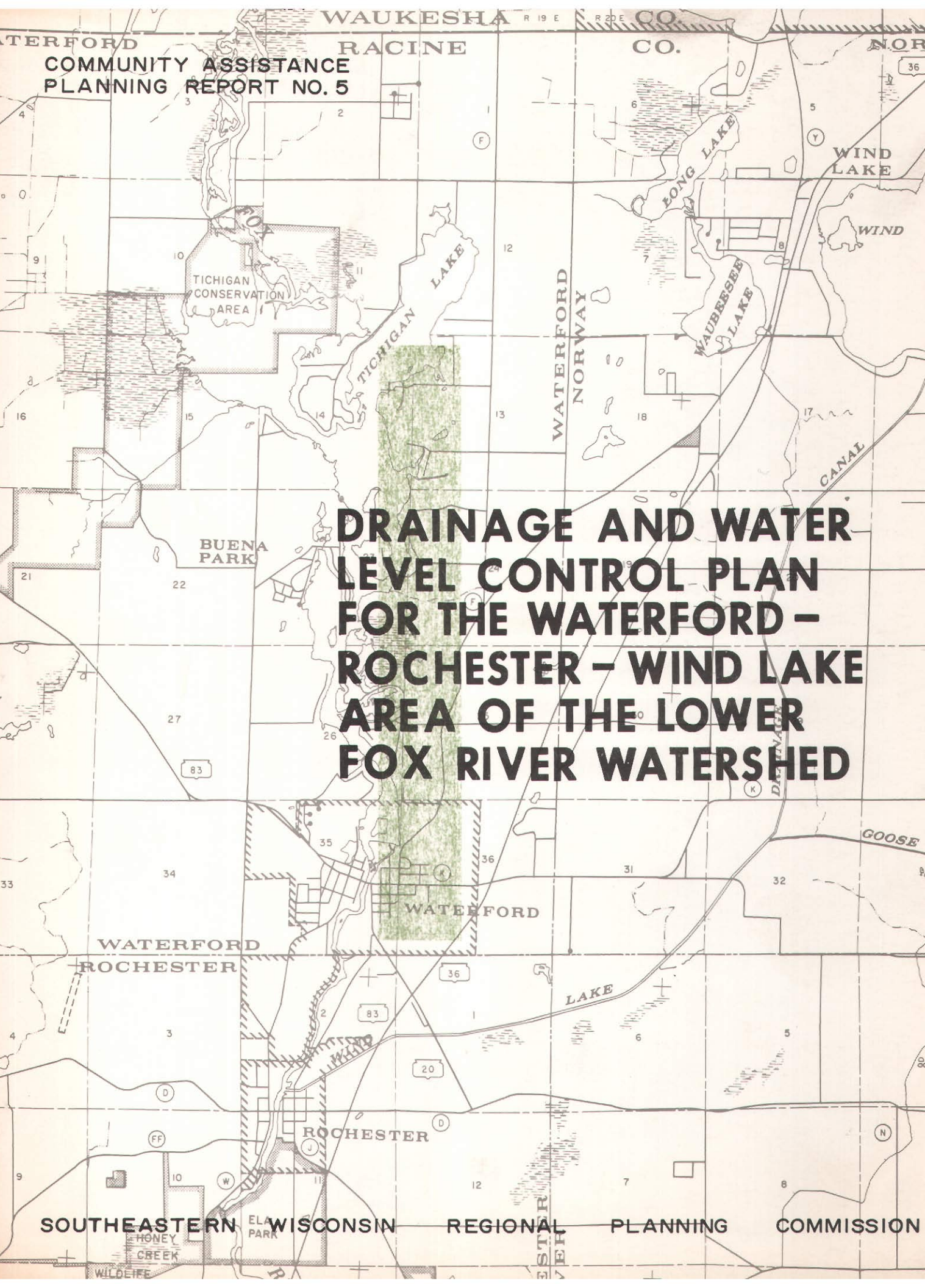
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 5




# DRAINAGE AND WATER LEVEL CONTROL PLAN FOR THE WATERFORD – ROCHESTER – WIND LAKE AREA OF THE LOWER FOX RIVER WATERSHED

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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COMMUNITY ASSISTANCE PLANNING REPORT
NUMBER 5

# DRAINAGE AND WATER LEVEL CONTROL PLAN FOR THE ROCHESTER-WATERFORD-WIND LAKE AREA OF THE LOWER FOX RIVER WATERSHED

Southeastern Wisconsin Regional Planning Commission
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and

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May 1975

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# Chapter I

## INTRODUCTION

On June 4, 1970, the Southeastern Wisconsin Regional Planning Commission adopted and certified to the concerned federal, state, areawide, and local units and agencies of government for adoption and implementation a comprehensive plan for the Fox River watershed. That plan, as documented in 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, contains specific recommendations for flood damage abatement within the Fox River watershed. The report documented not only the recommended flood control measures but also the alternatives thereto.

With respect to the abatement of damage from major floods, that is, floods having a recurrence interval of 10 years or more, the plan recommended preservation of the existing undeveloped floodlands of the main stem of the Fox River and the major tributaries thereto in essentially natural, open use through a combination of zoning and acquisition for public park and parkway use; the construction of dikes and floodwalls in the Cities of Waukesha and Burlington; the removal of existing residential development within the floodlands of the main stem of the Fox River in the Silver Lake area of the watershed; channel improvements in the headwater areas of Sugar and Honey Creek to protect agricultural areas; the construction of levees along the lower reaches of Hoosier Creek to protect agricultural areas; and the construction of a multi-purpose recreation, flood control, and low-flow augmentation reservoir on Sugar Creek. In addition, the plan evaluated the potential costs and benefits of regulating the levels of 10 major lakes within the watershed for flood control purposes: Pewaukee, Eagle Spring, Beulah, Big Muskego, Eagle, Lauderdale, Como, Geneva, Browns, and Silver (Kenosha County). Although it was concluded that the regulation of the levels of these 10 lakes for flood control purposes would have a positive benefit-cost ratio, the lake level regulation was not included in the adopted plan as a recommendation because, while abating damages from minor floods, it would not serve to eliminate damages from major floods within the waterhsed.

Although some very important plan implementation actions have occurred within the watershed since plan adoption, including, with respect to flood control, the enactment of sound floodland zoning ordinances throughout the watershed, implementation of the plan has lagged in the area of drainage and flood control improvements. This problem was discussed at an intergovernmental meeting held on June 3, 1974, on flood control problems in the lower watershed. As a result of that meeting, the Regional Planning Commission was requested to reconstitute and reactivate the Fox River Watershed Committee, which Committee directed preparation of the original plan. The Commission at its meeting on June 6, 1974, did reconstitute and reactivate the Fox River Watershed Committee, and directed the Committee to address the flooding and drainage problems existing in the lower watershed, with particular emphasis on controlling the water levels of the main stem of the Fox River and of the Wind Lake Drainage Canal in the lower watershed.

The reconstituted Fox River Watershed Committee met on June 28, 1974. The Committee recognized that detailed engineering investigation would be necessary to reevaluate and refine the adopted Fox River watershed plan as that plan relates to the flooding and drainage problems existing in the lower watershed. Accordingly, the Committee acted to create a special Subcommittee of public officials and interested citizens from the lower watershed to direct the necessary engineering investigation. That Subcommittee directed the Commission staff to prepare a memorandum outlining the scope and content of the necessary engineering investigation and recommending a procedure and time schedule for its conduct. The memorandum was submitted to, and adopted by, the Subcommittee on July 18, 1974, and pursuant to the recommendations contained in the memorandum, the engineering consulting firm of Technical Consultants was retained by the Commission to assist the Commission staff in the conduct of the necessary engineering investigation. Funds for the investigation were provided by the Racine County Board. This report sets forth the findings and recommendations of that engineering investigation.

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## Chapter II

## SCOPE OF WORK

### INTRODUCTION

This report, and the engineering investigation on which this report is based, are intended to provide an adequate basis for the public policy decisions required to resolve the drainage and water level control problems of the lower Fox River watershed. More specifically, the purpose and scope of the investigation is to:

1. Identify the nature and extent of the flooding drainage problems of the Waterford-Rochester-Big Bend, the Wind Lake Drainage Canal, and the Muskego Canal areas of the Fox River watershed.

2. Identify alternative solutions to these problems.

3. Determine the costs and benefits attendant to these alternative solutions.

4. Recommend the best solution.

5. Recommend the procedure for implementing the recommended solution.

The engineering investigation was to be carried out within the context of the adopted comprehensive plan for the entire Fox River watershed, and the recommended solution was to be consistent with that plan.

### AREAL LIMITS OF STUDY

The areas to be investigated encompass two subwatersheds of the larger Fox River watershed: that tributary to the main stem of the Fox River from Big Bend to Rochester, and that tributary to the Wind Lake Drainage Canal, including the Muskego Canal. More specifically, the study addresses that portion of the Fox River main stem which begins at the new STH 15 Freeway crossing of the river in Section 30, Town 5 North, Range 19 East, Town of Vernon, Waukesha County, and extends downstream to a point below the Rochester Dam in Section 11, Town 3 North, Range 19 East, Town of Rochester, Racine County. The majority of the reports of agricultural damages originated from the Town of Waterford in Racine County and the Town of Vernon in Waukesha County. The physical character of the Fox River floodplain changes significantly in the Vernon Marsh Area, and the reported damages are considerably less there than those reported downstream. Similarly, reports of agricultural damages downstream from the Rochester Dam were significantly less than the damages reported upstream. Recognizing that it is difficult to select a portion of the stem of a major riverway to study as a separate unit, these limits were agreed upon by the consulting engineer and the SEWRPC staff, and were approved by the Subcommittee.

In addition to that portion of the main stem of the Fox River described above, the study addresses the Wind Lake Drainage Canal and the Muskego Canal beginning at the outlet of Muskego Lake and extending downstream to the Fox River. The agricultural damages reported in this area are confined primarily to the Town of Norway and small portions of the Towns of Rochester and Dover, all in Racine County.

These two watersheds were studied relatively independently, although within the context of the overall watershed plan.

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## Chapter III

## DATA COLLECTION PROCEDURES

All existing pertinent information pertaining to stream reaches and related subwatersheds to be studied was collected. Such existing information included SEWRPC Fox River watershed reports, U. S. Soil Conservation Service reports and watershed data, Wisconsin Department of Natural Resources reports and records, local drainage district data, and small and large scale topographic and cadastral mapping as provided by SEWRPC and Racine County.

Approximately five days were spent in initial field reconnaissance of the study area by the consultant and Commission staff and by the Subcommittee Chairman in order to become totally familiar with the many physical aspects of the watershed. Five days of personal interviews were conducted with a wide variety of people, including local officials, farmers, landowners, and others that were experiencing problems due to high water levels in 1971, 1973, and 1974. The interview schedules were as follows:

1. Town of Waterford—agricultural interests—September 3, 1974.

2. Town of Vernon—agricultural interests—September 6, 1974.

3. Town of Norway—agricultural interests—September 10, 1974.

4. Town of Waterford—recreational-residential interests—October 19, 1974.

5. Village of Rochester—recreational-residential-commercial interests—December 7, 1974.

A summary of the results of these interviews is presented in summary form in Tables 1 through 4. It should be noted that almost everyone interviewed was extremely cooperative and helpful and that the personal interviews did, in fact, provide sound information useful in defining the flooding and drainage problems of the study areas, It should be further noted that the comments were very consistent as to the kind and degree of damages experienced.

**Table 1**

**SUMMARY OF INTERVIEWS–AGRICULTURAL DAMAGE**

Fox River–Towns of Waterford and Vernon
September 3 and 6, 1974

| Major Inventory Findings |
|---|
| 1. Interviews with farmers indicate high water problems increased greatly in 1968 when Waterford Dam mill race was closed. Reports very consistent. |
| 2. Fields remain wet too long in the spring to plant crops and remain wet too long in fall to harvest crops. |
| 3. Fields should be planted by the third or fourth week in May. |
| 4. Predominant crops measured in terms of acreage damaged:<br>Silage corn - 70 percent<br>Grain corn - 25 percent<br>Pasture - 5 percent |
| 5. When Waterford mill was in operation, the boards in the mill race were opened during high flows. Water levels would drop in one or two days. |
| 6. The new 30' by 1' notch in Waterford Dam constructed in August 1974 caused water levels to drop varying amounts from 5"± at dam to 12"± in upper part of impoundment relative to the crest of the spillway–elevation 773.4 feet mean sea level datum. |
| 7. Farmers would be satisfied with approximately 6" drop in water level compared to what it had been during 1971, 1972, 1973, and 1974. |

*Source: Technical Consultants and SEWRPC.*

Table 2

## SUMMARY OF INTERVIEWS
## AGRICULTURAL AND RECREATIONAL-RESIDENTIAL-COMMERCIAL DAMAGE

Fox River and Wind Lake Canal—Town of Norway and Village of Rochester
September 10 and December 7, 1974

| Major Inventory Findings |
|---|
| 1. New dam with two 10-foot radial gates was installed in Wind Lake Dam in 1972. Channel narrows downstream causing severe restriction in hydraulic capacity. |
| 2. Serious crop damages occur when Wind Lake Canal is overtopped. Overtopped in 1940, 1967, 1973, and 1974. |
| 3. Farmers above Wind Lake want gates opened during high flows, causing higher flows in canal below. |
| 4. Installation of two new 16-foot radial gates in the Rochester Dam is in progress by the Norway-Dover drainage district. |
| 5. Canal can handle runoff from normal rainfall if gates are properly operated at Rochester. Gates are now being operated by local drainage district. |
| 6. Canal should not be drained completely. Need water for ditch maintenance, weed spraying, to control bank erosion, and to prevent overdraining of fields. |
| 7. Largest flood in memory of farmers interviewed occurred in April 1973. |
| 8. Canal system consists of 7 miles of main canal and 40 miles of lateral ditches. Last dredged in 1952-54. |
| 9. Predominant crops measured in terms of acreage damaged:<br>Sod - $1,500 per acre<br>Carrots - $ 650 per acre<br>Celery - $5,000 per acre |
| 10. Approximately 15 farmers grow sod and 3 grow vegetables. |
| 11. Majority of farmers in drainage district (estimated to be 70 percent) grow field crops. Most of these are not affected by high water levels in canal. |
| 12. It was thought that the water level above Rochester Dam must be maintained at or above elevation 766.0 mean sea level for recreational users. |
| 13. Almost all land in marsh that is being worked has been tiled. Tiling costs up to $500 per acre. |
| 14. Sod farmers rely on many privately owned pumping plants to raise water into ditch system. |
| 15. Many farmers along Wind Lake Canal and Goose Creek Canal tile directly into canals. |

*Source: Technical Consultants and SEWRPC.*

Table 3

SUMMARY OF INTERVIEWS–RECREATIONAL DAMAGE

Fox River–Town of Waterford
October 19, 1974

| Major Inventory Findings |
|---|
| 1. Great majority of property owners on lake want water level raised at least 6" (from lowest level with notch in dam–Fall 1974). |
| 2. Water level dropped 12" maximum since notch was cut in Waterford Dam in August 1974. Reports from property owners also quite consistent regarding water levels. |
| 3. Boating has been impaired. Need minimum of 18" of water. Many boats cannot operate in shallow bays. Some boats have had propellors and transmissions damaged. |
| 4. Many concerned with damage to fishing. |
| 5. Lower water could affect water supply for fire trucks. |
| 6. Marina at Waterford has experienced serious loss of business ($8,000 loss in one month in 1974) since water was lowered. Many non-residents that used the impoundment for boating and fishing will not continue to use the lake with reduced water level. |
| 7. Three homes north of marina are very low and have experienced flooding. |
| 8. The interviews determined that about 90 percent of lakeshore owners are permanent residents. |
| 9. Several owners were experiencing shoreline erosion problems due to lower water level. |

*Source: Technical Consultants and SEWRPC.*

Table 4

SUMMARY OF INTERVIEWS
RESIDENTIAL SEPTIC TANK SEWAGE DISPOSAL SYSTEM PROBLEMS

Fox River–Town of Waterford
October 19, 1974

| Major Inventory Findings |
|---|
| 1. A small number of property owners complained about problems with septic tank sewage disposal systems due to high water levels. |
| 2. Approximately 170 houses and septic tank systems are presently located within 3 feet of the normal low water level in the Waterford Impoundment as determined from large-scale topographic maps. |
| 3. Sanitary sewers have been planned to service most of these 170 homes. Thirty dwellings near Tichigan Drive will not be serviced. |
| 4. Many lots are too small to accommodate a soil absorption sewage disposal system. Some systems are located on soils not suitable for soil absorption systems. |

*Source: Technical Consultants and SEWRPC.*

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## Chapter IV

## ASSESSMENT OF DAMAGES

### INTRODUCTION

The damage caused by high water levels on the Fox River, the Wind Lake Drainage Canal, and the Muskego Canal was separated into the following categories:

1. Fox River main stem agricultural damage.
2. Fox River main stem recreational damage.
3. Fox River main stem septic tank sewage disposal system damage.
4. Wind Lake Drainage Canal agricultural damage.
5. Muskego Canal agricultural damage.

### AGRICULTURAL DAMAGES

The following procedure was used in identifying and assessing agricultural damage. First, the croplands subjected to flooding and improper drainage as revealed by the personal interviews conducted with owners and operators were delineated on aerial photographs and topographic and cadastral maps. Normal or "low" water levels were determined by recorded stage readings and by review of recorded streamflows. The soil types as mapped in the regional detailed operational soil survey were studied to determine drainage requirements for agricultural purposes. From these data it was determined that croplands lying within five feet in elevation of the normal water level would be adversely affected by prolonged high water levels. Using aerial photographs and topographic maps provided, the cropland areas within five feet in elevation of normal water level were delineated.

The total acreage of land affected by high water levels or impaired drainage was determined to be as follows:

1. Town of Vernon—480 acres.
2. Town of Waterford—466 acres.
3. Town of Norway (Wind Lake Canal)—4,267 acres.
4. Town of Norway and City of Muskego (Muskego Canal)—268 acres.

This land is shown on Maps 1, 2, and 3.

In the Towns of Vernon and Waterford, most farmers indicated that the fields were too wet to plant over the past six to seven years. Therefore, the damages assessed in this area are based only on the value of the net crop loss, since the investment in planting would not be lost. The total average annual agricultural losses along the Fox River main stem (Towns of Vernon and Waterford) were determined to be $129,602 during the last five years (see Table 5).

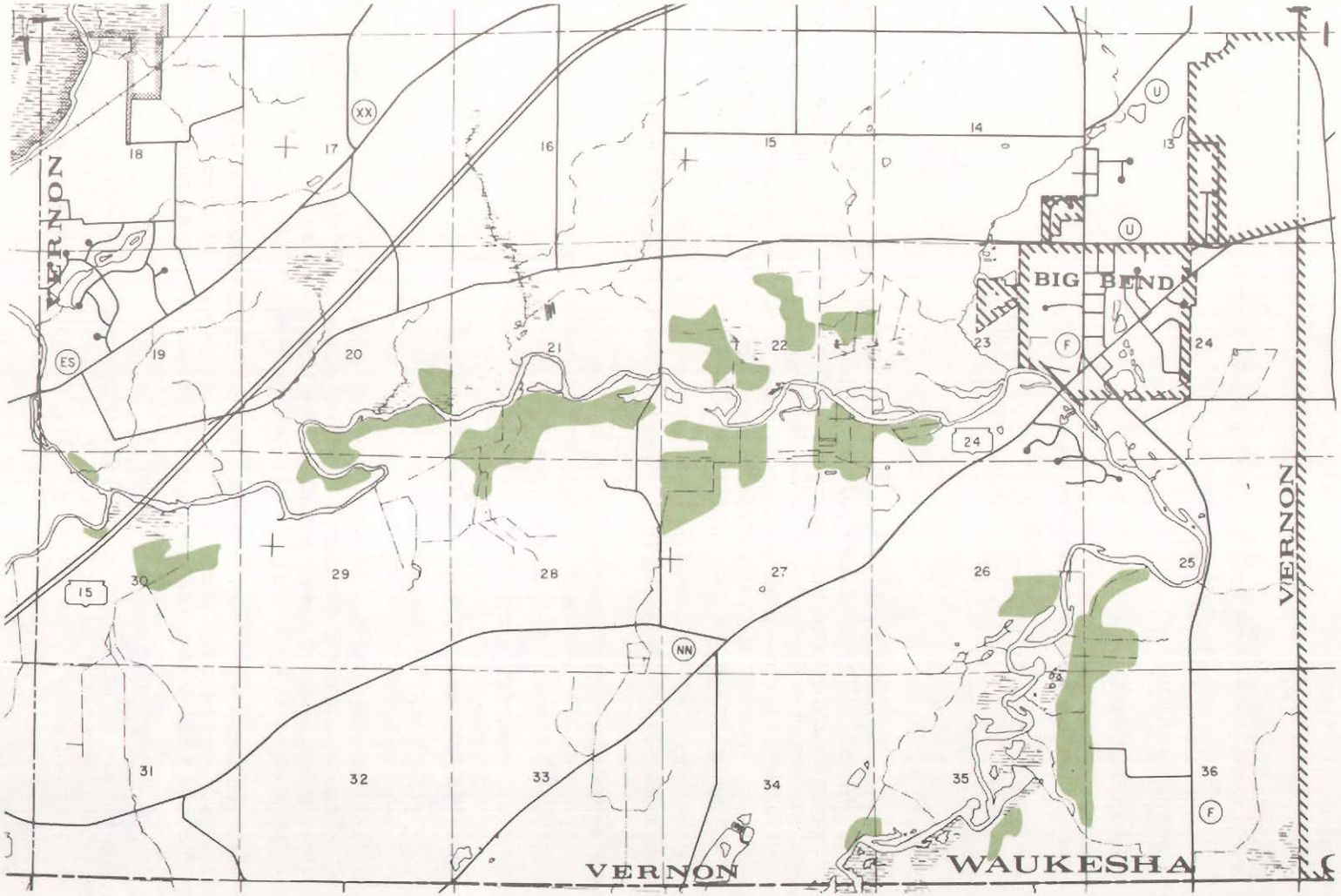
In the Wind Lake Drainage Canal Area in the Town of Norway, historical records indicate that major agricultural damage due to flooding occurs on a 10-year frequency or less. Minor or less severe damage occurs on an annual basis. Approximately 50 percent of the total 4,267 acres in cropland along the canal actually sustains serious damage during major runoff events.

The agricultural losses in this area are based upon the gross value of the crop less harvesting costs. It was assumed that flood damages will occur after the crops are planted. Consequently, the planting investment is also lost. The total average annual crop loss for the Town of Norway was determined to be $185,838 based on historical flood damage information (see Table 6).

A large area of low-lying cropland adjacent to the Muskego Canal from Wind Lake to Big Muskego Lake experiences agricultural damage regularly because of flooding or impaired drainage. Approximately 268 acres are affected, with an annual crop damage in excess of $24,000 (see Table 7).

Map 1

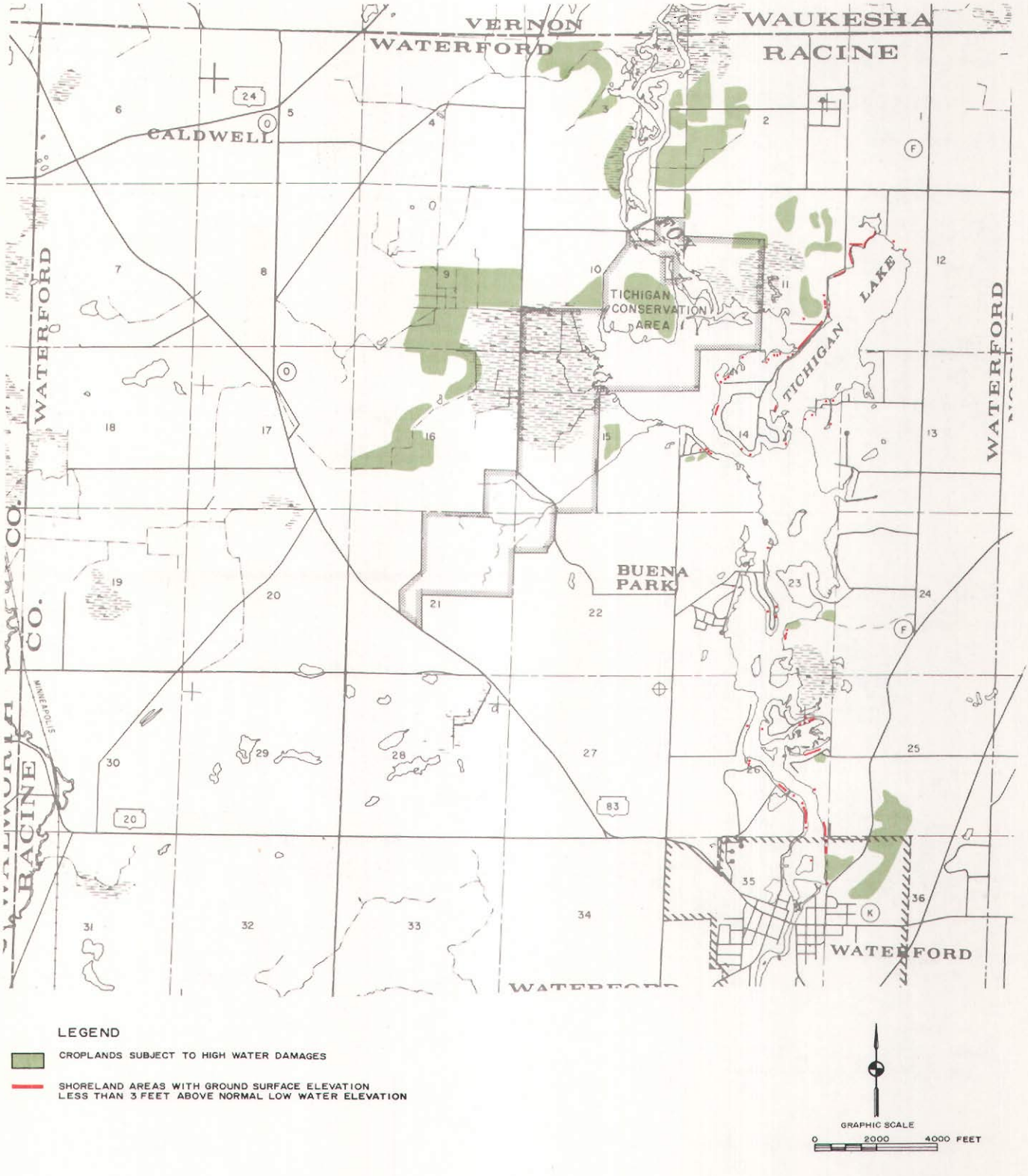
## LANDS ADVERSELY AFFECTED BY HIGH WATER LEVELS OR IMPAIRED DRAINAGE ALONG THE MAIN STEM OF THE FOX RIVER IN THE TOWN OF VERNON, WAUKESHA COUNTY: 1974




*Source: Technical Consultants and SEWRPC.*

Map 2

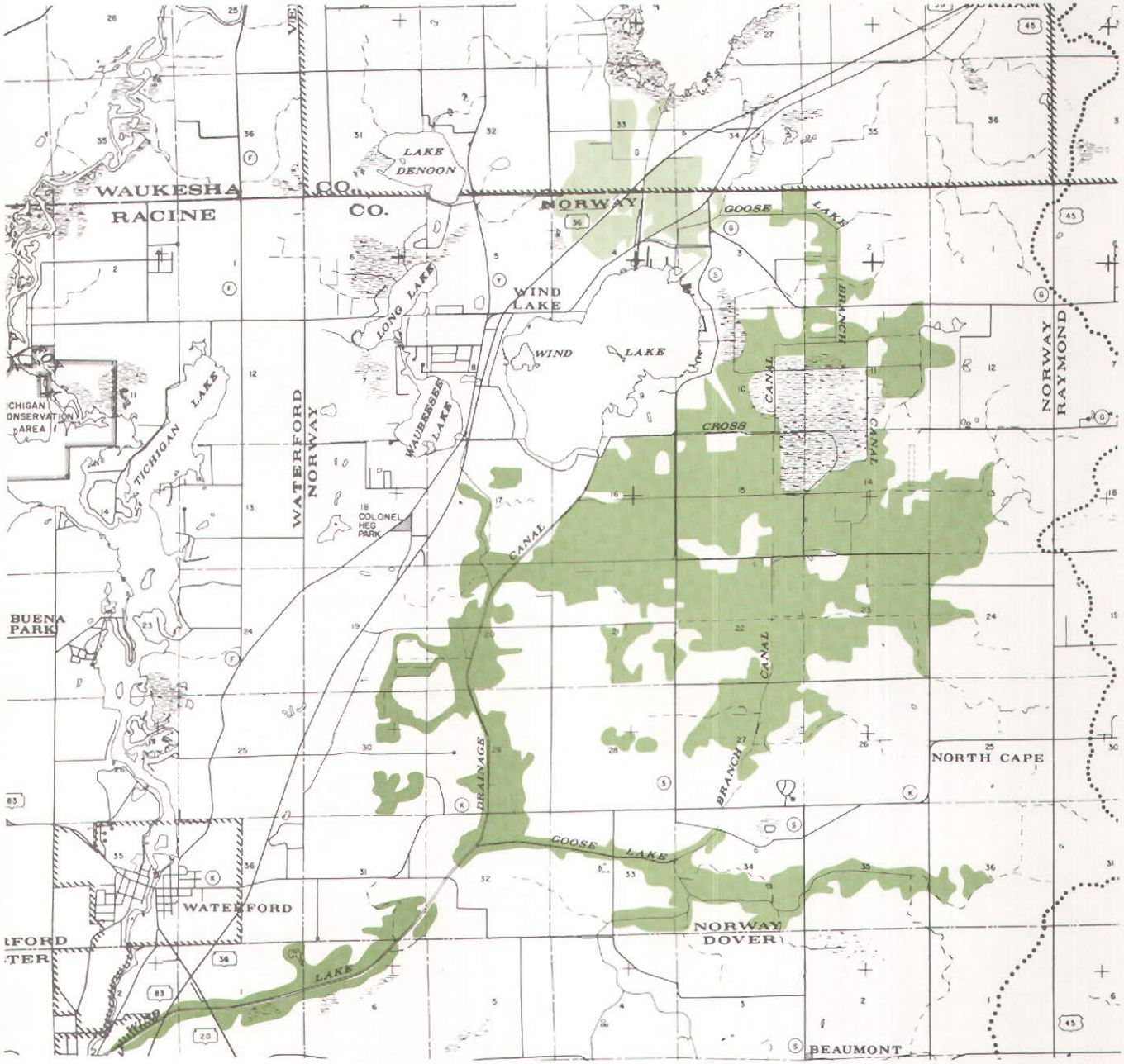
## LANDS ADVERSELY AFFECTED BY HIGH WATER LEVELS OR IMPAIRED DRAINAGE ALONG THE MAIN STEM OF THE FOX RIVER IN THE TOWN OF WATERFORD, RACINE COUNTY: 1974




*Source: Technical Consultants and SEWRPC.*

Map 3

## LANDS ADVERSELY AFFECTED BY HIGH WATER LEVELS OR IMPAIRED DRAINAGE ALONG THE WIND LAKE DRAINAGE CANAL AND THE MUSKEGO CANAL IN THE TOWNS OF DOVER, NORWAY, AND ROCHESTER, RACINE COUNTY, AND THE CITY OF MUSKEGO, WAUKESHA COUNTY: 1974




LEGEND

- CROPLANDS SUBJECT TO HIGH WATER DAMAGES ALONG THE WIND LAKE DRAINAGE CANAL
- CROPLANDS SUBJECT TO HIGH WATER DAMAGES ALONG THE MUSKEGO CANAL

GRAPHIC SCALE 0 2000 4000 FEET

*Source: Technical Consultants and SEWRPC.*

Table 5

DETERMINATION OF AGRICULTURAL DAMAGE ALONG THE MAIN STEM OF THE FOX RIVER IN THE TOWNS OF WATERFORD AND VERNON

| | |
|---|---|
| Agricultural lands (cropland) experiencing annual flooding and/or impaired drainage: | |
| Town of Vernon, Waukesha County | 480 acres |
| Town of Waterford, Racine County | 466 acres |
| Total | 946 acres |
| Agricultural losses based upon net value of crop, assuming that fields are generally too wet to plant in spring: | |
| 1. Corn (grain) - yield of 100 bu./acre | |
| Gross value = 100 bu. @ $3.00/bu. | $300/acre |
| Total cost | $100 |
| Net value or loss | $200/acre |
| 2. Corn (silage) - yield of 70 bu./acre | |
| Gross value = 70 bu. @ $3.00/bu. | $210/acre |
| Total cost | $100 |
| Net value or loss | $110/acre |
| Assume 30% grain corn and 70% silage corn with improved drainage: | |
| 1. Corn (grain) 30% of 946 acres | 283.8 acres |
| Agricultural loss–283.8 acres @ $200/acre | $56,760 |
| 2. Corn (silage) 70% of 946 acres | 662.2 acres |
| Agricultural loss = 662.2 acres @ $110/acre | $72,842 |
| Total annual agricultural loss | $129,602 |

*Source: Technical Consultants and SEWRPC.*

## RECREATIONAL DAMAGES

A permanent lowering of the water level in the Fox River above the Waterford Dam would help alleviate some of the agricultural damage upstream. However, it would adversely affect a large number of lakeshore property owners that use the Tichigan Lake and Waterford Impoundment for recreational purposes. This major recreational impoundment is used primarily for fishing, boating, water skiing, hunting, and aesthetic purposes.

Approximately 550 homes have been established on the lakeshore. Another 450 homes are located in very close proximity to the lakeshore. Based upon an examination of available hydrographic maps, it is estimated that approximately 380 lakeshore homes and 200 non-lakeshore dwellings would be adversely affected by lower water levels.

The loss in property values was conservatively estimated at 15 percent of the total property value for lakeshore dwellings and 5 percent for non-lakeshore dwellings. The total estimated potential loss of property value is about $2,000,000 (see Table 8).

It is estimated that a total of 68,000 hours of boating take place annually on Tichigan Lake and the Waterford Impoundment. This includes boating by both local property owners and nonresidents. Assuming a recreational value of $1.00 per person per hour, an average of two persons per boat, and a decrease in boating hours of 30 percent due to lower water levels, the annual recreational boating loss would be about $40,800 (see Table 8).

Table 6

DETERMINATION OF AGRICULTURAL DAMAGE ALONG THE WIND LAKE CANAL IN THE TOWN OF NORWAY

| | | |
|---|---|---|
| Agricultural lands (cropland) subject to flooding or impaired drainage based upon 10-year frequency rainfall event: | | 4,267 acres |
| Records indicate that approximately 50 percent of the total cropland actually sustains damages during major runoff events. | | |
| Agricultural losses are based upon gross value of crop, except harvesting costs, assuming that water damage will occur after crops are planted. | | |
| 1. Sod - gross value less harvesting cost = | $ | 1,300/acre |
| 2. Cash crops - vegetables (same basis) = | $ | 500/acre |
| 3. Corn = | $ | 280/acre |
| 4. Specialty high-value vegetables = | $ | 4,000/acre |
| Agricultural losses based upon acreage: | | |
| 1. Sod - 2,000 acres @ $1,300/acre @ 50 % loss = | | $1,300,000 |
| 2. Cash crops - vegetables 500 acres @ $500/acre @ 50% loss = | $ | 125,000 |
| 3. Corn - 1,667 acres @ 280/acre @ 50% loss = | $ | 233,380 |
| 4. Specialty crops - 100 acres @ $4,000/acre @ 50% loss = | $ | 200,000 |
| Total crop loss - 10-year frequency | $ | 1,858,380 |
| Annual crop loss | $ | 185,838 |

*Source: Technical Consultants and SEWRPC.*

Table 7

DETERMINATION OF AGRICULTURAL DAMAGE ALONG THE MUSKEGO CANAL IN THE TOWN OF NORWAY AND CITY OF MUSKEGO

| | |
|---|---|
| Agricultural lands (cropland) experiencing annual flooding and/or impaired drainage: | |
| Waukesha County | 130 acres |
| Racine County | 138 acres |
| Total | 268 acres |
| Agricultural losses are based upon gross value of crop, except harvesting costs, assuming that water damage will occur after crops are planted. | |
| 1. Cash crops - vegetables: gross value less harvesting cost = | $450/acre |
| Agricultural losses based upon acreage: | |
| 1. Cash crops - vegetables 268 acres @ $450/acre @ 100% loss = | $120,600 |
| Total crop loss - 5-year frequency | $120,600 |
| Annual crop loss | $ 24,120 |

*Source: Technical Consultants and SEWRPC.*

## SEPTIC TANK SYSTEM DAMAGES

Onsite soil absorption septic tank sewage disposal systems will not function properly in areas with a high water table. Wisconsin state codes require a minimum of six feet from the ground surface to the water table for the installation of soil absorption systems. Approximately 170 dwellings on the lakeshore of Tichigan Lake and Waterford Impoundment are located in areas having a ground surface elevation of less than three feet above the normal low water elevation (see Map 2). If water levels remain high for prolonged periods, the septic tank systems serving these dwellings may be expected to fail. At the present time, the only solution to the failure of a septic tank system due to a high water table is to replace the system with a holding tank. If it is assumed that only 50 percent of the 171 septic tank systems located on low ground near the river fail, the total capital cost of replacing the 85 septic systems with holding tanks is estimated at $85,000. The annual operating costs of the holding tanks are estimated at $1,040 per tank, for a total average annual cost of $94,575. Sanitary sewers have been proposed to serve all but 30 dwellings in this area. If it is assumed that sanitary sewers will be installed and that the septic system failures will be confined to the 30 dwellings not serviced, annual damages would approximate $33,380 (see Table 9).

Table 8

DETERMINATION OF RECREATIONAL DAMAGE ALONG THE MAIN STEM OF THE FOX RIVER IN THE TOWN OF WATERFORD

| | | |
|---|---|---|
| Number of dwellings on lakeshore: | | |
| From Wisconsin Department of Natural Resources Lake Use Report | 548 (use) | |
| From U. S. Geological Survey Map | 700 | |
| Number of properties that will have decreased property value due to lower water levels: | | |
| Lakeshore lots | | |
| Tichigan Lake | 60 | |
| Main Stem | 320 | |
| Total | 380 | |
| Non-lakeshore lots | 200 | |
| Loss in property value: | | |
| Assume 15 percent loss for average dwelling valued at $30,000, or $4,500 per dwelling on lake. | | |
| Assume 5 percent loss for dwellings not on lakeshore, or $1,500 per dwelling. | | |
| 380 dwellings @ $4,500/dwelling = | | $1,710,000 |
| 200 dwellings @ $1,500/dwelling = | | $ 300,000 |
| Total | | $2,010,000 |
| Recreational boating value loss: | | |
| Department of Natural Resources Lake Use Report indicates a total of 68,000 hours of boating annually. | | |
| Assume $1.00 recreational value per person per hour, and an average of two persons per boat, or $2.00 per boat per hour. | | |
| Assume 30 percent reduction in boating hours due to low water. | | |
| Total recreational boating annual value loss: | | |
| 68,000 x 0.30 x $2.00 = $40,800 | | |

*Source: Technical Consultants and SEWRPC.*

Table 9

DETERMINATION OF SEPTIC TANK SYSTEM DAMAGE ALONG THE MAIN STEM OF THE FOX RIVER IN THE TOWN OF WATERFORD

| | | |
|---|---|---|
| Number of dwellings below elevation 778 msl, or less than 3 feet above normal low water level = 171[a] | | |
| If water levels are to remain high, with no control, assume minimum of 50 percent failure of systems, or 85 total. | | |
| Replace with holding tank: | | |
| Initial cost: 2 - 1,000 gal. tanks @ $500/tank = | | $ 1,000 |
| Pumping cost: 52 weeks @ $20/week = | | $ 1,040/year |
| Total costs: | | |
| 1. 85 holding tanks @ $1,000/tank = | | $85,000 |
| Amortized at 6 percent over 30 years = | | $ 6,175/year |
| 2. 85 holding tanks x $1,040/tank = | | $88,400/year |
| Total | | $94,575/year |
| Sewers will be provided for most of area in future, except for approximately 30 dwellings along Tichigan Drive. Even with lowered water levels, the septic systems in this area must be considered as "marginal." | | |
| Annual Damages: | | |
| 1. 30 holding tanks @ $1,000/tank = | | $30,000 |
| Amortized at 6 percent over 30 years = | | $ 2,180/year |
| 2. Annual pumping costs: | | |
| 30 tanks @ $1,040/tank = | | $31,200/year |
| Total | | $33,380/year |

[a] *There may be a number of septic systems that are not operating properly for reasons other than high water levels. These were not considered in the analysis. The proposed sanitary sewers will alleviate present and potential septic system failures within the areas to be serviced.*

*Source: Technical Consultants and SEWRPC.*

There may be a number of septic tank systems that are not operating properly for reasons other than high water tables. These were not considered in the analysis. The predominant soil types adjacent to the Waterford Impoundment and Tichigan Lake and their rated limitations for onsite absorption of sewage effluent are set forth in Table 10. The provision of sanitary sewers would, of course, alleviate all present and potential septic tank system failures within the areas to be serviced.

Table 10

PREDOMINANT SOIL TYPES ADJACENT TO WATERFORD IMPOUNDMENT

| Soil Type Symbol | Name | Soil Limitations for Onsite Sewage Disposal Systems |
|---|---|---|
| Cw | Colwood silt loam | Very Severe |
| Ka | Kane loam | Very Severe |
| Az | Aztalan loam | Very Severe |
| He | Hebron loam | Severe |
| Mz | Montgomery silty clay | Very Severe |
| B1 | Blount silt loam | Very Severe |
| A1 | Ashkum silty clay loam | Very Severe |
| Sm | Sebewa silt loam | Very Severe |
| MS | Marsh | Very Severe |
| Fo | Fox loam | Moderate |
| Cr | Casco-Rodman complex | Moderate |
| Dr | Dresden loam | Severe |
| Zu | Zurich silt loam | Moderate |
| Fs | Fox silt loam | Moderate |
| Cc | Casco sandy loam | Moderate |

*Source: SEWRPC.*

## Chapter V

## TECHNICAL PROCEDURES

This chapter describes the technical procedures followed in analyzing the hydraulics and economics of the proposed solutions to the drainage and water level control problems existing in the study area. The first step in the hydraulic analyses was to determine a control elevation, or maximum allowable level, at which the water in the stream and canal reaches under consideration should be normally held in order to minimize flood damages. This control elevation was to be exceeded only for relatively short periods of time during major flood events. The control elevation recommended is shown on the profiles set forth in Appendix A, and was selected based upon careful consideration of the drainage requirements of the croplands experiencing water damage, and of the historical water level data provided by the landowners and farm operators interviewed during the study. Generally, the control elevation would maintain water levels three to four feet below the ground surface during crop growing season in order to permit full development of plant root systems. Elevations of presently damaged croplands were reviewed on topographic maps to determine control elevations which would provide adequate drainage. These elevations were then verified by field investigations and personal interviews with farmers affected.

The solutions to the water-related problems of the lower Fox River and the Wind Lake Drainage Canal-Muskego Canal systems were designed to maintain the water levels at or below the control elevations to the greatest extent possible. Since the flow capacity of the river and the canals within their banks is quite small, water levels may be expected to occasionally exceed the control elevations, sometimes more than once a year. Relief from water damage will be derived not from any attempt to contain excessive storm water runoff within the stream banks, but from moving the water more quickly through the damage reaches for the more frequent events, thereby reducing the extent of the time periods during which fields are flooded.

On the Fox River main stem, flow records were studied from stream gaging stations operated at Waukesha and Wilmot, pursuant to the recommendations of the Regional Planning Commission. Since the planting and harvesting period occurs from the middle of May to the end of November, the larger snow-melt type floods were not considered in these analyses. During the personal interview, the farmers consistently confirmed the need to work the land by the middle of May to harvest crops through late November.

The proposed solutions for the Fox River main stem were evaluated based on the ability to provide protection against high water for, on the average, about eight out of every 10 years, or for all flows up to and including a 5-year recurrence interval. This corresponds to a discharge of about 1,000 cfs at the Waterford Dam. The amount and frequency of damage to crops on individual fields will differ based upon the relative elevation of the fields and on the type of crops grown. In general, a higher percentage of corn should be expected to be harvested as grain, as opposed to silage, with adequate water level control.

The design discharges for the Wind Lake Canal area were determined primarily from agricultural drainage curves prepared by the U. S. Soil Conservation Service. These curves have been found to be reliable and used extensively throughout the Midwest for many years for design purposes. These curves are set forth in Appendix B.

Because of the need to preserve the natural floodwater storage capacity available in the watershed, as documented in the adopted comprehensive plan for the Fox River watershed, the design of flood control works which would protect adjacent lands against inundation by floods having a recurrence interval of 10 years or greater by eliminating storage is not considered sound. In order to prevent agricultural damage from such floods, it is instead considered necessary to remove the water that normally goes into storage beyond the banks of the canal system as soon as possible after the passage of a major flood event.

The design flow selected for the Wind Lake Drainage Canal was 1,180 cubic feet per second (cfs).[1] The flow has an estimated recurrence interval of 10 years, assuming that dikes are constructed, and is made up of the combined flow from three separate parts of the watershed as follows:

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[1] *It should be noted that this design flow exceeds the 10-year recurrence interval flood flow estimate of 730 cfs set forth in SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed, Volume Two, Alternative Plans and Recommended Plan, February 1970, by 450 cfs. This change in design flow was made in consideration of three factors: 1) a change in the capacity of the outlet structure in Wind Lake since 1970, 2) proposed removal of natural floodplain storage capacity along the Wind Lake Canal for floods up to a 10-year recurrence interval event, and 3) proposed facilities for providing rapid drainage of farmlands adjacent to the canal.*

1. Outflow from Wind Lake Dam.

   The control gates of this dam should be operated to limit the flow to approximately 500 cfs, which approximates the capacity of the canal immediately downstream from the dam.

2. Outlet channel from Waubeesee Lake.

   The design discharge from this channel approximates 80 cfs.

3. The remaining 44 square miles of the total tributary watershed.

   The design flow provides for drainage from this area at the rate of 13.7 cfs per square mile, or a total of approximately 603 cfs.

Water levels in the Wind Lake area canal systems under design flow conditions would be higher than the affected croplands. Therefore, the water would have to be contained in the channels by dikes, and farmers would continue to use individual pumping systems to outlet their water into the canals.

The design flow selected for the Muskego Canal was 560 cfs. This design flow was based upon the outflow from Big Muskego Lake for a 10-year recurrence interval discharge.

In order to facilitate the hydraulic analyses, cross sections were prepared for all culverts and bridges and for selected intermediate locations along both the Fox River main stem and the Wind Lake Drainage-Muskego Canals using available Commission survey data and large-scale topographic maps. Manning "n" values were determined for each channel reach and floodplain section based upon field inspection.

A number of alternative solutions to the high water problems were formulated in consultation with the Subcommittee. A preliminary hydraulic design was made for each of the alternatives. All of the above data were then entered into the stage backwater computation program maintained by the Regional Planning Commission. Application of this program provided design high water surface elevations and discharges for each of the selected alternatives.

Damages were then determined based upon the calculated water surface elevations. The total cost of each alternative was also estimated and a benefit-cost ratio calculated for each alternative.

## Chapter VI

## ALTERNATIVE DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN ELEMENTS FOX RIVER MAIN STEM

### ALTERNATIVE A—NO ACTION

To do nothing is always a possible alternative open to the public officials concerned. Analysis of this alternative is also helpful as a basis of comparison for all other alternative solutions. If nothing is done with respect to the drainage and water level control problems of the main stem of the Fox River through the Big Bend-Waterford-Rochester area, agricultural and septic tank system damages could be expected to continue to occur at an average annual cost of $161,102. Accordingly, this alternative is not an economically sound course of action to pursue.

### ALTERNATIVE B—INSTALL GATES IN THE WATERFORD DAM

One alternative damage abatement measure considered would control water levels on the main stem by the installation of two 20' by 4' radial gates in the Waterford Dam, as shown in Figure 1. This would allow the design discharge of 1,000 cfs to flow through the dam at a water surface elevation of 773.4 feet mean sea level datum, the elevation of the existing crest of the dam. This would provide approximately double the capacity of the gates provided in the old mill race when fully opened prior to the removal of these gates in 1967 (see Waterford Dam rating curve in Appendix B).

The gates would be automatically operated, with the operation controlled by water level sensors located at a point upstream near or at the STH 24 crossing in the Town of Vernon, so that the gates would open in a timely manner before high water levels occur at the dam itself. Subsequently, the gates would close in a timely manner before the water levels dropped at the dam to an elevation which would adversely affect recreational interests on the Waterford Impoundment and Tichigan Lake.

The river in its natural condition upstream from Tichigan Drive has a limited flow capacity with overbank flooding occurring when the discharge reaches from 200 to 300 cfs. Therefore, when at the design flow the river would overflow its banks in this area and would flood portions of the croplands located adjacent to the river along the reach from Tichigan Drive to STH 15. If the proposed control gates were properly operated, however, the water levels would recede rapidly as the flows decreased, and only minor damage should occur to the low-lying cropland areas adjacent to the river.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water levels along the main stem of the Fox River upstream from the Waterford Dam is estimated to be $128,900. This benefit would be achieved by rapidly lowering the normal water levels in this reach following high flows or a flood event.

Costs: The total installation cost of the proposed water level control works is estimated at $88,500 including construction, engineering, and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated average annual cost of $5,614. Annual operation and maintenance costs are estimated to be $500 (see Table 11).

Benefit-Cost Ratio: Since this proposal would reduce the average annual damages from $161,100 to $32,220, at an average annual cost of $38,334 the benefit-cost ratio of the proposal calculated at 6 percent interest would be 3.4-to-1.

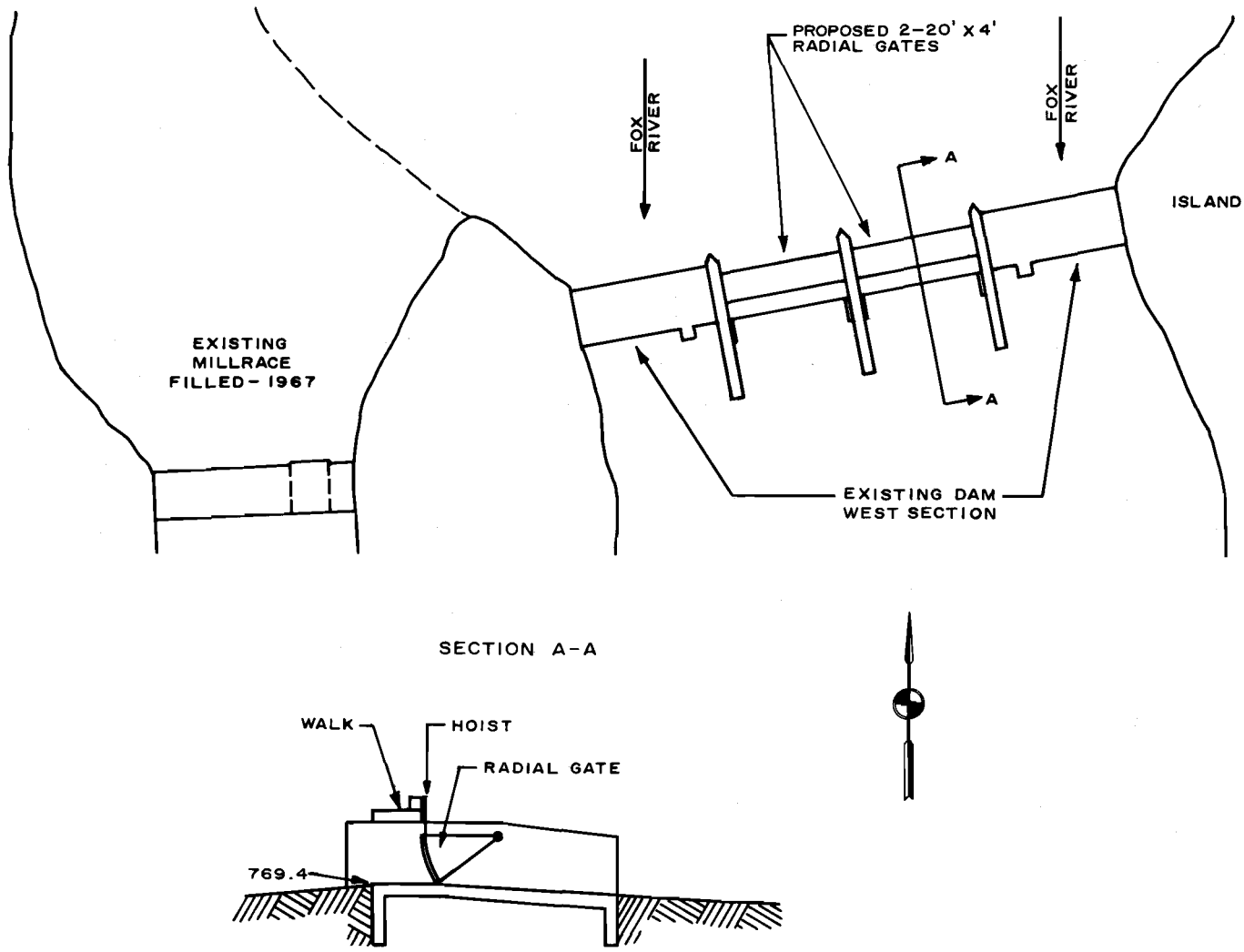
### ALTERNATIVE C—ON-FARM DIKES AND PUMPING STATIONS

A second alternative damage abatement measure would not involve any improvements to the river channel nor modifications to the existing dam. Water levels in the Waterford Impoundment would remain at present levels, thereby satisfying the majority of the recreational users. Earthen dikes would be constructed on the individual croplands that are presently damaged by high water levels. Individual pumping stations would be provided inside the dike systems to remove surface and ground water from the protected areas (see Figures 2 and 3).

The earth dikes would be designed to be overtopped by major flood events having a recurrence interval of 10 years or more, thereby making the diked floodplains available for needed temporary floodwater storage during major flood events. The earth dikes would range in height from approximately three to seven feet, with an average height of about 4.5 feet. Side slopes would be 1 on 2, with a minimum top width of six feet. Seepage beneath the dikes is not anticipated to constitute a major problem because a high percentage of the soils in the areas from which the dikes would be constructed have a high clay content.

Figure 1

PROPOSED INSTALLATION OF GATES AT THE WATERFORD DAM




*Source: Technical Consultants and SEWRPC.*

Table 11

COST ESTIMATES FOR ALTERNATIVE DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN ELEMENTS FOR THE MAIN STEM OF THE FOX RIVER FROM WATERFORD TO BIG BEND

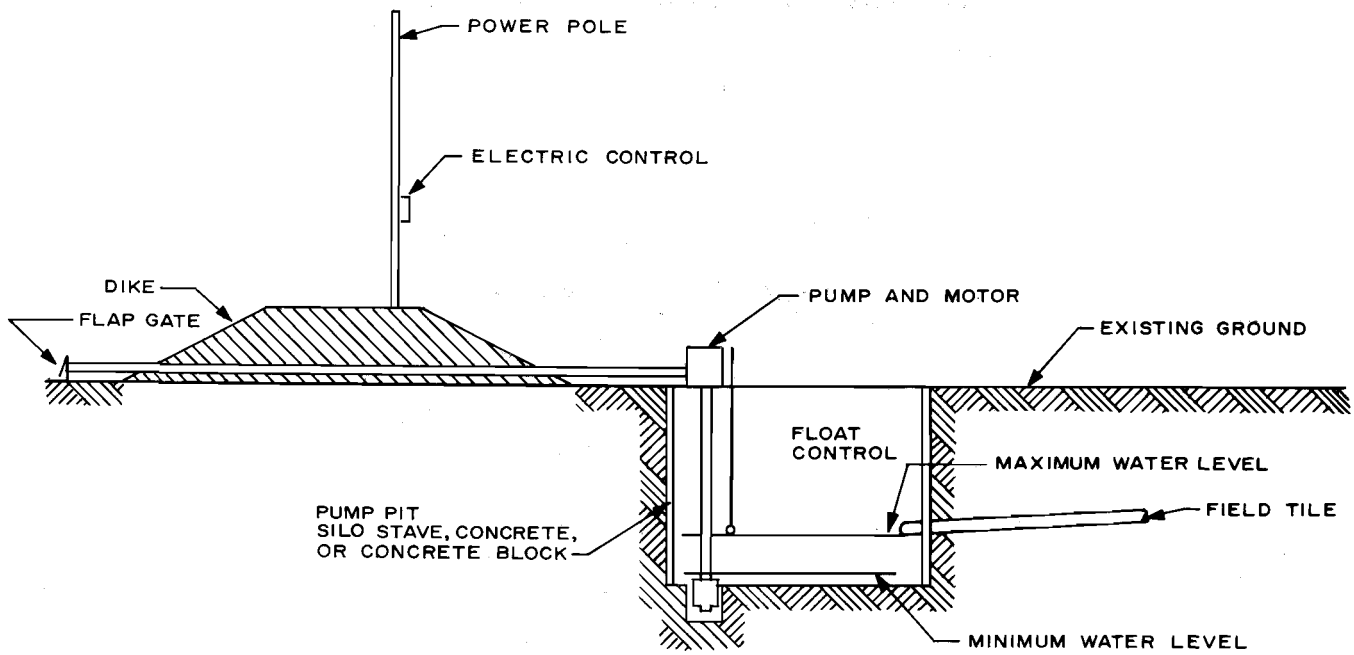
| Drainage and Water Level Control Alternative | | Costs | | | | | | Benefits | | Benefit-Cost Analysis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Annual | | | | | | | | | |
| Letter Description | Name | Capital | Amortization | Operation and Maintenance | Other | Total | Present Worth | Annual | Present Worth | Annual Benefits Minus Annual Costs | Benefit-Cost Ratio | Economically Feasible |
| A | No Action | $ -- | $ -- | $ -- | $161,102 | $161,102 | $2,539,290 | $ -- | $ -- | $-161,102 | -- | No |
| B | Install Gates in the Waterford Dam | 88,500 | 5,614 | 500 | 32,220 | 38,334 | 604,220 | 128,882 | 2,031,438 | 90,548 | 3.36:1 | Yes |
| C | On-Farm Dikes and Pumping Stations | 197,980 | 12,560 | 4,385 | 43,658 | 60,603 | 955,224 | 117,444 | 1,851,152 | 56,841 | 1.94:1 | Yes |
| D | Channel Dredging | 1,438,800 | 91,277 | -- | 64,441 | 155,718 | 2,454,427 | 96,661 | 1,523,571 | - 59,057 | 0.62:1 | No |
| E | Channel Dredging | 590,900 | 37,487 | -- | 64,441 | 101,928 | 1,606,589 | 96,661 | 1,523,571 | - 5,267 | 0.95:1 | No |
| F | Channel Dredging | 80,600 | 5,113 | -- | --[a] | 5,113 | 80,591 | 14,500 | 228,549 | 9,387 | 2.83:1 | Yes |
| G | Lake Level Management - Major Lakes | 25,000 | 1,586 | 300 | 144,992 | 146,878 | 2,315,091 | 16,110 | 253,926 | -130,768 | 0.11:1 | No |
| H | Removal of Waterford Dam | 2,045,000 | 129,735 | -- | 73,020 | 202,755 | 3,195,824 | 128,882 | 2,031,438 | - 73,873 | 0.64:1 | No |

[a] *Agricultural damages not applicable.*

*Source: Technical Consultants and SEWRPC.*

Figure 2

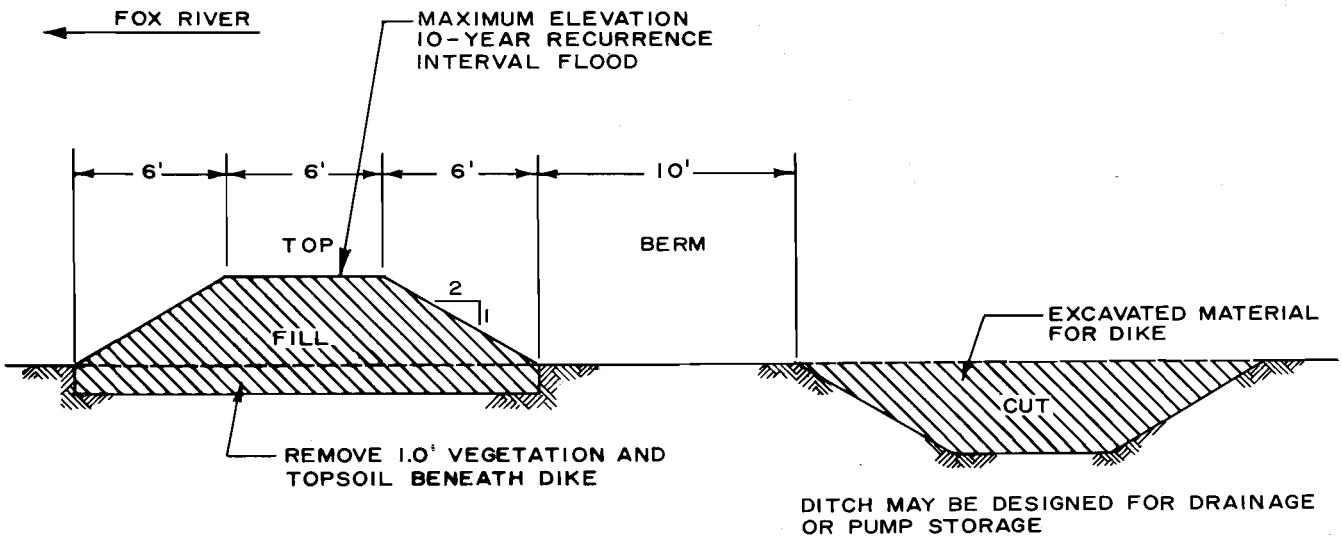
TYPICAL PUMPING STATION CROSS SECTION




*Source: Technical Consultants and SEWRPC.*

Figure 3

TYPICAL EARTHEN DIKE CROSS SECTION

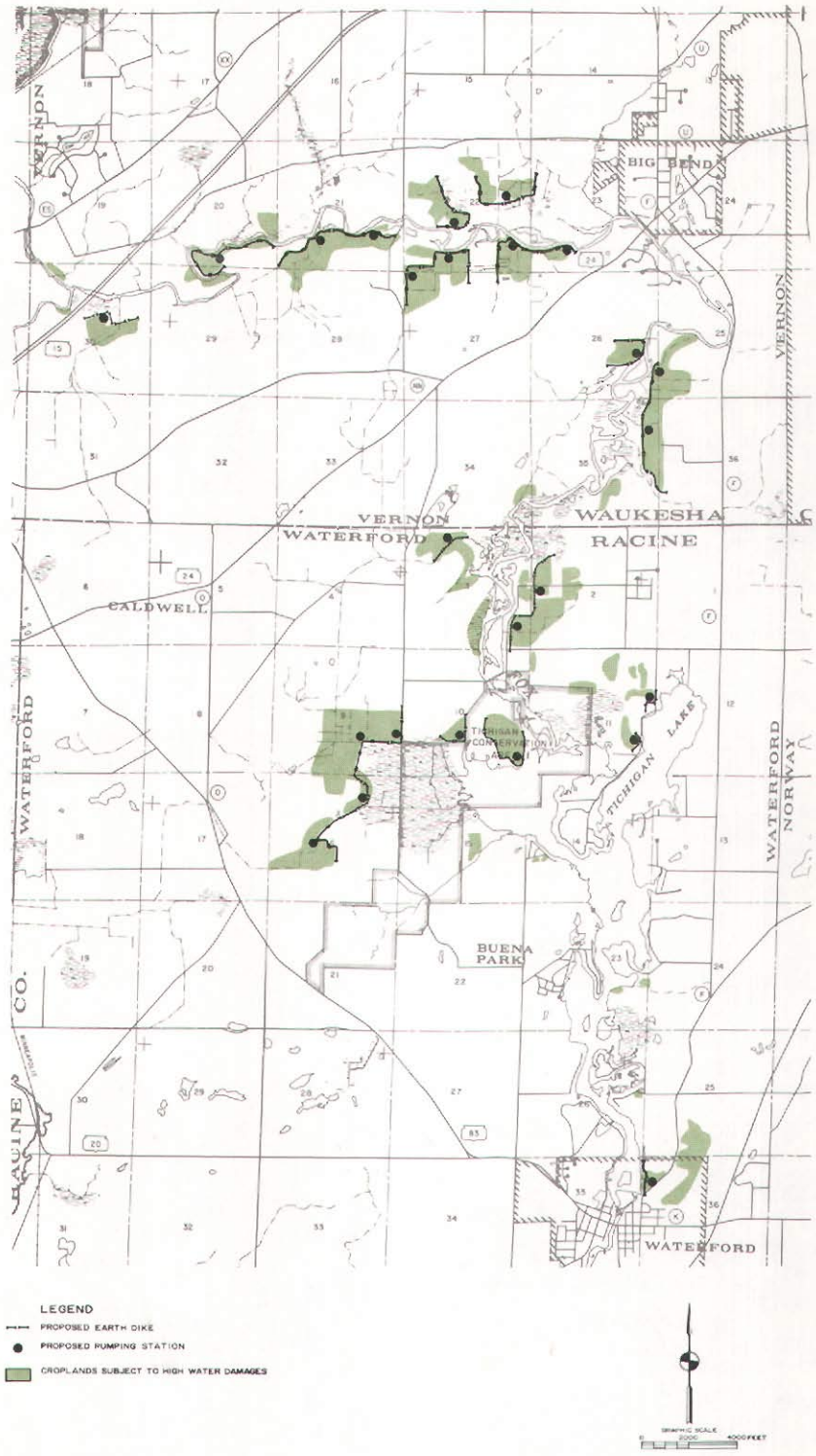



*Source: Technical Consultants and SEWRPC.*

The pumps would be high volume, low head propeller type drainage pumps, powered by either electric motors or internal combustion engines. The total length of dike required would be 70,500 linear feet, and the total number of pumping stations would be 25 (see Map 4).

Map 4

## PROPOSED DIKE AND PUMPING STATION SYSTEM FOR THE MAIN STEM OF THE FOX RIVER FROM WATERFORD TO BIG BEND




*Source: Technical Consultants and SEWRPC.*

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water damage upstream from the Waterford Dam is estimated to be $117,444. This benefit would be achieved by protecting croplands from all high water levels up to the 10-year recurrence interval flood event, and in addition would allow excessive water to be pumped from the fields much more quickly than by gravity flow.

Costs: The total installation cost of the proposed water level control works is estimated at $198,000, including construction, engineering, and administrative services, and the cost of necessary land easements. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated average annual cost of $12,560. Annual operation and maintenance costs are estimated at $4,385.

Benefit-Cost Ratio: Since this proposal would reduce average annual damages from $161,100 to $43,658 at an average annual cost of $60,603, the benefit-cost ratio of the proposed calculated at 6 percent interest would be 1.9-to-1.

A possible problem in the implementation of this proposal is the degree of acceptance by the individual farmers. It may be anticipated that less than 50 percent of the total damaged croplands would actually be diked and protected. In this event, costs and benefits would both be reduced, with the benefit-cost ratio approximating 0.5-to-1.

## ALTERNATIVE D—CHANNEL DREDGING

A third alternative damage abatement measure would permanently lower the water level in the Waterford Impoundment 1.0 foot from its present elevation of 773.4 feet mean sea level datum. This reduction in water level would be accomplished by dredging the entire impoundment area to lower the elevation of the bottom by about 1.0 foot. This plan could be expected to alleviate approximately 60 percent of the high water damage. No damage to the recreational interests would occur, since the net water depths before and after the changes in water level would remain the same.

An important consideration in the feasibility of this alternative would be the location of suitable sites for the disposal of the dredged material close enough to the impoundment for practical dredging operations. The Waterford Impoundment covers an area of approximately 893 acres (see Map 5). The cost of removing one foot of material over this area is estimated to be $1,438,800.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water damage upstream from the Waterford Dam is estimated to be $96,661. This benefit would be achieved by lowering the entire impoundment one foot by dredging.

Costs: The total cost of the proposed dredging is estimated to be $1,438,800, including engineering and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated annual cost of $91,277. Annual operation and maintenance costs are estimated to be negligible.

Benefit-Cost Ratio: Since this proposal would reduce the average annual damage from $161,100 to $64,400 at an average annual cost of $155,718, the benefit-cost ratio of this proposal calculated at 6 percent interest would be 0.6-to-1.

## ALTERNATIVE E—CHANNEL DREDGING

A fourth alternative damage abatement measure would also lower the water level 1.0 foot in the Waterford Impoundment. However, the impoundment would be deepened 1.0 foot by dredging only in areas less than three feet deep under the existing water level conditions (see Map 6). No dredging would be done in areas covered by water greater than three feet in depth. The area to be dredged approximates 363 acres, and all other aspects of this proposal would be identical to Alternative D set forth above.

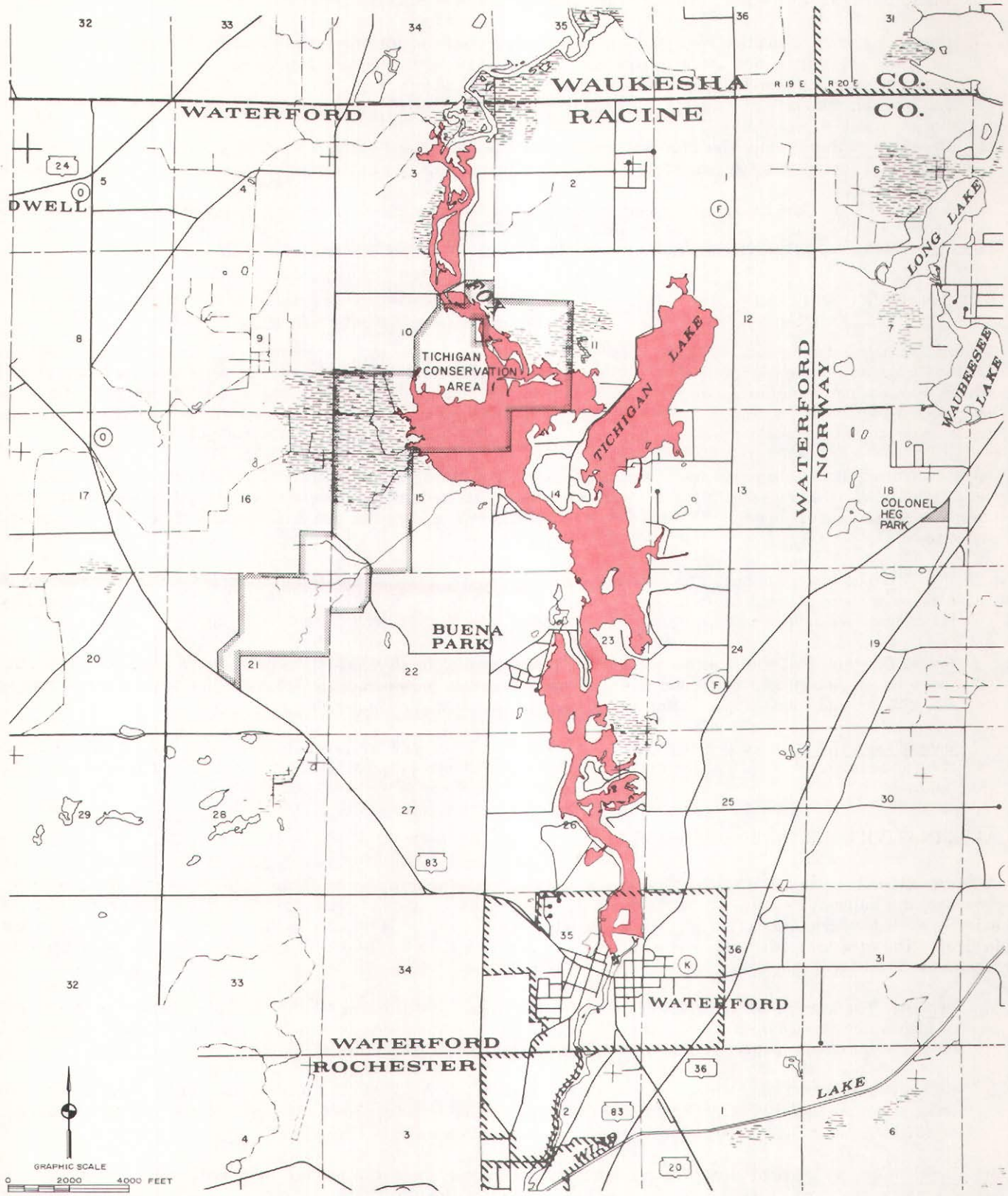
Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water damage upstream from the Waterford Dam is estimated to be $96,700. This benefit would be achieved by dredging 363 selected acres of the Waterford Impoundment one foot deeper.

Costs: The total cost of the proposed dredging is estimated to be $590,900, including engineering and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated average annual cost of $37,500. Annual operation and maintenance costs are estimated to be negligible.

Benefit-Cost Ratio: Since this proposal would reduce the average annual damage from $161,100 to $64,400, at an average annual cost of $101,928, the benefit-cost ratio of this proposal calculated at 6 percent interest would be 0.95-to-1.

Map 5

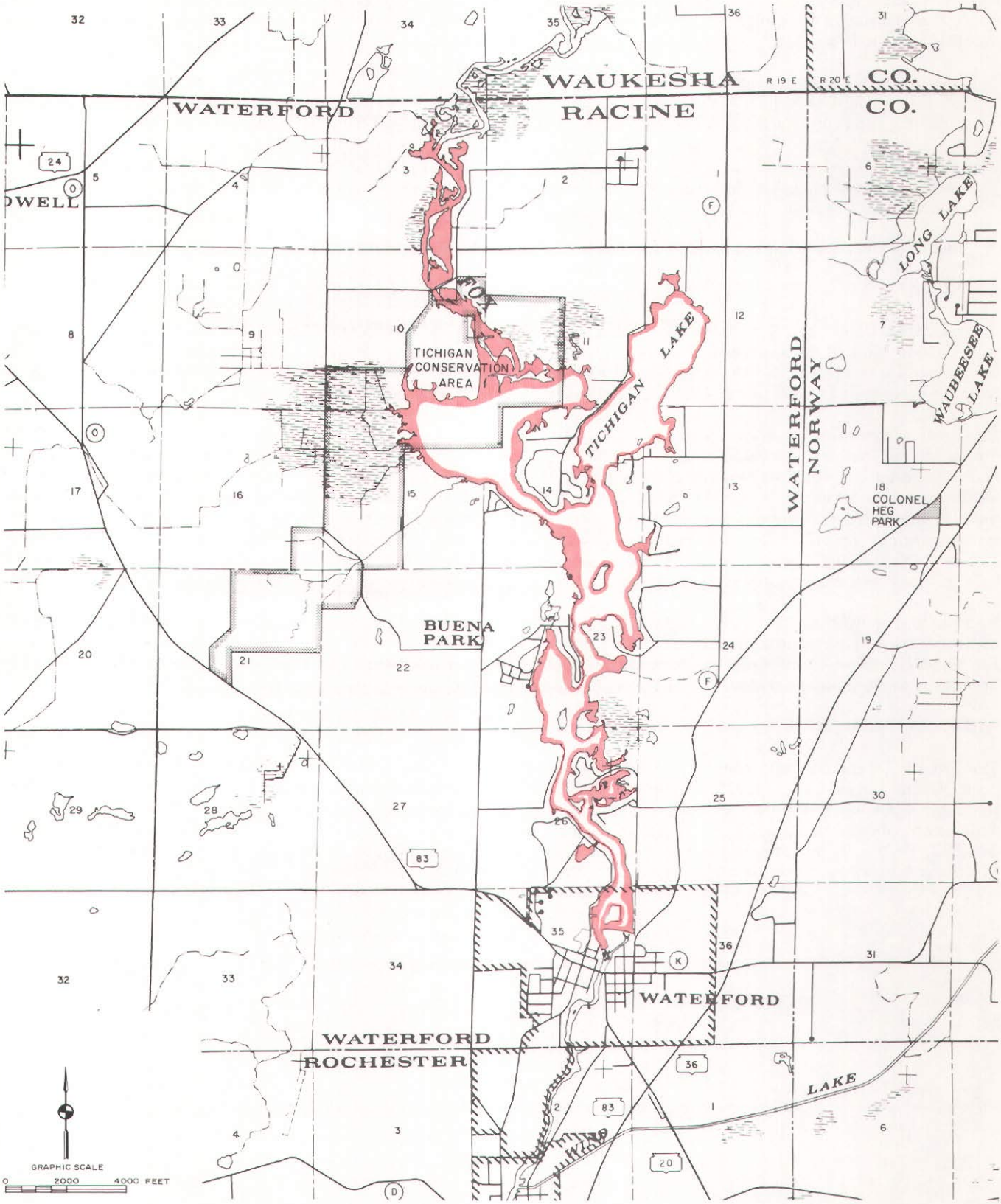
PROPOSED DREDGING OF THE ENTIRE WATERFORD IMPOUNDMENT–(±893 ACRES)




*Source: Technical Consultants and SEWRPC.*

Map 6

PROPOSED DREDGING OF A PORTION OF THE WATERFORD IMPOUNDMENT–(±363 ACRES)




*Source: Technical Consultants and SEWRPC.*

ALTERNATIVE F—CHANNEL DREDGING

A fifth alternative damage abatement measure would maintain the present water level in the Waterford Impoundment, but include selective dredging in areas with shallow bays and shallow areas (see Figure 4). The areas proposed to be dredged under this alternative are shown on Map 7, and generally lie in front of about 290 lakeshore lots. It is important to note that this alternative would do nothing to alleviate agricultural damages.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the deepening of existing shallow bays in the Waterford Impoundment is estimated to be $14,500. This benefit would be achieved by dredging about 50 selected acres in the Waterford Impoundment lying in front of about 290 lakeshore lots.

Costs: The total cost of the proposed dredging is estimated to be $80,600 including engineering and administrative services. Amortizing this cost at 6 percent interest over a 50-year period provides an estimated annual cost of $5,113. Annual operation and maintenance costs are estimated to be negligible.

Benefit-Cost Ratio: The benefit-cost ratio of this proposal calculated at 6 percent interest would be 2.83-to-1.

ALTERNATIVE G—LAKE LEVEL MANAGEMENT—MAJOR LAKES

An alternative flood control measure investigated in the original Fox River watershed study was the storage of floodwaters in 10 major lakes of the watershed. This proposal was reevaluated under this study as an alternative drainage and water level control measure. Of the 10 major lakes considered in the original watershed study, only three are located upstream from the Waterford Impoundment: Eagle Spring Lake, Pewaukee Lake, and Beulah Lake.

Under this alternative, the normal water levels in these lakes would either be lowered one foot prior to anticipated flood events, or the lake levels would be raised one foot above the normal water level during the flood events. In either case, controllable outlets would be required at the lakes. The primary concern of the agricultural interests is the control of water levels during the cropping season beginning in May, or past the time when snowmelt floods would occur. It is highly unlikely that lakeshore property owners in the upstream lakes would allow the water levels to be lowered one foot after spring snowmelt runoff has occurred. Raising the water levels in these lakes one foot above normal water level could result in damage to the shoreline improvements and to low-lying septic tank sewage disposal systems, and could also be expected to be resisted by the lakeshore property owners.

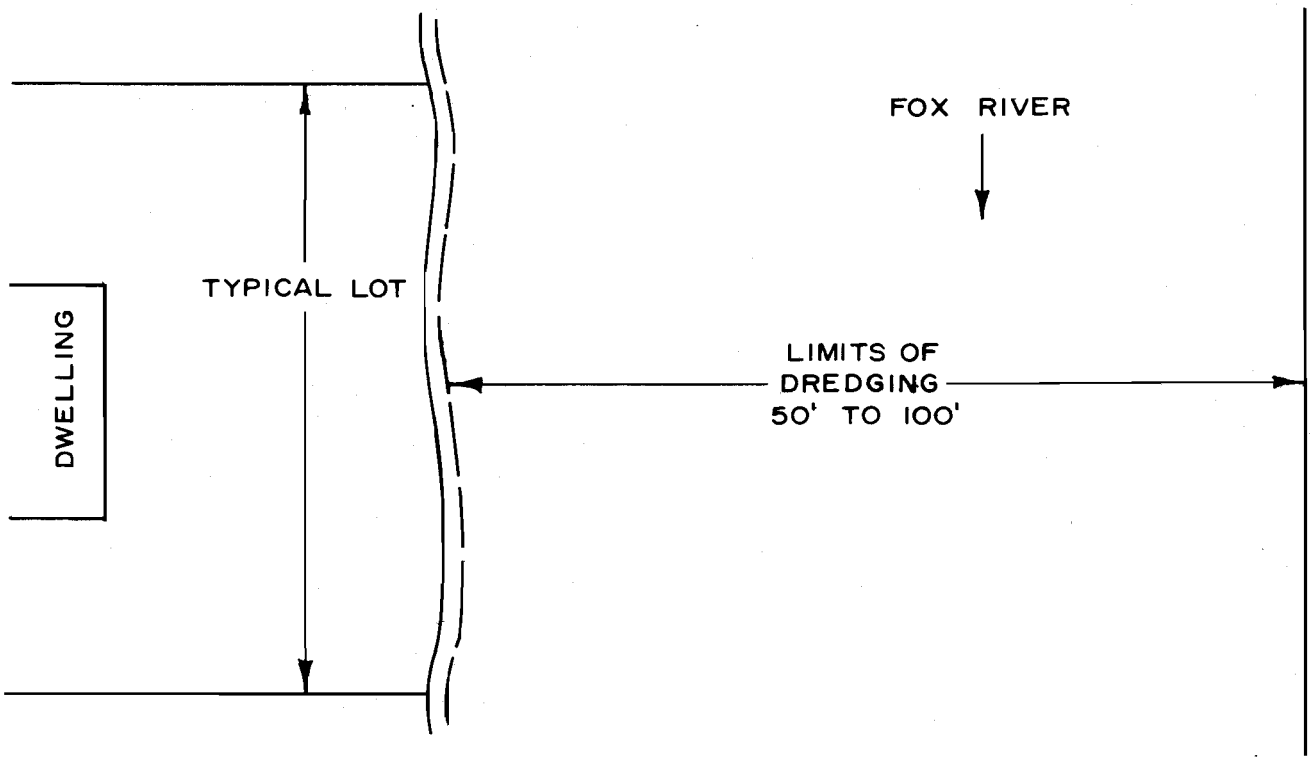
By installing controls in the outlets of these major lakes, however, the water levels in the main channel of the Fox River could be lowered by approximately 0.1 foot in the Waterford Impoundment and 0.4 foot in the reach upstream from Big Bend. Damages would only be reduced by about 10 percent, however. This alternative is not considered feasible because of the low benefit-cost ratio of 0.1-to 1, as indicated in Table 11.

ALTERNATIVE H—REMOVAL OF WATERFORD DAM

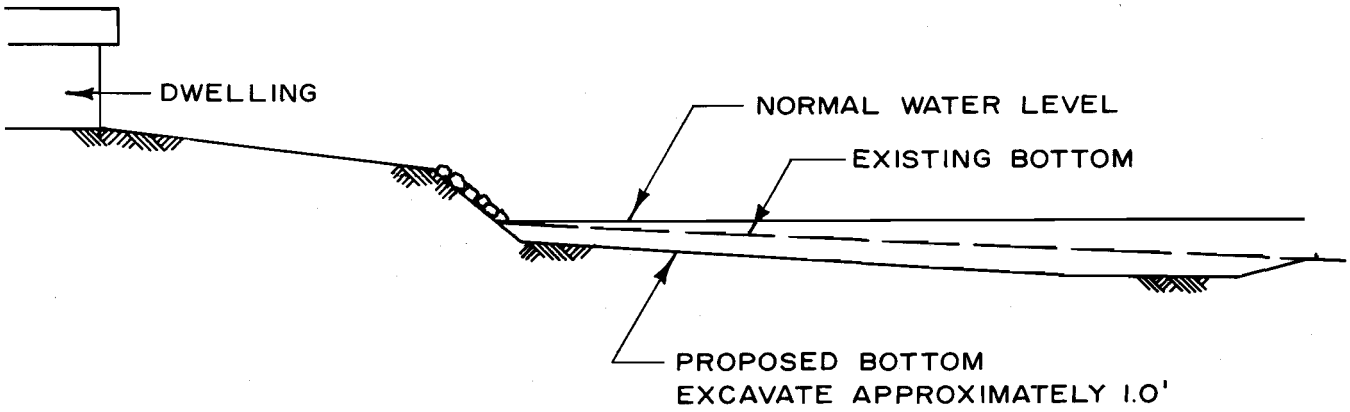
The seventh alternative flood control measure considered was the removal of the Waterford Dam. The costs for this proposal include the permanent loss in property value of lakeshore homes, recreational boating losses, and the cost of removing the dam. This total cost is estimated to approximate $202,755 annually. The benefits derived would be from protection of agricultural lands, totaling $128,882. Thus, the benefit-cost ratio would be 0.64-to-1, and the net annual costs would be $73,873. Therefore, this proposal is not economically feasible. In addition, this alternative does not consider the interests of the recreational users and riparian home owners along the Waterford Impoundment.

Figure 4

TYPICAL DREDGING OF THE WATERFORD IMPOUNDMENT




PLAN VIEW

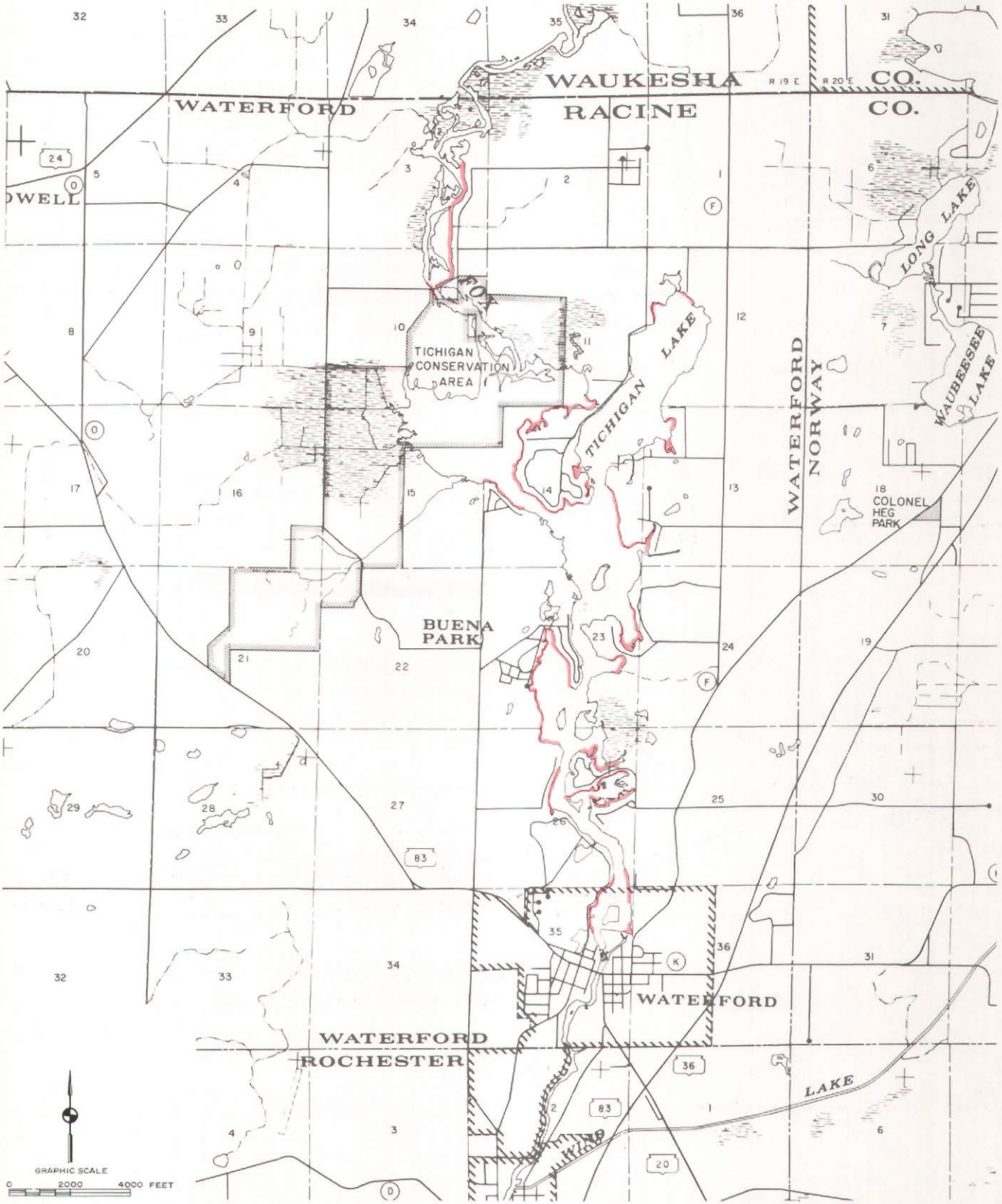



SECTION VIEW

*Source: Technical Consultants and SEWRPC.*

Map 7

PROPOSED DREDGING OF SELECTED SHALLOW AREAS OF THE WATERFORD IMPOUNDMENT–(±50 ACRES)




*Source: Technical Consultants and SEWRPC.*

## Chapter VII

# ALTERNATIVE DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN ELEMENTS WIND LAKE DRAINAGE CANAL

## INTRODUCTION

Many of the lakeshore property owners with recreational interests live along the main stem of the Fox River from the Rochester Dam upstream to Waterford. As in the case of the Waterford Dam area, this group is very concerned about maintaining water levels at an elevation which permits various boating and recreational uses. Water level records above the Rochester Dam indicate a considerable fluctuation in water levels throughout the year. This is caused by a large variance in the quantity of flow as well as by the manipulation of the Rochester Dam gates. An important objective of both the recreational and the agricultural interests is to establish more constant water levels that are mutually satisfactory to the greatest extent possible. To this end it would be possible to provide for the automatic operation of the gates in the Rochester Dam and for the coordinated operation of those gates with gates in the Waterford Dam, if such gates are installed.

## CHANNEL CLEANOUT

All of the various alternatives considered for the abatement of damages in the Wind Lake area would require maintenance of the required drainage system channel capacity through periodic channel cleaning operations. The channels were last cleaned in the period 1952 through 1954. It is estimated that this operation should be undertaken at least once every 25 years regardless of other actions.

The cost for a complete cleanout of seven miles of the main canal and 40 miles of lateral drainage channels is estimated at $179,500. The nonamortized annual cost would be $7,200. This cost has been added to each of the alternatives under operation and maintenance. However, Alternatives E and F call for excavation in an amount necessary for one complete cleanout. Therefore, over a period of 50 years only one additional cleanout would be required under these two proposals, at an annual cleanout cost of $3,600.

## ALTERNATIVE A—NO ACTION

Costs under the "no action" alternative would approximate the annual agricultural damages of $185,838. Accordingly, this alternative is not an economically sound course of action to pursue.

## ALTERNATIVE B—INSTALL GATES IN THE ROCHESTER DAM

One alternative damage abatement measure would entail the installation of two new 16' by 5' radial gates in the Rochester Dam, as shown in Figure 5. The Norway-Dover Drainage District is currently considering installing these gates in the dam, and the size of the gates selected for analysis under the study was based upon the gates being considered.

A design flood with a 10-year recurrence interval was selected for this portion of the study. The beginning water levels at the confluence of the Fox River and the canal are accordingly based upon the 10-year flood flow elevations on the main stem. With the existing and proposed two new gates open in the Rochester Dam, the water level at the confluence of the Wind Lake Canal could be drawn down to an elevation of 765.37 feet mean sea level datum, assuming a 10-year discharge of about 2,700 cfs. This would be 0.70 foot lower than the water level under existing conditions without the proposed gates.

There are two main causes of drainage problems in the Wind Lake area: the relatively low elevation of croplands to be drained in relation to the outlet elevations in the Fox River; and the limited capacity of the Wind Lake Canal.

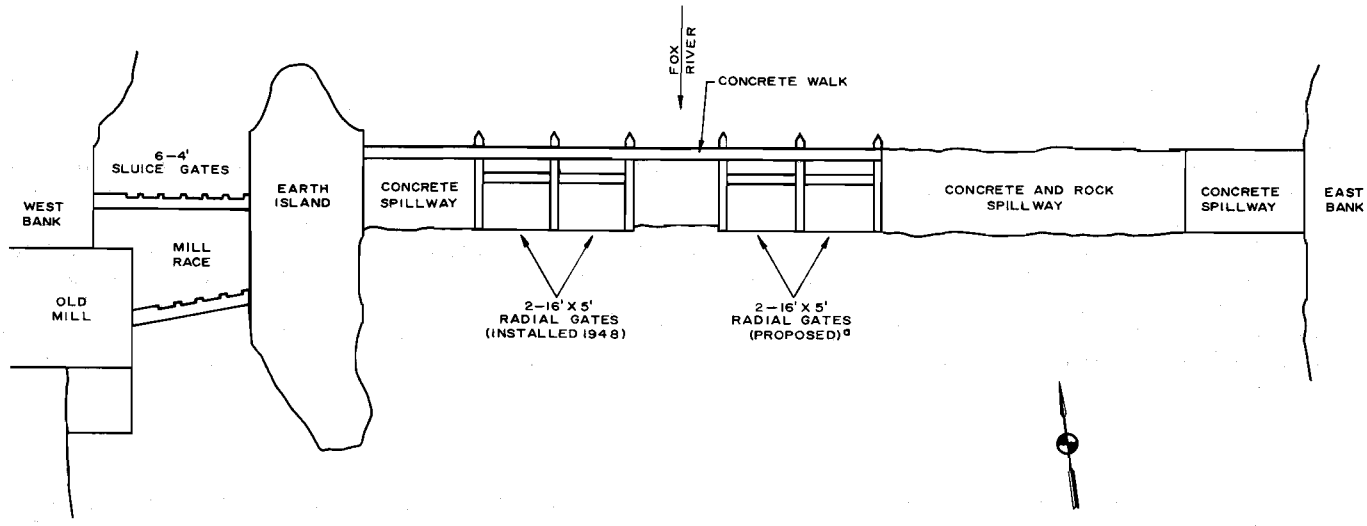
Considerable agricultural damage may be expected to occur unless both of these problems are alleviated. This alternative will remove only the first contributing cause by lowering the water level of the canal at its confluence with the Fox River.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water damage in the Wind Lake Canal area is estimated to be $111,500. This benefit would be achieved by rapidly lowering the normal water levels in the Norway-Dover Drainage District canals following high flows or a flood event.

Costs: The total installation cost of the proposed gate is estimated at $76,000, including construction, engineering, and administrative services. Amortizing this cost at 6 percent interest over a 50-year period provides an estimated average annual cost of $4,820. Annual operation and maintenance costs are estimated to be $7,800 (see Table 12).

Figure 5

PROPOSED INSTALLATION OF GATES AT THE ROCHESTER DAM




[a] NOTE: PROPOSED GATE INSTALLED 1975.

*Source: Technical Consultants and SEWRPC.*

Benefit-Cost Ratio: Since this proposal would reduce average annual damages from $185,800 to $74,300 at an average annual cost of $86,960, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 1.28-to-1.

## ALTERNATIVE C—ROCHESTER BYPASS CHANNEL

A second alternative drainage abatement measure investigated calls for the construction of a bypass channel that would reroute the Wind Lake Drainage Canal to a point downstream from the Rochester Dam. An earth dam would be placed in the existing outlet of the canal to prevent backwater from reaching the Wind Lake Canal. The proposed bypass channel would follow the route indicated on Map 8. The top width of the channel would vary from 94 to 122 feet, and the depth of the channel would vary from 16 to 32 feet. The total length of the bypass channel would be about 4,200 linear feet. At least two houses in the Village of Rochester would have to be relocated, and two bridges would have to be constructed over the channel in the Village of Rochester.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water levels in the Wind Lake Canal, Norway-Dover Drainage area is estimated to be $120,800. This benefit would be achieved by rapidly lowering the normal water levels in the area following high flows or a flood event.

Costs: The total installation cost of the proposed bypass channel is estimated at $540,300, including engineering and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated annual cost of $34,200. Annual operation and maintenance costs are estimated to be $7,200 (see Table 12).

Benefit-Cost Ratio: Since this proposal would reduce average annual damages from $185,800 to $65,000 at an annual average cost of $106,400, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 1.1-to-1.

## ALTERNATIVE D—WIND LAKE CANAL PUMPING STATION

A third alternative damage abatement measure investigated consists of the installation of a dam and pumping station in the Wind Lake Drainage Canal immediately upstream from the confluence with the Fox River. The pumps would be designed to handle a design discharge of 1,180 cfs. The pumps would operate only during periods of high flow in the Wind Lake Canal, high water levels on the main stem of the Fox River, or a combination of these two conditions. A number of suitable locations would be available for the construction of the station upstream from the Village of Rochester. During periods of normal or low flow, the gates in the Rochester Dam would be opened to allow gravity flow approximating existing conditions. The pumping station itself would consist of a series of high volume, low head pumps powered both by electric motors and standby internal combustion engines, control gates, and protective enclosures (see Figure 6).

Table 12

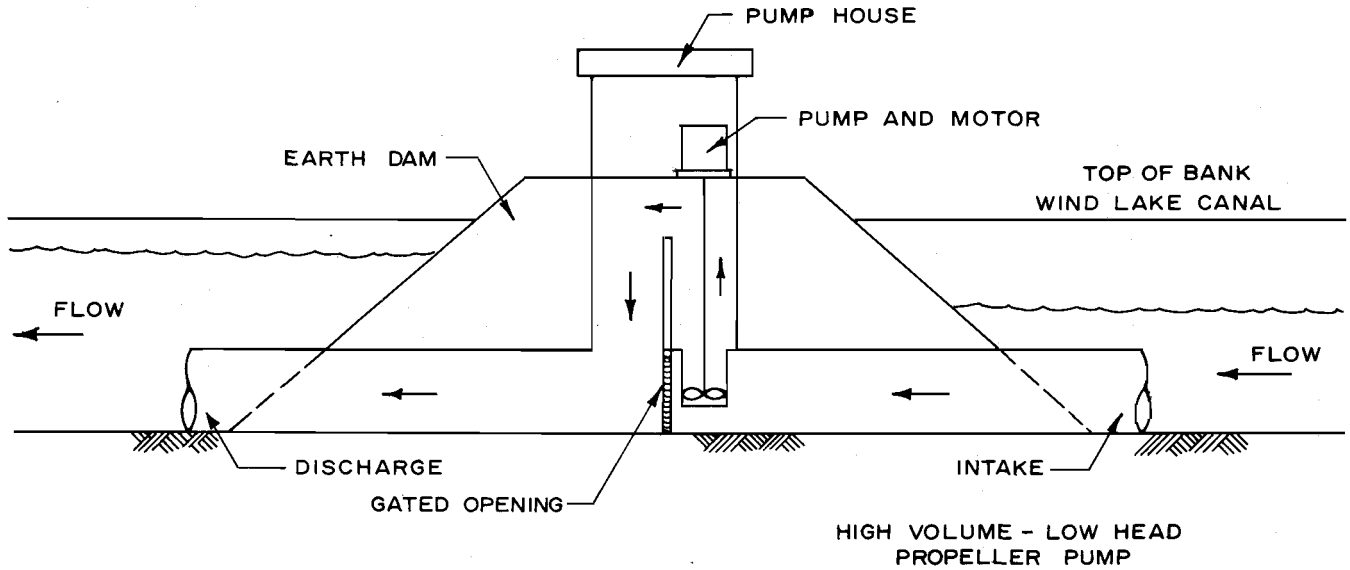
COST ESTIMATES FOR ALTERNATIVE DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN ELEMENTS FOR THE WIND LAKE DRAINAGE CANAL

| Drainage and Water Level Control Alternative | | Costs | | | | | | Benefits | | Benefit-Cost Analysis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Annual | | | | | | | | | |
| Letter Description | Name | Capital | Amortization | Operation and Maintenance | Other | Total | Present Worth | Annual | Present Worth | Annual Benefits Minus Annual Costs | Benefit-Cost Ratio | Economically Feasible |
| A | No Action | $ -- | $ -- | $7,200 | $185,838 | $193,038 | $3,042,665 | $ -- | $ -- | $-193,038 | -- | No |
| B | Install Gates in the Rochester Dam | 76,000 | 4,821 | 7,800 | 74,335 | 86,956 | 1,370,600 | 111,503 | 1,757,510 | 24,547 | 1.28:1 | Yes |
| C | Rochester Bypass Channel | 540,300 | 34,188 | 7,200 | 65,043 | 106,401 | 1,677,092 | 120,795 | 1,903,971 | 14,394 | 1.13:1 | Yes |
| D | Wind Lake Canal Pumping Station | 300,000 | 19,302 | 8,700 | 65,043 | 92,775 | 1,462,320 | 120,795 | 1,903,971 | 28,020 | 1.30:1 | Yes |
| E | Enlarging Canals | 1,109,900 | 70,412 | 3,600 | 18,584 | 92,596 | 1,459,498 | 167,254 | 2,636,257 | 74,698 | 1.81:1 | Yes |
| F | Construct Dikes Along Drainage Canals | 211,000 | 13,386 | 3,600 | 40,884 | 57,870 | 912,147 | 144,954 | 2,284,476 | 87,084 | 2.50:1 | Yes |
| G | Control Dam–Big Muskego Lake | 110,000 | 6,978 | 7,700 | 167,254 | 181,932 | 2,867,612 | 18,584 | 292,921 | -163,348 | 0.10:1 | No |
| H | Install Gates at Rochester Dam and Construct Dikes | 287,000 | 18,207 | 4,200 | 27,876 | 50,283 | 792,561 | 157,962 | 2,489,797 | 107,679 | 3:14:1 | Yes |

*Source: Technical Consultants and SEWRPC.*

Figure 6

SCHEMATIC CROSS SECTION OF PROPOSED WIND LAKE CANAL PUMPING STATION

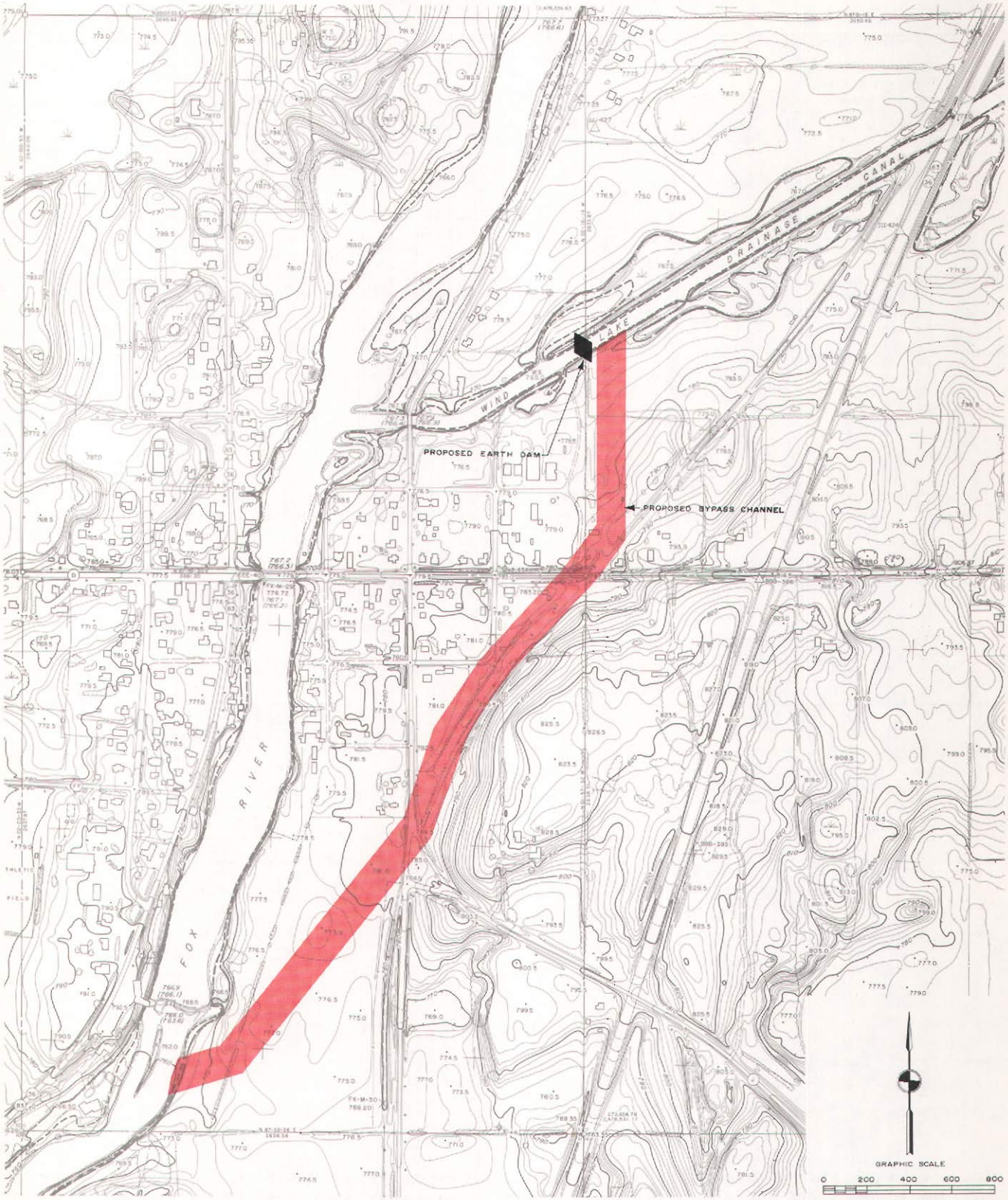



*Source: Technical Consultants and SEWRPC.*

This system would lower the level in the main drainage outlet during periods of high water on either the canal or the main stem. The drainage would still be controlled by the capacity of the existing channels and ditches. This alternative would provide approximately the same degree of protection as the bypass channel and new gates in the Rochester Dam.

Map 8

## LOCATION OF PROPOSED ROCHESTER BYPASS CHANNEL




*Source: Technical Consultants and SEWRPC.*

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water levels in the Wind Lake Canal area is estimated to be $120,800. This benefit would be achieved by rapidly lowering the normal water levels in this reach during and following high flows or a flood event.

Costs: The total cost of the proposed pumping facilities is estimated at $300,000, including engineering and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated annual cost of $19,000. Annual operation and maintenance costs are estimated to be $8,700 (see Table 12).

Benefit-Cost Ratio: Since this proposal would reduce average annual damages from $185,800 to $65,000 at an annual average cost of $92,800, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 1.3-to-1.

ALTERNATIVE E—ENLARGING CANALS

As previously noted, a major restriction to good drainage in the Wind Lake Canal area is the capacity of the channels themselves. This capacity is determined primarily by the slope and cross-sectional area of the channel. A fourth alternative damage abatement measure considered proposes enlarging both the Wind Lake Drainage Canal and the Goose Lake Branch Canal.

The Wind Lake Canal would be widened an average of about 30 feet. The Goose Lake Canal would be widened an average of approximately 13 feet. In addition, several bridges and a number of culverts would have to be enlarged. It would also be necessary to acquire additional land for the excavation.

This proposal would provide the highest degree of protection for agricultural lands. The costs of construction, however, are correspondingly high.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water levels for the Wind Lake Canal-Norway Dover area is estimated to be $167,200. This benefit would be achieved by providing for a rapid lowering of the water levels in this reach following high flows or a flood event.

Costs: The total installation cost of the proposed canal modifications is estimated at $1,110,000, including engineering and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated average annual cost of $70,400. Annual operation and maintenance costs are estimated to be $3,600 (see Table 12).

Benefit-Cost Ratio: Since this proposal would reduce average annual damages from $185,800 to $18,600 at an average annual cost of $92,596, the benefit-cost ratio of the proposal, calculated at 6 percent interest, would be 1.8-to-1.

ALTERNATIVE F—CONSTRUCT DIKES ALONG DRAINAGE CANALS

A fifth alternative damage abatement measure calls for the construction of earth dikes adjacent to all major drainage canals in the Wind Lake area. Dikes would be constructed to an elevation that would prevent overtopping during design flows. All water entering the canals from the low-lying areas would have to be pumped over the dikes.

A large percentage of the lowland areas are already protected by pumping stations located at the drainage outlets. However, about 900 acres of lowland adjacent to the Wind Lake Canal and the Goose Lake Canal presently rely on gravity drainage. These areas would have to be converted to pump systems or would continue to experience flooding damages. This proposal would benefit approximately 78 percent of the area in need of improved agricultural drainage. The total length of dike required would be 211,200 linear feet (see Map 9). Individual farmers would have to install any necessary additional pumping stations.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water damage in the Wind Lake Canal area is estimated to be $145,000. This benefit would be achieved by raising the dikes along the Norway-Dover Drainage District canals and by providing adequate pumping facilities to pump all land drainage over the dikes.

Costs: The total installation cost of the proposed diking is estimated at $211,000, including engineering and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated annual cost of $13,400. Annual operation and maintenance costs are estimated to be $3,600.[1]

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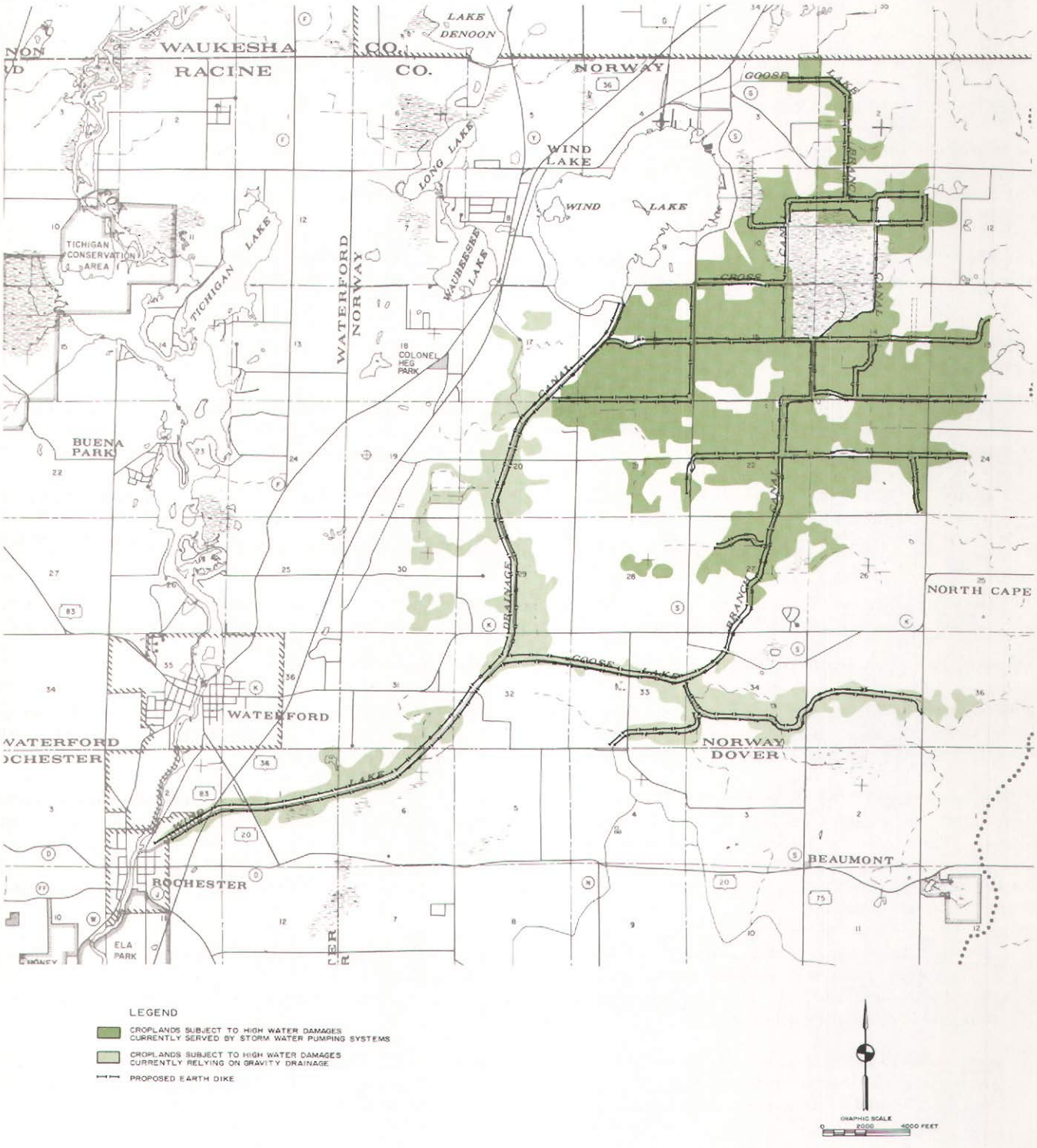
[1] *It is assumed that the cost of installing and operating the required pumping stations would be borne by the individual farmers; hence, no costs for such facilities have been included in these cost estimates.*

Map 9

## PROPOSED DIKE SYSTEM FOR THE WIND LAKE DRAINAGE CANAL AND GOOSE LAKE BRANCH CANAL




*Source: Technical Consultants and SEWRPC.*

Benefit-Cost Ratio: Since this proposal would reduce average annual damages from $185,800 to $40,900 at an annual average cost of $57,870, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 2.5-to-1.

ALTERNATIVE G—CONTROL DAM-BIG MUSKEGO LAKE

Big Muskego Lake is located immediately upstream from Wind Lake in the Wind Lake watershed. Due to its large size (2,270 acres), it has the potential for storing large quantities of surface runoff, thereby decreasing peak flows downstream. In 1970, the U. S. Soil Conservation Service made a study and flood-routing analysis using various size spillways in the Big Muskego Dam. This study concluded that water levels would be decreased only slightly in the Wind Lake Drainage Canal with the installation of a more restrictive control in Big Muskego Dam. Water levels were reduced by approximately 0.1 foot below the Wind Lake Dam for a 10-year recurrence interval flood discharge.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water damage in the Wind Lake Canal area is estimated to be $18,600. This benefit would be achieved by storing flood peaks or runoff temporarily in Big Muskego Lake, thus reducing high flows downstream in Wind Lake and the Wind Lake Canal.

Costs: The cost of the proposed gate installation is estimated at $110,000, including engineering and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated annual cost of $7,000. Annual operation and maintenance costs are estimated to be $7,700 (see Table 12).

Benefit-Cost Ratio: Since this proposal would only reduce average annual damages from $185,800 to $167,200 at an annual average cost of $181,932, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 0.1-to-1.

ALTERNATIVES B AND F COMBINED—INSTALL GATES AT ROCHESTER DAM AND CONSTRUCT DIKES

This proposal combines two alternatives previously considered—the installation of two 16' x 5' radial gates in the Rochester Dam plus the construction of dikes along the Wind Lake Drainage Canal, Goose Lake Branch Canal, and lateral ditches as necessary. Both measures would be carried out to the same extent as previously presented.

The diking would provide a relatively high degree of protection for all areas that are presently being pumped. As previously explained, the dike system alone would not provide drainage relief for the areas that rely on gravity drainage into the canals. Installation of new gates in the Rochester Dam would significantly benefit these areas and minimize the need for individual pumping stations.

Benefits: The average annual monetary benefit which could be attributed to this alternative through the reduction of high water damage in the Wind Lake Canal area is estimated to be $158,000. This benefit would be achieved by rapidly lowering the normal water levels in the Norway-Dover Drainage District canals following high flows or a flood event, and by raising the dikes along the Norway-Dover Drainage District canals, and by providing adequate pumping facilities to pump all land drainage over the dikes.

Costs: The total cost of the proposed diking and gate installation is estimated at $287,000, including engineering and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated average annual cost of $18,200. Annual operation and maintenance costs are estimated to be $4,200 (see Table 12).

Benefit-Cost Ratio: Since this proposal would reduce average annual damages from $185,000 to $28,000 at an average annual cost of $50,300, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 3.14-to-1.

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## Chapter VIII

## ALTERNATIVE DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN ELEMENTS MUSKEGO CANAL

### INTRODUCTION

An important factor contributing to agricultural damage in the Muskego Canal area was, until recently, the restrictive outlet in Wind Lake, causing water levels in the lake to remain high for prolonged periods of time. Two new radial gates were installed in the Wind Lake Dam in 1972, which more than doubled the hydraulic capacity of the former gates. A second important factor contributing to this damage is the restrictive capacity of the Muskego Canal itself, due to its limited cross-sectional area, flat slope, and flow obstructions in the channel.

### ALTERNATIVE A—NO ACTION

Costs under the "no action" alternative would approximate the annual agricultural damage in the Muskego Canal area of $24,000. Accordingly, this alternative is not an economically sound course of action to pursue.

### ALTERNATIVE B—CHANNEL ENLARGEMENT

The existing channel does not have capacity to pass the 10-year recurrence runoff without causing cropland damages. The channel is narrow, and a number of houses are built very close to the banks on both sides. One means of alleviating the problems would be channel enlargement. In order to enlarge the channel, it would be necessary to remove at least three houses from the west side of the channel. The channel could then be widened from its present top width of about 40 feet to a top width of 64 feet (see Map 10 and Figure 7). The channel capacity would in this way be increased from its present 317 cfs to 560 cfs.

Benefits: The average annual monetary benefit which could be attributed to this alternative is estimated at $19,200. This benefit would be achieved by providing greater capacity in the channel to pass the 10-year recurrence interval runoff, thus reducing although not entirely eliminating the estimated cropland damage.

Costs: The total installation cost of channel enlargement and house removal is estimated at $145,700, including construction, engineering, and administrative services. Amortizing these costs at 6 percent over a 50-year period provides an estimated average annual cost of $9,240. Annual operation and maintenance costs are estimated at $500 (see Table 13).

Benefit-Cost Ratio: Since this proposal would reduce the annual average damages from $24,000 to $4,800, at an average annual cost of $14,500, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 1.32-to-1.

### ALTERNATIVE C—DIKES AND PUMPING STATIONS

An alternative means of alleviating damages in the Muskego Canal area would be to construct earth dikes around all of the damaged croplands and install pumping stations to remove the excess water. The dikes and pumping stations would be similar to those shown in Figures 2 and 3, as described earlier for the Fox River main stem. Approximately 24,000 linear feet of earthen diking and seven pumping stations would be required to effect implementation of this alternative (see Map 11).

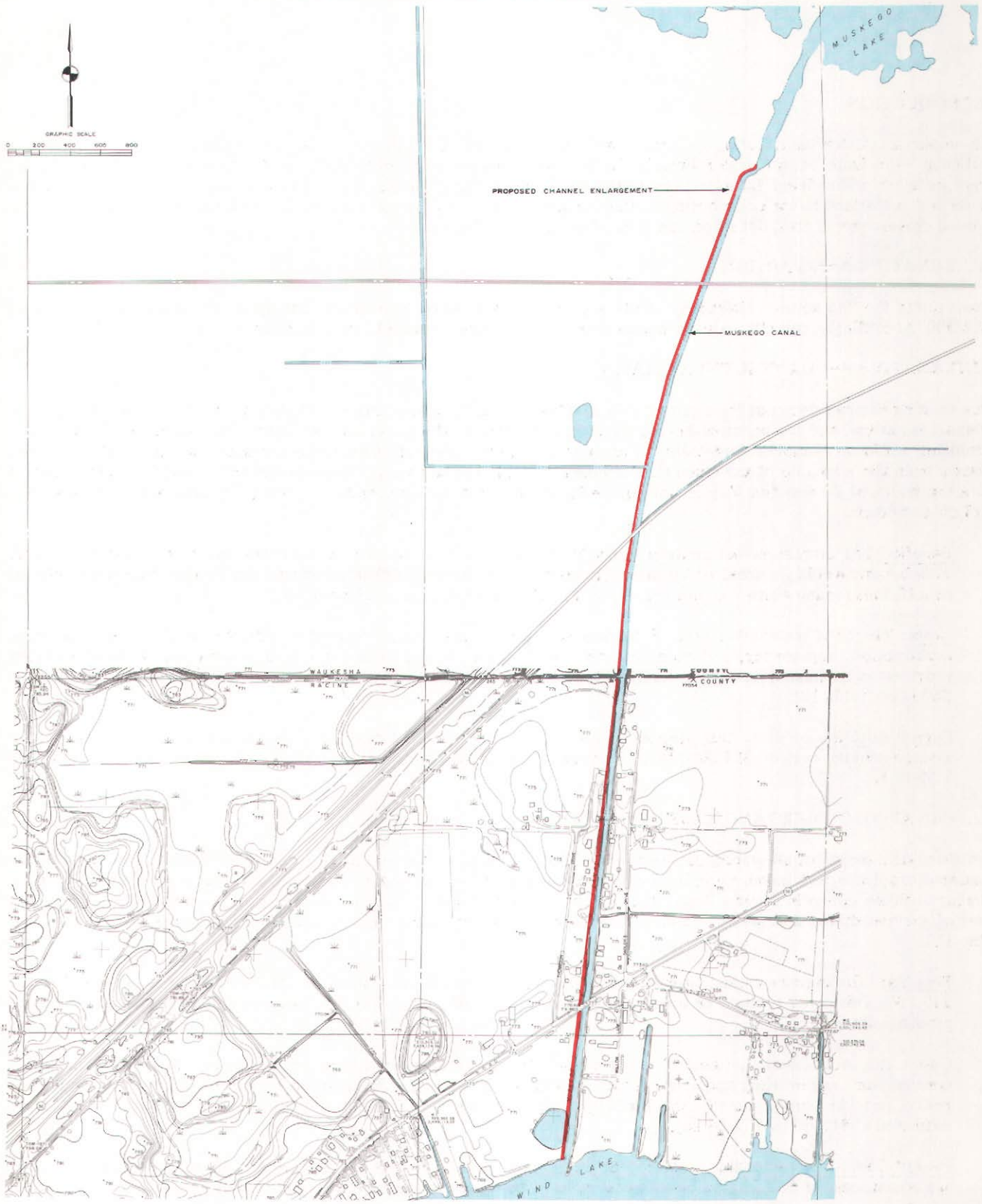
Benefits: The average annual monetary benefit which could be attributed to this alternative is estimated to be $19,200. This benefit would be achieved by providing the proposed system of dikes and pumping stations to reduce cropland damages.

Costs: The total installation cost of the proposed dike and pumping station system is estimated at $40,000, including construction, engineering, and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated annual average cost of about $2,540. Annual operation and maintenance costs are estimated at $1,150 (see Table 13).

Benefit-Cost Ratio: Since this proposal would reduce the annual average damages from $24,000 to $4,800, at an average annual cost of $8,500, the benefit cost ratio of the proposal calculated at 6 percent interest would be 2.26-to-1.

Map 10

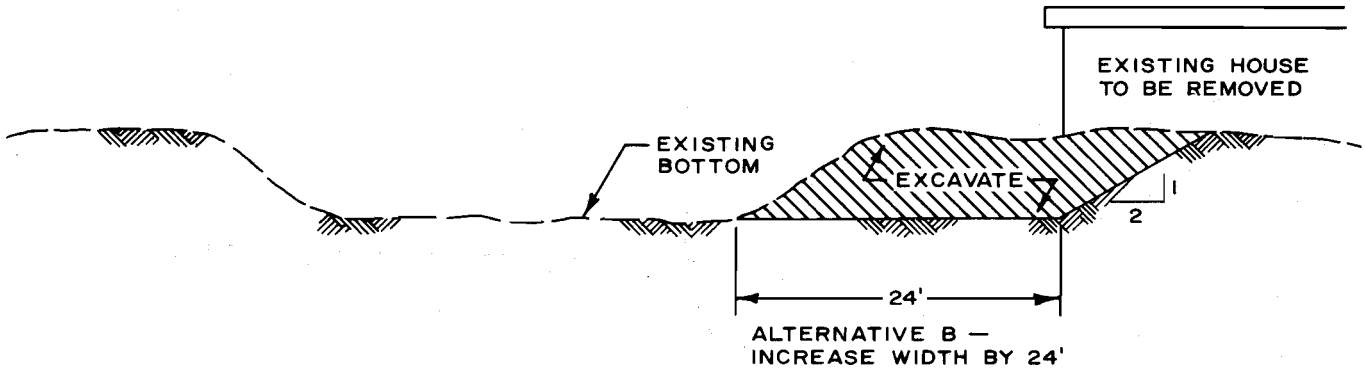
## PROPOSED ENLARGEMENT OF THE MUSKEGO CANAL




*Source: Technical Consultants and SEWRPC.*

Figure 7

TYPICAL CROSS SECTION OF THE PROPOSED MUSKEGO CANAL ENLARGEMENT




TYPICAL CROSS SECTION
LOOKING DOWNSTEAM

*Source: Technical Consultants and SEWRPC.*

Table 13

COST ESTIMATES FOR ALTERNATIVE DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN ELEMENTS FOR THE MUSKEGO CANAL

| Drainage and Water Level Control Alternative | | Costs | | | | | | Benefits | | Benefit-Cost Analysis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Annual | | | | | | | | | |
| Letter Description | Name | Capital | Amortization | Operation and Maintenance | Other | Total | Present Worth | Annual | Present Worth | Annual Benefits Minus Annual Costs | Benefit-Cost Ratio | Economically Feasible |
| A | No Action | $ -- | $ -- | $ -- | $24,000 | $24,000 | $ -- | $ -- | $ -- | $-24,000 | -- | No |
| B | Channel Enlargement | 145,700 | 9,243 | 500 | 4,800 | 14,543 | 229,700 | 19,200 | 302,630 | 4,657 | 1.32:1 | Yes |
| C | Dikes and Pumping Stations | 40,000 | 2,538 | 1,150 | 4,800 | 8,488 | 133,788 | 19,200 | 302,630 | 10,712 | 2.26:1 | Yes |
| D | Channel Cleanout and Deepening | 10,000 | 634 | 500 | 7,200 | 8,334 | 131,360 | 16,800 | 264,801 | 8,466 | 2.01:1 | Yes |
| E | Purchase Damaged Croplands | 402,000 | 25,503 | -- | -- | 25,503 | 402,000 | 24,000 | 378,288 | - 1,503 | 0.94:1 | No |

*Source: Technical Consultants and SEWRPC.*

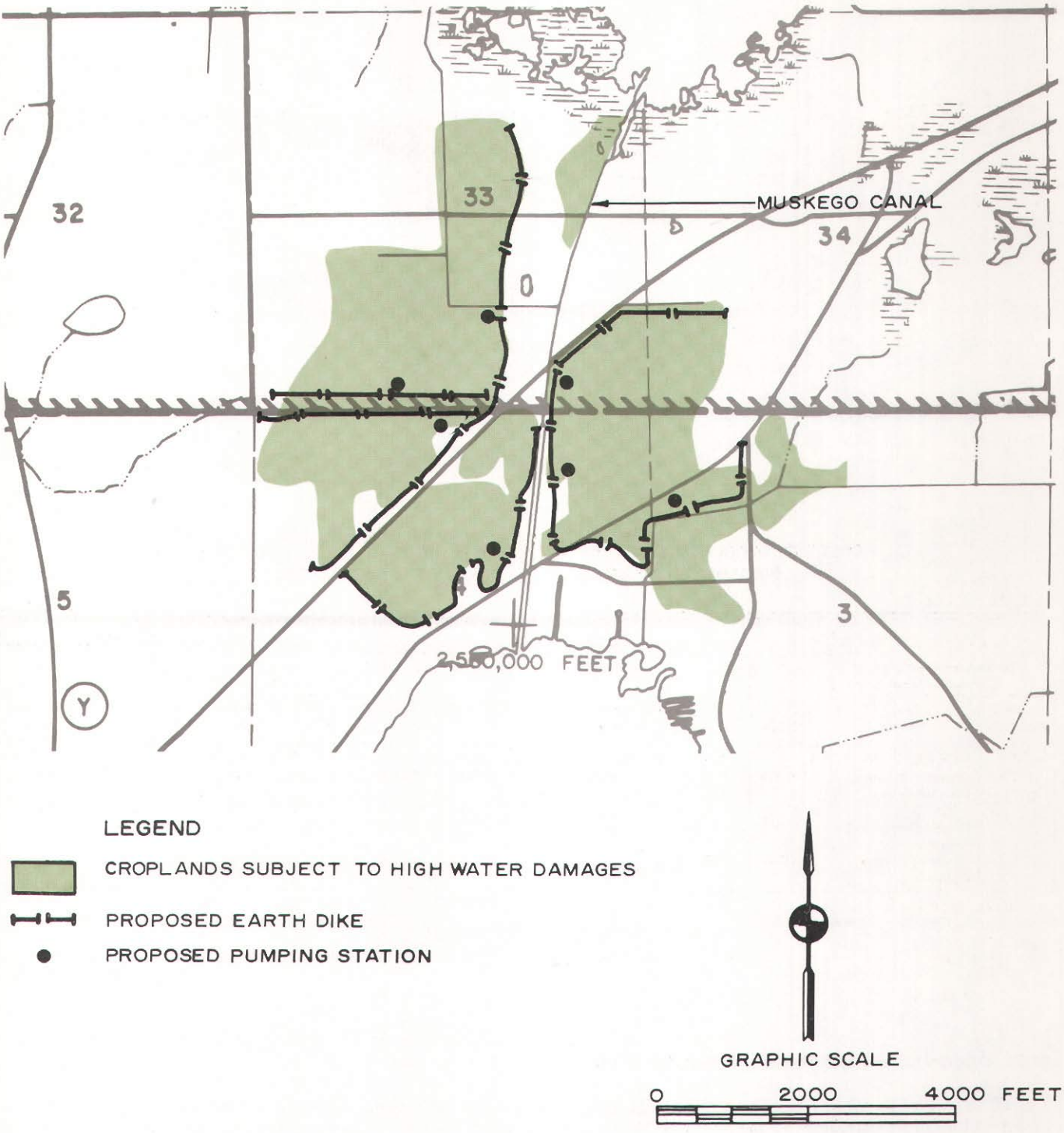
## ALTERNATIVE D—CHANNEL CLEANOUT AND DEEPENING

A third means of alleviating damage along the Muskego Canal would be to clean out and deepen the existing channel. This would not require alteration of the existing banks nor necessitate removal of houses. The channel would be cleared of debris and approximately three feet would be excavated from the bottom (see Figure 8). Spoil material would be spread and shaped into dikes along low areas of the banks. The channel capacity would be increased from its present 317 cfs to 477 cfs, providing protection against overbank flow for flows having a recurrence interval of up to 10 years.

Benefits: The average annual monetary benefit which could be attributed to this alternative is estimated at $16,800. This benefit would be achieved by clearing out and deepening the existing channel and thereby providing greater capacity to alleviate, although not entirely abate, flood damage to croplands.

Map 11

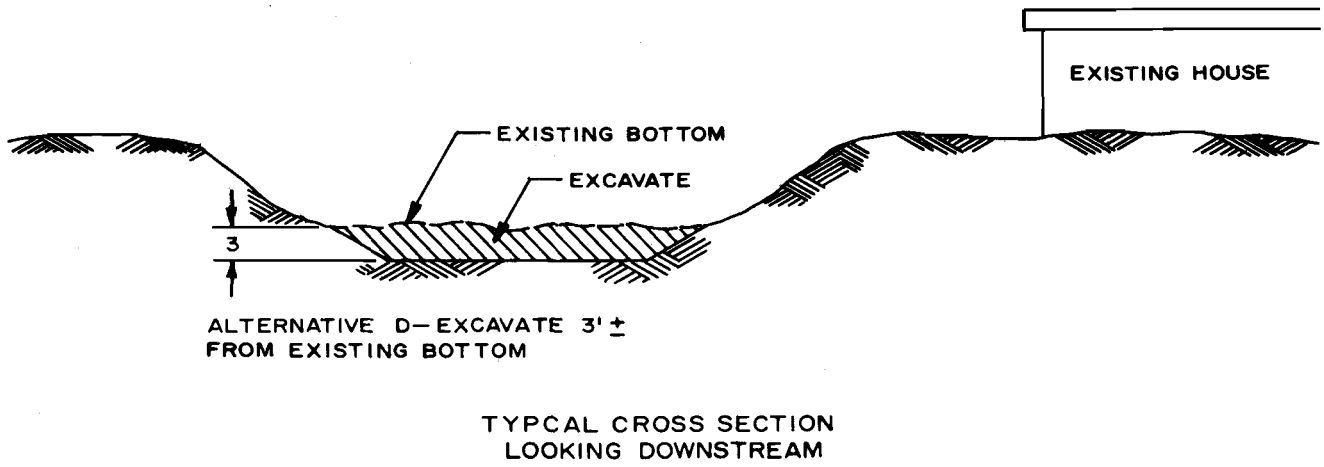
PROPOSED DIKE AND PUMPING STATION SYSTEM FOR THE MUSKEGO CANAL




*Source: Technical Consultants and SEWRPC.*

Figure 8

TYPICAL CROSS SECTION OF PROPOSED MUSKEGO CANAL EXCAVATION




*Source: Technical Consultants and SEWRPC.*

Costs: The total cost of the channel cleanout and deepening alternative is estimated at $10,000, including construction, engineering, and administrative services. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated annual cost of $630. Annual operation and maintenance costs are estimated at $500 (see Table 13).

Benefit-Cost Ratio: Since this proposal would reduce the annual average damages from $24,000 to $7,200 at an average annual cost of $8,334, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 2.01-to-1.

ALTERNATIVE E—PURCHASE DAMAGED CROPLANDS

A fourth means of alleviating flood damage to agricultural lands along the Muskego Canal would be to publicly purchase the damaged croplands and remove the lands from agricultural production. Under this alternative, all of the estimated 268 acres of damaged cropland would be acquired at an estimated cost of $1,500 per acre and the lands removed from crop production.

Benefits: The average annual monetary benefit which could be attributed to this alternative is estimated to be $24,000. This benefit would be achieved by removing the croplands from production and thus eliminating existing crop damages.

Costs: The total cost of acquiring the 268 acres of damaged cropland, at $1,500 per acre, is $402,000. Amortizing these costs at 6 percent interest over a 50-year period provides an estimated average annual cost of $25,503. Annual operation and maintenance costs are negligible (see Table 13).

Benefit-Cost Ratio: Since this proposal would reduce the average annual damages from $24,000 to $0.00 at an average annual cost of $25,503, the benefit-cost ratio of the proposal calculated at 6 percent interest would be 0.94-to-1. Hence, the proposal is not considered economically feasible.

It should also be noted that the foregoing alternative does not include the costs of acquiring other lands located adjacent to damaged croplands on farms. As a practical matter, individual farmers would be unlikely to sell only their damaged croplands, preferring instead to dispose of the entire farm. Thus, the true cost of the foregoing alternative would undoubtedly be higher than indicated, and thus even less feasible from an economic point of view. In addition, it should be noted that a positive benefit-cost ratio could be obtained with respect to this alternative if it could be assumed that the damaged croplands could be purchased for less than $1,500 per acre. For example, if it could be assumed that the damaged croplands could be purchased for an average cost of $1,200 per acre, this alternative would have a benefit-cost ratio of 1.18-to-1, indicating marginal economic feasibility.

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## Chapter IX

## RECOMMENDED DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN

### INTRODUCTION

The various alternative drainage and water level control management plan elements for the Lower Fox River main stem, the Wind Lake Drainage Canal, and the Muskego Canal, as described in the preceding three chapters of this report, were carefully considered by the special Subcommittee of the Fox River Watershed Committee at a meeting on March 13, 1975. Based upon that review, the Committee selected a recommended drainage and water level control management plan for presentation at a public hearing and for consideration thereafter by the Fox River Watershed Committee, the Regional Planning Commission, and the concerned local units of government and state agencies. The recommended plan consists of the following six major elements: 1) modifications to dams and the establishment of an integrated water level control system including the Waterford, Rochester, and Wind Lake Dams; 2) channel clearing and maintenance along the main stem of the Fox River in the Town of Vernon; 3) maintenance dredging in the Waterford Impoundment; 4) the construction of dikes along the Wind Lake Canal system; 5) the undertaking of channel clearing and maintenance activities along the Wind Lake Canal system; and 6) the undertaking of channel cleanout and deepening activities along the Muskego Canal. Each of these six major elements is discussed below and is shown in graphic summary form on Map 12. In addition, consideration is given to the downstream effects of the recommended drainage and water level control management plan elements and to the relationship of the recommended plan element along the main stem of the Fox River to the long-range comprehensive Fox River watershed plan.

### DAM MODIFICATION AND CONTROL

The dam modification and control element of the recommended plan is comprised of the following four subelements:

1. The installation of two 20' x 4' radial gates in the Waterford Dam to provide a means for water level control at that dam.

2. The establishment of a new crest elevation at the notch in the Waterford Dam at elevation 773.0 feet mean sea level datum. This will require filling 0.6' of the 30' x 1' notch recently cut into the dam.

3. The installation of two 16' x 5' radial gates in the Rochester Dam to provide a more adequate means for water level control at that dam.

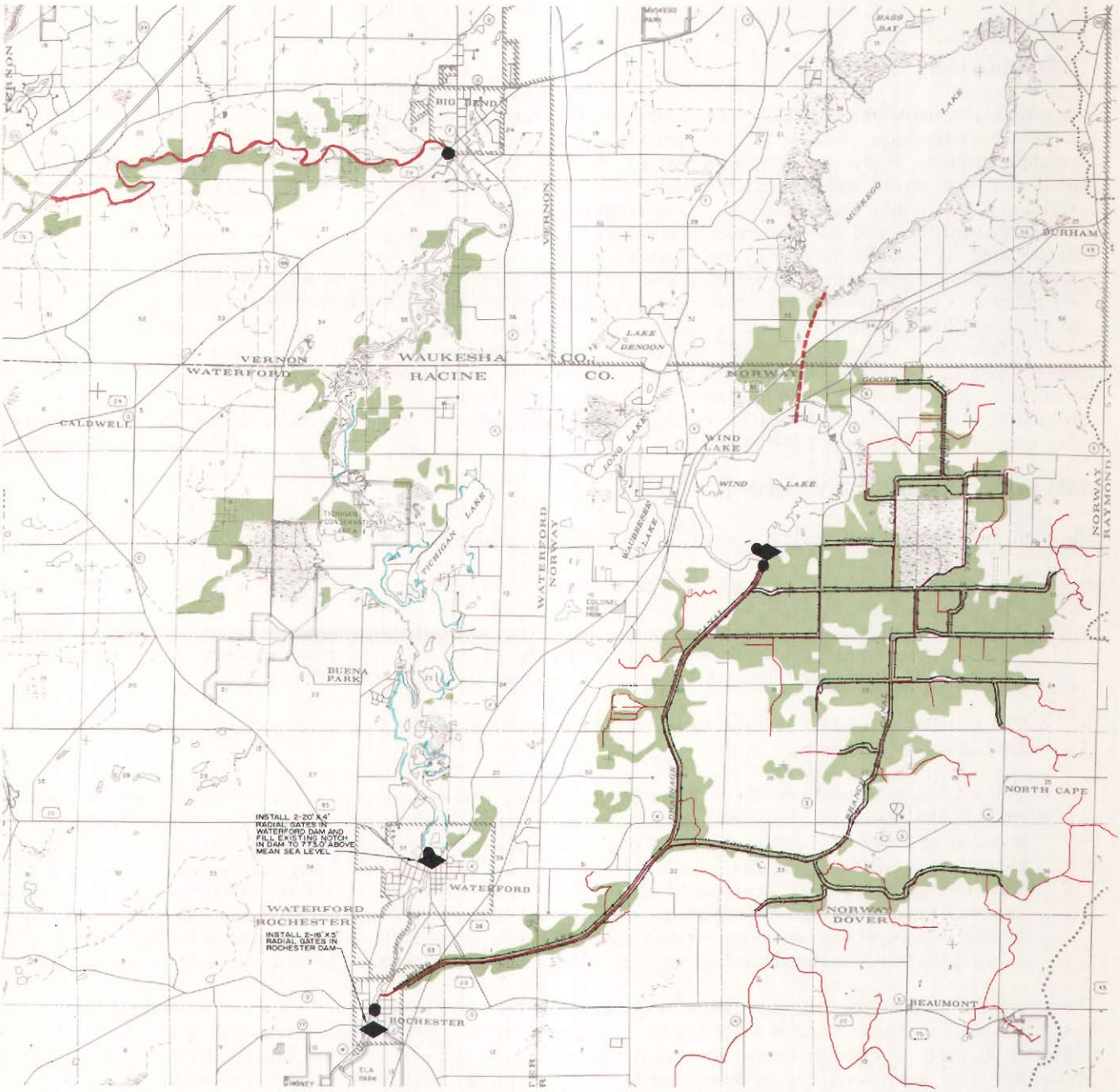
4. The establishment and operation of an integrated water level control system using remote sensors to operate the gates in the Waterford, Rochester, and Wind Lake Dams. It is recommended that five remote sensing devices be installed to provide for full management control of the affected river systems. These five sensing devices would be located at the STH 24 crossing of the Fox River in Big Bend; on the Waterford Impoundment just above the Waterford Dam; the CTH D crossing of the Fox River in Rochester; the Wind Lake Road crossing of the Wind Lake Drainage Canal in the Town of Norway; and on Wind Lake just above Wind Lake Dam. It is envisioned that the sensing devices would enable the establishment of a fully automated water level control system. However, in the event that the automatic control system would malfunction, all gates at all three dams could be operated manually.

The installation of the foregoing improvements would permit the water levels in the Lower Fox River main stem and Wind Lake Drainage Canal river systems to be returned rapidly to the desired control elevations shown in Table 14, thereby mitigating agricultural flood damages. The two proposed 20' x 4' radial gates in the Waterford Dam would be activated by the proposed water level sensing device located upstream in the vicinity of STH 24. The setting of the gates would be determined by the water levels at STH 24, with the gates beginning to open when the water level at STH 24 reaches 775.5 feet mean sea level datum. It is envisioned that the gates would close automatically when the water level in the Waterford Impoundment reached elevation 773.0 feet mean sea level datum, as monitored through a sensing device located in the Waterford Impoundment just above the dam. A normal water level would be established at the existing dam crest, elevation 773.0 feet mean sea level datum.

With the installation of the proposed new radial gates, the Rochester Dam would have four 16' x 5' radial gates plus five 4' hand operated shear gates. The operation of all four radial gates is proposed to be controlled by a sensing device located at CTH D. This device would trigger the opening of two of the gates when the Fox River reached elevation 765.5 feet mean sea level datum, and all four gates when the Fox River reached elevation 766.8 feet mean sea level datum. The operation of two of the radial gates would also be controlled by the sensing device proposed to be located on the Wind

Map 12

## RECOMMENDED DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN FOR THE WATERFORD-ROCHESTER-WIND LAKE AREA OF THE LOWER FOX RIVER WATERSHED




*Source: Technical Consultants and SEWRPC.*

Table 14

**RECOMMENDED WATER LEVEL CONTROL ELEVATIONS AND INITIAL TRIAL ELEVATIONS FOR REMOTE SENSING SYSTEM: WIND LAKE AND THE WATERFORD AND ROCHESTER IMPOUNDMENTS**

| Water Level Control Location | Dam Crest | | Desired Water Elevation[a] (feet/msl) |
|---|---|---|---|
| | Existing (feet/msl) | Proposed (feet/msl) | |
| STH 24 | -- | -- | 775.5 |
| Waterford Dam | 773.4[b] | 773.4[b] | 773.0 |
| Rochester Dam | 765.2 | 765.2 | 765.5 |
| Wind Lake Dam | 768.4 | 768.4 | 768.6 |

| Sensor Location | Initial Trial Elevation for Opening Dam Gates (feet/msl) | Initial Trial Elevation for Closing Dam Gates (feet/msl) |
|---|---|---|
| STH 24 | 775.5 | Not Applicable |
| Waterford Impoundment | Not Applicable | 773.0 |
| CTH D | 765.5[c] and 766.8[d] | 764.7 |
| Wind Lake | 768.6 | 767.9 |
| Wind Lake Road | 766.2[e] | Not Applicable |

[a] *Represents the optimum water level to accommodate agricultural drainage and recreational use.*

[b] *Existing 30' notch at elevation 772.4 feet mean sea level datum; proposed to be raised to elevation 773.0 feet mean sea level datum. It should be noted that on May 16, 1975 subsequent to the public hearing on this report, the Village of Waterford, acting pursuant to a Wisconsin Department of Natural Resources order, cut an additional 30' x 1' notch in the Waterford Dam.*

[c] *Sensor would trigger opening of two Rochester Dam gates.*

[d] *Sensor would trigger opening of all four Rochester Dam gates.*

[e] *Sensor would trigger opening of two Rochester Dam gates.*

*Source: Technical Consultants and SEWRPC.*

Lake Drainage Canal at Wind Lake Road. This device would trigger the opening of the two gates when the canal reached elevation 766.2 feet mean sea level datum. In addition, it is proposed that these latter two gates also be provided with an override switch which would allow manual opening of the gates in anticipation of high water in the canal. It is proposed that a minimum water level at Rochester be maintained at 0.5 feet below the existing crest of the dam, or at elevation 764.7 feet mean sea level datum.

It is further recommended that the operation of the Wind Lake Dam also be automated, with the control system being integrated into the operation of the Waterford and Rochester Dams. Water levels on Wind Lake are presently controlled by two 10' x 4' radial gates in the Wind Lake Dam. It is proposed that these gates be automatically operated by a sensing device located on Wind Lake above the dam. The gates would begin to open when the lake elevation reached 768.6 feet mean sea level datum, and would be closed when the lake elevation declined to 767.9 feet mean sea level datum.

It is anticipated that the setting and operation sequence of the sensing devices will initially require substantial trial and adjustment in order for their operation to most fully satisfy the various—and often conflicting—water interests of this portion of the watershed. Consequently, considerable patience will have to be exercised by all concerned during the trial adjustment period.

Analyses were performed under the study the determine the specific impact upon water levels on the main stem of the Fox River due to the installation and operation of the gates in the Waterford Dam as discussed above. These analyses indicated that water levels in the reach from Big Bend to the STH 15 Freeway crossing will be affected only slightly by the installation of the gates. Based upon an assumed discharge of about 224 cfs at the Waterford Dam, a flow approximating normal or low flow levels, the installation of the two proposed 20' x 4' radial gates in the dam may be expected to reduce the water levels upstream by the following amounts: Tichigan Drive, 3.0'; STH 24, 0.8'; Center Drive, 0.3'; and STH 15, 0.1'.

For a discharge of 1,122 cfs at the Waterford Dam, representing a flood flow having an approximate recurrence interval of four to five years, the two 20' x 4' radial gates in the dam may be expected to reduce the water levels upstream by the following amounts: Tichigan Drive, 1.2'; STH 24, 0.1'; Center Drive, 0.0'; and STH 15, 0.0'.

The computer backwater analyses, however, indicated that even though water levels in this reach of the Fox River will not be significantly affected by the gates in the Waterford Dam, the amount of time necessary to remove the excess water will be significantly reduced. The time now required to pass 224 cfs through the entire reach from the Waterford Dam to STH 15 is presently 92 hours. The installation and proper operation of the proposed gates in the Waterford Dam will permit this time to be reduced to 53 hours. Similarly, the time required to pass 1,122 cfs in this reach of the Fox River would be reduced from 32 hours to 27 hours. Thus, the major benefit of the proposed gates in the Waterford Dam would be the removal of excess water more quickly, with attendant more rapid drawdowns of high upstream water levels.

The total estimated capital cost of carrying out this recommended plan element is $168,500. The estimated annual operation and maintenance cost is $1,300 (see Table 15).

CHANNEL CLEARING AND MAINTENANCE—TOWN OF VERNON

While the foregoing recommendation to install gates at the Waterford Dam will significantly affect the duration of major flooding along the main stem of the Fox River from Waterford upstream to Big Bend, it is further recommended that

Table 15

COST ESTIMATES FOR RECOMMENDED DRAINAGE AND WATER LEVEL CONTROL MANAGEMENT PLAN FOR THE BIG BEND TO WATERFORD REACH OF THE LOWER FOX RIVER, THE WIND LAKE DRAINAGE CANAL SYSTEM, AND THE MUSKEGO CANAL

| Drainage and Water Level Control Management Plan Element | Capital Cost | Annual Operation and Maintenance Cost |
|---|---|---|
| Dam Modification and Control | $168,500 | $1,300 |
| Channel Clearing and Maintenance—Town of Vernon | 10,000 | 1,000 |
| Maintenance Dredging in the Waterford Impoundment | 80,600 | -- |
| Construction of Dikes Along the Wind Lake Canal System | 211,000 | 3,600 |
| Canal Clearing and Maintenance—Wind Lake Canal System | 180,000 | 3,600 |
| Canal Cleanout and Deepening—Muskego Canal | 10,000 | 500 |
| Total | $660,100 | $10,000 |

*Source: Technical Consultants and SEWRPC.*

routine channel clearing and maintenance activities be undertaken along the main stem of the Fox River from Big Bend to the STH 15 Freeway. The limited cross section area and slope of the stream channel in this reach place considerable restriction on the streamflow. To minimize this restriction, it is recommended that this reach be kept free of debris and floating material that might cause further flow restriction, and that steps be taken to provide for meander and erosion control through bank stabilization and the excavation of shoals or sediment deposits.

The total capital cost of carrying out this recommended plan element is estimated at $10,000. The estimated annual operation and maintenance cost is $1,000 (see Table 15).

MAINTENANCE DREDGING IN THE WATERFORD IMPOUNDMENT

It is recommended that a maintenance dredging program be undertaken on a selective basis in the Waterford Impoundment. This program would include selective dredging in shallow bays and other areas as identified on Map 7. In total, about 50 acres of the Impoundment should be provided with this maintenance dredging. This plan recommendation is directed specifically at maintaining the recreational values of the Impoundment.

The total estimated capital cost of carrying out this recommended plan element is $80,600. The estimated annual operation and maintenance cost is negligible (see Table 15).

CONSTRUCTION OF DIKES ALONG THE WIND LAKE CANAL SYSTEM

It is recommended that a system of dikes be constructed along the Wind Lake Canal system, including the Wind Lake Drainage Canal, the Goose Lake Branch Canal, and other unnamed tributary canals, and that individual farmers provide the necessary pumping stations to provide for storm water drainage. The total length of dike required will be 211,000 linear feet (see Map 9). The total number of pumping stations will be about 40. The large areas of organic soils located along the canal system may be expected to subside through further cultivation and drainage and through the removal of soil from sod farming. Thus, the need for the proposed diking and pumping station system will become more necessary in the future.

It should be noted that the proposed diking system is intended to provide protection to about 3,340 of the 4,270 acres of cropland subject to damage along the Wind Lake and tributary canal system. The remaining approximately 920 acres, as shown on Map 9, would, as at present, rely on gravity drainage. The installation of the gates in the Rochester Dam as proposed above would give a greater capability to provide gravity drainage for this acreage.

The total capital cost of carrying out this recommended plan element is estimated at $211,000. The estimated annual operation and maintenance cost is $3,600 (see Table 15).

CANAL CLEARING AND MAINTENANCE—WIND LAKE CANAL SYSTEM

In addition to the foregoing recommendation to construct a system of dikes and pumping stations along the canals in the Wind Lake Drainage Canal system, it is further recommended that periodic channel cleaning operations be undertaken throughout the entire Wind Lake Drainage Canal system. The channels were last cleaned in the early 1950s. It is recommended that a complete channel cleanout operation be undertaken at least once every 20 to 25 years.

The total capital cost of carrying out this recommended plan element is estimated at $180,000. The estimated annual operation and maintenance cost is $3,600 (see Table 15).

### CANAL CLEANOUT AND DEEPENING—MUSKEGO CANAL

It is recommended that steps be taken to clean out and deepen the existing channel of the Muskego Canal. The channel would be cleared of debris and approximately three feet would be excavated from the bottom. The increased channel capacity would provide protection against overbank flooding from flows having a recurrence interval of up to 10 years, and would greatly alleviate, although not entirely eliminate, flood damage to croplands.

The total capital cost of carrying out this recommended plan element is estimated at $10,000. The estimated annual operation and maintenance cost is $500 (see Table 15).

### COST SUMMARY

The total estimated capital cost of carrying out the foregoing recommended plan for drainage and water level control management in the Lower Fox River watershed is $660,100. The estimated annual operation and maintenance cost is $10,000 (see Table 15). Possible sources of funding to carry out the recommended plan are discussed in the following chapter of this report.

## DOWNSTREAM EFFECTS OF THE RECOMMENDED SOLUTIONS

Whenever works of improvement are proposed in a waterway or drainage system, it is essential that the downstream effects be analyzed. The following discussion presents the results of that analysis with respect to the recommended solutions to drainage problems along the main stem of the Fox River, the Wind Lake Drainage Canal, and the Muskego Canal.

The purpose of the proposed improvements in the Fox River is to provide drainage relief to agricultural lands during normal to moderate water levels. No attempt was made to provide flood relief for flood events of the 10-year to 100-year recurrence intervals. The proposed gates in the Waterford and Rochester Dams would, in effect, be water-level control gates, and thus would remove the water more quickly after the larger discharges had passed the damaged areas, with very little effect on major flood peaks. Therefore, the downstream areas would neither receive benefits or damages from these proposals.

One of the concerns expressed by the downstream property owners was the manner in which the Rochester gates were operated. At times, when the gates were opened very rapidly a "standing wave" of water would be released downstream causing erosive effects on the river banks. The proposed solutions call for automated controls to regulate the Rochester Dam. The controls would be set to open or close the gates gradually, thereby causing the water levels downstream to rise at a reasonable rate so as not to cause such wave damages.

## RELATIONSHIP OF FOX RIVER MAIN STEM RECOMMENDED DRAINAGE PLAN ELEMENT TO COMPREHENSIVE FOX RIVER WATERSHED PLAN

It is important to recognize that the comprehensive plan for the Fox River watershed recommended that the natural floodlands of the Fox River along the main stem be purchased by the counties and local units of government concerned for environmental corridor preservation and outdoor recreation purposes. The main stem primary environmental corridor does contain lands which are currently being cropped, in addition to many scattered wetlands and unused parcels. In terms of plan implementation staging, however, the Fox River watershed plan recommended that public monies that might be available in the early years of the plan implementation period be concentrated in purchasing natural floodlands located in and adjacent to urban areas, with rural floodland and corridor lands to be acquired during the later stages of plan implementation. Accordingly, it is reasonable to assume that if the plan implementation recommendations are followed, it will be at least 15 and perhaps 20 years before the natural floodlands along the main stem of the Fox River, including the damaged croplands identified on Maps 1 and 2, are publicly acquired for permanent corridor preservation purposes.

Since the damaged croplands to be protected through the installation of the gates in the Waterford Dam are largely included in the main stem primary environmental corridor along the Fox River, expenditure of public monies for dam control systems at Waterford might appear inconsistent with the long-range plan recommendation of public acquisition of lands in question. Because it is unlikely that public acquisition of these rural environmental corridor lands will begin much before 1990, however, it may be assumed that the dam control facilities proposed to be installed at Waterford will result in damage abatement to croplands for a period of at least 15 years. The benefit-cost ratio relating to the operation of the Waterford Dam control system over the next 15 years is over 2 to 1, and any public monies expended for the installation of water level control gates in the Waterford Dam would represent a sound investment. Accordingly, it may be concluded that the recommended water level control system is not inconsistent with the long-term objectives and recommendations of the comprehensive Fox River watershed plan.

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## Chapter X

## INSTITUTIONAL STRUCTURE FOR PLAN IMPLEMENTATION

### INTRODUCTION

The foregoing section of this report set forth the recommended solutions to the high water and drainage problems along the main stem of the Fox River upstream of the Waterford Dam, along the Wind Lake Drainage Canal, and along the Muskego Canal. Briefly stated, these recommendations are as follows:

1. Modifications to the Waterford and Rochester Dams and the establishment of an integrated water level control system including the Waterford, Rochester, and Wind Lake Dams, and utilizing remote sensors.

2. Channel clearing and maintenance activities with respect to that reach of the main stem of the Fox River from the Village of Big Bend to the STH 15 Freeway.

3. Maintenance dredging in specified areas of the Waterford Impoundment.

4. The installation of dikes along the Wind Lake Canal and Goose Lake Branch Canal.

5. General clearing and maintenance operations along the tributary canal system within the existing Norway-Dover Drainage District.

6. Canal cleanout and deepening along the Muskego Canal.

The foregoing drainage and water level control plan recommendations involve lands located within two counties, one city, two villages, and four towns. In addition, the drainage and water level control problems of the Lower Fox River, the Wind Lake Drainage Canal, and the Muskego Canal affect a multiplicity of private interests. It is essential, therefore, that the potential means of implementing the plan recommendations be identified, and a single best plan implementation strategy selected. Many sound plan recommendations are never carried out because the means of implementing the plans are not identified or are not well adapted to the available institutional arrangements. Accordingly, the following discussion identifies the available means for implementing the proposed plan recommendations, together with a recommendation for the best plan implementation strategy.

Six major alternative institutional structures are available for implementing all or portions of the plan recommendations:

1. The creation of a Lower Fox River Flood Control Board, as permitted under Chapter 87 of the Wisconsin Statutes.

2. The creation of a cooperative contract drainage and flood control commission, as authorized under Section 66.30 of the Wisconsin Statutes.

3. The expansion of the Norway-Dover Drainage District to include all of the lands affected, or the creation of a new areawide drainage district.

4. The expansion of the function of the Western Racine County Sewerage District to include storm water drainage, as permitted under Section 66.24 of the Wisconsin Statutes.

5. The formation of an inland lake protection and rehabilitation district, as authorized under Chapter 301 of the Wisconsin Laws of 1973.

6. The utilization of existing general-purpose units of government.

### CREATION OF A LOWER FOX RIVER FLOOD CONTROL BOARD

Chapter 87 of the Wisconsin Statutes makes provision for property owners living in a single drainage area, including drainage areas which involve more than a single municipal governmental unit, to petition the Wisconsin Department of Natural Resources for the formation of a flood control board for the sole purpose of effecting flood control measures. Such measures may include the straightening, widening, deepening, and altering of watercourses, ponds, lakes, and creeks, and the construction and maintenance of ditches, canals, levees, dikes, dams, and reservoirs. The Department of Natural Resources must determine the need for the creation of the board and the engineering feasibility of the proposed flood control projects.

A flood control board created under Chapter 87 of the Wisconsin Statutes becomes a special-purpose unit of government with the power to raise money by levying a special assessment against the benefited property owners. As an alternative to special assessment funding, the board can finance flood control projects in whole or in part by funds provided under agreements and contracts with local municipalities.

The principal advantage of creating a flood control board would be that it would have full power and authority to directly implement all six of the previously stated plan recommendations for solutions to the high water and drainage problems along the Fox River and Wind Lake Drainage Canal. It has the further advantage of providing alternative methods of financing, including total assessment of all costs against the benefited property owners; total reliance for funds upon the benefited cities, villages, and counties; or some combination of funding arrangement that would in part assess the implementation costs against the benefited property owners and in part rely upon the funds provided by the affected general-purpose local units of government. Perhaps the greatest disadvantage in this method is that it involves the creation of another single-purpose local unit of government with a geographic jurisdiction and powers overlapping that of the existing general-purpose local units of government.

### CREATION OF A COOPERATIVE CONTRACT DRAINAGE AND FLOOD CONTROL COMMISSION

Section 66.30 of the Wisconsin Statutes provides that local units of government may contract with each other to form cooperative service commissions for the joint provision of any services or the joint exercise of any powers that such local units of government may be authorized to exercise separately. Such commissions may be given bonding powers for the purposes of acquiring, developing, and equipping land, buildings, and facilities for areawide projects. It would appear that such a commission could be created to handle all of the six specified recommended solutions to the high water and drainage problems of the Fox River, the Wind Lake Drainage Canal, and the Muskego Canal.

To be successful, such a commission should be cooperatively created by all of the general-purpose local units of government that have jurisdiction over the geographic area to be served by the commission. In this case, the creation of such a commission would have to be approved at least by the City of Muskego, the Villages of Rochester and Waterford, and the Towns of Rochester, Waterford, Norway, and Vernon. Desirably, Racine and Waukesha Counties would also be parties to the creation of the joint commission. The contract creating such a commission would specify all of the powers and duties of the commission. Such commissions are fiscally dependent upon the general-purpose local units of government which created the commission. Formulas would have to be provided to determine the distribution of costs to each participating local unit of government for services rendered.

This approach has the advantage of relying heavily upon the existing general-purpose local units of government acting in a cooperative, voluntary manner, and therefore avoids the need to create a single-purpose special unit of government. It has the disadvantage, however, of needing the full cooperation of all of the involved local units of government. Should one local unit of government decide not to cooperate, it renders this approach virtually useless.

### EXPANSION OF THE NORWAY-DOVER DRAINAGE DISTRICT OR CREATION OF A NEW AREAWIDE DRAINAGE DISTRICT

It would be possible under the provisions of Chapter 88 of the Wisconsin Statutes to expand the jurisdictional area of the Norway-Dover Drainage District to include all of the lands affected by the six specific plan recommendations. Such a drainage district would have the power to own and operate all of the facilities necessary to carry out the plan recommendations. Variations of this alternative course of action would be to create one or more additional drainage districts in the Towns of Waterford and Vernon, or a single new areawide drainage district to carry out the plan recommendations. It should be pointed out in this respect that any new drainage districts created must come under the jurisdiction of the county drainage boards. In any case, under this alternative the costs of any drainage improvements must be assessed against the lands that are specifically benefited.

The drainage district approach to plan implementation has the advantage of being highly applicable to the specific recommended solutions to high water and drainage problems. This approach has the disadvantage, however, of not being directly applicable to those recommendations relating to maintenance dredging in the Waterford Impoundment and to the areawide system of dam control envisioned in the plan recommendations. In addition, this approach has the disadvantage of trying to bring together under the drainage laws the conflicting interests evident in this portion of the watershed with respect to agriculture and recreation.

### EXPANSION OF THE FUNCTION OF THE WESTERN RACINE COUNTY SEWERAGE DISTRICT

Already active in the general area under consideration is the special-purpose areawide unit of government known as the Western Racine County Sewerage District. This District serves the Villages of Waterford and Rochester and a portion of the Town of Rochester. In addition, it has been proposed that the District serve, by contract, a portion of the Town of Waterford. While the Western Racine County Sewerage District was formed for the specific purpose of providing areawide

sanitary sewage conveyance and treatment, the state enabling legislation does permit a metropolitan sewerage district to also undertake storm water drainage improvements. It is likely, therefore, that the Western Racine County Sewerage District could be expanded to include additional area both in Racine and Waukesha Counties, and that it could take on the function of storm water drainage and carry out all of the specified plan recommendations set forth above.

This approach has the advantage of utilizing an already existing areawide governmental mechanism. By the same token, this approach has the disadvantage of utilizing a governmental mechanism serving an urban community whose interests with respect to this study relate to recreation, and taking that governmental unit and making it also serve a conflicting community of interest, namely the rural agricultural interest.

### FORMATION OF AN INLAND LAKE PROTECTION AND REHABILITATION DISTRICT

Chapter 301 of the Wisconsin Laws of 1973 established a mechanism for the creation of a single-purpose governmental unit known as an inland lake protection and rehabilitation district. Such districts may be formed with respect to any inland lake, reservoir, or flowage by a county board upon petition of 51 percent of the owners of land in the proposed district, or persons owning 51 percent of the land in the proposed district. Cities and villages may be included within such a district upon approval of their governing body. The creation of such a district would have applicability in this study only with respect to implementation of that plan recommendation dealing with maintenance dredging in specified areas of the Waterford Impoundment. If such a district were to be formed in Racine County to include all lands abutting the Waterford Impoundment, it would be possible for that district to carry out not only the recommended maintenance dredging activities, but any additional lake protection-oriented activities such as weed cutting and harvesting.

### UTILIZATION OF EXISTING GENERAL-PURPOSE UNITS OF GOVERNMENT

It would be possible to carry out many of the plan recommendations through greater utilization of the powers of the existing general-purpose local units of government. It would be possible, for example, for Racine and Waukesha Counties to execute a cooperative agreement to simply carry out the plan recommendation with respect to the installation of automatically controlled gates at the Waterford and Rochester Dams. Since the physical activities would be located largely in Racine County, it would be conceivable that such an interagency agreement would provide for financial participation from both counties based upon benefits received and for assignment of implementing responsibility to Racine County, including utilization of Racine County's existing staff for any needed maintenance activities along its existing canal system, and with respect to the installation of dikes and pumping stations along the Wind Lake Canal and Goose Lake Branch Canal. In addition, the Town and Village of Waterford could cooperatively agree to carry out the recommendation relating to maintenance dredging in the Waterford Impoundment. Finally, the Town of Vernon could be assigned responsibility for carrying out the minor channel clearing and maintenance activities with respect to that reach of the Fox River from the Village of Big Bend to the STH 15 Freeway.

The approach of utilizing to the maximum extent possible the existing units of government in plan implementation has the advantage of not creating another layer of local government with overlapping responsibilities and areas of jurisdiction. Furthermore, this approach takes maximum advantage of local government staff capabilities. By the same token, however, reliance upon individual actions by general-purpose local units of government does not automatically assure that all of the plan recommendations will be carried out in a fully coordinated manner, if at all.

### RECOMMENDED PLAN IMPLEMENTATION STRATEGY

Based upon the foregoing discussion, it is recommended that the plan recommendations with respect to solution of the high water and drainage problems along the main stem of the Fox River upstream of the Waterford Dam and along the Wind Lake Drainage Canal be implemented through the following specific strategy:

1. With respect to the plan recommendation to install automatically controlled radial gates at the Waterford, Rochester, and Wind Lake Dams, it is recommended that the Racine and Waukesha County Boards of Supervisors execute a cooperative agreement whereby Racine would be responsible for the purchase of the three dams, the installation of the automatically conrolled gates at the Waterford Dam and the installation of a remote sensing system and automatic controls for all three dams, and the continued operation and maintenance of the dam system. It is further recommended that such agreement provide for cost sharing on the basis of estimated agricultural lands damaged along the Fox River main stem located in the two counties, with Waukesha County cost-sharing only with respect to those improvements that would benefit damaged croplands in the Town of Vernon. It is envisioned, in this respect, that the Racine County Board would assign operational staff for the dam control system from its Highway and Parks Committee, and thereby take full advantage of the existing County Highway and Parks staff in implementation of this critical plan recommendation. Waukesha County's responsibility would be limited to financial participation in the manner noted above, and to assistance in securing any necessary approvals for the location of the remote sensing device in the Town of Vernon.

It is further recommended that the transfer of the ownership of the dams from the local units of government concerned to Racine County be effected through a contractual agreement entered into by Racine County and the local units of government pursuant to Section 66.30 of the Wisconsin Statutes. This agreement, to be negotiated between the parties concerned, should clearly stipulate that the dam system is to be operated to achieve the water level control elevations agreed upon by the local units of government affected through the cooperative intergovernmental planning process documented in this report. These elevations are set forth in Table 14. The dam system should be operated to achieve these elevations under all streamflow conditions up to and including 10-year recurrence interval floodflows. The agreement should clearly stipulate that these water level control elevations can be changed only by mutual agreement among all of the local units of government concerned through the same planning process followed in their original development as documented herein.

The interagency agreement should further provide for the creation of an operating board to be responsible for supervising and directing the operation of the dam system on behalf of the county. It is recommended that this board consist of three members, one appointed by the Village of Rochester, one appointed by the Norway-Dover Drainage District, and one appointed by the Racine County Soil and Water Conservation District. The county employee or employees assigned responsibility for the day-to-day operation of the dam system should be made responsible to this operating board with respect to operation of the dam system.

2. With respect to that plan recommendation relating to channel clearing and maintenance activities along the main stem of the Fox River from the Village of Big Bend to the STH 15 Freeway, it is recommended that a drainage district be created in the Town of Vernon and given specific responsibility for the bank stabilization and stream channel excavation activities.

3. With respect to that plan recommendation related to maintenance dredging of the Waterford Impoundment, it is recommended that the Village and Town of Waterford and the lakeshore residents affected cooperatively act to seek the creation of an inland lake protection and rehabilitation district to carry out all specified maintenance dredging activities, as well as any other necessary water pollution control activities.

4. With respect to those plan recommendations relating to the installation of dikes and pumping stations along the Wind Lake Canal and the Goose Lake Branch Canal and to general clearance and maintenance operations along the tributary canal systems, it is recommended that these activities remain the exclusive responsibility of the Norway-Dover Drainage District.

5. With respect to that plan recommendation related to channel cleanout and deepening of the Muskego Canal, it is recommended that the land affected be included in the Norway-Dover Drainage District and that that District assume responsibility for all channel deepening and maintenance operations.

The foregoing recommended approach to plan implementation is founded in the basic assumption that areawide problems should, if at all possible, be solved by the existing local units of government acting in a cooperative manner, and that, accordingly, special-purpose units of government should only be created when it is clear that the local units of government either cannot act, or are unwilling to act in a timely manner. It is believed that there exists sufficient community interest in the drainage and water control problems in this portion of the Fox River watershed so that the existing local units of government will act in a timely and responsive manner to carry out the plan recommendations. To assist the local units of government in this important matter, it is further recommended that the Fox River Watershed Subcommittee continue to exist in order to monitor plan implementation activities and to provide guidance and advice as necessary to ensure that all of these important plan recommendations are fully carried out.

## POSSIBLE SOURCES OF FUNDING

In carrying out the recommended drainage and water level control management plan for the Lower Fox River watershed, the concerned local units of government should be aware of possible sources of financial aid, particularly from state and federal agencies of government. Accordingly, the following discussion is intended to alert the affected units of government to such aid sources, as well as to indicate local funding sources.

### Local Units of Government

The involved local units of government, primarily Racine and Waukesha Counties, the Villages of Rochester and Waterford, and the Towns of Vernon, Waterford, Rochester, and Norway, have the power to utilize revenue raised through the local property tax to carry out all or portions of the recommended plan. This funding source would be particularly appropriate for the recommendation to acquire the Waterford, Rochester, and Wind Lake Dams at the county level; to install new gates at the Waterford and Rochester Dams; and to establish and operate a water level control system utilizing remote sensing devices. This plan recommendation has particularly wide applicability, affecting not only agricultural interests but also urban interests, particularly those located directly on the banks of the Fox River, the Waterford Impoundment, and

Tichigan Lake. In addition to utilizing revenues raised through the property tax, these local units of government could elect to use the general revenue sharing funds made available to them by the federal government. In fact, part of the purpose of establishing the federal revenue sharing program was to replace specific categorical grant programs with an approach that had few if any strings attached.

Drainage Districts

The drainage districts involved in this portion of the watershed could elect to carry out certain improvements recommended in the plan through the special assessment procedure authorized by the state enabling legislation. This source of funding would be appropriate with respect to the channel clearing and maintenance activities recommended for the main stem of the Fox River in the Town of Vernon and along the Wind Lake Canal and tributary canal system. This approach would also be appropriate for funding the recommended installation of dikes and pumping stations along the Wind Lake Canal and the Goose Lake Branch Canal, and could also be applied to the recommended canal cleanout and deepening project along the Muskego Canal.

Lake Rehabilitation District

As noted above, recently enacted legislation enables the creation of an inland lake protection and rehabilitation district. Should such a district be formed in Racine County to include all lands abutting the Waterford Impoundment, it would be possible for that district to carry out the plan recommendation for maintenance dredging, and in so doing, secure state aid from the Wisconsin Department of Natural Resources pursuant to Chapter NR 60 of the Wisconsin Administrative Code. Dredging is a specific lake rehabilitation activity eligible for funding under this program. State aids up to 100 percent of project costs are available under this program.

Wisconsin Rural Environmental and Conservation Program

Under this program, the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service (ASCS), is permitted to assist farmers in carrying out approved conservation practices. It is possible that those plan elements specifically relating to agricultural drainage, including any channel cleaning and maintenance activities and perhaps including the installation of dikes and pumping stations, would be eligible for cost sharing under this program. Approved practices are determined annually by county level committees advising the ASCS. The cost sharing formula varies from project to project, ranging from 50 to 75 percent federal participation.

Resource Conservation and Development Program

All of the elements included in the recommended drainage and water level control management plan for the Lower Fox River watershed would be eligible for up to 100 percent federal funding under the Resource Conservation and Development Program conducted by the U. S. Department of Agriculture, Soil Conservation Service. In cooperation with the seven county Soil Conservation Districts, the Regional Planning Commission has developed an application for the establishment of a seven-county areawide resource conservation and development program for southeastern Wisconsin. This application is currently pending at the federal level, competing with many other applications for similar projects throughout the country. Decisions as to which of the many competing applications are to be funded are made by the U. S. Secretary of Agriculture. Accordingly, a concerted effort should be made by all parties concerned to secure the necessary Congressional support for the proposed program, and thereby put the application in a better competitive position when decisions are made by the Secretary.

LAWCON and ORAP Funding

Because of the recreational benefits associated with the water level control management plan for the Lower Fox River watershed, it may be possible for Racine County to secure both federal LAWCON (Land and Water Conservation Fund Act) and state ORAP (Outdoor Recreation Aid Program) funds to purchase, modify, and operate the three dams involved. Any application for such funds to the Wisconsin Department of Natural Resources would have to demonstrate the desirability of county ownership and operation of the three dams for outdoor recreation purposes, and perhaps include procedures to obtain additional public access to the water bodies involved.

Community Development Block Grants

Under a recently established special revenue sharing program, the U. S. Department of Housing and Urban Development annually has monies available to fund a wide variety of community development projects. The plan recommendation directed at Racine County to acquire, modify, and operate the three dams involved may be eligible for funding, at least in part, from this source. It should be noted, however, that these funds are quite limited and most likely will be spent for projects more directly related to the provision of housing. Nevertheless, it is an avenue of funding which could be explored.

Concluding Remark

The foregoing brief description of available funding sources to implement the recommended drainage and water level control management plan for the Lower Fox River watershed is set forth solely to indicate several possible sources of state and federal aids. Upon adoption of the recommended plan by the concerned local units of government, and upon securing the necessary intergovernmental agreements to carry out the plan recommendations, it is suggested that the local officials involved pursue each of the foregoing alternative sources of financial aid—and perhaps others—by discussing the proposed plan recommendations with the appropriate state and federal officials involved.

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# APPENDICES

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## Appendix A

## CONTROL ELEVATIONS AND SELECTED WATER SURFACE PROFILES

### Figure A-1

### CONTROL ELEVATIONS AND SELECTED WATER SURFACE PROFILES FOR THE BIG BEND-TO-ROCHESTER REACH OF THE LOWER FOX RIVER

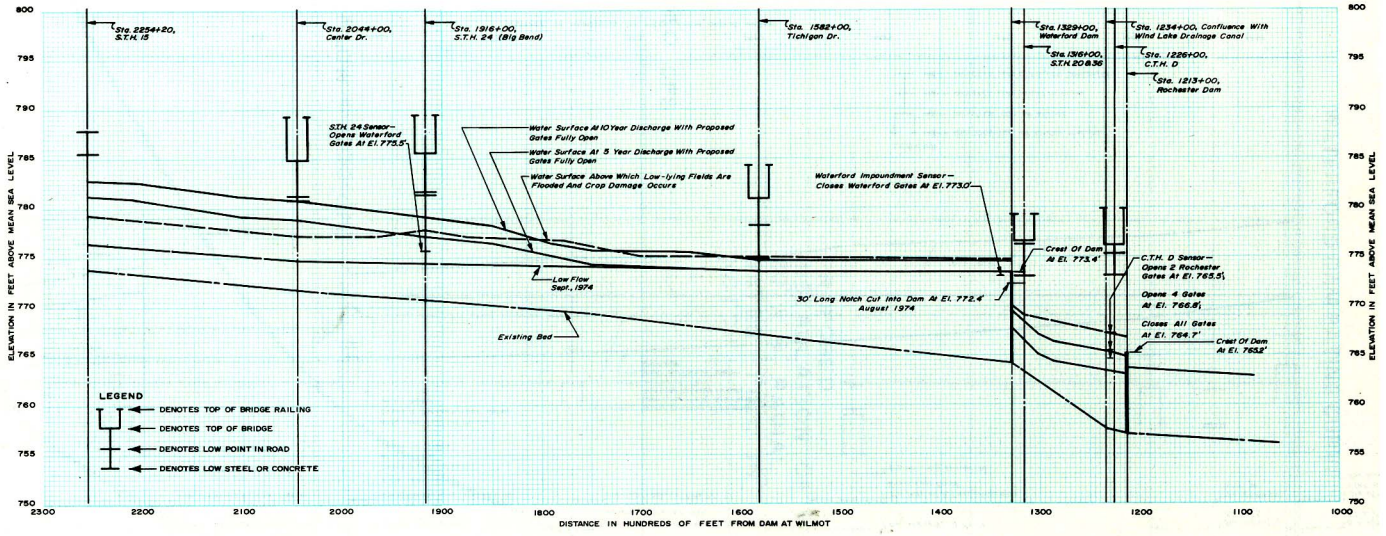
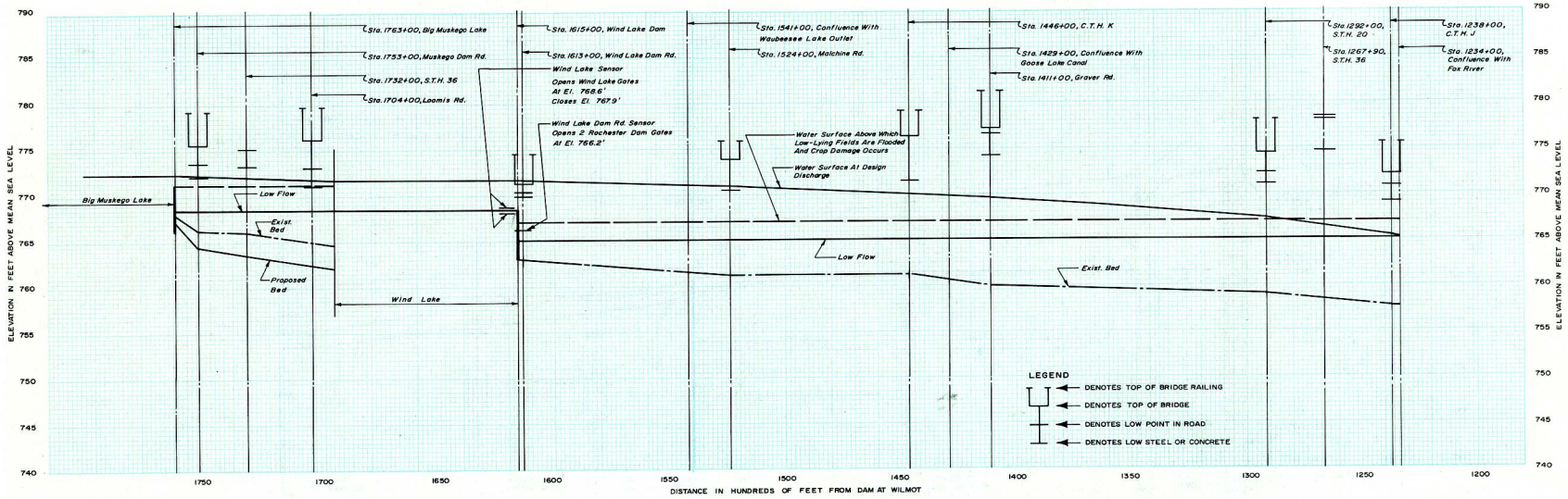


**Figure A-2**

## CONTROL ELEVATIONS AND SELECTED WATER SURFACE PROFILES FOR THE MUSKEGO CANAL AND THE WIND LAKE DRAINAGE CANAL

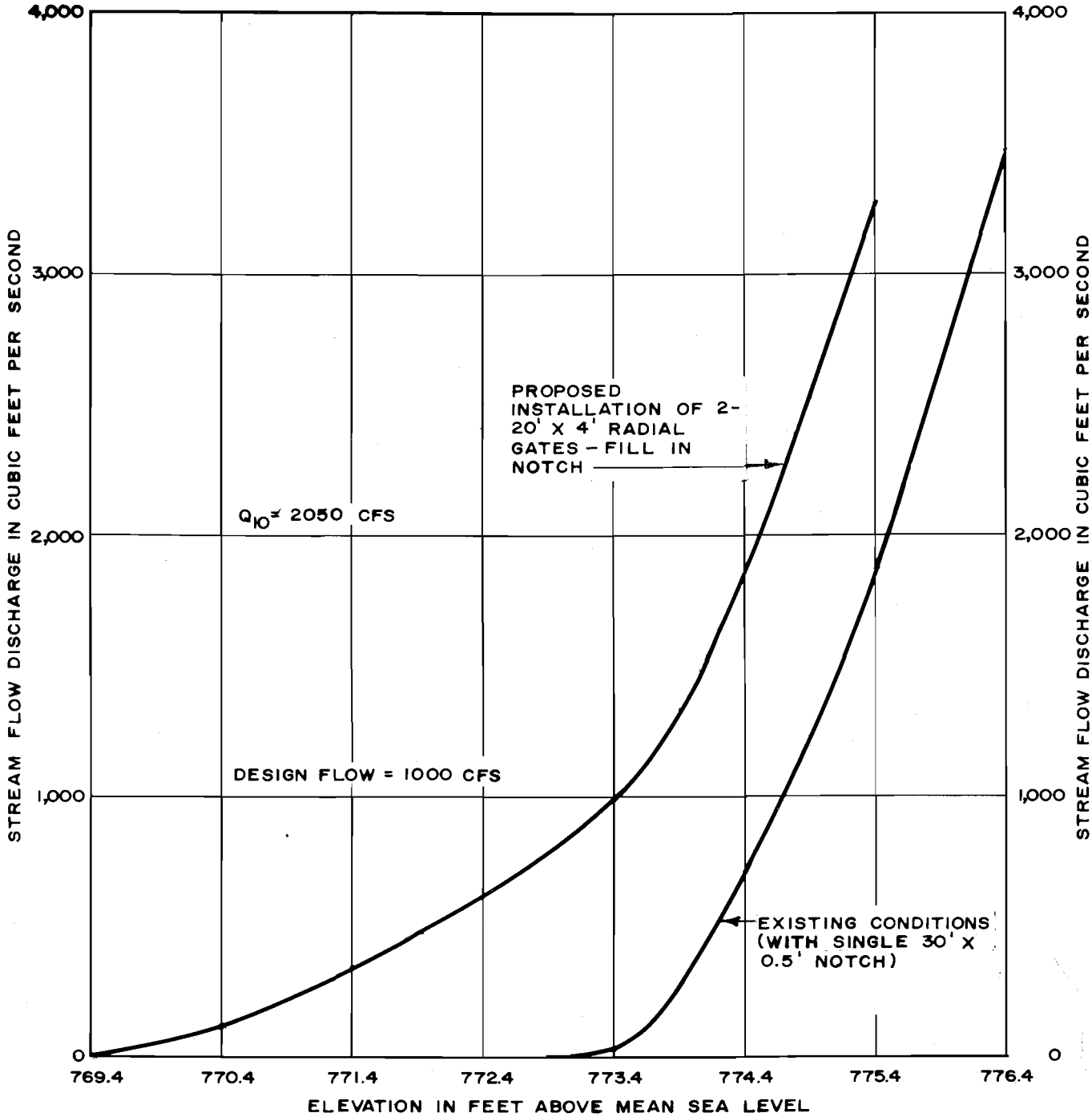


Appendix B

RATING AND RUNOFF CURVE

Figure B-1

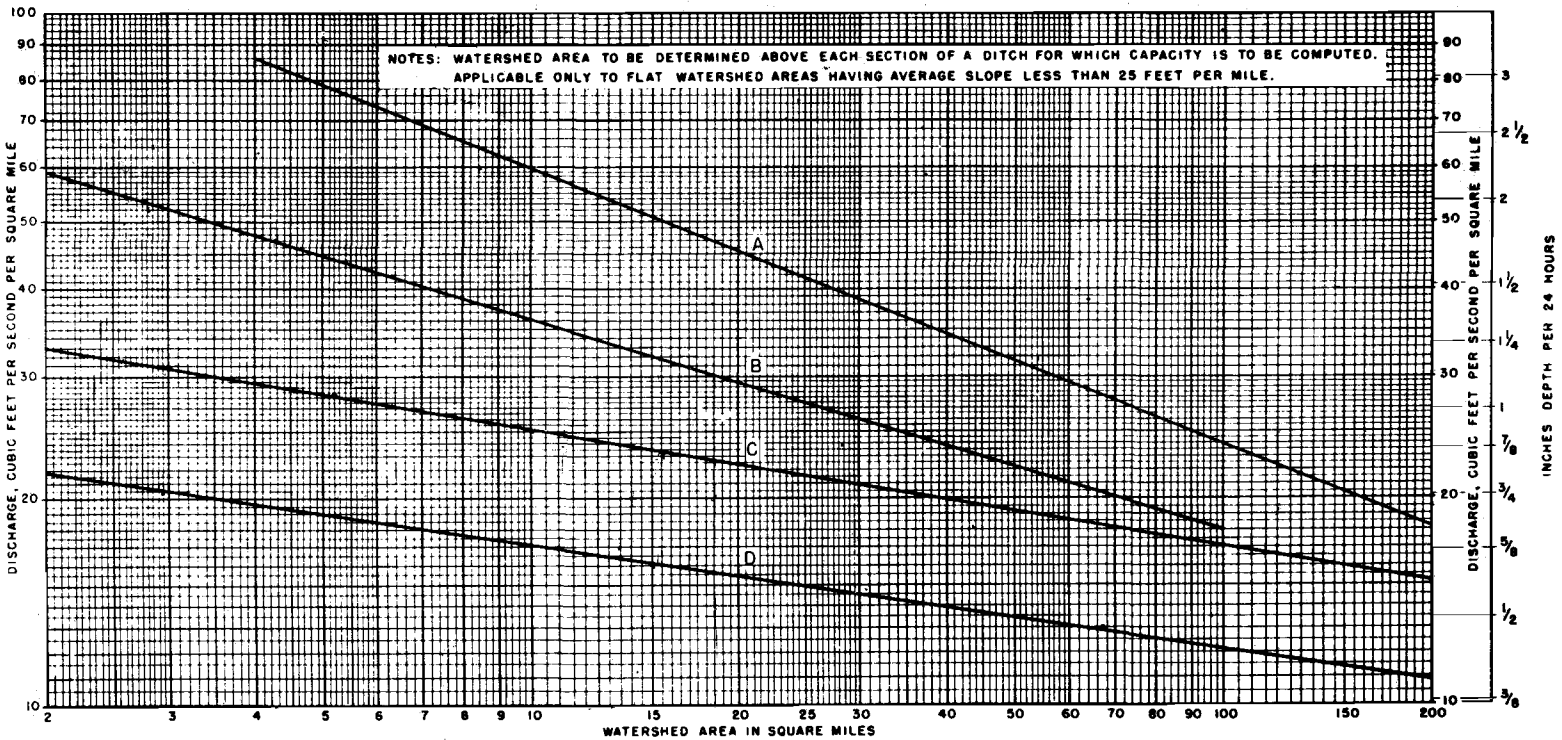
WATERFORD DAM RATING CURVE




*Source: Technical Consultants and SEWRPC.*

Figure B-2

## DRAINAGE RUNOFF CURVES FOR OPEN DITCH DESIGN IN FLAT WATERSHED AREAS OF MORE THAN TWO SQUARE MILES




### EXPLANATION OF CURVES

A - For good protection from overflow (not maximum flood runoff)

B - For excellent drainage except in Claypan soils in southern part of region. Very good drainage on these soils.

C - For excellent drainage in northern Minnesota, Wisconsin, Michigan. For very good agricultural drainage in Ohio, Indiana, Illinois, Iowa, northern Missouri, southern Minnesota, Wisconsin and Michigan. For good agricultural drainage in southern Missouri.

D - For good agricultural drainage in northern Minnesota, Wisconsin and Michigan. For fair agricultural drainage in Ohio, Indiana, Illinois, Iowa, northern Missouri, Southern Minnesota, Wisconsin and Michigan.

Reference "Hydraulics of Open Ditches" by John G. Sutton S.C.S. USDA Soil Conservation Service

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