program) can provide up to a 70 percent cost share for design and implementation of recommended Best Management Practices (BMPs). Access to these funds is normally contingent on the selection of the Middle Fox River as a Priority Watershed. Such selection is anticipated by the year 2000 under current administrative rules and legislative mandates. However, the project might be made eligible under special project provisions.

2. Chapter NR 191 Lake Management Protection Grant Program administered by the DNR may provide a 50 percent cost share of up to $100,000 State share for shoreline stabilization measures, pending adoption of currently proposed Administrative Code revision.

3. Conservation Corps programs, such as the Americorps Program, are Federal or State-funded programs which provide volunteer labor to assist in construction of environmental-related projects, such as river restoration. A host agency would be required to provide construction materials and equipment, as well as housing for the volunteers.

Potential sources of funding for purchase of the flood-prone lands portion of the recommended plan include:

1. Chapter NR 50/51 Stewardship Program (Urban Waterways Grants) administered by the DNR provides a 50 percent cost share for land acquisition.

2. Chapter NR 191 Lake Management Protection Grant Program administered by the DNR provides a 50 percent cost share up to a $100,000 State share for acquisition of lands or conservation easements providing water quality benefits to lakes.

The foregoing list of available funding sources for implementing the recommended plan is set forth solely to indicate several known possible sources of aid. Upon adoption of the recommended plan by the concerned local units of government it is suggested that the local officials involved pursue these and other potential sources by discussing the proposed plan recommendations with the appropriate State and Federal agencies.

CONCLUSION

The plan identifies cost-effective and environmentally sound means of resolving the current and expected future water level problems in the reach of the Fox River between IH 43 and the Waterford dam. Implementation of the recommended plan would improve navigation in the river system, including the Waterford Impoundment, and thus enhance the recreational uses of the river system. In addition, water quality and environmental conditions would be improved. Implementation of the recommendations would also reduce the flooding and drainage problems associated with high water levels and result in a step toward creation of a Fox River environmental corridor system. As such, the quality of life for the residents and visitors to the area should be enhanced.

* * *

APPENDICES

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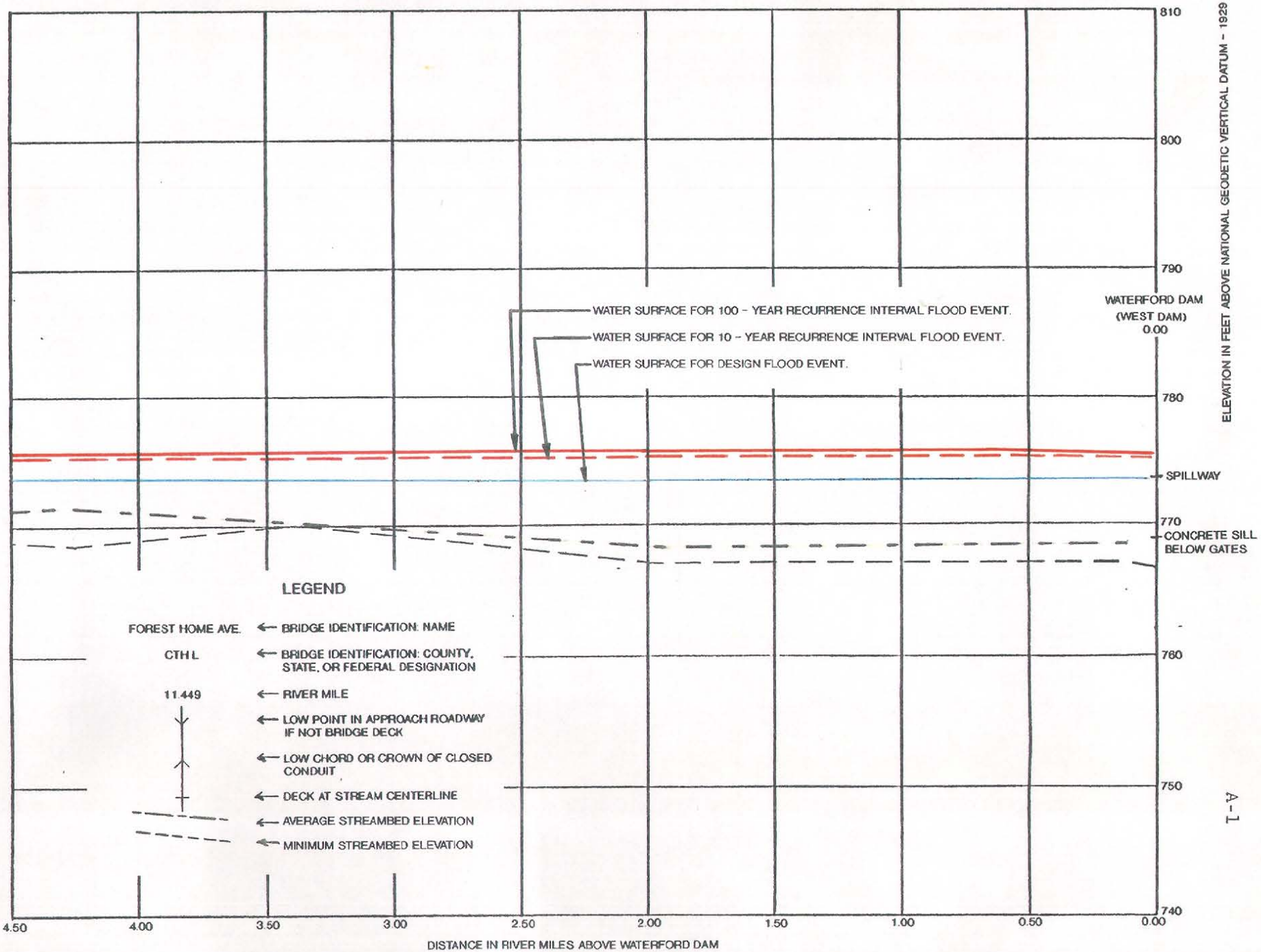
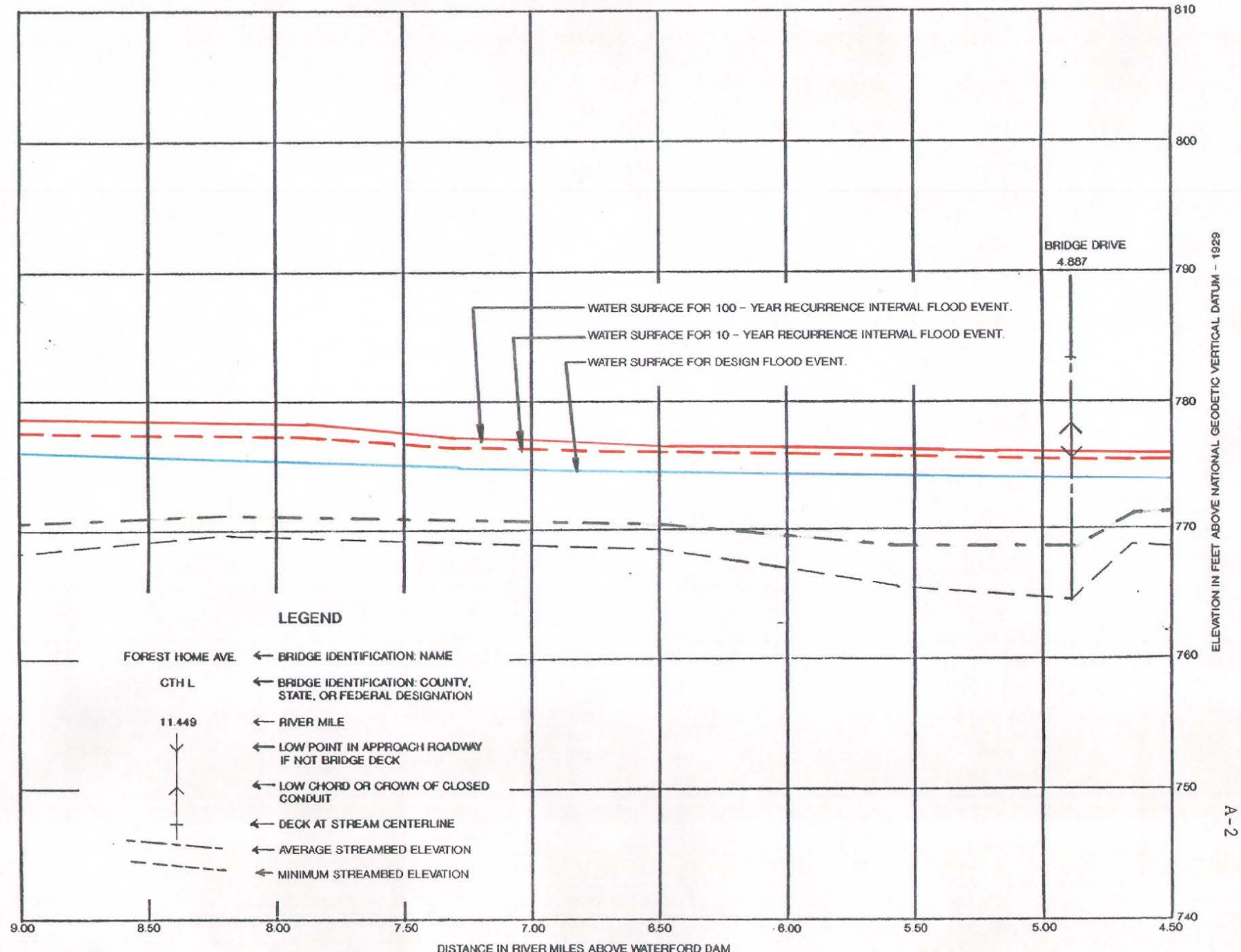
APPENDIX A

HIGH WATER AND STREAMBED PROFILES FOR THE MIDDLE FOX RIVER -- IH-43 TO WATERFORD DAM

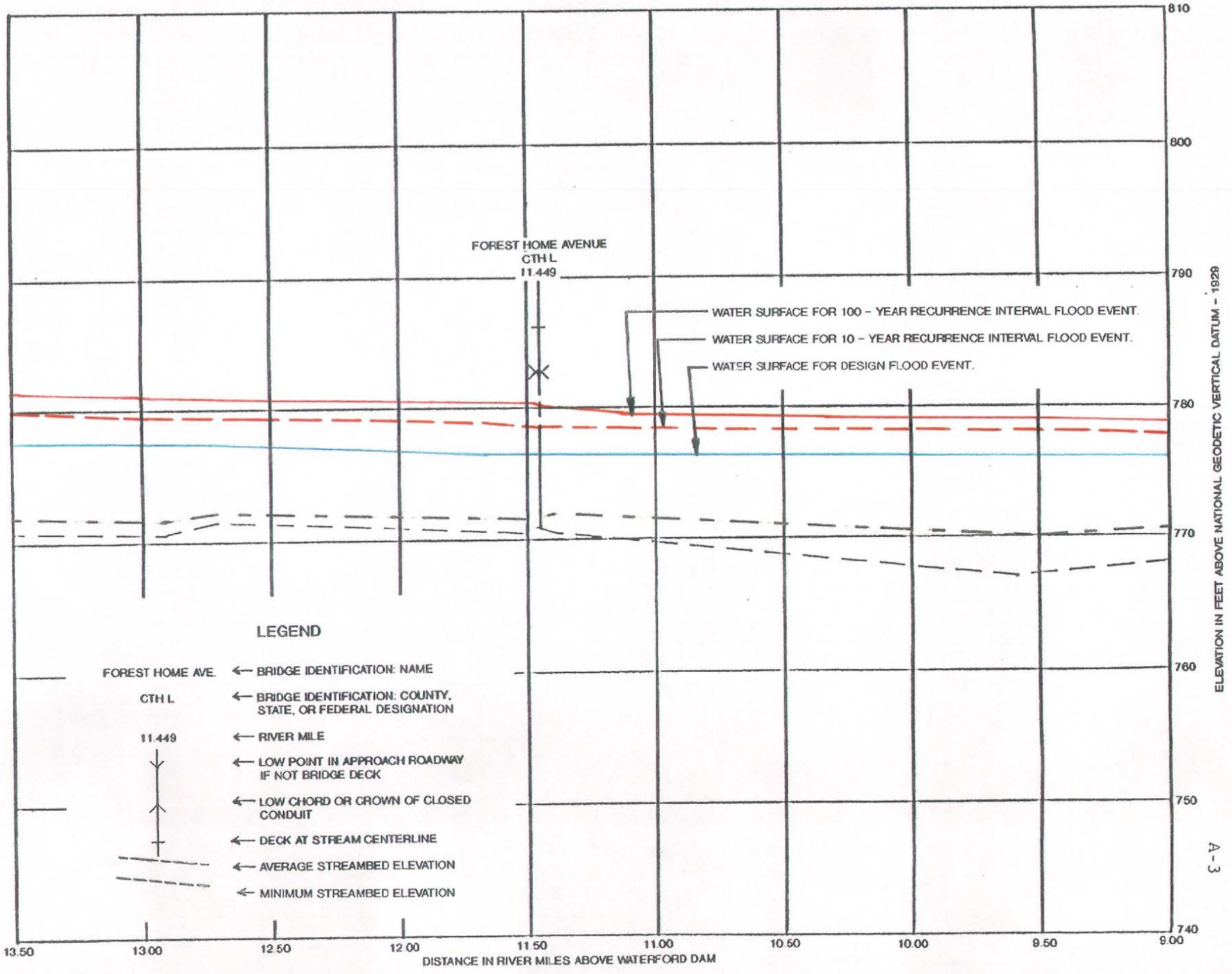


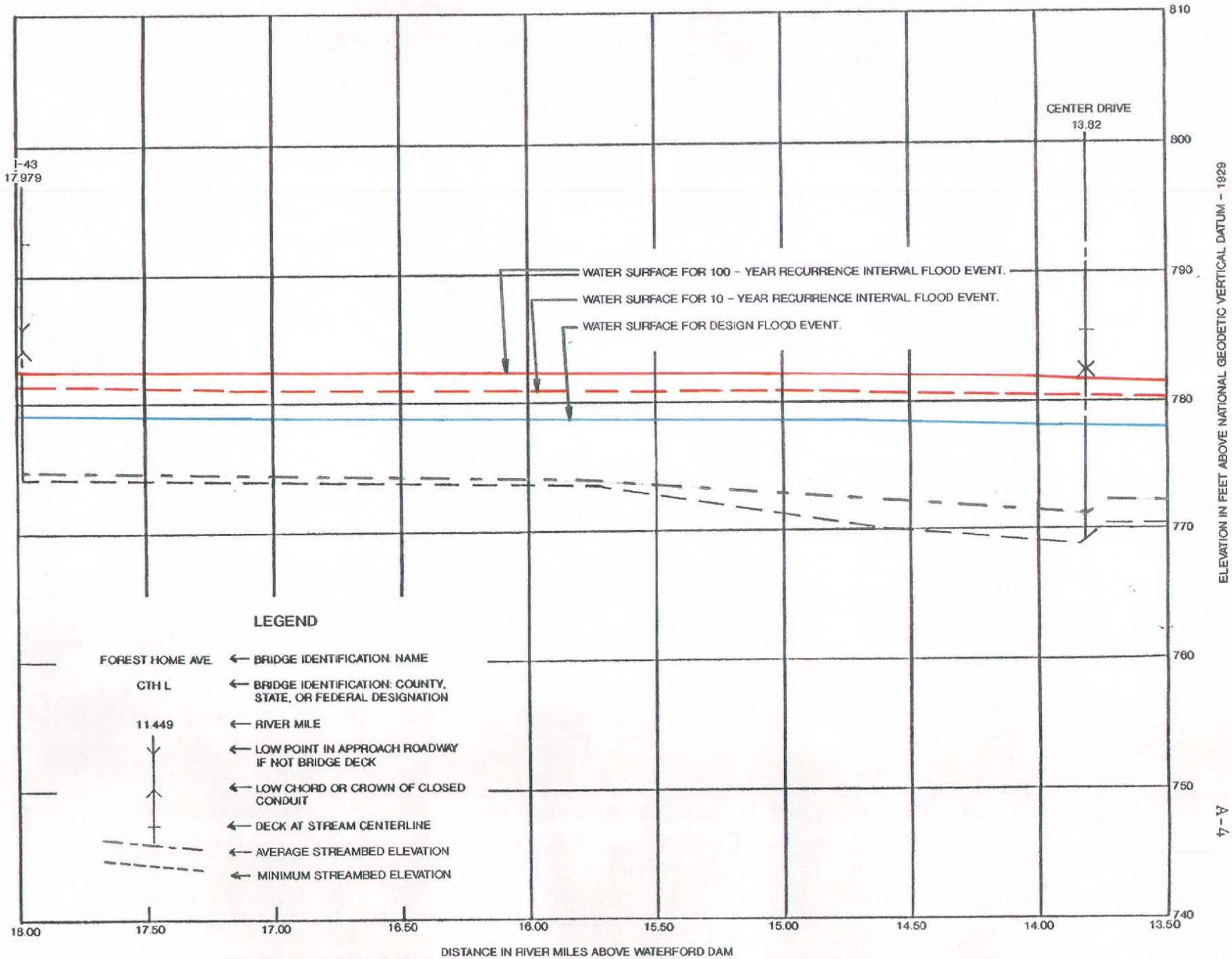
Source: SEWRPC



Source: SEWRPC.

APPENDIX A (CONTINUED)





Source: SEWRPC.

Appendix B

SEWRPC STAFF MEMORANDUM

SITE SELECTION AND CHEMICAL ANALYSIS OF RIVERINE AND LACUSTRINE SEDIMENTS IN THE MIDDLE FOX RIVER BASIN BETWEEN IH-43 AND STH 20

INTRODUCTION

The Southeastern Wisconsin Regional Planning Commission has entered into an agreement with the Town of Vernon, Village of Big Bend, and Waukesha County to undertake a study relating to the management of water levels for recreational, environmental, and flood control purposes on a 17.5-mile stretch of the Middle Fox River between IH 43 and Waterford Dam. The study would represent a review and updating, based upon current conditions, of the water level management plan prepared by the Regional Planning Commission in 1975.[1] Specific activities to be carried out in terms of the proposed planning program include:

1. The collection of field surveyed, channel cross sections and the collection of sediment samples from the Fox River channel;

2. An assessment of the degree of siltation, and an evaluation of the quality state of the sedimentation that has occurred in the river and lake since the completion of the 1975 plan;

3. An analysis of Waterford Dam operating procedures;

4. Development and evaluation of alternative means of providing for restoration of navigability and reducing flooding and drainage in the subject reach;

5. The selection of a recommended water level control plan; and

6. Documentation of the study in a report setting forth the results of the analyses conducted.

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[1] SEWRPC Community Assistance Planning Report No. 5, Drainage and Water Level Control Plan for the Waterford-Rochester-Wind Lake Area of the Lower Fox River Watershed, May 1975.

The 1975 plan covering the subject reach of the Fox River, set forth in SEWRPC Community Assistance Planning Report No. 5, Drainage and Water Level Control Plan for the Waterford-Rochester-Wind Lake Area of the Lower Fox River Watershed, was adopted as an amendment to the comprehensive plan for the Fox River watershed[2] on June 5, 1975. That 1975 plan set forth specific recommendations pertaining to the modification and control of the Waterford Dam and the maintenance of navigation and hydraulic capacity in both the influent river within the Town of Vernon and of the Waterford Impoundment, as well as other actions affecting the Muskego Creek-Wind Lake Drainage Canal system. The former recommendation providing for modification and automated control of the Waterford Dam was initially implemented by Racine County, but technical problems have resulted in the abandonment of the automated operation of the Dam. The latter recommendation has not been implemented, except of isolated dredging by private property owners along the shoreline of the Waterford Impoundment.

For these reasons, and giving due consideration to the passing of almost two decades since the original plan was completed, it was agreed that the studies upon which the initial plan was based should be reviewed and refined as necessary to reflect the existing situation in this portion of the Fox River watershed. This is especially true with regard to the recommendations made with respect to maintenance of navigation and hydraulic capacity. As a prerequisite to the analysis of sediment samples for possible contaminants as set forth under Section NR 347.06 of the Wisconsin Administrative Code, Commission staff conducted a reconnaissance of the study area in mid-May 1994 in order to characterize the riverine and lacustrine sediments and to identify likely points at which new channel cross-section surveys and sediment samples for analysis should be collected. Eighteen cross section and seven sediment sample locations were identified as a result of this survey. Channel cross-section surveys were made in late-June 1994, and sediment core samples were collected in late-August 1994. This memorandum presents the results of the survey and subsequent sediment sampling in the study area.

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[2] The comprehensive plan--SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed. Volume One: Inventory Findings and Forecasts, and Volume Two: Alternative Plans and Recommended Plan, April 1969 (Volume One) and February 1970 (Volume Two).

SITE DESCRIPTION

The proposed study area is the stretch of the Fox River between IH 43 in the north and the Waterford Impoundment in the south; the Waterford Impoundment portion of the Tichigan Lake-Buena Lake system created by the Waterford Dam is included in this study area. The study area is shown on Map 1.

SURVEY AND SAMPLING DESIGN AND METHODOLOGY

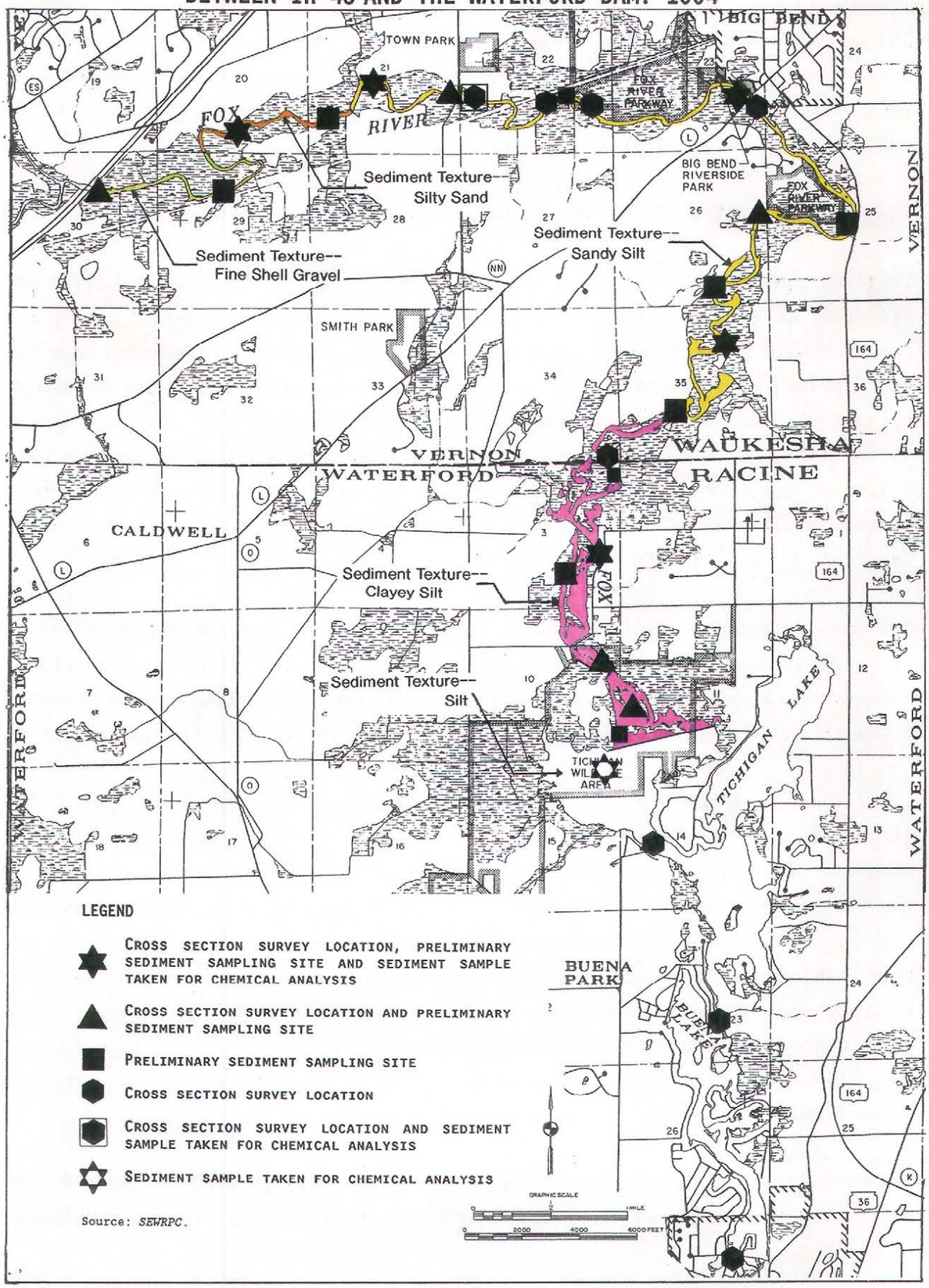
The 1975 plan for the study area was predicated upon the hydraulic analysis of the river at specific points. In order to maintain consistency with that plan, and to obtain a quantitative assessment of the degree of sedimentation that has taken place in the basin, it was proposed that these same stations supplemented by the addition of cross sections at selected locations be used during the current investigation. The locations of the cross sections to be used for the hydraulic capacity analyses are shown on Map 1. These stations were also adopted as potential sampling sites for the purposes of determining sediment quality described in this Memorandum.

A total of 18 cross-section surveys were prepared for the identified sites by Ayres Associates, Inc. under contract to the Regional Planning Commission. Surveys were made using conventional land survey methods supplemented by sounding methods in selected locations where deeper water levels were encountered.

Initial sediment samples were obtained with a PVC coring device equipped with a 3-foot long, 3-inch diameter core tube. Intact sediment cores were obtained by manually positioning the device over the river/lake bed in 0.5 to 1.5-feet of water and exerting downward pressure to the point where soil resistance prevented further penetration of the core tube--generally 6 to 12 inches. The corer was then withdrawn and the core decanted into a bucket where a sub-sample of sediment was obtained. This sediment was stored in one-gallon polyethylene storage bags and transported to the Commission's offices where they were visually examined and described within 48-hours of collection. Samples were characterized using the Shepard sediment texture classification scheme.

Subsequently, seven samples for chemical analysis were obtained using a Wildco Model 2450 hand-operated corer equipped with a 20-inch long, two-inch diameter

MAP 1
SEDIMENT SAMPLE AND CROSS SECTION SURVEY LOCATIONS ON THE FOX RIVER BETWEEN IH-43 AND THE WATERFORD DAM: 1994



Source: *SEWRPC*.

stainless steel barrel and CAB thermoplastic liner. Sample locations are identified on Map 1. Intact sediment cores were obtained as described above. Samples were decanted into a bucket where a well-mixed sub-sample was obtained. Samples were stored at 4°C in glass or polyethylene containers and transported to the Swanson Environmental, Inc. laboratories within 24-hours of collection. Samples were analyzed by Swanson Environmental Inc. for selected metals, nutrients, poly-aromatic hydrocarbons (PAHs), biocides, and poly-chlorinated biphenyls (PCBs) using standard methods.

Selection of the sampling sites described above and set forth on Map 1 reflected consideration of both significant changes in sediment texture within the river bed and recognition of the major potential sources of sediment contamination in the study area. These potential sources included highways--such as IH 43; urban settlements--such as the Village of Big Bend; and major agricultural and recreational land use areas--such as Edgewood Golf Course and the tiled agricultural lands of the lower portions of the subject stream reach.

RESULTS

Observations of the stream channel made during field inspections conducted by the Commission staff on May 10, May 12, August 25, September 23, and October 7, 1994, indicate that there has been sedimentation occurring due, at least, in part to bank erosion. The depth of the low flow channel has not appreciably changed on average over the past years. However, the total cross-sectional area does appear to have been reduced due to deposits along the outer banks of the channel. A total of 18 detailed cross sections of the river channel were field-surveyed in June 1994. Sixteen of these cross-section locations corresponded with sections used in the analysis of flood stages under the Federal flood insurance studies for Racine and Waukesha Counties published in 1981, while the remaining two represented new cross sections within the Waterford Impoundment. The results of these new surveys indicate that a significant amount of shifting of the streambed has taken place through scour and deposition. Of the 16 sections for which comparisons could be made, five showed a higher low-flow channel bed elevation, six showed lower elevations, and five showed little or no change. The channel grade has several areas with a negative grade.

During the field reconnaissance conducted on May 10 and 12, 1994, a total of 19 samples were obtained at the locations shown on Map 1. Textural descriptions of these sediment samples are set forth in Table 1. Samples 18 and 19 were obtained in the river delta and upper lake basin as shown on Map 1 and respond to concerns raised by the riparian communities that significant movement of sediments has taken place within this reach of the Fox River watershed and that extensive deposition of particulates has taken place in the headwaters of the Waterford Impoundment.

Generally, the riverine sediments within the study area can be divided into four topological groups, reflecting in large measure the surrounding soils classifications in various portions of this watershed.[3] Watershed soils ranged from the silty clays of the Sawmill Series in the upper reaches of the study area; to mixture of silty clays, clays and silts of the Houghton, Aztalan, Palms, and Adrian mucks and Sebewa and Pella Series in the middle reaches; to the silty clays of the Navan Series in the lower reaches of the study area. Riverine sediments ranged from fine shell gravel, to clayey sandy silt and sandy silt, to clayey silt in these same reaches of the study area. The distribution of these sediment textures are shown on Map 1.

Based on this preliminary analysis, seven sampling sites were identified and sampled during August 1994, including six riverine sites and one lacustrine site within the western lobe of the Waterford Impoundment as shown on Map 1. The first sampling site is located in the upper portion of the study area downstream of IH 43 in the area characterized by a silty sand and shell substrate. The second and third sampling areas are within the transition zone upstream of the Village of Big Bend characterized by a clayey sandy silt substrate. The fourth and fifth sampling area is the portion of river between CTH L and the Waukesha-Racine County Line characterized by a sandy silt substrate. The sixth sampling area is the portion of the Fox River study area within Racine County upstream of the Waterford Impoundment characterized by a clayey silt substrate. The seventh

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[3] SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin, June 1966; U.S. Department of Agriculture, Soil Conservation Service, Soil Survey of Milwaukee and Waukesha Counties, Wisconsin, July 1971; U.S. Department of Agriculture, Soil Conservation Service, Soil Survey: Kenosha and Racine Counties, Wisconsin, December 1970.

Table 1

LOCATIONS AND DESCRIPTIONS OF SEDIMENT SAMPLES TAKEN FROM THE FOX RIVER BETWEEN IH-43 AND THE WATERFORD DAM: MAY 1994

SAMPLE No.	SEDIMENT COLOR[a]	SEDIMENT TEXTURE
1	10 YR 8/1, 3/1 (Matrix)	Fine Shell Gravel
2	10 YR 8/1, 3/1 (Matrix)	Fine Shell Gravel
3	10 YR 2/1 (Matrix)	Clayey Sandy Silt with Organic Material and Shell Fragments
4	10 YR 3/1, 2/1 (Matrix)	Clayey Sandy Silt with Organic Material and Shell Fragments
5	10 YR 3/1, 2/1 (Matrix)	Clayey Sandy Silt with Organic Material and Shell Fragments
6	10 YR 3/1, 2/1 (Matrix) 10 YR 8/2 (Sand)	Sandy Silt
7	10YR 3/1, 2/1 (Matrix) 10YR 8/2 (Sand)	Sandy Silt
8	10YR 2/1 (Matrix)	Clayey Sandy Silt with Organic Material and Shell Fragments
9	10YR 3/1, 2/1 (Matrix) 10YR 8/2 (Sand)	Sandy Silt
10	10YR 3/1, 2/1 (Matrix) 10YR 8/2 (Sand)	Sandy Silt
11	10YR 3/1, 2/1 (Matrix) 10YR 8/2 (Sand)	Sandy Silt
12	10YR 3/1, 2/1 (Matrix) 10YR 8/2 (Sand)	Sandy Silt
13	10YR 2/1 (Matrix) 10YR 8/1 (Shell Fragments) 10YR 8/2 (Sand)	Sandy Silt with Organic Fibers
14	2.5Y 2.5/1 (Matrix)	Clayey Silt
15	2.5Y 2.5/1 (Matrix)	Clayey Silt
16	2.5Y 2.5/1 (Matrix)	Clayey Silt
17	2.5Y 2.5/1 (Matrix)	Clayey Silt
18	2.5Y 2.5/1 (Matrix)	Clayey Silt
19	N 1/0 (Matrix)	Clayey Silt

[a]Color determined by Munsell Soil Color Charts.

Source: SEWRPC

sampling area can be defined in the middle part of the western basin of the Waterford Impoundment.

The results of the chemical analysis of these sediments are given in Table 2. Generally, these samples reflected "clean" sediments with little detectable contamination.[4] Biocide concentrations were reported as "not detectable" at all seven sampling sites. Similarly, the detectable metals concentrations varied from site to site but none appeared to be a cause for concern. PAH concentrations were generally "not detectable" for most of the analyzed parameters with the exception of the following parameters and sampling sites:

Indeno(1,2,3-cd)pyrene: Site 1, 0.045 mg/kg

Benzo(a)anthracene: Site 2, 0.008 mg/kg; Site 3, 0.011 mg/kg; Site 4, 0.007 mg/kg; and Site 7, 0.009 mg/kg

Chrysene: Site 2, 0.005 mg/kg; Site 3, 0.009 mg/kg; Site 4; 0.007 mg/kg; and Site 7, 0.009 mg/kg

Pyrene: Site 2, 0.005 mg/kg; Site 3, 0.036 mg/kg; Site 4, 0.029 mg/kg; Site 5, 0.007 mg/kg; and Site 7, 0.025 mg/kg

Benzo(b)flouranthene: Site 3, 0.013 mg/kg; Site 4, 0.007 mg/kg; and Site 7, 0.012 mg/kg

Fluoranthene: Site 3, 0.069 mg/kg; and Site 7, 0.025 mg/kg

Phenathene: Site 3, 0.010 mg/kg

None of these analytes or their concentrations would appear to be cause for concern at this time.

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[4] Wisconsin Department of Natural Resources, Draft Inventory of Statewide Contaminated Sediment Sites and Development of a Prioritization System, June 1994.

Table 2

RESULTS OF CHEMICAL ANALYSES PERFORMED ON SEDIMENT SAMPLES FOR THE FOX RIVER BETWEEN CTH ES AND THE WATERFORD DAM: 1994[a]

Section NR 347.06 Analyses Inland Waters	Sampling Sites						
	1	2	3	4	5	6	7
PCB (Total)	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
Chlordane	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND
DDT	ND	ND	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND	ND	ND
Arsenic	1.7	2.2	3.0	2.3	2.0	2.1	5.7
Barium	17.9	33.4	34.7	82.6	29.6	47.0	84.3
Cadmium	2	2	4	7	3	4	5
Chromium	10	14	21	20	15	21	35
Copper	6	8	15	13	9	12	24
Cyanide	ND	ND	ND	ND	ND	ND	ND
Iron	3,290	5,720	6,590	23,900	7,250	11,000	13,800
Lead	13	17	28	27	18	30	54
Manganese	196	249	274	576	296	418	434
Mercury	ND	0.03	0.04	0.03	0.03	0.04	0.11
Nickel	6	9	9	12	9	12	19
Selenium	ND	0.3	0.4	ND	1.5	0.4	0.5
Zinc	26	31	69	45	34	44	100
Oil and Grease	15,900	360	1,100	850	1,200	560	1.400
TKN	1,040	603	1,190	793	1,090	1,280	2,280
Total P	180	250	140	140	110	220	210
Grain-size (%)							
gravel	2	2	11	1	1	1	0
sand	87	85	57	83	70	38	14
silt and clay	11	13	32	16	29	61	86
Total Organic Carbon	9,700	9,000	28,000	7,000	22,000	25,000	61,000
Total PAH[b]	0.045	0.048	0.148	0.050	0.007	ND	0.080

[a]Results in mg/kg (ppm) except where noted: ND = not detectable; -- not determined.

[b]Total PAHs were calculated as the sum of individual analytes.

Source: Swanson Environmental,Inc. and SEWRPC.

Grain-size analysis showed that grain size decreased (more clay and silt) with distance downstream, with the exception of site number 4. These results generally confirmed, in a quantitative manner, the observations reported following the spring reconnaissance survey. The slight increase in grain size at site number 4 was probably due to the location of the sampling site, adjacent to the public boat launch, parking area, and a stormwater outfall at CTH L in Big Bend. Runoff from these impervious surfaces and from the stormwater outfall would be likely to locally increase water flow rates, flush away the finer clay and silt particles, and leave behind the somewhat greater amount of heavier sands and gravels observed at this site. With this exception, then, the occurrence of coarse sediments in upstream reaches and the deposition of finer sediments in downstream reaches--or selective sorting or particulates--is typical of many rivers and streams in Southeastern Wisconsin which have similar flow and grade characteristics to those of the Middle Fox River.

IMPLICATIONS FOR FUTURE PROJECT ACTIVITIES

A total of 18 river channel cross sections were field-surveyed along the Fox River and Waterford Impoundment. Sixteen of these cross-section locations coincided with data obtained under earlier studies in order to permit an assessment to be made of the magnitude of the scour and deposition processes that have affected the River and Impoundment during the period since the 1975 plan was prepared. These new survey data will serve as input for hydraulic analysis modeling under the current study.

Concurrent with this hydraulic study, 19 preliminary core samples were obtained from the sampling areas outlined above and shown on Map 1. Textural analysis of these samples identified a grain-size gradient that ranged from coarse sands and gravels at the uppermost reach sampled--IH 43--to fine silts and clays at the Waterford Impoundment. This gradient could be further divided into roughly five stream reaches containing sediments of discrete texture.

On the basis of the textural analysis, seven further samples were subsequently obtained from within discrete stream reaches, characteristic of the five texturally-defined reaches described above, and submitted for chemical analysis. Analysis of these sediment samples was carried out by Swanson Environmental Inc., a State-approved laboratory, using the schedule of analytes set forth in Table 2

and derived from Section NR 347.06 of the Wisconsin Administrative Code. Levels of contamination present in the sediments were minimal. It should be recognized that these results serve as a screening measure to determine if the concentrations of these organic and inorganic chemicals in the sediments concerned may be expected to exceed established levels of concern. The results have been used in conjunction with a systems level analysis to develop costs of alternative stream water level management alternatives. Further sampling and analyses may be required by the Wisconsin Department of Natural Resources if the proposed plan should recommend and local authorities wish to pursue dredging of portions of the River. However, for cost estimating purposes, it will be assumed that the sediments are clean and can be managed by conventional means, including land spreading.