# FLOOD CONTROL STUDY

# FOX CREEK AND CONNECTING CANALS AREA

# AND

# HARDING CANAL AREA

# FINAL REPORT

COLEMAN A. YOUNG, MAYOR
CITY OF DETROIT

CITY ENGINEERING DEPARTMENT

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PREPARED BY

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JULY 1986

## EXECUTIVE SUMMARY

### General

The flood control study for Fox Creek and connecting canals area and the Harding Canal area was conducted to evaluate the technical, economic, operational, maintenance and other aspects of the flood control alternatives. The study areas shown in Figure 1 are a part of the East Jefferson Sewer District of the Detroit Wastewater Collection System.

The Fox Creek, as it exists, has three functions as:

1. An outlet to the Detroit River for combined sewage overflows (CSO) flowing in through the 12-foot cylindrical conduit (Alter Road outlet) from Grosse Pointe Park Pump Station.

2. An access canal for recreational boating for the properties along the west bank; and

3. A standby outlet for the storm and sanitary flows from the eastern and northeastern suburbs (Fox Creek enclosure and Ashland Sewer) if the Detroit sewer system is overloaded.

The Harding Canal functions as an access canal for recreational boating for the neighboring property owners.

Major flooding of the study area occurred during March 1973, when the water level on the Detroit River at Windmill Pointe reached the daily mean of 97.8 feet (City Datum). Currently in 1986, the Detroit River water levels are at record highs and repeated spillage occurs over the banks of the Fox Creek and the connecting canals and the Harding Canal. The water in the canal system was held back temporarily by dikes and stacked sandbags.

During an extremely low level stage in the Detroit River, the Fox Creek canal system was dredged (about 20 years ago) to maintain canal water depths for recreational boating. The Fox Creek lacks flowing current except when Grosse Pointe Park pumps storm water or flow is induced from downstream by the Detroit River. So, the dilution and dispersion of CSO flow into the canal system has been a slow process during dry weather periods.

The Detroit Water and Sewerage Department cleans the Fox Creek frequently during dry weather flow by opening the backwater gates located north of Jefferson Avenue. This action replaces the stagnant water with fresh river water and creates favorable aesthetics for boaters and neighboring property owners.

## Existing Conditions

The Fox Creek, Lakewood Canal, Philip Canal, and the Harding Canal had sheeting installed at the entrance to the Detroit River. The extent of the sheeting is shown in Figure 1, and the top elevation of the capped sheeting is approximately 100 feet (Detroit Datum). The east bank of Fox Creek has a dike whose crest elevation varies from 99 to 100 feet. The canal system around Klenk Island, Harbor Island, along Ashland Road, and along Harding Street has been experiencing overtopping at canal water levels of 97.7 feet or higher.

The primary cause of high water levels is the Great Lakes which continue to be high. Lake St. Clair set record high water levels in February 1986 for the sixth straight month. The Lake St. Clair level of 97.7 feet surpassed its previous record of 96.9 feet, set in 1974.

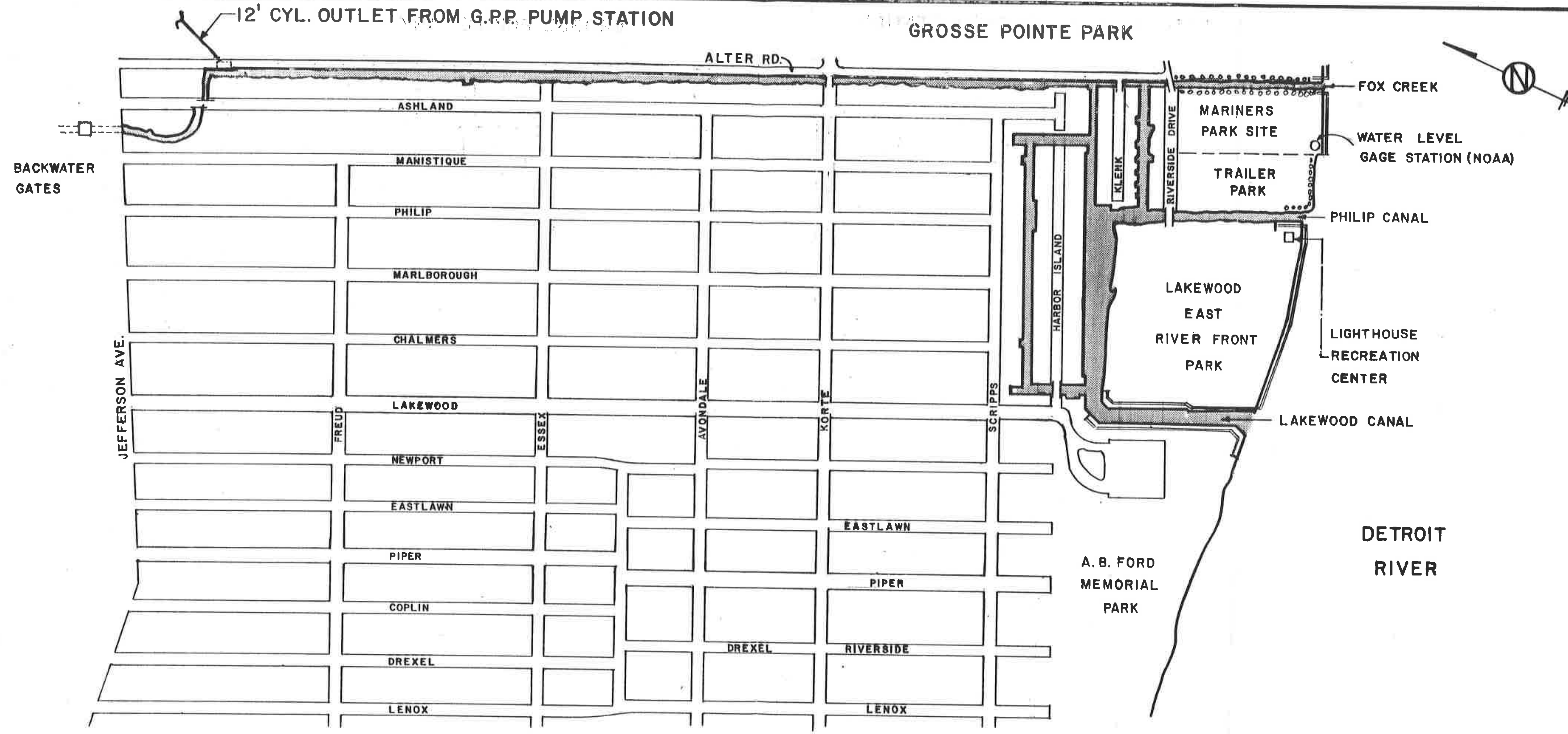
Six bridges span the Fox Creek canal system with deck elevations varying from 98.25 feet to 102.55 feet. The bridges impose limitations for recreational boat passage. The Lakewood Canal has no bridge obstructions and provides main boat access to the river. The Lakewood Canal bottom elevation is 88 feet with an average width of 80 feet. The Fox Creek Canal, Philip Canal, and Harding Canal are narrow and shallow and provide limited boating access.

## Conclusions

The criteria used to select and evaluate flood control alternatives were based on the goals and objectives of the City of Detroit. Several options studied for flood control include dredging, flood gates, and revetment or seawalls.

The Fox Creek canal system was dredged about 20 years ago and since then there has been no measurable change in the bottom elevation. Dredging, essentially a continuous operation for any canal system to minimize changes in water carrying capacity, cannot help eliminate the flood problems of the Fox Creek canal system.

A flood gate is a direct engineering technique to regulate and control flood waters and found to be appropriate for the Fox Creek flooding area. However, a 1100 cfs capacity pump station is required to drain and maintain the water level of the canal system should a storm occur during high water level in the Detroit River. Various flood gates investigated include locks, floodwalls, inflatable rubber dams and a flush lock system. The gate systems for locks may have guillotine gates, tumbling gates, rolling gates, or sector gates.

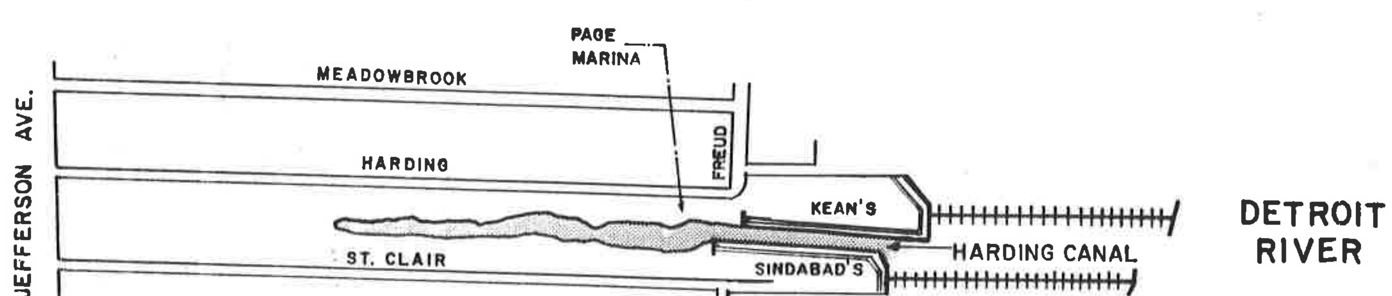



a) FOX CREEK & CONNECTED CANALS

**LEGEND**

STEEL SHEETING

RIP- RAP




b) CANAL ALONG HARDING ST.

| CITY ENGINEERING DEPARTMENT, DETROIT | |
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| EXISTING CANAL SYSTEM DETAILS | FIG. 3 |

Because the Fox Creek canal system allows recreational boating, the lock gate is the most suitable flood control method in the absence of adequate revetment. Water flows into or out of the lock to raise or lower a boat. Construction and maintenance of a pump station to drain and control canal water level is costly.

Optimum water level for the canals in the study area is defined as the level that prevents flooding while allowing maximum usage for recreational boating and is estimated to be 97 feet. The top elevation of flood gates and canal banks required to protect the area from wind-induced surges is 100 feet.

Revetment or seawall construction of the canal system banks is an effective flood control measure. The prevailing method of boat access to the canals complicates seawall construction. A combination tieback and cantilevered steel sheet pile seawall system was found suitable with cantilevered construction in the boat wells. The seawall finished elevation of 100 feet would protect the resident from higher Great Lakes basin water levels and surge caused by high velocity easterly winds. The adverse visual effect of a protruding seawall could be minimized by planned backfill and landscaping.

The list of alternatives and their construction costs, operation and maintenance costs and present worth values are presented in Table I.

## Recommendations

The goals and objectives of the City of Detroit could be met cost-effectively by providing a combination tieback and cantilever seawall system for the Fox Creek canals area and a guillotine gate on the Harding Canal. The estimated cost to implement the recommended plan to protect both the areas is $9,733,000 with a yearly operational and maintenance cost of $24,200.

## TABLE I FLOOD CONTROL ALTERNATIVES AND COST SUMMARY**

| ALTERNATIVE DESCRIPTION | ESTIMATED CONSTRUCTION O & M COST($) | ESTIMATED O & M COSTS($) | PRESENT WORTH VALUE($) |
|---|---|---|---|
| Alternative 1A | | | |
| I--Concrete encased sheet piles | 14,438,000 | 72,000/5yrs | 14,579,000 |
| II--Tieback or cantilevered sheet piles | 9,625,000 | 96,000/5yrs | 9,813,000 |
| Alternative 2A | | | |
| I--Two guillotine gates and one lock gate | 16,380,000 | 138,500/5yrs | 17,757,000 |
| II--Two inflatable rubber dams and one lock gate | 17,080,000 | 173,500/5yrs | 18,813,000 |
| Alternative 3A | | | |
| I--Three lock gates | 17,660,000 | 194,000/5yrs | 19,557,000 |
| II--Three inflat-able rubber dams* | 16,850,000 | 173,000/yr | 18,629,000 |
| Alternative 2B | | | |
| I--Guillotine Gate south of Freud Avenue* | 81,000 | 4,000 | 132,000 |
| II--Rubber dam south of Freud Avenue* | 430,000 | 21,500/yr | 659,000 |
| Alternative 3B | | | |
| Guillotine gate north of Page Marina* | 108,000 | 5,000/yr | 173,000 |

*Cannot allow boat passage while in flood control position.

**Chapter 5 of report gives Alternatives 4A and 1B details.

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# CHAPTER 1

## INTRODUCTION

This study is to identify alternative engineering designs to prevent the flooding of two areas.

1. Bounded by Lenox Street on the west, Fox Creek on the east, Jefferson Avenue on the north and the Detroit River on the south.

2. Along the Harding Street Canal.

Major flooding occurred during March 1973, when the water level on the Detroit River at Windmill Pointe reached the daily mean of 97.8 feet (City Datum). Currently in 1986, the Detroit River water levels are at record highs and repeated spillage over the banks of the Fox Creek and the connecting canals is occurring. A storm surge of 0.7 feet above lake levels was predicted on the Detroit Shoreline by a computerized storm surge model, National Oceanic and Atmospheric Administration, (NOAA), Great Lakes Environmental Research Laboratory based on sustained winds for a 2-hour period of 20 knots easterly or 22 knots northeasterly. However, higher velocity winds would produce higher storm surges. The water in the canal system is held back temporarily by dikes and stacked sandbags.

The Fox Creek, as it exists, has three functions:

1. An outlet to the river for combined sewage overflows (CSO) flowing in through the 12 foot cylindrical conduit (Alter Road outlet) from Grosse Pointe Park Pump Station.

2. An access canal for recreational boating for the properties along the west bank.

3. A standby outlet for the storm and sanitary flows from the eastern and northeastern suburbs (Fox Creek enclosure and Ashland Sewer) if the Detroit sewer system is overloaded (See Figure 2).

# CHAPTER 2

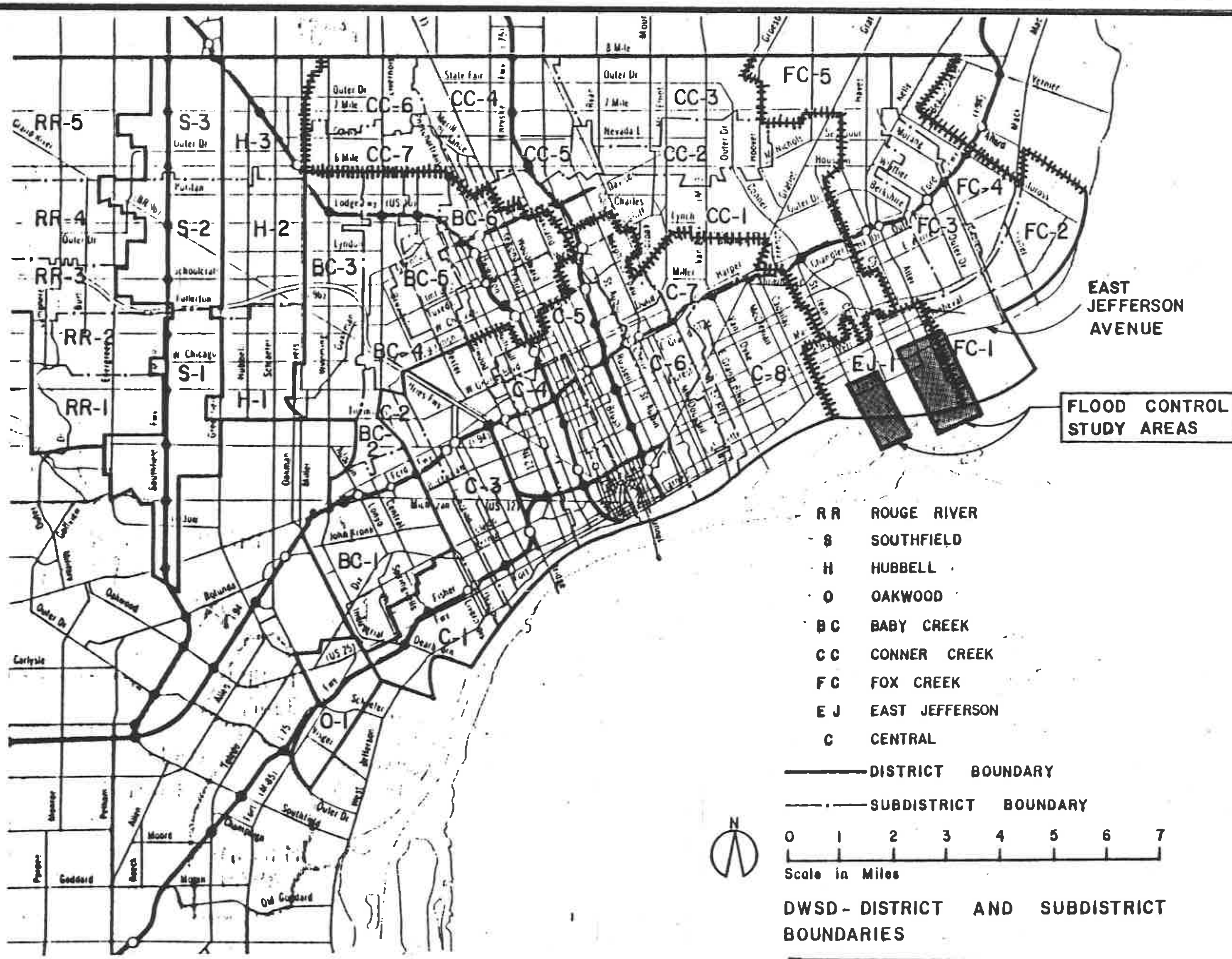
## EXISTING CONDITIONS

The flood control study areas, shown in Figure 1, is a part of the East Jefferson Sewer District of the Detroit Wastewater Collection System. The East Jefferson Sewer District serves an estimated 39,900 people (1980 census) on 2,600 acres of land. Part of this district lies below the high water level of the Detroit River. Dikes and seawalls protect this area, which was landfilled when the river was at a low stage. This district contributes a dry weather flow of 9.2 mgd to the Detroit waste water collection system.

As shown in Figures 1 and 2, the East Jefferson Sewer District receives combined sewage flow from the Conner Creek and Fox Creek Sewer Districts via the Fox Creek Relief Sewer, Ashland Relief Sewer, Fox Creek Enclosure and Conner Creek Sewer. Two major components of the East Jefferson District are the Conner Creek and Freud Pump Stations. Freud Pump Station is used primarily as a storm relief facility. As shown in Figure 2, backwater gates at Jefferson Avenue eliminated natural upstream flow to the Fox Creek canals. The Fox Creek canals have limited flow induced by the Detroit River under normal conditions. So, the dilution and dispersion of combined sewage overflow (CSO) to the Fox Creek canals from Grosse Pointe Park Pump station is slow. Table 1 shows CSO quantity and maximum pumping rates for overflows to Fox Creek from 1972 through 1976.* The number of overflow events per year is an average of about four. The largest

**TABLE 1 CSO OVERFLOW VOLUMES TO FOX CREEK FROM GROSSE POINTE PARK PUMP STATION**

| DATE | VOLUME (MILLION GALLONS) | MAXIMUM PUMPING RATE, cfs | AVERAGE TIME AT MAXIMUM PUMPING RATE, hrs |
|---|---|---|---|
| 3-14-72 | 5.8 | 150 | 1.44 |
| 4-16-72 | 8.8 | 150 | 2.18 |
| 8-14-72 | 26.8 | 750 | 1.33 |
| 8-16-72 | 15.7 | 450 | 1.30 |
| TOTAL 1972 | 57.1 | | |
| 6-12-73 | 6.8 | 150 | 1.68 |
| 6-28-73 | 18.6 | 450 | 1.53 |
| 7-02-73 | 6.1 | 150 | 1.51 |
| 7-28-73 | 5.7 | 150 | 1.41 |
| 8-01-73 | 17.5 | 750 | 0.87 |
| TOTAL 1973 | 54.7 | | |
| 2-22-74 | 8.1 | 150 | 2.00 |
| 4-03-74 | 12.1 | 450 | 1.00 |
| 8-08-74 | 9.8 | 450 | 0.81 |
| 8-16-74 | 11.1 | 450 | 0.92 |
| TOTAL 1974 | 41.1 | | |
| 5-30-75 | 11.1 | 450 | 0.92 |
| 6-24-75 | 7.8 | 150 | 1.93 |
| 8-03-75 | 16.2 | 450 | 1.34 |
| 8-24-75 | 5.7 | 150 | 1.41 |
| TOTAL 1975 | 40.8 | | |
| 2-16-76 | 8.1 | 150 | 2.00 |
| 7-28-76 | 80.3 | 1,050 | 2.84 |
| TOTAL 1976 | 88.4 | | |

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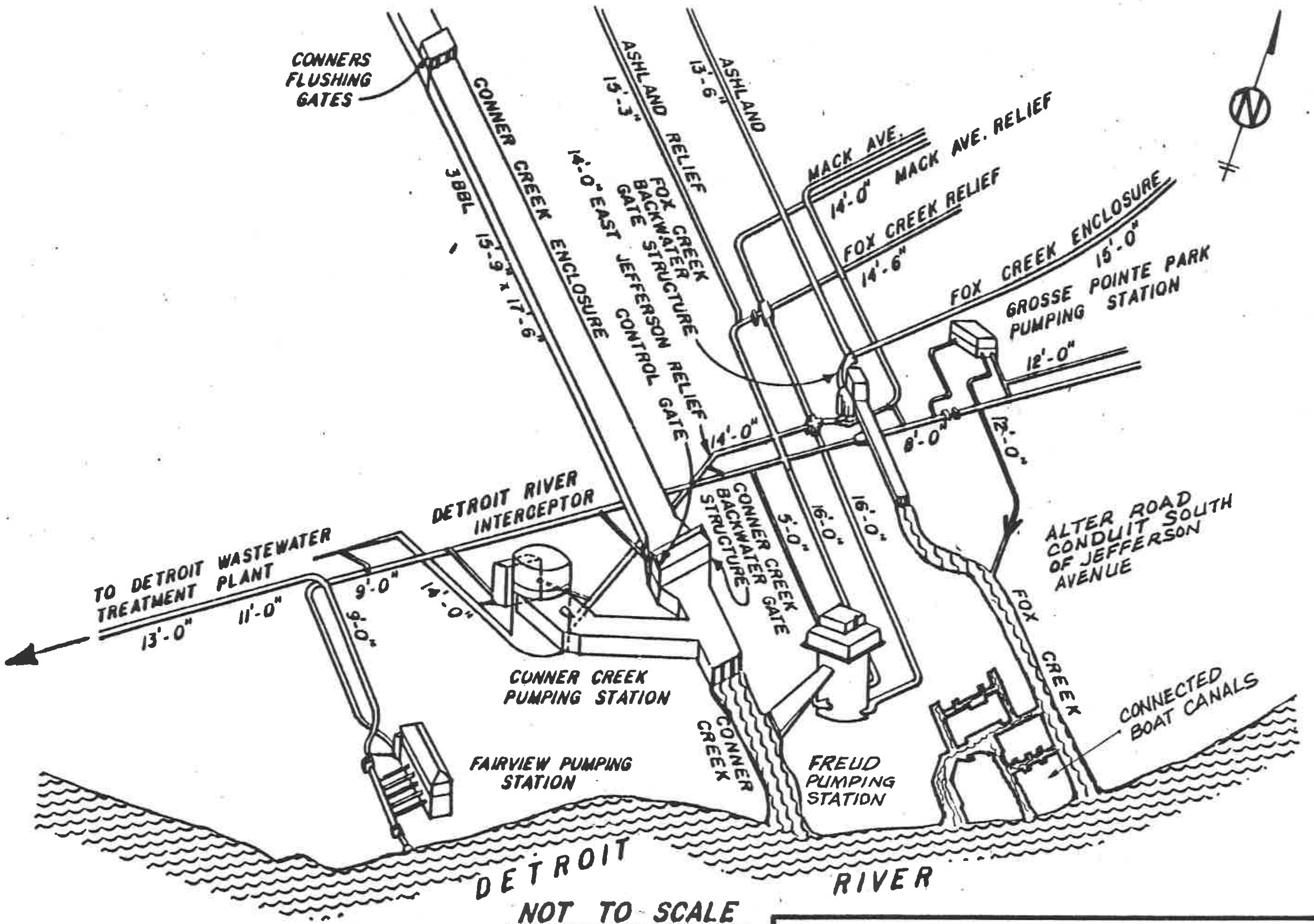
| LOCATION OF STUDY AREAS | FIG. 1 |

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| C E D, DETROIT | |
| M M I | JOB NO. 8538 |
| COMBINED SEWER FLOWS TO FOX CREEK CANAL | FIG. 2 |

overflow was recorded during the storm of July 28-29, 1976, when 80 million gallons were pumped into the Fox Creek during a period of 2.84 hours.

Detroit Water and Sewerage Department cleans the Fox Creek frequently during dry weather flow by opening the backwater gates north of Jefferson. This action creates a flow that removes offensive floating materials into the Detroit sewer system and reduces odors generated by stagnant water in the Fox Creek Canals. Also, this action replaces the stagnant water with fresh river water and creates favorable aesthetics for boaters and neighboring property owners.

Alter Road runs adjacent to and parallel to the east bank of the Fox Creek. The dike along the east bank is owned and maintained by the City of Detroit. Houses that line the west bank have experienced repeated flooding problems.

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*Fox Creek Facilities Plan, EPA Project C262601-01, Draft Report for Wayne County Drain Commission, p. 162, June 1981.

Fox Creek and the three canals (Philip, Lakewood and Harding) have sheeting installed at the entrance to the Detroit River. The extent of sheeting is shown in Figure 3, and the top elevation of capped sheeting is about 100 feet (Detroit Datum). The canal system around Klenk Island, Harbor Island and along Ashland Road has been experiencing overtopping at canal water levels of 97.7 feet or higher. Water seepage through pavement joints and stone banks could be found at lower than 97.7 ft elevation. There is evidence on the roadways of freezing of overtopped water during winter seasons.

All of the Great Lakes continue to be high and Lake St. Clair set record high water levels in February 1986 for the sixth straight month. The Lake St. Clair level of 97.7 feet surpassed its previous record of 96.9 feet, set in 1974, (see Figure 4 for details.)

There are six bridges over the Fox Creek canal system with varying deck elevations. With reference to the canal system water level of 97.6 ft, the bridge deck elevations and clearances at the center point are presented in Table 2.

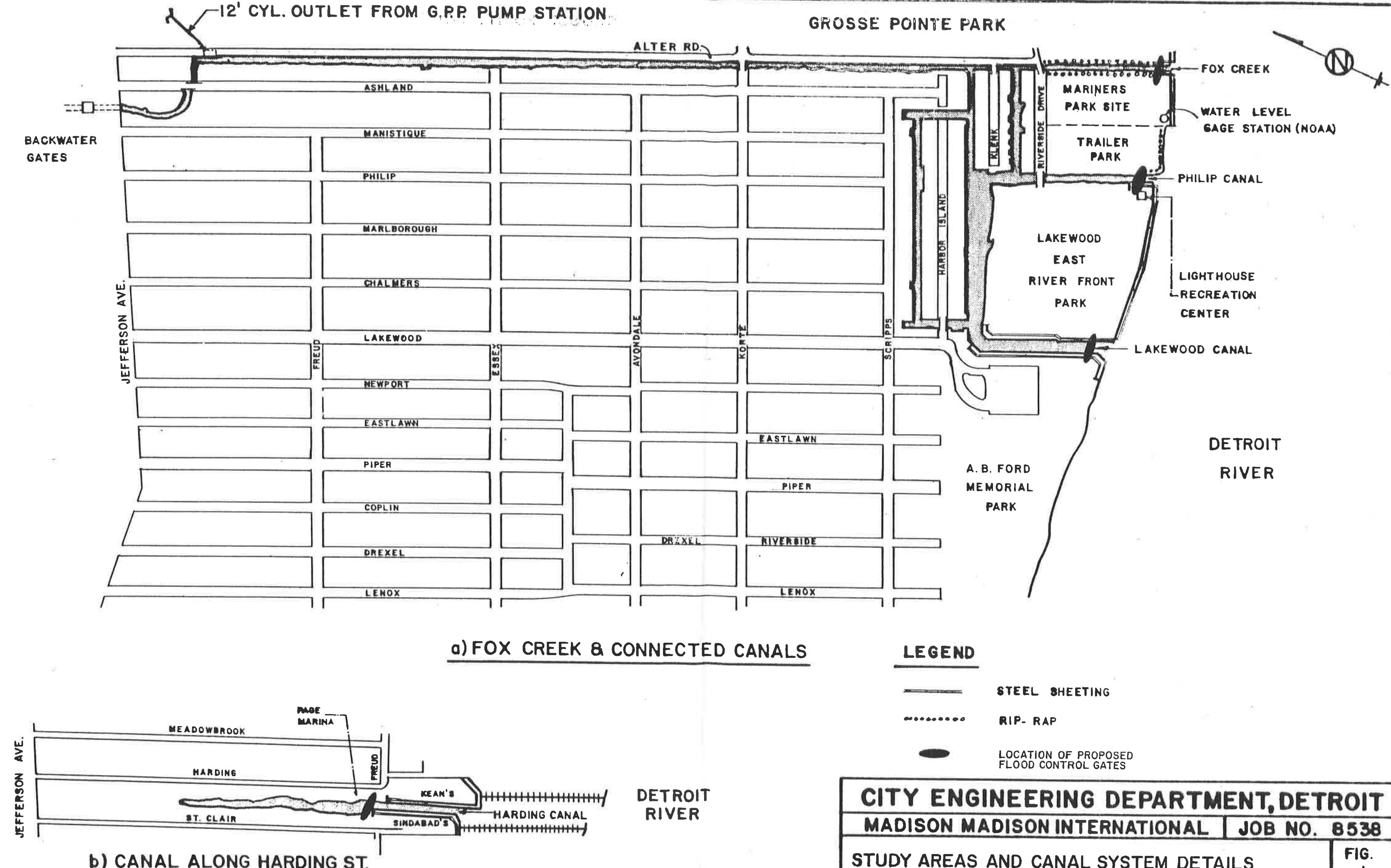
The bridge clearances are affected by the canal system water level which changes with the Detroit River water level. These bridges impose limitation for recreational boat passage through the Fox Creek and canal system. Figure 5 defines the waterways for passage of recreational boats. The Detroit River is accessed

**TABLE 2 FOX CREEK CANAL BRIDGE CLEARANCES**

| NUMBER | BRIDGE NAME | CANAL CROSSING | ELEVATION, Ft * | CLEARANCE, Ft ** |
|---|---|---|---|---|
| 1. | Riverside Drive Bridge | Fox Creek | 101.75 | 4.15 |
| 2. | Riverside Drive Bridge | Philip Canal | 102.55 | 4.95 |
| 3. | Harbor Island Bridge | Lakewood Canal | 98.25 | 0.65 |
| 4. | Klenk Bridge | Fox Creek | 100.85 | 3.25 |
| 5. | Korte Bridge | Fox Creek | 102.35 | 4.75 |
| 6. | Ashland Bridge | Fox Creek | N/A | N/A |

* The elevations are at bridge deck bottom from City of Detroit Datum, 479.755 ft to USGS.

** The clearance refers to canal water level of 97.6 ft.




| | |
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| CITY ENGINEERING DEPARTMENT, DETROIT | |
| MADISON MADISON INTERNATIONAL | JOB NO. 8538 |
| STUDY AREAS AND CANAL SYSTEM DETAILS | FIG. 1 |

**FIGURE 4 - GREAT LAKES WATER LEVELS**

US Army Corps of Engineers
North Central Division

# GREAT LAKES LEVELS UPDATE, NO. 8 3 March 1986

All of the Great Lakes continue to be dangerously high. Lakes Superior, Michigan-Huron, St. Clair and Erie have again all set new monthly record high levels in February. For Lakes Superior and St. Clair, this is the sixth straight month that record highs have been set; for Lakes Michigan-Huron, it is the fifth; and for Lake Erie, it is the fourth. The Lake Ontario level is well above normal and Criterion (k), which requires that Lake Ontario be regulated so as to provide all possible relief to riparians upstream and downstream of the St. Lawrence River control structures, is still in effect. As a result, the International Joint Commission's St. Lawrence River Board is maximizing the Lake Ontario outflows while maintaining a stable ice cover on the river.

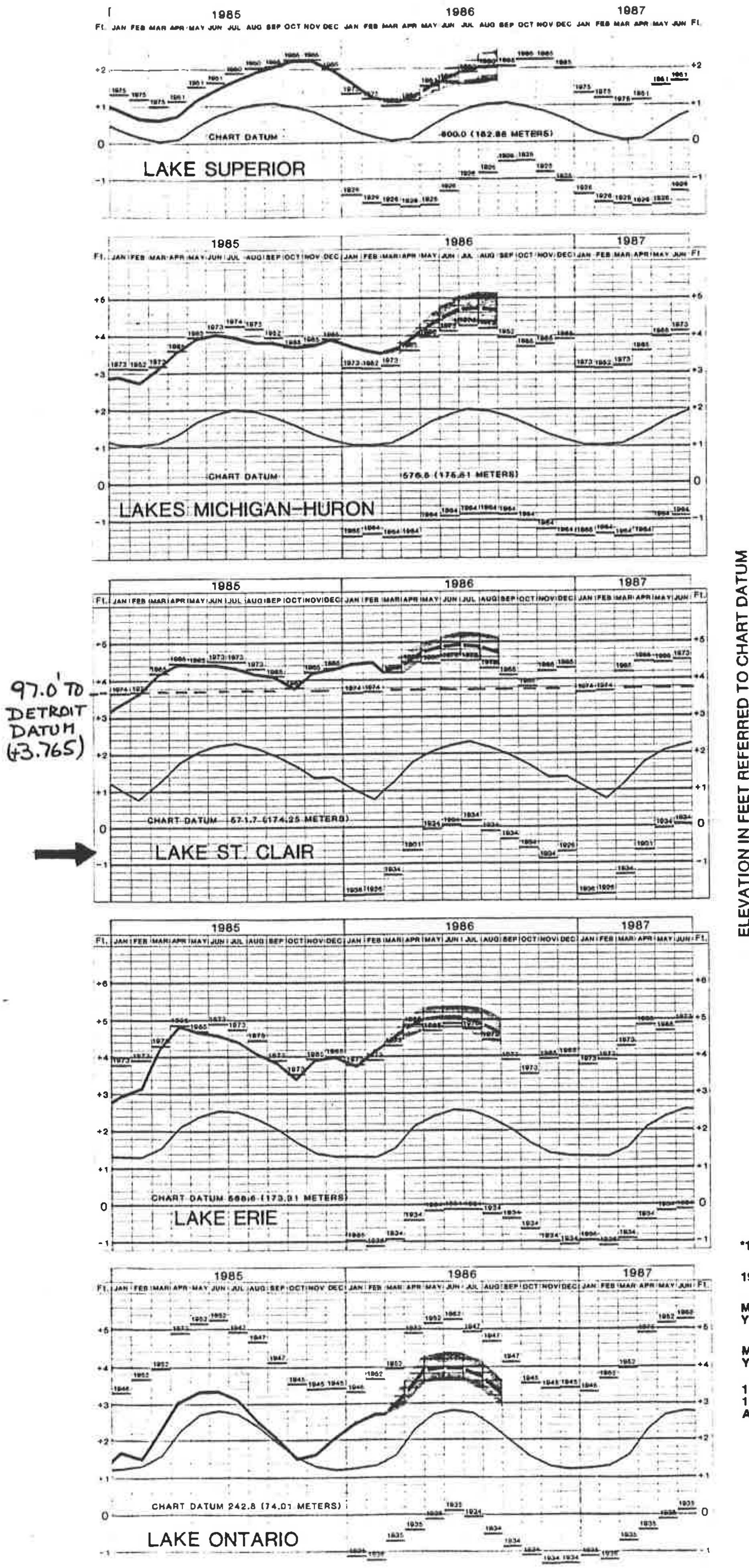
The attached bulletin shows our projected levels for the period March 1, 1986, through August 31, 1986. All the upper Great Lakes are predicted to remain extremely high for the next six months. The Lake Superior February monthly mean level was 601.24 feet, which is 3/4 inch above the previous February record of 601.18 feet, set in 1975. Lakes Michigan-Huron's February level was 580.37 feet, 5-1/2 inches above the previous record of 579.91 feet that was set in 1952. Lake St. Clair's level was 9-1/4 inches above its previous record of 575.39 feet, set in 1974. The Lake Erie level was 3 inches above its previous record February high level of 572.53 feet that was set in 1973. Continued high inflows from upstream and some local basin runoff in February caused the Lake Ontario level to rise to 245.48 feet, or about 16 inches above normal.

With Lake Superior at its maximum winter outflow setting and Lake Ontario being regulated under Criterion (k), the two Great Lakes that can be regulated are discharging the maximum flows possible while maintaining the integrity of the river ice covers. Lakes Michigan-Huron and Erie have no control structures on their outflow rivers. Ice jamming, and resultant flooding, in the lower St. Clair River occasionally occurs because of the high water levels and climatic conditions such as winds and temperature changes.

The outlook is for all the lakes except Lake Ontario to remain near or above record high levels at least through August 1986. As spring weather approaches and the ice cover dissipates, there is concern that severe storms acting on the record high levels can cause serious damage to shoreline properties. Riparian property owners should be alert to take necessary precautions.

The Corps of Engineers has authority under Public Law 84-99 to carry out preventive work prior to a flood threat to life and improved property. This program, known as Advance Measures, was initiated on the Great Lakes early in 1985 at the request of the Governors of Michigan and Ohio to counter the threat presented by the high Great Lakes water levels. The program is underway at a number of sites in these states.

In Michigan, five projects have been approved and are under construction at Luna Pier, Estral Beach, Detroit Beach in Frenchtown Township, and Labo Island and Milleman in Brownstown Township. Five other projects are under consideration. In Ohio, three projects have been approved; Reno Beach/Howard Farms, Whites Landing and Bayview. Only the Bayview project is under construction. A project at Eastlake, Ohio, appears to be viable, but has yet to be authorized. Projects at all other potential locations in both states either are ineligible or have been declined by the Communities.




US Army Corps of Engineers
Detroit District

## MONTHLY BULLETIN OF LAKE LEVELS FOR THE GREAT LAKES

FEBRUARY 1986

Recorded levels for the previous year and the current year to date and the probable levels for the next six months are shown in red. The shaded red area shows the probable range of levels (one standard deviation of the long-term average predictive error) over the next six months dependent upon weather variations.

These are compared with the 1900-1985 average and extreme levels which are shown in black.

### LEGEND

LAKE LEVELS

RECORDED

PROBABLE †

1900—1985 AVERAGE

MAXIMUM 1985 1985 1973 1973

MINIMUM 1936 1934 1926 1934

Hydrographs are in feet above (+) or below (-) Chart Datum, the plane on each lake to which navigation chart depths and Federal navigation improvement depths are referred.

Chart Datum and all other elevations are in feet above the mean water level at Father Point, Quebec (International Great Lakes Datum 1955). To convert feet to meters, multiply feet by 0.30480.

### FEBRUARY MEAN LAKE LEVELS

| | Superior | Mich.-Huron | St. Clair | Erie | Ontario |
|---|---|---|---|---|---|
| *1986 | 601.24 | 580.37 | 576.16 | 572.79 | 245.48 |
| 1985 | 600.66 | 579.57 | 575.34 | 571.77 | 244.33 |
| MAX. YEAR | 601.18 1975 | 579.91 1952 | 575.39 1974 | 572.53 1973 | 246.46 1952 |
| MIN. YEAR | 598.37 1926 | 575.44 1964 | 569.88 1926 | 567.49 1936 | 241.59 1936 |
| 1900-1985 AVG. | 600.16 | 577.81 | 572.48 | 569.89 | 244.13 |

94.02 TO CITY DATUM.

* provisional

† The forecast takes into account the emergency actions authorized by the International Joint Commission.

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A ELES ALSH ALSF ANSH BESH BYSF BYCD BZSH CXSH CHSH ETSF EMSH
GTCD GHSF HASF HUSH JASF ICSH LLSH MOCD MASH MNSF MSSH
MUPD NOSF NGSF OESH OTSH PPSF PESF FISH ROSF SSSF SISF
SNSH TCSF TUSH VBSH WARP SCSH ARSH.

ATTN: EMERGENCY SERVICES COORDINATORS

SUBJECT: LAKE STORM SURGE PREDICTIONS

THE FOLLOWING PREDICTION DATA WAS EXTRACTED FROM INFORMATION THE DNR OBTAINED FROM A COMPUTERIZED STORM SURGE MODEL PROVIDED BY THE NOAA GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY WITH ASSISTANCE FROM THE U.S. ARMY CORP OF ENGINEERS (DETROIT DISTRICT). THESE STORM SURGE PREDICTIONS WILL BE USEFUL FOR EMERGENCY RESPONSE AND COASTAL FLOOD PREPAREDNESS PURPOSES.

1. LAKE ERIE AT MONROE COUNTY - SUSTAINED WINDS FOR AN 8 HOUR PERIOD OF 21 KNOTS NORTHEASTERLY, 19 KNOTS EASTERLY, OR 23 KNOTS SOUTHEASTERLY COULD RESULT IN FLOODING OCCURRING TO THE 100 YEAR FLOOD LEVEL (A STORM SURGE OF 2.8 FEET ABOVE 1986 LAKE LEVELS). GREATER WINDS COULD PRODUCE COMMENSURATELY HIGHER STORM SURGES.

2. LAKE ST. CLAIR AT WAYNE COUNTY AND SOUTHERN MACOMB COUNTY - SUSTAINED WINDS FOR A 2 HOUR PERIOD OF 20 KNOTS EASTERLY OR 22 KNOTS NORTHEASTERLY OR SOUTHEASTERLY COULD RESULT IN FLOODING OCCURRING TO THE 100 YEAR FLOOD LEVEL (A STORM SURGE OF 0.7 FEET ABOVE 1986 LAKE LEVELS). GREATER WINDS WOULD PRODUCE COMMENSURATELY HIGHER STORM SURGES.

3. LAKE ST. CLAIR AT ANCHOR BAY - SUSTAINED WINDS FOR A 2 1/2 HOUR PERIOD OF 22 KNOTS SOUTHERLY, 25 KNOTS SOUTHEASTERLY, OR 27 KNOTS SOUTHWESTERLY COULD RESULT IN FLOODING OCCURRING TO THE 100 YEAR FLOOD LEVEL (A STORM SURGE OF 1.9 FEET ABOVE 1986 LAKE LEVELS). GREATER WINDS WOULD PRODUCE COMMENSURATELY HIGHER STORM SURGES.

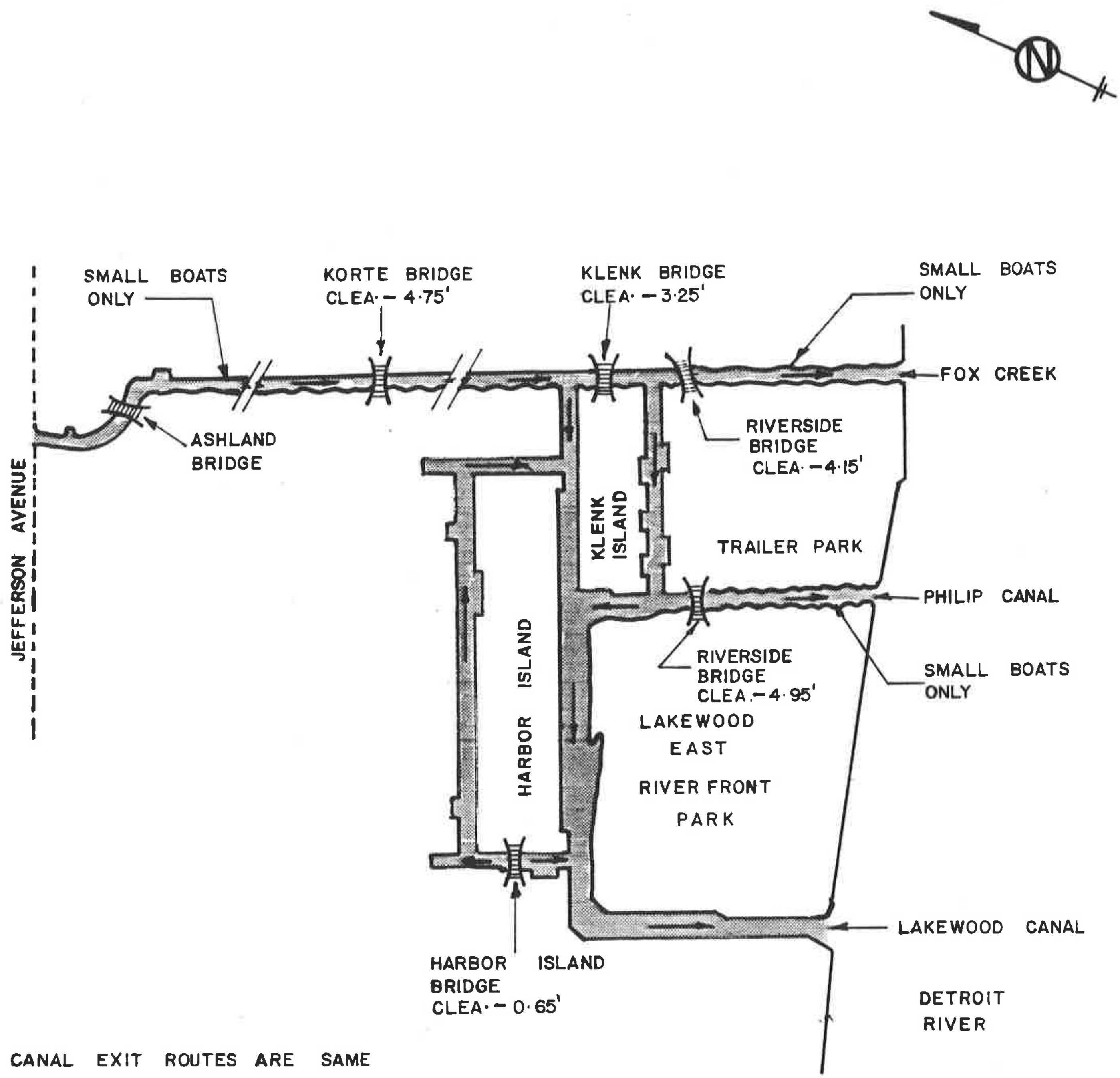
4. SAGINAW BAY AT ESSEXVILLE - SUSTAINED WINDS FOR A 7 HOUR PERIOD OF 20 KNOTS NORTHEASTERLY OR 26 KNOTS EASTERLY COULD RESULT IN FLOODING OCCURRING TO THE 100 YEAR FLOOD LEVEL (A STORM SURGE OF 2.9 FEET ABOVE 1986 LAKE LEVELS). GREATER WINDS WOULD PRODUCE COMMENSURATELY HIGHER STORM SURGES.

QUESTIONS SHOULD BE DIRECTED TO MR. DANIEL MORGAN (TX: 517/373-3930), ENGINEERING WATER MANAGEMENT DIVISION, DNR.

AUTHORITY: CAPTAIN PETER R. BASOLO, EMERGENCY MANAGEMENT DIVISION

OPERATOR: THERESA WEST

through the Lakewood Canal which is about 80 feet wide. The Fox Creek and the Philip Canal, which are shallow, provide limited access for small boats. The water depth of Philip Canal at Detroit River is 5 feet, the Lakewood Canal is 10 feet, Fox Creek 9 feet and Harding Canal 7 feet (varies).




CANAL EXIT ROUTES ARE SAME AS ENTRY ROUTES.

ALL CLEARANCES ARE BASED ON CANAL WATER LEVEL OF 97·6'

| C E D, DETROIT | |
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| M M I | JOB NO. 8538 |
| ROUTING OF RECREATIONAL BOATS THRU THE CANALS & CREEK SYSTEM | FIG. 5 |

## CHAPTER 3

### DEVELOPMENT OF FLOOD CONTROL PLAN

The study area is an established urban area. The flooding is caused by the high water levels in the entire Great Lakes Drainage Basin as presented in Figure 4. The flood control measures will be very specific. However, general approaches to the floodplain management are briefly described here first.

Basic approaches to floodplain management have been defined as:

1. Actions to reduce susceptibility to floods,
2. Actions (engineering solutions) that modify the flood, and
3. Actions that assist individuals and community in responding to floods.

Actions to reduce susceptibility of a floodplain to flood damage include regulation of floodplain development, governmental development and redevelopment policies, floodproofing, disaster preparedness and response plans, and flood forecasting and warning systems.

Engineering solutions that modify the flood include the various direct control measures such as levees, floodwalls, locks, flood gates and other canal improvements. Indirect measures such as land treatment and stormwater detention in urban areas also can modify the nature of floods.

In the response to flood problems, actions that assist include information dissemination and education, methods to spread a flood loss over time, and methods to spread the costs of floods to a wider community.

It was determined that direct engineering solutions would be most effective to the existing conditions of the Fox Creek flooding area. Only the engineering techniques for flood control are discussed in detail.

Selection of modern effective engineering design and operational criteria are needed for effective planning, implementation, and operation of a selected flood control plan. Criteria provide the basis for consistent planning, controls and design. For example, it is essential to provide maintenance access to all major drainage-way improvements.

Established engineering criteria that are thoughtfully developed based on the goals and objectives of the City of Detroit will help ensure the following:

1. Workable engineering plans and designs
2. Maintenance access for operations, repair and modifications
3. Consistent agreement with standard hydraulic design criteria
4. Maintain and improve access in the canal system for recreational boating.
5. Cost-effective solution based on orginal implementation and operating costs.

An engineering flood control plan for the study area may include some or all of the following:

1. Maintain the existing configuration of the canals
2. The use of lined canals
3. Selected or limited structure improvements or additions (flood gates, locks, etc.) and canal improvements (realignment, maintenance access, etc.)
4. Dividing Fox Creek to allow combined sewer overflows to the river separated from boating activities (partial solution only).
5) Elimination of combined sewer overflows to Fox Creek (partial solution only).

The operation and maintenance aspects of each of the best alternate plan should consider the following:

1. Access to entire length of canal system,
2. Bank stabilization,
3. Removal of debris from canals
4. Repair of structures.

Because the study area is an established urban area, selection and implementation of remedial programs would be complex. Several options for the redevelopment of the Fox Creek canal system and the Harding Canal are:

- Revetment (clay and broken concrete dikes, steel sheet piling, and sand bags)
- Dredging
- Flood gates (lock gate, inflatable rubber dam, and guillotine gates)

## Revetment

Revetment is the material placed on the bank slope to inhibit bank erosion and hold back and control the water from flowing over or through the bank. The most common type of revetment found along the Fox Creek canal system consists of steel sheet piling, stone paving, and broken concrete with clay dike. The latter method is most often used by property owners and has been adopted by the City as one means of a flood control measure.

Although revetment is an effective flood control measure, the prevailing method of boat access to the canals complicates its construction. There would still be overtopping from higher Great Lakes basin water levels and high velocity easterly winds, because it is not feasible to construct cost-effective protection high enough to ensure overtopping that will never occur, without impacting access for the recreational boating.

## Dredging of the Canal System

Another redevelopment measure investigated was dredging of the canal system and Fox Creek. This is a process whereby the bed material in the canal system would be removed thereby increasing the flow depth. Assuming there is no change in discharge or width of the various canals with time, the slope will decrease which in turn will decrease the sediment discharge. Gradually, sediment deposition would take place, restoring the canal depths to their original values. Thus dredging must essentially be a continuous operation in the canal system, if changes in water carrying capacity is to be minimized.

During an extremely low lake level condition, the Fox Creek canal system was dredged (about 20 years ago) to maintain canal water depths for recreational boating. Fox Creek lacks flowing current except when Grosse Pointe Park pumps storm water (see Figure 2).

There is no evidence of change in canal depths due to sediment deposition. Also, dredging would have no effect on canal water levels which is essentially the water level of the Detroit River. So, dredging cannot help eliminate the flood problems of the Fox Creek canal system.

**Flood Gates**

A flood gate is a direct engineering technique to regulate and control flood waters. The lock gate is the most suitable for boating canals like the Fox Creek canal system. Locks are built in the canals to raise or lower vessels from one level to another.

A lock is an enclosed part of a canal with a watertight gate at each end. Water is let into or out of the lock to raise or lower a boat. Locks are built in pairs when justified by boat traffic so that boats can go in both directions at the same time. Other gate systems that could be used to protect the Fox Creek canal system from the river high water are:

1. Flush Lock System (single gate)
2. Guillotine Gates (lifted vertically)
3. Tumbling Gates (sinks into canal floor)

4. Rolling Gates (Emerge from slots in canal sides)

5. Sector Gates (Swing into cavities in canal walls)

6. Inflatable rubber dam

These gate systems will restrict boating activity.

Impact of gates installation to canal system is presented below.

Adverse impacts:

1. Disruption to recreational boating activities in terms of increased time required to enter and/or exit river and the possible creation of a bottleneck.

2. Degradation of water quality without increased backflush of canals into the East Jefferson sewer system.

3. Increased operational, inspection and repair costs for gates.

4. Storm water drain pumps for the Fox Creek canal system at the Detroit River to maintain the canal water level.

Beneficial impacts:

1. Alleviation of health and sanitary hazard to adjoining property owners

2. Reduction in the maintenance cost from flood damage

3. Control of water level in entire canal system at an optimum level.

Optimum water level for the Fox Creek canal system is defined as the level that prevents flooding while allowing for maximum usage for recreational boating. The historical extremes for Detroit River water levels at Windmill Pointe for the period 1960 through 1979, are presented in Table 3 (see Appendix B for more details).

**TABLE 3 DETROIT RIVER LEVELS NEAR STUDY AREA (BASED ON ACTUAL MEASUREMENTS AT WINDMILL POINTE 1960 THROUGH 1979)**

| DESCRIPTION | LEVEL, Ft * |
|---|---|
| Maximum Instantaneous Hourly (March 1973) | 98.30 |
| Maximum Average Level (1969-1978) | 96.84 |
| Low Water Datum | 93.24 |
| Channel Bottom | 89.24 |
| Maximum Monthly Mean (June 1973) | 97.60 |
| Maximum Daily Mean (June, 17, 1973) | 97.80 |
| Minimum Monthly Mean (February 1964) | 91.99 |
| Minimum Daily Mean (January 25, 1964) | 90.90 |

*The levels are from the City of Detroit Datum.

Based on the existing canal system, bridge clearances and historical water levels of the Detroit River, optimum water level for the canal system is estimated to be 97 feet (Table 2, Figure 4, Appendix B). The top elevation of flood gates and canal banks has to be 100 ft to protect the area from wind induced surges (See Figure 4).

Flood gate installation to the canals requires drainage pumps to maintain the optimum water level in the boating canals. Maximum capacity of the drainage pumps has to be 1100 cfs to drain the water generated by the Grosse Pointe Park Pump Station and leakage from or operation of flood gates.

# CHAPTER 4

## FLOOD REGULATION AND CONTROL ALTERNATIVES

This chapter details various alternatives identified for evaluation. The objective is to establish various means of regulation and flood control measures suitable for the entire canal systems.

Based on the nature of the flooding and the flood control plans discussed in Chapter 3, the following alternatives are proposed for further study. The flood control alternatives proposed for the Fox Creek and connecting canals are different from those of the Harding Canal because of differences in their topographic configuration. The alternatives for the Fox Creek canals are presented first followed by the alternatives for the Harding Canal area.

### 4.1 Fox Creek and Connecting Canals

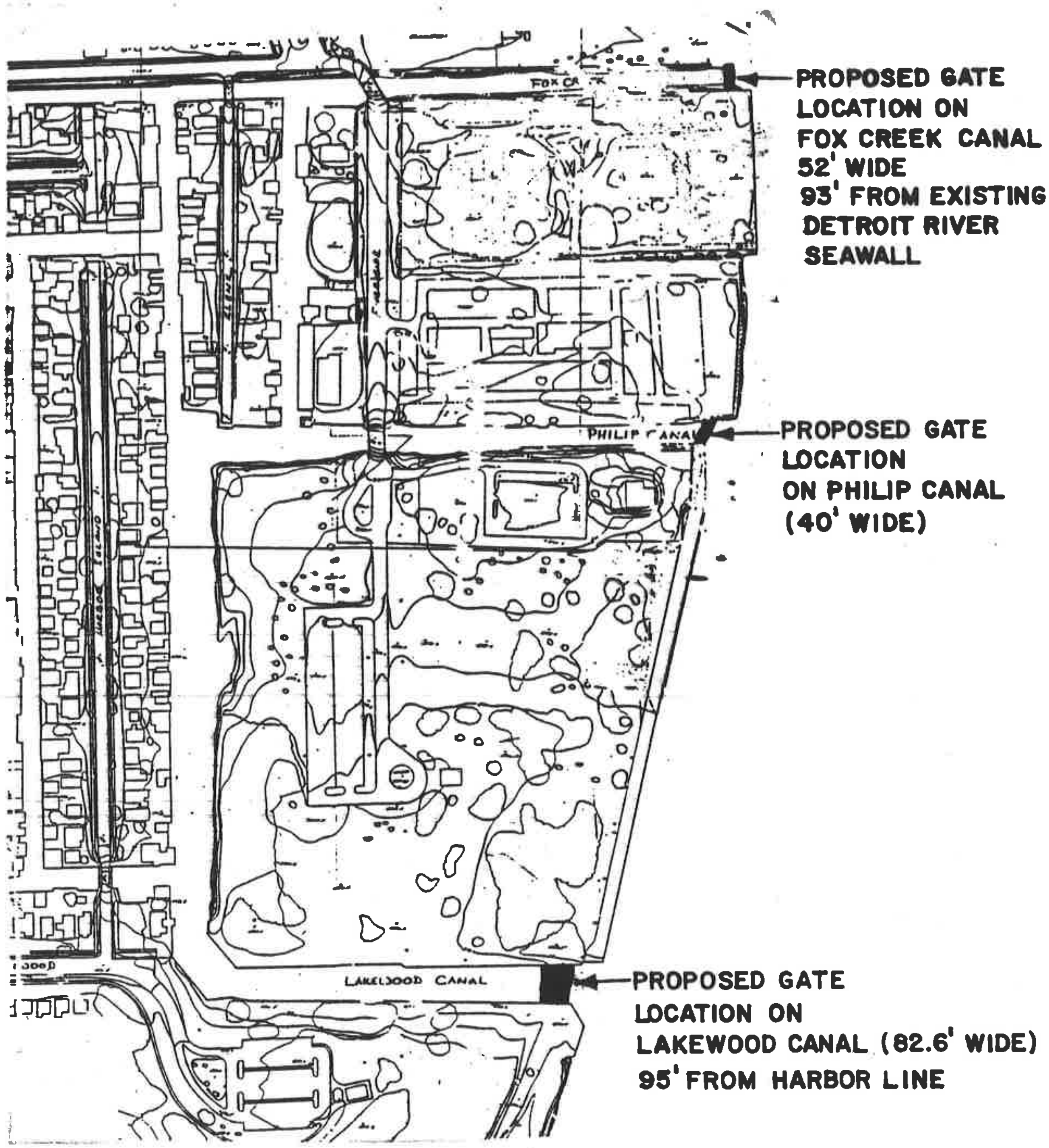
1A. Build seawalls along banks of the canal system.

2A. Install lock gate on Lakewood Canal, flood gates on Fox Creek Canal and Philip Canal.

3A. Install lock gates on all three canals (Lakewood, Philip and Fox Creek).

4A. Divide Fox Creek canal to eliminate CSO overflows to the Fox Creek canal system in addition to alternative 2A.

Under each proposed alternative, the specific control measure applicable to individual canals, has been evaluated from the engineering standpoint of durability, ease of construction and less frequency of maintenance. Proposed flood control gate locations are shown in Figure 6.




| CED, DETROIT | |
|---|---|
| MMI | JOB NO. 8538 |
| PROPOSED FLOOD GATE LOCATIONS ON FOX CREEK CANALS | FIG 6. |

Alternative 1A: Build seawalls along banks of the canal system

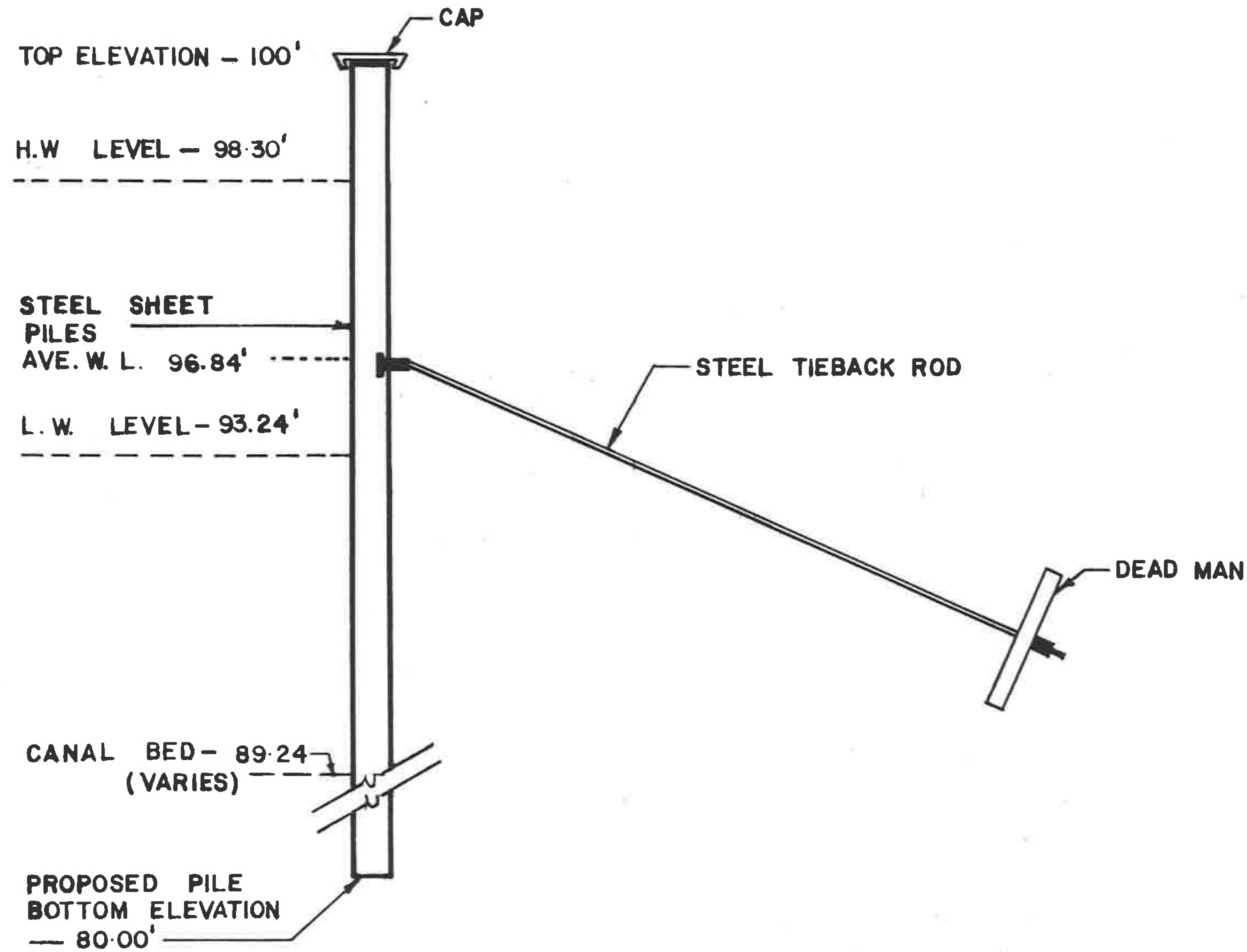
Seawalls are typically steel, concrete or wood, shafts installed in the ground by driving or a combination of drilling and driving. They range from massive concrete retaining wall structure and cellular cofferdams to simpler anchored sheet piling and cantilevered sheet piling.

The selection of an appropriate type of seawall applicable to the Flood Control Study area was based on the availability of space that will cause minimal construction-related impact to the neighboring home owners. The nature of the environment surrounding the Fox Creek study area necessitates the use of a combination of tieback and cantilevered steel sheet piles. However, concrete encasement can reduce the corrosion of steel sheet piles.

Although a protective bituminous coating like tar or other coating can be substituted for concrete encasement, the frequency of its applications may not significantly increase the life of the piles. A combination tieback and cantilevered steel sheet pile seawall proposed for the Fox Creek canal system is shown in Figure 7.

Alternative 2A: Install Lock Gate on Lakewood Canal and Flood Gates on Fox Creek Canal and Philip Canal

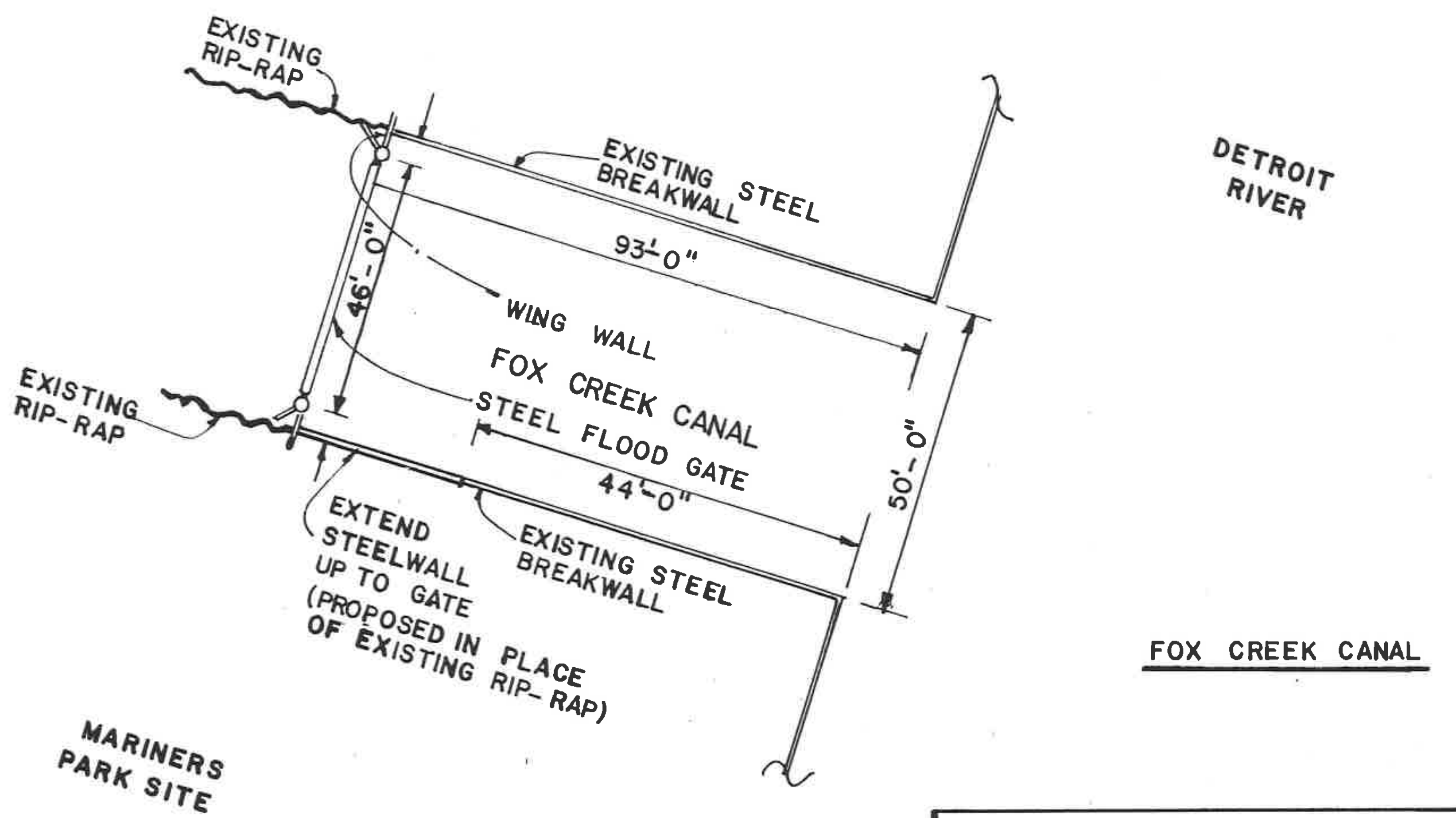
Two specific flood gates were evaluated in addition to installing a lock system in Lakewood Canal. They are guillotine gates (Figure 8) and inflatable rubber dams.




NOT TO SCALE

ALL ELEVATIONS FROM CITY DATUM

| C E D, DETROIT | |
|---|---|
| M M I | JOB NO. 8538 |
| STEEL PILE SYSTEM FOR CANAL SEAWALL | FIG. 7 |




| | |
|---|---|
| CED, DETROIT | |
| MMI | JOB NO. 8538 |
| PROPOSED FLOOD GATE LOCATION ON FOX CREEK CANAL | FIG. 8 |

A rubber dam is a sealed rubber tube installed across the water course and raised by inflating with air, filling with water or using a combination of the two.

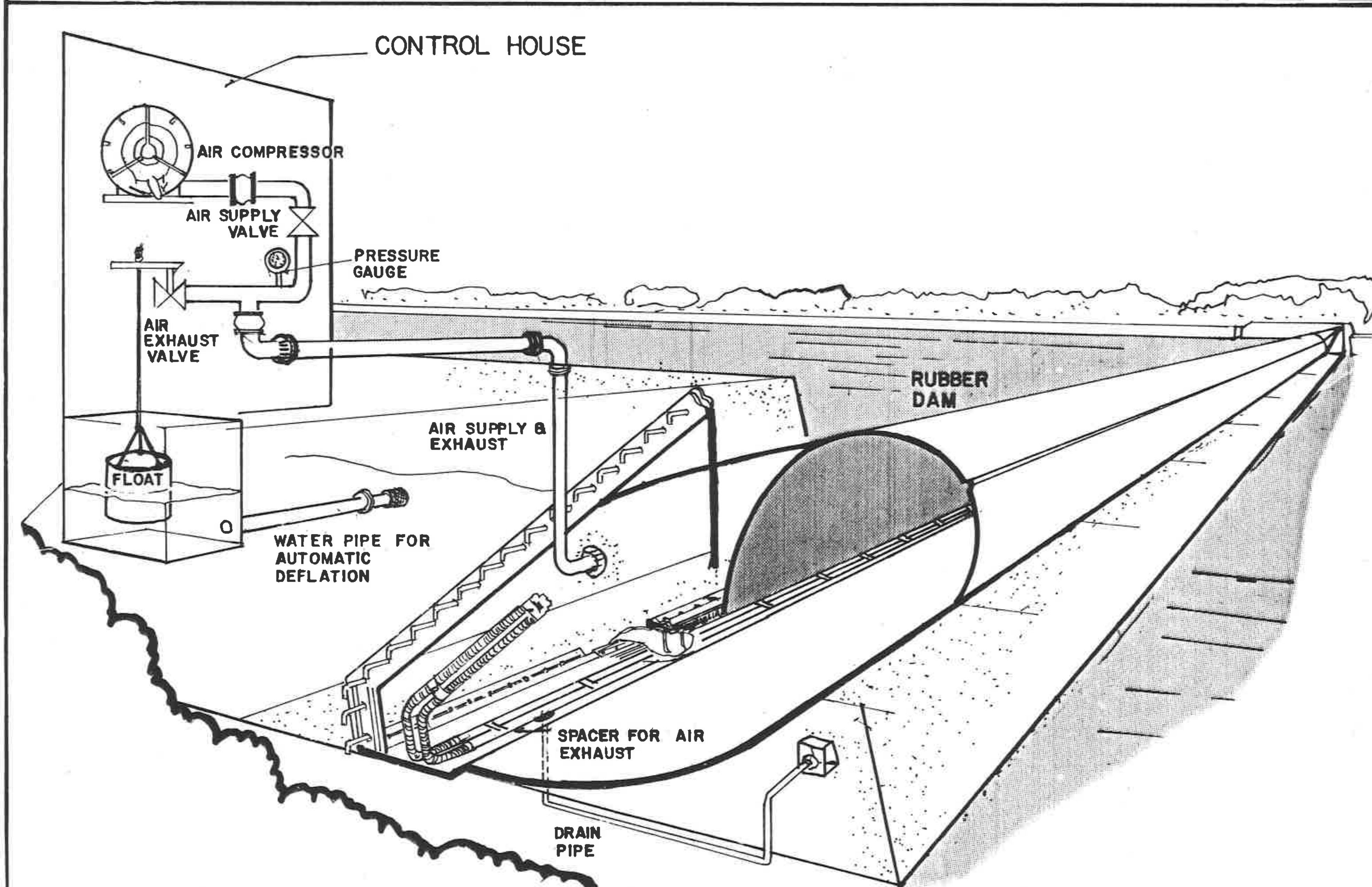
Deflation of the rubber dam is achieved through discharge of its contents. The rubber dam is made up of a rubber and nylon laminated sheet body which is anchored to a simple concrete foundation with clamps and nuts. A control room built close to the rubber dam would house the intake valves, exhaust valves, and compressor.

Although the rubber dam has a lower frequency of maintenance, it is susceptible to vandalism. If the rubber dam body should be penetrated by a bullet or any sharp object, a notch hole would be made in the rubber body. The hole could be repaired with the body fully inflated or the inner pressure could be controlled by operating the blower. Figure 9 details the configuration of a rubber dam.

A guillotine gate consists of a steel structure installed across a water course. Built-in hooks at the top of the steel structure would permit the periodic removal of the gate during low water levels. This alternative requires an on-site or off-site gate storage facility.

Some disadvantages of the guillotine gate are:

1. It incorporates many rigid built-in mechanical parts
2. It often develops distortions or bends that cause it to function improperly.




| C E D, DETROIT | |
|---|---|
| MMI | JOB NO. 8538 |
| INFLATABLE RUBBER DAM | FIG. 9 |

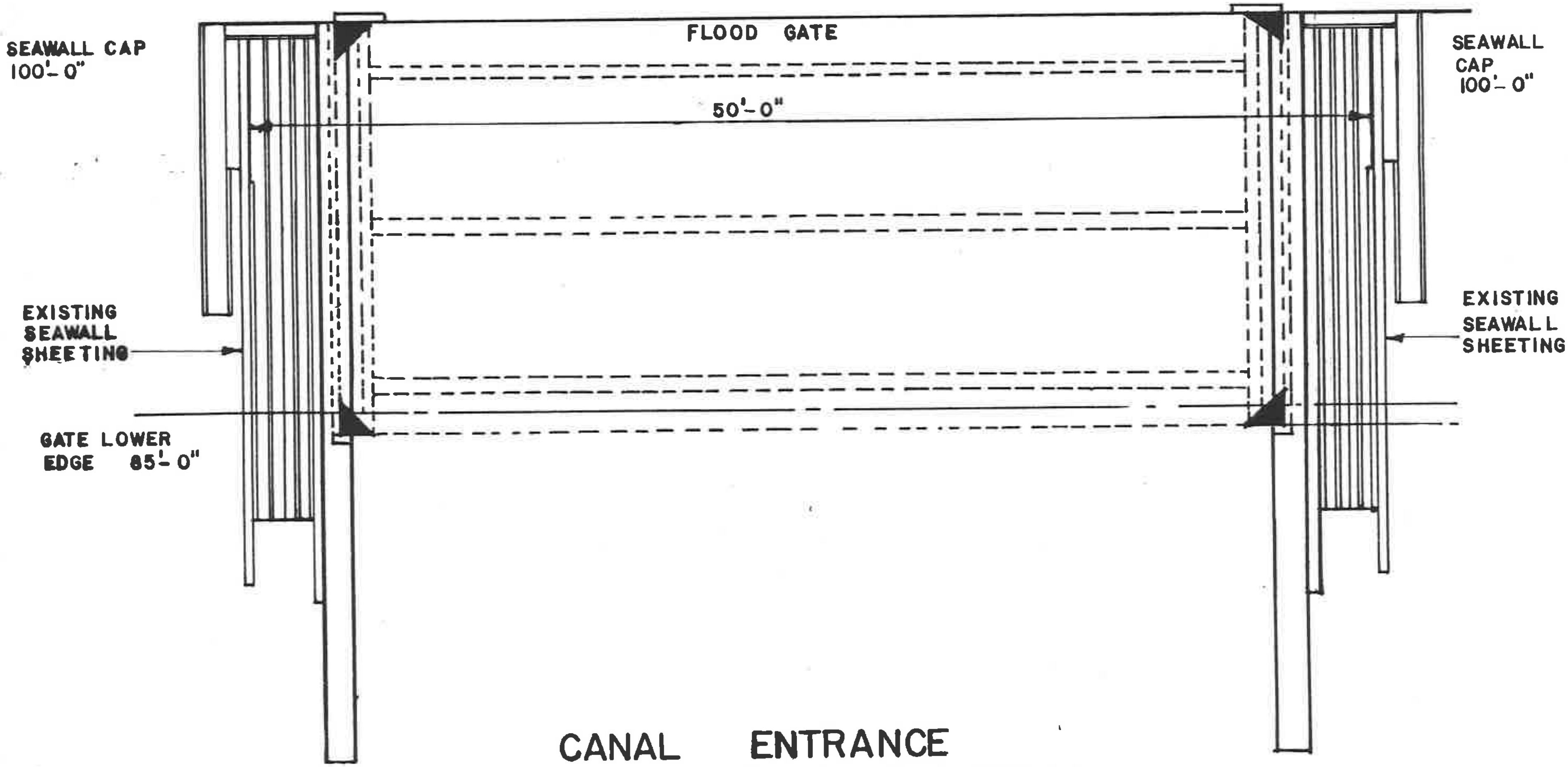
3. The effect of freezing, thawing, wetting, drying, and wave action may cause corrosion or disfiguration that might affect its subsequent closure after opening. See figures 10 and 11 for detailed information.

There will be no boat passage through the canals when the flood gates are in operation. The details of the lock gate are presented under alternative 3A. A pump station as proposed in Figure 12 will maintain desired canal water level.

Alternative 3A: Lock Gates on All Three Canals

The lock gate structure would consist of an enclosed concrete compartment called lock chamber with watertight shutter gates at each end. Water level in the lock chamber would be controlled by two sluice gates built into shutter gates on both ends of the lock chamber. See Figures 12, 13 and 14 for details.

Entry and departure of boats in the lock chamber will be regulated by the shutter gates and the sluice gates. Apart from regulating the boating activities in the canals, the locks also would serve as a protection for the area against flooding with the rise of water level in the Detroit River. The shutter gates will require frequent maintenance and operation. A 32 ft x 120 ft lock chamber designed for a 10-minute cycle time is proposed to handle the boating traffic. A pump station as proposed in Figure 12 will maintain the desired canal water level.

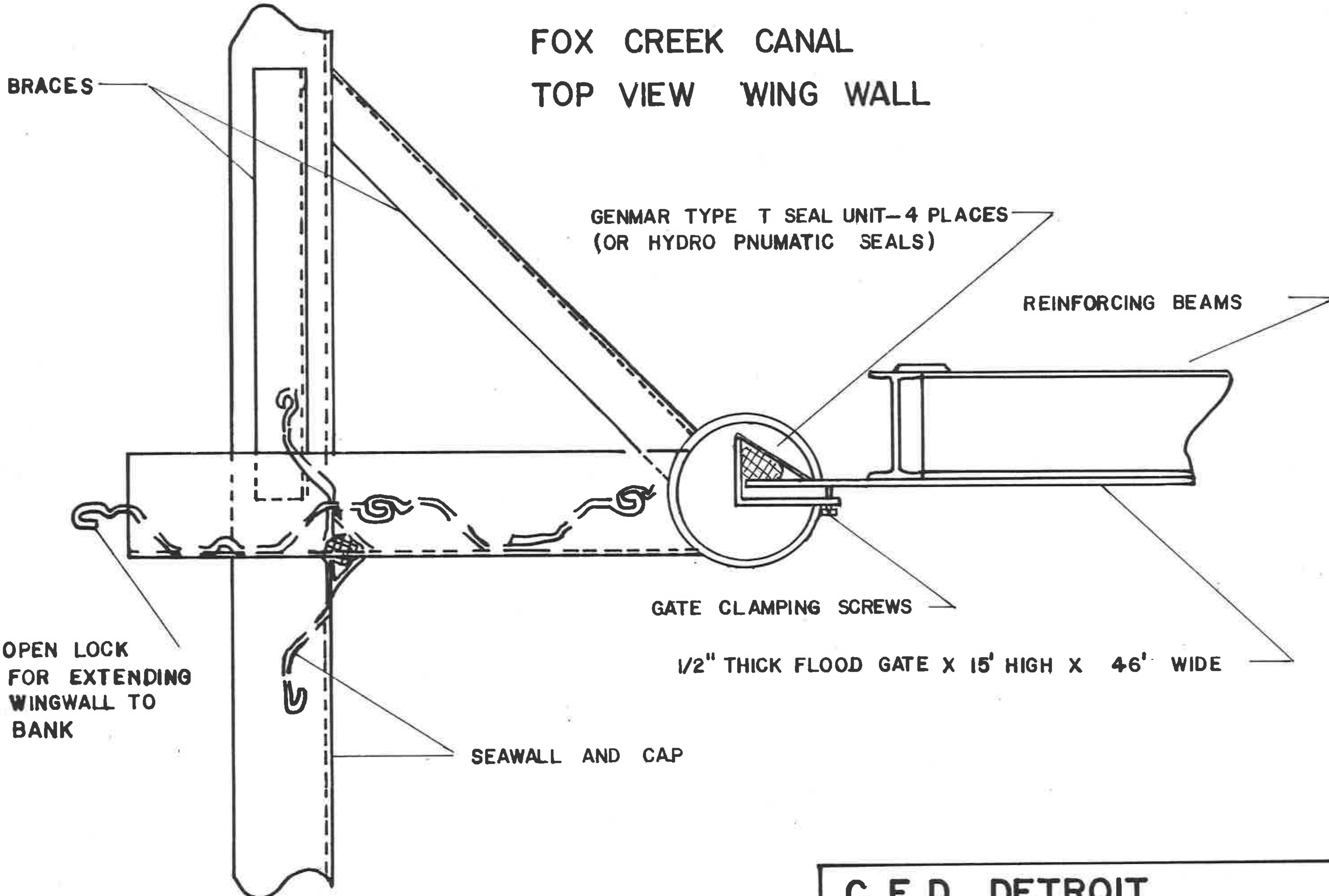



CANAL ENTRANCE
GUILLOTINE GATE SYSTEM

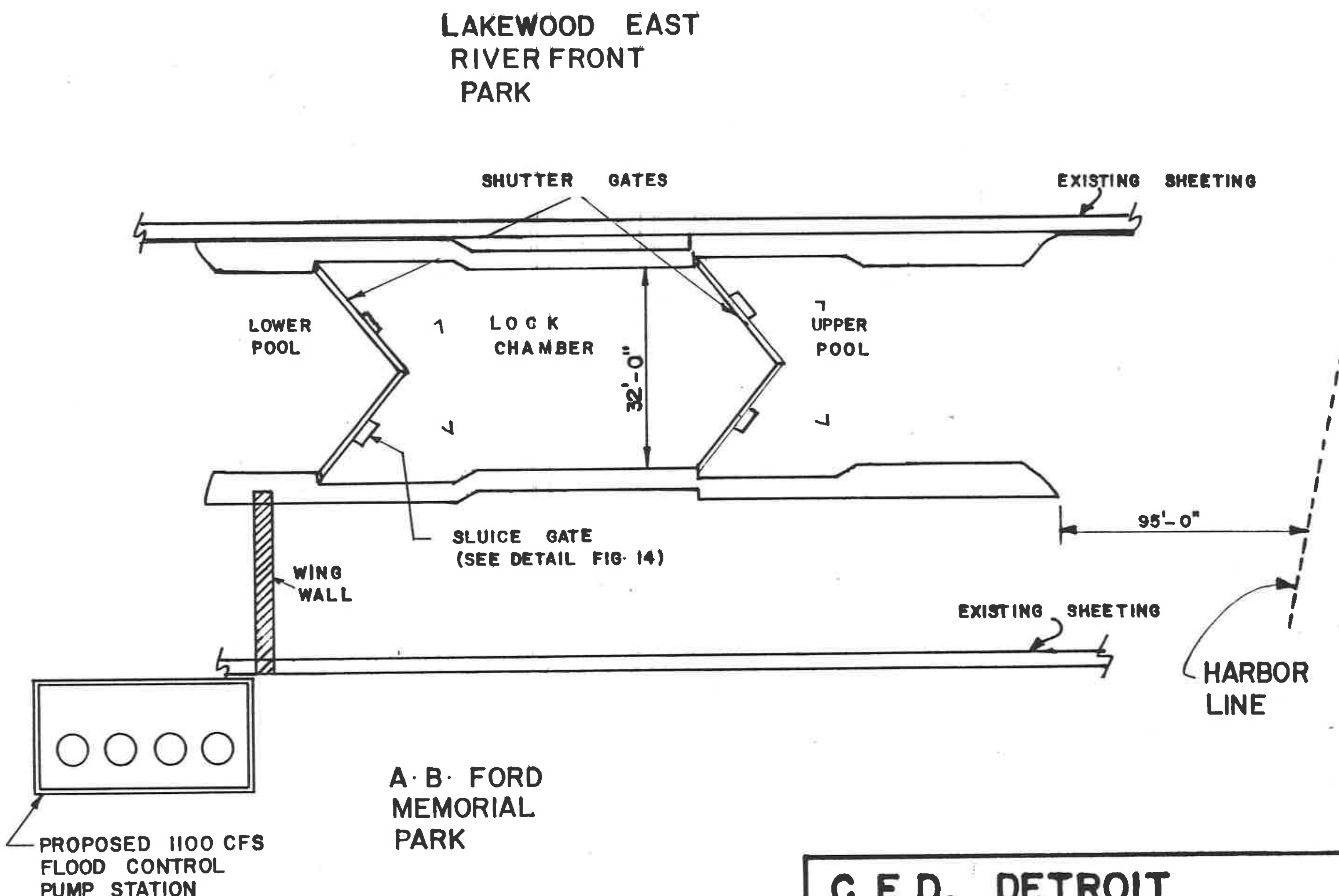
ALL ELEVATIONS
FROM CITY DATUM

| | |
|---|---|
| C E D, DETROIT | |
| M M I | JOB NO. 8538 |
| PROPOSED GUILLOTINE GATE SYSTEM | FIG. 10 |

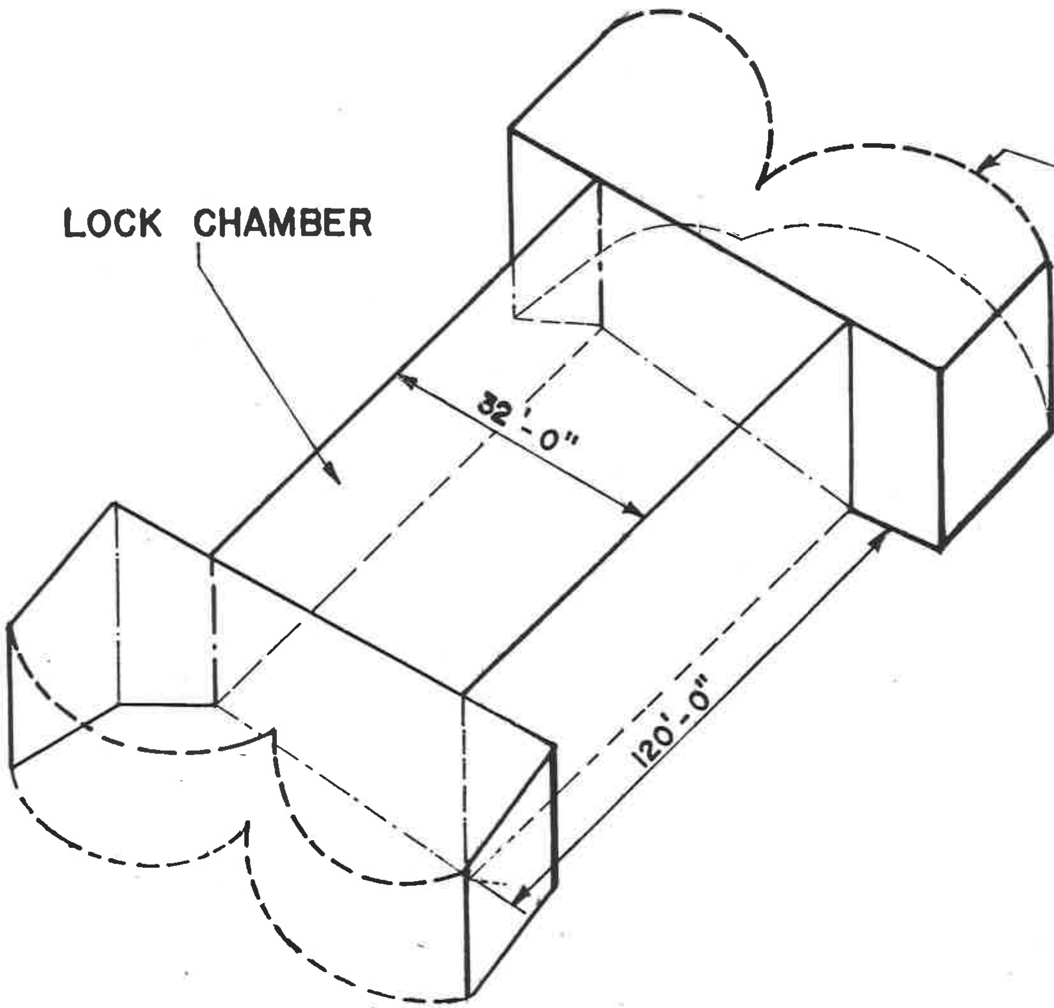
# FOX CREEK CANAL
## TOP VIEW WING WALL



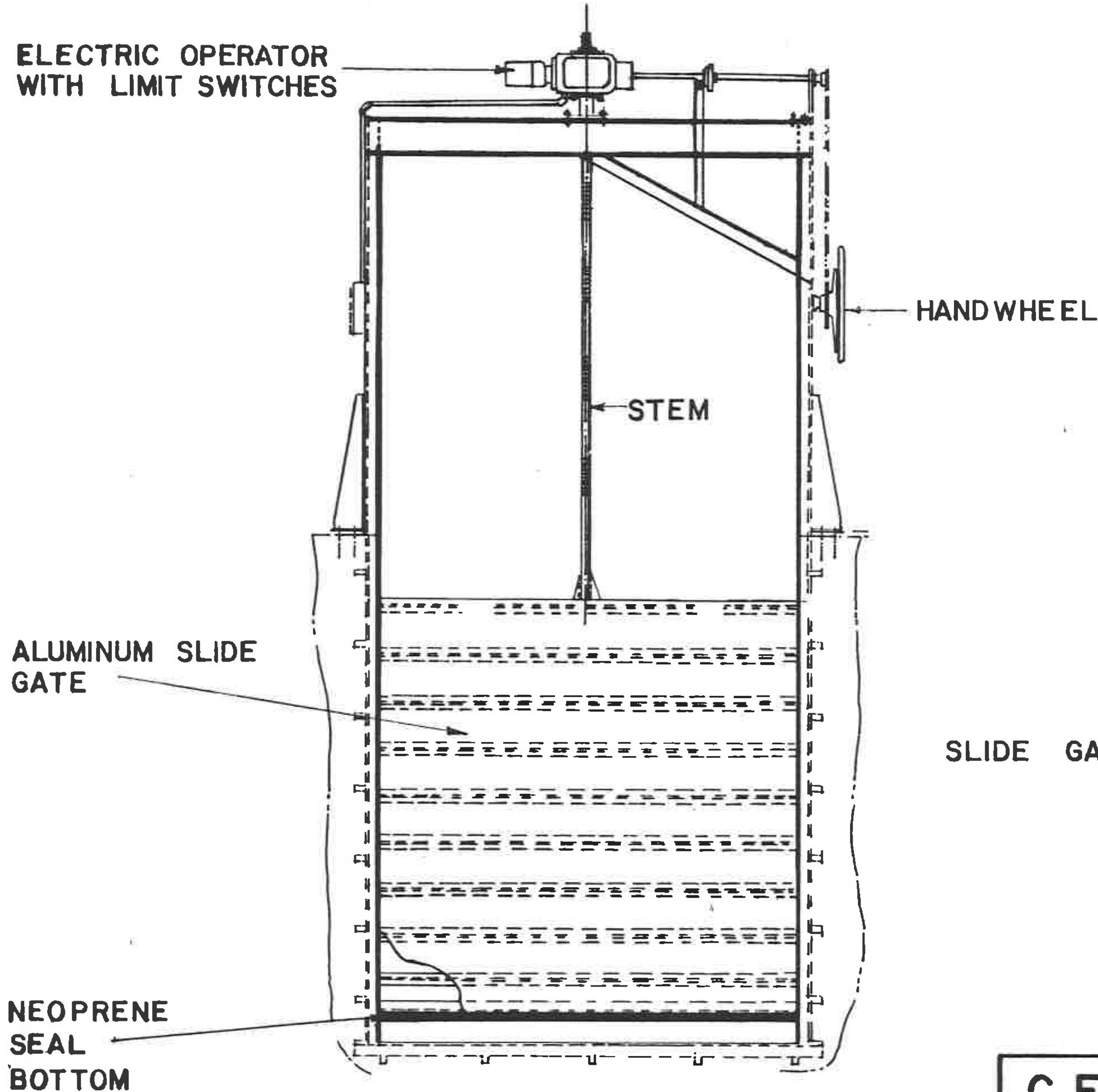

| | |
|---|---|
| C E D, DETROIT | |
| MMI | JOB NO. 8538 |
| GUILLOTINE GATE DETAILS | FIG. 11 |

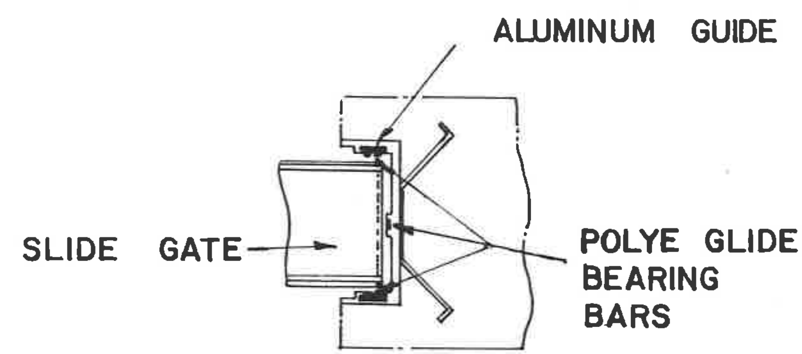



| | |
|---|---|
| C E D, DETROIT | |
| MMI | JOB NO. 8538 |
| PROPOSED LOCK GATE LOCATION ON LAKEWOOD CANAL | FIG. 12 |




| | |
|---|---|
| C E D, DETROIT | |
| M M I | JOB NO. 8538 |
| LOCK GATE MECHANISM | FIG. 13 |




GATE GUIDE DETAIL

| | |
|---|---|
| C E D, DETROIT | |
| M M I | JOB NO. 8538 |
| TYPICAL SLUICE GATE DETAILS | FIG. 14 |

Alternative 4A: Divide Fox Creek Canal to Eliminate Combined Sewer Overflows to the Fox Creek Canals in Addition to Flood Gates on Three Canals

As stated previously, there is a perodic bypass of up to 80.3 million gallons of CSO from Grosse Pointe Park into the Fox Creek Canal. The CSO bypass pollutes the Fox Creek Canal because the canal lacks natural flowing currents.

A possible solution is an alternative that would help separate and convey the bypassed overflow into the Detroit River in addition to installing two guillotine gates and one lock gate to protect from river high water levels.

The structure proposed was 7000 ft long, twin 9.5 ft x 9.5 ft box culvert. Because most of the water that could accumulate into the canal system is bypassed, a small drainage pump station is required to drain leakage from flood gates and storm water accumulation. This condition requires further evaluation.

## 4.2 HARDING CANAL AREA

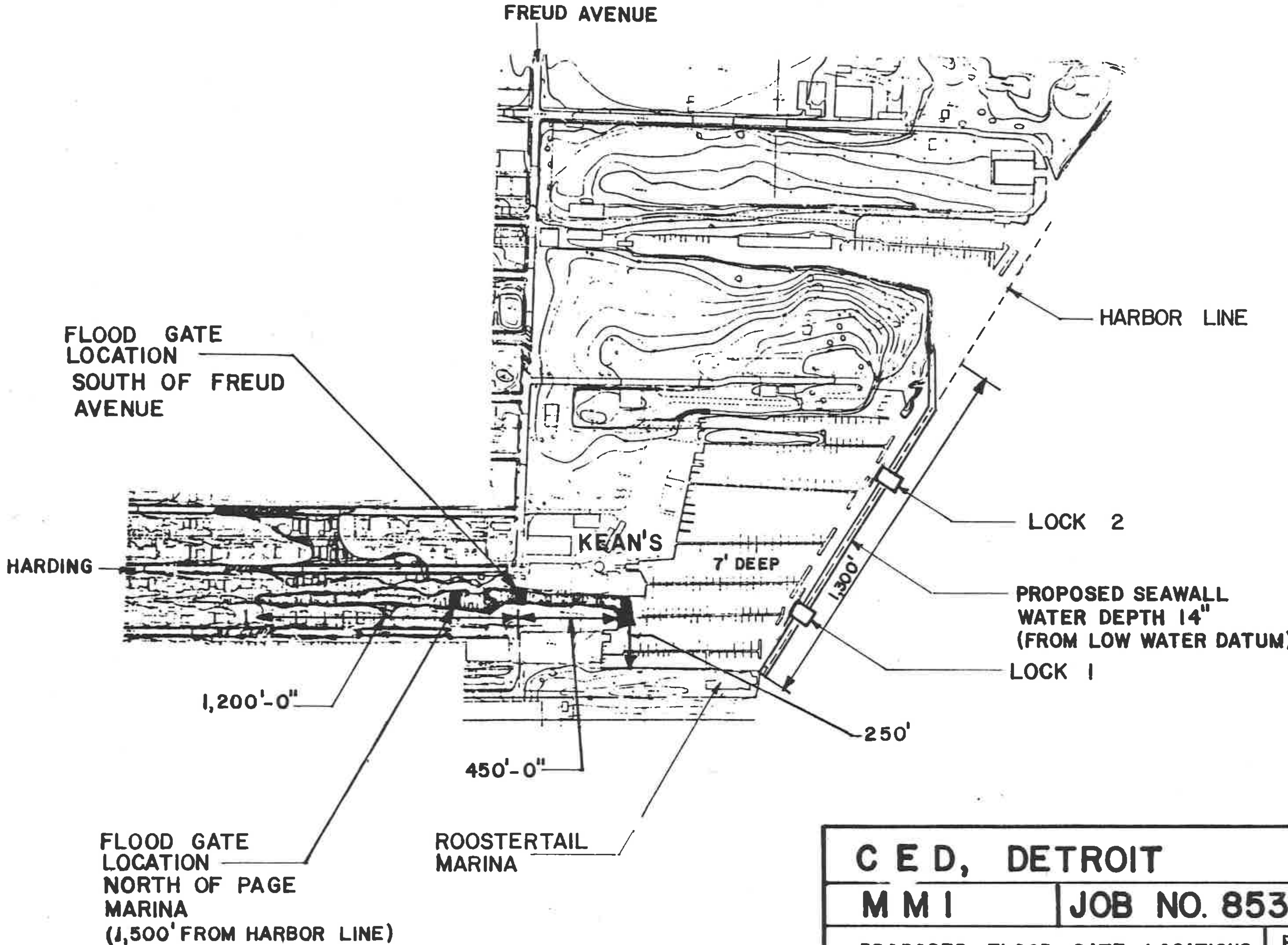
The flood control alternatives for the Harding Canal area are:

1B. Install seawall along harbor line with two lock gates

2B. Install flood control gate south of Freud Avenue

3B. Install flood control gate north of Page Marina.

Proposed flood control gate locations for the Harding Canal area are shown in Figure 15.




| | |
|---|---|
| C E D, DETROIT | |
| M M I | JOB NO. 8538 |
| PROPOSED FLOOD GATE LOCATIONS FOR HARDING CANAL AREA | FIG. 15 |

**Alternative 1B: Install Seawall Along Harbor Line with Two Lock Gates**

Seawall for this alternative is similar to that proposed in Alternative 1A except that the seawall will be exposed to water on both sides and the piles will be longer. Length of the seawall is estimated to be 1300 feet, protecting the Harding Canal, Roostertail Marina and Kean's Marina. Two lock gates are proposed to maintain boat traffic to the Detroit River. An extensive drainage system should be developed to eliminate water accumulation into the protected area.

The type and configuration of the lock gates proposed are of the type described in Alternative 2A.

**Alternatives 2B & 3B: Install Flood Gate North of Freud Avenue or North of Page Marina**

The type of flood gate proposed for this area is very much dependent upon the site condition around the Harding Canal. Two solutions proposed to achieve our desired objective are guillotine gates and inflated rubber dams. The description of each of the above specific measures and their limitations has been described under Section 4.1.

Alternative 3B eliminates adverse impacts on boating activities in the Page Marina. However, these two alternatives are not a complete flood control solution, without building up extensive sections of existing seawalls. This alternative only eliminates overtopping of the Harding Canal banks north of Freud Avenue.

# CHAPTER 5

## Evaluation of Alternatives and Cost Estimates

The alternatives proposed in Chapter 4 have been examined and their cost estimates presented in this chapter. In evaluating each of the alternatives, the methodology and assumptions used are presented as follows.

1. The design life is assumed to be 40 years.
2. A straight line depreciation was applied to the cost of all the alternatives proposed as solutions to the flood problems. In other words, each alternative, would have zero salvage at the end of its estimated service life.
3. An interest rate of 10 percent from EPA municipal construction grant program manual is used.
4. The annual operating and maintenance cost was estimated by assuming 6 percent of each alternative construction cost except for the sheeting alternative.
5. The inflation rate is not taken into account because of the uncertainty in predicting the rate of inflation over such a long period of time.

The cost of construction including costs of structures and auxiliary equipment was made for each alternative based on data obtained from representatives of various equipment manufacturers. An allowance in the construction cost for each alternative was made to reflect the installation cost and other miscellaneous costs not accounted for.

The fact that the alternatives selected as a possible solution have a different life span; the alternative with the lowest first cost may not be the most economical choice for the project.

Consequently, these specific individual projects were evaluated by the appropriate economic analysis tools which attaches economic equivalence to all the alternatives. By attaching economic equivalence to all the alternatives an unbiased judgment can be made in selecting the most cost-effective alternative that can best meet the goal of the City of Detroit. The service life of each alternative was either obtained from various manufacturers' representatives or from historical records of performance.

The cost analysis of proposed alternatives are presented in Tables 4 through 8.

**TABLE 4 COST ESTIMATE FOR ALTERNATIVE 1A**

| DESCRIPTION | ESTIMATED CONSTRUCTION COST ($) | ESTIMATED O&M COST ($) | ESTIMATED SERVICE (YR) | PRESENT WORTH ($) |
|---|---|---|---|---|
| I-- Concrete encased steel sheet piles | $14,438,000 | $72,000/5 yrs | 40 | 14,579,000 |
| II-- Tieback and Cantilevered Steel sheet piles | $ 9,625,000 | $96,000/5 yrs | 40 | 9,813,000 |

**TABLE 5 COST ESTIMATE FOR ALTERNATIVE 2A**

| DESCRIPTION | ESTIMATED CONSTRUCTION COST ($) | ESTIMATED O&M COST ($) | ESTIMATED SERVICE LIFE (YR) | PRESENT WORTH ($) |
|---|---|---|---|---|
| Item 1 | | | | |
| Two Guillotine Gates | 150,000 | 7,500/yr | 20 | 246,000 |
| One lock gate | 1,430,000 | 63,000/yr* | 40 | 2,046,000 |
| Pump Station | 14,800,000 | 68,000/yr** | 40 | 15,465,000 |
| TOTAL | 16,380,000 | 138,500/yr | - | 17,757,000 |
| Item II | | | | |
| Two rubber dams | 850,000 | 42,500/yr | 30 | 1,302,000 |
| One lock gate | 1,430,000 | 63,000/yr* | 40 | 2,046,000 |
| Pump Station | 14,800,000 | 68,000/yr** | 40 | 15,465,000 |
| TOTAL | 17,080,000 | 173,500/yr | - | 18,813,000 |

* Reflects two shifts, one person per shift and six months per year operation.

** Reflects energy, lubrication, maintenance, and operating costs.

**TABLE 6 COST ESTIMATE FOR ALTERNATIVE 3A**

| DESCRIPTION | ESTIMATED CONSTRUCTION COST ($) | ESTIMATED O&M COST ($) | ESTIMATED SERVICE LIFE (YR) | PRESENT WORTH ($) |
|---|---|---|---|---|
| Item I | | | | |
| Three Lock Gates | 2,860,000** | 126,000/yr | 40 | 4,092,000 |
| Pump Station | 14,800,000 | 68,000/yr | 40 | 15,465,000 |
| TOTAL | 17,660,000 | 194,000/yr | - | 19,557,000 |
| Item II | | | | |
| Three Inflatable rubber dams* | 2,050,000 | 105,000/yr | 30 | 3,164,000 |
| Pump Station | 14,800,000 | 68,000/yr | 40 | 15,465,000 |
| TOTAL | 16,850,000 | 173,000/yr | - | 18,629,000 |

*Will not allow boat passage when inflated

**Based on 32 ft x 120 ft lock gate on Lakewood Canal and two smaller gates on Fox Creek and Philip Canals

**TABLE 7 COST ESTIMATE FOR ALTERNATIVE 4A**

| DESCRIPTION | ESTIMATED CONSTRUCTION COST ($) | ESTIMATED O&M COST ($) | ESTIMATED SERVICE LIFE (YR) | PRESENT WORTH ($) |
|---|---|---|---|---|
| Two (7,000)ft long 9.5ft x 9.5ft Box Culverts | 11,200,000 | 56,000/5 yrs | 40 | 11,310,000 |
| Two guillotine gates | 150,000 | 7,500/yr | 20 | 246,000 |
| One lock gate | 1,430,000 | 63,000/yr | 40 | 2,046,000 |
| Drainage Control | | Undetermined* | | |

* Removed from further consideration

## TABLE 8 COST ESTIMATES FOR HARDING CANAL AREA

| DESCRIPTION | ESTIMATED CONSTRUCTION COST ($) | ESTIMATED O&M COST ($) | ESTIMATED SERVICE LIFE (YR) | PRESENT WORTH ($) |
|---|---|---|---|---|
| 1B-- Seawall and two lock gates | 12,750,000 | 200,000 | 40 | 14,706,000 |
| Drainage Control | | Undetermined* | | |
| 2B-- Guillotine gate, south of Freud Avenue** | 81,000 | 4,000/yr | 20 | 132,000 |
| Rubber dam south of Freud Avenue** | 430,000 | 21,500/yr | 30 | 659,000 |
| 3B-- Guillotine Gate north of Page Marina and extend sheeting** | 108,000 | 5,000/yr | 20 | 173,000 |

* Removed from further consideration

** Will not allow boat passage above flood level of canal.

## CHAPTER 6

## CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the significant conclusions and recommendations based on the flood regulation and control study. It must be emphasized here that the flood control study evaluated direct engineering solutions. The study had as its sole purpose the objective comparison of technical, economic, environmental, operational, maintenance and other aspects of the flood control alternatives. A summary of cost estimates for all alternatives studied, is presented in Table 9. A summary comparison of advantages and disadvantages is presented in Tables 10 and 11.

### 6.1 Conclusions

- Spillage over the banks of the Fox Creek canals and the Harding Canal occur whenever the Detroit River water level rises above 97 feet (City of Detroit Datum).
- Recorded extreme water levels of the Detroit River are minimum daily mean (January 25, 1964) 90.9 ft; maximum instantaneous hourly (March 1973) 98.3 ft; and maximum daily mean (June 17, 1973) 97.8 ft.
- A storm surge from northeasterly winds can occur above the Detroit River water level.
- Fox Creek canals serve as a combined sewage overflow (CSO) outlet to the Detroit River and an access canal for recreational boating for the neighboring property owners.
- Natural upstream flow to the Fox Creek canals does not exist except for the flow induced by the Detroit River, downstream.
- CSO flow from Grosse Pointe Park pump station occurs on an average four times per year.
- Six bridges span over the Fox Creek canal system with limited clearances.

- The Detroit Water and Sewerage Department backflushes the Fox Creek canals frequently during dry weather flow by opening the backwater gates north of Jefferson Avenue to replace stagnant water with fresh river water.

- Complete elimination of flooding in the Harding Canal area requires seawall construction along Harbor Line.

- Revetment, although an effective flood control measure, cannot eliminate the flood problems of the study areas without impacting access for the recreational boating.

- Dredging by itself cannot help eliminate the flood problems of the study areas.

- Flow control system by locking or providing gates at the points of flow influx from the Detroit River was evaluated to be an effective flood control method for the study areas. However, the canal system draining requires a pump station which is costly.

- A combination of a tieback and cantilever steel seawall system was evaluated to be the least cost alternative for the Fox Creek canals area. This system also has a minimum construction-related impact to the boat wells and future boating activity.

## 6.2 Recommendations

Based on the goals and objectives of the City of Detroit, it was determined that a combination tieback and cantilever steel seawall system for the Fox Creek canals area and a guillotine gate to the Harding Canal would present a cost-effective solution. Details of sheeting locations, property lines, and boat wells are to be developed.

The estimated cost to implement the recommended flood control alternative for both areas is $9,733,000 with a yearly operational and maintenance cost of $24,200. The seawall system is suitable for staged construction, if budget requirements so dictate.

## TABLE 9 SUMMARY OF COST ESTIMATES

| ALTERNATIVE DESCRIPTION | ESTIMATED CONSTRUCTION COST ($) | ESTIMATED O & M COSTS ($) | PRESENT WORTH VALUE ($) |
|---|---|---|---|
| Alternative 1A | | | |
| I--Concrete encased Sheet piles | 14,438,000 | 72,000/5 yrs | 14,579,000 |
| II--Tieback and cantilever sheet piles | 9,625,000 | 96,000/5 yrs | 9,813,000 |
| Alternative 2A | | | |
| I--Two guillotine gates and one lock gate | 16,380,000 | 138,500/yr | 17,757,000 |
| II--Two inflatable rubber dams and one lock gate | 17,080,000 | 173,500/yr | 18,813,000 |
| Alternative 3A | | | |
| I--Three lock gates | 17,660,000 | 194,000/yr | 19,557,000 |
| II--Three inflatable rubber dams* | 16,850,000 | 173,000/yr | 18,629,000 |
| Alternative 2B | | | |
| I--Guillotine Gate south of Freud Avenue* | 81,000 | 4,000/yr | 132,000 |
| II--Rubber dam South of Freud Avenue* | 430,000 | 21,500/yr | 659,000 |
| Alternative 3B | | | |
| Guillotine gate north of Page Marina* | 108,000 | 5,000/yr | 173,000 |

* Cannot allow boat passage while in flood control position.

** Chapter 5 of report gives Alternatives 4A and 1B details.

TABLE 10 SUMMARY COMPARISON OF ALTERNATIVES FOR FOX CREEK AREA

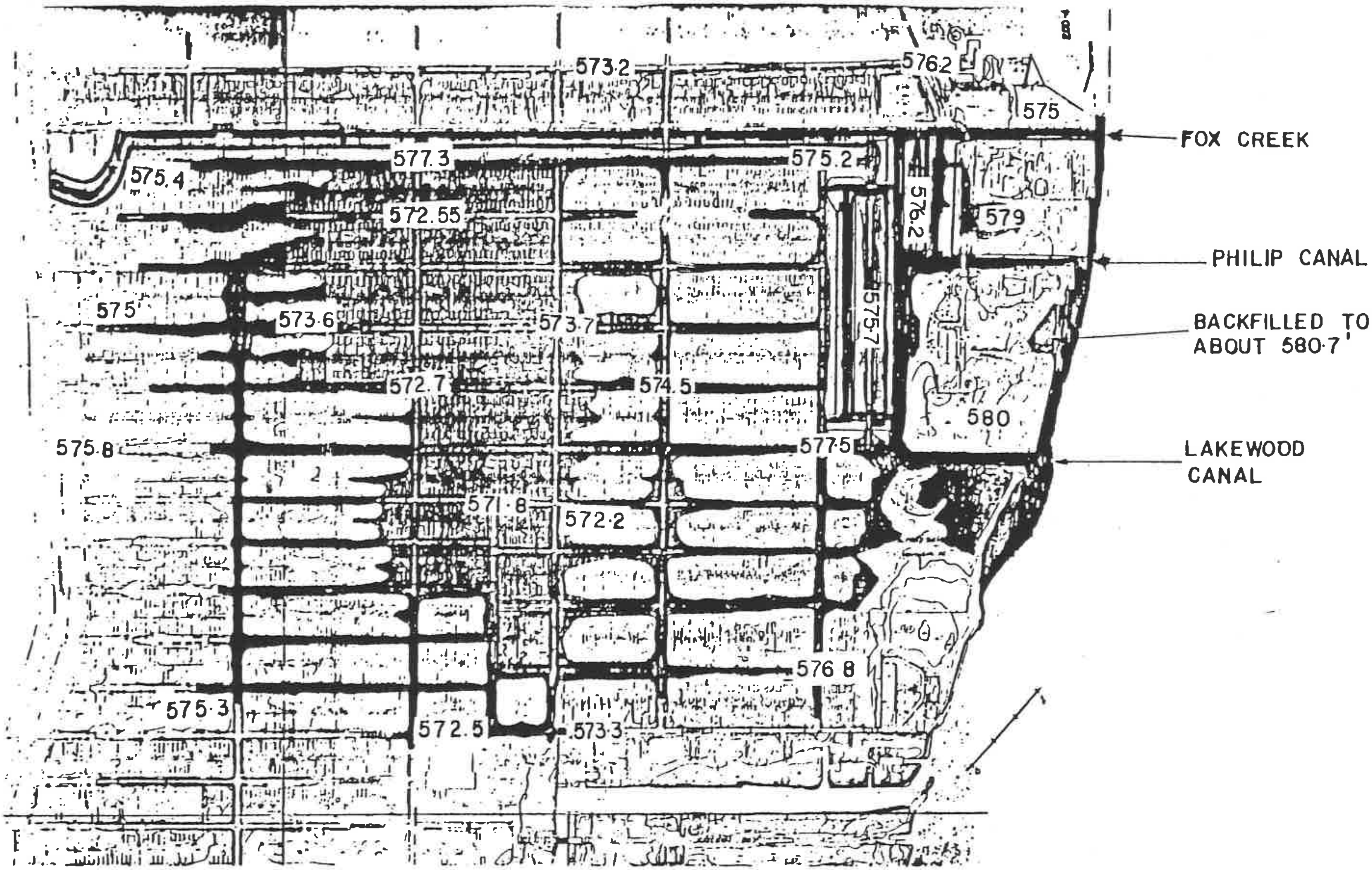
| ALTERNATIVE 1A-I CONCRETE ENCASED STEEL SHEET PILES | ALTERNATIVE 1A-II COMBINATION TIE-BACK AND CANTILEVER STEEL SHEET PILES | ALTERNATIVE 2A-I TWO GUILLOTINE GATES AND ONE LOCK GATE | ALTERNATIVE 2A-II TWO INFLATABLE RUBBER DAMS AND ONE LOCK GATE | ALTERNATIVE 3A-I THREE LOCK GATES | ALTERNATIVE 3A-II THREE INFLATABLE RUBBER DAMS | ALTERNATIVE 4A SEPARATE AND BYPASS SEWER OVERFLOWS IN ADDITION TO FLOOD GATES ON THREE CANALS |
|---|---|---|---|---|---|---|
| Adverse visual effect of seawall | Adverse visual effect of seawall | Disruption to recreational boating activities | Disruption to recreational boating activities | No impact on existing boat routing and minimum disruption to recreational boating activities | No river access for boats during water level at or above flood level | Disruption to recreational boating activities |
| Temporary adverse noise and physical disruption to residents | Temporary adverse noise and physical disruption to residents, less than that of IA-I | Increased operational, inspection, and repair costs | Increased operational, inspection, and repair costs | Reduced noise and physical disruption to residents | Susceptible to vandalism, but can be repaired | Increased operational, inspection and repair costs |
| Very difficult to construct through existing boat wells | Compared to 1A-I, easier to construct through existing boat wells | No noise and physical disruption to residents | No noise and physical disruption to residents | Increases the recreational value of neighboring parks | Reduced noise and physical disruption to residents | Temporary adverse noise and physical disruption to residents |
| Absence of flood damage and inconvenience for residents | Absence of flood damage and inconvenience for residents | Increases the recreational value of neighboring parks. | Increases the recreational value of neighboring parks | Higher operational inspection and repair costs | Higher operational, inspection, and repair costs | Requires additional study on drainage |
| Long life | Exposed to corrosion effects. Coating may be required | Absence of flood damage and inconvenience for residents | Rubber dams are susceptible to vandalism. | Absence of flood damage and inconvenience for residents | Absence of flood damage and inconvenience for residents | Absence of flood damage and inconvenience for residents |
| Minimized corrosion | Higher O & M costs | Control of water level in entire canal system at an optimum level | Absence of flood damage and inconvenience for residents | Control of water level in entire canal system at an optimum level | Control of water level in entire canal system at an optimum level | Control of water level in entire canal system at an optimum level |
| Minimum O&M costs | | | Control of water level in entire canal system at an optimum level | | | Improved canal system water quality |
| | | | Ease in operation | | | |

## TABLE 11 SUMMARY COMPARISON OF ALTERNATIVES FOR HARDING CANAL AREA

| ALTERNATIVE 1B SEAWALL ALONG HARBOR LINE WITH TWO LOCK GATES | ALTERNATIVE 2B-I GUILLOTINE GATE SOUTH OF FREUD AVENUE | ALTERNATIVE 2B-II RUBBER DAM SOUTH OF FREUD AVENUE | ALTERNATIVE 3B GUILLOTINE GATE NORTH OF PAGE MARINA |
|---|---|---|---|
| Totally eliminates flood damage and inconvenience for residential and commercial properties | Disruption to boating activities of residents and Page Marina. | Disruption to boating activities of residents and Page Marina. | Disruption to boating activities of residents only |
| Restricts recreational boating activity | Increased operational, inspection and repair costs. | Ease in operation | Increased operational, inspection, and repair costs. |
| Requires additional study on drainage | Absence of flood damage for residents. | Increased operational, inspection, and repair costs. | Absence of flood damage for residents. |
| Control of water level north of harbor line. | | Absence of flood damage for residents | |
| | | Susceptible to vandalism but can be repaired. | |

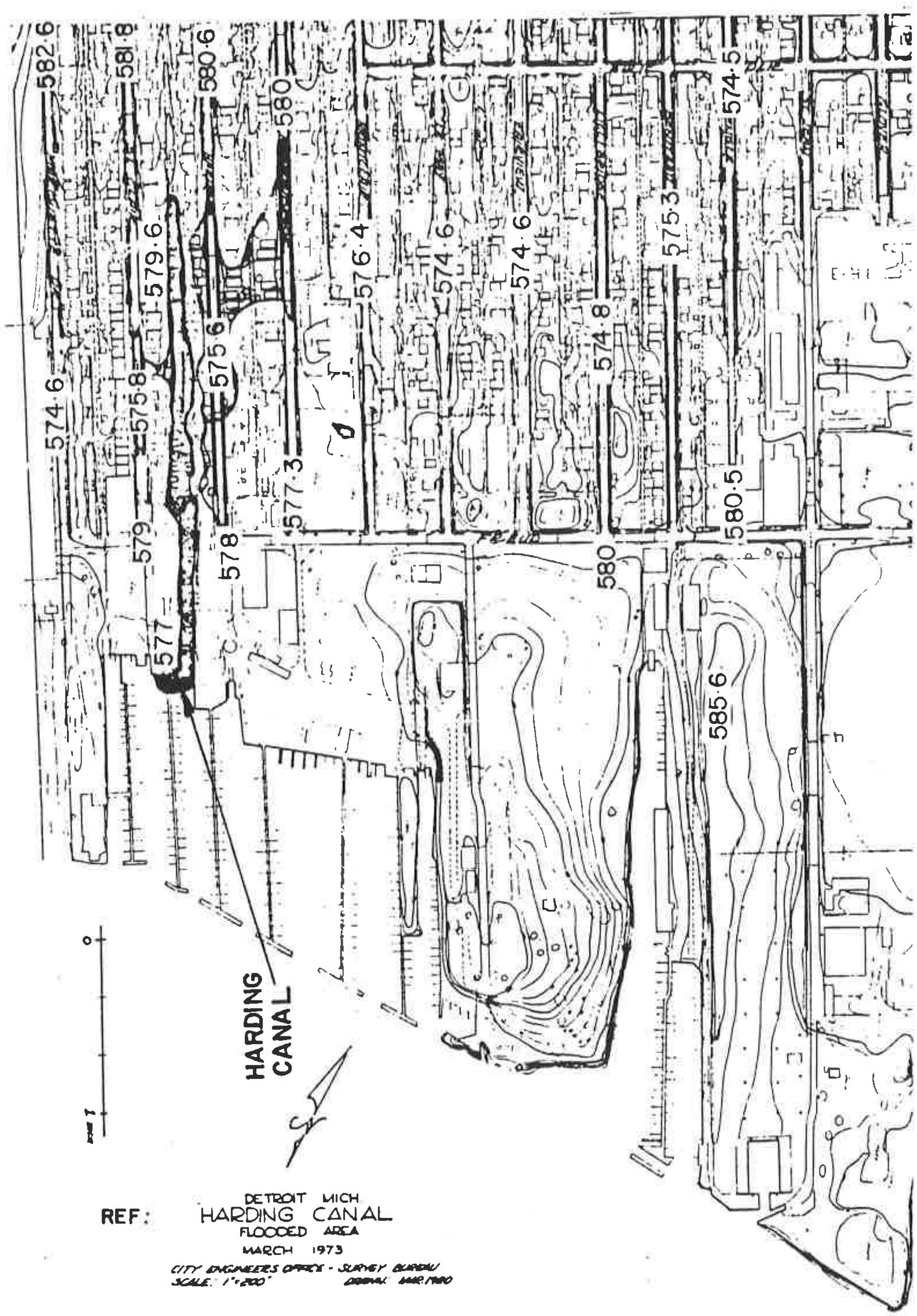
## APPENDIX A

## SELECTED TOPOGRAPHIC ELEVATIONS FOR THE FLOOD CONTROL STUDY AREAS



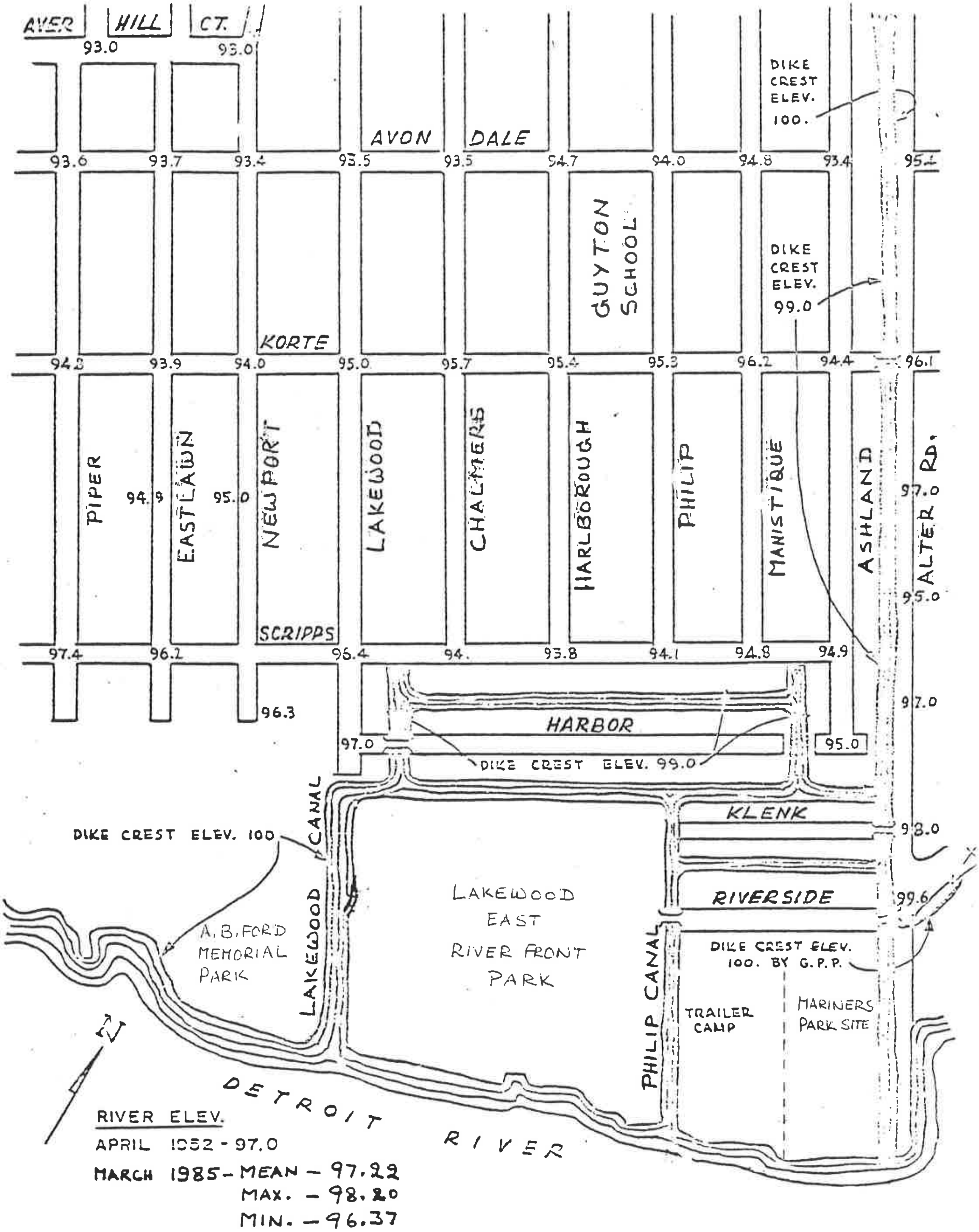

**REF:** FOX CREEK AND HARBOR ISLE FLOODED AREA, MARCH 1973, BY CITY ENGINEERS OFFICE SURVEY BUREAU

SELECTED TOPOGRAPHIC ELEVATIONS IN THE FLOOD CONTROL STUDY AREA A




M261-FP3

SELECTED ELEVATIONS IN THE
FLOOD CONTROL STUDY AREA


AVER HILL CT.
93.0
93.0
DIKE CREST ELEV. 100.
AVON DALE
93.6
93.7
93.4
93.5
93.5
94.7
94.0
94.8
93.4
GUYTON SCHOOL
DIKE CREST ELEV. 99.0
KORTE
94.3
93.9
94.0
95.0
95.7
95.4
95.3
96.2
94.4
96.1
PIPER
94.9
EASTLAWN
95.0
NEWPORT
LAKEWOOD
CHALMERS
HARLBOROUGH
PHILIP
MANISTIQUE
ASHLAND
ALTER RD.
97.0
95.0
SCRIPPS
97.4
96.2
96.4
94.
93.8
94.1
94.8
94.9
96.3
97.0
HARBOR
97.0
95.0
DIKE CREST ELEV. 99.0
CANAL
KLENK
98.0
DIKE CREST ELEV. 100
LAKEWOOD EAST RIVER FRONT PARK
RIVERSIDE
99.6
A.B. FORD MEMORIAL PARK
LAKEWOOD
DIKE CREST ELEV. 100. BY G.P.P.
PHILIP CANAL
TRAILER CAMP
MARINERS PARK SITE
N
DETROIT RIVER
RIVER ELEV.
APRIL 1952 - 97.0
MARCH 1985 - MEAN - 97.22
MAX. - 98.20
MIN. - 96.37

# APPENDIX B

## WATER LEVELS AT WINDMILL POINTE, DETROIT, MICHIGAN ON THE DETROIT RIVER

U. S. DEPARTMENT OF COMMERCE
NOAA - NOS ROCKVILLE, MARYLAND
GREAT LAKES WATER LEVELS, C234

MAXIMUM AND MINIMUM ELEVATIONS
WATER LEVELS IN FEET, IGLD (1955)

Station 4049 : Windmill Point, Detroit, Michigan on the Detroit River

| | MAXIMUM STAGES | | | | | | MINIMUM STAGES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR | MONTHLY MEAN | | DAILY MEAN | | INSTANTANEOUS (Hourly) | | MONTHLY MEAN | | DAILY MEAN | | INSTANTANEOUS | |
| 1960 | AUG | 574.16 | 18 JUN | 574.32 | 1 SEP | 574.80 | FEB | 571.80 | 7 FEB | 571.26 | 8 FEB | 571.15 |
| 1961 | MAY | 573.89 | 14 JUN | 574.08 | 7 JUL | 574.83 | DEC | 572.52 | 7 DEC | 572.05 | 5 DEC | 571.63 |
| 1962 | AUG | 572.52 | 12 JUN | 573.44 | 12 JUN | 573.77 | FEB | 571.38 | 5 FEB | 571.02 | 5 FEB | 570.97 |
| 1963 | JUN | 572.48 | 12 MAY | 572.68 | 10 JUN | 573.36 | DEC | 571.25 | 14 DEC | 570.69 | 13 DEC | 570.51 |
| 1964 | MAY | 571.85 | 13 MAY | 572.04 | 19 MAY | 572.40 | FEB | 570.45 | 25 JAN | 569.36 | 5 MAR | 568.94 |
| 1965 | JUN | 572.36 | 25 DEC | 572.69 | 25 DEC | 572.92 | JAN | 570.57 | 28 JAN | 569.63 | 27 JAN | 569.52 |
| 1966 | JUN | 573.08 | 27 APR | 573.86 | 27 APR | 574.25 | NOV | 571.99 | 4 NOV | 571.49 | 3 NOV | 570.99 |
| 1967 | JUN | 573.53 | 1 AUG | 573.79 | 11 JUL | 573.99 | FEB | 572.10 | 16 FEB | 571.75 | 16 FEB | 571.13 |
| 1968 | JUL | 573.93 | 26 JUN | 574.38 | 25 JUN | 574.78 | JAN | 573.04 | 5 DEC | 572.52 | 5 DEC | 571.98 |
| 1969 | JUL | 575.06 | 8 JUL | 575.26 | 4 JUL | 575.45 | JAN | 573.34 | 31 DEC | 572.82 | 20 MAR | 572.59 |
| 1970 | JUL | 574.34 | 26 JUN | 574.51 | 19 APR | 574.70 | JAN | 572.57 | 9 JAN | 572.05 | 9 JAN | 571.99 |
| 1971 | JUN | 574.64 | 11 JUL | 574.76 | 29 JUN | 574.98 | FEB | 573.47 | 30 JAN | 572.79 | 15 DEC | 572.56 |
| 1972 | JUL | 575.08 | 14 NOV | 575.66 | 14 NOV | 576.29 | FEB | 573.90 | 25 JAN | 573.31 | 25 JAN | 572.89 |
| 1973 | JUN | 576.04 | 17 JUN | 576.26 | 17 MAR | 576.76 | NOV | 574.75 | 6 DEC | 574.25 | 5 DEC | 573.84 |
| 1974 | MAY | 575.86 | 20 MAY | 576.25 | 20 MAY | 576.34 | NOV | 574.55 | 15 NOV | 573.92 | 15 NOV | 573.64 |
| 1975 | JUN | 575.44 | 25 JUN | 575.71 | 31 AUG | 575.92 | NOV | 574.44 | 1 DEC | 573.77 | 10 NOV | 573.12 |
| 1976 | MAY | 575.56 | 25 APR | 575.96 | 25 APR | 576.45 * | DEC | 573.59 | 30 DEC | 573.21 | 30 NOV | 573.10 |
| 1977 | MAY | 574.28 | 31 DEC | 574.79 | 8 MAY | 574.99 | NOV | 573.62 | 11 NOV | 573.10 | 2 DEC | 572.69 |
| 1978 | MAY | 574.61 | 6 JAN | 574.88 | 6 APR | 575.06 | DEC | 573.32 | 21 DEC | 572.98 | 17 NOV | 572.39 |
| 1979 | JUL | 574.93 | 13 JUL | 575.10 | 25 MAY | 575.42 | MAR | 573.82 | 6 APR | 573.25 | 5 APR | 572.40 |

Remarks: * Indicates, for 1970-1979, at Least one whole month of data missing.

REVISED COPY
B1

U.S. Dep tment of Commerce
NOAA, NC Rockville, Maryland
Great La..s Water Levels, N/OMA12

Water Levels in Feet, IGLD (1955)
D3,F1

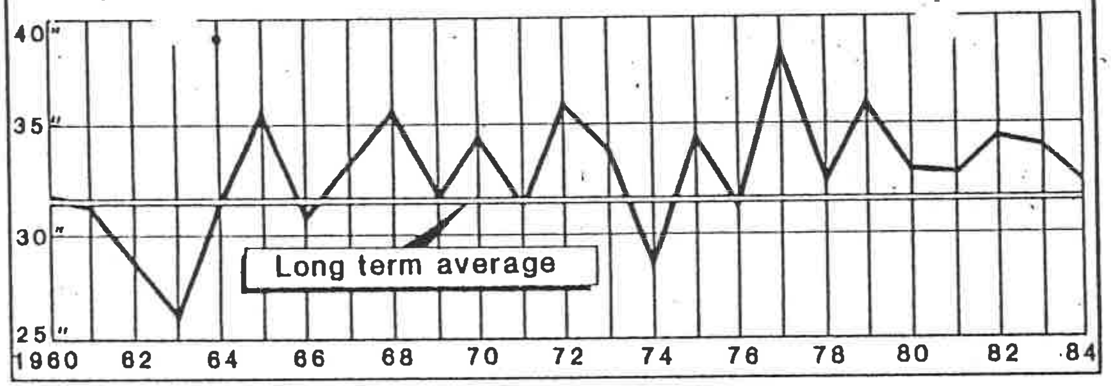
Station 4049 : Windmill Point, Detroit, Michigan on Detroit River , YEAR 1985

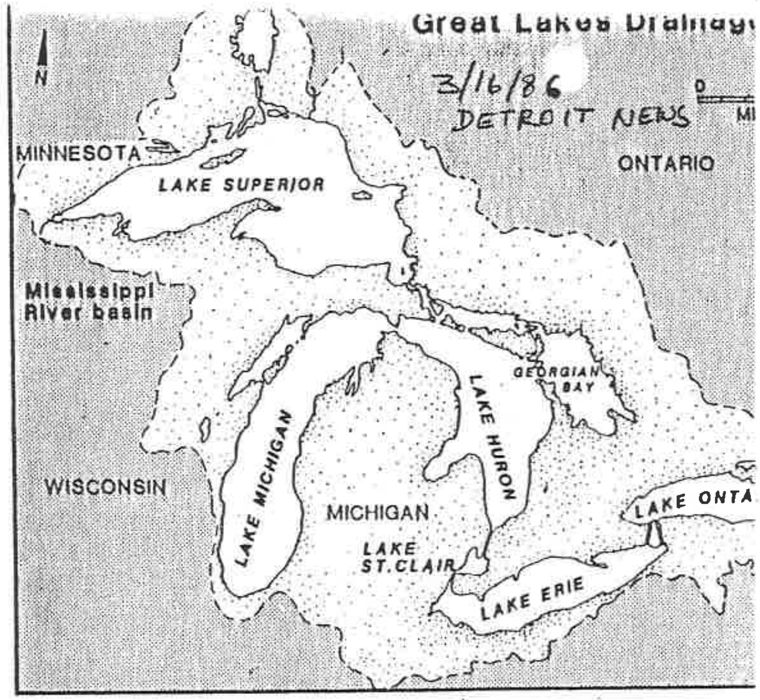
| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 575.09 | 574.98 | 575.70 | 575.52 | 576.07 | 575.95 | 575.93 | | | | | |
| 2 | 575.18 | 574.98 | 575.72 | 575.80 | 576.14 | 576.05 | 575.90 | | | | | |
| 3 | 575.24 | 574.97 | 575.82 | 575.80 | 576.02 | 576.09 | 575.90 | | | | | |
| 4 | 575.17 | 574.91 | 575.86 | 576.09 | 575.95 | 576.02 | 575.84 | | | | | |
| 5 | 575.08 | 574.92 | 575.29 | 576.05 | 575.86 | 575.97 | 575.82 | | | | | |
| 6 | 574.90 | 574.91 | 575.49 | 575.28 | 575.89 | 575.96 | 575.79 | | | | | |
| 7 | 574.74 | 574.90 | 575.50 | 576.05 | 575.95 | 575.97 | 575.81 | | | | | |
| 8 | 574.74 | 574.94 | 575.44 | 576.11 | 576.02 | 575.94 | 575.82 | | | | | |
| 9 | 574.81 | 575.00 | 575.59 | 576.12 | 575.92 | 575.78 | 575.86 | | | | | |
| 10 | 574.96 | 575.01 | 575.69 | 575.92 | 575.90 | 575.91 | 575.91 | | | | | |
| 11 | 574.88 | 575.03 | 575.75 | 576.13 | 575.92 | 576.12 | 575.87 | | | | | |
| 12 | 574.75 | 575.09 | 575.39 | 576.15 | 575.87 | 575.95 | 575.89 | | | | | |
| 13 | 574.66 | 575.15 | 575.74 | 576.12 | 575.90 | 575.86 | 575.81 | | | | | |
| 14 | 574.64 | 575.07 | 575.68 | 576.04 | 575.96 | 575.91 | 575.75 | | | | | |
| 15 | 574.59 | 575.06 | 575.74 | 576.02 | 575.94 | 575.90 | 575.89 | | | | | |
| 16 | 574.66 | 575.05 | 575.59 | 576.09 | 575.92 | 575.91 | 575.93 | | | | | |
| 17 | 574.65 | 574.97 | 575.70 | 576.09 | 576.00 | 575.91 | 575.94 | | | | | |
| 18 | 574.52 | 574.96 | 575.68 | 575.91 | 575.92 | 575.78 | 575.90 | | | | | |
| 19 | 574.53 | 574.92 | 575.60 | 575.98 | 575.83 | 575.85 | 575.82 | | | | | |
| 20 | 574.39 | 574.98 | 575.67 | 575.99 | 575.84 | 575.89 | 575.87 | | | | | |
| 21 | 574.43 | 574.95 | 575.71 | 575.97 | 576.00 | 575.90 | 575.80 | | | | | |
| 22 | 574.59 | 574.94 | 575.70 | 575.95 | 575.98 | 575.79 | 575.90 | | | | | |
| 23 | 574.71 | 575.10 | 575.68 | 575.96 | 575.98 | 575.79 | 575.91 | | | | | |
| 24 | 574.85 | 575.38 | 575.73 | 575.94 | 575.92 | 575.93 | 575.82 | | | | | |
| 25 | 574.97 | 575.64 | 575.69 | 575.92 | 575.89 | 575.94 | 575.70 | | | | | |
| 26 | 575.06 | 575.75 | 575.59 | 576.03 | 575.89 | 575.94 | 575.86 | | | | | |
| 27 | 575.03 | 575.84 | 575.52 | 576.04 | 575.97 | 575.98 | 575.85 | | | | | |
| 28 | 575.01 | 575.78 | 575.64 | 576.04 | 576.07 | 575.95 | 575.75 | | | | | |
| 29 | 575.02 | | 575.82 | 576.01 | 576.00 | 575.92 | 575.77 | | | | | |
| 30 | 575.01 | | 576.07 | 575.99 | 575.94 | 575.97 | 575.85 | | | | | |
| 31 | 574.99 | | 576.22 | | 575.76 | | 575.89 | | | | | |
| MEAN | 574.83 | 575.11 | 575.68 | 575.97 | 575.94 | 575.93 | 575.85 | | | | | |
| MAX. | 575.38 | 575.91 | 576.66 | 576.50 | 576.26 | 576.31 | 576.26 | | | | | |
| | 0500/01 | 2100/27 | 0600/31 | 2100/26 | 0400/02 | 0400/03 | 2200/22 | | | | | |
| MIN. | 574.27 | 574.86 | 574.83 | 574.92 | 575.28 | 575.59 | 575.27 | | | | | |
| | 2100/20 | 0300/19 | 0400/12 | 0500/06 | 2000/31 | 1600/09 | 0100/14 | | | | | |

* Indicates Less than 90% of the Hourly Data Available.
/ Indicates No Data.

B 2

## Aug. annual precipitation in Great Lakes basin

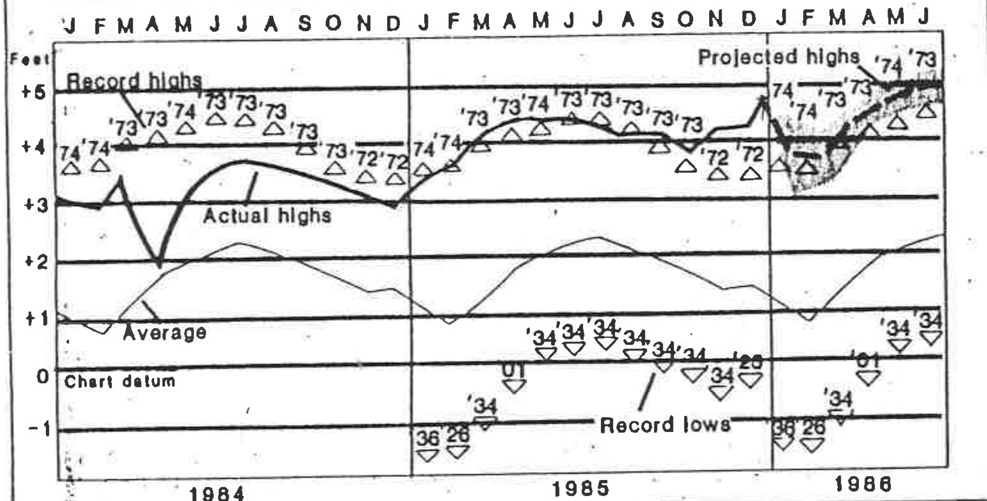



## Growing flood threat

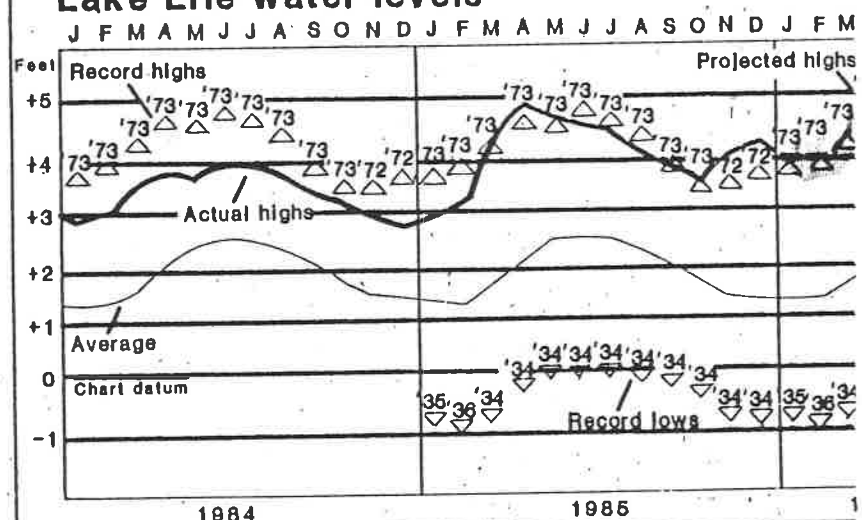
Since the late 1960s, the 300,000-square-mile Great Lakes' basin has received more precipitation than in the past. Much of the rain and snow fell into the lakes, which collect runoff from the rest of the basin. Cooler temperatures in the last decade have reduced evaporation of water from the lakes, contributing to a rise in water levels.

## Lake St.Clair water levels




In Metro Detroit, Lakes St. Clair and Erie stand at record levels and are expected to rise another 10 inches by late June. Some scientists speculate that the present levels are normal and that those recorded in the last 100 years were the result of an extended dry spell.

## Lake Erie water levels




NEWS ARTWORK/HANK

Storm winds from the east could drive the swollen lake waters into flood shore. That threat has prompted a variety of emergency measures in along the shoreline.

DAILY WATER LEVELS

WINDMILL POINT, DETROIT, MI. ON DETROIT RIVER

| DAY | MONTH | MONTHLY MEANS | | | | | | | | | | | | HIGH DAY | TIME | ELEV. | LOW DAY | TIME | ELEV. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 10 | JAN 73 | | 574.83 | 575.21 | 575.43 | 574.93 | 575.12 | 575.28 | 575.33 | 575.32 | 575.19 | 575.12 | | | | | | | |
| 11 20 | JAN 73 | | 575.08 | 575.09 | 575.09 | 575.07 | 574.93 | 574.78 | 574.85 | 574.94 | 574.86 | 574.98 | | | | | | | |
| 21 31 | JAN 73 | 575.09 | 575.08 | 575.11 | 574.92 | 575.07 | 575.08 | 575.16 | 575.19 | 575.21 | 575.18 | 575.05 | 575.35 | 14 | 1000 | 575.98 | 4 | 0400 | 574.61 |
| 1 10 | FEB 73 | | 574.94 | 575.17 | 575.21 | 575.28 | 575.57 | 575.53 | 575.39 | 575.35 | 575.26 | 575.23 | | | | | | | |
| 11 20 | FEB 73 | | 575.16 | 575.00 | 574.84 | 574.77 | 574.69 | 574.70 | 574.79 | 574.77 | 574.72 | 574.74 | | | | | | | |
| 21 28 | FEB 73 | 575.02 | 574.74 | 574.76 | 574.85 | 574.88 | 574.99 | 575.04 | 575.06 | 575.01 | | | | 6 | 0200 | 575.65 | 15 | 1600 | 574.40 |
| 1 10 | MAR 73 | | 574.96 | 574.94 | 574.97 | 574.98 | 575.09 | 575.14 | 575.22 | 575.30 | 575.38 | 575.40 | | | | | | | |
| 11 20 | MAR 73 | | 575.42 | 575.44 | 575.61 | 575.72 | 575.55 | 575.87 | 576.07 | 575.68 | 575.94 | 576.03 | | | | | | | |
| 21 31 | MAR 73 | 575.57 | 576.00 | 575.89 | 575.81 | 575.78 | 575.79 | 575.84 | 575.80 | 575.77 | 575.73 | 575.76 | 575.86 | 17 | 0800 | 576.76 | 2 | 2100 | 574.92 |
| 1 10 | APR 73 | | 575.86 | 575.77 | 575.82 | 575.87 | 575.76 | 575.70 | 575.88 | 576.00 | 576.16 | 575.67 | | | | | | | |
| 11 20 | APR 73 | | 575.62 | 575.76 | 575.73 | 575.71 | 575.69 | 575.50 | 575.64 | 575.69 | 575.71 | 575.70 | | | | | | | |
| 21 30 | APR 73 | 575.74 | 575.62 | 575.56 | 575.71 | 575.74 | 575.77 | 575.76 | 575.79 | 575.56 | 575.67 | 575.74 | | 9 | 1500 | 576.72 | 16 | 1500 | 575.19 |
| 1 10 | MAY 73 | | 575.69 | 575.56 | 575.41 | 575.55 | 575.65 | 575.72 | 575.78 | 575.80 | 575.74 | 575.81 | | | | | | | |
| 11 20 | MAY 73 | | 575.73 | 575.75 | 575.80 | 575.82 | 575.78 | 575.62 | 575.78 | 575.80 | 575.81 | 575.78 | | | | | | | |
| 21 31 | MAY 73 | 575.76 | 575.76 | 575.78 | 575.82 | 575.84 | 575.84 | 575.84 | 575.98 | 575.84 | 575.88 | 575.89 | 575.80 | 27 | 1700 | 576.21 | 3 | 1700 | 575.26 |
| 1 10 | JUN 73 | | 575.84 | 575.93 | 575.95 | 575.90 | 575.95 | 576.00 | 576.00 | 575.97 | 576.00 | 576.02 | | | | | | | |
| 11 20 | JUN 73 | | 575.98 | 576.05 | 576.05 | 576.05 | 576.02 | 576.10 | (576.26 | 576.16 | 576.12 | 576.06 | | | | | | | |
| 21 30 | JUN 73 | 576.04 | 576.04 | 576.05 | 575.99 | 576.06 | 576.10 | 576.04 | 576.09 | 576.17 | 576.19 | 576.21 | | 17 | 0300 | 576.42 | 1 | 1400 | 575.63 |
| 1 10 | JUL 73 | | 576.18 | 576.19 | 576.19 | 576.13 | 576.13 | 576.10 | 576.06 | 576.08 | 576.09 | 576.08 | | | | | | | |
| 11 20 | JUL 73 | | 576.12 | 575.99 | 575.84 | 575.96 | 576.02 | 576.00 | 575.98 | 575.97 | 575.92 | 575.98 | | | | | | | |
| 21 31 | JUL 73 | 576.01 | 576.03 | 576.06 | 576.05 | 576.01 | 575.92 | 575.91 | 575.78 | 575.79 | 575.88 | 575.86 | 575.90 | 2 | 2200 | 576.35 | 27 | 2400 | 575.58 |
| 1 10 | AUG 73 | | 575.96 | 575.94 | 575.92 | 575.92 | 575.87 | 575.82 | 575.81 | 575.79 | 575.76 | 575.82 | | | | | | | |
| 11 20 | AUG 73 | | 575.78 | 575.84 | 575.86 | 575.92 | 575.90 | 575.86 | 575.87 | 575.82 | 575.83 | 575.78 | | | | | | | |
| 21 31 | AUG 73 | 575.82 | 575.87 | 575.90 | 575.84 | 575.85 | 575.80 | 575.75 | 575.71 | 575.72 | 575.70 | 575.68 | 575.68 | 1 | 1900 | 576.04 | 9 | 1700 | 575.20 |
| 1 10 | SEP 73 | | 575.70 | 575.71 | 575.73 | 575.68 | 575.65 | 575.56 | 575.59 | 575.66 | 575.69 | 575.56 | | | | | | | |
| 11 20 | SEP 73 | | 575.51 | 575.56 | 575.63 | 575.62 | 575.48 | 575.49 | 575.52 | 575.44 | 575.35 | 575.43 | | | | | | | |
| 21 30 | SEP 73 | 575.50 | 575.49 | 575.24 | 575.29 | 575.39 | 575.37 | 575.29 | 575.25 | 575.31 | 575.41 | 575.52 | | 14 | 0100 | 575.86 | 27 | 0800 | 575.02 |
| 1 10 | OCT 73 | | 575.41 | 575.29 | 575.25 | 575.26 | 575.21 | 575.29 | 575.30 | 575.32 | 575.29 | 575.27 | | | | | | | |
| 11 20 | OCT 73 | | 575.26 | 575.17 | 575.00 | 574.94 | 575.00 | 574.90 | 574.98 | 575.02 | 574.98 | 575.06 | | | | | | | |
| 21 31 | OCT 73 | 575.13 | 575.07 | 575.06 | 575.02 | 575.02 | 574.91 | 574.95 | 575.11 | 575.30 | 575.25 | 575.10 | 574.98 | 28 | 0100 | 575.62 | 14 | 0300 | 574.67 |
| 1 10 | NOV 73 | | 574.46 | 574.90 | 574.89 | 574.96 | 574.85 | 574.69 | 574.81 | 574.59 | 574.69 | 574.74 | | | | | | | |
| 11 20 | NOV 73 | | 574.66 | 574.64 | 574.64 | 574.65 | 574.80 | 574.71 | 574.72 | 574.75 | 574.79 | 574.88 | | | | | | | |
| 21 30 | NOV 73 | 574.75 | 574.75 | 574.70 | 574.74 | 574.75 | 574.85 | 574.90 | 574.84 | 574.85 | 574.64 | 574.71 | | 28 | 0600 | 575.11 | 1 | 1100 | 573.98 |
| 1 10 | DEC 73 | | 574.98 | 574.93 | 574.78 | 574.90 | 574.50 | 574.25 | 574.69 | 574.80 | 574.75 | 574.36 | | | | | | | |
| 11 20 | DEC 73 | | 574.52 | 574.66 | 574.89 | 574.83 | 574.96 | 574.95 | 574.86 | 574.82 | 575.02 | 574.77 | | | | | | | |
| 21 31 | DEC 73 | 574.80 | 574.73 | 574.69 | 574.78 | 574.87 | 574.87 | 574.98 | 574.90 | 574.86 | 574.92 | 574.90 | 575.09 | 26 | 2300 | 575.15 | 5 | 2300 | 573.84 |

INTERNATIONAL GREAT LAKES DATUM (1955)

STATION NUMBER 4049

B4