Michigan Department of Natural Resources

Remedial Action Plan

for

WHITE LAKE

Area of Concern

October 27, 1987

Michigan Department of Natural Resources
Surface Water Quality Division
Great Lakes and Environmental Assessment Section
P.O. Box 30028
Lansing, Michigan 48909

ACKNOWLEDGEMENT

The initial draft of the White Lake Remedial Action Plan was completed through the technical assistance of Science Application International Corporation under EPA Contract No. 68-04-5041, Work Assignment GL86-07, SAIC Project No. 2-813-03-202-07. Assistance in reviewing, selecting, extracting, organizing available information and shaping it into a readable initial draft is acknowledged and appreciated. Special recognition goes to Ms. Cindy Hughes and assocaiates.

Thanks is also given to those individuals that have provided technical assistance and information during the preparation of this remedial action plan. Special thanks goes to Irnie Jousma and Roger Przybysz - Grand Rapids District staff and Jim Heinzman - Geological Survey Division who took the time to become involved in this project.

Special thanks goes to Connie Pennell, Supervisor, MDNR Word Processing, and her staff; Julie Rann and Teresa Kent for their patience, understanding and conscientious efforts in the preparation of this RAP.

John Wuycheck
RAP Coordinator

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

PROLOGUE - WHITE LAKE REMEDIAL ACTION PLAN

In 1985, the Water Quality Board (WQB) of the International Joint Commission (IJC) identified 42 Areas of Concern (AOCs) for which Remedial Action Plans (RAPs) should be developed. In their report on Great Lakes Water Quality, the WQB further identified specific impaired beneficial water uses and water quality problems in each AOC that the RAPs were to address. The identified problems were suspected of contributing to the degradation of one of the Great Lakes. The intent of each RAP is to outline the course of action that will result in the restoration of designated uses and resolution of water quality problems that impact the Great Lakes. Once it is confirmed that those uses identified in the 1985 WQB report are restored, the AOC should be removed from the AOC list.

In 1986, The Michigan Department of Natural Resources (MDNR) began work on RAPs to address identified impaired uses in each of Michigan's fourteen AOCs. During the data collection, fact finding and analysis phases of RAP development, problems other than those reported in the 1985 WQB Report were identified. The newly identified problems are listed in this RAP regardless of their status as RAP issues in order to document known environmental issues in the AOC. Inclusion of all documented problems in the RAP is sound from an ecosystem management perspective. Furthermore, it indicates to the public what the problems are and how they may be addressed.

An attempt was made to clearly distinguish between those water quality problems and impaired uses identified as truly RAP issues and those problems that are of local and/or regional (Lake Michigan wide) concern. RAP issues included those identified in the 1985 WQB Report as causing or contributing to an impact or loading to the Great Lakes.

The RAP issue identified in the 1985 WQB Report used to designate White Lake as an AOC was the venting of contaminated groundwater to White Lake from the defunct Occidental (Hooker) Chemical Company site. Current well monitoring data, purgewell system operation and groundwater treatment indicate that 100% of the contaminated groundwater plume is being captured and treated. The final effluent quality meets limits designed to protect environmental and public health concerns. Studies to-date indicate no apparent impacts to designated uses of Lake Michigan due to conditions in White Lake.

Various issues of local importance discussed in the White Lake RAP include other contaminated groundwater sites, urban stormwater runoff, nutrient enrichment and contaminated sediments. These issues are being addressed through state, federal, county and/or local programs as indicated in this RAP. They are not expected to be resolved through the RAP process.

In addition to the identification of local issues, PCB and chlordane concentrations were found to be elevated in carp collected from White Lake. There is inadequate information to determine if this is a regional or site specific phenomenon. Therefore, carp were scheduled to be collected from Lake Michigan and analyzed in 1988-89 to define PCB and chlordane levels. Results may indicate that PCB and chlordane levels found in White Lake carp reflect a regional problem versus a site specific problem (RAP issue). Further, White River sediments will be collected in 1988 and be analyzed for PCBs, chlordane and other pesticides to determine if they are a potential source of environmental contaminants. PCB and chlordane loadings to the region, as part of an air toxics monitoring program, needs to be determined in order to assess this potential source of environmental contaminants to the region as well as the White Lake area.

MDNR staff appreciated the Water Quality Board's Programs Committee review of the 1987 White Lake RAP that was submitted in October 1987. MDNR's responses to the reviewer(s) comments are included in Appendix 10.0. Staff are hopeful that our responses address the AOC issues of concern. A major effort was made to clarify, better define and separate AOC issues from localized and/or potentially regional problems.

MDNR UPDATE
21 September 88

Muskegon Lake Remedial Action Plan:

The following paragraph will be added to page 10 under Section 3.2.3 entitled Hydrology of the Muskegon Lake Remedial Action Plan:

Sorrell (1988) concluded that the Muskegon River flows into Lake Michigan under normal conditions. His conclusion was derived by comparing the average annual rate of rise of Lake Michigan of 0.2 cm/day or 0.08 inches/day over a 5 month period (equivalent to 0.42 m3/s or 15 cfs) with the lowest recorded discharge of the Muskegon River of 1.47 m3/s or 52 cfs (Newaygo U.S.G.S. gage located 30 miles upstream from the lake). The inflow volume from the Muskegon River to Muskegon Lake is, therefore, greater than inflow volume into Muskegon Lake caused by the normal rise of Lake Michigan. Although the level of Muskegon Lake fluctuates in response to the normal cycle of Lake Michigan, it always receives a sufficient amount of inflow volume from the Muskegon River watershed to show a net inflow into Lake Michigan.

Reference:

Sorrell, R. 1988. Effect of Lake Michigan on Muskegon and White Lakes. A 15 September 88 memo to Jack Wuycheck (Surface Water Quality Division) from Rick Sorrell (MDNR Land and Water Management Division hydrologist).

1.0 EXECUTIVE SUMMARY

White Lake is a 1,040 hectare (2,571 acre) lake located in Muskegon County along the east shoreline of Lake Michigan in the vicinity of the communities of Montague and Whitehall. The White Lake AOC includes White Lake proper and a 0.4 km (0.25 mi) wide zone around the lake. White Lake is an excellent walleye, perch, largemouth bass and northern pike fishery and sustains other popular recreational activities such as boating and swimming.

The major environmental problem identified in the 1985 WQB report was the discharge of contaminated groundwater to White Lake from the Occidental (Hooker) Chemical Company property. Groundwater contaminants of concern that enter White Lake include chloroform, trichloroethylene, carbon tetrachloride and tetrachloroethylene. Major soil contaminants at the site, located about 1.2 km (0.75 mi) north of White Lake, are hexachlorobutadiene (C-46 or HCBD), hexachlorocyclopentadiene (C-56 or HCP), hexachlorobenzene (C-66 or HCB) and octachlorocyclopentene (C-58 or OCP). These latter contaminants are not entering White Lake from the contaminated plume.

A 1979 Consent Judgment between the Hooker Chemical Company and the State of Michigan required the company to completely halt the flow of contaminated groundwater to White Lake. The Consent Judgment required the installation of purge wells to purge groundwater from the contaminated aquifer and provide treatment of the groundwater to remove contaminants of concern. The company has installed a series of purge wells and a carbon absorption treatment system. The treated purge well water is discharged to White Lake pursuant to an NPDES permit.

After installation of the purge well system, Michigan Department of Natural Resources (MDNR) has, on an on-going basis, evaluated the effectiveness of the purge well system and determined that the purge well system is not completely halting the flow of contaminated groundwater to White Lake. In May 1985 the State filed a Motion to Compel with the Ingham County Circuit Court to enforce the provisions of the 1979 Consent Judgment and to compel the chemical company to improve its groundwater purge well and treatment system so that the flow of contaminated groundwater to White Lake is completely halted. In December, 1985, the Circuit Court affirmed the State's position that the Consent Judgment requires Hooker to completely halt the flow. Since that time, Hooker Chemical Company has made incremental increases in the groundwater purge rates, but the company still is not purging at a rate sufficient to halt the flow of contaminated groundwater to White Lake. Hooker increased the total pumping rate of a nine well system, during the summer of 1987, to 2580 liters/minute (685 gpm). This pumping rate appears to be effective in capturing greater than 95% of the plume entering White Lake. One major factor that influences plume capture is lake level. Pumping rates must be sufficient to maintain the level of the plume below the level of the lake. Increased pumping rates have reduced contaminant loadings to White Lake based on White Lake sampling data. Further improvements must be made before the company will be in compliance with the Consent Judgment on this issue. The State is continuing its efforts to obtain compliance.

In order to evaluate the potential for bioconcentration of HCBD, HCB, OCP and mirex effluent concentrations, normally less than the level of detection, Occidental (Hooker) Chemical was required to conduct a contaminant uptake study which involved exposing fish to the treated effluent. Study results showed the absence of detectable levels (detection level of 10 ppb) of hexachlorobutadiene, octachlorocyclopentene, hexachlorobenzene and mirex in whole rainbow trout after 28 days exposure to 100% carbon filter treated effluent discharged from Outfall 001.

The 1984 fish contaminant monitioring data for White Lake indicated that carp populations contain an average concentration of 3.7 ppm PCBs which exceeds 2.0 ppm wet weight action level used by the Michigan Department of Public Health (MDPH) and U.S. Food and Drug Administration (U.S. FDA). These same carp also contained elevated concentrations of chlordane that exceeded the MDPH's and U.S.FDA action level of 0.3 ppm. Heavy metals and other organic contaminant levels were found to be less than established levels of concern. PCB sources to the carp population is suspected to be lake sediments and/or atmospheric loadings to Lake Michigan and the White Lake watershed. Suspected chlordane sources may be agricultural and/or atmospheric. White Lake 1986 sediment sample analysis indicated chlordane levels were less than levels of detection (67 to 430 ppb). White Lake sediment samples are currently being reanalyzed for PCBs to determine if they are a significant potential source to the lake's carp population.

White Lake sediment survey data for December 1986 indicated the littoral zones on the north, west and south sides of the lake are primarily sand. Sand typically contains low contaminant levels and, during the survey, was, therefore, not sampled except in the vicinity of Occidental (Hooker) Chemical Company's contaminated groundwater plume. Sediments northeast of the lake near the inlet were found to be primarily organic influenced by runoff from upstream muck land.

A major sediment contaminant commonly found throughout the lake in the sublittoral areas, during the 1986 survey, was chromium. A maximum chromium concentration of 4,300 ppm was collected in the vicinity of the now defunct outfall of Whitehall Leather Company. Prior to 1976, the company discharged process water to White Lake. Lake sediment chromium concentrations in the vicinity of the discharge, reportedly contained more than 20,000 ppm in 1970. The benthic community in the vicinity was degraded by the company discharge but is improving. Although elevated, the observed sediment chromium concentrations do not appear to be causing any impaired use of White Lake or Lake Michigan, nor was there any indication of excessive uptake of chromium by fish.

Since the mid-1970's industrial and municipal wastewater from Whitehall and Montague have been treated at the Whitehall-Montague wastewater land application facility located about 3.2 km (2 mi) upstream of White Lake. Implementation of an approved industrial pretreatment plant has further reduced the discharge of process wastes to the treatment facility. Underdrainage from several land application sites are presently discharged to Silver Creek, a designated coldwater stream, and thence to the White River and White Lake. The facility is being upgraded and the oufall diverted to the White River just downstream of the Silver Creek confluence.

Runoff from agricultural areas and nonpoint source loadings in the watershed are suspected of contributing 95-97% of the nutrient loadings to the lake. Phosphorus is the limiting nutrient for White Lake and an inlake phosphorus concentration goal less than 30 ppb phosphorus is recommended for White Lake by the MDNR in order to maintain acceptable water quality. December 1986 and May 1987 lake sampling indicated average phosphorus concentrations of 15 and 25 ppb, respectively. Additional survey data characterizing seasonal lake conditions is recommended to determine if remedial actions are needed to reduce nonpoint source nutrient loadings to the lake.

A public meeting was held on June 17, 1986, to provide the general public, local units of government, industrial representatives and environmental groups an overview of the Remedial Action Plan development process, findings to date and an opportunity to provide comments and recommendations concerning the White Lake AOC.

A second public meeting was held on October 19, 1987, following the completion and release of a draft of the remedial action plan in order to afford an opportunity for comments and suggestions for the final report.

Based on available data, the following conclusions and recommendations are made:

1. White Lake AOC has no known adverse effects on Lake Michigan.

2. The only documented impaired use in White Lake is a fish consumption advisory for carp because of elevated PCBs and chlordane.

3. The reduction of the discharge of contaminated groundwater from Occidental (Hooker) Chemical Company to White Lake is occuring because of increased purgewell capture of the plume. Pumping rates need to be increased in order to completely halt the flow of contaminated groundwater to White Lake under varying lake levels.

4. Evaluate nonpoint nutrient loadings and contaminants (pesticides) to determine seasonal loadings and the need for developing a nonpoint source nutrient loading minimization plan.

5. Air toxics monitoring in the region is recommended to determine atmospheric loadings of PCBs and chlordane to the White Lake area.

6. Carp from Lake Michigan should be collected and analyzed for PCBs and chlordane to help determine if PCBs and chlordane in White Lake carp are a specific or regional phenomenon.

A summary of impaired uses, causes, sources, and remedial actions is provided in Table 10-1.

2.0 INTRODUCTION

2.1 BACKGROUND

The International Joint Commission (IJC), the Great Lakes National Program Office (GLNPO), and the State of Michigan have designated White Lake as an Area of Concern (AOC). The White Lake AOC is located on the east shore of Lake Michigan and is connected to the lake by a federally maintained navigational channel. For purposes of this Remedial Action Plan (RAP), the White Lake AOC includes White Lake and a 0.4 km (0.25 mi) zone around the lake. This remedial investigation was developed as an evaluation of water quality, sediment quality and impaired designated uses in the White Lake AOC.

One impaired use is evident in the Area of Concern. A fish advisory was issued in 1986 that advised for "Restricted Consumption" of carp due to the presence of PCBs (average 3.7 ppm) that exceeded the MDPH and U.S. FDA action level of 2 ppm. Chlordane concentrations (average 0.6 ppm and range of 0.13 to 1.24 ppm), in these same carp, exceeded the 0.3 ppm action level used by the MDPH and U.S.FDA.

Other documented environmental issues are contamination of bottom sediments, groundwater and surface water. Contaminant sources have been identified as historical surface water discharges, contaminated groundwater and nonpoint sources. Groundwater contamination has been detected in at least 10 locations in the vicinity of the the AOC. The major site is Occidental (Hooker) Chemical Company whose contaminated plume discharges to White Lake.

There is some indication of lake sediment quality improvements since the 1973-74 due to wastewater diversion to the Muskegon County WMS No. 2 land application site. However, contaminated groundwater seepage, excessive nutrient loadings and degraded benthic communities, although improving, still represent measureable problems for White Lake that need evaluation. NPDES permitted point source dischargers no longer appear be contributing to current pollution concerns in the lake.

Great Lakes Water Quality Management

The Great Lakes Water Quality Board (GLWQB) is responsible for reporting water quality research activities and the environmental quality of the Great Lakes to the IJC. The GLWQB has adopted a system of categories to track and measure the progress of the 42 identified Areas of Concern in terms of environmental health. The categories identify the status of the information base, programs which are underway to fill the information gaps, and the status of remedial efforts. According to the GLWQB (1985), resolution occurs when evidence can be presented verifying that the full complement of uses has been restored. The site can then be removed from the Area of Concern list. The following categories form the described sequence:

Category	Explanation
1	Causative factors are unknown and there is no investigative program to identify causes.
2	Causative factors are unknown and an investigative program is underway to identify causes.
3	Causative factors known, but Remedial Action Plan not developed and remedial measures not fully implemented.
4	Causative factors known and Remedial Action Plan developed, but remedial measures not fully implemented.
5	Causative factors known, Remedial Action Plan developed, and all remedial measures identified in the Plan have been implemented.
6	Confirmation that uses have been restored and deletion as an Area of Concern.

2.2 PURPOSE AND OBJECTIVES

The purpose of the Remedial Action Plan process is to provide a coordinated (i.e., Great Lakes watershed) approach to environmental management that will ultimately lead to the successful rehabilitation of the Great Lakes and, in this instance, the White Lake Area of Concern. This approach requires an integration of available data on the environmental conditions, socioeconomic influences and political/institutional frameworks. The plan's purpose is to focus the data gathering and data synthesis towards the resolution of the immediate problems which impair the AOC's designated uses. Recommendations towards resolving the identified problems will be based on the current available data and within the framework of current institutional programs.

2.3 INTENDED USE

This RAP is intended as a technical management document that provides a review of available data, defines impaired uses, data needs, prioritizes necessary investigations and necessary remedial options to provide a platform for future analyses and decision-making. The RAP also represents a detailed review and synthesis of available data and/or information relevant to the problems in the Area of Concern. Every attempt has been made to identify the major documents pertaining to the critical environmental issues affecting this AOC. Remedial action planning is an iterative process, however, and suggestions and additions are welcomed in as much as they contribute to RAP issues and final goals.

3.0 ENVIRONMENTAL SETTING

The State of Michigan and the International Joint Commission (IJC) have identified White Lake and the surrounding 0.4 km (0.25 mi) zone as the White Lake Area of Concern (AOC). Environmental characteristics, land and water uses and water quality standards are presented in this section to provide background information for effective evaluation of the existing situation in the AOC.

3.1 LOCATION

The White Lake AOC, located in Muskegon County in the west central portion of Michigan, is on the eastern shoreline of Lake Michigan (Figure 3-1). The AOC is part of the White River Drainage Basin. Headwaters for the entire drainage system originate in Newaygo County and flow westward, eventually draining into Lake Michigan.

3.1.1 IJC/State Area of Concern

The Area of Concern for this Remedial Action Plan (RAP) has been designated as White Lake and the surrounding 0.4 km (0.25 mi) zone.

3.2 NATURAL FEATURES

3.2.1 Drainage Basin

The White Lake AOC lies within the White River Drainage Basin (Figure 3-2). The basin drains portions of Newaygo, Oceana and Muskegon Counties covering a total drainage area of 131,831 hectare (509 mi^2)

(U.S. EPA, 1975). The drainage area consists of the White River 124,579 hectare (481 mi^2) and minor tributaries and immediate drainage of 6,216 hectare (24 mi^2). The West Michigan Shoreline Regional Development Commission (WMSRDC) further divided the portion of the White River Basin that lies in Region 14 (Oceana and Muskegon Counties) into four Watershed Management Units (WMUs) as part of their regional development and planning program (WMSRDC 1978a). Total drainage area for the four WMUs is 64,232 hectare (248 mi^2), or 51 percent of the total basin drainage area (WMSRDC 1978a). The individual WMUs and their drainage areas are provided in Table 3-1.

Of the four WMUs, North Branch is the largest, occupying approximately 17 percent of the total basin drainage area. The north branch of the White River originates in Oceana County at McLaren Lake. The South Branch WMU, the main branch of the White River, originates in Newaygo County and covers approximately 11 percent of the total drainage basin. White River drops 123 m (400 ft) in elevation from its headwaters in north central Newaygo County to its termination in White Lake, 173 km (453 mi) away. White River WMU is the smallest of the four, covering only 6 percent of the area, and joining the North Branch and South Branch WMUs to White Lake WMU. The second largest in size, White Lake WMU covers approximately 17 percent of the drainage area.

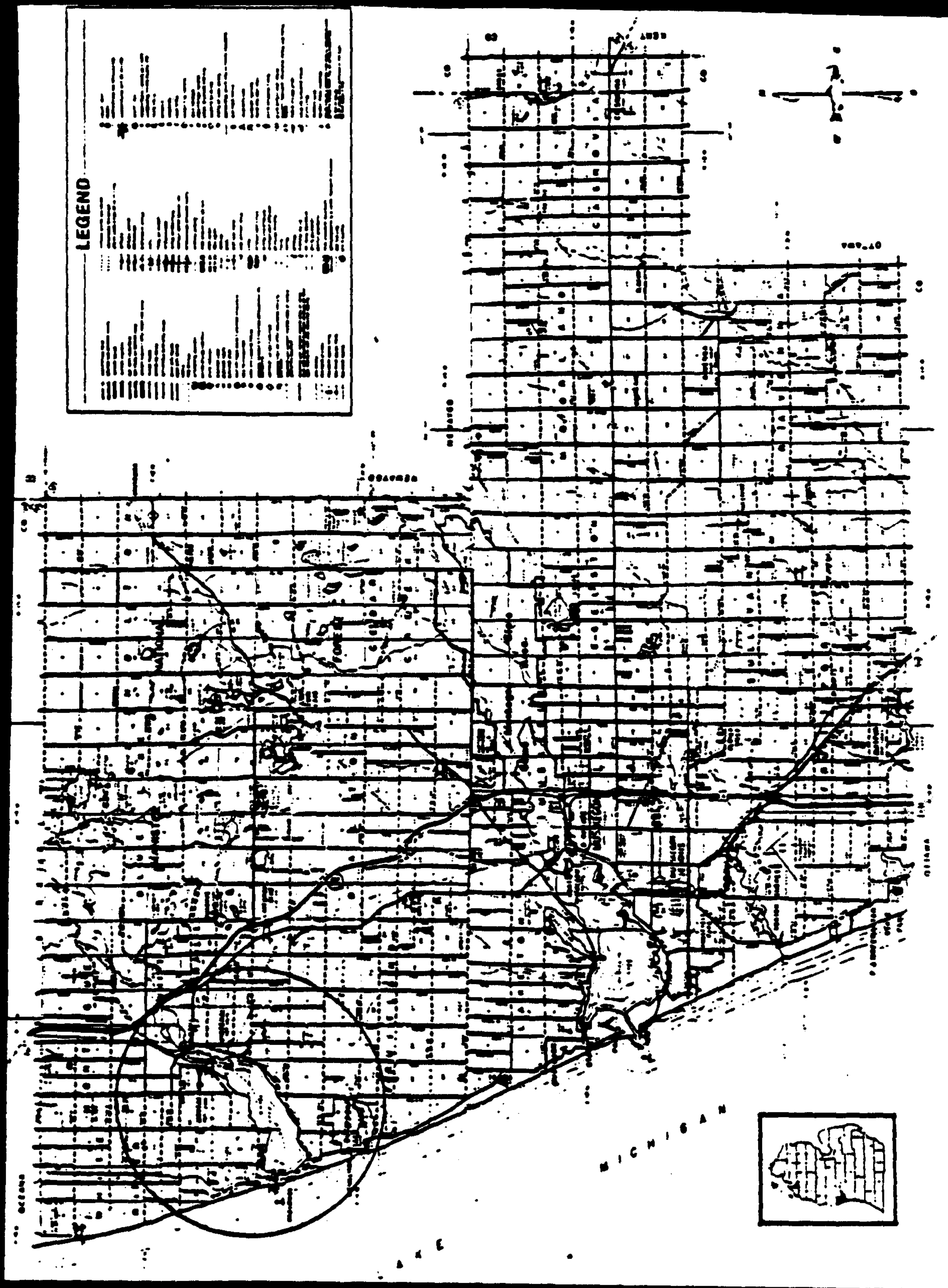


Figure 3-1 Location of White Lake in Muskegon County, Michigan.

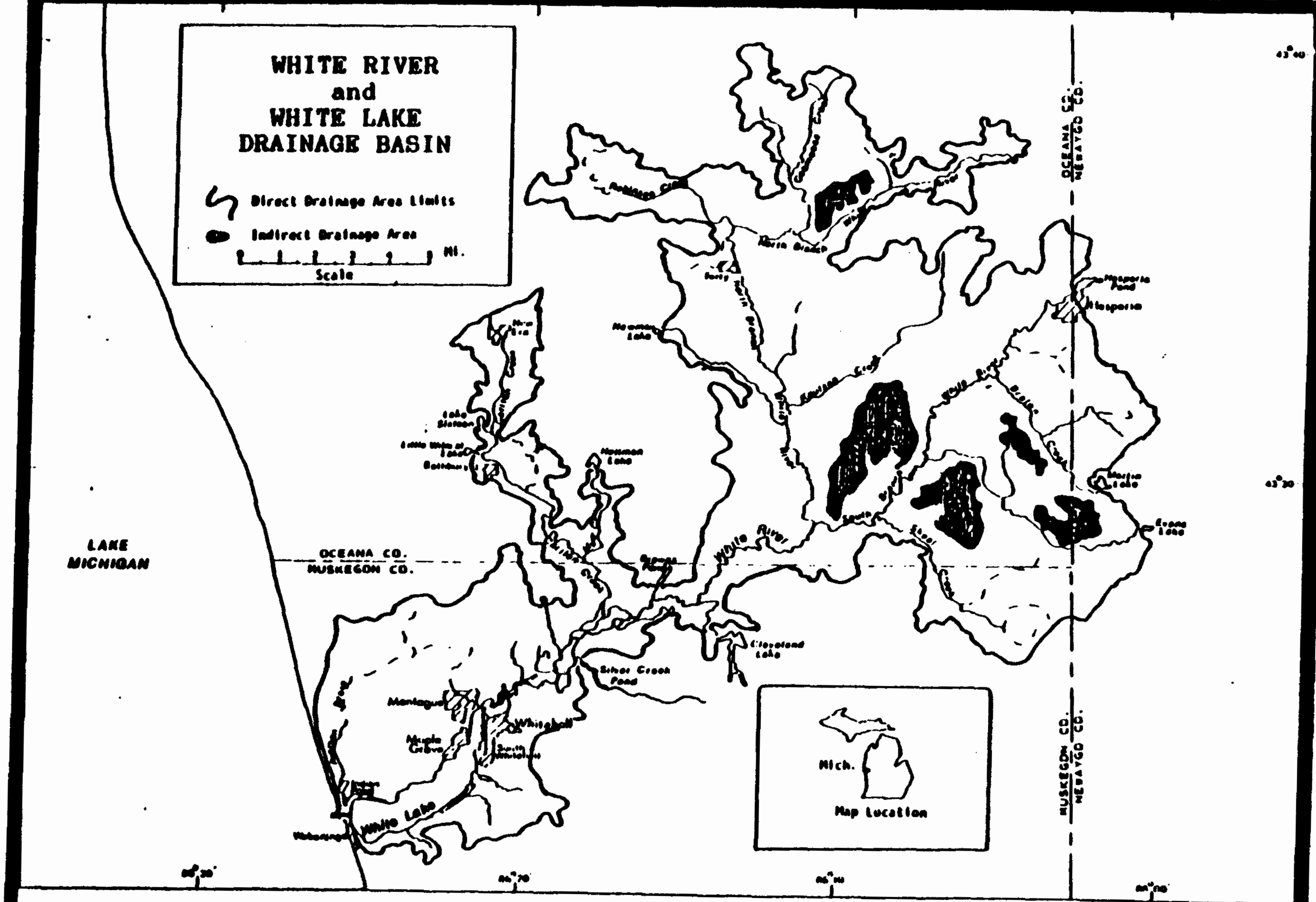


Figure 3-2 White River / White Lake drainage basin. Michigan.

Table 3-1. White River Basin Watershed Management Units
(Region 14 Only)

Watershed Management Unit	Hectare (mi ·)	Percent of Total Basin
North Branch	21,756 (84)	17
South Branch	13,986 (54)	11
White River	6,993 (27)	6
White Lake	21,497 (83)	17

Source: Modified from WMSRDC 1978a.

Major tributaries within the White Lake AOC and White River WMUs are Mill Pond Creek, Coon Creek, Silver Creek, Carlton Creek, and Buttermilk Creek.

The portions of the White River Basin within Muskegon County are emphasized throughout this RAP because this portion of the basin possesses the greatest potential for affecting the AOC.

3.2.2 Topography

The majority of Muskegon County is characterized by level to gently sloping topography. Large sand dunes stretch across the Lake Michigan shoreline gradually decreasing in size towards the east that flattens into a wide plain. Stream channels and lake basins are located throughout the plain. Elevations in the county range from 170 m (580 ft) above sea level at Lake Michigan to 246 m (800 ft) at the lakeshore dunes (Metcalf & Eddy 1982).

3.2.3 Hydrology

U.S.EPA (1975) reported mean flows for the White River and immediate drainage area of the lake basin of 14 m^3/s (495 ft^3/s) and 0.8 m^3/s (27.2 ft^3/s). Average flow rates for White River and tributaries located in the White River Basin are provided in Table 3-2 (WMSRDC, 1978a). Recent flow measurements at the Fruitvale Road USGS gaging station, located near Whitehall, measured a 28-year average flow rate of 12.4 m^3/s (439 ft^3/s) (U.S.G.S.,1985). Typical variations in yearly flow rates reported by WMSRDC (1978a) for the period 1961 to 1975 are presented in Figure 3-3. Typical seasonal differences in flow rates are illustrated in Figure 3-4. Annual and seasonal variations in flow rates are moderated by groundwater which provides approximately 79 percent of the White River flow (WMSRDC

1978a). The White River represents 95% of the drainage area of White Lake and provides at least 95% of the basin discharges to the lake (U.S. EPA, 1975).

Table 3-2 Flow Rates of Streams per Watershed Management Unit in White River Basin

Watershed Management Unit	Associated Streams	Average Flow Rate m^3/s	(ft^3/s)
North Branch	Cobmoosa	0.45	15.9
	Knutson	0.08	2.9
	Newman	0.15	5.3
	Robinson	0.66	23.5
South Branch	Brayton	0.31	10.8
	Cushman	0.25	8.9
	Skeels	not provided	
White River	Carleton	0.10	3.7
	Carlton	1.09	38.4
	Cleveland	0.67	23.6
	Mud	not provided	
	Sand	0.54	29.1
	Silver	0.51	18.0
	White River	12.8	454.6
White Lake	Birch	0.03	1.0
	Buttermilk	0.04	1.6
	Coon	0.01	0.2
	Mill Pond	0.08	2.8
	Pierson	0.02	0.9
	Strawberry	0.01	0.3
	Wildcat	0.02	0.7

Source: Modified from WMSRDC 1978a. (17-year period of record).

U.S.G.S. - Water Resources Data/Water Year 1985

White River at Whitehall (Fruitvale Road Gage) - 28 year period of record.
Average: 12.4 m^3/s (439 ft^3/s)

Extremes:
Minimum - 4.6 m^3/s (163. ft^3/s)
Maximum - 152.9 m^3/s (5,400 ft^3/s)

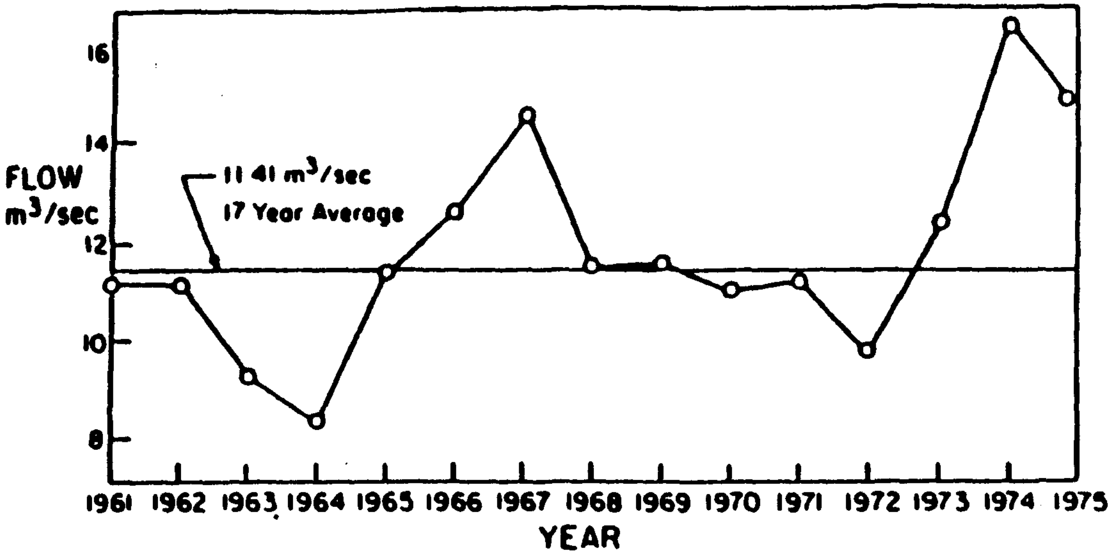


FIGURE 3-3. AVERAGE ANNUAL FLOW OF THE WHITE RIVER AT WHITEHALL (WMSRDC, 1978a).

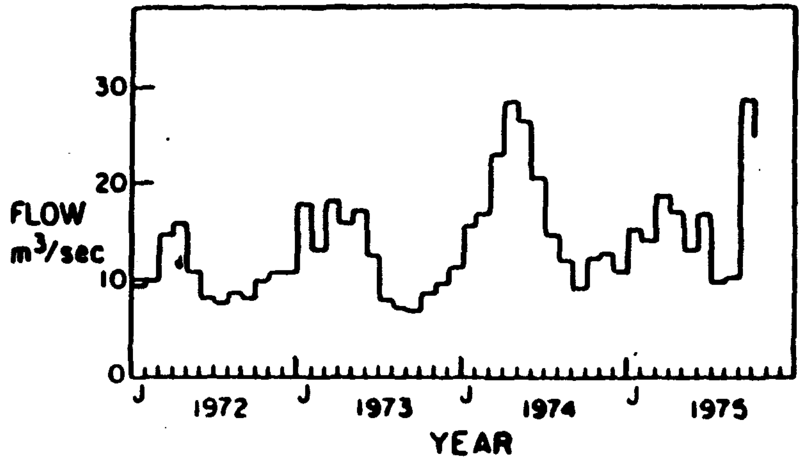


FIGURE 3-4 MEAN MONTHLY FLOW OF THE WHITE RIVER AT WHITEHALL (WMSRDC, 1978a).

3.2.4 Soil Types, Runoff, Erosion

A variety of soil types cover the Muskegon County area. Figure 3-5 illustrates the eight major soil associations in Muskegon County. Soil types range from well-drained sandy soils to poorly drained mucks (Melcalf & Eddy 1982). Six of the soil associations are found in the White Lake area and include the following:

- Rubicon-Croswell-Deer Park
- Carlisle-Tawas
- Montcalm-Nester-Belding-Kawkawlin
- Au Gres-Roscommon-Granby
- Nester-Ubly-Sims
- Belding-Allendale-Rubicon (Metcalf & Eddy 1982).

The Rubicon-Croswell-Deer Park association consists of almost level to steep, well to moderately well drained sandy soils located on outwash plains and uplands (Metcalf & Eddy 1982). The Carlisle-Tawas association consists of almost level to depressional, poorly drained peats and mucks. The Montcalm-Nester-Belding-Kawkawlin association consists of sloping to rolling, poorly drained and well drained sandy and loamy soils located on lake plains, outwash plains, and glaciated uplands. The Au Gres-Roscommon-Granby association consists of almost level to depressional, poorly drained sandy soils located on outwash plains, uplands, and lake plains. The Nester-Ubly-Sims association consists of sloping to hilly, well to moderately well drained and poorly drained loamy soils located on lake plains and uplands. The Belding-Allendale-Rubicon association consists of almost level to slightly sloping, poorly to well drained loamy and sandy soils located on lake plains.

Soils along the river are highly erosive as evidenced by steep, eroded banks and gullies created near the river and its tributaries. Surface runoff from the watershed contributes to sediment loads because of erosive soils located in the immediate vicinity of the White River (Mund, 1987).

Specific data concerning runoff and erosion potential for soils are not yet available (Mund, 1987). Generally, soils that are highly permeable are more resistant to erosion and runoff than poorly drained soils. Additional information on runoff and erosion potential are presented under Section 3.3, Land Cover and Land Uses.

3.2.5 Limnology

White Lake, a drowned river mouth, has a surface area of 1,040 hectare (2,571 acres) with mean and maximum depths of 6.9 m (22.5 ft) and 21.5 m (70+ ft), respectively. The lake has a volume of 7.1×10^7 m (57,940 acre-ft) and a mean hydraulic retention time of 56 days (U.S. EPA, 1975).

LEGEND

1. RUBICON–CROSWELL–DEER PARK
2. RUBICON–AU GRES–ROSCOMMON
3. AU GRES–ROSCOMMON–GRANBY
4. NESTER–ULBY–SIMS
5. BELDING–ALLENDALE–RUBICON
6. MONTCALM–NESTER–BELDING–KAWKAWLIN
7. CARLISLE–TAWAS
8. SELKIRK–KENT–KAWKAWLIN

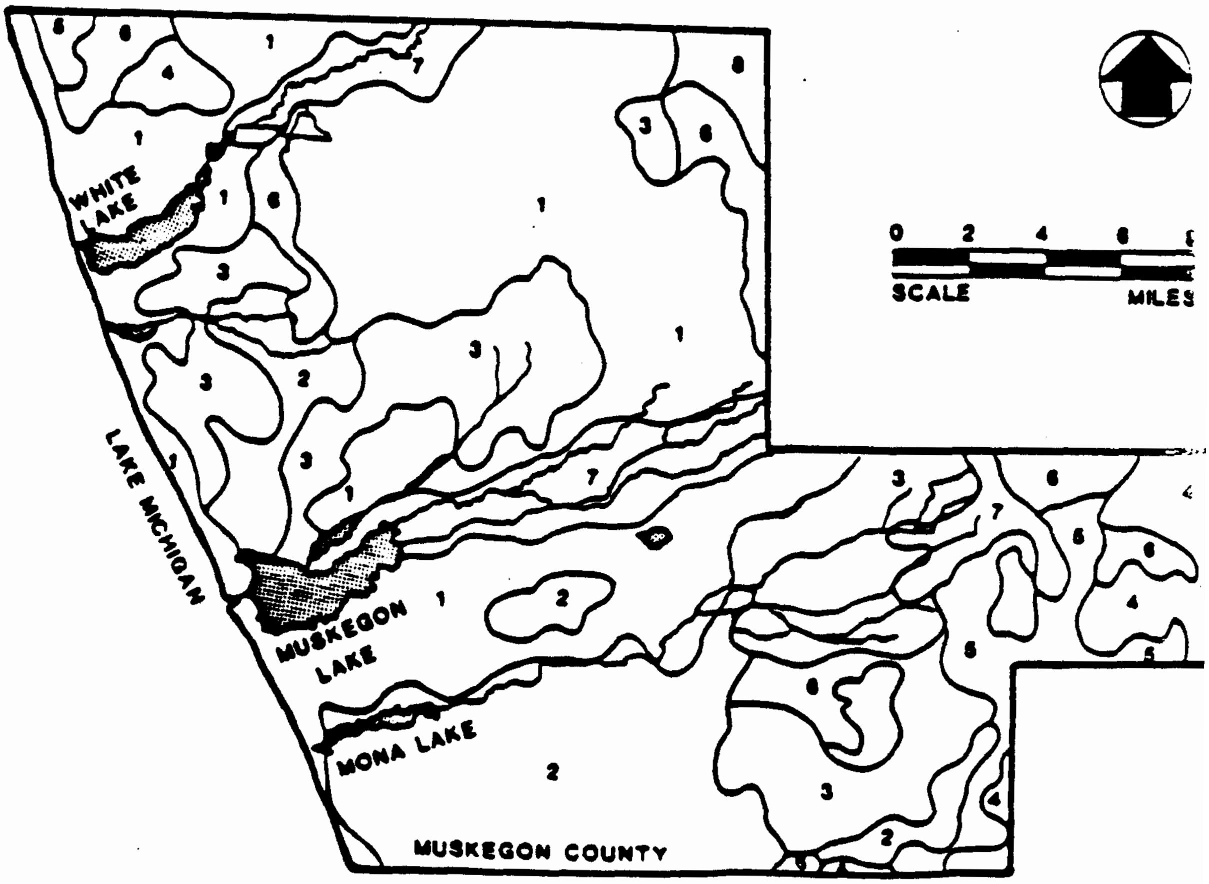


FIGURE 3-5. MAJOR SOIL ASSOCIATIONS IN MUSKEGON COUNTY (WMSRDC, (no date) b).

White Lake contains three basins: 1) the upper third of the lake; 2) west of Dowies Point; and 3) west of Long Point (Figure 3-6). White Lake is approximately 8 km (5 mi) long, 261 to 1923 m (850 to 6,250 ft) wide, and is surrounded by 34.6 km (21.5 mi) of shoreline. The lake has a mean hydraulic retention time of 56 days (U.S. EPA, 1975).

White Lake remains classified as eutrophic even after the 1973 diversion of municipal and industrial discharges. Nonpoint source nutrient loadings from the watershed is the most important factor in maintaining the eutrophic state of White Lake. Internal loadings from lake sediments and their resuspension may also serve as a significant source of phosphorus, especially, in the shallow east end of the lake where depths average 2.5 to 3.0 m (8 to 10 ft). The lake has extensive shallows that support prolific growths of macrophyte growths (Limno-Tech, 1981). The lake is dimictic and eutrophic and experiences periods of summer hypolimnetic anoxia.

3.2.6 Climate and Air Quality

Climate in the AOC fluctuates depending upon wind direction. Winds blowing from the west produce a quasimarine climate, while winds blowing from the east or south produce a continental climate. Proximity of Lake Michigan creates mild winters and cool summers, with annual average daily maximum and minimum temperatures of 13.8°C (56.9°F) and 4.2°C (39.5°F), respectively. Annual precipitation averages 79.7 cm or 31.4 inches (Metcalf & Eddy 1982). Figure 3-7 provides a summary of climatological data for 1985. Meteorological data for Muskegon County, including information on monthly precipitation rates temperature and cloud cover, appear in Appendi : 3.1.

The Michigan Department of Natural Resources (MDNR) monitors air quality for all pollutants under the National Ambient Air Quality Standards (NAAQS), except hydrocarbons. Under this program, levels of sulfur dioxide, carbon monoxide, and lead have been found to be less than established standards.

Monitoring for air pollutants in Muskegon County is conducted by the Muskegon County Health Department's Air Quality Section and by local industries. No violations of the primary or secondary particulate levels were recorded for years 1980, 1981, 1983, 1985 and 1986. One violation of the secondary standard was recorded in 1982 and 1984. No violations of the sulfur dioxide or lead standard have been recorded in over 8 years. The last violation of the carbon monoxide standards was recorded in 1978.

Muskegon County has recorded violations of the ozone standards in the past 8 years. However, the pollutants which lead to the formation of ozone are believed to be generated from outside of Muskegon County (MDNR, 1985e, Annual Air Quality Report).

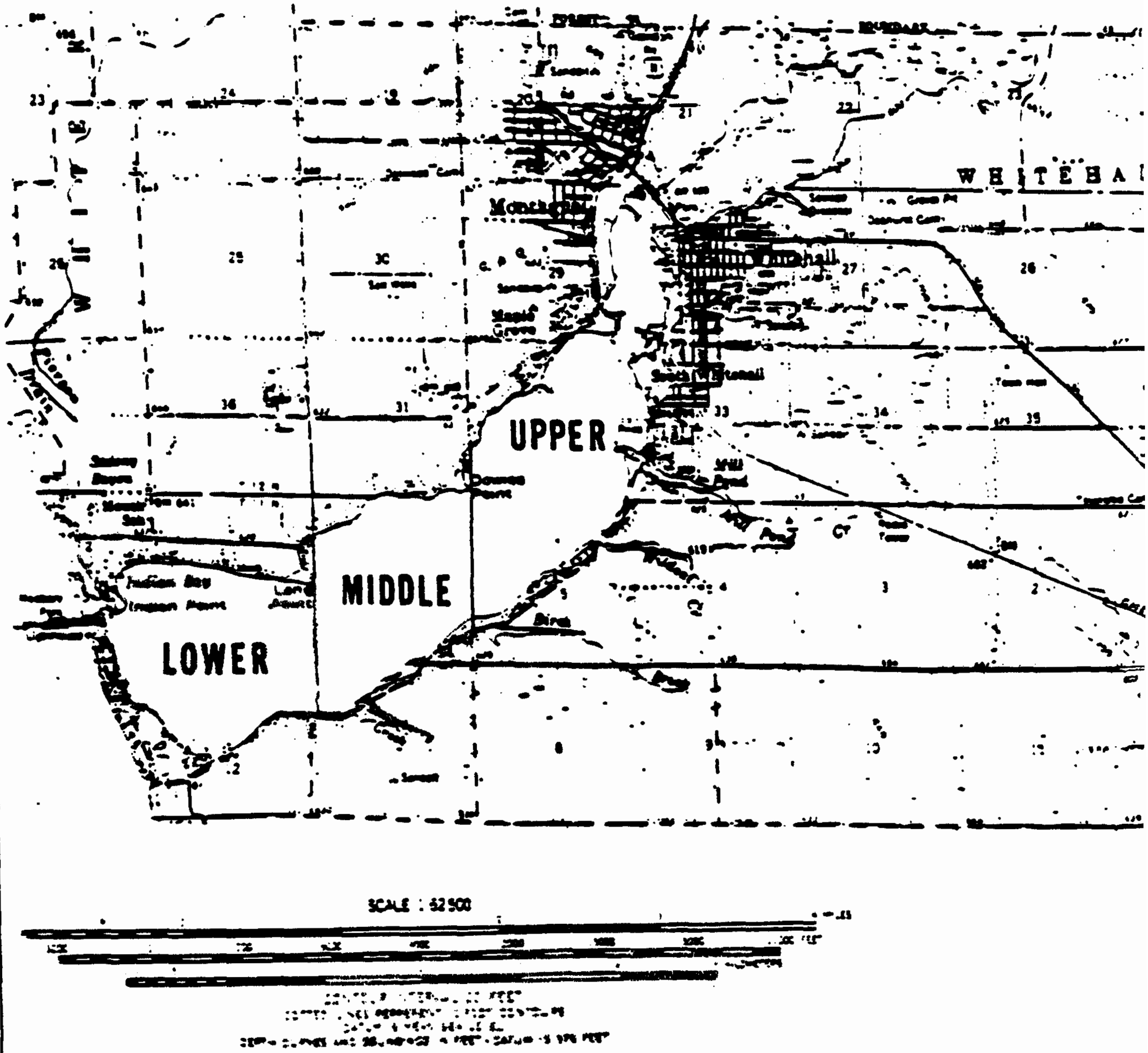


FIGURE 3-6. LOWER, MIDDLE, AND UPPER BASINS OF WHITE LAKE (ERG, 1980).

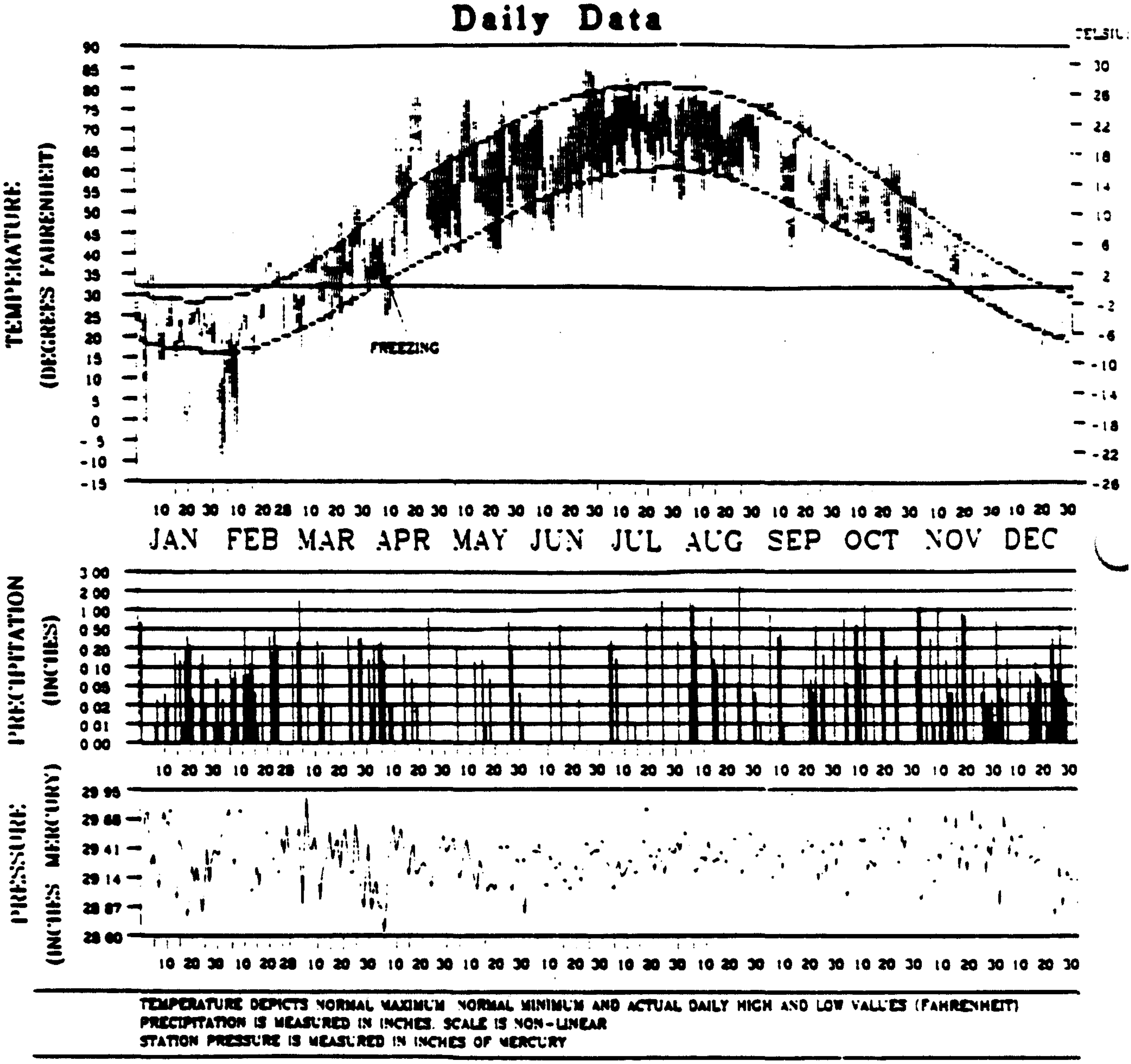


FIGURE 3-7. MUSKEGON COUNTY CLIMATOLOGICAL DATA (NOAA, 1985).

3.3 LANDCOVER AND USES

The WMSRDC has completed an extensive investigation of land cover and land uses in Muskegon County. Information presented in this section has been recovered from "Sourcebook for Water Quality Planning Part III Estimates of Land Cover and Use" (WMSRDC (no date)b).

3.3.1 Land Cover

The extent of runoff and erosion occurring in an area is generally dependent upon the type of land cover present. Land cover classes include:

- Water
- Bare earth
- Wooded
- Grassy vegetation
- Impermeable surfaces (paved areas)

Percentage and acreage of each type of land cover are provided for each Watershed Management Unit in the White River Basin (Table 3-3). Extent and type of land cover in the area was estimated through the use of aerial photography. Due to seasonal changes, values presented here are only general estimates. Difficulty in the identification of water bodies or bare earth where some vegetation was present may have caused under representation of these two categories.

Table 3-3. Estimates of Land Cover per Watershed Management Unit

Type of Land Cover	Units	North Branch WMU	South Branch WMU	White River WMU	White Lake WMU
Water	%	1.4	1.9	3.2	13.6
	Acres	738	644	1,669	2,311
Bare	%	2.1	1.4	2.3	3.4
	Acres	1,101	497	1,226	584
Grassy	%	49.5	40.9	31.7	44.2
	Acres	26,519	14,049	16,759	7,519
Wooded	%	46.6	55.0	61.9	35.5
	Acres	24,986	18,863	32,761	6,028
Impermeable	%	0.5	0.8	1.0	3.2
	Acres	264	262	523	552

Source: Modified from WMSRDC (no date)b

Predominant types of land cover vary between Watershed Management Units, but wooded and grassy areas are generally the most common. Impermeable surfaces are the least common land cover type in each WMU.

Areas predominantly covered with vegetation or sandy soils with high infiltration rates experience lower degrees of runoff and erosion than areas of clay-rich soils or impermeable materials. Generally, areas with relatively high percentages of impermeable surface cover have a greater potential for contamination resulting from urban runoff.

Perhaps the single most important characteristic governing the water regime and drainage patterns in Muskegon County, more than anything else except precipitation, is the high soil infiltration rate due to sandy soils. The high infiltration rate of the Muskegon County soils, for the most part, exceeds the rainfall intensities for all but the severest of storm events (Muskegon County, 1974). This quality increases the potential for increased groundwater contamination due to man's activities.

3.3.2 Land Use

Types of land use provide information for the potential for contamination. The West Michigan Shoreline Regional Development Commission (1978) divided land use into nine categories ranging from areas with land uses that possess the greatest potential for pollutant production to those with the least:

- Waste disposal
- Industrial
- Residential
- Agricultural
- Transportation
- Extractive
- Institutional
- Open space and recreation
- Commercial

Table 3-4 lists the extent of land use types per Watershed Management Unit in the White Lake Basin. Percentages and actual acreages of land use types were determined using aerial photographs. Due to the subjective nature of the method utilized for classification of land areas into the nine categories, the amount of land presented per category are generally estimates of land uses in the White River Drainage Basin. In areas where questions arose concerning the identification of the land use type, the areas were classified as the land use category containing the greater potential for pollutant production. Specific types of land use are described in the following paragraphs.

Waste disposal land uses refer to areas containing dumps, landfills, sewage treatment facilities, incineration facilities, sludge or industrial disposal sites and waste injection well sites.

Industrial land uses refer to areas containing factories, manufacturing plants, power generating plants, or any operations that process raw materials into purchase products.

Table 3-4. Estimates of Land Use per Wate{shed Management Unit

Type of Land Cover	Units	North Branch WMU	South Branch WMU	White River WMU	White Lake WMU
Waste Disposal	%	0.0	0.0	1.5	0.7
	Acres	21	0	792	118
Industrial	%	0.0	0.0	0.0	4.0
	Acres	0	0	0	673
Residential	%	1.9	1.7	1.8	11.4
	Acres	1,027	573	970	1,937
Agricultural	%	36.6	28.1	25.7	29.2
	Acres	19,547	9,659	13,540	4,956
Transportation	%	2.0	1.7	2.5	4.2
	Acres	1,081	600	1,340	710
Extractive	%	0.1	0.6	0.1	0.2
	Acres	59	217	60	33
Institutional	%	0.0	0.0	0.0	0.1
	Acres	0	0	29	22
Recreational	%	59.3	67.8	68.1	49.7
	Acres	31,723	23,264	35,858	8,450
Commercial	%	0.0	0.0	0.1	0.6
	Acres	4	10	51	101

Source: Modified from WMSRDC (no date)b

Residential uses include areas containing not only private homes but also hotels, motels, apartments, prisons or any type of housing unit. The major pollutant that would result from this category of land use is sewage. These sources have been eliminated by the construction of collection sewers, as part of the Muskegon County WMS No.2 facility.

Agricultural uses relate to areas used for livestock and crop production. Cropland, orchards, barnyards, and equipment storage yards are examples of areas covered by this category. There are approximately 4168 hectare (10,300 acres) of cropland in the White Lake basin in Muskegon County (Mund, 1987). The cash crops raised are corn, wheat, green beans, asparagus and alfalfa. A few livestock operations are also present. There are muck operations along the White River with celery the primary crop. The amounts of soil erosion and actual sediment yield from these croplands are not presently quantified. Contamination resulting from agricultural use would be in the form of fertilizers, pesticides, herbicides and animal wastes.

Estimates of restricted use pesticides used in Muskegon County in 1986 are listed on Table 3-5.

Table 3-5. Restricted Use Pesticides used in Muskegon County in 1986 (Creagh, 1987).

Pesticides	Amount Used kg	(lbs)
Azinphos methyl	2562	(1,164.5)
Carbamate	776	(352)
Parathion	635	(288)
Chlorinated hydrocarbons	3.3	(1.5)
Methomyl	222	(100.6)
Paraquat/Diquat	842	(382)
Pyrethroids	116	(52.7)
Organo-Phosphate	2697	(1,223)
Chlorinated Benzene Compounds	5.2	(2.4)

Transportation uses refer to any areas used for movement from one place to another. These areas include roads, sidewalks, railroads, telephone lines, parking lots, and pipelines. Areas used for transportation of vehicles cover the majority of this category. Contamination resulting from transportation uses primarily includes fuel, heavy metals, grease, road salt, and other debris commonly resulting from vehicle use.

Extractive uses refer to mining, commercial hunting or fishing, petroleum, and any commercial processes that involve permanent removal of natural resources. Trash, sediment production, or oil well leakage are examples of contaminants that may result for extractive uses.

Commercial uses refer to areas where products or services are bought or sold. Contaminants resulting from this use category are generally runoff in nature.

Institutional uses refer to areas maintaining operations such as educational institutions, churches, or government offices. Contamination resulting from this use category may be residential (i.e., sewage) or commercial in nature.

Open space and recreation uses refer to outdoor activities only. Open space and recreation uses include all bodies of water, forest land, camps, parks, golf courses, and any other areas designed for outdoor use in addition to "unused" land. Three State parks exist in Muskegon County, one located directly adjacent to the Area of Concern. Contamination results from three main sources: litter, effluents and erosional sediments, and natural sediments and nutrients.

Open space and recreation areas cover the largest percentage of land use in each of the four Watershed Management Units in the White River Drainage Basin. Agricultural land uses encompass the second highest percentage in each WMU. Industrial, waste disposal, commercial, extractive, and institutional uses are low in each WMU. Among the WMU's, the White River WMU has the highest waste disposal use of the four WMUs.

3.3.3 Sewer Service Systems

The cities of Whitehall and Montague are the only areas that maintain a sewer service system in the White Lake AOC (Metcalf & Eddy 1982).

The sewage collection system discharges to the Whitehall/Montague Waste Management System located east of Whitehall. This lagoon storage, treatment and land application system presently discharges underdrainage to Silver Creek, a designated trout stream.

Combined stormwater overflows have occurred at two pump stations, one located upstream of Business Route 31 and the other in the vicinity of Spring Street and Slocum Street. Both stations, located along the south shoreline of White Lake are scheduled to be upgraded with emergency electrical generators to maintain pumping capability during power outages.

Storm sewer systems service the cities of Whitehall and Montague. Drainage area, number of outfalls, and receiving waters are provided for each collection system in Table 3-6. Total drainage area covered by these systems is 200 hectare (495 acres) (WMSRDC 1978a). These sewers direct stormwater runoff into the White River and White Lake.

Table 3-6. White River Basin Storm Sewer Network

Political Jurisdiction	Number of Outfalls	Area Drained Hectare	(Acres)	Receiving Waters
City of Montague	4	61	(151)	Buttermilk Creek Coon Creek
City of Whitehall	19	139	(344)	White Lake Bush Creek

Source: Modified from WMSRDC 1978a.

Information concerning the effects of stormwater on the water quality of the White River Basin was not available. Because stormwater runoff can contain biochemical oxygen demanding (BOD) substances, suspended solids, chemical oxygen demanding (COD) substances, total nitrogen and total phosphorus, its addition to surface waters can deteriorate water quality. WMSRDC 1978a estimated pollutant loadings from stormwaters to White lake are provided in Section 6.2. WSMRDC indicated that stormwater runoff has not been a documented problem affecting White Lake water quality.

3.4 WATER USES (WHITE LAKE AOC)

3.4.1. Water Supply

White Lake is not used as a drinking water supply.

Drinking water supplies in the White Lake AOC are provided primarily by municpal wells and a limited number of private water wells. Montague and Whitehall now operate three and five Michigan Department of Public Health (MDPH) certified water supply wells, respectively.

Montague's uncontaminated municipal water wells are 49 to 55 m (160 to 180 ft) deep. One is located in the vicinity of Church Street and Water Street and the other two are located, east of town, off Lasley Street in the vicinity of the White River.

3.4.2 Commercial Fishing

There is no commercial fishing in White Lake.

In 1986, three commercial fishing licenses were authorized by the MDNR to fish the waters of Lake Michigan in the vicinity of White Lake. They are authorized to fish from the Port of Muskegon. By law, these licensees may only fish the waters of Lake Michigan within a 80.4 km (50 mi) radius of their docks in Muskegon Lake. In fact, these licensees fish in close proximity to Muskegon Lake and do not use the full radius granted by their licenses.

Two of these enterprises are multispecies operations. Specifically, they harvest whitefish with largemesh trap nets in waters 27.7 m (90 ft) or less; and they harvest chubs with small mesh nets in waters deeper than 73.8 m (240 ft). The third operation is exclusively a chub fishery.

These fisheries are highly regulated by the State to reduce both conflicts with sports anglers and nontarget fish mortality. There is no indication that the commercial fishing use is impacted.

3.4.3. Sport Fishery

Fishing is one of the primary tourist attractions in the White River and White Lake basin. Fish species common to the White Lake AOC include white bass, smallmouth bass, largemouth bass, crappie, carp, perch, walleye, northern pike, bluegills, steelhead and salmon. Smith (1986 personal communication) described White Lake to be second, only to

Muskegon Lake, in popularity and value as a fishery in western Michigan. The lake supports a tremendous sports fishery.

Jamsen (1986 personal communication) reported that estimated annual angler days for White Lake increased from 23,00 to 60,000 between 1972 and 1982 (Table 3-7).

Table 3-7. Estimated annual angler days for all fishing by licensed anglers on White Lake. Muskegon County, Michigan

Year	Angler Days[1]
1972	23,000
1973	42,000
1974	unavailable
1975	43,000
1976	40,000
1977	54,000
1978	32,000
1979	49,000
1980	31,000
1981	28,000
1982	60,000

[1] Estimates based on mail survey of 13% of licensed anglers in Michigan, Margin of error unknown.

Kolar (1986) reported that White Lake supports anadromous (upstream migration to spawn) runs of chinook salmon which is listed, by the U.S. Fish and Wildlife Service, as a National Species of Special Emphasis. Listed species are those for which the U.S. Fish and Wildlife Service has legal responsibility and a high interest based on biological, social and economic criteria.

3.4.4 Wildlife Habitat

Kolar (1986) reported that White Lake provides important breeding, migratory and wintering habitats for numerous waterfowl species. Species breeding in the White Lake area include mallards, black ducks and wood ducks. Overwintering species include, mallards, black ducks and ringnecked ducks. In addition, the lake provides migratory habitat to pintails, redheads, canvasbacks, Canada geese, tundra swans and snow geese. Waterfowl data for White Lake has been summarized by Grettenberger (1985).

3.4.5 Contact and Noncontact Recreation

Approximately 53 percent of the land in the White Lake Basin is reserved for recreational uses (WMSRDC 1978a). Several parks exist in the White Lake Basin that provide facilities for noncontact recreational activities, including camping, picnicking and sports. The major park facility, upstream from the AOC, is the Manistee National Forest. The western margin of the park is located to the northeast of the White Lake AOC and partially situated in Montague Township. Contact recreation uses of the park include swimming and boating.

Sylvan Beach and Medbery Park and the nearshore areas of Lake Michigan are used extensively for contact reaction purposes (i.e . swimming and boating).

White Lake has no defined swimming beach area but does have three public access sites and parks that allow boat access.

Information provided by the MDNR's Recreational Facilities Division indicates that Muskegon County has over 12,000 registered watercraft, both pleasure and commercial, as of December 31, 1986. Sixty percent are represented by those craft 3.7 to 4.9 m (12 to 16 ft) in length, 22% by those 4.9 to 6.2 m (16 to 20 ft) in length and 13% by those craft greater than 6.2 m (20 ft) in length.

Six marinas provide for boat storage, docking and/or launching facilities. The charter boat industry also uses White Lake to access Lake Michigan for sports fishing. These marinas provide docking facilities for about 100, 142, 32 and 15 craft of lengths less than 6 m (20 ft), 6 to 9 m (20 to 30 ft), 9 to 12 m (30 to 40 ft) and greater than 12 m (40 ft), respectively. These facilities also provide an additional 288 m (936 ft) of broadside mooring. Based on recent marina expansion and development permit requests, required under Act 346 (Inland Lakes and Streams Protection Act), there will be an increase in available facilities in White Lake in the near future. This development is an indication that boat access to White Lake and Lake Michigan is very important for boating pleasure, fishing and other recreational uses of White Lake and Lake Michigan.

3.4.6 Navigation

Tributaries to White Lake are protected for navigation as per Michigan's Water Quality Standards.

In recent years, dredging of the White Lake harbor and navigation channel has been performed approximately every other year, depending on need based on U.S. Army Corps of Engineer inspections. Maintenance dredging of this area use to be necessary for deep draft vessels that provided cargo to the Occidental (Hooker) Chemical Company facility prior to its closure in 1982. The navigational channel is presently maintained for recreational watercraft.

The Federal project consists of a navigational channel that begins at the east shore of Lake Michigan and extends to the west shore of White Lake for a total length of 600 m (1950 ft). The maximum channel width is 61 m (200 ft) with a desired maintenance project depth of 5 m (16 ft). Sediments in the channel consist primarily of sand. Sediment quantities dredged since 1971 annually averaged 42,048 m (55,000 yd) from the White Lake (Grazioli, 1987).

It was determined in 1976, that some shoreline erosion at the White Harbor site was occurring due to the presence of the Federal navigation structures and that beach nourishment of the Lake Michigan shoreline, in the vicinity of the channel, was desired. Accordingly, shore erosion mitigation plans were formulated to provide about 29,230 m (38,000 yd) of sand annually (if required) at affected shoreline locations.

The U.S. Army Corps of Engineers performed dive inspections at the beach nourishment sites in 1977. They found the bottom areas to be sandy and suitable for deposition of clean dredged material.

The most recent (1979) sediment testing and benthic data for White Lake Harbor indicated the sediments are suitable for openwater disposal and/or beach nourishment. The sediment sampling frequency for the White Lake Harbor has been extended to once every 20 years.

3.4.7 Waste Disposal

There are four NPDES-permitted dischargers in the vicinity of the White Lake AOC (Table 3-8). The Muskegon County WMS No. 2 facility discharges underdrainage from a land application wastewater treatment site to Silver Creek, a designated coldwater stream tributary to the White River. The WMS treatment facility is located about 4.4 km (2.75 mi) east of White Lake. Section 5.1.2 provides additional characteristics of these surface water dischargers included in the White Lake AOC review.

3.5 WATER QUALITY STANDARDS, GUIDELINES, OBJECTIVES AND APPLICABLE DESIGNATED USES

The State of Michigan designed the Intra-State Water Quality Standards for the State of Michigan in 1972 (WMSRDC, 1977). The standards, most recently revised in 1986, provides water quality guidelines and criteria for the Great Lakes and all other surface waters in Michigan. The State of Michigan established six different designated uses for surface waters. The following designated uses establish the degree of water quality standards required:

- Total Body Contact Recreation
- Fish, other aquatic life, wildlife
- Agricultural water supply
- Industrial water supply
- Public Water supply at the point of intake
- Navigation

Table 3-8. Surface Water Dischargers to AOC

Industry	NPDES Permit Number	Receiving Water	Discharge
E.I. duPont deNemours & Co.	MI0000884	Lake Michigan White Lake	- treated process waste - intake filter backwash
Occidental Chemical (formerly: Hooker Chemical and Plastics Company)	MI0002631	White Lake	- treated purge well water, vault drainage, stormwater runoff and equipment wash water
Muskegon County Wastewater Management System No. 2	MI0029173	White River via Silver Creek	- treated sanitary and industrial wastewater
Howmet Corp. Misco Division (Whitehall) Plant No. 1	MI0002623	White Lake	- NCCW

Source: MDNR Files

In cases where the same body of water has more than one use, the more stringent use dictates which water quality standard applies.

Once the State has designated the specific uses of a water body, eleven criteria are used to assess water quality:

- Suspended Solids
- Dissolved oxygen
- Acidity/alkalinity (pH)
- Taste and oder producing substances
- Toxic substances
- Radioactive substances
- Plant Nutrients
- Fecal coliform
- Dissolved oxygen
- Temperature
- Residues

In 1977, the West Michigan Shoreline Regional Development Commission (WMSRDC) determined that White Lake failed to meet the 1983 "fishable and swimmable" goal, set forth by Public Law 92-500 (The Federal Water Pollution Control; Act of 1972). White Lake was predicted to fail this goal for an estimated 20 years (WMSRDC 1977). This was attributed to fish contamination, nutrient enrichment, a degraded benthic community, contaminated sediments, raw sewage discharges and fish tainting (WMSRDC, 1977).

Specific issues and concerns about the quality of White Lake, raised by WMSRDC (1978a), in order of decreasing significance, were as follows:

- Fish contamination
- Eutrophication
- Benthic community degradation
- Contaminated lake sediments
- Raw sewage discharge
- Fish tainting

WMSRDC also recommended further investigation of groundwater contamination in the AOC.

Currently, water quality of Michigan's surface waters is evaluated using updated (1986) Michigan Water Quality Standards that includes Rule 57 defines procedures for developing protective limits for toxic substances discharged to waters of the State (Appendix 4.1). Some of the parameters of concern in the White Lake AOC and Rule 57(2) guideline values for surface waters are as follows:

Toxic Substance	CAS Number	Rule 57(2) Guideline (ppb)	Basis
Bis(2-chloroethyl) ether	111444	3.4	HLSC
Carbon tetrachloride	56235	27	CRV
Chlorobenzene	108907	71	ACV
Chloroform	67663	43	CRV
1,2-dichloroethane (ethylene dichloride)	107062	560	CRV
Hexachlorobenzene	118741	0.0019	CRV
Hexachlorobutadiene	87683	6.5	HLSC
Hexachlorocylopentadiene	77474	0.5	ACV
Octachlorocyclopentene	706785	-	-
Tetrachlorethylene (perchloroethylene)	127184	20	CRV
1,1,1-trichloroethane	71556	120	ACV
Trichloroethene (trichloroethylene)	79016	94	ACV
1,2-bis(2-chloroethoxy) ethane (triethylene glycol dichloride)	112265	800	ACV
Polychlorinated biphenyls (PCB)	Class 079	0.000012	CRV

ACV = Aquatic Chronic Value
CRV = Cancer Risk Value
HLSC = Human Life-Cycle Safe Concentration
CAS = Chemical Abstract Service Number

Sediment quality is an important component to evaluate because contaminants in the aquatic environment often accumulate to higher concentrations in the sediments than in the overlying water column. The major concern is that contaminated sediments may, in turn, act as a source of contaminants to biota associated with the sediments and overlying water. Numerical sediment criteria, based on the relationship of contaminant concentrations to biological effects, have not been developed because of inadequate scientific understanding of the complex ways the many possible combinations of inorganic and organic constituents in sediment interact to influence the biogeochemical behavior, and thus effects, of sediment contaminants (U.S.EPA, 1987).

In the absence of effects-based sediment criteria, a variety of approaches have been developed to evaluate potential environmental effects of contaminated sediments that include physical characteristics, biological oxygen demand and other sanitary engineering measurements and elutriate test results comparison with water quality criteria. Bioassays and bioaccumulation tests are being developed and have only recently been used to directly evaluate the potential environmental effects of contaminated sediments. However, acceptable testing methods and procedures have yet to be developed. The development of effect-based criteria continues (Ehorn, July 1987). Some affect conclusions are discussed as part of the Benthic Community Section 4.2.3.1 based on organism associations with contaminated sediments.

Table 4-5 of Section 4 provides four sediment evaluation criteria: the U.S.EPA Dredge Spoils criteria (used to determine if sediments are suitable for open water disposal as part of harbor maintenance projects), Lake Michigan background concentrations of selected contaminants, Michigan lakes and streams background values reported by Hesse and Evans (1972) and dredge spoils criteria used by the Ontario Ministry of the Environment. Sample results were compared with these values to determine relative level of contamination and do not represent effect-based criteria, as discussed above.

It is the collective opinion and experience of MDNR staff that, with the exception of mercury and possibly selenium, common heavy metals do not bioaccumulate in fish tissues at levels much greater than Statewide background concentrations.

The Michigan Department of Public Health (MDPH), U.S. Food and Drug Administration (FDA) and International Joint Commission (IJC) guidelines used for evaluating levels of certain toxic substances in edible portions of fish and the need for fish consumption advisories are as follows:

Parameter	FDA (ppm)	MDPH (ppm)	IJC (ppm)
Aldrin/Dieldrin	0.3	0.3	0.3
DDT	5	5	1
Lindane			0.3
Endrin	0.3	0.3	0.3
Heptachloroepoxide	0.3	0.3	0.3
Chlordane	0.3	0.3	
Kepone	0.3	0.3	
Mercury	1	0.5	0.5
Mire [illegible]	0.1	0.1	less than detection
PCB	2	2	0.1
Toxaphene	5	5	
PBB	0.3	0.3	
Dioxin	25-50 ppt	10 ppt	10 ppt
Unspecified organic compounds			less than detection

Health consumption advisories are annually updated and published in the Michigan Fishing Guide provided with the purchase of a Michigan fishing license.

4.0 IMPAIRED USE ASSESSMENT

The intent of this section is to define impaired uses of the White Lake AOC based on environmental monitoring data. Data reviewed included water quality (nutrients, inorganic and organic contaminants), benthic (bottom dwelling organisms) community assessments and environmental contaminant monitoring data for sediments and fish. Groundwater contamination potentially affecting the AOC was also discussed.

4.1 IMPAIRMENT EVALUATIONS

White Lake reportedly experienced increased degradation during the 1950s to the mid-1970s due to increased industrial and municipal discharges directly to and upstream of White Lake. Surveys conducted since 1952 indicated that White Lake experienced conditions causing the occurrence of nuisance algal blooms, tainted fish flesh, loss of white bass fishery, reduction of walleye, perch and northern pike populations, fish contamination, sediment contamination, nutrient enrichment, dissolved oxygen depletion and degradation of the benthic community. These conditions resulted in a variety of lake quality concerns (Table 4-1) that were used to justify placing White Lake on the IJC's Areas of Concern list. Table 4-2 provides a listing of the historical impacts to tributaries within the White Lake AOC provided by WMSRDC (1978).

Diversion of point sources to the Muskegon County Wastewater Management System (WMS) No. 2 in 1973-1974 and the elimination of several septic tank and runoff source discharges resulted in reduced loadings of environmental contaminants and improvement in the environmental quality of White Lake. Even though some pollution sources were eliminated by 1974, some contaminant sources remained in the area, Hooker Chemical Company's discharge and contaminated industrial groundwater discharges. After 1974, some of these contaminant sources continued to affect the quality and resources of White Lake and its tributaries.

In 1977, the West Michigan Shoreline Regional Development Commission (WMSRDC) determined that White Lake failed to meet the 1983 "fishable and swimmable" goal, set forth by Public Law 92-500 (The Federal Water Pollution Control; Act of 1972). White Lake was predicted to fail this goal for an estimated 20 years (WMSRDC 1977). This was attributed to fish contamination, nutrient enrichment, a degraded benthic community, contaminated sediments, raw sewage discharges and fish tainting (WMSRDC, 1977).

Specific issues and concerns about the quality of White Lake, raised by WMSRDC (1978a), in order of decreasing significance, were as follows:

- Fish contamination
- Eutrophication
- Benthic community degradation
- Contaminated lake sediments
- Raw sewage discharge
- Fish tainting

Table 4-1. Historical Impaired Uses of White Lake and Current Status

Impaired Uses	Causes	Sources	Current Status
Contaminated fish	Polluted bottom sediments	Hooker Chemical and Plastics Corporation, Howmet Corporation - Misco Division, Whitehall Leather Company	Carp PCBs and chlordane
Fish tainting	Polluted bottom sediments	Hooker Chemical and Plastics Corporation, Howmet Corporation - Misco Division, Whitehall Leather Company	No longer
Loss of fish production	Loss of benthos	Sediments contaminated with heavy metals, chlorides, organics	Improving
Elimination of benthic substrate	Substrate covered with hair and hides, high concentrations of heavy metals	Whitehall Leather Company	Improving
Degradation of benthic populations	Dissolved oxygen depletion, high levels of P and N, contaminated sediments	Point and nonpoint sources of P and N, metals, and organic compounds	Improving, needs to be checked
Recreational activities restricted, aesthetics impaired	High phosphorus algal blooms	Point and nonpoint sources of P and N	Improved

Source: WMSRDC 1978a.

Table 4-2. Historical Impaired Uses of Tributaries to White Lake Prior to WMSRDC, 1977

Impaired Uses	Causes	Sources	Status
Buttermilk Creek			
Recreational activities restricted, aesthetics impaired	Excess of phosphorus, nitrogen, fecal coliform bacteria, suspended solids, oxygen demanding substances, oils and greases	Raw domestic sewage discharge	Corrected
White River			
	Exceeds established phosphorus/nitrogen standards	Septic contamination from unsewered areas	Corrected
Carlton Creek			
Recreational activities restricted, aesthetics impaired	Excess of phosphorus, nitrogen, fecal coliform bacteria, oxygen demanding substances	Septic contamination from unsewered areas	Corrected
Millpond Creek			
Recreational activities restricted	Potential excess of phosphorus, nitrogen, fecal coliform bacteria, suspended solids, oxygen demanding substances, organic contaminants	Septic contamination from unsewered areas, contaminated groundwater	Corrected except contaminated groundwater

Source: WMSRDC 1977.

WMSRDC also recommended further investigation of groundwater contamination in the AOC.

4.2 MAJOR WHITE LAKE AOC COMPONENT EVALUATIONS

4.2.1 Water Quality

4.2.1.1 Tributaries to White Lake

Since the majority of Montague and Whitehall were sewered, in 1973, septic tank discharges to the tributaries of White Lake have been eliminated. Mill Pond Creek remains a problem site because it receives contaminated groundwater from both the Koch (Muskegon) Chemical Company site and Howmet Corporation's Plant No. 4 and possibly No. 5 sites.

Several volatile organic contaminants were detected in groundwater seeps to Mill Pond Creek and in Mill Pond Creek proper. MDNR biological surveys (Section 5.2.1.1.) of 1981 and 1983 indicated the absence of any obvious impacts to the Mill Pond Creek macroinvertebrate community downstream of the Muskegon Chemical Company contaminated seeps.

Fish were collected in June, 1983 from the Mill Pond (located downstream of Zellar Road) for fish contaminant monitoring purposes (Beck, 1983c). Four species of fish were analyzed as composite samples of three to five whole fish. Triethylene glycol dichloride and bis (2-chloroethyl) ether were less than a level of detection of 0.2 ppm. Analysis for other purgeable organic compounds was not done for lack of approved analytical methods. None of the substances were expected to bioaccumulate.

Analytical results reported by Beck (1983) and Przybysz (1986) for Mill Pond Creek water samples collected just upstream of White Lake or Mill Pond indicated contaminant concentrations were less than Rule 57 (2) guideline levels used to protect aquatic organisms (Appendix 4.1). The Michigan Public Health Department advised, because of the presence of known carcinogens, against swimming and wading in the unnamed pond upstream from White Lake Drive where chemical levels are elevated because of close proximity to the contaminated groundwater seeps (Boehm, 27 July 83 letter to Whitehall residents).

The presence of fish in the Mill Pond and macroinvertebrates just downstream of White Lake Dirve indicated the absence of acute toxic concentrations of the subject organic compounds. Therefore, there is little likelihood that there is any perceptible impact to uses of White Lake or Lake Michigan from these contaminated groundwater sources.

4.2.1.2 White Lake

4.2.1.2.1 Nutrients

White Lake is a dimictic system that thermally stratifies and undergoes spring and fall turnover or mixing. Nutrient (phosphorus and nitrogen) concentrations were historically elevated and characteristic of a eutrophic system (Limno-Tech, 1981; Grant, 1972 and Robinson, 1967). As a result, this lake sustained nuisance blooms of blue-green and green

algae. Ketelle and Uttermark (1971) listed White Lake among the "Problem Lakes of United States" based on existing nutrient enriched conditions.
Oxygen depletion does occur in the deeper basins but Limno-Tech (1981) indicated the duration decreased slightly after the diversion of wastewater to the Muskegon County WMS No. 2.

U.S.EPA (1975) reported results for a 1972 nutrient budget survey of White Lake that indicated that the lake was extremely eutrophic. Results showed White Lake to be nitrogen limited from June to September and phosphorus limited by November. During this study chlorophyll a ranged from 1.2 tp 18.9 ppb with the highest levels occurring in June and September and the lowest in November. Inlake phosphorus concentrations ranged from 25 to 44 ppb.

Limno-Tech (1981), subsequent to a nutrient budget study of White Lake from 1972 through 1980, concluded that White Lake became a phosphorus limited system by 1980. Based on a comparison of 1980 nutrient budget survey results with earlier survey data, Limno-Tech estimated that nutrient loadings and overall White Lake water quality showed very little improvement after municipal and industrial process wastewater was diverted to the Muskegon County WMS No. 2 facility in 1973-74. They indicated that total phosphorus loading concentrations and resultant inlake concentrations remained steady despite the elimination of most point source loadings to the lake. Phosphorus loading estimates are discussed further in Section 6.

An inlake phosphorus goal of 30 ppb (during spring and fall turnover periods) is recommended by the MDNR in order to provide good recreational water quality by reducing nuisance algal blooms that commonly occur at greater concentrations. Inlake phosphorus concentrations during lake turnover conditions of May 1987 averaged 24 ppb (range 19 to 36 ppb) at the 21.5 m (70 ft) deep middle basin (Appendix 4-1). This is in contrast to an inlake concentration of 58 ppb measured May 1980 in the same vicinity. The most recent data does indicate that water quality of White Lake has improved. (Additional lake survey data was collected October 1987 to evaluate nutrient conditions but results were unavailable prior to the completion of the RAP).

Limno-Tech did note some improvement, since the 1973-74 diversion. The duration of reduced dissolved oxygen concentrations, in the deep basins during summer stratification, has slightly decreased during periods of stratification and that algal mass and chlorophyll a concentrations have also shown a slight decrease.

4.2.1.2 Toxic Substances

In addition to nutrient budget evaluations, other water quality studies were performed to determine contaminant levels in White Lake.

Concern about contaminant loadings from Hooker lead to a lake survey, by the Company consultants (Williams and Works, June 1977), in the vicinity of the Hooker Chemical Company's discharge (Dowies Point). Survey results showed the presence of several toxic compounds in 45 lake profile samples: chloroform (less than 1.0 to 4.9 ppb), carbon tetrachloride (less than 1.0 to 54.8 ppb), trichloroethylene (less than 1.0 to 6.4 ppb), tetrachloroethylene (1.7 to 60.5 ppb). Approximately half of 21 samples analyzed contained detectable concentrations of hexachlorobutadiene or HCBD (0.05 to 1.0 ppb), hexachlorocyclopentadiene or HCP (0.1 to 1.1 ppb), octachlorocyclopentiene or OCP (0.1 to 0.4 ppb) and hexachlorobenzene or HCB (0.8 to 0.8 ppb). Some samples contained carbon tetrachloride, tetrachloroethylene, hexachlorocyclopentadiene and hexachlorobenzene concentrations that exceeded current Rule 57(2) guidelines for toxic substances listed in Table 4-3.

Table 4-3 Rule 57 (2) Guideline Levels in Surface Waters

Parameter	CAS Number	Guideline (ppb)	Basis
Bis (2-chloroethyl) ether	111444	3.4	HLSC
Carbon tetrachloride	56235	27	CRV
Chlorobenzene	108907	71	ACV
Chloroform	67663	43	CRV
1,2-dichloroethane (ethylene dichloride)	107062	560	CRV
Hexachlorobenzene	118741	0.0019	CRV
Hexachlorbutadiene	86783	6.5	HLSC
Hexachlorocylopentadiene	77474	0.5	ACV
Octachlorocyclopentene	706785	no value	
Tetrachloroethylene (perchloroethylene)	12184	20	CRV
1,1,1-trichloroethane	71556	120	ACV
Trichloroethene (trichloroethylene)	79016	94	ACV
1,2-bis(2-chloroethoxy) ethane (triethylene glycol dichloride)	112265	800	ACV
Polychlorinated biphenyls (PCB)	Class 079	0.000012	CRV

ACV = Aquatic Chronic Value
CRV = Cancer Risk Avlue
HLSC = Human Life-Cycle Safe Concentration
CAS = Chemical Abstract Service Number

By February 1977 the Company shut down the "Fine Chemical Production Facility" since it was unable to meet effluent limits in a 1976 Final Order prepared by the MDNR. Thus, the discharge of some of the above chlorinated hydrocarbons previously found in their effluent was discontinued. However, January and February 1978 sampling by the Company's indicated their effluent contained HCBD (0.1 to 0.1 ppb), HCP (1.8 to 2.8 ppb), HCB (0.3 ppb) and tetrachloroethylene (35 to 66 ppb) (Hooker Chemical Co. letter to MDNR, 8 March 78). Tetrachloroethylene concentrations in intake water, during the same period, ranged from 51 to 106 ppb. Another source, other than the Company's discharge to White Lake, was suspected. Additional sampling results for the Company's White Lake water intake (located nearshore, east of Dowies Point), in 1978, indicated the presence of 85 to 115 ppb tetrachloroethylene (Hogarth, 1978).

MDNR studies were performed in 1978 and 1979 on White Lake during periods of ice cover to determine the influence of the contaminated groundwater plume and point source discharge during stable lake conditions. Evans (1978) found thermal and chemical stratification of White Lake water due to elevated concentrations of chlorides. Chloride concentrations increased with depth in the deep basins, reaching 210 to 310 ppm (10 to 20 times greater surface concentrations of 15 to 20 ppm). Carbon tetrachloride (20 to 40 ppb) and dichloroethylene (40 to 80 ppb) were present in the deep water samples from the upper, middle and lower basins as well as in the immediate vicinity of Hooker's water intake.

Evans' (1979) study indicated that chlorides ranged from 9.7 to 320 ppm at the White Lake inlet and deep upper basin, located east of the Hooker outfall, respectively. Carbon tetrachloride (2.0 to 16 ppb) and trichloroethylene (2.0 to 4.0 ppb) were detected near the Hooker Chemical Company's intake. The highest concentrations of carbon tetrachloride (140 ppb) was found near the bottom of the lower basin. Tetrachloroethylene (28 ppb) and chloroform (9.0 ppb) were highest in in the basin east of Dowies Point and in the upper basin, respectively. Evans' 1979 survey results indicated that inlake concentrations of HCBD, HCP, OCP and HCB were less than a level of detection of 1.0 ppb

Recent MDNR surveys of White Lake in the vicinity of the Hooker Chemical Company plume (1981, 1982, 1984, 1985, 1986 and 1987) indicated a downward trend in lake concentrations of "low boiler" compounds (chloroform, carbon tetrachloride, trichloroethylene and tetrachloroethylene) off Dowies Point (Table 4-4, Figure 4.1). This reduction has resulted from the increased pumping rate in the purge well system that was increased from 135 gpm in 1987 to 560 gpm in February 1987. The pumping rate was increased to 685 gpm in August 1987 and recent evaluations indicate almost 100% capture of the plume. Evaluation of recent data is ongoing and a determination of final pumping rates necessary to maintain 100% plume capture will be defined in a meeting between Company.

Since 1979, inlake concentrations of HCBD, HCP, OCP and HCB have remained near or less than the levels of detection of 0.05, 1.0, 1.0 and 0.2 ppb. Two of fifteen lake water samples, collected in February 1986, contained 0.21 and 0.85 ppb HCBD that are less than the Rule 57(2) guideline value of 6.5 ppb.

The West Michigan Shoreline Regional Development Commission (WMSRDC) began a project in 1979 entitled "The Muskegon County Surface Water Toxics Study." During this project, the WMSRDC analyzed water samples, taken from White River and White Lake, for inorganic contaminants and a limited number of organic contaminants. Priority pollutants detected in these samples included arsenic, copper, lead and zinc (Appendi : 4.1).

Table 4-4 Summary of "Low Boiler" data for water samples from White Lake monitoring stations off Hooker Chemical Company's contaminated groundwater plume. 1981 - 1987. Values as ppb. (Source: Hooker Chemical Co. via Grand Rapids District staff)

Sampling Site	1/20/81	2/18/82	1/24/84	3/13/84	2/6/85	2/25/86	2/12/87
1	58	105	42	4	13	3	2
2	17	63	49	5	K 1	82	3
3	27	85	80	14	11	K 1	2
4	63	K 1	1	1	K 1	31	2
5	1	K 1	K 1	K 1	K 1	27	7
6	K 1	K 1	K 1	K 1	9	8	6
7	K 1	66	16	2	48	5	K 1
8	68	K 1	K 1	K 1	1	K 1	K 1
9	1	1	K 1	K 1	1	K 1	K 1
10	1	20	21	7	11	6	*
11	K 1	28	12	45	49	2	*
12	*	*	*	1	2	K 1	*
13	*	*	*	53	1	K 1	*
Average	21	34	20	10	11	13	3
GPM Collected	135	190	305[a]	305	345	490[b]	560

* = locations not sampled.
K = values less than the detection level indicated.
a = Purgewell system down for maintainance
b = Wells PH and PI down

"Lower Boiler" values represent sum concentrations of chloroform, trichloroethylene, carbon tetrachloride, tetrachloroethylene.

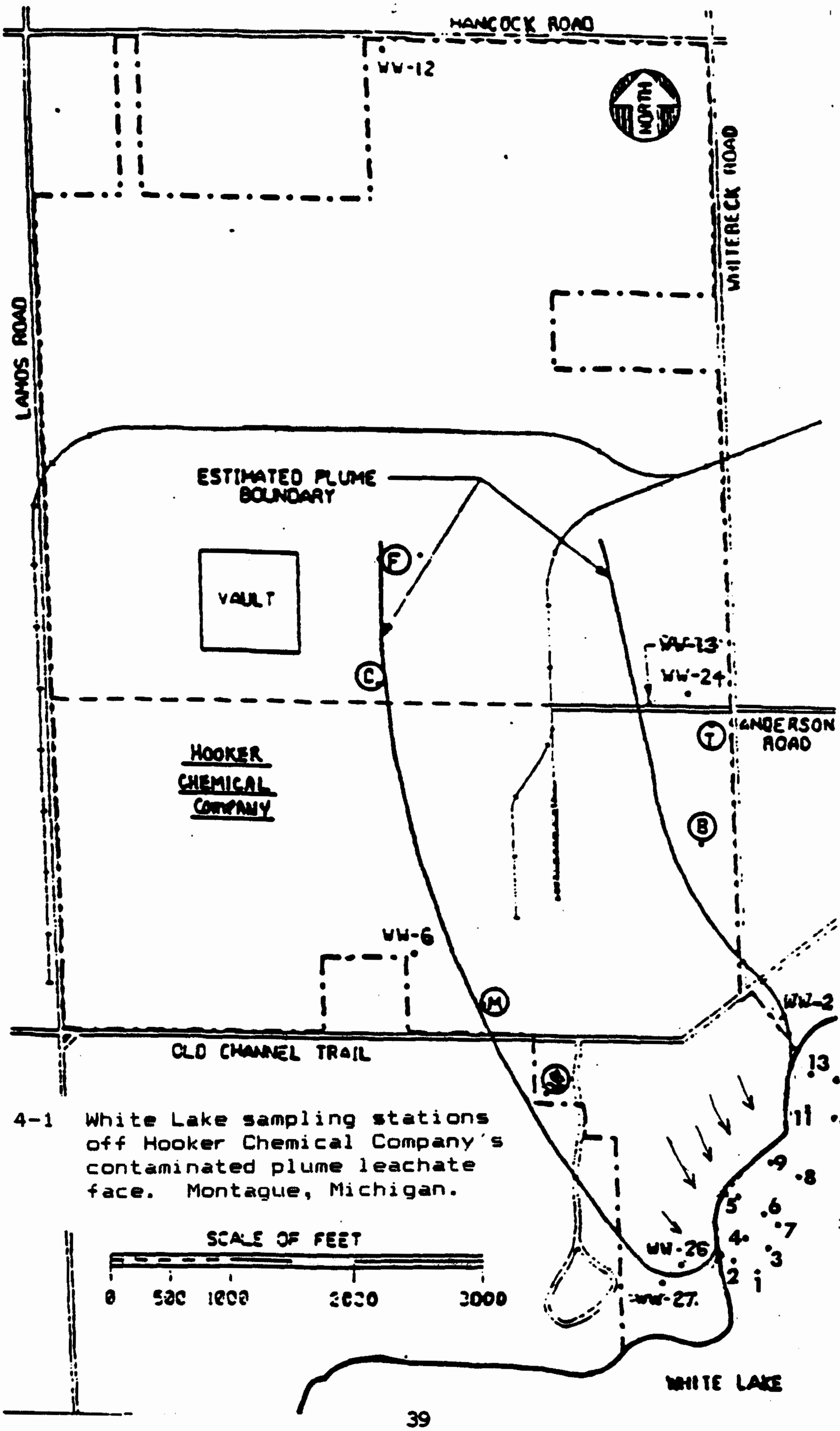


Figure 4-1 White Lake sampling stations off Hooker Chemical Company's contaminated plume leachate face. Montague, Michigan.

WMSRDC staff collected water samples from the backwater area adjacent to the Montague Dump, located on the north side of the White River upstream of White Lake. These samples were found to contain 50 and 130 ppb of lead and zinc which exceed or approximate the Rule 57 Aquatic Chronic Values (ACV) of 5.7 and 138 ppb, respectively, assuming a water hardness of 150 ppm as $CaCO_3$, typical of White Lake. The observed hardness near the dump site was 430 ppm in this backwater area. Increased water hardness reduces the toxic effects of lead and zinc as is reflected by the increase in the Aquatic Chronic Values of 29 and 338 ppb based on a water hardness of 430 ppm.

4.2.2 White Lake Sediment Quality

Several sediment sampling surveys were conducted in White Lake to document environmental contaminant levels. These surveys included: MDNR - 1972, 1975, 1980, and 1986; WMSRDC (1982) surveys during the period 1979 to 1982; U.S.EPA (ca. 1978-79) and U.S. Army Corps of Engineers' Federal White Lake Harbor maintenance sampling data for November 1979 (Appendix 4.2).

Table 4-5 provides four nonaffect sediment classification guidelines the U.S.EPA Dredge Spoils criteria (used to determine if sediments are suitable for open water disposal as part of harbor maintenance projects), Lake Michigan background concentrations of selected contaminants, Michigan lakes and streams background values reported by Hesse and Evans (1972) and dredge spoils criteria used by the Ontario Ministry of the Environment. Sample results were compared with these values to determine relative level of contamination and do not represent effect-based criteria, as discussed above.

Results of the 1972, 1980 and/or the 1986 MDNR surveys, for samples collected at similar locations (Figure 4-2), were compared (Table 4-6). White Lake sediment concentrations of mercury, arsenic, cadmium, copper, nickel and oil/grease decreased to levels at or below U.S.EPA dredge spoils criteria, by 1980. Chromium, lead and zinc concentrations exhibited a downward trend since 1972, but continue to exceed the above contamination evaluation criteria in samples from Tannery Bay, off Whitehall Leather Company; the 12 m (40 ft) deep basin off Hooker Company property, east of Dowies Point and/or in the other deeper lake basins, including the lower (west) basin.

The 1986 data (Appendix 4.2) for fifteen stations, in White Lake, included the analysis of twenty-five organic compounds. All the organic compounds, including PCBs, were less than their respective levels of detection which ranged from 68 to 3500 ppb. Oils and grease ranged from less than 20 to 27 ppm.

Although none of the sediment samples collected contained more than 10 ppm PCBs (U.S.EPA dredge spoils criteria), Michigan DNR staff are concerned about sediment concentrations greater than 1.0 ppm. PCB

Table 4-5 Nonaffect sediment classification criteria. (Concentrations as ppm)

Parameter	U.S. EPA	M.O.E.	Lake Michigan 1 Present	Lake Michigan 1 Past	Hesse Evans (1972)
Arsenic	8	8	10.5	5.3	0.4
Barium	60				
Cadmium	6	1	0.9		4.2
Chromium	75	25	46	62	1.6
Copper	50	25	22	21	
Cyanide	0.25				
Iron	25000				
Lead	60	50	40	19	37
Manganese	500				
Mercury	1	0.3	0.11	0.06	0.19
Nickel	50	25	24	36	
Selenium			1.2	1.8	
Zinc	200	100	97	74	31
Polychlorinated biphenyl (PCB)	10	0.05	0.01		
Volatile Solids	80000				
Chemical O ygen Demand	80000				
Total Kjeldhal Nitrogen	2000				
Oil and Grease	2000				
Phosphorus	650	1000	650		

1 = precolonial or natural average concentrations

Sources: Great Lakes Water Quality Board. 1982. Guidelines and Register for Evaluation of Great Lakes Dredging Projects. Report of the Dredging Subcommittee. Windsor, Ontario. 365 pp.

U.S. EPA Dredge Spoils Criteria. 1987.

TABLE 4-6 White Lake Sediment Data; 1972, 1980, and 1986.

Parameters[1]	A-10-N NE Basin Station 1			A-10-S Tannery Bay Stations 2 and 2A			B-50-N Station 4		
	1972	1980	1986[2]	1972	1980	1986	1972	1980	1986
Oils (mg/kg)	1300	86	20	1300	37	20	1500	230	-
TKN (mg/kg)	15714	-	15000	10667	-	13500	15333	-	14000
TP (mg/kg)	1920	-	1350	2467	-	10500	1933	-	1000
As (mg/kg)	7	< 1	-	7	< 1	-	7	< 1	-
Cd (mg/kg)	3	< 2	< 2	4	< 2	< 2	4	< 2	< 2
Cr (mg/kg)	171	30	39	6400	400	2535	2133	1400	907
Cu (mg/kg)	24	14	19	35	9	29.5	34	20	29
Fe (mg/kg)	-	40000	16700	-	19000	161000	-	60000	23000
Hg (mg/kg)	0.14	< 1	< 0.5	1.67	< 1	< 0.5	1.00	< 1	< 0.5
Mn (mg/kg)	-	320	-	-	1100	-	-	1000	-
Ni (mg/kg)	43	13	11	53	15	32	40	20	22
Pb (mg/kg)	37	40	26	147	40	95.5	173	120	94
Zn (mg/kg)	103	130	70	160	80	123.5	160	170	115
COD (%)	-	56	67	-	23	-	-	42	49

Parameters[1]	E-70-N		G-70-N West of Hooker Station 8			F-50-N West Basin Station 11		
	1972	1980	1972	1980	1986[2]	1972	1980	1986
Oils (mg/kg)	2100	209	1600	100	-	3700	77	-
TKN (mg/kg)	10167	-	6905	-	12500	11000	-	1300
TP (mg/kg)	1333	-	1524	-	1950	1900	-	1900
As (mg/kg)	9	< 1	5	< 1	-	10	< 1	< 0.5
Cd (mg/kg)	7	< 2	6	< 2	< 2	4	< 2	< 2
Cr (mg/kg)	1250	1000	619	700	697	260	690	460
Cu (mg/kg)	33	20	21	20	26	20	30	25
Fe (mg/kg)	-	65000	-	69000	22500	-	65000	22300
Hg (mg/kg)	0.75	< 1	0.29	< 1	< 0.5	0.1	< 1	< 0.5
Mn (mg/kg)	-	2000	-	2700	-	-	1300	-
Ni (mg/kg)	50	40	30	20	22	40	20	19
Pb (mg/kg)	203	130	324	120	96	100	230	102
Zn (mg/kg)	102	160	76	150	89	220	170	80
COD (%)	-	31	-	26	49	-	24	40

Sources: Modified from Evans, ca 1981, unpublished report and 1986 survey data.

[1] Values measured in mg/kg dry weight unless otherwise specified.

[2] Average of repeated analytical results.

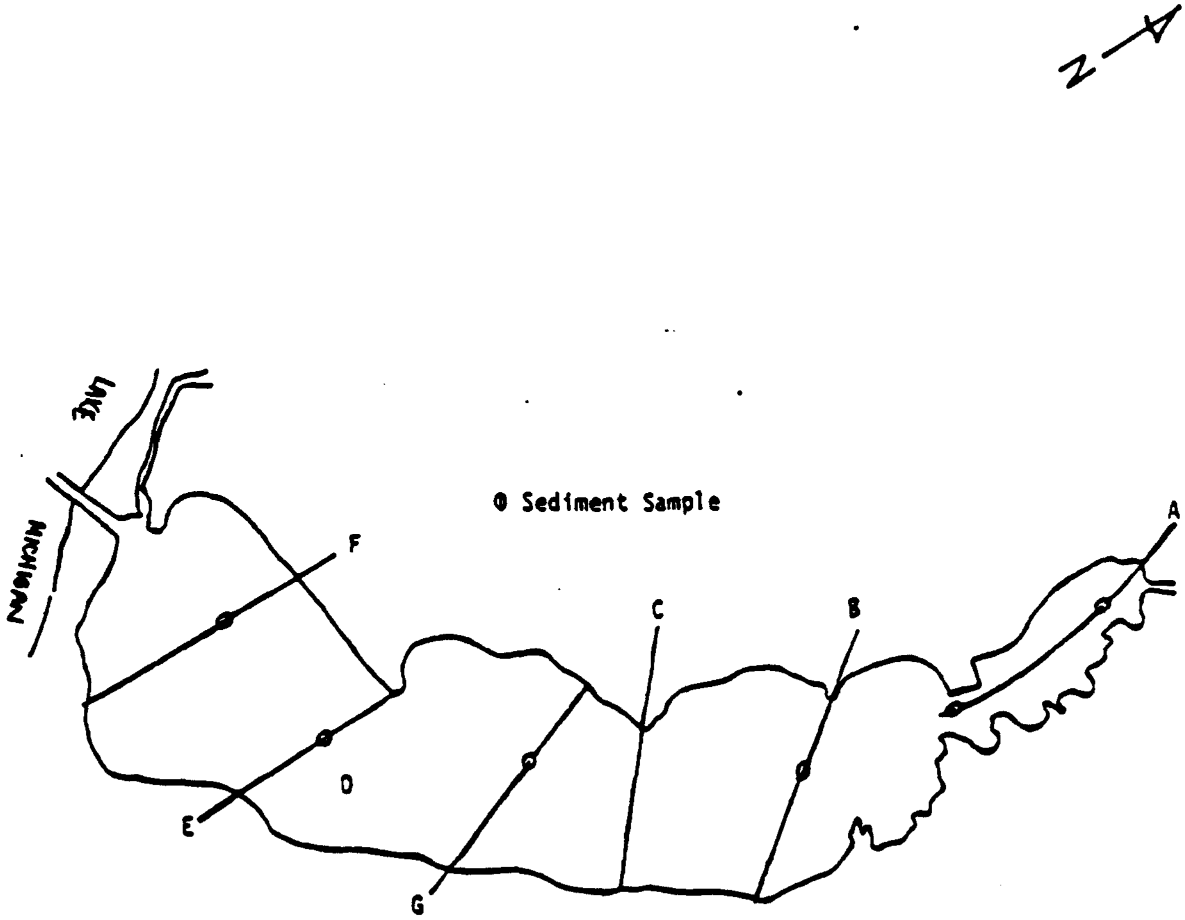


Figure 4-2 Location of similar sediment sampling stations in White Lake in 1972, 1980 and/or 1986. Muskegon County, MI.
Sources: Evans, ca. 1981 and MDNR survey data - December 1986.

concentrations of 1.0 ppm can possibly serve as sources to aquatic biota. Analytical results for sediment samples collected by the MDNR in June 1975 from four deep basins (Table 4-7, Figure 4-3) indicated the presence of 2.3 ppm of Arochlor 1254 in sediments in the 15 m (50 ft) upper (east) basin (Evans, ca. 1981). Arochlor 1254 was less than the detection level of 0.1 ppm in sediments from the other three basins. Concentrations of Arochlors 1242 and 1260 were less than their respective detection levels of 0.1 and 0.05 ppm at all four locations. The 1986 sediment survey samples are being reanalyzed for PCBs using a method with a detection limit less than 1.0 ppm. PCBs and chlordane are of concern since they are the only two contaminants that exceeded MDPH and U.S.FDA action levels in White Lake carp (see 4.2.3.2, below).

Table 4-7 Analytical results for polychlorinated biphenyls in White Lake sediment samples collected 30 June 75. Muskegon County, MI. Values on a dry weight basis.

Station	Arochlor 1242 (ppm)	Arochlor 1254 (ppm)	Arochlor 1260 (ppm)
WL - 1	K 100	K 100	K 50
WL - 3	K 100	2300	K 50
WL - 4	K 100	K 100	K 50
WL - 6	K 100	K 100	K 50

Source: MDNR file

Phases I through IV of the WMSRDC (1982) study involved the analysis of 12 and 5 sediment samples from White Lake and tributries (White River, unnamed tributary receiving Howmet Corporation discharge and Pierson Creek), respectively. These data indicated lake wide chromium, lead and zinc concentrations ranged from 10 to 5600 ppm, 15 to 160 ppm and 48 to 140 ppm, respectively. The highest contaminant levels were associated with Tannery Bay and/or the deeper lake basins, including the west basin.

Further, WMSRDC (1982) intensively sampled (18 samples) White Lake sediments in the northeast third of the lake during the fifth and final phase of their Muskegon County lakes. Analytical results indicated that chromium, lead and zinc concentrations ranged from less than 1.3 to 3900 ppm, less than 2.5 to 240 ppm and 3.0 to 160 ppm, respectively (Appendix 4.2). Specific locations for the eighteen sampling stations were not reported making it difficult to conclude anything about the distribution of these contaminants in relation to suspected point sources.

WMSRDC survey results also indicated that sediments in an unnamed tributary to White Lake, receiving Howmet Corporation's discharge, contained elevated levels of chromium (280 ppm), lead (460 ppm), zinc (120 ppm), nickel (720 ppm), copper (380 ppm) and oil/grease (2200 ppm). Newell (1970) observed, during a MDNR point source survey, that Howmet

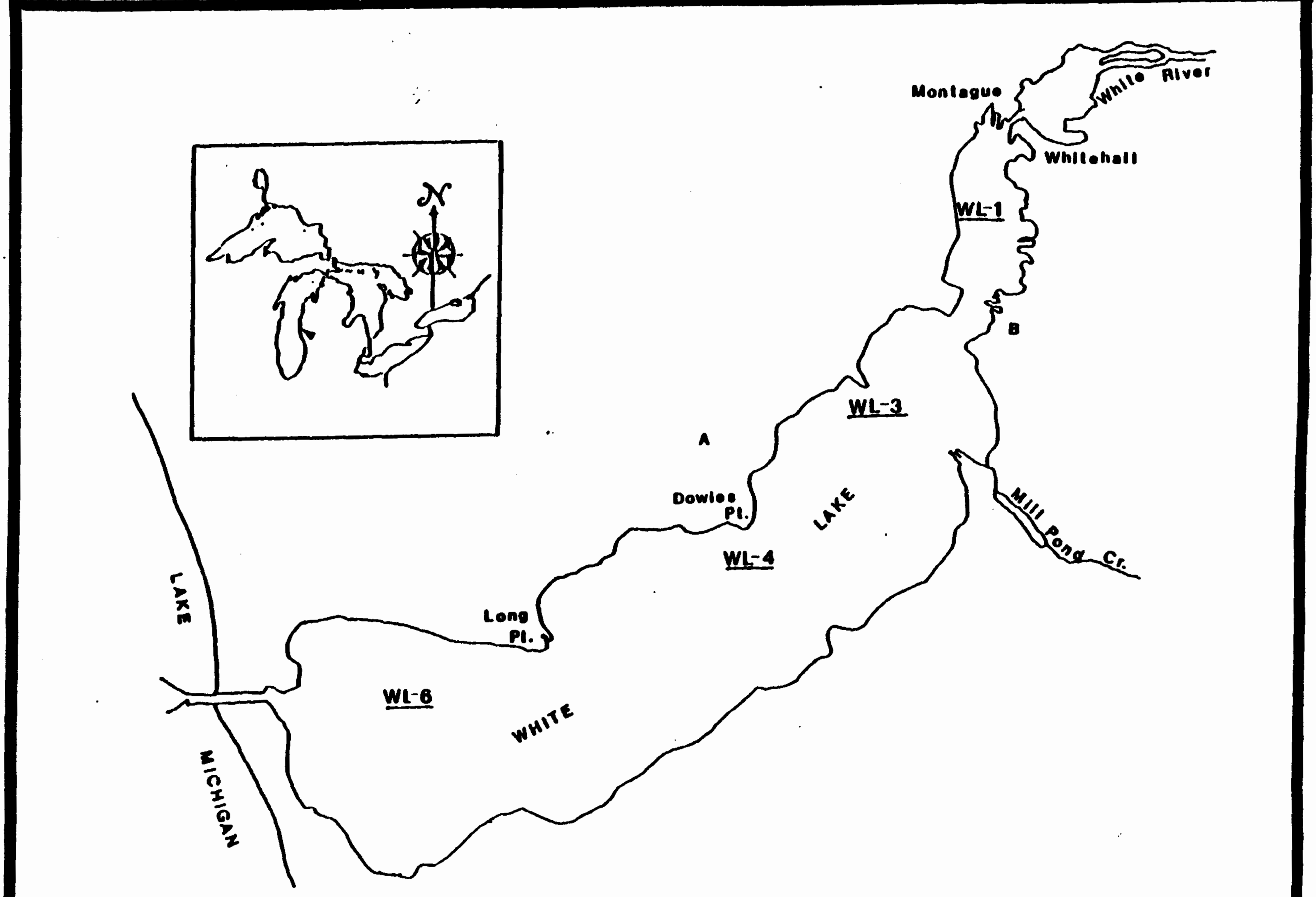


Figure 4-3 White Lake sediment monitoring stations during the 30 June 75 survey. Muskegon County, MI.

Corporation discharge flows through a landfill area used by the Whitehall Tannery. He also noted that the Howmet Corporation, at the time, did not use a chrome plating process.

WMSRDC (1982) determined that White Lake sediments contained elevated levels of inorganic contaminants (primarily chromium, lead and zinc that exceeded dredge spoils criteria). They concluded that "...the Commission shall recommend no lake reclamation efforts beyond support for the MDNR regarding the site clean-up and groundwater pollution containment of both the E.I. duPont deNemours Company and Hooker Chemical and Plastics Corporation. While the pollution of the sediments undoubtedly degrades aquatic habitat, White Lake is apparently able to support a substantial fishery. The ubiquitous distribution of toxic inorganic substances throughout White Lake's bottom sediments makes removal or isolation difficult."

WMSRDC (1982) also reported, during Phase I (in 1979) of their intensive study, a PCB concentration of 25.56 ppm (as Arochlor 1254) in sediments from the upper basin. WMSRDC (1982) also found sediment PCB concentrations, greater than 1.0 ppm, along the north shoreline of White Lake at concentrations ranging from 3.5 ppm of Arochlor 1242 (West of Long Point) and 3.1 ppm and 2.0 ppm Arochlor 1248 to the west and east of Dowies Point, the latter two, in the vicinity of Hooker Chemical Company's discharge.

Concern about organic contaminants in Hooker's discharge (see Section 5.1) raised concern about contamination of lake sediments and biota. Swanson (1976) reported analytical results for nine lake sediment samples (six from the vicinity of Hooker Chemical Company's discharge) collected from White Lake on May 26, 1976. These data indicated that hexachlorocyclopentadiene (HCP), hexachlorobenzene (HCB) and hexachlorobutadiene (HCBD), previously (1976) detected in Hooker's discharge, were less than detection levels of 500, 1000 and 100 ppb, respectively. In addition, U.S.EPA (ca. 1978-79) collected and analyzed White Lake sediments collected in the vicinity of Hooker's discharge (White Lake sediments near discharge and 200 m or 650 ft from discharge). None of eighteen chlorinated organic compounds, including the above, were detected in the White Lake sediment samples using analytical methods with detection limits that ranged from 10 to 100 ppb.

Five sediment samples were collected (November 1986) and analyzed for PCBs and total chromium by representatives for the Crosswind Marina. Their development project, located west of Sophia Street on the east shoreline at Whitehall, required dredging the nearshore area and sediment analysis was required. Analysis of the five sediment samples indicated less than 5.0 ppb total PCBs and total chromium concentrations that ranged from 0.97 to 3.8 ppm. Total solids ranged from 72.0 to 81.39 percent indicating a high percentage of sand present in the project area (MDNR File No. 86-9-132).

The U.S. Army Corps of Engineers collected sediments in 1979 as part of their White Lake navigational channel maintenance program. Six samples were collected from Lake Michigan and the navigational channel. Parameters analyzed included arsenic, cyanide, 10 heavy metals, PCBs and 6 pesticides (Appendix 4.2). The analytical results indicated the sediments were suitable for open water disposal as well as for beach nourishment of the Lake Michigan shoreline in the vicinity of the harbor. PCB, mirex, HCB and HCP concentrations in all six samples were less than 10.0, 4.0, 4.0 and 6.0 ppb, respectively.

The sediment quality of nearshore Lake Michigan near the White Lake outlet and navigational channel was summarized using data from Kenaga's study (1976). Average contaminant concentrations and ranges detected in sediments are summarized in Table 4-8. Based on comparisons with U.S.EPA dredge spoil criteria and background levels provided in Table 4-5, none of the contaminants detected in sediments in the Lake Michigan nearshore area indicated elevated levels.

Table 4-8. Summary of Lake Michigan Sampling Data Near White Lake Outlet - Sediments (ppm)

Contaminant	Number of Samples	Average	Range	Sediment Levels Indicating Contamination
Cu	7	2.1	0.6-4.3	25-50
Hg	6	0.02	0.01-0.04	1*
Cd	1	0.3	0.3	6*
Cr	7	2.91	1.5-5.4	25-75
Zn	7	17.1	5.5-36	90-200
Ni	7	6.4	3.2-11.0	20-50
Pb	7	8.13	1.6-18.0	40-60
Fe	7	2142.86	1300-3200	17,000-25,000
Mn	7	129.7	29-280	300-500
TKN	7	154.86	26-360	1,000-2,000
TP	7	76.429	37-126	420-650
COD	7	3771.43	1200-8500	40,000-80,000
TOC	7	1.231	0.41-2.7	NC
Oil-Hexane Extractables	7	82.86	20-140	1,000-2,000
DDT	1	7.4	7.4	NC

Sources: Kenaga 1976, U.S./Canadian Great Lakes Water Quality Agreement of 1978.

NC = No criteria available
* = Moderate criteria were not available, levels indicated are heavy levels

4.2.3 White Lake AOC Biota

4.2.3.1 Benthic Community

A number of studies were conducted to assess the condition of the benthic community of White Lake. Evans (ca. 1981) summarized these studies in his report entitled "Mona, White, and Muskegon Lakes in Muskegon County, Michigan, the 1950s to the 1980s." No benthic studies have been done since 1980.

Significant degradation of the White Lake benthic community occurred after 1954 primarily because of the discharge of toxic substances and oxygen depletion in the deeper basins associated with increased eutrophication from elevated nutrient loadings from the now defunct Whitehall Wastewater Treatment Plant, located just upstream from the inlet to White Lake and White Lake watershed.

Appendix 4.3 illustrates sampling results for the White Lake benthic community for 1972, 1975, and 1980 (Evans, ca. 1981). Studies conducted in 1952 and 1954 by Surber (1952 and 1954) revealed relatively normal benthic conditions. Surber concluded that biological conditions had not been altered since the 1952 survey.

After 1954, the percentage of oligochaetes, a pollutant-tolerant species, increased while the percentage of pollutant-sensitive mollusks decreased. Between 1972 and 1975, a series of sampling events found few or no molluscs at any of the stations sampled. These results show an extensive decrease from 1952 and 1954 where mollusc densities were approximately 327 and 382 organisms/m^2, respectively. The oligochaete population recorded at water depths greater than 6 meters (20 ft) increased from approximately 45 percent in 1952 to 90 percent in 1957. Figure 4-4 summarizes the average percent of oligochates reported from MDNR surveys (1952 to 1980) and Meier (1979) during 1973-74. The percent oligochaetes in 1980 are just slightly higher than observed in 1952-54, implying improved conditions.

Evans (ca. 1981) concluded that "White Lake benthos in 1980 indicated substantial lake quality improvements as as result of improved wastewater treatment by the Hooker Chemical Company. Densities and percent composition of aquatic oligochaetes and midges were similar to those found one year after Hooker Chemical Company began discharging to White Lake in 1953. Fingernail clams have begun to recolonize the lake bottom after an absence of at least eight years ..." Densities by 1980 were 14 to 72/m^2 among 40 stations, whereas, lakewide densities averaged 327/m^2 in 1952 among 16 samples. Lakewide mollusc densities averaged 382/m^2 in 1954 with 607/m^2 near the river mouth stations. Evans

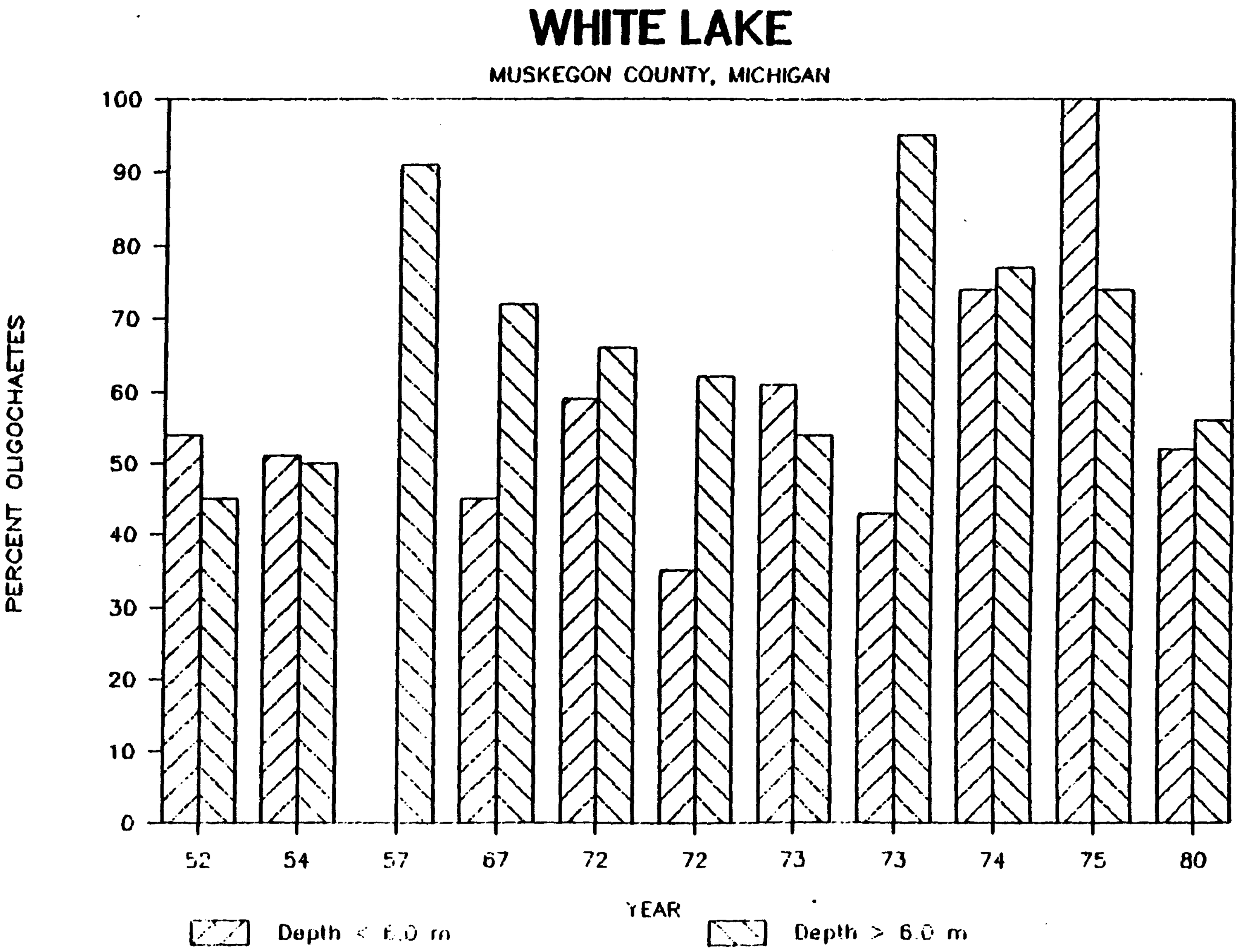


Figure 4-4. Percent oligochaetes in White Lake sediments

concluded that the river mouth area was unimpacted by the waste discharged from the municipal or Whitehall Leather Company.

Information relating to benthic studies completed in Lake Michigan near the White Lake outlet is limited. Sightly elevated numbers of oligochaetes were found in Lake Michigan offshore from the White Lake outlet in 1976 (Kenaga et al., 1983). Kenaga concluded that these results indicated possible nutrient enrichment in that area.

4.2.3.2 Fish Community

Fishing conditions in White Lake have historically been reported as good. Weaver (1968 MDNR memorandum) reported that, prior to the 1950's, White Lake sustained good populations of perch, walleye, black crappie, white bass and northern pike. After the 1950's, the white bass, perch, walleye and northern pike populations declined, the white bass population most severely. The bluegill and largemouth bass fishery improved. The decline in perch and walleye, Weaver indicated, coincided with a general decline observed throughout Lake Michigan and connecting waters. No reasons for the changes in fish populations were provided by Weaver.

White Lake presently supports excellent populations of northern pike, largemouth bass, smallmouth bass, walleye, yellow perch, redhorse sucker, white sucker, bluegills, crappie and carp. Salmon and trout species also have been observed in the area, especially during spawning runs up the White River (D. Smith - MDNR Fisheries Division). The MDNR and White Lake Area Sport Fishing Association collected 615 and 1674 adult white bass in 1983 and 1984 from the Detroit River and stocked them in White Lake in a cooperative effort to reestablish the White Bass population.

A fish taint study (evaluation of odor and taste of cooked fish) involving White Lake smallmouth bass, largemouth bass, white suckers, northern pike and carp, was conducted in 1975 (Lundgren,1976). Lundgren concluded from a statistical analysis of the rating-panel data, that a carp and white sucker collected off Long Point, located near the lower basin, had lower aroma and/or flavor quality. Carp and white suckers collected from the shallow areas near the upper basin and middle basin of White Lake, as well as all the other fish species collected, were found to be untainted. A white sucker collected from the Lake Michigan side of the navigational channel had a "good" rating in both flavor and aroma.

The analysis of contaminant levels in representative residential fish populations of different trophic levels (bottom feeders and predators) provides a reasonable assessment of the environmental fate of the contaminants that are in White Lake. Table 4-9 provides current FDA, MDPH fish consumption advisory action levels and IJC objectives for environmental contaminants.

Table 4-9 MDPH and U.S. FDA fish consumption advisory action levels and IJC objectives for environmental contaminants in fish. Concentrations as ppm unless otherwise indicated.

Parameter	FDA	MDPH	IJC
Aldrin/Dieldrin	0.3	0.3	0.3
DDT	5	5	
Lindane			0.3
Endrin	0.3	0.3	0.3
Heptochloroepoxide	0.3	0.3	0.3
Chlordane	0.3	0.3	
Kepone	0.3	0.3	
Mercury	1	0.5	0.5
Mirex	0.1	0.1	less than detection
PCB	2	2	0.1
Toxaphene	5	5	
PBB	0.3	0.3	
Dioxin	25-50 ppt	10 ppt	
Unspecified organic compounds			less than detection

U.S. FDA = U.S. Food and Drug Administration
MDPH = Michigan Department of Public Health
IJC = International Joint Commission

Several fish contaminant monitoring survey results were conducted by the MDNR (1971, 1976, 1977, 1978, 1979, 1980 and 1984); WMSRDC (1982); and U.S.EPA studies DeVault (1984), Camanzo (1985) and DeVault (1986). The level of study, indicated by the number of studies, was prompted, primarily, because of concern about the environmental contaminant loadings to the lake by industrial dischargers and contaminated ground-water plumes.

Swanson (1976) reported that MDNR fish contaminant monitoring results for 1972 indicated detectable concentrations of the toxic substance hexachlorobenzene (HCB). This prompted increased effluent monitoring requirements for Hooker Chemical Company.

Fish contaminant monitoring results for fillet samples collected on May 26, 1976 showed HCP, HCB and HCBD were less than detection levels of 2.0, 20 and 1 ppb in pumpkinseeds, brown bullheads and a northern pike (70 cm / 27.5 inches length) from near the inlet. However, suckers from the vicinity of Hooker's discharge and the west end of the lake contained 18 and 17 ppb of HCP, 66 and 90 ppb of HCB and 2 and 3 ppb HCBD, respectively. Pumpkinseed and northern pike from the same two locations contained less than 10 ppb of HCP and 1.0 ppb or less of HCBD. HCBD was less than 20 ppb in pumpkinseed, brown bullhead and northern pike collected from the vicinity of the Hooker discharge. The same species, collected from near the outlet, contained 21, 50 and 44 ppb of HCB, respectively.

Contaminant monitoring data for White Lake fish collected on July 23, 1976 indicated HCP was less than a detection level of 2.0 ppb in carp and dogfish fillets. HCB concentrations of 48 to 110 ppb were detected in carp and dogfish from near the White Lake inlet and 100 to 60 ppb in individual carp and dogfish fillets collected off Hooker's discharge, respectively (Swanson, 1976 memorandum).

Analysis of white suckers, northern pike, bluegill and/or bullhead from the White Lake inlet, vicinity of Hooker's discharge and west of Long Point on 23 August 77 indicated that HCBD, HCP, OPC and HCB were less than detection levels of 10, 20, 50 and 50 ppb, respectively. The adipose tissue (61.5% lipids) of a turtle collected near the lake inlet, however, contained 720 ppb of HCB. A U.S.FDA guideline for HCB of 300 ppb in fat of cattle, goats, horses, sheep and swine was established in 1972 after contaminated cattle were reported in Louisiana. No guidelines are available for fish tissue consumption advisories.

Humphrey, et al. (1980) reviewed White Lake fish contaminant monitoring results for White Lake of 1976, 1977, 1978 and 1979 and concluded the following:

> "It is the judgment of the Michigan Department of Public Health that the confirmed quantitative data generated to-date (especially in the last 6 months) do not warrant the need for a ban on catching and eating fish (indigenous) to White Lake or fish migrating through the lake while spawning."

Humphrey, et al. made several recommendations regarding which fish to consume, proper preparation and restricted consumption of anadromous fish migrating upstream from Lake Michigan (Appendi : 4-4).

The most recent fish contaminant monitoring surveys of White Lake were in 1980 and 1984 (Forney, 1980 and Rossio, 1985). The 1980 survey involved 25 fish that included 7 northern pike, 2 suckers, 2 largemouth bass, 3 smallmouth bass, 4 yellow perch and 7 carp. Tissue concentrations for HCB, HCP, mirex and polybrominated biphenyls (PBB) were less than 0.02 ppm, DDT plus DDE were less than 1.0 ppm and PCBs were less than 1.0 ppm in most species except carp which averaged 1.4 ppm (MDPH lab. results) to 1.8 ppm (MDNR lab. results) among six carp collected off Dowies Point and from the lower basin area called, Indian Bay (Appendix 4.4)

The 1984 survey involved the analysis of fillets from 34 fish that included 10 northern pike, 11 suckers, 4 walleye and 8 carp (Appendix 4.4). Mercury analysis indicated four northern pike contained 0.2 to 0.6 ppm with an average of 0.4 ppm that did not exceed the MDPH action level of 0.5 ppm for mercury. PCB (as Arochlor 1254) in carp, exceeded the MDPH and FDA 2.0 ppm action level, averaging 3.7 ppm with a maximum of 9.0 ppm. Total chlordane (expressed as the sum of alpha-chlordane, gamma-chlordane, cis-nonachlor and oxy-chlordane) exceeded the MDPH and FDA action level of 0.3 ppm among the eight carp analyzed. Total chlordane averaged 0.6 ppm and ranged from 0.13 to 1.24 ppm.

The Michigan Department of Public Health issued an advisory in 1986 for the consumption of carp due to elevated PCB levels. The advisory recommends the following:

- No more than 1 meal per week (or 12 kg/yr or 26 lbs/yr) of carp should be eaten
- Nursing mothers, pregnant women, women anticipating bearing children, and children younger than 15 years of age should not eat carp
- Before eating, fish should be skinned, trimmed, and filleted to remove fatty portions and cooked by baking, barbecuing, or broiling on a rack to reduce contaminant level (advisory)

In a USEPA study entitled "Contaminants in Lake Michigan Nearshore Fish," fish were collected from a series of tributaries and harbors of Lake Michigan between 1980 and 1983. Table 4-10 presents results of fish samples collected from the White Lake outlet. The White Lake outlet was reported to be one of three sites with the highest concentrations of DDT found during the study (Lahvis et al. no date). DDT levels in White Lake fish were, however, less than 5.0 ppm, the MDPH and FDA's action level.

Table 4-10. Contaminants Found in White Lake Outlet Fish During Lake Michigan Tributary Study, 1980-1983. Based on whole fish.

Parameter	Concentrations (ppm) Carp	Bowfin
Oxychlordane	0.011	0.144
Heptachlorepoxide	0.002	0.020
Beta BHC	0.0010	0.0020
Cisnozachlor	0.020	0.123
Transnonachlor	0.055	0.351
Alpha BHC	0.20	0.23
Cischlordane	0.015	0.009
Transchlordane	0.002	0.005
Aldrin	0.0001	NA[1]
Heptachlor	0.003	0.001
Methoxychlor	0.004	0.005
Endrin	0.027	0.027
Dieldrin	0.020	0.205

Source: Lahvis et al. no date.

[1]NA = Not Applicable.

Lake Michigan - A fish advisory restricting consumption has been issued for lake trout (20-23"), coho salmon (over 26"), chinook salmon (21-32") and brown trout (up to 23") because of elevated polychlorinated biphenyls (PCB's). Recommended consumption should be restricted to no more than one meal per week, and women and children are advised not to eat these fish at all. The fish consumption advisory further advises all citizens not to consume lake trout (over 23"), chinook salmon (over 32"), brown trout (over 23"), carp or catfish. These advisories apply to all of Lake Michigan's waters.

4.3 SUMMARY

Use impairments in the White Lake AOC are restricted consumption of carp due to elevated PCBs (average 3.7 ppm, maximum of 9.0 ppm). Carp were found, in 1984, to contain chlordane concentrations greater than the 0.3 ppm action level. The same consumption advisory applies.

Water quality appears to be improving due to reduced nutrient loadings observed since 1973. Major point source dischargers to White Lake were eliminated in 1973 and 1974 with diversion to the Muskegon County WMS No. 2. Annual average phosphorus loadings to White Lake, from the watershed, remain elevated, but have declined by about 40 to 50 percent since 1973. Late fall 1986 and May 1987 inlake phosphorus average concentrations of 15 and 25 ppb were less than a desired goal of 30 ppb.

The quality of biota, sediment and water conditions were severely degraded in 1950s through the 1970s do to substances discharged by Hooker Chemical Company. Since that time, improvements in sediment quality and associated benthic community have been noted. Specifically, there has been a decline in heavy metals and oils/greases and the 1980 benthic community survey indicates mollusc densities are increasing. The causative discharge has been eliminated because of the more restrictive NPDES requirements and ultimately the closure of the facility in 1982.

5.0 SOURCES OF POLLUTION

Sources of most pollutants to White Lake have been identified. Historically, the major pollutant sources included: municipal and industrial point sources, combined sewer overflows, watershed runoff, contaminated groundwater and contaminated in-place sediments.

5.1 PRIMARY SOURCES OF POLLUTANTS

Primary sources of pollutants are defined, herein, in the White Lake AOC as current or historical contributors of contaminants. Primary pollutant sources to the AOC, identified in the area prior to the 1973 - 1974 wastewater diversion to the Muskegon County WMS No.2, were surface water discharges and possibly contaminated groundwater. Those contaminated discharges resulted in reduced water quality, a reduced lake benthic community and long-term contamination of lake sediments.

Agricultural practices were not considered to be a significant source of pollutants in the White River Drainage Basin (WMSRDC 1978a). However, agricultural activity within 1.5 km (2.0 mi) upstream need further investigation with regard to seasonal loadings of nutrients and pesticides. Presently, the primary source of nutrient loadings to White Lake is the White River watershed which is discussed in Section 6.3.

5.1.1 Urban Stormwater Runoff/Combined Sewer Overflows

Urban runoff in the AOC has been referred to as a potential nonpoint source of pollution. Stormsewer systems service the cities of Whitehall and Montague. WMSRDC (1978a) reported the following number of sewer outfalls in the AOC and tributaries:

- White River - 2 outfalls
- White Lake - 14 outfalls
- Bush Creek - 5 outfalls
- Buttermilk Creek - 3 outfalls
- Coon Creek - 1 outfall

Section 6.2 provides additional information on specific pollutants and estimated loadings.

Table 5-1 summarizes industries located within storm drain basins in the White Lake area. The impact of these industries on stormwater quality has not been determined; however, these facilities are potential pollutant sources because of materials used in manufacturing processes.

5.1.2 Surface Water Dischargers

Four facilities currently have NPDES permits allowing them to discharge treated wastewater or noncontact cooling water to the White Lake AOC. Two facilities discharge directly to White Lake, one to White River, one to White River via Silver Creek, and one to Lake Michigan and White Lake. Two facilities that previously discharged to the AOC (Whitehall

Leather and Whitehall WWTP) discontinued operations or diverted flow to the Muskegon County WMS No. 2 in 1974. Facilities that discharged directly to White Lake or its tributaries in the past are described in addition to the current dischargers because significant contaminant problems were created by their discharge (Table 5.2).

Table 5-1. Industries Within Storm Drain Basins

Company Name	Product Manufactured	Storm Drain Basin	Watershed Management Unit (WMU)	Comments
Ahlstedt Widgit Corp.	Electric Vehicles	Buttermilk Creek	White Lake	
Old Century Forge, Inc.	Weathervanes, house signs	White River Marsh to White River	White River	Some type of drain
White Lake Castings Corp.	Iron foundry, high alloys	Buttermilk Creek	White Lake	Sand floors in foundry (cooling water discharge?)
Whitehall Metal Studies, Inc.	Weathervanes, nameplates	Buttermilk Creek	White Lake	

Source: WMSRDC 1979

Table 5.2 Current and discontinued point source dischargers.

Current Dischargers:

- Muskegon County Wastewater Management System (WMS) #2 (White River via Silver Creek)
- Howmet Corporation - Misco Division (White Lake)
- Occidental Chemical (formerly Hooker Chemical and Plastics Company) (White Lake)
- E.I. DuPont de Nemours and Company, Inc. (Lake Michigan and White Lake)

Discontinued Dischargers:

- Whitehall WWTP (serviced Whitehall and Montague) eliminated in 1973
- Whitehall Leather Company (diverted flow to WMS in 1974)

- Howmet Corporation - (process wastewater diverted to WMS in 1974)

Table 5.3 provides a listing of current permitted surface water dischargers, contaminated groundwater sites, current municipal and industrial disposal sites and former municipal and industrial disposal sites. Locations of these facilities are illustrated in Figure 5-1 and identified in Table 5.3.

Table 5.3 Municipal, Industrial and Contaminated Groundwater Sites in the AOC. (See Figure 5-1 for locations)

Surface Water Point Source Dischargers

1. E.I. duPont deNemours and Company (Discharge to White Lake and Lake Michigan)

2. Occidental (Hooker) Chemical and Plastics Company

3. Howmet Corporation Plant #1 - Misco Divison

4. Muskegon County Wastewater Management System #2 (Whitehall-Montague WMS)

Contaminanted Groundwater Sites

1. E.I. duPont deNemours and Company

2. Occidental (Hooker) Chemical and Plastics Company

3. Howmet Corporation Plants #1 and #3

4. Muskegon County Wastewater Management Site #2

5. Howmet Corporation Plants #4 and #5.

7. Tech-Cast, Inc.

8. Koch (Muskegon) Chemical Company

9. White Lake Landfill

10. Shell Cast, Inc.

Active Municipal or Industrial Disposal Sites

1. E.I. duPont deNemours and Company

9. White Lake Landfill

Former Municipal or Industrial Disposal Sites

1. E.I. duPont deNemours and Company

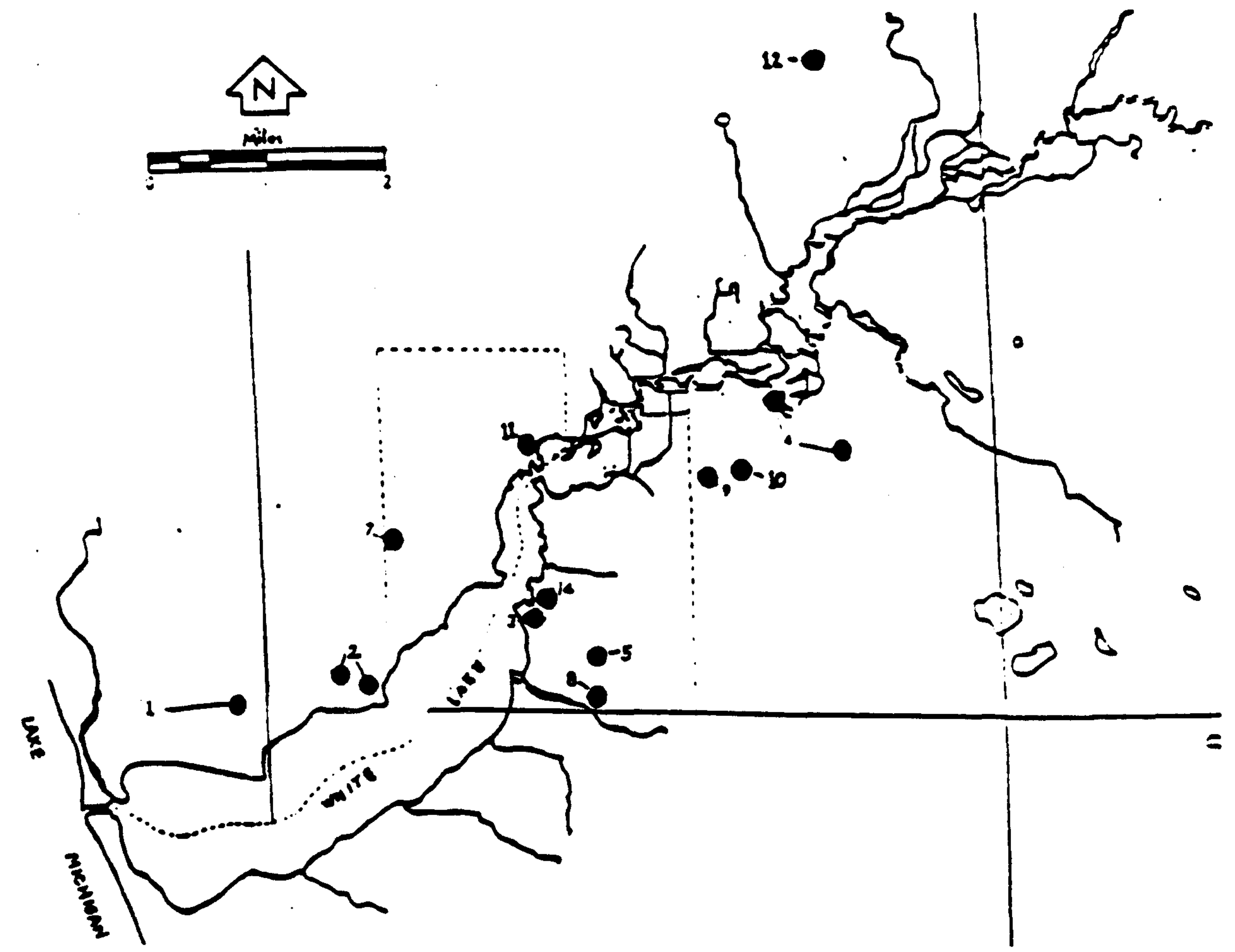
2. Occidental (Hooker) Chemical and Plastics Company

11. City of Montague Dump

12. Montague Township Dump

14. Whitehall Leather Company

Source: MDNR Files



Note: Locations shown are diagramatic only.

FIGURE 5-1. LOCATION OF HISTORICAL AND POTENTIAL POLLUTION SOURCES TO THE WHITE LAKE AOC (WMSRDC, 1982). Modified

Table 5-4 provides NPDES permit numbers and receiving waters for surface water dischargers.

Table 5-4. Current Surface Water Dischargers

Industry	NPDES Permit Number	Receiving Water	Watershed Management Unit
Occidental Chemical (formerly Hooker Chemical and Plastics Company)	MI 0002631	White Lake	White Lake
Muskegon County Wastewater Management System (WMS) #2	MI 0029173	White River via Silver Creek	White River
Howmet Corporation - Misco Division (Whitehall) Plant #1	MI 0002623	White Lake	White Lake
E.I. duPont deNemours and Company, Inc.	MI 0000884	Lake Michigan White Lake	Coastal Zone White Lake

Source: MDNR Files

E.I. duPont deNemours and Company

E.I. duPont deNemours and Company is located on the northwest shore of White Lake in close proximity to Pierson Creek. The company, which began operations in 1955, produces flurocarbons (Freons) and halogenated carbon chemicals used in refrigerants and in Teflon. The Company has a NPDES permit to discharge treated process wastewater directly to Lake Michigan and intake backwash to White Lake. The company is permitted to discharge up to 0.41 m^3/s (9.4 MGD) of treated process wastewater, lime pile interceptor well water, purged and treated organic feedstock interceptor wellwater and noncontact cooling water through their outfall to Lake Michigan. Parameters limited in the NPDES permit include:

- Chemical oxygen demand (COD)
- Total residual chlorine (TRC)
- Sulfates
- Chlorides
- Trichlorofluoromethane (F-11)
- Trichlorotrifluoroethane (F-113) (PCE)
- Total suspended solids
- Fluoride
- Antimony
- Carbon tetrachloride
- Chloroform
- Methylene chloride
- Tetrachloroethylene
- Chloroform

- Biochemical oxygen demand (BOD)
- Total phosphorus
- 1,1,1-trichloroethane
- Trichloroethylene (TCE)

The Company is also authorized to discharge up to 7.6 m^3/d (2,000 gpd) of intake filter backwash to White Lake. No parameters were listed in the NPDES permit for discharge to White Lake but effluent must be visually monitored prior to discharge to determine any unusual characteristics that must be reported.

E.I. duPont deNemours and Company exceeded permit requirements for pH levels in July 1976 and January 1977 (recorded as minor excursions), August 1976 (recorded as a violation), and October 1976 (noncompliance). PCB (as Arochlor 1254) was detected (0.67 ppb) in a 1976 MDNR survey of E.I. duPont's effluent. PCB (1254) is listed on the "Critical Materials Register" for the State of Michigan (WMSRDC 1978a). MDNR point source survey reports (1986, 1983 and 1980) indicate the Company has met their final effluent limitations provided in their NPDES permit.

Howmet Corporation - Misco Division

The Howmet Corporation is currently permitted to discharge up to 1,715 m^3/d (0.453 MGD) of noncontact cooling water to White Lake via an unnamed drain (NPDES permit). Temperature, flow and outfall observations are required.

In 1968, Howmet Corporation effluent was added to White River water to determine whether a change in algal production rates would occur. Samples containing the effluent produced up to seven times the amount of algae as those samples containing only White River water (Robinson 1968). This indicated nutrient enriched effluent.

Prior to 1975, oils and suspended materials were noted in the discharge. PCB (1254) was detected in the discharge at 2.5 ppb in 1975. By 1976, less than 1 ppb was found; no PCBs were observed in 1977. PCBs in the White Lake upper basin are suspected to have come from Howmet's historical discharge (Evans, ca.1981)

In 1974, process wastewater and sewage from the Company were diverted to the Muskegon County WMS No.2 facility.

Evans (ca. 1981) also reported that toxicity testing of the Company's final effluent in 1976, using fathead minnows, indicated 100% survival after exposure to 100 percent effluent for 72 hours.

Muskegon County WMS No. 2

The Muskegon County WMS No. 2 is currently permitted to discharge underdrainage from their land application site to Silver Creek, a tributary of the White River. The WMS NPDES permit includes limitations for the following parameters:

- Carbonaceous biochemical oxygen demand
- Ammonia nitrogen
- Total suspended solids
- pH
- Fecal coliform bacteria
- Total phosphorus
- Bis(2-chloroethyl) ether
- Bis(2-chloroethoxy) ethane (triethylene glycol dichloride)
- Nitrate
- Nickel
- Zinc
- Chromium
- Copper
- Chloride

The WMS is required by conditions set forth in the NPDES permit to conduct daily monitoring of flow and quality data of equalization basin effluent, primary clarifier effluent, and irrigation water. Monitoring of daily flow is required for raw sewage and daily depth readings taken from storage lagoons are also required. In addition, irrigation water and aerated lagoon effluent must be monitored five times monthly and quarterly measurements for organic chemicals must be taken from irrigation water and outfall effluent. The WMS is required to report this information monthly to the Surface Water Quality Division of the Michigan Water Resources Commission.

In addition to the requirements listed above, the NPDES permit also stipulates that a groundwater monitoring program must be performed. Kecks Consultants have just completed a site assessment report that is to be reviewed by MDNR. WMS No. 2's contribution to groundwater contamination is discussed in Section 5.2.1.1.

Some information was available on the effectiveness of the system. Equalization basins, the clarifier, and aerated lagoons reduce BOD and suspended solids in the influent by 90 percent and 82 percent, respectively (Metcalf & Eddy 1982). Samples collected from onsite purge wells in 1980 produced the following pollutant concentrations:

- BOD5 - 5.6 ppm
- Suspended solids - 1 ppm
- Total phosphorus - 0.10 ppm
- NH3 - 1.12 ppm (Metcalf & Eddy 1982).

Some complaints concerning odors emanating from the WMS have been reported.

<u>Whitehall Leather Company</u>

Prior to diversion to the WMS in 1974, the Company discharged animal hide, hair and elevated heavy metals, primarily chromium used in the hide tanning process. The discharge of these materials was evidenced by benthic surveys (Evans, ca. 1981). Deposits of these materials degraded benthic communities of macroinvertebrates in "Tannery Bay".

The effluent from the company may also have created conditions favoring increased algal production in White Lake. A study conducted in 1968 reported that effluent from the Whitehall Leather Company resulted in three times the algal growth that was reported in raw White River water (Robinson 1968).

During the 1960s, the waste disposal problems became a concern for the company. Waste disposal remained a problem at Whitehall Leather until diversion of its discharge to the WMS No. 2 in 1974 (Evans, ca. 1981).

Occidental - (Hooker) Chemical and Plastics Company

Hooker Chemical and Plastics Company operations were terminated in June 1982 when control of the 356 hectare (880 acre) site was assumed by Occidental Chemical (WMSRDC 1982). The site is referred to as Hooker Chemical and Plastics Company regarding contamination that may have affected the White Lake AOC and Occidental Chemical during discussion of current NPDES discharge limitations.

Occidental Chemical is currently authorized to discharge up to 1.0 MGD of treated groundwater purge water, treated vault leachate water, treated equipment wash water and treated stormwater to White Lake. NPDES effluent maximum limits, for organic compounds of concern, are as follows: carbon tetrachloride (1 ppb), chloroform (1 ppb), trichloroethylene (1 pbb), tetrachloroethylene (1 ppb), hexachlorobenzene (0.2 ppb), hexachlorobutadiene (0.05 ppb), hexachlorocyclopentadiene (1 ppb), octachlorocyclopentene (1 ppb) and mirex (1 pbb).

The NPDES permit limits, for the organic compounds associated with their discharge, are treatment technology based values required in the Consent Judgment. These limits, developed prior to Rule 57(2) Guidelines to protect human and aquatic life, are more restrictive than Rule 57(2) derived numbers for protecting human and/or aquatic life (Table 4.3) with the exception of hexachlorobenzene.

Chloroform, carbon tetrachloride and tetrachloroethylene maximum concentrations (3, 6 and 4 ppb) in the Company's discharge to White Lake have occasionally exceeded NPDES permit daily maximum effluent limits (1 ppb) no more than 3 times in 1986 - 1987. Improved treatment requirements are being implemented by the Company to achieve permit effluent limit requirements. Average effluent concentrations were less than or approximate to permit limits for all nine compounds indicating that effluent limits are not frequently exceeded.

The current NPDES permit required that a fish biouptake study be conducted using treated final effluent discharged to White Lake. The permit required that the fish be analyzed for the following chemicals: hexachlorobenzene, hexachlorobutadiene, octachlorocyclopentene and mirex. Results of the study, as described in Michigan Water Resources Commission's (MWRC) interoffice communications in 1987, report that no detectable levels of these chemicals were found in fish samples following exposure to 100 percent treated effluent for 28 days.

Hooker Chemical and Plastics Company appears to have had the greatest effect among the surface water dischargers on environmental conditions in White Lake. The company, located on the north side of White Lake, began operations in the early 1950s and discharged into the middle basin of White Lake from Dowies Point. Hooker Chemical manufactured chlorine, sodium hydroxide and hydrochloric acid. Prior to February 1977, the facility also produced hexachlorocyclopentadiene (C-56), a compound used by other manufacturers to produce pesticides and fire retardants. Chloroform, carbon tetrachloride, trichloroethylene (TCE), tetrachloroethylene (PCE), octachlorocyclopentene (C-58), hexachlorobenzene (C-66), hexachlorobutadiene (C-46) and mirex were also produced as by-products of the C-56 manufacture.

Twelve surveys of the wastewater discharge were completed between 1965 and 1980. Discharge volumes ranged from 7.92 to 16.65 MGD; pH ranged from 7.1 to 11.4; sulphates ranged from 2,600 to 8,100 kg/day; chlorides ranged from 5,600 to 100,000 kg/day; and phosphorus ranged from 2 to 50 kg/day (Evans, ca. 1981).

In 1970, the MDNR completed a bioassay to determine the toxicity of Hooker's effluent to fathead minnows. None of the minnows were able to survive greater than 2.1 percent effluent. When exposed to 100 percent of the effluent, a bullhead could not survive for 15 minutes. The effluent was found to contain elevated chlorine levels (60 mg/l) and high pH levels. The study concluded that the effluent would create a toxic environment in White Lake (Evans, ca. 1981). The current Rule 57(2) water quality based limit for total residual chlorine is 0.036 ppm as a daily maximum effluent limit.

During 1976 and early 1977, the Company exceeded permit limitations for hexachlorobenzene, sulfates and pH levels and did not report pH levels for November 1976. PCBs and phthalates were detected in their effluent in 1973. Subsequent MDNR sample analysis of the Company's effluent indicated HCB concentrations of 0.84 to 2.0 ppb. In June 1976, the MDNR cited Hooker Chemical for discharging the toxicants asbestos, hexachlorocyclopentadiene (C-56), hexachlorobenzene (C-66) and hexachlorobutadiene (C-46) generated by its "fine" chemical plant. Additional effluent sampling (25-27 July 76) revealed that Hooker's discharge contained 56 to 170 ppb hexachlorocylopentadiene (HCP) and 2.1 ppb hexachlorobutadiene (HCBD).

The primary damage attributed to Hooker Chemical and Plastics surface water discharge was the degradation of approximately 405 hectare (1,000 acres) of sediments and associated benthic community. Damages to the benthos were used to estimate fish production losses (Truchan 1976). Loss estimates to the fishery, due to Hooker's discharge were based on the impact to benthos that would affect a loss in fish production. No information was available on fish species lost, but approximately one-half of the fish lost were considered game fish (Evans and Borgeson 1977). Game fish are important to the local economy because fishing is a major tourist attraction in the White Lake AOC. Hooker payed a $135,000 fine for damages to the fishery.

In February 1977, Hooker closed down the fine chemicals plant which served as a primary source of toxic substances and closed the facility in 1982.

5.2 SECONDARY SOURCES OF POLLUTANTS

Groundwater contamination by industry and contaminated in-place sediments are two other sources of contaminants to the AOC.

5.2.1 Groundwater Contamination

Sandy soils constitute the major soil type surrounding the White Lake AOC. These soils have high porosity which permits liquids to readily percolate into the ground and facilitate the movement of surface contaminants into the groundwater. Contaminated groundwater has been documented in numerous areas in Muskegon County and within the White Lake AOC.

The potential for the groundwater to affect the White Lake has been documented for Occidental (Hooker), E.I. duPont deNemours and Company, and Howmet Corporation and Koch (Muskegon) Chemical Company. This section also discusses groundwater contamination from other industries and landfills.

5.2.1.1 Groundwater Contamination by Industries

Seven companies whose operations have resulted in groundwater contamination in the vicinity of the Area of Concern have been placed on the Michigan Act 307 Priorities Lists. (MDNR, 1986d) Hooker and E. I. DuPont sites have been proposed for inclusion on the National Priority List (NPL). Industries with documented groundwater contamination problems include the following:

- Occidental (Hooker) Chemical and Plastics Company
- E.I. duPont de Nemours and Company
- Howmet Corporation - Misco Division
- Koch (Muskegon) Chemical Company
- CMI- Dearborn (Tech-Cast, Inc.)
- Muskegon County WMS No. 2
- White Lake Landfill and Shell Cast site

The individual industries are discussed in the following paragraphs:

<u>Occidental (Hooker) Chemical and Plastics Corporation</u>

This chlo-alkali industry manufactured chlorine, sodium hydroxide, hydrochloric acid and, until 1977, manufactured hexachlorocyclopentadiene (HCP or C-56), a toxic substance used by other manufactures for the manufacture of pesticides and flame retardants. By-products formed during the C-56 production process included the following chlorinated hydrocarbons: chloroform, carbon tetrachloride, trichloroethylene (TCE), tetrachloroethylene or perchloroethylene (PCE), octachlorocyclopentene (OCP or C-58), hexachlorobenzene (HCB or C-66), hexachlorobutadiene (C-46) and mirex.

MDNR point source surveys between 1965 and 1980 indicated that the quality of their effluent had changed because of different production processes that involved chlorinated hydrocarbons. Elevated chlorine concentrations (60 ppm) were detected in 1971 during a MDNR fish bioassay of the effluent. Such chlorine concentrations would certainly account for the observed mortality (Wuerthele, 1970). The current acute toxicity value for chlorine is 36 ppb. DeKraker (1976) reported the effluent was very toxic to fathead minnows. Again, chlorine was suspected because of an effluent chlorine concentration of 8,700 ppb. No mortality was observed during two static bioassays in 1980 (Bohn-Swanson, 1980).

In 1971 toxic, suspected toxic and potentially bioaccumulative organic compounds were being detected in Hooker's discharge (Swanson, 1976). Swanson (1976), in a review involving Hooker, concluded that asbestiform materials, hexachlorcyclopentadiene, hexachlorobenzene and hexachlorobutadiene were constituents of the Company's discharge.

Improper production waste disposal practices by the Company resulted in extensive soil and groundwater contamination on site (MDNR 1986d). The Hooker site has been proposed for inclusion on the NPL. Contaminants, improper disposal practices and areas contaminated included the following:

- C-56 and by-products were stored in 55-gallon drums, dumped in earthen pits and and covered with flyash. Groundwater contamination caused by leachate from the drums was determined at several locations.

- Chlorinated hydrocarbons contaminated the fine chemical production plant where C-56 was manufactured.

- Contamination of soils and groundwater underlying sludge and solid waste disposal areas and the fine chemical production plant from leachate.

- Chlorinated hydrocarbons contaminated a concrete equalization basin. Wastewater from the fine chemical production plant containing asbestos and organic compounds were treated in the basin prior to discharge to White Lake.

- Numerous lagoon areas containing brine sludges and equalization basin sludges resulted in groundwater contamination.

During 1977, the Company produced approximately 46,179 kg (101,826 lb) of a variety of heavy sludge materials from chemical manufacturing processes (WMSRDC 1978). Approved Industrial Removal Company of Grand Rapids removed and disposed of these wastes which had been stored in tank trailers. An estimated 19,809 kg (43,680 lb) of wet solid wastes were also produced in 1977, but stored onsite.

A contaminated groundwater plume, originating from the Hooker Chemical Company plant site, was determined by the mid-1970's to be discharging into White Lake at Dowies Point in the vicinity of the Company's water intake. Both the point source discharge and ground water discharge were found to contain organic contaminants that listed on Michigan's Critical Materials Register.

Subsequent sampling programs, conducted at the site, indicated severe contamination of the underlying aquifer with chlorinated hydrocarbons. The groundwater contamination affected a number of residential wells south-southeast of the Company's site near White Lake. The contaminated groundwater plume (Figure 4-1) migrated and discharged to White Lake, located approximately 1.2 km (0.75 mi) to the south. The contaminated plume has entered the lake along a 708 m (2300 ft) wide "leachate face" located just northeast of Dowies Point (WMSRDC, 1978). The plume discharge to White Lake is discussed in 4.2.1.2.

The State of Michigan entered into litigation against Hooker Chemical in February 1979 in order to reduce the source of environmental contamination on the plant site and completely halt the contaminated groundwater plume discharging to White Lake. The Ingham County Court entered a Consent Judgment which included the following determination:

> "The Court determines, from a review of the matters before the Court, that the terms and conditions herein are reasonable, adequately resolve the environmental issues raised in this action, constitute a full restorative program or eliminating any threat to the lands and waters of this State, properly protect the interests of the people of the State of Michigan, and are hereby adopted by this Court"

The Consent Judgment provided the following statement of jurisdiction:

> "ENFORCEMENT. This Court specifically retains jurisdiction over both the subject matter hereof and the parties hereto to enforce this Judgment until December 31, 2030, and thereafter until jurisdiction in this cause is terminated by Order of this Court."

Additional information involving the terms of the suit are provided in Section 7.1.3.

By 1982, most of the contaminated soils and onsite waste were excavated, and confined to a clay lined and capped vault, located on site. The MDNR also instructed the Company to excavate and dispose of additional contaminated soils located in a 1263 m^2 (13,600 ft^2) area north of the defunct C-56 production plant site referred to as "No-Man's Land (Courchaine, 23 November 81). Johnson and Anderson, Inc. (1982) estimated the amount of contaminated soils to be removed to range from 7548 to 27,924 m^3 (9,873 to 36,525 yd^3). This issue remains unresolved (Przybysz, 1986).

Heinzman (1979), MDNR geologist, estimated chlorinated hydrocarbon compound loadings of 367 kg/day (810 lb/day) to White Lake, based on an aquifer volume of 1.8 billion gallons and an average hydrocarbon concentration of 75,111 ppb. A groundwater purgewell and treatment system was installed in June 1979 to capture and treat the contaminated plume (MDNR, 1980). The purgewell system presently collects and treats liquids from the contaminated groundwater plume, storage vault leachate and stormwater runoff originating from the contaminated Company site.

The company purge wells are currently pumping at a rate of 685 gpm in an attempt to capture the contaminated plume (Heinzman, 1987 personal communication). Heinzman's 1987 estimated loadings from the plume is about 18 to 27 kg/day (40 to 60 lb/day) based on about 100% plume capture with the existing purgewell system and pumping rate of 2589 liters/min (685 gpm). Verification testing is ongoing and company and MDNR staff are reviewing future requirements to achieve and maintain 100% capture of the plume.

The company is also studying the effects of White Lake's water level on the plume capturing efficiency of the purge well system. Lower water levels increase the gradient of the contaminatd plume, increasing the potential for bypassing the purge well collection system and discharging to White Lake. The Consent Judgment requires drawdown on the contaminated groundwater to be maintained 6 cm (0.2 ft) below White Lake water level to maintain a positive flow of lake water into the purgewell system located along the lake shore. Northwesterly winds can cause the water level to rise and fall 15 to 30 cm (0.5 to 1.0 ft.) during a day, thereby, affecting plume discharge rates.

The contaminated groundwater plume discharge to White Lake remains as an existing source for contaminat loadings to White Lake.

Table 5.5 represents monitoring results water samples collected from plume definition wells in 1986 as well as purge well monitoring wells (Figure 5.2). Among the plume definition wells, well S had the highest concentrations of chloroform (65 ppb), carbon tetrachloride (1,713 ppb), trichloroethylene (68 ppb), tetrachloroethylene (7,590 ppb) and HCB (0.09 ppb). The highest contaminant concentrations among the purge well system monitoring wells were in Wells PA, WW-31 and WW-33. Concentrations of HCP, OCP and HCBD were less than levels of detection (1, 1 and 0.2 ppb, respectively among 19 wells. Eight purge wells intercept the contaminated groundwater plume headed towards the lake (Figure 5-3). Monthly monitoring data (Table 5-6) of the purge wells in 1986 indicated, among the eight wells, average concentration ranges of toxics were as follows: chloroform (less than 1 to 774 ppb), carbon tetrachloride (less than 1 to 9,169 ppb), trichloroethylene (less than 1 to 245 ppb), tetrachloroethylene (8 to 20,212 ppb) and HCB (less than 0.05 to 0.2 ppb). HCP, OCP and HCBD were undetected (less than 1, 1 and 0.2 ppb, respectively.

Table 5-5 Summary of 1986 quarterly monitor results for Hooker Chemical Company's contaminated groundwater plume monitoring well data. Mean values as ppb. Data for April, July, September and December 1986.

Plume Definition Wells

	$CHCl_3$	CCl_4	C_2HCl_3	C_2Cl_4	HCB	HCP	OCP	HCBD
B	K1	K1	K1	K1	K0.05	K1	K1	K0.2
C	K1	K1	K1	K1	K0.05	K1	K1	K0.2
F	2	K1	K1	132	K0.05	K1	K1	K0.2
M	3	34	K1	46	0.05	K1	K1	K0.2
S	65	1,713	68	7,590	0.09	K1	K1	K0.2
T	K1	K1	K1	K1	0.09	K1	K1	K0.2
WW-2	K1	K1	K1	7	K0.05	K1	K1	k0.2
WW-6	K1	K1	K1	K1	K0.05	K1	K1	K0.2
WW-12	K1	K1	K1	K1	0.06	K1	K1	K0.2
WW-13	K1	K1	K1	5	0.05	K1	K1	K0.2
WW-24	K1	K1	K1	K1	K0.05	K1	K1	K0.2
WW-26	7	K1	K1	K1	K0.05	K1	K1	K0.2
WW-27	7	K1	K1	K1	K0.05	K1	K1	K0.2

Purgewell System Monitoring Wells

	$CHCl_3$	CCl_4	C_2HCl_3	C_2Cl_4	HCB	HCP	OCP	HCBD
PA	380	8,054	115	10,099	K0.05	K1	K1	K0.2
GM-3	1	6	18	552	K0.05	K1	K1	K0.2
WW-7	7	40	6	180	K0.05	K1	K1	K0.2
WW-8	8	113	15	1,107	K0.05	K1	K1	K0.2
WW-31	1,260	10,707	676	15,558	K0.05	K1	K1	K0.2
WW-33	1,058	6,371	151	7,943	K0.05	K1	K1	K0.2

K = values less than detect level indicated
$CHCl_3$ = chloroform, CCl_4 = carbon tetrachloride, C_2HCl_3 = trichloroethylene, C_2Cl_4 = tetrachloroethylene, HCB = hexachlorobenzene, HCP = hexachlorocyclopentadiene, OCP = octachlorocyclopentene and HCBD = hexachlorobutadiene.

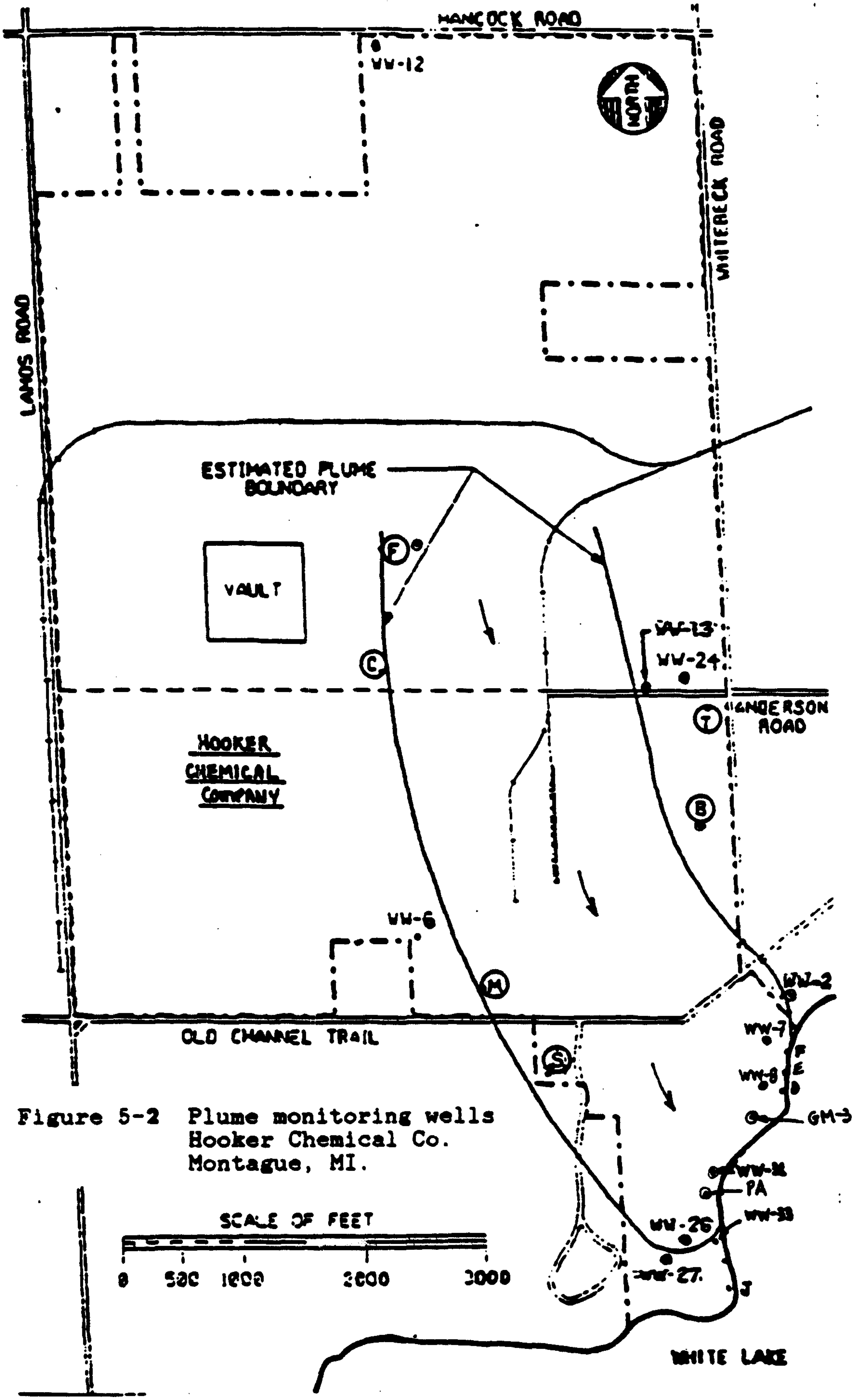


Figure 5-2 Plume monitoring wells
Hooker Chemical Co.
Montague, MI.

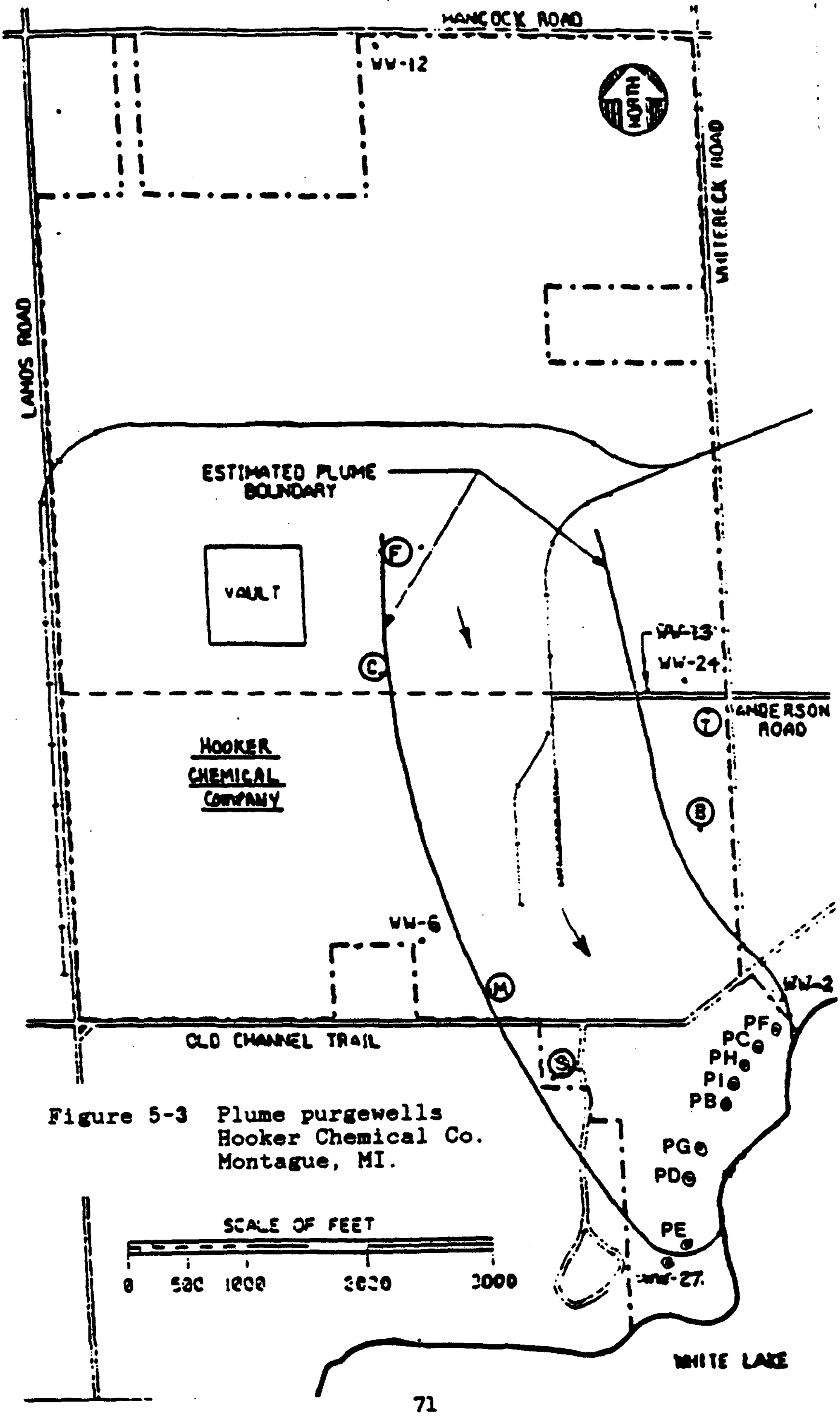


Figure 5-3 Plume purgewells
Hooker Chemical Co.
Montague, MI.

Table 5-6 Mean analytical results for purge well water samples collected in 1986 from the Hooker Chemical Company purge wells located between the contaminated plume and White Lake, Muskegon County, MI.

	Purgewell							
Parameter	PE	PD	PG	PB	PI	PH	PC	PF
Chloroform	330	774	150	199	35	11	14	K1
Carbon Tetrachloride	3,535	8,228	9,169	398	157	60	14	K1
Trichloroethylene	20	245	204	42	56	36	2	K1
Tetrachloroethylene (Perchloroethylene)	4,726	15,793	20,212	2,703	5,988	1,574	52	8
Hexachlorobenzene	0.08	0.2	0.11	0.13	K0.05	0.06	K0.05	K0.05
Hexachlorocyclopentadiene	K1	K1	K1	K1	K1	K1	K1	K1
Octachlorocyclopentene	K1	K1	K1	K1	K1	K1	K1	K1
Hexachlorobutadiene	K0.2	K0.2	K0.2	K0.2	K0.2	K0.2	K0.2	K0.2

K = less than level at detection indicated
Data based on samples collected monthly for ten months except wells PH and PI which represent a nine month period.

E.I. duPont deNemours and Company

E.I. duPont deNemours and Company, located in White River Township, began operations in 1955. Various solid waste disposal methods were employed by the company and include the following:

- A lime pile covering 12.2 hectare (30 acres) and containing up to one million cubic yards of solids that contain traces of ammonia, arsenic, copper and thiocyanate. The lime pile is not considered a hazardous waste and efforts are to commercially use the material for acid neutralizers and agriculture lime. The Company proposes to remove the pile over the next ten years (Przybysz, 1987 personal communication).

- A bury pit and northeast dumpsite containing steel drums (used for neoprene tar and latex disposal), copper chloride salts, potassium and ammonium latex, potassium hydroxide, and general refuse

- Frequent small spills at the former bulk storage area releasing TCE, PCE, carbon tetrachloride, and methyl chloroform (MDNR 1986d).

In 1961, contamination of several residential wells was determined. E.I. duPont deNemours completed several hydrogeologic investigations and installed two groundwater purgewell systems to retard migration of the contaminant plume from the plant site. E.I. duPont deNemours has been proposed by U.S.EPA for inclusion on the NPL because of the lime pile and associated groundwater contamination.

Howmet Corporation - Plants #4 and #5

The Howmet Corporation Plants No. 4 and 5 manufacture turbine engine components. Groundwater contamination has been confirmed at this site. Groundwater samples collected March 1984 from observation wells contained tetrachloroethylene, (1.4 ppb), trichloroethane (6.8 ppb) and 14 ppm total chromium. (MDNR 1986d). The contaminated groundwater vents to Mill Pond Creek, a White Lake tributary (Figure 5-4).

Przybysz (1986), MDNR Grand Rapids District staff, stated trichloroethane contamination appears unique to Howmet Plant No. 4's plume, whereas, triethylene glycol dichloride and bis (2-chloroethyl) ether are unique to Muskegon Chemical Company's plume. Seeps from the Muskegon Chemical plume appear to discharge to Mill Pond Creek upstream of White Lake Drive, whereas the Howmet Plant No. 4 plume vents to the creek just upstream of Zellar Road. Zellar Road is located about 0.5 km (0.75 mi) upstream from White Lake. The two plumes vent at separate locations about 300 m (1000 ft) apart. Based on current well monitoring data, the two plumes appear to be running parallel to each other but do not appear to overlap or intersect.

Mill Pond Creek water samples, collected April 1984 in the vicinity of the Zellar Road and Howmet Plant No. 4 plume seeps, contained

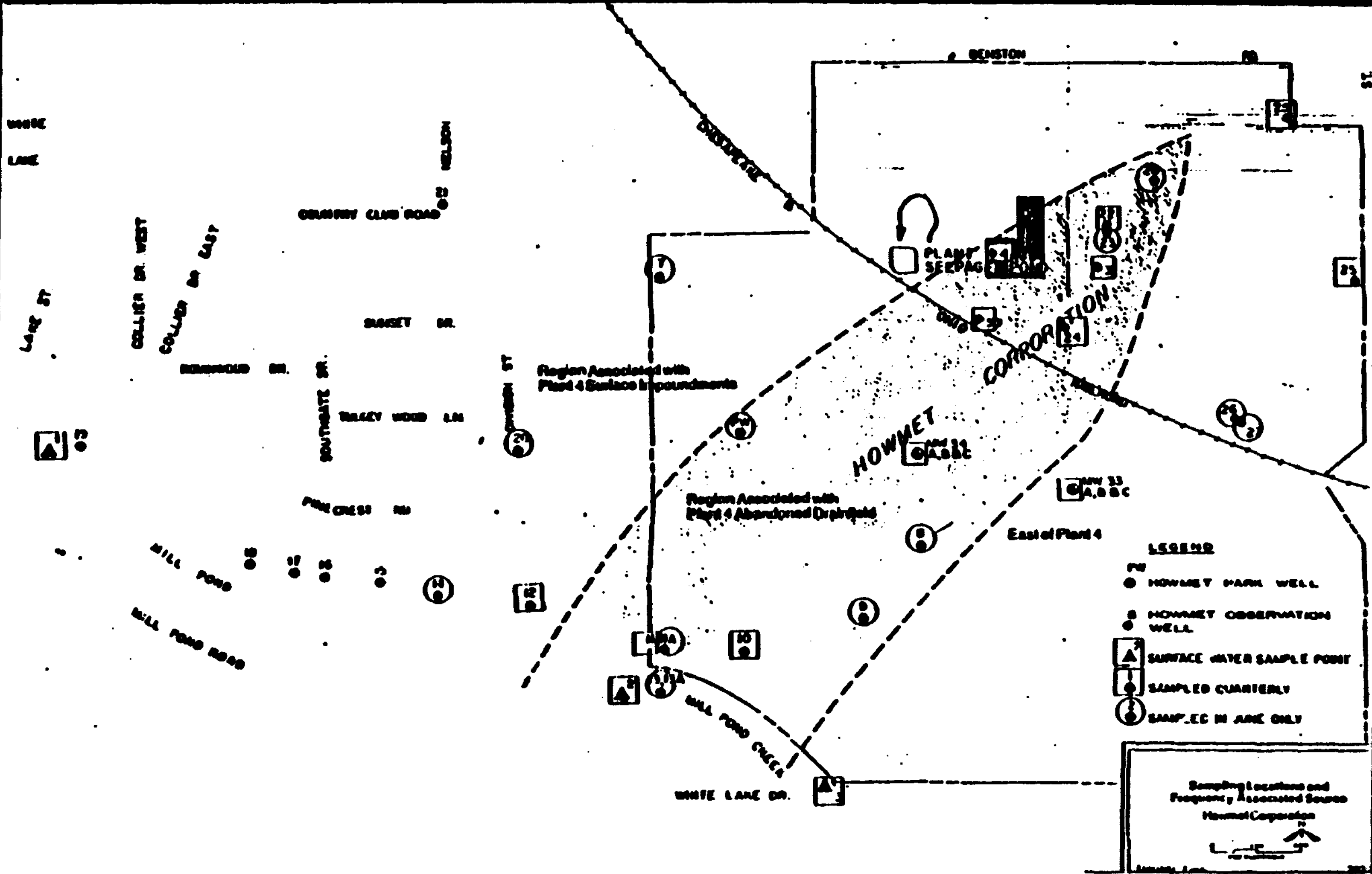


Figure 5-4 Contaminated groundwater plume associated with Howmet Corporation Plant # 4. Whitehall, Muskegon County, MI.

tetrachloroethylene (1.4 ppb) and trichloroethane (5.2 ppb). These concentrations do not exceed their respective Rule 57(2) guideline levels of 20 and 120 ppb, respectively. The Company is currently monitoring and making efforts at source determination and plume definition. Leaking underground chemical storage tanks and a defunct seepage lagoon are suspected sources.

Howmet Plant No. 5, located northeast of Plant No. 4, is a suspected source of contaminated groundwater influencing the Howmet plume to Mill Pond Creek. Groundwater plume definition studies are planned by the Company for fall 1987.

Koch (Muskegon) Chemical Company

The Muskegon Chemical Plant, located south of Whitehall in the vicinity of Howmet Plant No. 4 and No. 5, manufactures a variety of industrial organic compounds. The plume extends from the Company property to the southeast underneath White Lake Drive to Mill Pond Creek (Figure 5-5).

MDNR (1986d) groundwater monitoring well data for samples collected (north of White Lake Drive) on August 1984 indicated the presence of 1,2-dichloroethane (9800 ppb), bis (2-chloroethyl) ether (5000 ppb), triethylene glycol dichloride (2200 ppb), trichloroethylene (80 ppb), tetrachloroethylene (360 ppb) and chlorobenzene (360 ppb). The contaminated groundwater plume boundaries are well defined and have not been intercepted by any residential wells.

Prior to 1984, Beck (1982, 1983a and 1983b) reported that groundwater seeps to Mill Pond Creek upstream of White Lake Drive contained elevated concentrations of triethylene glycol dichloride, 1,2-dichloroethane and bis (2-chloroethyl) ether on three occasions (Table 5-7). Current Rule 57(2) guideline levels of 800, 560 and 3.0 ppb, respectively, would have been exceeded. Analytical results for water samples collected June 1983 from Mill Pond Creek, just upstream of White Lake, indicated concentrations greater than Rule 57(2) guidelines at concentrations of 39, 1 and 2 ppb, respectively).

Qualitative biological assessment surveys of Mill Pond Creek (1981 and 1983) indicated no apparent impacts to macroinvertebrate communities downstream of White Lake Drive, located immediately downstream of the unnamed pond that receives contaminated groundwater seepage and upstream of Mill Pond Creek (MDNR files).

Fish were collected in June 1983 from the Mill Pond (located downstream of Zellar Road) for fish contaminant monitoring purposes (Beck, 1983c). Four species of fish were analyzed as composite samples of three to five whole fish. Triethylene glycol dichloride and bis (2-chloroethyl) ether were less than a level of detection of 0.2 ppm. Analysis for other purgeable organic compounds was not done for lack of approved analytical methods. None of the substances were expected to bioaccumulate.

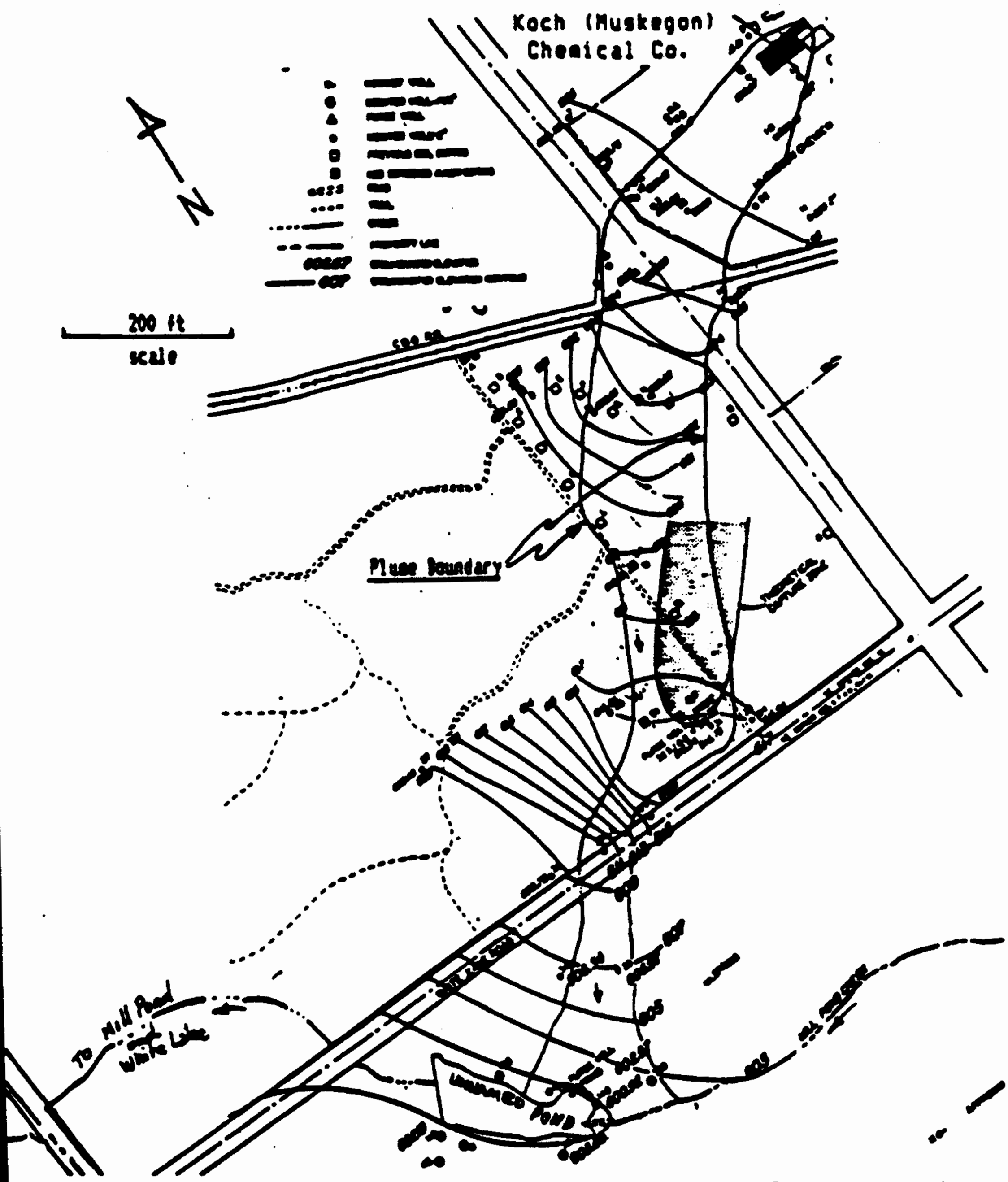


Figure 5-5 Contaminated groundwater plume associated with Koch (Muskegon) Chemical Company. Source: MDNR Grand Rapids District.

Table 5-7. Analytical results for Muskegon Chemical Company contaminated groundwater seepage to Mill Pond Creek. Whitehall, Michigan.

Parameter	December 1982	June 1983	August 1983	Rule 57(2) Guidelines	Basis
Triethylene glycol dichloride (ppm)	17	10 to 16	2.3 to 19	0.8	ACV
1,2-dichloroethane (ethylene (dichloride) (ppm)	7.5	1.3 to 3.3	0.46 to 0.7	0.56	CRV
Bis(2-chloroethyl) ether (ppm)	0.9	0.3 to 1.3	0.052 to 0.5	0.003	HLSC

ACV = Aquatic Chronic Value
CRV = Cancer Risk Value
HLSC = Human Life-Cycle Safe Concentration

Source: MDNR Surveys

The presence of fish in the Mill Pond and macroinvertebrates just downstream of White Lake Drive indicated the absence of acute toxic concentrations of the subject organic compounds. Therefore, there is little likelihood that there is any perceptible impact to uses of White Lake or Lake Michigan from these contaminated groundwater sources.

Muskegon Chemical Company installed a groundwater purgewell and treatment system in 1985. The purgewell, to date, has failed to capture the entire contaminated plume but has retarded the discharge to Mill Pond Creek. MDNR Grand Rapids District staff indicate that captured contaminated groundwater is treated via carbon filtration to remove the organic contaminants. Treated wastewater is then discharged to the Muskegon County WMS No. 2. MDNR staff indicated the Company was in compliance, during 1986, with requirements set forth in a 1985 Consent Agreement between the MDNR and Company.

Tech-Cast, Inc.

Tech-Cast, Inc., (the facility is presently owned by CMI-Dearborn) is located on the west side of Montague. This site has confirmed levels of trichloroethylene of up to 478 ppb in their supply and monitoring wells. Additional contaminants detected include 1,1,1-trichloroethane (100 ppb), benzene (6 ppb), ethylbenzene (42 ppb), toluene (42 ppb), xylene (56 ppb) and 1,1-dichloroethane (2 ppb). A solitary spill incident at the facility is the suspected source of contamination.

The MDNR believes the contaminant plume is migrating, but no information is available on rates or direction of movement (MDNR 1986d). Tech-Cast, Inc. terminated its operations on December 28, 1984.

The drinking water supply at CMI-Dearborn (Tech Cast) was replaced with municipal water.

Muskegon County Wastewater Management System No. 2

The Muskegon County WMS No. 2, located east of Whitehall, uses land application methods for wastewater treatment. Treatment practices at the site have resulted in the migration of two contaminant plumes from the site. Uncollected irrigation water has produced a northwesterly directed plume and storage lagoon leakage has produced a northeasterly directed plume. The northwesterly directed plume is intercepted by White River, located approximately 154 to 308 m (500 to 1,000 ft) from the corner of the site, while the northeasterly directed plume is intercepted by Silver Creek (Metcalf & Eddy 1982). Some contamination was confirmed in residential wells to the west of the site. MDNR information (December 1984) indicated that effluent permit limitations for ammonia had been exceeded. Corrective actions are being pursued by the MDNR. A report from Keck Consultants detailing site conditions is due this fall (1987).

Groundwater at the WMS site has been found to contain elevated levels of nutrients. Table 5-8 summarizes chlorides and nutrients detected in wells at the site in 1981 (Figure 5-6). Chloride concentrations of 1 to 2 ppm are considered back ground concentrations for the site, indicating that higher levels are from the influence of wastewater. High chloride concentrations of up to 450 ppm were detected onsite predominantly to the northeast. Although no information was available concerning background nutrient levels, areas that were strongly influenced by wastewater, as indicated by elevated chloride concentrations, were also tended to show elevated levels of nutrients (Metcalf & Eddy 1982).

Table 5-8. Chloride and Nutrient Levels Detected in Groundwater at the WMS Site, 1981

Well No.	Depth (Ft.)	Chloride (mg/l)	NH3-N (mg/l)	NO3-N (mg/l)	Total P (mg/l)
A-1	68	260	0.48	10.89	0.06
A-2	83	351	0.07	14.08	0.07
A-3	103	5	0.07	0.41	0.03
B-2	73	7	0.07	0.52	0.11
B-3	103	97	0.05	0.02	0.03
C-1	68	450	8.50	3.45	0.10
C-2	83	430	20.00	0.03	0.71
C-3	103	415	22.15	0.03	0.34
D-2	77	8	0.06	0.01	0.07
D-3	97	4	0.06	0.01	0.16
E-1	48	2	0.05	0.08	0.18
E-2	73	1	0.01	0.01	0.11
E-3	103	1	0.01	0.01	0.29

Table 5-8 (continued)

Well No.	Depth (Ft.)	Chloride (mg/l)	NH3-N (mg/l)	NO3-N (mg/l)	Total P (mg/l)
F-1	48	1	0.01	0.09	0.37
F-2	73	1	0.02	0.11	0.37
F-3	103	11	0.06	0.01	0.38
G-2	73	2	0.01	0.03	0.11
H-1	63	12	0.01	0.81	0.13
H-2	88	13	0.02	0.01	0.19
H-3	128	3	0.02	0.01	0.28
I-2	73	4	0.03	0.01	0.23
I-3	103	4	0.01	0.01	0.30
K	93	10	0.01	0.42	0.29
L	78	6	0.01	0.01	0.27
M	78	250	0.01	0.01	0.07

Source: Metcalf & Eddy 1982.

Elevated levels of organics have also been found at the site. Table 5-9 summarizes priority pollutants and additional organic compounds detected in observation and monitoring wells onsite in 1981 and 1982. Organics detected in groundwater at the WMS site were found to be at levels of concern. Additional sampling of wastewater, completed later in 1982, indicated levels of bis(2-chloroethyl) ether at 16 and 11 ppm a decrease from the earlier samplings (Metcalf & Eddy 1982).

A report on the Muskegon County WMS No. 2 facility is due in the fall of 1987.

Table 5-9. Trace Organic Concentrations Detected in Monitoring and Observation Wells at the WMS Site (ppm)

	August 1981							
Compound	A-1	A-2	A-3	B-2	B-3	C-1	C-2	C-3
<u>Priority pollutants</u>								
Bis(ethylhexyl)phthalate	0.013	--	--	--	--	0.009	--	--
Vinyl chloride	0.10	0.020	0.025	0.004	0.065	0.065	0.059	0.023
Chloroform	0.001	--	--	--	0.001	0.001	--	--
1,2-Dichloroethane	--	0.001	--	--	--	0.035	0.13	0.10
Tetrachloroethane	--	--	--	--	0.004	--	--	--
Bis(2-chloroethyl)ether	--	--	--	--	--	0.17	0.48	0.57
Chloromethane	--	--	--	--	--	0.009	--	--
Toluene	--	--	--	--	--	--	0.001	0.001

Table 5-9 (continued)

Compound	A-1	A-2	A-3	B-2	B-3	C-1	C-2	C-3
	August 1981							
Additional organic compounds								
Bis(2-chloroethoxy)ethane	0.078	--	--	--	--	3.4	6.5	5.5
Tetraethylene glycol dichloride	0.14	0.016	--	--	--	0.18	0.34	0.49
Pentaethylene glycol dichloride	0.050	0.027	--	--	--	0.057	0.092	0.11
Hexaethylene glycol dichloride	0.28	0.10	--	--	--	0.36	0.22	0.34
Tetrahydrofuran	0.19	0.041	0.015	0.16	0.015	2.4	0.33	0.21
Methyl aniline	--	--	--	--	--	0.018	0.037	0.024
N,N-dimethylaniline	--	--	--	--	--	--	0.030	0.011
Alkyl subst phenol (2)	--	--	--	--	--	--	0.026	0.027
Bis(2-chloroethoxy)ethanol	--	--	--	--	--	--	--	0.002
4 chlorobenzoic acid	--	--	--	--	--	--	--	0.002

Compound	MW-1	MW-4	MW-5	MW-6	MW-8	MW-9	MW-10
	February 1982						
Priority pollutants							
1,2-Dichloroethane	0.012	--	--	--	--	0.090	0.15
1,1,1-Trichloroethane	0.011	0.0045	--	--	--	0.003	--
Trichloroethylene	0.001	--	--	--	--	0.001	--
Tetrachloroethylene	0.003	--	--	--	--	0.002	--
Bis(2-chloroethyl)ether	0.018	--	--	--	--	0.38	0.81
Toluene	0.001	--	--	--	--	--	--
Bis(ethylhexyl)phthalate	--	0.055	0.034	0.070	0.078	--	--
Trans-1,2-Dichloroethylene	--	--	--	--	--	0.001	--
1,1-Dichloroethane	--	--	--	--	--	0.003	0.001
Chlorobenzene	--	--	--	--	--	0.004	--
Additional organic compounds							
1,4-Dioxane	0.005	--	--	--	--	0.001	0.013
Methyl aniline	0.007	--	--	--	--	--	--
Bis(2-chloroethoxy)ethane	0.310	--	--	--	--	2.1	5.4
N,N-Dimethylaniline	0.053	--	--	--	--	--	--
Tetraethylene glycol dichloride	0.018	--	--	--	--	0.17	0.16
Hexaethylene glycol dichloride	0.018	--	0.019	--	0.074	0.20	1.4
Pentaethylene glycol dichloride	--	--	0.002	--	0.018	0.066	0.12

Source: Metcalf & Eddy 1982. Note: -- indicates not detected

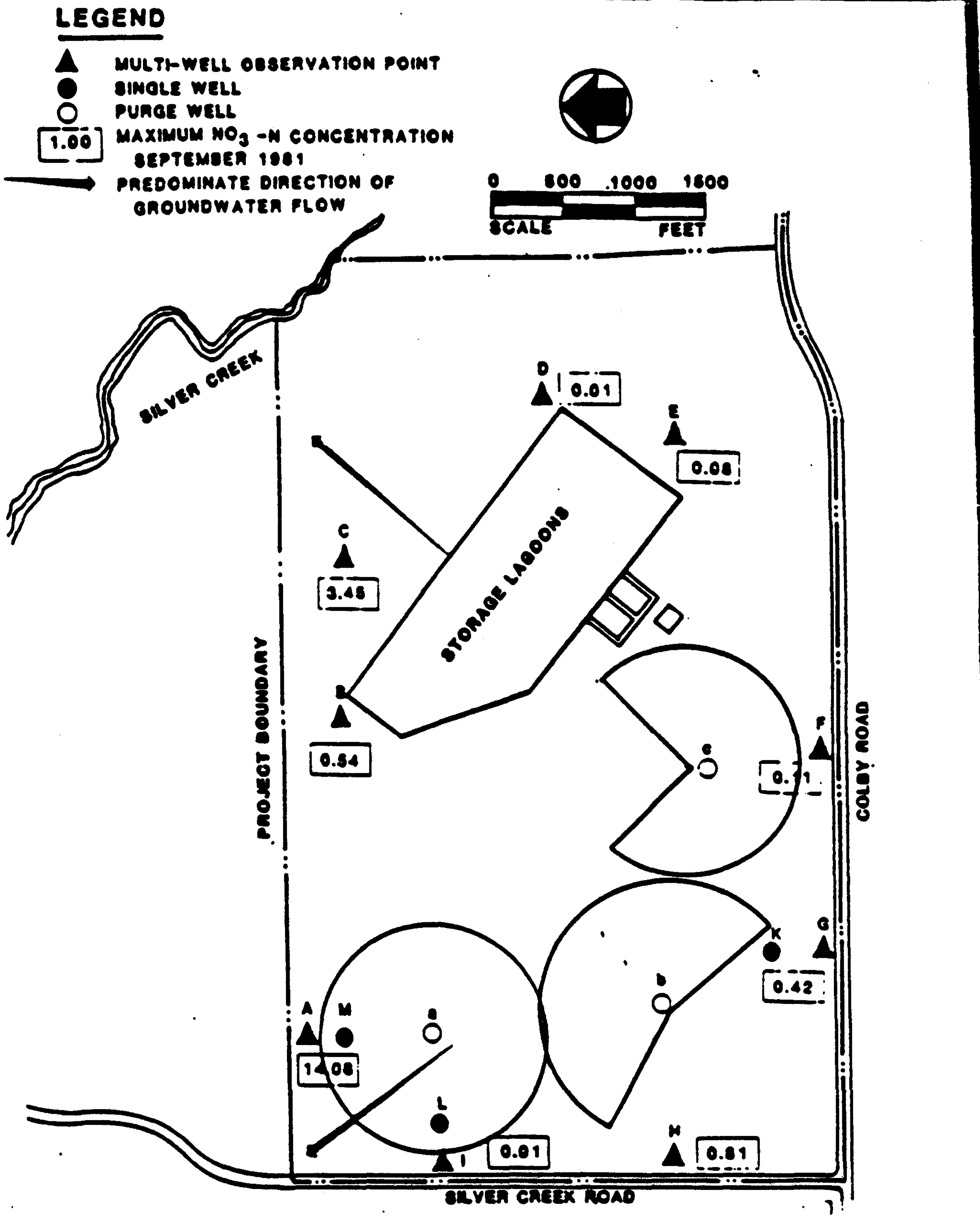


Figure 5-6 Groundwater monitoring well locations at the Muskegon County WMS No. 2. Muskegon County, MI. (Source: Metcalf and Eddy, 1982)

5.2.1.2 Localized Groundwater Contamination by Industries

The proximity of White Lake and numerous municipal and private wells to industrial and even residentual sites suggests the potential for contamination by these facilities. Additional sites have been identified, as per Act 307, as having contaminated groundwater that does not appear to be venting to surface waters of the AOC. They are as follows:

- Residential Well - White Lake Drive - Whitehall
- Montague Municipal Well - Coon Creek Well
- Whitehall Municipal Wells No. 3 and No. 4
- San Juan Subdivision
- White Lake Landfill
- Blue Lake Township Dump (Closed)
- Old City of Montague Dump (Closed)
- Montague Township Dump
- Montague Salt Storage Site
- White River Township Dump
- Whitehall Salt Storage Site
- Montague City Garage

Whitehall Municipal Wells No. 3 and No. 4:

Whitehall municipal wells No. 3 and No. 4, two observation wells and six residential wells were determined to be contaminated with volatile organic compounds in 1983. The two Whitehall municipal wells were placed on the NPL. Wash King Laundromat facility (Soap Opera), located in town, appears to be the source of organic solvents and cleaners detected in the Whitehall municipal #3. Potential sources of contamination of Well No. 4 appear to be from the vicinity of Howmet Corporation Plant No. 4 and Muskegon Chemical Company. These wells are sampled quarterly in order to monitor contaminant levels.

Whitehall Leather Company:

Whitehall Leather Company is a leather tanning and finishing industry located in Whitehall along the south shore of White Lake. Between 1940 and 1974, the Company used a settling lagoon system for treating tanning process wastewater. Chromium was a major pollutant associated with the process waste. The lagoon discharged directly to White Lake at "Tannery Bay".

The lagoons have been dredged and the solids deposited in the vicinity of the factory within 154 m (500 ft.) of White Lake. The lagoons and sludge piles have been capped with a clay cover. These sludges can serve as a source of contaminants to White Lake and possibly to groundwater. There is some concern that private and municipal wells, located within one mile of the site, could be affected by groundwater contamination if cones of depression were created by overpumping at these wells (MDNR, 1986d). Przybysz (1987 personal communication) indicated that monitoring well data, from around the lagoons, indicates no migration of contaminants.

White Lake Landfill and Shell Cast, Inc.:

These facilities are located east of the White Lake Landfill and are responsible for the contamination of some residential wells located just west of the White Lake Landfill/Shell Cast area (Przybysz, 1987 personal communication). The landfill reportedly received spent solvent waste from heavy industry and is suspected to contain buried crushed barrels from a chemical manufacturer. Leachate seeps have been observed on the north perimeter despite the installation of a clay liner (MDNR 1986d). Monitoring of water wells in the vicinity of the landfill site indicated the Shell Cast's water supply well contained 58 ppb tetrachloroethylene, 5 ppb trichloroethylene and 2 ppb cis-1,2-dichloroethylene. Since the well was located upgradient of the landfill site it was suspected that the company had inadvertently contaminated its own well. Shell Cast and White Lake Landfill have agreed to investigate this matter further (Przybysz, 1987 personal communication).

Montague Municipal Well - Coon Creek Well Site:

The Montague City garage is thought to be the source of trichloroethylene that contaminated the Montague municipal well (Coon Creek well). The well is to be used for emergencies only and is sampled quarterly (MDNR, 1986d).

Residential Well - White Lake Drive, Whitehall:

This well was contaminated with low levels of benzene. A suspected source of benzene contamination, at this site, is residential use and improper disposal.

San Juan Subdivision Residential Wells:

The San Juan subdivision, located approximately 4.8 km (3.0 mi) southwest of Montague along the north shore of White Lake, is considered a potential source of groundwater contamination. Data indicate that a resident in the subdivision used to degrease car engines in his backyard, possibly resulting in groundwater contamination. This information is unconfirmed (MDNR 1986d). Quarterly monitoring results indicate concentrations of the degreaser are less than levels of detection (1 pbb) Koehler, MDPH, personal communication.

Montague Municipal Well - Coon Creek Well:

Montague City Garage is considered the source of trichloroethylene that contaminated Montague Coon Creek municipal water well. This well is shut down except for emergency use only.

The remaining dumps, landfills and salt storage sites listed above are all potential sources for groundwater contamination due to the materials stored or disposed there.

5.2.2 Sediment Contamination

As a result of previous surface water discharges (Section 5.1.2), the bottom sediments of White Lake received a number of contaminants. These in-place sediments can act as a pollutant source for biota and water in the AOC. Howmet Corporation and Hooker Chemical Company discharged PCBs in the early 1970's that caused sediment contamination.

Evans and Borgeson (1977) concluded that the major impact to the White Lake benthic community was due to Hooker Chemical Company's surface water discharge between 1952 and 1975. Improvement and recovery in the lake's benthic community was documented in 1980 (Evans, ca. 1981), subsequent to more restrictive discharge permit effluent limits.

5.3 SUMMARY

Several sources of pollutants to the AOC are identified. In-place lake sediments and contaminated groundwater are potential sources of contaminants to the AOC.

Industrial and municipal sites in the White Lake AOC, that have confirmed groundwater contamination that has vented to surface waters in the AOC are: Occidental (Hooker) Chemical Company, E.I. duPont deNemours and Company, Howmet Corporation Plants 4 and 5, Koch (Muskegon) Chemical Company and Muskegon County WMS No.2. CMI-Dearborn (Tech-Cast Inc.), White Lake Landfill/Shell Cast, Wash King Laundromat have contaminated municipal or residential wells in either Whitehall or Montague.

Three municipal wells and six residential wells were identified by the County and State Health Departments as having been contaminated.

Volatile organic solvents (degreasers) and/or other highly mobile organic compounds constituted the major contaminants detected at all sites. Most of the organic compounds involved are miscible with water and readily migrate through the porous sandy soils located at all the sites.

Historical surface water discharges (chemical production plants, heavy industries, tannery and municipal wastewater treatment plant) increased environmental contaminants (heavy metal and organic compounds) in White Lake water and sediments causing severe degradation to White Lake quality. Sediments of White Lake were contaminated with heavy metals making it unsuitable to support a healthy benthic community PCB contaminated sediments resulting from industrial discharges in the 1970s are declining but appear to be a source of PCBs being bioaccumulated in the White Lake carp population at levels that exceed MDPH's action level of 2.0 ppm.

Four facilities currently discharge to surface waters in the AOC and do not have an adverse impact on the environmental quality of White Lake AOC. The development of environmentally sound NPDES permit limits and requirements, groundwater purgewell/treatment systems, municipal pretreatment requirements, proper use of approved waste management and disposal procedures and other remedial actions developed in the 1970's and 1980's have resulted in improved lake quality.

Urban runoff may serve as a source of localized nutrient enrichment and suspended solids loadings to the lake, but is considered a very minor source. The White River watershed serves as the major source of nutrients and suspended solids to White Lake.

6.0 POLLUTANT TRANSPORT MECHANISMS AND LOADINGS

Pollutants may be transported and released to the environment from several sources: air, surface water, groundwater, soils and sediments. Atmospheric deposition may occur when contaminants are discharged into the air, volatilized, subsequently contacted by rainwater and/or adsorbed particulate matter and deposited on land and surface waters within river and lake basins. Surface waters transport contaminants from wastewater discharges or surface runoff from industrial, municipal and agricultural sites to other surface waters. Contaminated groundwater, resulting from contaminated soils can migrate and vent to surface waters. Contaminated soils can pollute the aquatic environment by contaminating runoff to surface waters. In-place contaminated sediments can release contaminants to the water column, and organisms may acquire contaminants directly from the sediments and pore water.

Continuous, intermittent, nonpoint and in-place pollutant sources are discussed in this chapter in terms of pollutant transport mechanisms and loadings, where possible.

6.1 CONTINUOUS POINT SOURCES

Continuous point sources refer to those facilities that discharge contaminants, at levels of concern, directly to the Area of Concern. These types of potential pollutant sources include municipal wastewater treatment systems and industrial dischargers.

The following industries have NPDES permits and limits that permit their discharge to White Lake AOC: E.I. duPont deNemours, Howmet Corporation and Occidental (Hooker) Chemical. E.I. duPont deNemours and Company also discharges treated process wastewater to Lake Michigan. The Muskegon County WMS No. 2 discharges to White River via Silver Creek.

Required treatment and permit limits have reduced or eliminated contaminant loadings to levels that protect the water quality and biota in the AOC.

6.2 INTERMITTENT POINT SOURCES

Intermittent point sources are those sources that periodically discharge, rather than continuously discharge, to the AOC. These sources include, sanitary sewer overflows (SSOs) and bypasses, urban stormwater discharges and/or industrial dischargers that do not discharge continuously.

6.2.1 Urban Stormwater Discharges

Limited information is available on the effect of stormwater loadings on the White Lake AOC. Table 6-1 provides estimated stormwater loadings for five types of pollutants in the White Lake Watershed Management Units (WMUs).

Table 6-1. Estimated White River Basin Stormwater Loadings

Pollutant	White Lake WMU (lbs/yr)	(kg/yr)
Suspended Solids	403,000	182,766
BOD_5	37,600	17,048
COD	148,000	67,120
Total N	3,660	1,660
Total P	1,390	630

WMSRDC

Stormwater loadings presented above are only estimates provided in order to show that large volumes of nonpoint source pollutants potentially enter the White Lake AOC yearly. These data indicate that nonpoint sources may be significant sources of solids loadings to the AOC, but limited data prohibit the estimation of percentages resulting from these sources.

6.3 NONPOINT SOURCES

Nonpoint sources are diffuse sources of nutrients and toxic substances within a watershed. Nonpoint pollutant sources include rural and suburban runoff, urban/industrial site runoff, polluted groundwater discharges and atmospheric deposition.

WMSRDC (1977a) reported that, in 1975, nonpoint sources to White River contributed 98 percent of the total phosphorus loading to White Lake and 99.1 percent of the dissolved inorganic nitrogen. This was after the point source dischargers were diverted to the Muskegon County WMS No. 2 facility.

A comparison of estimated annual total phosphorus loading rates (Table 6-2), for example, as pounds/cfs river flow (Figure 6-1), and annual average instream phosphorus concentrations (Figure 6-2) indicates reduced loadings of phosphorus between 1973 to 1980 (MDNR STORET Station 610178). The phosphorus loading estimates were based on an average of monthly phosphorus concentrations (single grab) and annual average river flows, the latter from U.S.G.S. gage Number 04122200 located at Fruitvale Road, Muskegon County (Table 4-3). The water quality monitoring station was located upstream from White Lake on north bound U.S. Route 31 within a mile downstream of the Muskegon County WMS No. 2 outfall to Silver Creek.

Table 6-2 White River total phosphorus loadings to White Lake. Muskegon County, Michigan.

Year	Annual Average Flow (cfs)	Annual Average Conc. (ppm)	Annual Loading (lb/yr)	Annual Loading (kg/yr)	Average Loading Rate (lb/cfs)
1973	433	63	53999	24489	125
1973	433	56	47621	21597	110
1974	598	57	66473	30146	111
1974	598	53	62245	28229	104
1975	566	55	61693	27979	109
1975	566	39	43352	19660	77
1976	577	30	33996	15418	59
1977	407	35	27976	12687	69
1978	433	33	28063	12727	65
1979	523	25	25678	11645	49
1980	436	48	40844	18523	94
1980	436	31	26544	12038	61

Sources: MDNR and Limno-Tech

Estimated phosphorus loadings from the Muskegon County WMS No. 2 to the White River in 1983 and 1987 ranged from 82 to 109 kg/yr (180 to 240 lb/yr). These estimates were based on facility monitoring reports. Maximum outfall phosphorus concentrations, for the two years, were 0.1 to 0.03 ppm and daily discharge rates averaged 0.026 and 0.068 m^3/s (0.6 and 2.6 MGD), respectively. Total phosphorus loadings from the WMS facility presently represent less than 1% of total loadings to White Lake as was also reported by Limno-Tech (1981). Elimination of this discharge would not significantly change phosphorus in-lake concentrations. Limno-Tech estimated that a 50% reduction of phosphorus loadings was necessary to eliminate eutrophic conditions in White Lake. This percent reduction would require control of basinwide contributions from diffuse and natural sources.

6.3.1 Atmospheric Deposition

Atmospheric deposition of PCBs to the White Lake AOC watershed and Lake Michigan may contribute to the available PCBs and chlordane being bioaccumulated by White Lake carp. Strachan and Eisenreich (1987) estimated PCB annual loadings to Lake Michigan of 685 kg/yr (1,507 lb/yr). Seventy-three percent (500 kg or 1,100 lbs) of the loadings are attributed to atmospheric inputs. There is insufficient air toxics monitoring data for chlordane to determine if it is a significant source to Lake Michigan and drowned river mouth lakes (Bidelman, 1987 personal communication).

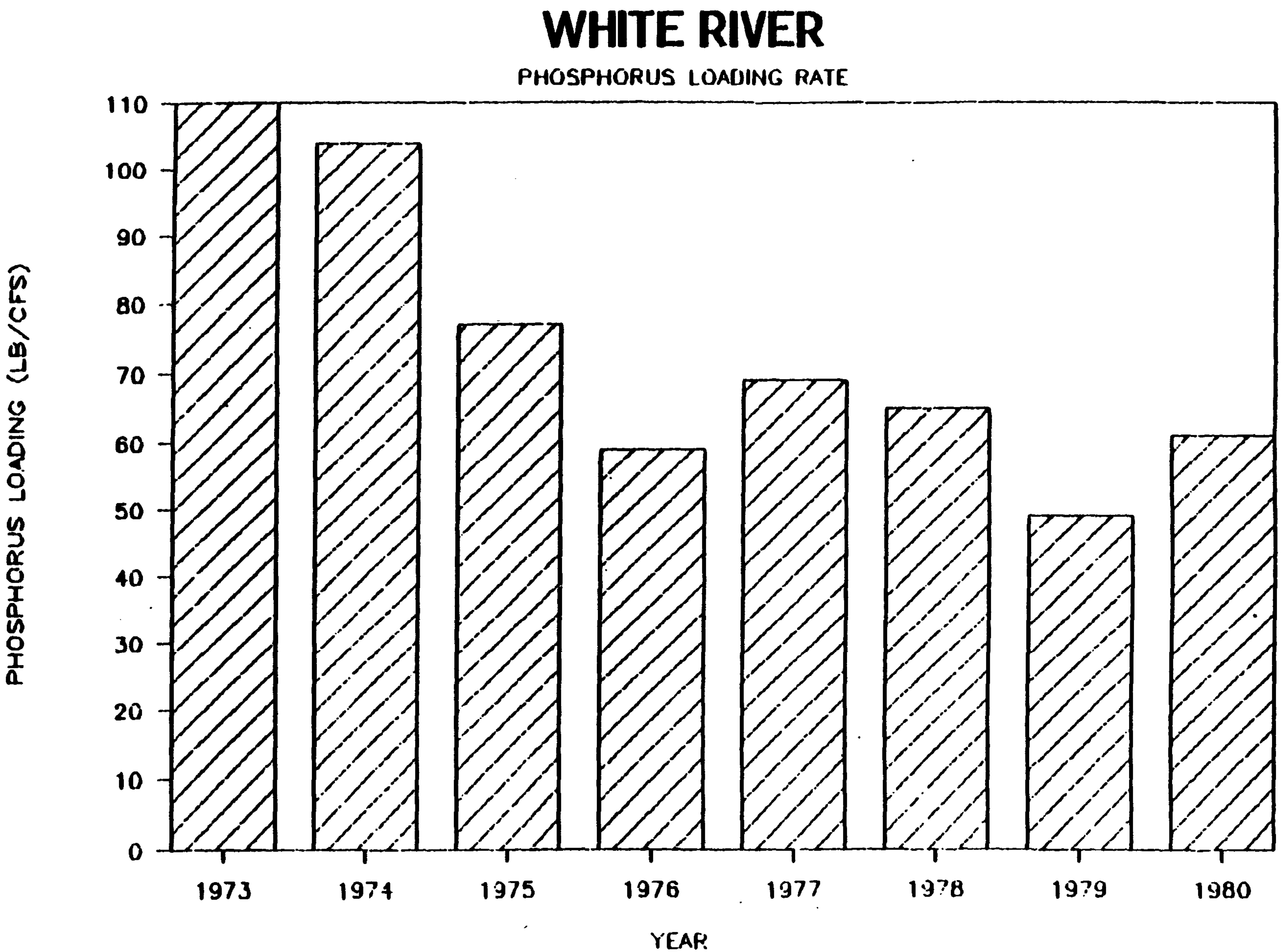


Figure 6-1 Annual average phosphorus loading rate to White Lake.

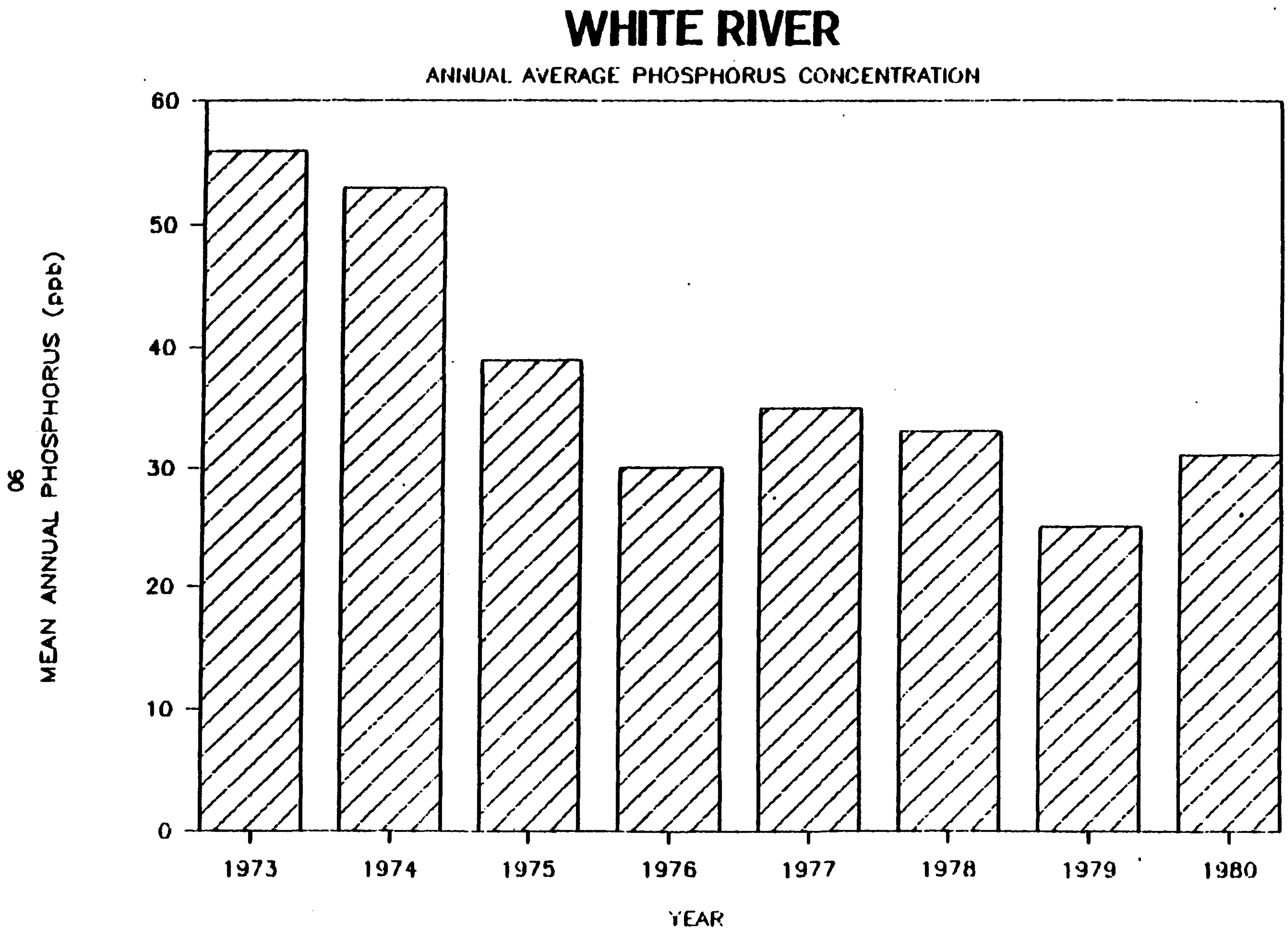


Figure 6-2 Average annual phosphorus concentrations in the White River just upstream of White Lake.

6.3.2 Groundwater Discharges

Once contaminants have entered a groundwater system they may be transported to and released into surface waters. Groundwater movement may be vertical or horizontal and may occur in one or more directions. Groundwater movement in the White Lake AOC is generally directed toward surface waters. Once the contamination has been detected, removal typically requires an expenditure of time (sometimes years) often at great expense. Often, the extent of contamination may be difficult to define.

Groundwater composes 79 percent of the White River water (WMSRDC 1978a) upstream of White Lake. Contaminants of the White River Basin soils and groundwater would ultimately be discharged to the White River and White Lake.

The majority of the contaminants that have been determined, to date, at most of the sites that could affect the White Lake AOC are highly mobile organic compounds that readily volatilize. These compounds are short lived in the aquatic environment and do not readily bioaccumulate.

6.4 IN-PLACE POLLUTANTS (CONTAMINATED SEDIMENTS)

Pollutants originating from point or nonpoint sources can accumulate in the bottom sediments of aquatic systems creating a potential contaminant source for the surface water body. Under reducing conditions (low pH, low dissolved oxygen) pollutants can enter the water column at the sediment/water interface.

Historical point and nonpoint sources are primarily responsible for the elevated organics and metals detected in White Lake sediments. There are no active municipal or industrial dischargers that are currently known to be contributing to the sediment pollutant load. Contaminated groundwater and urban runoff may be current but minor pollutant sources that do not affect the AOC or Lake Michigan.

6.5 SUMMARY

Historical mass loadings of pollutants to the White Lake AOC were not calculated. Nonpoint sources of contamination, primarily urban runoff and contaminated groundwater are the current potential sources for pollutant loadings to the AOC. Because groundwater makes up approximately 79 percent of the White River flow, it provides an excellent vehicle for contaminant transport to White Lake. In-place bottom sediments are improving in quality, but still contain elevated chromium, lead and zinc at concentrations that may continue to degrade the lake's benthic community. Inorganic contaminants do not exceed levels of concern in tissues of White Lake fish.

7.0 HISTORICAL RECORD OF REMEDIAL ACTIONS

The Michigan Environmental Response Act (P.A. 307) created a methodology for the ranking of contaminant sites using a risk assessment model. An interagency technical committee drafted the risk assessment model in 1983, creating a method entitled the Michigan Site Assessment System (MSAS). Present and potential risks to public health, safety, welfare and the environment from a site are assessed by the MSAS. The MSAS was used to rank a number of sites in the White Lake AOC. Appendix 7.1 identifies sites that have been scored and screened by the MSAS. Scored sites are ranked on a scale of 1 to 2000 and only include sites identified prior to September 19, 1986. Sites screened by the MSAS have been ranked on a scale of 1 to 15, relevant to the site's risks. Sites that have been screened greater than or equal to 9 are also scored (MDNR 1986c).

Injection wells, sewer system installation, attempts to control deicing and dust control procedures have been implemented to improve water quality conditions in Muskegon County. Cleanup operations have been conducted at various industries, some of which are listed on the National Priority List (NPL). In addition, remedial actions have been completed at specific spill sites.

The various remedial measures taken in the vicinity of the Area of Concern (AOC) are described in the following sections. Detailed descriptions of wastes disposed at these sites and disposal methods used are provided in Section 5.2.1.

7.1 COMPLETED ACTIONS

7.1.1 Muskegon County Wastewater Management System (WMS) No. 2

Prior to the installation of the Muskegon County Wastewater Management System (WMS) No. 2, severe pollution problems were evident in White Lake due to individual disposal methods used by industries and the now defunct Whitehall/Montague wastewater treatment plant. Disposal methods used involved the direct discharge of insufficiently treated industrial and municpal wastewater to White Lake (Metcalf & Eddy 1982a).

The Muskegon County WMS No. 2 began operations in 1973. Figure 7-1 illustrates the location of the system in relation to the AOC. The system was developed under a program with the United States Environmental Protection Agency (USEPA) as a research and development project.

The Department of Public Works applied to U.S.EPA for additional funding through the Michigan Department of Natural Resources (MDNR) for the preparation of a facilities plan. The facilities plan contains an evaluation of the current operation of the WMS No. 2, determination of future requirements and alternative actions and determination of the best alternative based on cost and environmental requirements. An amendment to this plan was completed in 1985 (Metcalf & Eddy 1985a).

The Muskegon County WMS No. 2, located in Whitehall Township, treats wastewater by land application methods. The wastewater is pretreated and applied to irrigated agricultural land where it is allowed to percolate through the soil. After percolation, collection and discharge of wastewater is provided by the system. The system was designed to treat 1.36 MGD (Metcalf & Eddy 1982a).

A collection system, consisting of two pumping stations and forcemains, and a treatment and disposal network are maintained by the facility. The facility conducts preapplication treatment, storage, irrigation, groundwater collection and discharge operations. Figure 7-2 illustrates features of the treatment facility. Table 7-1 provides a summary of the features at each pumping station.

Table 7-1. WMS No. 2 Pumping Station Summary

Station	No. of Pumps	Standby Power	Alarm Telemetry	Capacity (MGD) Installed	Capacity (MGD) Firm	Average Flow (MGD)	Ratio of Firm Capacity to Avg. Firm	Design Ratio[1]
M	3	No	No	2.0	1.4	0.5	2.8	3.0
W	2	No	No	3.6	3.2	1.3	2.5	2.7

Source: Modified from Metcalf & Eddy 1982.

[1]Recommended firm pump capacity for size of station.

Uncollected irrigation water and storage lagoon leakage have resulted in the migration of two individual groundwater plumes from the WMS No. 2 contaminated with ammonia, bis(2-chloroethyl)ether and/or 2-chloroethoxyethane contamination was evident in residential wells on Silver Creek Road located to the west. Owners of the residences in the affected vicinity were provided carbon filters for their water system to remove the organic contaminants. Available information (MDNR, December 2, 1984) indicated the case was in litigation due to violation of permit requirements by the WMS. A treatment system evaluation report has recently been prepared for Muskegon County by Keck Consultants. Copies have not been provided to appropriate MDNR staff for review.

A residential well, located southwest of the WMS, in the vicinity of Holton/Whitehall Road, was found to be contaminated with tetrachloroethylene (perchloroethylene). The well has been replaced with Act 307 funding (Koehler, 1987 personal communication). The source of the contamination remains unknown.

Specific problems identified by Metcalf and Eddy at the Muskegon County WMS No. 2 included:

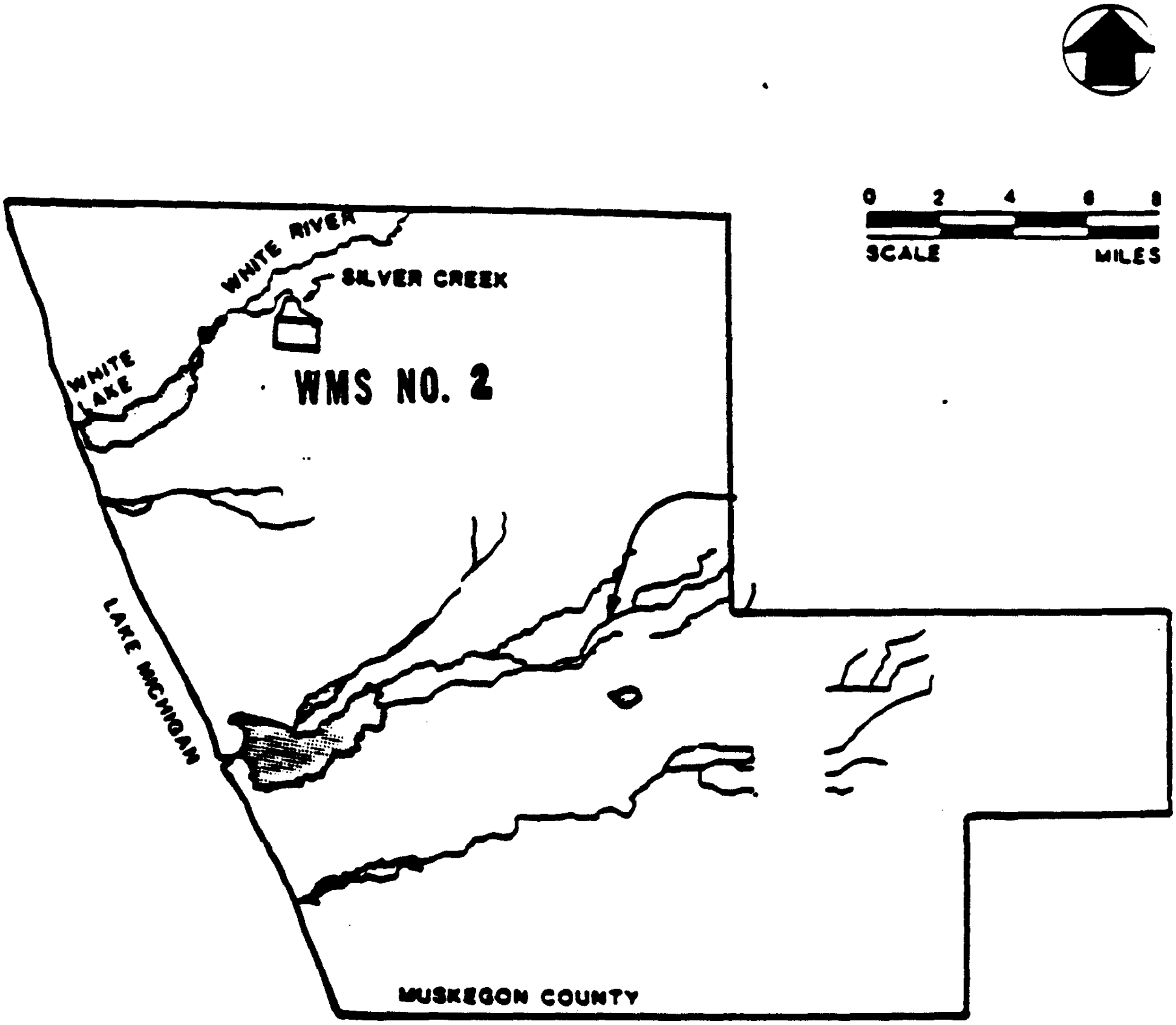


FIGURE 7-1. LOCATION OF THE WMS NO. 2 (Metcalf & Eddy, 1982).

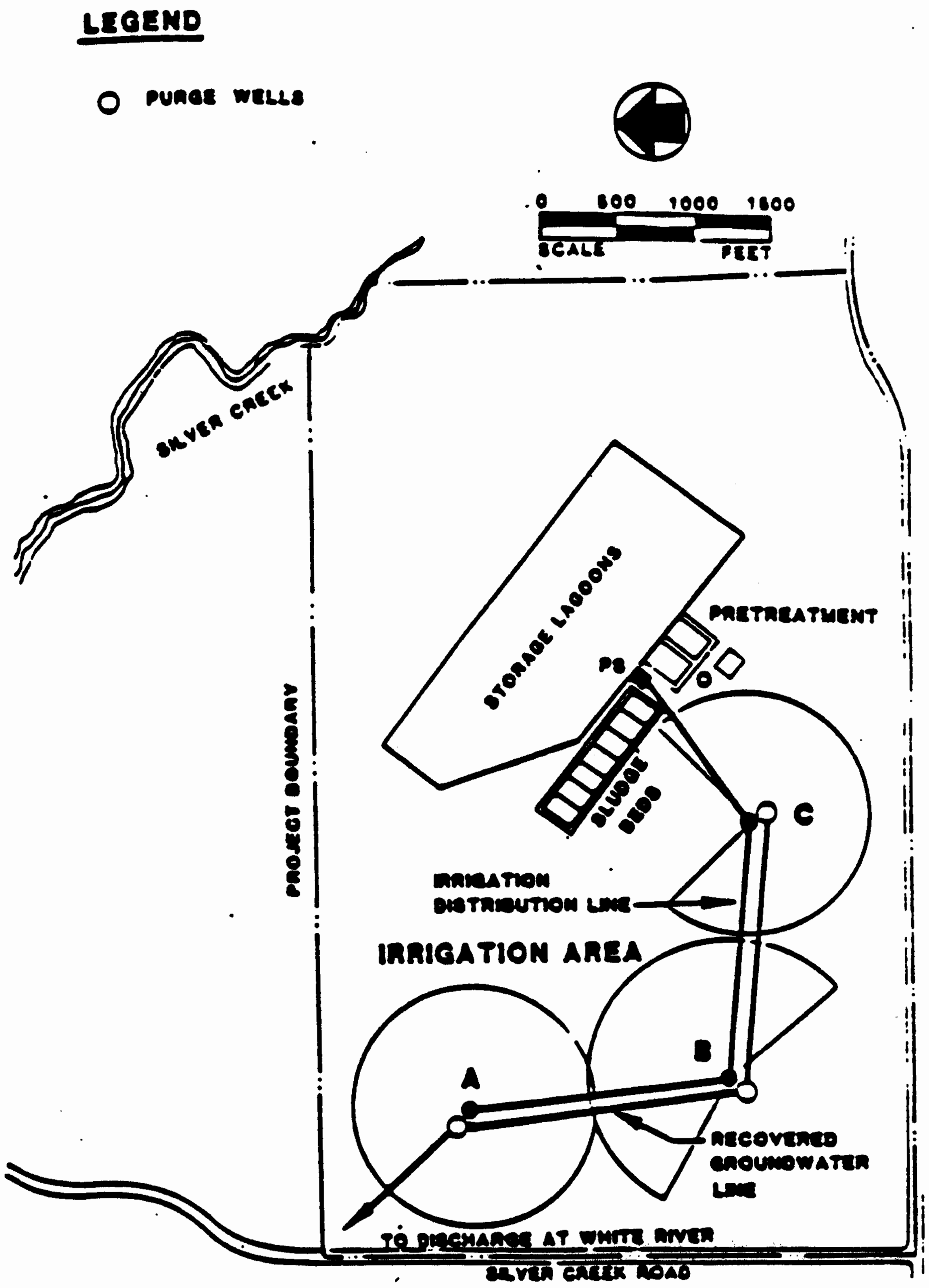


FIGURE 7-2. GENERAL LAYOUT OF THE WMS NO. 2 (Metcalf & Eddy, 1982a).

- Groundwater Control - Facility well can only recover approximately 17 percent of the irrigation flow; the remainder migrates with groundwater from the site.

- Storage Lagoon Seepage - Wastewater seeps from lagoons, contaminating the groundwater. There is no control for this problem.

- Nutrient Loading - The agricultural system has very high phosphorus and nitrogen loadings; report recommends addition of chemicals to increase precipitation of phosphorus.

- Sludge Accumulation - No system exists for removal and processing of sludge in basins.

- Preapplication Treatment - The storage lagoon maintains a high organic load, producing odors in the lagoon and irrigation distribution system (Metcalf & Eddy 1982a).

After evaluation of the current concerns at the Muskegon County WMS No. 2 and consideration of future requirements of the system, the following changes were recommended:

- Control groundwater degradation
- Control storage lagoon seepage
- Increase storage capacity to 1.7 MGD
- Improve the sludge handling process (Metcalf & Eddy 1982a).

A consent agreement was entered between the State of Michigan and Muskegon County for cleanup of the contaminated groundwater plume at the WMS No. 2 site. Requirements of the agreement include:

- Installation of two interceptor wells by January 31, 1985. Wells would intercept the groundwater plume migrating northeast from the storage lagoon and collect groundwater contaminated from the irrigation fields.

- Sealing of the storage lagoon by October 1987 (Metcalf & Eddy 1985a).

The plan presented by Metcalf & Eddy (1985a) for improvement of the WMS No. 2 includes the following objectives:

- Restriction of the contamination of the northeasterly migrating groundwater plume by sealing the storage lagoon

- Modification of aeration lagoon system to sludge system, "providing" winter nitrification

- Improve process for handling sludge

- Improve equalization basin

- Expand rapid infiltration system to enlarge capacity to 1.7 MGD and to treat an estimated 1.1 MGD of contaminated groundwater collected from the northeast interceptor wells

7.1.2 Superfund Sites

One site located in the White Lake AOC is included on the NPL. The Whitehall municipal wells #3 and #4 are 34 and 43 m (110 and 140 ft) deep, respectively, and were determined to be contaminated in 1983. Well monitoring data (1984 to 1987) indicates that neither of these two wells contain contaminants at levels of concern and the MDPH has restored their use for emergency use only. Restricted water withdrawals from Well #3 were implemented to minimize the drawing in of known contaminants, from the surrounding aquifers. U.S. EPA and the MDPH continue to monitor these wells as part of a superfund program.

7.1.3 Proposed Superfund Sites

Two other sites in the AOC have been proposed for inclusion on the NPL and are detailed below.

Occidental (Hooker) Chemical and Plastics Company

From the 1950's to 1970's Hooker Chemical and Plastics Corporation used improper disposal methods which resulted in the contamination of soils, groundwater and residential water wells with chlorinated hydrocarbons (Weaver, 1987).

The presence of some environmental problems at this site became became apparent to the State of Michigan in the mid 1970's. In 1976 and 1977, the MDNR required the Company to conduct a hydrogeological study to determine the rate and direction of groundwater flow and the extent of contamination and to conduct a soil sampling program to determine the source(s) of the groundwater contamination. These studies indicated that soils and the groundwater at the Company's site was severely contaminated with chlorinated hydrocarbons. During an inspection of the Company site in 1978, the MDNR became aware of several toxic waste disposal areas on the Hooker Chemical Company's property. In October 1978, the Company submitted a solid waste disposal plan to the MDNR. The MDNR concluded that the plan was inadequate and that contaminated solid wastes should be excavated and placed in a secure clay lined vault located on site.

The State filed suit against the Company on February 21, 1979 in order to reduce the contamination at the site. The suit was settled with the entry of a Consent Judgment on October 30, 1979. The judgment required the Company to do the following: complete a hydrogeological investigation to define the full extent of the groundwater contamination; install and properly operate a groundwater purged treatment system to completely halt the flow of contaminated groundwater to White Lake and remove and treat (remove contaminants) the contaminated groundwater; excavate the solid wastes from the disposal areas at the site and place them into a clay lined vault located on the Company's property; and provide an alternate water supply to local residents with contaminated wells.

The Company installed and operated a groundwater purge and treatment system since 1979. During this period, the Company failed to demonstrate the effectiveness of the system to completely halt the flow of contaminated groundwater to White Lake. The MDNR directed the Company to improve the system to increase capture of the contaminated groundwater. The Company responded by making incremental increases in the pumping rate of the purge well system but these increases were insufficient to halt the flow of contaminated groundwater to White Lake.

From 1980 to 1982, the Company constructed a clay lined containment vault on their property. They then excavated most of the accumulated production process wastes and contaminated solids stored on the property and placed it into the vault. Contaminated soils from an area referred to as "No-Man's Land" were not removed during the excavation period. The MDNR ordered the Company to excavate and place these wastes in the vault. The Company refused.

In May 1985, the State brought an action in circuit court to compel the Company to upgrade the groundwater purge well/treatment system to completely halt the flow of contaminated groundwater into White Lake and to excavate and properly contain the contaminated soils located in "No-Man's Land". As a result of that action, the Company has increased the size of the purge well system and increased the purge well pumping rates. Additional rates are in progress in order capture and treat the contaminated groundwater plume. Approximately 85 to 90% of the plume is being captured and treated (Heinzman, 1987 personal communication). The Company is also evaluating the impact of lake level fluctuations (15 to 30 cm or 0.5 to 1.0 ft change in a single day due to prevailing NW winds) on the pumping efficiencies necessary to capture the contaminated plume. The MDNR continues to evaluate the effectiveness of the system to assure compliance with the Consent Judgment.

Court proceedings to compel the Company to remove contaminated materials from "No Man's Land" are pending. A separate federal enforcement action to clean-up the contaminated soils, under the authority of the Resource Conservation and Recovery Act (RCRA), is currently being considered by U.S.EPA.

Estimated damages also were sought from Hooker Chemical and Plastics for deterioration of the fishery of White Lake. Evans and Borgeson (1977) estimated fish loss worth $353,656. A settlement for $135,000 was subsequently made.

Occidental (Hooker) Chemical and Plastics Company shutdown production operations and "mothballed" the site in 1982.

<u>E.I. DuPont de Nemours</u>

The Company operates a chemical (primarily refrigerants) manufacturing plant west of Montague and Occidental (Hooker) Chemical Company site. As a result of the Company's activities, groundwater in the vicinity of their feed stock unloading area has been contaminated with chlorinated solvents; specifically carbon tetrachloride, tetrachloroethene, 1,1,1-trichloroethane, chloroform and trichloroethylene. In addition, waste lime sludge from the manufacture of acetylene (1955 to 1972) contaminated the groundwater with dissolved minerals, ammonia, and thiocyanate compounds. A waste lime pile of 0.76 m^3 (1.0 million yd^3) was estimated. The Company has implemented a groundwater remedial action plan which consists of two purgewell systems to intercept the flow of contaminated groundwater and treat, then discharge the final effluent to Lake Michigan under the provisions of a NPDES Permit (MI 0000884).

The two purgewell systems are identified as the "Lime Pile Interceptor" and the "Organic Feed Stock Unloading Area". The Lime Pile interceptor well is located south of the lime pile and has been in operation for over 20 years. The purge rate of this well is 12 l/s (190 gpm) based on May 1983 aquifer pump test results. The Organic Feed Stock interceptor well is located south of the unloading area and has been in operation since 1982. Two purge wells comprise this system, each pumping at 10.5 l/s (166 gpm) for a total of 21 l/s (332 gpm) based on February 1982 aquifer pump test results.

The State of Michigan and the Company entered into a Consent Agreement on May 6, 1986. The Company now has a MDNR approved groundwater monitoring plan which specifically required frequencies and types of monitoring activities. One Consent Agreement stipulation was that "The Company shall continue to operate the purge well and treatment system(s) until the levels of contamination being monitored in the groundwater achieve background levels, determined from upgradient wells, for six (6) consecutive purge well samples."

7.1.4 Michigan Enviromental Response Act (307) Sites (Non-Superfund Sites)

Nine sites exist within the White Lake AOC. These sites include:

- Muskegon County WMS No. 2
- Residential Well - White Lake Drive, Whitehall
- Koch (Muskegon) Chemical Company - Whitehall
- CMI Dearborn (Tech Cast) Area - Montague
- Whitehall Leather - Whitehall
- Howmet Corporation Plant No. 4 - Whitehall
- San Juan Subdivision - Montague
- White Lake Landfill - Whitehall.

The Muskegon County WMS No. 2 is discussed in Section 7.1.1. Remedial measures completed at the other eight sites are discussed below (MDNR 1986d).

Residential Well White Lake Drive, Whitehall

A residential well off White Lake Drive in Whitehall found that their well was contaminated with 1 to 3 ppb benzene based on analytical results for samples collected November 1985 and January 1986. Neighboring wells have not contained any detectable level of benzene. The source of contamination in this individual well remains unknown.

The resident was provided bottled water under Act 307 funding. Recent monitoring of the well indicates that benzene concentrations are less than the detection level of 1.0 ppb. Additional sampling is planned for August 1987 and if found to contain less than 1.0 ppb may be useable for domestic purposes.

Montague Municipal Well - Coon Creek Well

Organic contaminants from the city garage were suspected to have caused contamination in the Montague Coon Creek Well. The well is sampled quarterly and is used only in the event of an emergency. Latest available data (June 1986) do not provide any information on additional remedial action.

Koch (Muskegon) Chemical Company

This company produces specialty chemicals that requires the use of numerous chemical compounds. Poor chemical containment and handling practices during 1977-1979 period resulted in the loss of an undetermined amount of organic chemicals to the plant site soils and underlying groundwater. Contamination of the groundwater was discovered in 1979 and a subsequent hydrogeological survey define local groundwater was discovered in 1979. A subsequent hydrogeological survey defined the area of the plume and indicated that the contaminated groundwater plume extended about 770 m (2500 ft) down gradient from the facility in a southwesterly direction toward Mill Pond Creek.

The resulting contaminated groundwater plume was contaminated with elevated levels of bis (2-chloroethyl) ether, triethylene glycol dichloride, 1,2-dichloroethane, trichloroethylene, tetrachloroethylene and chlorobenzene. The contaminated plume has migrated to Mill Pond Creek upstream of the White Lake Drive and vented to the surface at numerous seeps along the margin of Mill Pond Creek and unnamed impoundment of the creek. Muskegon Chemical installed a ground water purgewell system to capture and treat the contaminated groundwater and reduce the amount of contaminants venting to the surface waters. Captured groundwater is treated with a carbon filtration system, then discharged to the Muskegon County WMS No. 2 system.

Abatement techniques and actions were agreed upon as part of a Consent Agreement entered into by the State of Michigan and Muskegon Chemical Company on March 6, 1981.

CMI Dearborn (Tech Cast) Area Montague

Tech Cast, Inc., determined contamination of their monitor and supply wells in 1982 and 1983. The well contained 478 ppb trichloroethane, 100 ppb 1,1,1-trichloroethane, 6 ppb benzene and 42 ppb ethylbenzene. Although the source(s) remains undetermined, a "one-time spill" is thought to have caused the groundwater contamination. Cleanup measures were not implemented, but Tech Cast, Inc., switched its drinking water source to the municipal system. By November 19, 1984, the trichloroethane concentrations had declined to 120 ppb. The company continued to use its contaminated well for cooling water. On December 28, 1984, Tech

Cast, Inc., terminated its operations and was replaced by CMI-Dearborn which uses the site as a warehouse.

A private facility (Davignon Mill Point Products) located in the vicinity of the Tech Cast facility was also supplied municipal water supply due to detectable concentrations of the above organic compounds.

Whitehall Leather Company

Previous disposal practices used at Whitehall Leather potentially affect the AOC. In the 1940s, the company's process wastewater and solids were discharged to a lagoon system which discharged directly to White Lake.

Remedial measures completed at the site included the diversion of process wastes to the Whitehall-Montague WMS in 1974 and dredging of the lagoon sludges. The lagoons and resulting sludge piles were covered with a clay cap. Test results for monitoring wells surrounding the capped lagoon site indicate contaminants are not migrating off site. (Przybysz, 1987 personal communication).

Howmet Corporation Plant No. 4

Previous leakage of underground storage tanks and a seepage lagoon are thought to have resulted in contamination of surface water and groundwater at the Howmet Corporation Plant No. 4. Losses from Plant No. 5 are also being investigated as a possible source of groundwater contamination. Contamination of Mill Pond Creek from contaminated groundwater seeps was determined in samples collected in March and April 1984. A plume assessment is in progress by the Company to determine the extent of contaminated plume and if a purgewell/treatment system will be necessary to rehabilitate the area (Przybysz, 1987 personal communication). A definition study has been initiated by the company to study groundwater contamination at Plant #5.

San Juan Subdivision

In 1979, four residential wells located in the San Juan Subdivision and adjacent to the northwest shoreline of White Lake were found to be contaminated with 11 to 38 ppb of 1,1,1-trichloroethane. Koehler (1987 personal communication) reported that recent well sampling results for samples collected by the Muskegon County Health Department staff indicate that contaminant levels are continuing to decline but remain greater than 1.0 ppb (detection level) in one or two of the wells. Additional testing continues.

White Lake Landfill/Shell Cast

Although undetermined, the White Lake Landfill is thought to be a potential source for contamination of the Whitehall municipal well system. A supply well for Shell Cast, Inc., located in the vicinity of the landfill, was determined to be contaminated as well. A Consent Agreement between the U.S. EPA and White Lake Landfill and Shell Cast Company has been entered to address the problem of groundwater contamination in some of the private wells west of the landfill site. The companies have funded the provision of municipal water supply systems to these private homes. Monitoring of cluster wells around the landfill has been recently completed and analytical results are anticipated for late fall 1987.

7.2 ACTIONS CURRENTLY IN PROGRESS

7.2.1 Muskegon County WMS No. 2

Although general performance of the facility has been effective, several limitations of the system exist. As summarized by Metcalf & Eddy's "Wastewater Management System Facilities Plan Update Summary Report," the major concerns are described as follows:

- Limits of capacity
- System's ability for optimum performance
- System's ability to comply with environmental requirements

The facility currently is being upgraded to address the above issues as wells as those raised in Section 7.1.1. Improvements include putting an 80 mil. thick liner in the storage lagoon, rapid infiltration beds and an additional purgewell to intercept contaminated groundwater in the northwest plume. The facility's outfall is being diverted away from Silver Creek directly to the White River. Improvement costs, listed by specific area of improvement, are identified in Table 7-2.

Table 7-2. Cost Estimates for Site Construction at WMS No. 2

Construction Area	Estimated Cost
Equalization basin	$ 150,000
Aeration basin	140,000
Rapid infiltration system	700,000
Settling tanks	600,000
Storage lagoon	1,600,000
Sludge beds	300,000
TOTAL	$3,490,000

Source: Modified from Metcalf & Eddy 1985a.

8.0 DEFINITION OF SPECIFIC GOALS, OBJECTIVES AND MILESTONES FOR RESTORATION OF IMPAIRED USES

8.1 USES TO BE RESTORED, MAINTAINED, OR DISCONTINUED

The Michigan Water Resources Commission has designated water uses for which all waters of the State are to be protected, based on Part 4 of the General Rules of the Water Resources Commission, which covers water quality standards. These rules were most recently amended in November 1986. All Michigan waters, including the Area of Concern, are to be protected for the following uses:

- Agriculture
- Navigation
- Industrial water supply
- Public water supply at the point of water intake
- Warmwater fish
- Other indigenous aquatic life and wildlife
- Partial body contact all year
- Total body contact recreation from May 1 to October 31.

As discussed in previous chapters of this plan, the waters in the source Area of Concern have occasionally failed to support some of these uses, based on the minimum standards set forth in Part 4 of the Michigan Water Resources Commission General Rules. Based on current Michigan regulations, all of these uses should continue to be supported by any remedial actions undertaken pursuant to this RAP. The White Lake AOC exhibits impaired uses of carp for consumption because of elevated PCB concentrations (average of 3.7 ppm).

8.2 GOALS FOR BIOTA AND HABITAT RESTORATION

Based on Michigan water quality standards, the Area of Concern should be restored to the point where it can support a healthy and diverse fishery. PCB and chlordane concentrations in carp populations should be reduced to less than 2.0 ppm and 0.3 ppm. The sources of these two contaminants should be determined.

8.3 WATER USE AND QUALITY OBJECTIVES

The ultimate goal of this Remedial Action Plan, as envisioned by the International Joint Commission Water Quality Board, is to provide direction to remedial activities aimed at protecting water quality and restoring impaired designated uses of White Lake. This is to be accomplished by minimizing negative effects on the lake due to the influence of pollutants from the White River Basin. Water use and quality objectives for the Area of Concern may be very generally stated as the elimination or substantial reduction of detrimental effects on White Lake from the White River Basin.

8.4 SUMMARY

All tributaries to the White River and White Lake are protected for coldwater fish. White Lake is protected for warmwater fish species as a minimum.

A health advisory was issued by the Michigan Department of Public Health recommending restricted consumption (no more than one meal a week) of carp from White Lake due to elevated levels (3.7 ppm average) of PCBs that exceed an action level of 2.0 ppm. These same carp contain an average of 0.6 ppm of chlordane which exceeds the MDPH and FDA action level of 0.3 ppm.

Habitat restoration goals for the White Lake AOC, in general, are for the restoration of a warm water fishery. Water quality objectives are to optimize lake water quality conditions.

9.0 PROGRAMS AND PARTICIPANTS

This section describes regulatory and administrative programs relevant to pollution problems in the Area of Concern (AOC). Procedures for dissemination of information to the public and public participation in environmental issues also are discussed. Political implementability of the relevant programs is presented.

9.1 REGULATORY AND ADMINISTRATIVE PROGRAMS

Recommendations provided by this Remedial Action Plan (RAP) are made under existing programs for water quality management in the State of Michigan.

9.1.1 Status of Water Quality Standards, Guidelines and Objectives

Water quality standards for all surface waters of the State of Michigan have been adopted pursuant to a mandate from the Michigan Water Resources Commission and the Federal Water Quality Act of 1987. Michigan's Water Resources Commission General Rules state that the purpose of Michigan's water quality standards is "...to protect the public health and welfare, enhance and maintain the quality of water, to protect the State's natural resources, and serve the purposes of P.L. 92-500 (the Federal Water Pollution Control and Clean Water Acts) as amended, Act No. 245 of the Public Acts of 1929 (the Michigan Water Resources Commission Act), as amended, being 323.1 et seq. of the Michigan Compiled Laws, and the Great Lakes water quality agreement enacted November 22, 1978." (Michigan Department of Natural Resources, Water Resources Commission General Rules, November, 1986, Part 4).

The Water Resources Commission was created under Michigan Act 245 of 1929. Its powers and responsibilities were expanded in 1972 (based on Michigan Acts 3, 129, and 293) to bring it into compliance with the Federal Water Pollution Control Act. The administrative functions of the Commission are achieved through the Michigan Department of Natural Resources (MDNR). Figure 9.1 illustrates the organizational chart of the MDNR. The Commission is charged with protecting and conserving water resources of the State of Michigan, controlling pollution of any waters of the State and the Great Lakes, and controlling alteration of watercourses and flood plains of all rivers and streams in the State. The Commission also was empowered to make rules, require registration of manufacturing products, materials, and waste products where certain wastes are discharged to State waters to cover investigation, monitoring, and surveillance necessary to prevent and abate water pollution.

Current use designations for the White Lake AOC are listed in Chapter 3 of this plan. Michigan's water quality standards were most recently updated in November 1986 to include more stringent minimum standards relative to plant nutrients, designated uses and microorganisms, dissolved oxygen and antidegradation. The new rules also designate certain waters as "protected waters" under State authority, to implement strong antidegradation goals. Protected waters now include all Michigan waters of the Great Lakes and trout streams in the southern portion of the Lower Peninsula.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
Organization Chart

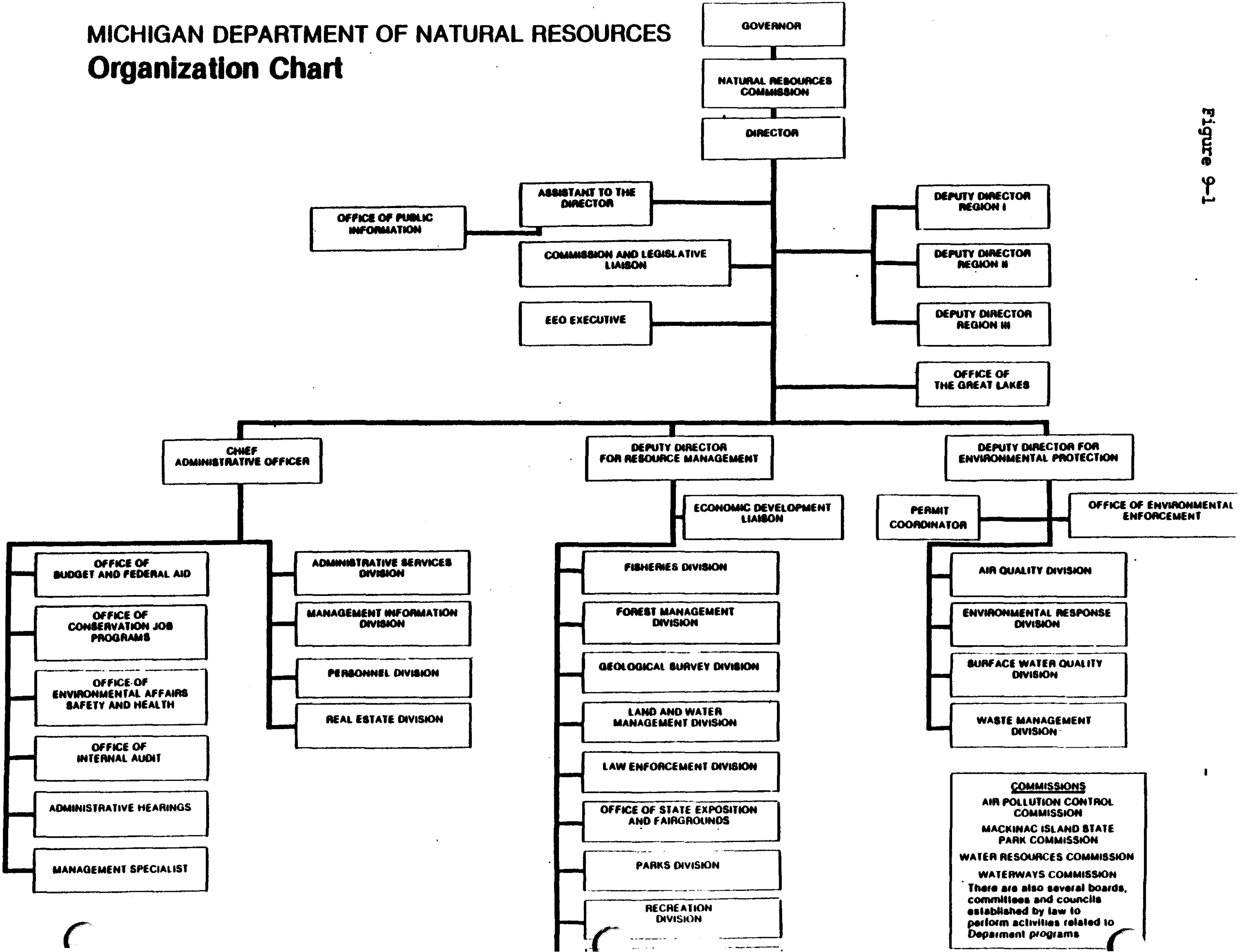


Figure 9-1

Technical work for the proposal of water use designations and water quality standards is carried out by the Surface Water Quality Division of MDNR.

9.1.2 Compliance Status of Point Source Controls

The Water Resources Commission was empowered to require permits regulating the discharge or storage of any substance that could affect water quality and also to impose restrictions that would ensure compliance with State standards, applicable Federal laws and regulations. The Commission is authorized as the State agency to cooperate and negotiate with other governments and agencies in matters concerning State water resources and to provide penalties for violations of the Water Resources Commission Act.

Michigan's Water Resources Commission obtained Federal approval to administer the National Pollutant Discharge Elimination System (NPDES) program for Michigan dischargers in October 1973. The permit program for municipal and industrial dischargers is operated by the Surface Water Quality Division of MDNR.

Appendix 5.0 provides the State's current NPDES permit development procedure. For additional information, please refer to reference MDNR (1987a) available from Surface Water Quality Division, Michigan Department of Natural Resources, P.O. Box 30028, Lansing, Michigan 48909.

Because NPDES permits in Michigan are issued under the authority of the Water Resources Commission Act in addition to the Federal Water Quality Act, permit violations are considered violations of the State Act and may be subject to civil or criminal penalties. Dischargers are notified of alleged violations by written notices of determination setting forth specific permit provisions that the Commission asserts, through MDNR, have been violated.

NPDES permittees are obliged to comply with the terms and conditions of their discharge permits, which normally are reissued at 5-year intervals. Permits specify final effluent limits for applicable parameters (and interim limits, where applicable), monitoring requirements, test procedures, reporting and records retention requirements and compliance schedules for completing system upgrading or studies necessary to ensure that dischargers are able to meet effluent limits and avoid causing violations of water quality criteria and standards. Permits also may specify the penalties for noncompliance, indications of the need to modify permits, spill containment facility requirements, operator certification requirements and noncompliance notification procedures. Procedures for spill notification and bypass notification are included in current permits. Permits also contain industrial pretreatment program requirements.

Michigan's Water Resources Act requires permitted dischargers to submit reports in compliance with requirements in thir NPDES permits; to file annual reports with the State, describing the nature of the enterprise discharging wastewater, quantities of materials used in or incidental to manufacturing processes, quantities of any by-products and waste products on the Michigan register of critical materials and volume of wastewater discharged to State waters or any sewer system, including cooling waters.

Section 5.1 shows dischargers holding current NPDES permits allowing them to discharge wastewater and/or storm water into the AOC and significant tributaries. Currently, these dischargers are in compliance with their permits except Hooker Chemical Company which has experienced minor excursions. The company has upgraded its treatment system in order to eliminate permit noncompliance occurrences.

9.1.3 Superfund and State Hazardous Site Cleanup

Michigan's Environmental Response Act (MERA, Public Act 307) and Federal Superfund authority, based on the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), provide for identifying, assessing risks and evaluating priorities for cleaning up environmental contamination at specific sites. MERA and CERCLA both provide means for publicly financing remedial actions at sites where hazardous substances have polluted the environment and prioritize sites to determine which are most in need of limited public funds. However, MERA provides Michigan with the ability to take action at sites not eligible for remedies through the Superfund program or at sites that do not rank high enough to receive Federal Superfund money. Michigan's priority ranking system does rank sites according to present conditions, while the Federal system ranks sites according to the time they were at their worst (Michigan DNR, Michigan Site of Environmental Contamination Priority Lists, Act 307, February 1986 for Fiscal Year 1987). The programs are administered through MDNR Environmental Protection Bureau's Environmental Response Division.

9.1.4 Nonpoint Source Control Efforts

Michigan's Rural Nonpoint Source Pollution Subcommittee of the Governor's Cabinet Council on Environmental Protection recently recommended a Strategy for the Reduction of Rural Nonpoint Source Pollution in Michigan (Rural Nonpoint Source Pollution Subcommittee, A Strategy for the Reduction of Rural Nonpoint Source Pollution in Michigan: A Report to the Governor's Cabinet Council on Environmental Protection 1985).

In addition, the Surface Water Quality Division of MDNR developed a strategy (MDNR, 1985a) for determination of nonpoint source contamination in the State. The strategy is intended to identify the following:

- Location, type and degree of use impairment
- Identification of the nonpoint contaminant sources.

In order to complete the nonpoint assessment, the Surface Water Quality Division issued a survey form (see Appendix 9.1). The survey form was submitted to the MDNR divisions of Fisheries, Land Resource Programs and Surface Water Quality for completion by their field personnel. The results of the assessment survey is included in the nonpoint source pollution control strategy.

9.1.5 Hazardous Waste Management

Hazardous waste control regulations in Michigan are designed to protect surface waters, groundwater and soils from toxic contamination. Hazardous waste control programs are administered by MDNR based on State mandates from the Water Resources Commission Act and the Hazardous Waste Management Act (Michigan Public Act 64 of 1979) as well as the Federal Resource Conservation and Recovery Act (RCRA), and the Hazardous and Solid Waste Amendments (HSWA) of 1984.

Michigan also has groundwater rules that prohibit discharges of substances to groundwater that may cause degradation to groundwater quality or to groundwater in usable aquifers (i.e., aquifers yielding sufficient quantities and qualities to be usable for water supply purposes) (SEMCOG, River Basin Management Strategy Framework for the Clinton River Basin 1981).

The State of Michigan, through MDNR, licenses and supervises hazardous waste management in the Muskegon Lake area. All Michigan counties have been required to develop solid waste plans for State approval. The MDNR has produced an extensive series of rules, under the Hazardous Waste Management Act, concerning the management of hazardous waste.

A number of hazardous waste management facilities exist in the White River Basin potentially affecting the AOC. These facilities include landfills, dumps, storage lagoons and seepage ponds. Appendix 7.1 includes a detailed list of these facilities and their locations.

9.1.6 Urban Stormwater Pollution Control Efforts

The State of Michigan has no comprehensive mandate to regulate directly stormwater runoff and pollutants carried by runoff unless it can be defined as a point source discharge. However, several State programs have overlapping mandates to address various aspects of pollution carried to surface waters by urban stormwater. These include programs to manage flood hazards, water quality, soil erosion and sedimentation and wetlands.

Urban stormwater runoff is a potential source of contaminants and nutrients to the White Lake AOC. The WMSRDC recommended a program to monitor storm sewer contaminant contributions. (local responsibility)

9.1.7 COE Projects/Other Agency Actions

The U.S. Army Corps of Engineers are to inspect the White Lake Harbor area and navigational channel in 1987 as part of their dredge maintenance and beach nourishment program. Sediment contaminant and benthic analysis is scheduled on a twenty year cycle.

9.2 PUBLIC INVOLVEMENT

A public meeting was held at the Whitehall City Hall on July 17, 1986 to inform attendees of the White Lake Remedial Action Plan (RAP) development process. This first meeting, one of two planned, was intended to provide attendees an overview of initial investigation findings and stress the importance of citizen involvement in the RAP development process. Citizen concerns, questions and recommedations were solicited at the meeting. A list of agency representatives and interested citizens (that attended the first meeting) that have been involved in the RAP development process, to-date, is provided in Appendix 9.

A second public meeting was held in October 1987 at the Whitehall City Hall in order to provide attendees an opportunity to comment on the draft RAP. Comments and recommendations during the meeting and those received after the meeting were taken into consideration during the development of this RAP. This report was submitted to the International Joint Commission and U.S. Environmental Protection Agency, the Cities of Montague and Whitehall and Muskegon County to further inform and provide guidance in improving and maintaining a high level of environmental quality in the White Lake AOC.

9.3 INTERAGENCY AGREEMENTS

9.3.1 Great Lakes Water Quality Agreement of 1978

This agreement established water quality planning and regulatory standards for the Great Lakes to be followed by the United States and Canada, the two signatories of the agreement. The International Joint Commission is the principal organization charged with carrying out the provisions of the Agreement through Federal agencies in the U.S. and Canada, and the authority of State and Provincial regulations. Designation of Areas of Concern and drafting of Remedial Action Plans are results of this international treaty.

9.4 SUMMARY

Pollution control and environmental management programs relating to remedial actions in the AOC are discussed in this chapter. Key regulatory and administrative responsibilities include setting water quality standards monitoring compliance of point source dischargers and hazardous waste control. Other programs involve monitoring the status of hazardous waste cleanup, urban stormwater and nonpoint source pollution control efforts and Corps of Engineers projects. Public involvement was discussed. A list of RAP development particpants, including citizens, agency representaives and company representatives is provided in Appendix 9.0.

10.0 REMEDIAL ACTION STEPS

Recommendations for remediation in the White Lake AOC involve completion of specific diagnostic studies and integration of these studies with specifically designed remedial measures. Remedial actions recommended by this RAP include the continuation of current programs in addition to the implementation of new activities. Ongoing investigative studies are recommended throughout remediation to determine the efficiency of the measures taken.

Table 10-1 summarizes impaired uses, causes, sources and remedial actions in the White Lake AOC. The following sections define required studies, specific remedial measures and recommendations for future prevention of contaminant problems in the White Lake AOC.

10.1 RECOMMENDED PLANS AND STUDIES

10.1.1 Contaminated Groundwater

Remedial measures have been implemented at known sites with documented groundwater contamination problems that influence surface waters in the AOC. Additional sites have been identified as being potential sources for groundwater contamination in localized areas.

Recommendation

Regulatory actions under Superfund should continue. At sites where groundwater contamination is known to exist but no remediation is underway, definition of size, rate of movement and direction of groundwater plume movement should be made. Sites that have been recognized as potential sources of groundwater contamination should be investigated. Direction and rates of groundwater movements and contaminant concentrations should be defined.

10.1.2 Urban Stormwater Runoff

The impact of urban stormwater runoff on the White Lake AOC has not been determined. No current data are available providing pollutant loadings to the lake.

Recommendation

MDNR staff work with Montague, Whitehall and County staff to document specific sites of need to concern that may be impacted by stormwater. Biological site assessments and sediment contaminant evaluations need to be made at specific sites of concern to evaluate conditions. If obvious impacts are apparent, then the types and volumes of pollutants occurring in the White River Basin stormwaters should be determined and controlled.

Table 10-1. Proposed Remedial Actions - White Lake Area of Concern

Potential Use Impairment	Causes	Sources	Remedial Actions
White Lake			
Fish consumption advisory - carp	PCBs in contaminated sediments	Historical surface water discharges	Air toxics monitoring for PCBs and chlordane to determine loadings
Degraded benthic community, pollutant-tolerant species dominant	Low DO due to elevated levels of nitrogen/ phosphorus, contaminated sediments (excessive levels of heavy metals)	Historical point sources, stormwater, in-place pollutants, contaminated groundwater seepage	Improving. Evaluation of stormwater pollutant loadings to assess localized impacts. Wtaershed nutrient loadings need to be assessed. Control/treatment of stormwater if problem
Loss in fish production	Reduced benthos from contaminated sediments	Contaminants in sediments resulting from Hooker Chemical discharge	Eliminated discharge
Millpond Creek			
Body Contact	Contaminated groundwater seeps to stream	Muskegon Chemical and Howmet Corporation	Purgewell Treatment System
Recreational activities	Organic contaminants	Contaminated groundwater plume migrating from Muskegon Chemical site	Cleanup of plume

10.1.3 Contaminated Sediments

White Lake sediments are contaminated with heavy metals and some organic compounds. Sediment quality has improved since diversion of the major point source dischargers to the Muskegon County WMS No. 2. Poor sediment quality and the Hooker Chemical Company discharge created degraded benthic conditions in the lake where pollutant-tolerant species used to dominant. Loss of fish production has been linked to benthic community degradation due to Hooker Chemicals' discharge, prior to 1982. The impact of in-place contaminants on water quality and fish toxicity appears to be nonexistent or minimal. Fish contaminant monitoring of resident White Lake fish indicates the presence of PCBs and chlordane in carp populations that exceeds MDPH, U.S. FDA action levels of 2.0 ppm and 0.3 ppm, respectively. Suspected sources of elevated PCBs and chlordane in White Lake carp are sediments and/or atmospheric deposition.

Recommendation

Sediment contaminant and benthic community trend monitoring of White Lake should be conducted to evaluate habitat quality.

10.1.4 Nutrient Enrichment

Nonpoint source loadings from the White River watershed comprise the major source of nutrients to White Lake. Agricultural activities immediately upstream of White Lake may serve as a source of nutrients and solids that affects water quality in the east end of White Lake. Seasonal dewatering of the agricultural muck land may represent a significant source of nutrient loadings to White Lake.

Recommendation

Nutrient loadings from the White River and agricultural areas should be evaluated to further define the trophic state of White Lake and determine if further remedial actions are necessary.

10.1.5 Fish Contaminants

White Lake carp populations contain PCBs and chlordane concentrations that exceed MDPH and U.S. FDA action levels of 1.0 and 0.3 ppm, respectively.

Recommendation

- Lake Michigan carp should be collected, at a point away from the drowned river mouths, and analyzed for PCBs and chlordane. This information would assist in determining if contamination of White Lake cap is either a site specific or a regional phenomenon.

- Air toxics monitoring for PCBs and chlordane is recommended to determine atmospheric loadings. GLNPO and the MDNR Michigan Air Quality Division should coordinate and implement monitoring programs in, at least, the Muskegon County region.

11.0 BIBLIOGRAPHY

Amendola, Gary. October 1984. Re: Michigan Dioxin Studies Fish and Avian Sampling Program. Letter to Mr. Linn Duling, Toxic Chemical Evaluation Section MDNR.

Beck, M. July 21, 1983 memorandum. Results of Fish Analysis - Mill Pond vicinity of Muskegon Chemical Company. MDNR report.

Bidleman, T., University of South Carolina. Specialist on Air Toxics Monitoring of Organochlorine Pesticides and PCBs.

Boehm, W. Whitehall City Manager. July 27, 1983. Letter to Whitehall Residents about toxics in Mill Pond Creek from Muskegon Chemical Company.

Bohn-Swanson, J. 1980. Report of Two Toxicity Screening Tests conducted with Effluent from Hooker Chemical Company, Montague, Michigan. MDNR staff report.

Courchaine, R. 1987. Certified letter to Nichter informing Hooker to cleanup contaminated soils in "No-Man's Land" site.

DeKracker, D. 1976. In-Lab Static-Bioassay Conducted on the Process Wastewater Discharge at Outfall 610094 (001) by Hooker Chemical Company, Muskegon County, Montague, Michigan. March 16-19, 1976.

Ehorn, July 1987. Letters - Technology Exchange Document Entitled "Regulatory Applications of Sediment Criteria".

Environmental Research Group. 1982. Toxics Survey Technical Report. Ann Arbor, MI.

Environmental Research Group. 1982a. Sample Collection and Analysis Report - Final-Third Source Identification Survey Phase V. Ann Arbor, MI.

Environmental Research Group. 1980. Sample Collection and Analysis Report - Draft - First Source Identification Survey. Ann Arbor, MI.

Environmental Research Group. 1980a. Sample Analysis Report - Revised Draft-First Problem Definition Survey, Ann Arbor, MI.

Evans, Elwin D. (No date). Mona, White, and Muskegon Lakes in Muskegon County, MI (The 1950s to 1980s). MDNR Draft Report.

Evans, E. 1983. Unionized Ammonia in Silver Creek Pond near Whitehall, Michigan, July 11, 1983. MDNR Staff Report.

Evans, Elwin D. 1978. Water Chemistry of White Lake, Muskegon County, Michigan, March 1, 1978. MDNR Staff Report.

Evans, Elwin and David Borgeson. 1977. MDNR Interoffice Communication to Jim Truchan. Re: Revised Fish Loss Estimates in White Lake. May 16, 1977.

Evans, Elwin. 1973. MDNR Interoffice Communication to Karl Zollner. Re: Heavy Metals, Oils and Nutrients in Sediments of Mona, White, and Muskegon Lakes, Muskegon County. August 10, 1973.

Final Report of Michigan Bureau of Water Management's Investigation of the Sediments and Benthic Communities of Mona, White, and Muskegon Lake, Muskegon County, Michigan, 1972.

Forney, Jim. 1980. Fish Contaminant Survey at White Lake Muskegon County, July 1-2, 1980. MDNR Interoffice Communication to Dennis Swanson.

Grant, J. 1972. Primary Production of White Lake. M.S. Thesis. Michigan Technological University. Houghton, Michigan. 76 pp.

Harvey, C. 1962. Staff Report - Fish Mortality - White Lake. July 20, 1962.

Hesse, J. February 5, 1973 memorandum to G. Guenther. MDNR Files.

Hesse, J. and E. Evans. 1972. Heavy Metals in Surface Waters, Sediments and Fish in Michigan. MDNR Report, Lansing, Michigan. 58 pp.

Humphrey, Harold E.B., David Wade, Daniel Williams, and Arthur Bloomer. 1980. White Lake Fish Contamination. MDNR Division of Environmental Epidemiology. Position Paper.

IJC. 1982. Great Lakes Water Quality Board. Guidelines and Register for Evaluation of Great Lakes Dredging Project. Report of Dredging Subcommittee, Windsor, Ontario. 365 pp.

Johnson and Anderson, Inc. November 82. Hooker Chemical Company Project Record Memorandum Concerning "No-Man's Land".

Kenaga, David. 1984. A Benthic Macroinvertebrate Survey of the White River at White Cloud in the Vicinity of an Old (Abandoned) WWTP, Newaygo County, MI. September 16, 1983. MDNR Staff Report, January 1984.

Kenaga, David E., William S. Creal, and Robert E. Basch. 1983. Limnology of Michigan's Nearshore Waters of Lake Michigan in 1976. Water Quality Division, MDNR Project Number R005146-01.

Key to TSD's in Michigan.

Lahvis, Garet P., David S. DeVault, and J. Milton Clark. Contaminants in Lake Michigan Nearshore Fish. USEPA Draft Report.

Meier, P. 1979. Summary of Benthic Macroinvertebrates, Phytoplankton and Zooplankton Data and Analysis Gathered from Muskegon County Lakes 1972-1975. University of Michigan.

MDNR. 1987a. Michigan Guidebook for Surface Water Dischargers - The NPDES Permit Program. Lansing, MI. 18p.

MDNR. 1986. E. I. duPont deNemours and Company. Point Source Survey, June 16-17, 1986.

MDNR. 1986. Michigan Fishing Guide. Fisheries Division.

MDNR. 1986a. Interoffice Communication Re: Strategy for Developing Remedial Action Plans for Areas of Concern in Michigan's Great Lakes Waters. September 6, 1986.

MDNR. 1986b. Part 4 Rules--Water Quality Standards. October 14, 1986.

MDNR. 1986c. Michigan Sites of Environmental Contamination Proposed Priority Lists Act 307.

MDNR. 1986d. White Lake Area Michigan Sites of Environmental Contamination Priorities List Act 307, May 1986.

MDNR. 1986e. Water Quality and Pollution Control in Michigan. 1986 Report. Ed. by Greg W. Goudy.

MDNR. 1985. Hazardous Waste Management Rules (Rev. September 6, 1985) MDNR Hazardous Waste Division.

MDNR. 1985a. Nonpoint Assessment for Small Watersheds. Staff Report. Surface Water Quality Division - Water Quality Surveillance Section.

MDNR. 1985b. Department of Natural Resources Water Resources Commission General Rules. January 18, 1985.

MDNR. 1985c. White Lake Sample Data. Environmental Laboratory Inorganic Unit. March 28, 1985.

MDNR. 1985d. White Lake Sample Data. Environmental Laboratory Inorganic Unit.

MDNR. 1983. E. I. duPont deNemours and Company. Point Source Survey, April 25-26, 1983.

MDNR. 1980. E. I. duPont deNemours and Company. Point Source Survey, February 26-27, 1980.

MDNR. 1979. Hazardous Waste Management Act. State of Michigan.

MDNR. 1979a. Hazardous Waste Management Act. Act 64 of 1979, as amended.

MDNR. 1979b. Water Sampling White Lake, Muskegon County, March 6, 1979. Water Quality Division - Staff Report.

MDNR Interoffice Communication. 1976. From Elwin Evans. Re: Muskegon and Mona Lake Tributary Sediments and Water Quality. December 13, 1976.

MDNR Interoffice Communication. 1973. From Elwin Evans. Re: Heavy Metals, Oils, and Nutrients in Sediments of Mona, White, and Muskegon Lakes, Muskegon County. August 10, 1973.

MDNR. 1972. Tests Conducted with E.I. duPont de Nemours and Company, Inc. Effluent, Montague, Michigan, June and July 1972.

MDNR. 1970. A Continuous-Flow Bioassay of the E.I. duPont de Nemours and Company, Inc. Effluent, August 17-20, 1970.

MDNR. 1970a. A Continuous-Flow Bioassay of The Hooker Chemical Company Effluent, Montague, Michigan, August 10-11, 1970.

Metcalf & Eddy, Inc. 1985. Wastewater Management System Amendment to Facilities Plan Update.

Metcalf & Eddy. 1985a. Personal Communication to Mr. David Krusik, Municipal Facilities, Administrative Section, Community Assistance Division, MDNR. December 16, 1985. Re: Treatment Works Grant C262771-01 Step 1 Whitehall-Montague Facilities Planning.

Metcalf & Eddy, Inc. 1983. Report to the County of Muskegon Michigan on 1982 Field Studies at Wastewater Management System.

Metcalf & Eddy, Inc. 1982. Wastewater Management System Facilities Plan Update. Draft Final Report.

Metcalf & Eddy, Inc. 1982a. Wastewater Management System Facilities Plan Update - Summary Report.

Muskegon County. 1974. Storm Drainage Management Investigation. Wright-McLaughlin Engineers. Denver, Colorado.

MWRC, BWM, MDNR. 1976. Fish Taint Studies Mona Lake, Muskegon Lake, White Lake, Pere Marquette Lake, Maniskee Lake, and Betsie Lake - Staff Report.

MWRC, BWM. (No date.) Final Report of Michigan Bureau of Water Management's Investigation of the Sediments and Benthic Communities of Mona, White and Muskegon Lakes, Muskegon County, Michigan, 1972.

MWRC. NPDES Permit for E.I. duPont de Nemours & Company. Permit No. MI 0000884. Issued August 25, 1986.

MWRC. NPDES Permit for Occidental Chemical Corporation. Permit No. MI 0002631. Issued January 17, 1985.

MWRC. NPDES Permit for Whitehall-Montague Wastewater Treatment System. Permit Number MI 0029173. Issued January 4, 1985.

MWRC. NPDES Permit for Howmet Turbine Components Corporation. Permit No. 0002623. Issued July 28, 1980.

MWRC. 1967. White Lake Nutrient Survey, Muskegon County. MDNR.

Newell, T. 1970. Industrial Wastewater Survey Report - Howmet Corporation, Misco Division, City of Whitehall, Muskegon County, Michigan. November 3-4, 1970. MDNR Staff Report.

NOAA. 1985. Local Climatological Data. Annual Summary with Comparative Data. Muskegon, Michigan.

Office of The Great Lakes Public Meeting Summary. June 17, 1986.

Part One - Geology and Hydrology of Michigan.

Part Two - Groundwater Contamination Problems in Michigan.

Passero, Richard N., Straw, Thomas W., and SMC Martin Inc. 1985. Hydrology for Underground Injection Control in Michigan and Hydrogeologic Atlas of Michigan. A Training Session for the USEPA.

Przybysz, R. October 23, 1986 memorandum to Liz Hinton concerning remaining controversial groundwater related issues in Grand Rapids District.

Public Water Supply Intakes in Michigan.

Robinson, J. 1968. Algal Growth Potential of the White River and Selected Wastewater Discharges. June 19, 1968.

Robinson, R. 1967. White Lake Nutrient Survey. Muskegon County, Michigan. MDNR Water Resources Commission.

Rogers, R. 1974. Report of Wastewater Survey Conducted at Hooker Chemical Corporation, Montague, Michigan. October 15-17, 1973. MDNR Point Source Survey.

Rossio, Jim. 1985. Personal Communication to Fish Contaminant Advisory Committee. Re: White Lake Fish Collection at Montague. MDNR. July 16, 1985.

Soil Conservation Service. 1968. Soil Survey Muskegon County Michigan. USDA.

Strachen, W. and S. Eisenreich. 1987. Mass Balancing of Toxic Chemicals in the Great Lakes. Burlington Workshop Report October. 1986 Report to IJC.

Surber, Eugene W., Chester Harvey, and Gerald Calhoun. May 26, 27, 1954 Biological Survey of White Lake, Muskegon County.

Surber, Eugene W. Results of Bottom and Plankton Sampling in White Lake, August 19, 1952.

Swanson, D. July 23, 1976 memorandum: - Fish Samples - HCP, HCB Analysis to R. Courchaine concerning White Lake, Mona Lake and Muskegon Lake.

Swanson, D. July 15, 1976. Discharges from Hooker Chemical Company. MDNR Staff Report.

The Michigan Water Resources Commission Act.

Truchan, James. 1976. MDNR Interoffice Communication. Re: Meeting to Determine Damage to White Lake from Hooker Chemical Company. November 18, 1976.

United States/Canadian Great Lakes Water Quality Agreement of 1978.

U.S. EPA. 1987. Regulatory Applications of Sediment Criteria. Office of Water Regulations of Standards.

Weaver, D. 1968. Memo. MDNR Fisheries Division concerning White Lake Fishery in 1950-60's.

WMSRDC. 1982, Revised 1983. The Muskegon County Surface Water Toxics Study Executive Summary.

WMSRDC. 1982. The Muskegon County Surface Water Toxics Study Control Measure Options.

WMSRDC. 1982a. The Muskegon County Surface Water Toxics Study Toxic Survey General Summary.

WMSRDC. 1981. Work Order #4 for the Muskegon County Surface Water Toxics Study. Program Phase IV. (Revised March 17, 1981).

WMSRDC. 1979. Inventory of Industrial Dischargers to Storm Drains-Preliminary Staff Report.

WMSRDC. 1978. The Water Pollution Potential of On-Land Industrial Waste Disposal Systems.

WMSRDC. 1978a. Areawide Water Quality Management Plan - Region 14 -Part One - River Basin Studies.

WMSRDC. 1978b. Areawide 208 Water Quality Management Plan - Region 14 - Part Two - Recommended Control Measures.

WMSRDC. 1977. Future Lake and Stream Quality 1977 to 1998.

WMSRDC. 1977a. Technical Supplement to "Future Lake Stream Quality" 1977 to 1998.

WMSRDC. (No date). Sourcebook for Water Quality Planning, Part 1 Areas, Places & Boundaries Region 14.

WMSRDC. (No date)a. Sourcebook for Water Quality Planning, Part II Estimates of Population & Housing.

WMSRDC. (No date)b. Sourcebook for Water Quality Planning, Part III Estimates of Land Cover and Use.

WMSRDC. (No date)c. Sourcebook for Water Quality Planning, Part IV Estimates of Wasteloads & Flow.

WMSRDC. (No date)d. Sourcebook for Water Quality Planning, Part V Summary of Public Participation.

WMSRDC. (No date)e. Sourcebook for Water Quality Planning, Part VI Appendix A Sewerless Methods of Household Waste Disposal.

WMSRDC. (No date)f. Sourcebook for Water Quality Planning, Part VI Appendix B Point Source Inventory.

WMSRDC. (No date)g. Sourcebook for Water Quality Planning, Part VI Appendix C Assessment of Groundwater Quality.

Wujek, Daniel E. and Meredith L. Welling. 1980. Phytoplankton and Water Chemistry from Three Water Intakes in Michigan's Nearshore Waters of Lake Michigan, February 1978 to January 1979.

Wuerthele, M. 1970. A Continuous Flow Bioassay of the Hooker Chemical Effluent. August 10-11, 1970. MDNR Staff Report.

Wuycheck, John. 1986. MDNR Interoffice Communication to Dave Kenaga. Re: Comments, Recommended Monitoring and RAP. Issues to be Presented to Kent Fuller - USEPA. September 11, 1986.

Wuycheck, John. 1983. A Biological Assessment of Unnamed Tributary Receiving the Whitehall-Montague Wastewater Treatment Spray Irrigation Facility Discharge, Muskegon County, Michigan. August 16, 1983.

APPENDIX 3.1 METEOROLOGICAL DATA FOR 1985
(NOAA, 1985)

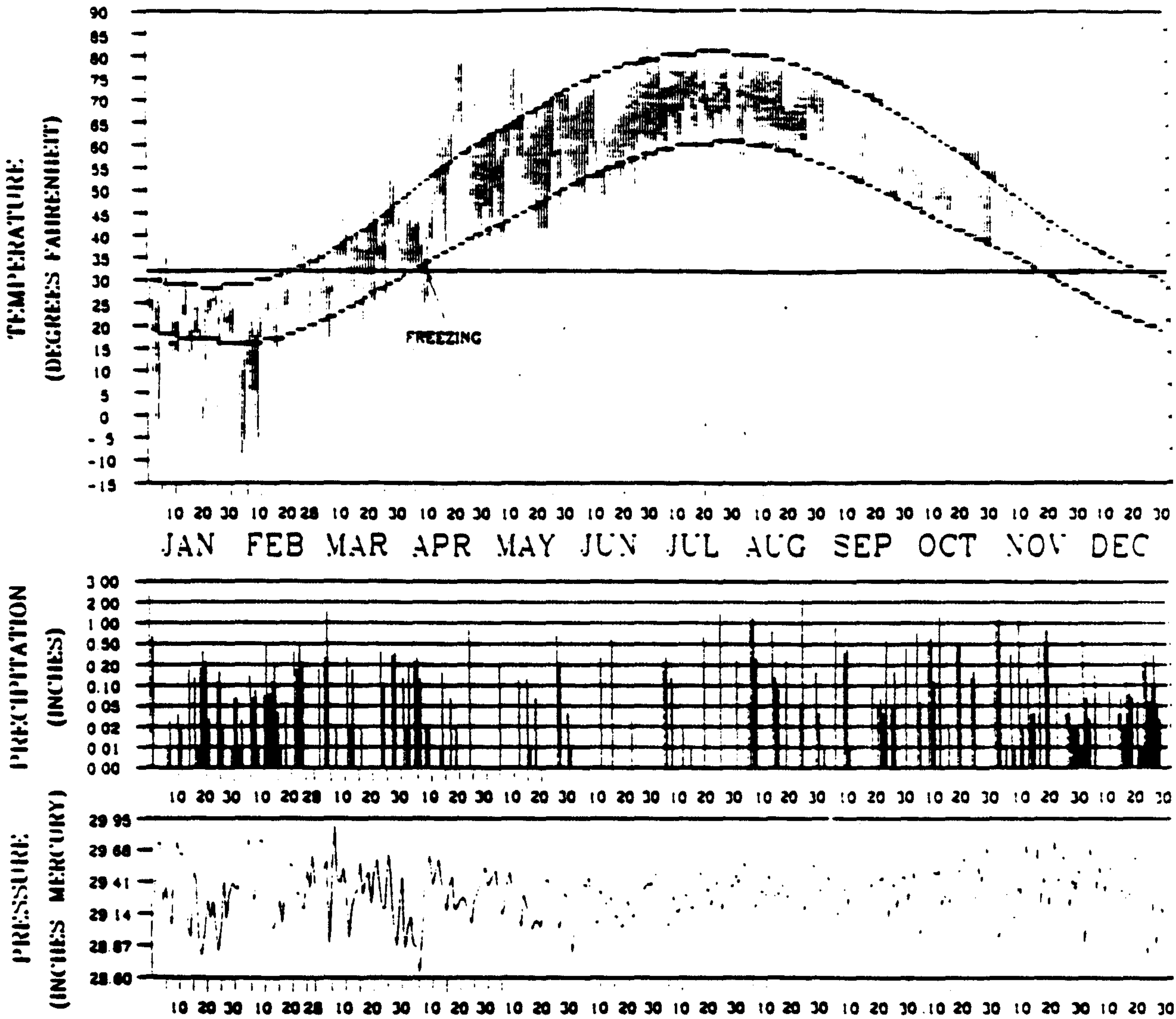
ISSN 0.9

1985 LOCAL CLIMATOLOGICAL DATA

ANNUAL SUMMARY WITH COMPARATIVE DATA

MUSKEGON,
MICHIGAN

Daily Data



TEMPERATURE DEPICTS NORMAL MAXIMUM, NORMAL MINIMUM AND ACTUAL DAILY HIGH AND LOW VALUES (FAHRENHEIT)
PRECIPITATION IS MEASURED IN INCHES. SCALE IS NON-LINEAR
STATION PRESSURE IS MEASURED IN INCHES OF MERCURY

I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC DATA CENTER, ASHEVILLE, NORTH CAROLINA, 28801

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION — NATIONAL ENVIRONMENTAL SATELLITE, DATA AND INFORMATION SERVICE — NATIONAL CLIMATIC DATA CENTER ASHEVILLE NORTH CAROLINA

DIRECTOR
NATIONAL CLIMATIC DATA CENTER

METEOROLOGICAL DATA FOR 1985

MUSKEGON MICHIGAN

[illegible]

TEMPERATURE °F:													
Averages													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Extremes													
[illegible]	[illegible]	[illegible]	[illegible]	84	84	89	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Date	[illegible]	[illegible]	[illegible]	[illegible]	14	29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33	[illegible]	43	46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Date	[illegible]	[illegible]	[illegible]	8	3	14	23	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DEGREE DAYS BASE 65 °F:													
[illegible]	[illegible]	[illegible]	[illegible]	465	214	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	30	24	[illegible]	[illegible]	98	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% OF POSSIBLE SUNSHINE													
AVG. SKY COVER (tenths)													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NUMBER OF DAYS:													
[illegible]													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	12	[illegible]	3	8	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43
Thunderstorms	[illegible]	[illegible]	[illegible]	[illegible]	6	2	4	6	[illegible]	[illegible]	[illegible]	[illegible]	32
Heavy Fog [illegible]	0	[illegible]	[illegible]	3	3	1	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]
Temperature °F													
[illegible] and above	[illegible]	[illegible]	[illegible]	0	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32° and below	26	[illegible]	[illegible]	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	20	[illegible]
32° and below	30	24	23	[illegible]	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29	[illegible]
0° and below	[illegible]	[illegible]	0	0	0	0	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AVG. STATION PRESS. (mb)	[illegible]	995.6	993.2	990.5	989.3	990.9	[illegible]	994.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RELATIVE HUMIDITY (%)													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67	67	[illegible]	[illegible]	[illegible]	[illegible]	92	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	76	73	[illegible]	93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	55	47	48	55	62	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PRECIPITATION (inches):													
[illegible]													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Date	[illegible]	[illegible]	[illegible]	24	26-27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]													
[illegible]	[illegible]	[illegible]	[illegible]	2.2	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Date	[illegible]	[illegible]	3-4	5-6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
WIND:													
[illegible]													
[illegible]	[illegible]	[illegible]	190	232	210	252	244	225	[illegible]	[illegible]	[illegible]	282	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	4.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	18	20	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	30	[illegible]	31	[illegible]	[illegible]	32	[illegible]	[illegible]	[illegible]	[illegible]
-Date	[illegible]	[illegible]	[illegible]	[illegible]	20	22	4	[illegible]	23	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	43	[illegible]	[illegible]	46	[illegible]	[illegible]	[illegible]	[illegible]
-Date	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22	[illegible]	[illegible]	23	[illegible]	[illegible]	[illegible]	[illegible]

See Reference Notes on Page 68

Page 2

NORMALS, MEANS, AND EXTREMES

MUSKEGON MICHIGAN

LATITUDE [illegible] LONGITUDE [illegible] ELEVATION FT. GRND [illegible] BARO [illegible] TIME ZONE EASTERN [illegible]

(a)		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE °F:														
Normals														
-Daily Maximum		[illegible]	[illegible]	[illegible]	54.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Daily Minimum		[illegible]	[illegible]	[illegible]	35.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Monthly		23.[illegible]	24.[illegible]	[illegible]	45.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Extremes														
-Record Highest	46	[illegible]	[illegible]	80	86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Year		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1964	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Record Lowest	46	[illegible]	[illegible]	[illegible]	[illegible]	22	[illegible]	[illegible]	36	28	[illegible]	[illegible]	[illegible]	[illegible]
-Year		[illegible]	[illegible]	[illegible]	1982	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NORMAL DEGREE DAYS:														
Heating (base 65°F)		[illegible]	[illegible]	998	594	29[illegible]	[illegible]	[illegible]	22	[illegible]	440	[illegible]	[illegible]	[illegible]
Cooling (base 65°F)		0	0	0	0	8	[illegible]	[illegible]	[illegible]	24	[illegible]	0		
% OF POSSIBLE SUNSHINE														
MEAN SKY COVER (tenths)														
Sunrise - Sunset	43	[illegible]	[illegible]	[illegible]	6.6	[illegible]	5.[illegible]	[illegible]	5.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
MEAN NUMBER OF DAYS:														
Sunrise to Sunset														
-Clear	43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Partly Cloudy	43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Cloudy	43	25.[illegible]	2[illegible]	[illegible]	15.8	13.9	[illegible]	[illegible]	9.4	[illegible]	[illegible]	22.[illegible]	[illegible]	[illegible]
Precipitation														
.01 inches or more	45	[illegible]	13.8	13.[illegible]	12.0	[illegible]	9.6	8.[illegible]	8.5	[illegible]	[illegible]	13.[illegible]	[illegible]	[illegible]
Snow, Ice pellets														
1.0 inches or more	45	[illegible]	[illegible]	3.9	0.8	[illegible]	0.0	0.0	0.0	0.0	[illegible]	[illegible]	[illegible]	[illegible]
Thunderstorms	45	0.2	0.4	[illegible]	3.5	4.5	6.4	6.2	6.2	4.9	2.3	[illegible]	[illegible]	[illegible]
Heavy Fog Visibility 1/4 mile or less	42	[illegible].5	[illegible]	2.[illegible]	2.0	2.4	2.0	[illegible]	2.2	[illegible]	2.4	[illegible]	[illegible]	[illegible]
Temperature °F														
-Maximum														
90° and above	25	0.0	0.0	0.0	0.0	[illegible]	0.6	[illegible]	0.4	0.0	0.0	0.0	[illegible]	[illegible]
32° and below	25	19.9	16.0	6.[illegible]	0.4	0.0	0.0	0.0	0.0	0.0	0.0	2.[illegible]	[illegible]	[illegible]
-Minimum														
32° and below	25	29.5	26.2	23.8	[illegible].4	2.[illegible]	[illegible]	0.0	0.0	0.2	4.[illegible]	15.[illegible]	26.[illegible]	[illegible]
0° and below	25	2.0	2.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	[illegible]
AVG. STATION PRESS (mb)	13	993.7	994.5	99[illegible].[illegible]	991.8	991.0	991.3	992.8	994.0	994.5	994.7	993.5	993.[illegible]	[illegible]
RELATIVE HUMIDITY (%)														
Hour 01	25	80	78	7[illegible]	7[illegible]	73	78	81	85	84	79	78	80	
Hour 07	25	80	80	79	7[illegible]	75	81	84	88	88	83	80	8[illegible]	
Hour 13 (Local Time)	25	75	[illegible]	64	57	54	57	59	62	64	64	[illegible]	7[illegible]	
Hour 19	25	7[illegible]	73	67	59	55	59	60	66	72	[illegible]	74	7[illegible]	
PRECIPITATION (inches):														
Water Equivalent														
-Normal		2.37	[illegible]	2.54	3.[illegible]	2.[illegible]	2.[illegible]	[illegible].42	3.[illegible]	2.92	2.[illegible]	2.[illegible]	2.[illegible]	[illegible]
-Maximum Monthly	46	4.55	3.07	6.59	[illegible]	[illegible]	[illegible].46	6.93	9.88	9.54	9.56	[illegible]	[illegible]	[illegible]
-Year		1982	1960	1976	1947	1984	[illegible]	1952	1975	[illegible]	1969	[illegible]	1949	[illegible]
-Minimum Monthly	46	0.45	0.36	0.55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].33	[illegible]	[illegible]	[illegible]
-Year		1956	1982	1958	1942	[illegible]	1959	[illegible]	1969	1979	1944	[illegible]	[illegible]	[illegible]
-Maximum in 24 hrs	46	[illegible]	[illegible]	2.36	2.31	2.[illegible]	3.[illegible]	2.54	3.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-Year		1974	1957	1976	1963	[illegible]	1967	1959	1975	[illegible]	1954	[illegible]	[illegible]	[illegible]
Snow, Ice pellets														
-Maximum Monthly	46	102.4	45.8	35.[illegible]	20.4	[illegible].4				[illegible]	4.[illegible]	2[illegible]	92.[illegible]	[illegible]
-Year		1982	198[illegible]	1965	1982	1954				1983	1967	[illegible]	[illegible]	JAN [illegible]
-Maximum in 24 hrs	46	22.0	17.[illegible]	9.[illegible]	[illegible]	[illegible]				[illegible]	4.[illegible]	[illegible]	2[illegible]	[illegible]
-Year		1982	[illegible]	196[illegible]	1982	1954				1983	[illegible]	1964	[illegible]	JAN [illegible]
WIND:														
Mean Speed (mph)	25	12.5	[illegible]	12.0	[illegible]	10.[illegible]	9.4	8.7	8.5	9.4	10.8	[illegible]	[illegible]	[illegible]
Prevailing Direction through 1963		W	ENE	ENE	SSW	SSW	SSW	W	SSW	SSW	SSW	NW	WNW	
Fastest Obs. 1 Min.														
-Direction (!!)	25	31	2[illegible]	2[illegible]	2[illegible]	22	24	28	[illegible]	20	34	[illegible]	23	[illegible]
-Speed (MPH)	25	44	4[illegible]	4[illegible]	46	4[illegible]	44	35	32	40	38	44	40	[illegible]
-Year		197[illegible]	197[illegible]	197[illegible]	1970	1964	197[illegible]	197[illegible]	1980	196[illegible]	1963	[illegible]	1982	[illegible]
Peak Gust														
-Direction (!!)	2	NW	NW	NW	S	S	S	S	S	S	NW	SW	NW	
-Speed (mph)	2	44	4[illegible]	59	56	40	5[illegible]	39	35	46	55	52	55	
-Date		1985	1985	1985	1984	1985	1984	1984	1985	1985	1985	1985	1985	MAR [illegible]

See Reference Notes on Page 58
Page 3

PRECIPITATION (inches)

MUSKEGON MICHIGAN

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1956	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1957	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1958	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1959	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1960	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1961	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1962	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1963	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1964	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1965	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1966	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1967	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1968	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1969	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1970	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1971	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1972	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1973	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1974	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1976	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1977	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1978	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1979	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1980	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1981	[illegible]	2.85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1982	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1983	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1984	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1985	[illegible]	2.63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.35	[illegible]	[illegible]	[illegible]	[illegible]
Record Mean	[illegible]	[illegible]	2.54	3.06	[illegible]	2.62	2.40	3.08	[illegible]	2.66	[illegible]	2.72	[illegible]

See Reference Notes on Page 68

Page 4A

AVERAGE TEMPERATURE (deg. F)

MUSKEGON, MICHIGAN

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
1956	[illegible]	25.4	29.6	42.4	53.3	[illegible]	68.2	68.8	58.5	54.9	40.5	[illegible]	[illegible]
1957	[illegible]	[illegible]	33.6	45.8	54.6	66.0	[illegible]	67.9	59.2	48.4	39.6	[illegible]	[illegible]
1958	[illegible]	[illegible]	[illegible]	46.5	55.0	[illegible]	68.1	68.3	60.8	52.6	40.8	[illegible]	46.2
1959	[illegible]	[illegible]	30.3	44.2	60.5	[illegible]	70.2	[illegible]	64.3	48.7	33.2	[illegible]	[illegible]
1960	[illegible]	25.2	24.3	46.8	55.9	63.2	68.2	70.4	64.4	[illegible]	[illegible]	26.5	[illegible]
1961	[illegible]	[illegible]	35.9	[illegible]	52.3	63.4	68.9	69.5	66.8	53.1	41.3	28.4	[illegible]
1962	[illegible]	[illegible]	31.8	44.8	[illegible]	[illegible]	68.9	[illegible]	58.9	52.9	39.9	[illegible]	[illegible]
1963	[illegible]	[illegible]	34.4	[illegible]	55.4	66.9	[illegible]	[illegible]	60.4	58.4	43.9	22.8	[illegible]
1964	[illegible]	[illegible]	[illegible]	47.2	60.3	67.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1965	[illegible]	[illegible]	[illegible]	44.5	[illegible]	[illegible]	[illegible]	[illegible]	62.8	[illegible]	39.8	33.5	[illegible]
1966	[illegible]	[illegible]	36.8	43.5	50.6	67.0	[illegible]	[illegible]	60.9	[illegible]	40.2	[illegible]	46.9
1967	[illegible]	[illegible]	33.5	45.4	52.5	69.4	69.9	[illegible]	[illegible]	50.9	[illegible]	[illegible]	[illegible]
1968	[illegible]	[illegible]	38.9	49.0	54.5	64.9	68.9	[illegible]	62.6	52.8	38.9	[illegible]	[illegible]
1969	[illegible]	[illegible]	[illegible]	46.8	56.8	[illegible]	[illegible]	[illegible]	62.8	49.7	[illegible]	[illegible]	[illegible]
1970	[illegible]	[illegible]	28.6	46.8	58.4	67.0	[illegible]	69.4	61.8	53.2	39.4	[illegible]	[illegible]
1971	[illegible]	[illegible]	29.3	42.9	53.6	68.6	67.9	[illegible]	64.5	57.8	[illegible]	[illegible]	[illegible]
1972	[illegible]	[illegible]	30.3	42.6	58.7	[illegible]	68.0	[illegible]	62.3	[illegible]	38.2	[illegible]	[illegible]
1973	[illegible]	[illegible]	41.4	44.9	51.9	66.5	[illegible]	[illegible]	62.3	54.5	[illegible]	26.9	45.8
1974	[illegible]	[illegible]	32.9	45.2	[illegible]	62.2	[illegible]	68.7	58.5	47.9	[illegible]	[illegible]	[illegible]
1975	[illegible]	26.0	31.0	41.0	59.5	67.4	[illegible]	70.2	56.8	53.3	[illegible]	[illegible]	[illegible]
1976	[illegible]	32.3	37.6	46.5	52.0	67.7	70.0	[illegible]	58.3	46.0	[illegible]	20.6	46.3
1977	[illegible]	[illegible]	38.9	50.3	[illegible]	62.3	[illegible]	66.6	62.3	[illegible]	39.5	[illegible]	[illegible]
1978	[illegible]	[illegible]	29.2	44.6	[illegible]	63.2	[illegible]	68.5	63.2	[illegible]	[illegible]	26.4	[illegible]
1979	[illegible]	[illegible]	33.6	[illegible]	[illegible]	64.2	68.6	66.4	[illegible]	49.4	39.4	[illegible]	[illegible]
1980	[illegible]	22.0	30.6	44.8	56.4	[illegible]	[illegible]	70.7	60.9	45.5	37.8	25.2	45.9
1981	[illegible]	[illegible]	34.9	[illegible]	53.8	65.9	[illegible]	69.6	58.9	47.2	[illegible]	[illegible]	[illegible]
1982	[illegible]	[illegible]	30.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60.4	[illegible]	[illegible]	[illegible]	[illegible]
1983	[illegible]	[illegible]	36.4	[illegible]	[illegible]	66.2	[illegible]	72.2	62.6	[illegible]	[illegible]	[illegible]	[illegible]
1984	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66.9	68.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1985	[illegible]	[illegible]	[illegible]	50.3	58.[illegible]	62.3	69.3	[illegible]	63.3	50.9	38.[illegible]	[illegible]	46.9
Record Mean	[illegible]	[illegible]	[illegible]	[illegible]	55.5	65.2	70.0	68.9	61.3	[illegible]	[illegible]	[illegible]	[illegible]
Max	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75.8	80.3	79.9	71.0	[illegible]	45.6	[illegible]	[illegible]
Min	[illegible]	[illegible]	[illegible]	[illegible]	44.9	54.6	[illegible]	58.8	51.6	[illegible]	32.6	[illegible]	38.5

See Reference Notes on Page 68

Page 4B

HEATING DEGREE DAYS Base 65 deg F   MUSKEGON MICHIGAN

SEASON	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	TOTAL
1956-57	22	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1957-58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1958-59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1339	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1959-60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	983	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1960-61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1961-62	[illegible]	[illegible]	[illegible]	363	[illegible]	[illegible]	1345	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1962-63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1482	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1963-64	[illegible]	[illegible]	[illegible]	[illegible]	625	1299	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1964-65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1965-66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	969	1424	[illegible]	868	638	[illegible]	[illegible]	[illegible]
1966-67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1106	1120	1230	[illegible]	582	[illegible]	[illegible]	[illegible]
1967-68	15	32	[illegible]	438	832	1030	[illegible]	1236	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1968-69	35	[illegible]	[illegible]	402	[illegible]	1184	1296	[illegible]	[illegible]	538	[illegible]	[illegible]	[illegible]
1969-70	[illegible]	[illegible]	[illegible]	[illegible]	850	1192	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1970-71	9	20	[illegible]	367	763	[illegible]	1387	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1971-72	[illegible]	[illegible]	[illegible]	246	[illegible]	[illegible]	1333	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1972-73	[illegible]	[illegible]	[illegible]	529	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1973-74	3	8	[illegible]	328	743	[illegible]	1229	1246	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1974-75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1046	[illegible]	1085	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975-76	[illegible]	[illegible]	249	[illegible]	[illegible]	1066	1275	942	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1976-77	[illegible]	43	[illegible]	[illegible]	[illegible]	[illegible]	1564	1200	[illegible]	436	[illegible]	[illegible]	[illegible]
1977-78	[illegible]	[illegible]	[illegible]	526	[illegible]	[illegible]	1402	1374	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1978-79	29	[illegible]	[illegible]	[illegible]	[illegible]	1190	1481	1408	969	708	[illegible]	[illegible]	[illegible]
1979-80	[illegible]	[illegible]	[illegible]	482	[illegible]	1039	[illegible]	1239	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1980-81	[illegible]	9	[illegible]	592	[illegible]	1228	1368	1028	923	[illegible]	[illegible]	[illegible]	[illegible]
1981-82	[illegible]	[illegible]	[illegible]	545	[illegible]	1089	1509	1209	1064	[illegible]	[illegible]	[illegible]	[illegible]
1982-83	9	[illegible]	[illegible]	390	[illegible]	899	[illegible]	969	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1983-84	20	[illegible]	[illegible]	457	723	1365	1411	954	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1984-85	23	[illegible]	[illegible]	374	[illegible]	[illegible]	1376	1206	920	[illegible]	[illegible]	[illegible]	[illegible]
1985-86	[illegible]	[illegible]	153	[illegible]	802	1244							

See Reference Notes on Page 68

Page 5A

COOLING DEGREE DAYS Base 65 deg F   MUSKEGON, MICHIGAN

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	TOTAL
1969	0	0	0	0	25	52	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]
1970	0	0	0	13	49	[illegible]	220	[illegible]	54	7	0	0	[illegible]
1971	0	0	0	0	5	[illegible]	[illegible]	82	[illegible]	28	0	0	[illegible]
1972	0	0	0	0	43	[illegible]	[illegible]	149	[illegible]	[illegible]	0	0	[illegible]
1973	0	0	0	4	0	[illegible]	[illegible]	220	75	[illegible]	0	0	[illegible]
1974	0	0	0	0	3	38	[illegible]	137	27	[illegible]	0	0	[illegible]
1975	0	0	0	0	38	[illegible]	213	[illegible]	6	[illegible]	0	0	[illegible]
1976	0	0	0	[illegible]	2	[illegible]	166	[illegible]	[illegible]	0	0	0	[illegible]
1977	0	0	0	4	[illegible]	42	237	[illegible]	28	0	0	0	[illegible]
1978	0	0	0	0	[illegible]	57	[illegible]	[illegible]	[illegible]	0	0	0	[illegible]
1979	0	0	0	0	[illegible]	67	137	103	36	7	0	0	[illegible]
1980	0	0	0	0	[illegible]	54	191	190	36	0	0	0	[illegible]
1981	0	0	0	0	[illegible]	67	172	160	20	0	0	0	[illegible]
1982	0	0	0	0	[illegible]	[illegible]	220	126	[illegible]	0	0	0	[illegible]
1983	0	0	0	0	4	122	319	230	72	2	0	0	[illegible]
1984	0	0	0	0	[illegible]	81	134	227	40	0	0	0	[illegible]
1985	0	0	0	30	[illegible]	47	153	88	108	0	0	0	[illegible]

See Reference Notes on Page 68

Page 5B

SNOWFALL (inches)

MUSKEGON MICHIGAN

SEASON	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	TOTAL
1956-57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1957-58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1958-59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1959-60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1960-61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1961-62	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1962-63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1963-64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1964-65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1965-66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1966-67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1967-68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1968-69	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1969-70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1970-71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1971-72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1972-73	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1973-74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1974-75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1975-76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1976-77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1977-78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1978-79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1979-80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1980-81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1981-82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1982-83	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1983-84	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1984-85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1985-86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Record Mean	0.0	0.0	[illegible]	[illegible]	[illegible]	24.0	33.0	[illegible]	[illegible]	[illegible]	[illegible]	0.0	[illegible]

See Reference Notes on Page 68

REFERENCE NOTES

MUSKEGON MICHIGAN

GENERAL

[illegible]

SPECIFIC

[illegible]

EXCEPTIONS

[illegible]

APPENDIX 4.1 WHITE LAKE BASIN WATER SAMPLING DATA

For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

TABLE 6

Analytical Results for Water and Fish Samples from White Lake

(page 1 of 10)

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
1. Field Measurements			
dissolved oxygen	8.6	NA	NA
hydrogen ion concentration (pH)	7.8	NA	NA
temperature (°C)	10.0	NA	NA
specific conductance (µmho/cm)	330	NA	NA
2. Nutrients			
total phosphorus	.06	NA	NA
dissolved orthophosphate as P	<.01	NA	NA
total Kjeldahl nitrogen	.45	NA	NA
nitrate & nitrite nitrogen	.05	NA	NA
ammonia nitrogen	.15	NA	NA
3. Indicators			
methylene blue active substances	.031	NA	NA
nitrilotriacetic acid	<1	NA	NA

NA = not applicable.

TABLE 6
White Lake
Page 2
For Sediments and Fish, inorganic parameters as dry weights;
organic parameters as wet weights.

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
4. General			
chemical oxygen demand	5	NA	NA
total hardness	170	NA	NA
filterable residue	6	NA	NA
non-filterable residue	220	NA	NA
total organic carbon	<1	NA	NA
oil & grease (as % in sediments)	NA	NA	NA
5. Metals			
antimony	<.050	<1.4	<1.4
arsenic	.0013	.60	.37
beryllium	<.002	<.071	<.068
cadmium	<.003	<.071	<.068
chromium	<.005	.86	1.8
copper	<.005	.68	1.3
lead	<.010	.29	6.0
mercury	<.0002	.019	.034
nickel	<.010	.36	<.27
selenium	<.001	2.1	2.9
silver	<.002	.32	.44
thallium	<.020	<.71	<.68
zinc	<.005	20	20

NA = not applicable.

TABLE 6
White Lake
Page 3
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
6. Other Ions			
chlorides	32	NA	NA
sulfates	17	NA	NA
7. Organics: Priority Pollutants			
acenaphthene	<.01	<1.4	<.53
acrolein	<1	<10	<10
acrylonitrile	<1	<10	<10
benzene	<.01	<.30	<.03
benzidine	<.01	<1.4	<.53
carbon tetrachloride (tetrachloromethane)	<.01	<.01	<.01
chlorobenzene	<.01	<.01	<.01
1,2,4-trichlorobenzene	<.01	<1.4	<.53
hexachlorobenzene	<.01	<1.4	<.53
1,2-dichloroethane	<.01	<.01	<.01
1,1,1-trichloroethane	<.01	<.01	<.01
hexachloroethane	<.01	<1.4	<.53
1,1-dichloroethane	<.01	<.01	<.01
1,1,2-trichloroethane	<.01	<.01	<.01
1,1,2,2-tetrachloroethane	<.01	<.01	<.01
chloroethane	<.01	<.01	<.01

NA = not applicable.

TABLE 6
White Lake
Page 4
For Sediments and Fish, inorganic parameters as dry weights;
organic parameters as wet weights.

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
7. Organics: Priority Pollutants (continued)			
bis(chloromethyl)ether	<.01	<1.4	<.53
bis (2-chloroethyl)ether	<.01	<1.4	<.53
2-chloroethyl vinyl ether (mixed)	<.01	<1.4	<.53
2-chloronaphthalene	<.01	<1.4	<.53
2,4,6-trichlorophenol	<.025	<2.6	<.98
p-chloro-m-cresol	<.025	<2.6	<.98
chloroform (trichloromethane)	<.01	<.01	<.01
2-chlorophenol	<.025	<2.6	<.98
1,2-dichlorobenzene	<.01	<1.4	<.53
1,3-dichlorobenzene	<.01	<1.4	<.53
1,4-dichlorobenzene	<.01	<1.4	<.53
3,3-dichlorobenzidine	<.01	<1.4	<.53
1,1-dichloroethylene	<.01	<.01	<.01
1,2-trans-dichloroethylene	<.01	<.01	<.01
2,4-dichlorophenol	<.025	<2.6	<.98
1,2-dichloropropane	<.01	<.01	<.01
1,3-trans-dichloropropene	<.01	<.01	<.01
2,4-dimethylphenol	<.025	<2.6	<.98
2,4-dinitrotoluene	<.01	<1.4	<.53

TABLE 6
White Lake
Page 5
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
7. Organics: Priority Pollutants (continued)			
2,6-dinitrotoluene	<.01	<1.4	<.53
1,2-diphenylhydrazine	<.01	<1.4	<.53
ethylbenzene	<.01	<.01	<.01
fluoranthene	<.01	<1.4	<.53
4-chlorophenyl phenyl ether	<.01	<1.4	<.53
4-bromophenyl phenyl ether	<.01	<1.4	<.53
bis(2-chloroisopropyl)ether	<.01	<1.4	<.53
bis(2-chloroethoxy)methane	<.01	<1.4	<.53
methylene chloride (dichloromethane)	<.01	<.09	<.08
methyl chloride (chloromethane)	<.01	<.01	<.01
methyl bromide (bromomethane)	<.01	<.01	<.01
bromoform (tribromomethane)	<.01	<.01	<.01
dichlorobromomethane	<.01	<.01	<.01
trichlorofluoromethane	<.01	<.01	<.01
dichlorodifluoromethane	<.01	<.01	<.01
chlorodibromomethane	<.01	<.01	<.01
hexachlorobutadiene	<.01	<1.4	<.53
hexachlorocyclopentadiene	<.01	<1.4	<.53

TABLE 6
White Lake
Page 6
For Sediments and Fish, inorganic parameters as dry weights;
organic parameters as wet weights.

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
7. Organics: Priority Pollutants (continued)			
isophorone	<.01	<1.4	<.53
naphthalene	<.01	<1.4	<.53
nitrobenzene	<.01	<1.4	<.53
2-nitrophenol	<.025	<2.6	<.98
4-nitrophenol	<.025	<2.6	<.98
2,4-dinitrophenol	<.5	<52	<20
4,6-dinitro-o-cresol	<.5	<52	<20
N-nitrosodimethylamine	<.01	<1.4	<.53
N-nitrosodiphenylamine	<.01	<1.4	<.53
N-nitrosodi-n-propylamine	<.01	<1.4	<.53
pentachlorophenol	<.025	<2.6	<.98
phenol	<.025	<2.6	<.98
bis(2-ethylhexyl)phthalate	<.01	<1.4	20
butyl benzyl phthalate	<.01	<1.4	<.53
di-n-butyl phthalate	<.01	38.8	5.85
di-n-octyl phthalate	<.01	<1.4	<.53
diethyl phthalate	<.01	<1.4	<.53
dimethyl phthalate	<.01	<1.4	<.53
1,2-benzanthracene (benzo(a)anthracene)	<.01	<1.4	<.53
benzo(a)pyrene (3,4-benzopyrene)	<.01	<1.4	<.53

TABLE 6
White Lake
Page 7
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
7. Organics: Priority Pollutants (continued)			
3,4-benzofluoranthene (benzo(b)fluoranthene)	<.01	<1.4	<.53
11,12-benzofluoranthene (benzo(k)fluoranthene)	<.01	<1.4	<.53
chrysene	<.01	<1.4	<.53
acenaphthylene	<.01	<1.4	<.53
anthracene	<.01	<1.4	<.53
1,12-benzoperylene (benzo(g,h,i)perylene)	<.025	<3.4	<1.3
fluorene	<.01	<1.4	<.53
phenanthrene	<.01	<1.4	<.53
1,2,5,6-dibenzanthracene (dibenzo(a,h)anthracene)	<.025	<3.4	<1.3
indeno(1,2,3-c,d)pyrene	<.025	<3.4	<1.3
pyrene	<.01	<1.4	<.53
tetrachloroethylene	<.01	<.01	<.01
toluene	<.01	<.02	<.01
trichloroethylene	<.01	<.01	<.01
vinyl chloride (chloroethylene)	<.01	<.01	<.01
aldrin	<.0001	<.01	<.01
dieldrin	<.0001	<.01	<.01

TABLE 6
White Lake
Page 8
For Sediments and Fish, inorganic parameters as dry weights;
organic parameters as wet weights.

	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
7. Organics: Priority Pollutants (continued)			
chlordane (technical mixture and metabolites)	<.0001	<.01	< 01
4,4'-DDT	<.0001	<.01	01
4,4'-DDE (p,p'-DDT)	<.0001	<.01	<5
4,4'-DDD (p,p'-TDE)	<.0001	<.01	<.01
alpha-endosulfan	<.0001	<.01	<.01
beta-endosulfan	<.0001	<.01	<.01
endosulfan sulfate	<.0001	<.01	<.01
endrin	<.0001	<.01	<.01
endrin aldehyde	<.0001	<.01	<.01
heptachlor	<.0001	<.01	<.01
heptachlor epoxide	<.0001	<.01	<.01
alpha-BHC	<.0001	<.01	<.01
beta-BHC	<.0001	<.01	<.01
gamma-BHC (lindane)	<.0001	<.01	<.01
delta-BHC	<.0001	<.01	<.01
atrazine	<.0001	<.01	<.01
kepone	<.0001	<.01	<.01

TABLE 6
White Lake
Page 9
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
7. Organics: Priority Pollutants (continued)			
mirex	<.0001	<.01	<.76
PCB 1242 (Arochlor 1242)	<.0009	<.09	<.09
PCB 1254 (Arochlor 1254)	<.0032	<.32	<.32
PCB 1221 (Arochlor 1221)	<.0018	<.18	<.18
PCB 1232 (Arochlor 1232)	<.0004	<.04	<.04
PCB 1248 (Arochlor 1248)	<.0013	<.13	<.13
PCB 1260 (Arochlor 1260)	<.0032	<.32	<.32
PCB 1016 (Arochlor 1016)	<.0071	<.71	<.71
toxaphene	<.0085	<.85	<.85
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	unknown	unknown	unknown
1,3-cis-dichloropropene	<.01	<.01	<.01
1,1,2,2-tetrachloroethene	<.01	<.01	<.01
8. Organics: General			
benzothiazole	<.01	<1.4	<.53
xylene	<.01	<.10	<.01
pentachloroethane	<.01	<1.4	<.53
methylene-bis-2-chloroaniline	<.01	<1.4	<.53
triaryl phosphate ester	<.01	unknown	unknown

TABLE 6
White Lake
Page 10
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	Water ERG 39928 (mg/l)	Bluegill Composite ERG 40074 (mg/kg)	Bullhead Composite ERG 40073 (mg/kg)
8. Organics: General (continued)			
chloroaniline	<.01	<1.4	<.53
dichlorobenzophenone	<.01	<1.4	<.53
N,N-dimethylaniline	<.01	<1.4	<.53
chlorinated dibenzofurans	<.01	<1.4	<.53
chlorinated dibenzodioxins	<.01	<1.4	<.53
pentachloronitrobenzene	<.01	<1.4	<.53
styrene	<.01	<1.4	<.53
N-ethylaniline	<.01	<1.4	<.53
polybrominated biphenyls	<.002	<.02	<.02

STATE OF MICHIGAN

JAMES J. BLANCHARD, Governor

DEPARTMENT OF NATURAL RESOURCES

STEVENS T. MASON BUILDING
P.O. BOX 30028
LANSING, MI 48909

GORDON E. GUYER, Director

January 27, 1987

TO: All Interested Parties

FROM: Paul D. Zugger, Chief
Surface Water Quality Division

SUBJECT: Rule 57(2) Guideline Levels

The Rule 57(2) Guidelines state that the most recent calculations of water quality-based levels of toxic substances developed pursuant to the Guidelines shall be compiled on an annual basis and be available for distribution by February 1 of each year. The following list is in fulfillment of that requirement, and is complete as of January 27, 1987. The values are subject to change as new data or information becomes available.

Rule 57(2) Guideline Levels are utilized in making water quality-based permit recommendations to the Water Resources Commission concerning toxic substances in the surface water after a point source discharge is mixed with the receiving stream volume specified in R323.1082. These levels do not represent acceptable ambient levels in all waters of the state, nor do they represent or reflect necessary treatment-based considerations.

This list is informational only and is not a mechanism to establish water quality-based permit limits. It is advisory in nature and not meant to be binding on anyone.

Water quality-based permit limitations for toxic chemicals are developed pursuant to existing procedures by staff in the Great Lakes and Environmental Assessment Section using the R323.1057(2) Guidelines and appropriate scientific data.

Questions concerning this list should be directed to Linn Duling, of the Great Lakes and Environmental Assessment Section at 517/335-4188.

R1026
1-86

27-Jan-87

CHEMICAL NAME	CAS NUMBER	Rule 57(2) Level Non-Drinking Water Value (ug/l)	Basis
Arsenic	Class 011	150	ACV
Cadmium	Class 013	@exp(0.83(@ln(H))-4.84)	ACV
Chromium	Class 015	@exp(0.83(@ln(H))+0.131)	ACV
Copper	Class 017	@exp(0.94(@ln(H))-1.3)	ACV
Cyanide	Class 018	5	ACV
Lead	Class 019	@exp(1.53(@ln(H))-5.92)	ACV
Nickel	Class 022	@exp(0.92(@ln(H))+0.12)	ACV
Selenium	Class 023	13	ACV
Silver	Class 024	0.15	ACV
Zinc	Class 027	@exp(0.85(@ln(H))+0.67)	ACV
PCB *	Class 079	0.000012	CRV
DDT *	50293	0.00013	CRV
Carbon tetrachloride *	56235	27	CRV
Phenol, 4-chloro-3-methyl	59507	4.4	ACV
Aniline *	62533	0.4	ACV
Acetone	67641	500	TLSC
Chloroform *	67663	43	CRV
Hexachloroethane *	67721	13	CRV
Benzene *	71432	51	TLSC
Ethane, 1,1,1-trichloro	71556	120	ACV
Methylene chloride *	75092	430	ACV
Ethylene oxide *	75218	56	CRV
Ethylene, 1,1-dichloro *	75354	3	CRV
Hexachlorocyclopentadiene	77474	0.5	ACV
Propane, 1,2-dichloro	78875	160	TLSC
Trichloroethylene *	79016	94	ACV
Pentachlorophenol	87865	@exp(1.0051*pH-3.6617)/4.6	ACV
2,4,6-Trichlorophenol *	88062	1.5	CRV
Dinoseb	88857	@exp(1.5837*pH-8.8767)/55.5	ACV
Naphthalene	91203	29	ACV
Benzidine, 3,3-dichloro *	91941	0.04	CRV*
Benzidine *	92875	0.0051	CRV*
Silvex	93721	3	HLSC
Benzene, 1,2-dichloro	95501	7	ACV
Phenol, 2-chloro	95578	10	ACV
Ethylbenzene	100414	62	ACV
Styrene *	100425	19	CRV
Benzene, 1,4-dichloro	106467	43	ACV
Phenol, 4-chloro	106489	9.3	ACV
Ethane, 1,2-dibromo *	106934	1.2	CRV*
Acrolein	107028	3	ACV
Ethane, 1,2-dichloro *	107062	560	CRV
Acrylonitrile *	107131	2.2	CRV*
Toluene	108883	100	ACV
Chlorobenzene	108907	71	ACV
Phenol	108952	230	HLSC
Bis(2-chloroethoxy) methane	111911	4.6	TLSC

27-Jan-87

CHEMICAL NAME	CAS NUMBER	Rule 57(2) Level Non-Drinking Water Value (ug/l)	Basis
Hexachlorobenzene #	118741	0.0019	CRV*
Benzene, 1,2,4-trichloro	120821	22	HLSC
Phenol, 2,4-dichloro	120832	@exp(0.3589*pH+3.395)/13.95	ACV
1,4-dioxane #	123911	360	ACV
Tetrachloroethylene #	127184	20	CRV
Ethylene, t-1,2-dichloro	156605	90	TLSC*
Benzene, 1,3-dichloro	541731	20	HLSC
Xylene	1330207	40	ACV
Di-N-propyl formamide	6282004	63	TLSC
Mercury, methyl	7439976	0.0006	HLSC
Ammonia (Coldwater)	7664417	20	ACV
Ammonia (Warmwater)	7664417	50	ACV
Chlorine	7782505	6	ACV
Chromium, hexavalent	18540299	6	ACV

NOTES:

\# - This chemical is regulated as a carcinogen. The Rule 57(2) Level is not necessarily based on its 1 in 100,000 cancer risk value.
* - Professional judgement was used - minimum data not available.

ACV- Aquatic Chronic Value
TLSC- Terrestrial Life-cycle Safe Concentration
HLSC- Human Life-cycle Safe Concentration
CRV- Cancer Risk Value
CAS = Chemical Abstract Service Number

Exponential equations: e.g., @exp(0.83(@ln(H))-4.84) = $e^{0.83(\ln H)-4.84}$

where H = Hardness (mg/l)

@exp(1.0051*pH-3.6617)/4.6 = $\frac{e^{1.0051(pH)-3.6617}}{4.6}$

where pH is in Standard Units

Table 4- Analytical results for White Lake water samples collected 6 May 87 from the Middle Basin. Muskegon County, Muskegon (Storet Station 610230)

Depth m (ft)	Temp (°C)	Transparency Secchi Disc. m (ft)	Chlorophyll a (ppb)	Dissolved Oxygen (ppm)	Nitrite (ppm)	Nitrite + Nitrate (ppm)	Ammonia (ppm)	Kjeldhal Nitrogen (ppm)	Ortho Phosphate (ppm)	Total Phosphorus (ppm)	Suspended Solids (ppm)	Dissolved Solids (ppm)
	Air - 19.8											
Surface	16.3	2.0/(6.5)	12	11.3	0.005	0.09	0.01	0.36	T 0.001	0.019	K 4	200
3.1 (10)	16.3											
6.1 (20)	15.8											
9.2 (30)	15.3			10.7		0.10	0.02	0.38		0.019		
12.3 (40)	15.1											
15.4 (50)	14.8											
18.5 (60)	14.3											
20.0 (65)	14.1			8.7		0.12	0.05	0.46		0.036		
20.9 (68)	14.0											

K = value less than the detection level indicated.
T = Trace amount detected.
* = Represents a depth composited sample from the surface to a maximum depth equal to 2x the Secchi Disc reading.

Source: John Wuycheck

APPENDIX 4.2 WHITE LAKE SEDIMENT ANALYSIS DATA
(ERG, 1982a and ERG, 1980a)

E N V I R O N M E N T A L   R E S E A R C H   G R O U P

WEST MICHIGAN
SHORELINE REGIONAL
DEVELOPMENT COMMISSION

MUSKEGON TOXIC SURFACE
WATER INVESTIGATION

ANALYTICAL RESULTS
PHASE V
REPORT DATE 09-13-82

ERG SAMPLE NUMBER	106/075220	106/075221	106/0752?2
CLIENT-ID	ID-9, D GRID	ID-12, D GRID	ID 13, D GRID
	WHITE	WHITE	WHITE
MATRIX	SEDIMENT	SEDIMENT	SEDIMENT
	RESULTS, UNITS	RESULTS, UNITS	RESULTS, UNITS
OIL AND GREASE	2500 mg/Kg	80 mg/Kg	40 mg/Kg
PERCENT MOISTURE	69 %	32 %	18 %
ZINC	28 mg/Kg	14 mg/Kg	5 5 mg/Kg
TOTAL CADMIUM	<0 8 mg/Kg	ND (0 8) mg/Kg	ND (0 8) mg/Kg
TOTAL CHROMIUM	8 7 mg/Kg	23 mg/Kg	8 0 mg/Kg
TOTAL COPPER	5 5 mg/Kg	2 3 mg/Kg	<1 5 mg/Kg
TOTAL LEAD	3 5 mg/Kg	5 2 mg/Kg	ND (2 5) mg/Kg
MERCURY	<0 1 mg/Kg	<0 1 mg/Kg	ND (0 1) mg/Kg
TOTAL NICKEL	7 2 mg/Kg	<2 5 mg/Kg	<2 5 mg/Kg
ARSENIC	------	------	------
TOTAL CYANIDE	ND (1) mg/kg	ND (0 8) mg/kg	ND (1) mg/kg

144

ERG SAMPLE NUMBER	06/075199	106/075200	106/075201	106/075202	106/075223
CLIENT-ID	D-15, D GRID	ID-16, D GRID	ID-17, D GRID	ID-18, D GRID	ID-14, D GRID
	WHITE LAKE	WHITE LAKE	WHITE LAKE	WHITE LAKE	WHITE
MATRIX	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
	RESULTS, UNITS	RESULTS, UNITS	RESULTS, UNITS	RESULTS, UNITS	RESULTS, UNITS
OIL AND GREASE	110 mg/Kg	250 mg/Kg	220 mg/Kg	220 mg/Kg	330 mg/Kg
PERCENT MOISTURE	78 %	82 %	82 %	77 %	83 %
ZINC	74 mg/Kg	130 mg/Kg	140 mg/Kg	99 mg/Kg	160 mg/Kg
TOTAL CADMIUM	ND (0 8) mg/Kg	<0 8 mg/Kg	1 0 mg/Kg	<0 8 mg/Kg	1 2 mg/Kg
TOTAL CHROMIUM	180 mg/Kg	550 mg/Kg	620 mg/Kg	46 mg/Kg	3900 mg/Kg
TOTAL COPPER	14 mg/Kg	22 mg/Kg	25 mg/Kg	17 mg/Kg	27 mg/Kg
TOTAL LEAD	31 mg/Kg	48 mg/Kg	59 mg/Kg	29 mg/Kg	99 mg/Kg
MERCURY	ND (0 1) mg/Kg	ND (0 1) mg/Kg	ND (0 1) mg/Kg	ND (0 1) mg/Kg	0 2 mg/Kg
TOTAL NICKEL	8 1 mg/Kg	26 mg/Kg	35 mg/Kg	13 mg/Kg	56 mg/Kg
ARSENIC	4 8 ppm	------	------	------	6 1 ppm

SD = SAMPLE DAMAGED
FR = SEE FIELD REPORT FOR RESULT
NA = NOT APPLICABLE TO TEST REQUESTED
SR = SEE ATTACHED REPORT FOR RESULT
< = POSITIVE RESULT BUT AT AN UNQUANTIFIABLE CONCENTRATION BELOW INDICATED LEVEL
ND = NONDETECTED, DET LIMIT IN () OR IN QA/QC REPORT
------ = TEST NOT REQUESTED FOR THIS SAMPLE

ENVIRONMENTAL RESEARCH GROUP

WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

MUSKEGON TOXIC SURFACE WATER INVESTIGATION

ANALYTICAL RESULTS
PHASE V
REPORT DATE 09-13-82

ERG SAMPLE NUMBER	106/075189	106/075190	106/075191	106/075192
CLIENT-ID	ID-1. D GRID WHT LAKE	ID-2. D GRID WHITE LAKE	ID-3. D GRID WHITE LAKE	ID 4. D GRID WHITE LAKE
MATRIX	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
	RESULTS. UNITS	RESULTS. UNITS	RESULTS. UNITS	RESULTS. UNITS
OIL AND GREASE	850 mg/Kg	480 mg/Kg	310 mg/Kg	360 mg/Kg
PERCENT MOISTURE	88 %	88 %	86 %	[illegible] %
ZINC	130 mg/Kg	120 mg/Kg	140 mg/Kg	150 mg/Kg
TOTAL CADMIUM	1 5 mg/Kg	1 5 mg/Kg	1 2 mg/Kg	1 5 mg/Kg
TOTAL CHROMIUM	660 mg/Kg	750 mg/Kg	470 mg/Kg	850 mg/Kg
TOTAL COPPER	21 mg/Kg	25 mg/Kg	24 mg/Kg	26 mg/Kg
TOTAL LEAD	110 mg/Kg	240 mg/Kg	87 mg/Kg	140 mg/Kg
MERCURY	<0 1 mg/Kg	0 1 mg/Kg	0 1 mg/Kg	0 1 mg/Kg
TOTAL NICKEL	18 mg/Kg	16 mg/Kg	16 mg/Kg	18 mg/Kg
ARSENIC	5 3 ppm	------	------	

ERG SAMPLE NUMBER	06/075193	106/075194	106/075195	106/075196	106/075197	106/075198
CLIENT-ID	D-5. D GRID WHITE LAKE	ID-6. D GRID WHITE LAKE	ID-7. D GRID WHITE LAKE	ID-8. D GRID WHITE LAKE	ID-10. D GRID WHITE LAKE	ID 11. D GRID WHITE LAKE
MATRIX	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
	RESULTS. UNITS	RESULTS. UNITS	RESULTS. UNITS	RESULTS. UNITS	RESULTS. UNITS	RESULTS. UNITS
OIL AND GREASE	130 mg/Kg	390 mg/Kg	310 mg/Kg	8 mg/Kg	150 mg/Kg	100 mg/Kg
PERCENT MOISTURE	22 %	88 %	87 %	28 %	85 %	81 %
ZINC	3 0 mg/Kg	140 mg/Kg	140 mg/Kg	4 0 mg/Kg	110 mg/Kg	120 mg/Kg
TOTAL CADMIUM	1 0 mg/Kg	2 5 mg/Kg	1 7 mg/Kg	1 0 mg/Kg	1 2 mg/Kg	1 0 mg/Kg
TOTAL CHROMIUM	ND (1 3) mg/Kg	1000 mg/Kg	440 mg/Kg	ND (1 3) mg/Kg	650 mg/Kg	1100 mg/Kg
TOTAL COPPER	ND (1 3) mg/Kg	27 mg/Kg	23 mg/Kg	ND (1 3) mg/Kg	21 mg/Kg	23 mg/Kg
TOTAL LEAD	<2 5 mg/Kg	160 mg/Kg	87 mg/Kg	<2 5 mg/Kg	67 mg/Kg	75 mg/Kg
MERCURY	0 1 mg/Kg	0 1 mg/Kg	0 2 mg/Kg	0 1 mg/Kg	ND (0 1) mg/Kg	0 1 mg/Kg
TOTAL NICKEL	ND (2 5) mg/Kg	18 mg/Kg	17 mg/Kg	ND (2 5) mg/Kg	13 mg/Kg	19 mg/Kg
ARSENIC	1 4 ppm	------	------	------	------	

SD = SAMPLE DAMAGED NA = NOT APPLICABLE TO TEST REQUESTED
FR = SEE FIELD REPORT FOR RESULT SR = SEE ATTACHED REPORT FOR RESULT
< = POSITIVE RESULT BUT AT AN UNQUANTIFIABLE CONCENTRATION BELOW INDICATED LEVEL
ND = NONDETECTED. DET LIMIT IN ( ) OR IN QA/QC REPORT
------ = TEST NOT REQUESTED FOR THIS SAMPLE

For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

TABLE 8

Analytical Results for Sediment Samples
Central, West and East Basins
White Lake

(page 1 of 10)

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
1. Field Measurements			
dissolved oxygen	NA	NA	NA
hydrogen ion concentration (pH)	NA	NA	NA
temperature (°C)	NA	NA	NA
specific conductance	NA	NA	NA
2. Nutrients			
total phosphorus	189	135	120
dissolved phosphorus	.24	2.6	.22
total nitrogen	1200	990	1200
nitrate & nitrite nitrogen	0.5	1.0	1.5
ammonia nitrogen	150	110	140
3. Indicators			
methylene blue active substances	NA	NA	NA
nitrilotriacetic acid	NA	NA	NA

NA = not applicable.

TABLE 8
White Lake
Page 2
For Sediments and Fish, inorganic parameters as dry weights;
organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
4. General			
chemical oxygen demand	NA	NA	NA
total hardness	NA	NA	NA
filterable residue	NA	NA	NA
non-filterable residue	NA	NA	NA
total organic carbon	NA	NA	NA
oil & grease (as % in sediments)	.026	.017	.012
5. Metals			
antimony	<12	<12	<12
arsenic	1.2	.89	.87
beryllium	.75	.76	.75
cadmium	3.5	3.8	.75
chromium	750	620	1200
copper	22	27	23
lead	98	160	92
mercury	.50	.93	.11
nickel	22	23	22
selenium	<0.7	<0.6	<0.7
silver	2.5	3.0	3.2
thallium	<5.0	<5.1	<5.0
zinc	120	140	130

NA = not applicable.

TABLE 8
White Lake
Page 3
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
6. Other Ions			
chlorides	NA	NA	NA
sulfates	NA	NA	NA
7. Organics: Priority Pollutants			
acenaphthene	<5	<5	<5
acrolein	<10	<10	<10
acrylonitrile	<10	<10	<10
benzene	<.01	<.01	<.01
benzidine	<5	<5	<5
carbon tetrachloride (tetrachloromethane)	<.01	<.01	<.01
chlorobenzene	<.01	<.01	<.01
1,2,4-trichlorobenzene	<.01	<.01	<.01
hexachlorobenzene	<.01	<.01	<.01
1,2-dichloroethane	<.01	<.01	<.01
1,1,1-trichloroethane	<.01	.014	<.01
hexachloroethane	<5	<5	<5
1,1-dichloroethane	<.01	<.01	<.01
1,1,2-trichloroethane	<.01	<.01	<.01
1,1,2,2-tetrachloroethane	<.01	<.01	<.01
chloroethane	<.01	<.01	<.01

NA = not applicable.

TABLE 8
White Lake
Page 4
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
7. Organics: Priority Pollutants (continued)			
bis(chloromethyl)ether	<5	<5	<5
bis (2-chloroethyl)ether	<5	<5	<5
2-chloroethyl vinyl ether (mixed)	<5	<5	<5
2-chloronaphthalene	<5	<5	<5
2,4,6-trichlorophenol	<10	<10	<10
p-chloro-m-cresol	<10	<10	<10
chloroform (trichloromethane)	<.01	<.01	<.01
2-chlorophenol	<10	<10	<10
1,2-dichlorobenzene	<5	<5	<5
1,3-dichlorobenzene	<5	<5	<5
1,4-dichlorobenzene	<5	<5	<5
3,3-dichlorobenzidine	<5	<5	<5
1,1-dichloroethylene	<.01	<.01	<.01
1,2-trans-dichloroethylene	<.01	<.01	<.01
2,4-dichlorophenol	<10	<10	<10
1,2-dichloropropane	<.01	<.01	<.01
1,3-trans-dichloropropene	<.01	<.01	<.01
2,4-dimethylphenol	<10	<10	<10
2,4-dinitrotoluene	<5	<5	<5

TABLE 8
White Lake
Page 5
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
7. Organics: Priority Pollutants (continued)			
2,6-dinitrotoluene	<5	<5	<5
1,2-diphenylhydrazine	<5	<5	<5
ethylbenzene	<.01	<.01	<.01
fluoranthene	<5	<5	<5
4-chlorophenyl phenyl ether	<5	<5	<5
4-bromophenyl phenyl ether	<5	<5	<5
bis(2-chloroisopropyl)ether	<5	<5	<5
bis(2-chloroethoxy)methane	<5	<5	<5
methylene chloride (dichloromethane)	<.01	.02	<.01
methyl chloride (chloromethane)	<.01	<.01	<.01
methyl bromide (bromomethane)	<.01	<.01	<.01
bromoform (tribromomethane)	<.01	<.01	<.01
dichlorobromomethane	<.01	<.01	<.01
trichlorofluoromethane	<.01	<.01	<.01
dichlorodifluoromethane	<.01	<.01	<.01
chlorodibromomethane	<.01	<.01	<.01
hexachlorobutadiene	<5	<5	<5
hexachlorocyclopentadiene	<5	<5	<5

TABLE 8
White Lake
Page 6
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
7. Organics: Priority Pollutants (continued)			
isophorone	<5	<5	<5
naphthalene	<5	<5	<5
nitrobenzene	<5	<5	<5
2-nitrophenol	<10	<10	<10
4-nitrophenol	<10	<10	<10
2,4-dinitrophenol	<200	<200	<200
4,6-dinitro-o-cresol	<200	<200	<200
N-nitrosodimethylamine	<5	<5	<5
N-nitrosodiphenylamine	<5	<5	<5
N-nitrosodi-n-propylamine	<5	<5	<5
pentachlorophenol	<10	<10	<10
phenol	<10	<10	<10
bis(2-ethylhexyl)phthalate	<5	5.80	7.53
butyl benzyl phthalate	<5	5.06	26.3
di-n-butyl phthalate	<5	<5	<5
di-n-octyl phthalate	<5	<5	<5
diethyl phthalate	<5	<5	<5
dimethyl phthalate	<5	<5	<5
1,2-benzanthracene (benzo(a)anthracene)	<5	<5	<5
benzo(a)pyrene (3,4-benzopyrene)	<5	<5	<5

TABLE 8
White Lake
Page 7
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
7. Organics: Priority Pollutants (continued)			
3,4-benzofluoranthene (benzo(b)fluoranthene)	<5	<5	<5
11,12-benzofluoranthene (benzo(k)fluoranthene)	<5	<5	<5
chrysene	<5	<5	<5
acenaphthylene	<5	<5	<5
anthracene	<5	<5	<5
1,12-benzoperylene (benzo(g,h,i)perylene)	<13	<13	<13
fluorene	<5	<5	<5
phenanthrene	<5	<5	<5
1,2,5,6-dibenzanthracene (dibenzo(a,h)anthracene)	<13	<13	<13
indeno(1,2,3-c,d)pyrene	<13	<13	<13
pyrene	<5	<5	<5
tetrachloroethylene	<.01	<.01	<.01
toluene	<.01	<.01	<.01
trichloroethylene	<.01	<.01	<.01
vinyl chloride (chloroethylene)	<.01	<.01	<.01
aldrin	<.01	<.01	<.01
dieldrin	<.01	<.01	<.01

TABLE 8
White Lake
Page 8
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
7. Organics: Priority Pollutants (continued)			
chlordane (technical mixture and metabolites)	<.01	<.01	<.01
4,4'-DDT	<.01	<.01	<.01
4,4-DDE (p,p-DDT)	<.01	<.01	<.01
4,4'-DDD (p,p'-TDE)	<.01	<.01	<.01
alpha-endosulfan	<.01	<.01	<.01
beta-endosulfan	<.01	<.01	<.01
endosulfan sulfate	<.01	<.01	<.01
endrin	<.01	<.01	<.01
endrin aldehyde	<.01	<.01	<.01
heptachlor	<.01	<.01	<.01
heptachlor epoxide	<.01	<.01	<.01
alpha-BHC	<.01	<.01	<.01
beta-BHC	<.01	<.01	<.01
gamma-BHC (lindane)	<.01	<.01	<.01
delta-BHC	<.01	<.01	<.01
atrazine	<.01	<.01	<.01
kepone	<.01	<.01	<.01

TABLE 8
White Lake
Page 9
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
7. Organics: Priority Pollutants (continued)			
mirex	<.01	<.01	<.01
PCB 1242 (Arochlor 1242)	<.09	<.09	<.09
PCB 1254 (Arochlor 1254)	<.32	<.32	25.56
PCB 1221 (Arochlor 1221)	<.18	<.18	<.18
PCB 1232 (Arochlor 1232)	<.14	<.14	<.14
PCB 1248 (Arochlor 1248)	<.13	<.13	<.13
PCB 1260 (Arochlor 1260)	<.32	<.32	<.32
PCB 1016 (Arochlor 1016)	<.71	<.71	<.71
toxaphene	<.85	<.85	<.85
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	unknown	unknown	unknown
1,3-cis-dichloropropene	<.01	<.01	<.01
1,1,2,2-tetrachloroethene	<.01	<.01	<.01
8. Organics: General			
benzothiazole	<5	<5	<5
xylene	<.01	<.01	<.01
pentachloroethane	<5	<5	<5
methylene-bis-2-chloroaniline	<5	<5	<5
triaryl phosphate ester	unknown	unknown	unknown

TABLE 8
White Lake
Page 10
For Sediments and Fish, inorganic parameters as dry weights; organic parameters as wet weights.

PARAMETERS	C Sediment ERG 39936 (mg/kg)	W Sediment ERG 39938 (mg/kg)	E Sediment ERG 39937 (mg/kg)
8. Organics: General (continued)			
chloroaniline	<5	<5	<5
dichlorobenzophenone	<5	<5	<5
N,N-dimethylaniline	<5	<5	<5
chlorinated dibenzofurans	<5	<5	<5
chlorinated dibenzodioxins	<5	<5	<5
pentachloronitrobenzene	<5	<5	<5
styrene	<5	<5	<5
N-ethylaniline	<5	<5	<5
polybrominated biphenyls	<.02	<.02	<.02

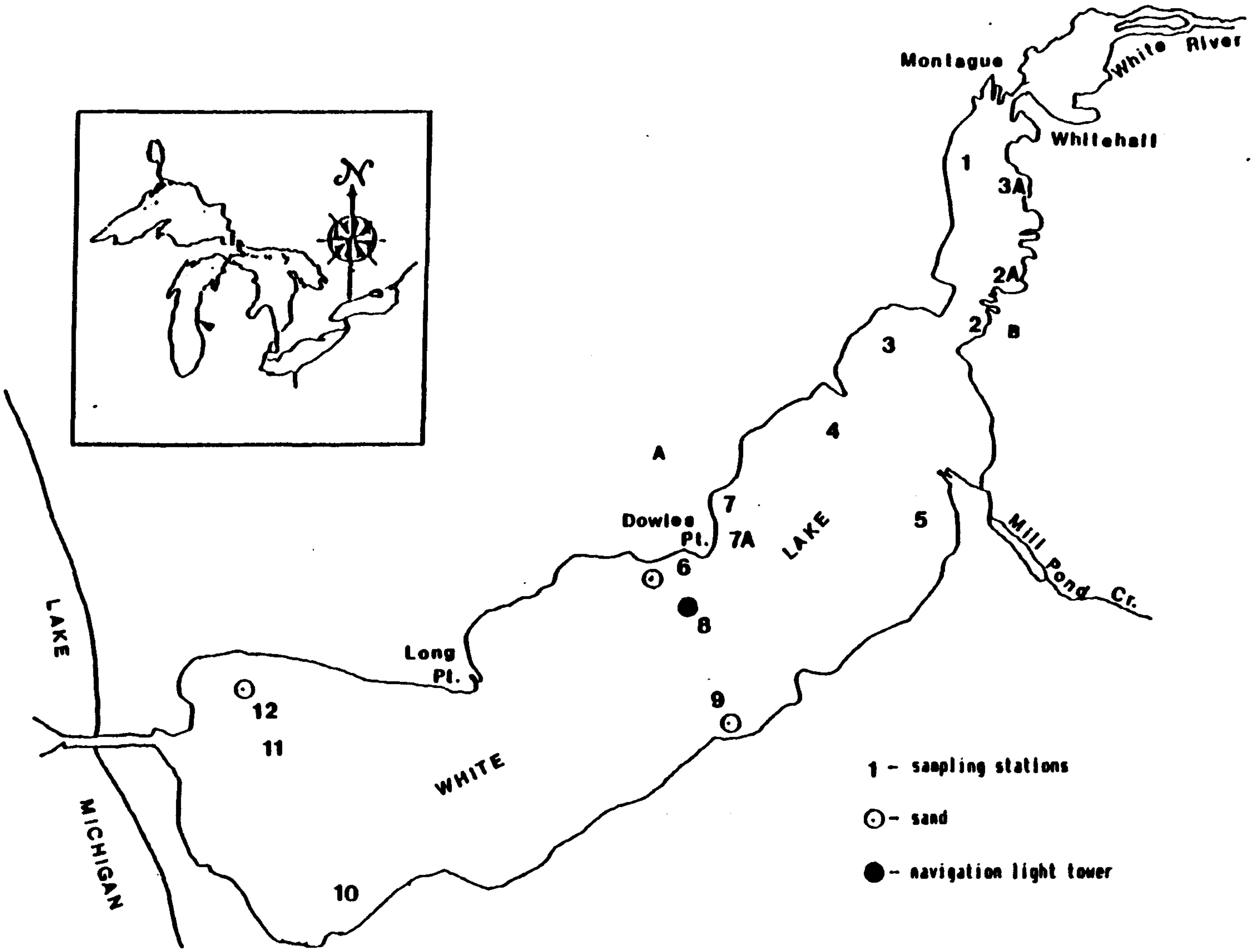


Figure 1 - White Lake sediment sampling stations on 9 December 87. Muskegon County, MI.

Table 1 - Analytical results for heavy metals in White Lake sediment samples collected 9 December 86. Muskegon County, MI. Values on a dry weight basis.

Parameter		Station 1 (Sample 1)	Station 1 (Sample 2)	Station 2	Station 2A	Station 3	Station 3A	Station 4 (Sample 1)	Station 4 (Sample 2)	Station 5
Cadmium	(mg/kg)	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0
Chromium	(mg/kg)	35.0	43.0	4300.0	770.0	825.0	39.0	910.0	905.0	9.0
Copper	(mg/kg)	19.0	19.0	25.0	34.0	27.0	3.5	29.0	29.0	K 2.0
Iron	(mg/kg)	16900.0	16500.0	10500.0	21700.0	18100.0	2000.0	22400.0	24200.0	1170.0
Mercury	(mg/kg)	K 0.5	K 0.5	1.0	K 0.5	K 0.5 (K 0.5)	K 0.5	K 0.5	K 0.5	K 0.2
Nickel	(mg/kg)	11.0	11.0	29.0	35.0	20.0	9.0	22.0	22.0	K 5.0
Lead	(mg/kg)	24.0	29.0	107.0	84.0	81.0	14.0	92.0	96.5	7.0
Zinc	(mg/kg)	75.0	81.0	92.0	150.0	110.0	21.0	110.0	120.0	5.0
Total Solids	(%)	75.0	14.7	16.2	14.2	13.2	39.1	11.4	11.2	73.6

Parameter		Station 6	Station 7	Station 7A	Station 8 (Sample 1)	Station 8 (Sample 2)	Station 9	Station 10	Station 11	Station 12
Cadmium	(mg/kg)	K 2.0 (K 2	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0	K 2.0
Chromium	(mg/kg)	K 5.0 (K 5.0)	25.0	905.0	665.0	730.0	76.5	33.0	460.0	14.0
Copper	(mg/kg)	K 2.0 (K 2.0)	7.0	27.0	25.0	27.0	6.5	2.5	25.0	K 2.0
Iron	(mg/kg)	675.0 (690)	10200.0	21500.0	22300.0	22800.0	45000.0	10300.0	22300.0	1070.0
Mercury	(mg/kg)	K 0.2 (K 0	K 0.5	K 0.5	K 0.5	K 0.5	K 0.2	K 0.2	K 0.5	K 0.2
Nickel	(mg/kg)	K 5.0 (K 5	K 5.0	23.0	21.0	23.0	K 5.0	K 5.0	19.0	5.0
Lead	(mg/kg)	K 5.0 (K 5.0)	27.0	118.0	95.0	96.0	25.0	9.5	102.0	8.5
Zinc	(mg/kg)	K 5.0 (K 5.0)	35.0	110.0	88.5	91.5	60.0	25.0	88.5	5.0
Total Solids	(%)	77.0	25.1	11.0	10.3	10.7	51.7	61.4	16.6	74.7

Values in parentheses are from a repeat analysis of the sample.

K = Value less than the detection level indicated.

Source: John Wuycheck
MDNR
March 87

Table 2 - Analytical results for organic compounds in White Lake sediment samples collected 9 December 86. Muskegon County, MI. Values on a dry weight basis.

Parameter		Station 1 (Sample 1)	Station 1 (Sample 2)	Station 2 *	Station 2A *	Station 3 *	Station 3A *	Station 4 * (Sample 1)	Station 4 (Sample 2)	Station 5 *	Station 6
Aldrin	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Polychlorinated biphenyls	(ug/kg)	K 2800	K 2400	K 2500	K 2600	K 2800	K 2500	K 3500	K 3500	K 680	K 680
g-BHC (lindane)	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
BP-6 (PBB)**	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
a-Chlordane	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
g-Chlordane	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
2-Chloronapthalene	(ug/kg)	K 2800	K 2400	K 2500	K 2600	K 2800	K 2500	K 3500	K 3500	K 680	K 680
4,4'-DDD	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
4,4'-DDE	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
2,4'-DDT	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
4,4'-DDT	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
1,2-Dichlorobenzene	(ug/kg)	K 2800	K 2400	K 2500	K 2600	K 2800	K 2500	K 3500	K 3500	K 680	K 680
1,3-Dichlorobenzene	(ug/kg)	K 2800	K 2400	K 2500	K 2600	K 2800	K 2500	K 3500	K 3500	K 680	K 680
1,4-Dichlorobenzene	(ug/kg)	K 2800	K 2400	K 2500	K 2600	K 2800	K 2500	K 3500	K 3500	K 680	K 680
Heptachlor	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Heptachlor epoxide	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Hexabromobenzene	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Hexachlorobenzene	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Hexachlorobutadiene	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Hexachloroethane	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Methoxychlor	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Mirex	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Pentachloronitobenzene	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Toxaphene**	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
1,2,4-Trichlorobenzene	(ug/kg)	K 280	K 240	K 250	K 260	K 280	K 250	K 350	K 350	K 68	K 68
Oil and Grease	(mg/kg)	20	40	K 20	K 20	20	20	20	23	27	K 20

Parameter		Station 7		Station 7A		Station 8 (Sample 1)		Station 8 (Sample 2)		Station 9		Station 10		Station 11		Station 12	
Aldrin	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Polychlorinated biphenyls	(ug/kg)	K	2200	K	4100	K	3400	K	2700	K	880	K	1100	K	4300	K	670
g-BHC (Lindane)	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
BP-6 (PBB)**	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
a-Chlordane	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
g-Chlordane	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
2-Chloronapthalene	(ug/kg)	K	2200	K	4100	K	3400	K	2700	K	880	K	1100	K	4300	K	670
4,4'-DDD	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
4,4'-DDE	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
1,4'-DDT	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
4,4'-DDT	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
1,2-Dichlorobenzene	(ug/kg)	K	2200	K	4100	K	3400	K	2700	K	880	K	1100	K	4300	K	670
1,3-Dichlorobenzene	(ug/kg)	K	2200	K	4100	K	3400	K	2700	K	880	K	1100	K	4300	K	670
1,4-Dichlorobenzene	(ug/kg)	K	2200	K	4100	K	3400	K	2700	K	880	K	1100	K	4300	K	670
Heptachlor	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Heptachlor epoxide	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Hexabromobenzene	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Hexachlorobenzene	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Hexachlorobutadiene	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Hexachloroethane	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Methoxychlor	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Mirex	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Pentachloronitobenzene	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Toxaphene**	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
1,2,4-Trichlorobenzene	(ug/kg)	K	220	K	410	K	340	K	270	K	88	K	110	K	430	K	67
Oil and Grease	(mg/kg)		20	K	20	K	20	K	20	K	20	K	20	K	20	K	20

* - except for oil and grease, quality control indicated possible low recovery. therefore the actual level may have been higher than the reported value.

** - denotes that standards for these "seldom encountered" compounds are analyzed when their pattern is recognized.

K - denotes concentration less than the detection level indicated.

Source:

John Huycheck
MDNR
March 87

DEPARTMENT OF THE ARMY
DETROIT DISTRICT, CORPS OF ENGINEERS
BOX 1027
DETROIT, MICHIGAN 48231

NCEED-ER

25 January 1980

PRELIMINARY FINDING OF NO SIGNIFICANT IMPACT

In accordance with Section 404 of the Clean Water Act of 1977, the National Environmental Policy Act of 1969 (NEPA), and Section 122 of the 1970 River and Harbor Act, the Detroit District, Corps of Engineers, has assessed the environmental impacts of the following project: Revisions of Plan for Mitigation of Shore Damage Attributed to the Federal Navigation Structures at White Lake Harbor, Michigan.

It has been determined that shoreline erosion near White Lake Harbor is caused partly by the harbor breakwaters, which interrupt normal littoral sand movement. The Corps has authorization under Section 111 of the River and Harbor Act (Public Law 90-483) to engage in projects for the prevention or mitigation of shore damages caused by Federal navigation works.

The original plan for mitigation called for the establishment of beach nourishment sites near White Lake Harbor. Sand dredged from the harbor entrance was to have been the source for beach nourishment. The considered plan was to discharge the dredged sand offshore of selected beach nourishment sites for subsequent transport to eroded shoreline reaches by the action of longshore currents. This plan is discussed in detail in the Final Environmental Statement entitled, "Mitigation of Shore Damage Attributed to the Federal Navigation Structures at White Lake Harbor, Michigan," issued in February 1976.

Plan revisions now being considered include the use of a hydraulic dredging system in addition to possible use of barges for transporting sand to nourishment sites. It is proposed to dredge sand from within the harbor channel as well as at the harbor entrance. The dredged sand would be transported directly to eroded shoreline areas by a flexible pipeline. Trucking sand obtained from upland sources for use in beach nourishment activities is also a viable alternative under consideration.

An environmental review of the proposed revisions indicates that they do not constitute major Federal actions significantly affecting the quality of the human environment. Therefore, an Environmental Impact Statement (EIS) will not be prepared.

An environmental assessment report and a preliminary Section 404 Evaluation, which discuss the reasons why an EIS is not required, are attached. Anyone having information that could lead to a reversal of the decision not to prepare an EIS should respond within 30 days of the date of this Finding of No Significant Impact.

ENVIRONMENTAL ASSESSMENT-404 EVALUATION

Revisions of Plan for Mitigation of Shore Damage Attributed to the Federal Navigation Structures at White Lake Harbor, Michigan

Prepared by:

U.S. ARMY ENGINEER DISTRICT
Detroit, Michigan
January 1980

INCL 5

ENVIRONMENTAL ASSESSMENT

MITIGATION OF SHORE DAMAGE ATTRIBUTED
TO THE FEDERAL NAVIGATION STRUCTURES
AT WHITE LAKE HARBOR, MICHIGAN

REVISION OF PLAN

Prepared by:
U.S. ARMY ENGINEER DISTRICT
Detroit, Michigan

ADDRESS: U.S. Army Engineer District, Detroit
Corps of Engineers
P.O. Box 1027
Detroit, Michigan 48231
Telephone (313) 226 6752

I. ABSTRACT

The Detroit District of the Corps of Engineers is considering the plan to utilize dredged sand from within the White Lake Harbor channel and harbor mouth for beach nourishment. Sand would be dredged from these areas and hydraulically transported to eroded shoreline reaches north and south of the harbor entrance via a flexible pipeline. Shallow draft barges could also be used to transport dredged sand to designated nourishment sites between the shoreline and the 8 foot depth contour of Lake Michigan. The original plan for beach nourishment described in the Final Environmental Statement for the White Lake Harbor Mitigation Project involved the use of sand dredged from the harbor mouth only. The dredging was originally to be accomplished by a hopper dredge. At present, the use of a hopper dredge in the White Lake Harbor area is not considered feasible due to shallow water depths. The channel area is being maintained only to a depth of 12 feet, primarily to provide for recreational boating usage of the harbor. This Environmental Assessment has been prepared to address changes in the method for accomplishing beach nourishment.

TABLE OF CONTENTS

II. PURPOSE OF AND NEED FOR THE PROPOSED ACTION

2.01 It has been determined that some shoreline erosion in the vicinity of White Lake Harbor is due to the existence of the Federal navigation structures, which interrupt littoral sand movement. The Corps has authorization to engage in projects designed to nourish these eroded areas.

The plan recommended in "Section 111 Detailed Project Report on Shore Damage at White Lake Harbor, Michigan " (February 1976) and in its accompanying Final Environmental Statement provides for mitigating shoreline erosion by establishing shoreline nourishing areas which would restore the beaches by littoral currents. The source of nourishing materials would be the littoral material dredged only at the harbor entrance. It was originally proposed to transport the material to the nourishing areas by shallow draft, split-hull barges.

2.02 Description Of The Proposed Action. The proposed revision involves the use of sand that would be hydraulically dredged from within the White Lake Harbor channel as well as at the harbor entrance. Dredged sand would be conveyed by flexible pipeline directly onto and near eroded shoreline areas. Barges may also be utilized for the transport of sand to the designated beach nourishment sites between the shoreline and the 8 foot depth contour of Lake Michigan. Figure 1 (page 3-1) identifies dredging locations, and Figure 2 (page 3-2) identifies the areas for beach nourishment.

2.03 The hydraulic pumping system, known as a "sand eductor" system, has the capability of transporting sand for a distance of approximately 2,000 feet. A 2,000 foot length of pipeline would be positioned across the channel breakwaters, and sand would be discharged along the shoreline north and south of the harbor entrance. Two booster pumps would be utilized to extend the hydraulic pumping system's range to approximately 15,000 feet. The flexible pipeline would be located on shore and/or in the nearshore area.

2.04 A land source for obtaining sand for beach nourishment is also being considered, if acceptable borrow areas can be located. An Environmental Assessment was prepared and circulated in May of 1979 to address the impacts of using sand from a land source. The upland source material would probably be obtained from regional sand quarries, and it would be clean sand, similar in size and composition to the material now constituting the beaches to be nourished.

2.05 A sediment density gauge may be used in conjunction with the hydraulic pumping system. The density gauge contains a source of ionizing radioactivity (Cesium-137) to determine the specific gravity of sediment slurry. Any radioactive source, even if inconsequential, frequently raises concerns to the public; therefore, the use of Cesium-137 isotope is discussed in the following paragraphs.

2.06 The sediment density gauge utilizes ionizing radiation for its operation. A Cesium-137 radiation source of 500 millicuries (mc) emits, through the decay process, a collimated beam of gamma photons. The attenuation of the beam is a measure of sediment density. The operation of the density gauge will take place on board the hydraulic dredging system during pumping of sandy sediments.

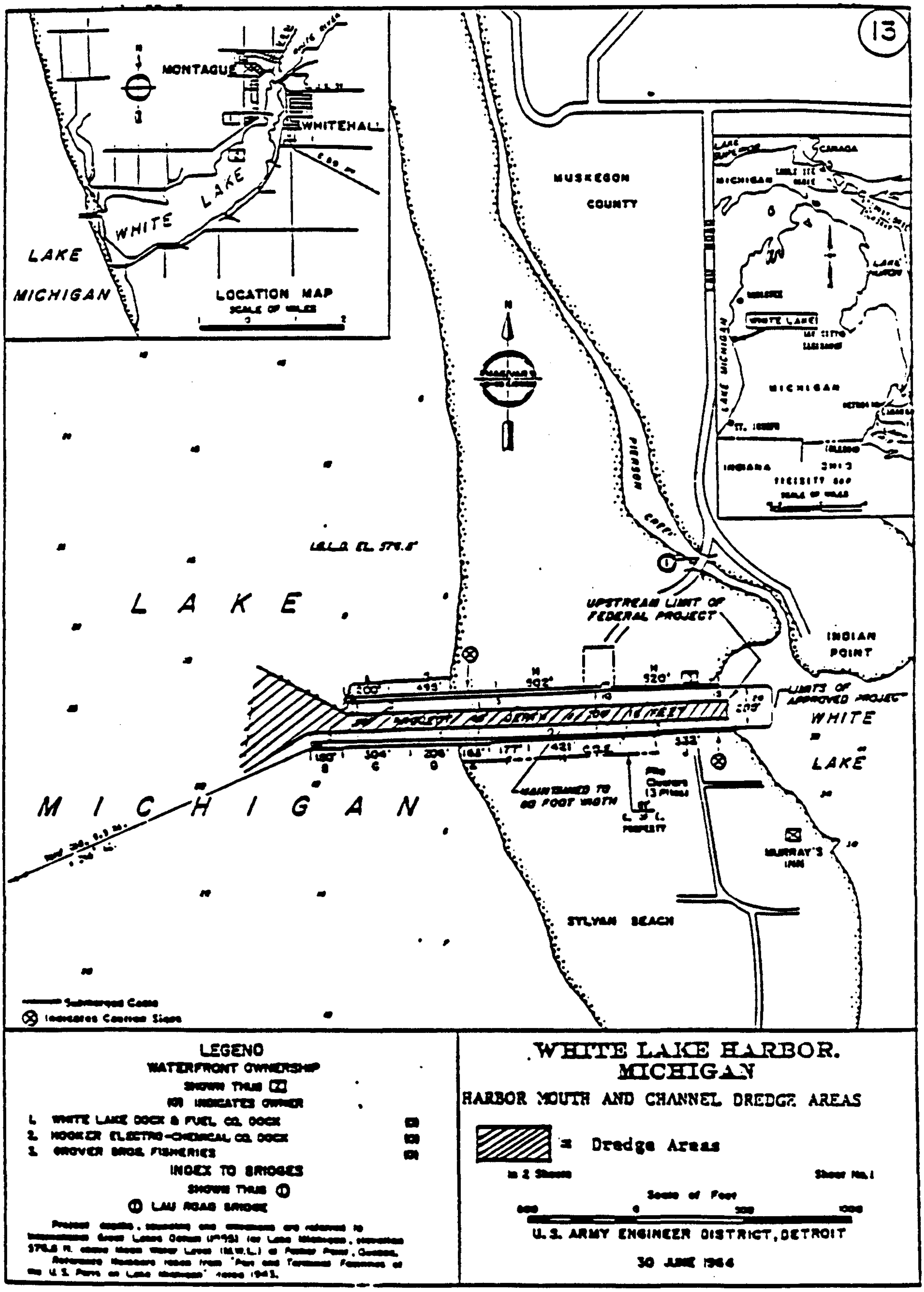

13
MONTAGUE
WHITEHALL
WHITE LAKE
LAKE MICHIGAN
LOCATION MAP
SCALE OF MILES
MUSKEGON COUNTY
PIERSON DITCH
LAKE MICHIGAN
WHITE LAKE
MICHIGAN
INDIANA
VICINITY MAP
CANADA
LAKE HURON
L A K E
M I C H I G A N
UPSTREAM LIMIT OF FEDERAL PROJECT
INDIAN POINT
LIMITS OF APPROVED PROJECT
WHITE LAKE
MAINTAINED TO 80 FOOT WIDTH
MURRAY'S INN
SYLVAN BEACH
Submerged Cable
Indicates Caution Signs
LEGEND
WATERFRONT OWNERSHIP
SHOWN THUS
INDICATES OWNER
1. WHITE LAKE DOCK & FUEL CO. DOCK
2. HOOKER ELECTRO-CHEMICAL CO. DOCK
3. GROVER BROS. FISHERIES
INDEX TO BRIDGES
SHOWN THUS
1 LAU ROAD BRIDGE
WHITE LAKE HARBOR, MICHIGAN
HARBOR MOUTH AND CHANNEL DREDGE AREAS
= Dredge Areas
In 2 Sheets
Sheet No. 1
Scale of Feet
U.S. ARMY ENGINEER DISTRICT, DETROIT
30 JUNE 1964

FIGURE 1

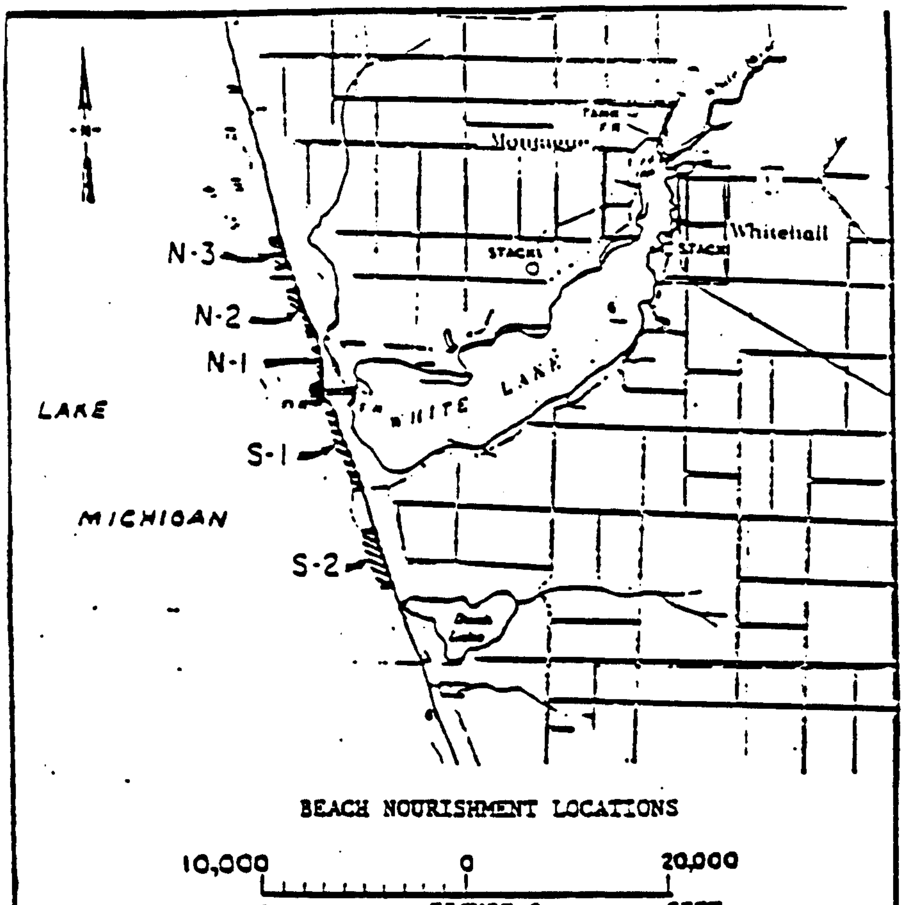


FIGURE 2

NOURISHMENT LOCATION	STATION TO STATION (In feet measured from the southerly edge of of the entrance channel)
N-1	N 1000' - N 2300'
N-2	N 3000' - N 5400'
N-3	N 6600' - N 10,300'
S-1	S 1000' - S 5000'
S-2	S 6100' - S 10,000'

NOTE: The discharge of dredged sand will occur at the sites indicated between the Ordinary High Water Mark and the 8 foot depth contour of Lake Michigan.

2.07 A stream of sediment passes by the 14° cone of radiation from the Cs-137 source beam port at an intensity level of about 1.5 Roentgen/hour. While potentially hazardous in an occupational health sense to tissue placed in the beam path, this radiation has a negligible effect on the sediment; it will neither induce radiation nor chemical changes. Such changes require impingment by neutrons, and this device utilizes a gamma radiation source.

2.08 Authorization. Section 111 of the River and Harbor Act of 1968 authorizes the Secretary of the Army, acting through the Chief of Engineers, to investigate, study, and construct projects for the prevention or mitigation of shore damages attributed to Federal Navigation Works.

III. ALTERNATIVES INCLUDING THE PROPOSED ACTION

3.01 Eleven alternative solutions to mitigate shore damage and their respective effects were discussed in the Final Environmental Statement for the White Lake Harbor Mitigation Project. Therefore, a discussion of these alternatives will not be repeated in this Environmental Assessment. The following paragraphs primarily address alternative sources of sand for use in beach nourishment and mechanical methods of transporting sand to eroded areas.

3.02 The original plan for beach nourishment recommended that sand obtained from annual maintenance dredging of the White Lake Harbor mouth be utilized. A split-hull bottom barge would receive dredged sand from a hopper dredge. The material would be discharged from the barge in shallow, nearshore water areas, and it was anticipated that long shore currents would aid in rebuilding the offshore areas and help to reduce beach erosion. At present, the use of a hopper dredge in the White Lake Harbor area is not considered feasible, due to shallow water depths.

3.03 The Proposed Action. In order to augment the quantities of sand for beach nourishment, the Corps is proposing to use sand dredged from within the White Lake Harbor channel. The plan to use a hydraulic system for sand transport in addition to possible use of barges is now proposed.

3.04 Alternatives. The alternative of trucking sand from upland sources is being considered as a viable alternative. When this alternative was suggested in May of 1979 and subsequently addressed in an Environmental Assesment, concerns were raised that the nearby Flower Creek Sand Dune would be used as a source of sand by Corps' contractors. Following a site inspection of the dune area by Corps personnel and the receipt of letters from citizens in the White Lake Harbor area, a determination was made to prohibit the use of the Flower Creek Dune area as a source for beach nourishment material. The prohibition was made because of the environmentally sensitive nature of the dune. Use of the land source alternative is dependent upon locating acceptable borrow areas and the economics involved.

3.05 Various types of dredging equipment could be employed to accomplish beach nourishment activities. At other harbors along the Lake Michigan shoreline, a hopper dredge has been used to dredge sand from within harbors. The hopper dredge has deposited sand offshore, near the 18 foot depth contour, and then the sand has been hydraulically pumped onshore in areas subject to erosion. While the use of a hopper dredge is currently not feasible in the White Lake Harbor channel due to shallow water depths, other replacement equipment could be used. For example, a clamshell dredge could dredge the harbor channel and harbor mouth. Barges filled with sand by a clamshell dredge could be towed to areas fronting eroded beaches for offshore discharge. If barges are employed to deposit sand within the 8 foot depth contour, littoral currents would be sufficient to provide beach nourishment. It is possible that other combinations of dredging equipment may be utilized.

IV. THE AFFECTED ENVIRONMENT

4.01 White Lake Harbor Description. This harbor is located on the east shore of Lake Michigan 120 miles northeasterly from Chicago, Illinois and 45 miles southerly from Ludington, Michigan. Existing project was authorized by R&H Acts of March 2, 1867, March 3, 1873, July 5, 1884, July 13, 1892 and March 2, 1907. This provides for the abandonment of the old outlet and the creation of a new channel 16 feet deep, 200 feet wide and 1,950 feet long from Lake Michigan to White Lake between parallel piers and revetments having lengths of 1,717 feet and 1,953 feet on the north and south sides respectively. The piers and revetments are built of stone-filled timber cribs and piling all of which are capped with a concrete superstructure.

4.02 General. The coastline in the vicinity of White Lake Harbor is generally oriented northerly. Except for localized fillets at the harbor, the beaches have a maximum width of about 60 feet. In numerous locations sand dunes are directly exposed to wave action. The dunes rise 8 to 80 feet above the lake surface. Sand bars are prominent along the shoreline.

4.03 The coastline at White Lake Harbor is used by a variety of birds, fish and other animals. The birds include shorebirds, doves, crows, hawks and owls. Fish include alewife, trout, salmon, perch and carp. Rabbits, foxes, squirrels, raccoons, deer and skunk inhabit the near interior.

4.04 The largest communities in the White Lake area are Whitehall and Montague, which had 1970 populations of about 3,000 and 2,400 respectively. The major industries relate to chemistry and metallurgy. Shipments of caustic soda from the chemical plant make up the bulk of commercial traffic at the harbor. The harbor is popular with recreational boaters.

4.05 The Flower Creek Dunes are located along Lake Michigan near the Muskegon County-Oceana County boundary line. The Dunes occur in Clay Banks Township, Oceana County (T 13N-R18W Sections 33 and 34) and in White River Township, Muskegon County (T 12N-R18W - Sections 3 and 4).

4.06 Details. Details of the project area were fully addressed in the Final Environmental Statement for the White Lake Harbor Mitigation Project. This statement should be referred to for additional description.

4.07 Sediment. Sediment samples have been taken in the White Lake Harbor channel, at the harbor entrance, and at locations north and south of the harbor entrance. This sediment data is provided in the Appendix of this Environmental Assessment. Analysis of the sediment samples taken in the project area indicates that the sediment is a good quality, sandy material suitable for open water disposal and/or beach nourishment.

V. ENVIRONMENTAL CONSEQUENCES

5.01 The environmental effects of the proposed beach nourishment activities involving the dredging and discharge of sand are described in the following paragraphs. The dredging areas would be the White Lake Harbor mouth and channel. Discharge of sand would occur between the shoreline (Ordinary High Water Mark) and the 8 foot depth contour of Lake Michigan at designated beach nourishment sites (See figure 2, page 3-2). The discharged material would consist of sand obtained from the dredging actions and/or that obtained from an upland source. Section 122 of the River and Harbor Act of 1970 (PL 91-611) presents possible areas of impact that should be considered in relation to the proposed project. These areas include, but are not limited to:

Noise	Employment
*Displacement of People	*Regional Growth
Aesthetic Values	*Business/Industrial Activity
*Community Cohesion	*Displacement of Farms
*Desirable Community Growth	Man-made Resources
Tax Revenues	Natural Resources
Property Values	Air Pollution
*Public Facilities	Water Pollution
*Public Services	

*Areas not expected to be affected by the proposed work.

5.02 The primary adverse effect of the dredging and discharging operations for beach nourishment would be a temporary increase in turbidity (water cloudiness). Some benthic organisms in a localized area could be subject to smothering. However, benthic organisms do not normally colonize the nearshore area due to the wave washed character of the shoreline in the White Lake harbor vicinity.

5.03 No harmful environmental effects are anticipated from the operation of the density gauge in conjunction with the hydraulic dredging system. The level of Cs-137 absorbed by the dredging crew under safe working conditions would be considerably less than one millirad/hour. The Nuclear Regulatory Commission requires regular dosage monitoring and regularly scheduled maintenance practices.

5.04 Recreation. Extensions of flexible pipe from the harbor mouth and channel area to the nourishment sites could be temporary hindrances for recreational craft. The pipe would be marked with international orange - colored, 30 gallon pontoon floats. In additon to compliance with Department of Army General Safety Requirements, an official "Notice to Mariners" would be publicized for the information of commercial and pleasure craft 10 days prior to the proposed work.

5.05 Fisheries. Beach nourishment activity could present a problem to fisheries in the project area, if operations are conducted during the spawning or migratory seasons. Activities would be coordinated with the Michigan Department of Natural Resources to avoid interference with fish spawning or migration.

5.06 Aesthetics. There would be minor amounts of noise and air pollution from the operation of the hydraulic pumping system. The hydraulic pumps operate at noise levels similar to that generated by a diesel truck engine. Lengths of pipeline placed onshore and near the shoreline may cause temporary inconveniences for recreational users of the Lake Michigan shoreline near White Lake Harbor.

5.07 The beach nourishment operation would have the beneficial effect of rebuilding the forebeach thereby providing erosion protection and helping to stabilize property values.

5.08 Water Quality. The dredged material proposed for use in beach nourishment activities has been tested to determine its suitability for beach nourishment. This test data is included in the Appendix of this Environmental Assessment. Analysis of the data indicates that the material is uncontaminated and that no significant impacts on water quality would result from use of the material. Likewise, no significant adverse impacts on water quality would occur if sand from upland sources is utilized, since only clean sand would be selected.

5.09 The proposed activities are consistent with the State of Michigan Coastal Management Program. The Coastal Management Program provides for Corps harbor maintenance operations and Section 111 shoreline mitigation projects.

VI. COORDINATION AND DETERMINATION

6.01 A public notice entitled, "Beach Nourishment White Lake Harbor, Michigan" was issued on 16 April 1979. Before the implementation of the proposed actions described in this Environmental Assessment, a new public notice will be issued and circulated with the Assessment.

6.02 The analysis presented in this Environmental Assessment has shown that no major adverse impacts would result from the considered plan revisions or possible alternatives discussed. These beach nourishment activities involve the placement of dredged and/or fill material into the water system of the United States. Therefore, they are subject to an evaluation under Section 404 of the Clean Water Act of 1977. In accordance with Department of Army Regulations (ER-200-2-2), a preliminary evaluation of Section 404 factors has been included in the Appendix of this Environmental Assesment. The proposed beach nourishment operations described in this Environmental Assessment have been found to be in compliance with the guidelines of Section 404.

6.03 I will review all comments received in response to the public notice, the preliminary Section 404 Evaluation, and the Environmental Assessment before finally determining whether or not major adverse impacts would result from the proposed beach nourishment operations. Anyone having information within the context of this Environmental Assessment should respond within 30 days of the date of this Assessment.

Date of Signature 25 JAN 1980

ROBERT V. VERMILLION
Colonel, Corps of Engineers
District Engineer

VII. LIST OF PREPARERS

		Discipline
Daniel R. Allega	Environmental Assessment Manager	Landscape Architecture
A.J. Nicholson	Supervisory Civil Engineer	Civil Engineering
John Collis	Consultant	Physical Science
Romeo Pinto	Consultant (Project Manager)	Engineering

APPENDIX

INCL 6

VII. REFERENCES

"Environmental Assessment, Mitigation of Shore Damage Attributed to the Federal Navigation Structures at White Lake Harbor, Michigan; Revision of Plan to Incorporate Land Source Nourishing Materials". U.S. Army Engineer District, Detroit, Michigan. May 1979.

"Final Environmental Statement, Mitigation of Shore Damage Attributed to the Federal Navigation Structures at White Lake Harbor, Michigan". U.S. Army Engineer District, Detroit, Michigan. Feburary 1976.

"Section 111 Detailed Project Report on Shore Damage at White Lake Harbor, Michigan". U.S. Army Engineer District, Detroit, Michigan. February 1976.

PRELIMINARY SECTION 404 EVALUATION

Section 404 of the Clean Water Act of 1977 requires that Corps projects involving the placement of dredged or fill material into waters of the United States be evaluated under Title 40 Code of Federal Regulations, Section 230, an Environmental Protection Agency regulation. In accordance with 40 CFR 230 guidelines, the following paragraphs describe the environmental effects of proposed beach nourishment activities at White Lake Harbor, Michigan.

a. Effects on Wetlands. The project area for the beach fill is not considered to be wetland. There would be no effects on wetlands.

b. Effects on Water Quality. The material to be dredged and utilized for beach nourishment has been tested. The test data is included in the appendix of this Environmental Assessment. Analysis of the data indicates that the material is uncontaminated and that no significant impacts on water quality would result from use of the material for beach nourishment. Likewise, any material obtained from an upland source for beach nourishment purposes would be clean sand, similar in size and composition to the material now constituting the beaches to be nourished.

c. Effects of Released Chemical Constituents. Same as b. above.

d. Effects on Shellfish. There would be no effects on shellfish, since there are no commercial shellfish beds in the area.

e. Effects on Fishery Resources. Beach nourishment activities could present a problem to fisheries in the project area if operations are conducted during the spawning or migratory seasons. Activities would be coordinated with the Michigan Department of Natural Resources to avoid interference with fish spawning or migration.

f. Effects on Wildlife. The beach fill operation is not anticipated to significantly affect wildlife. Some shorebirds may avoid the project area during the beach nourishment operation due to noise and shoreline distrubance.

g. Effects on Recreation. There may be some inconvenience caused to recreational boaters because of the hydraulic dredging equipment and the flexible pipeline leading from the dredge to discharge areas. Where the pipeline is placed onshore, recreational users of the shoreline may experience temporary minor inconveniences.

h. Effects on Aesthetics. There would be minor effects on aesthetics, such as noise and air pollutant emissions from the operation of equipment. Reestablishment of eroded beaches along the shoreline is considered a beneficial effect on aesthetics.

i. Effects on Commercial Fishing. There would be no measurable effects on commercial fishing as a result of the sand eductor operation. Any displacement of fish caused by the turbidity raised by the dredging and placement operation is expected to be very localized and of short duration.

j. Effects on Endangered or Threatened Species. The proposed action would not impact on any endangered or threatened species or critical habitat.

k. Effects on Benthos. Some benthic organisms at the project site could be subject to smothering from sedimentation and beach filling. Benthic organisms are not abundant in the project area due to the wave-washed character of the shoreline. Adverse effects on benthos, therefore, are considered to be minor.

l. Effects on Submerged Vegetation. The nearshore submerged area in the vicintiy of White Lake Harbor is characterized by a uniform sandy bottom. Few species of submergent vegetation are able to take root and survive in this environment. Continuous wave action prevents colonization of these species. Adverse effects to submerged vegetation would be negligible.

m. Effects on Historical Places. No effects on any historical or archaeological sites are anticipated.

n. Effects on Municipal Water Supplies. The beach nourishment operation is not expected to affect water supplies due to the rapid settling nature of the sand. Only uncontaminated materials will be utilized for beach nourishment. There are no municipal water intakes located in the vicinity of White Lake Harbor channel or the proposed nourishment sites.

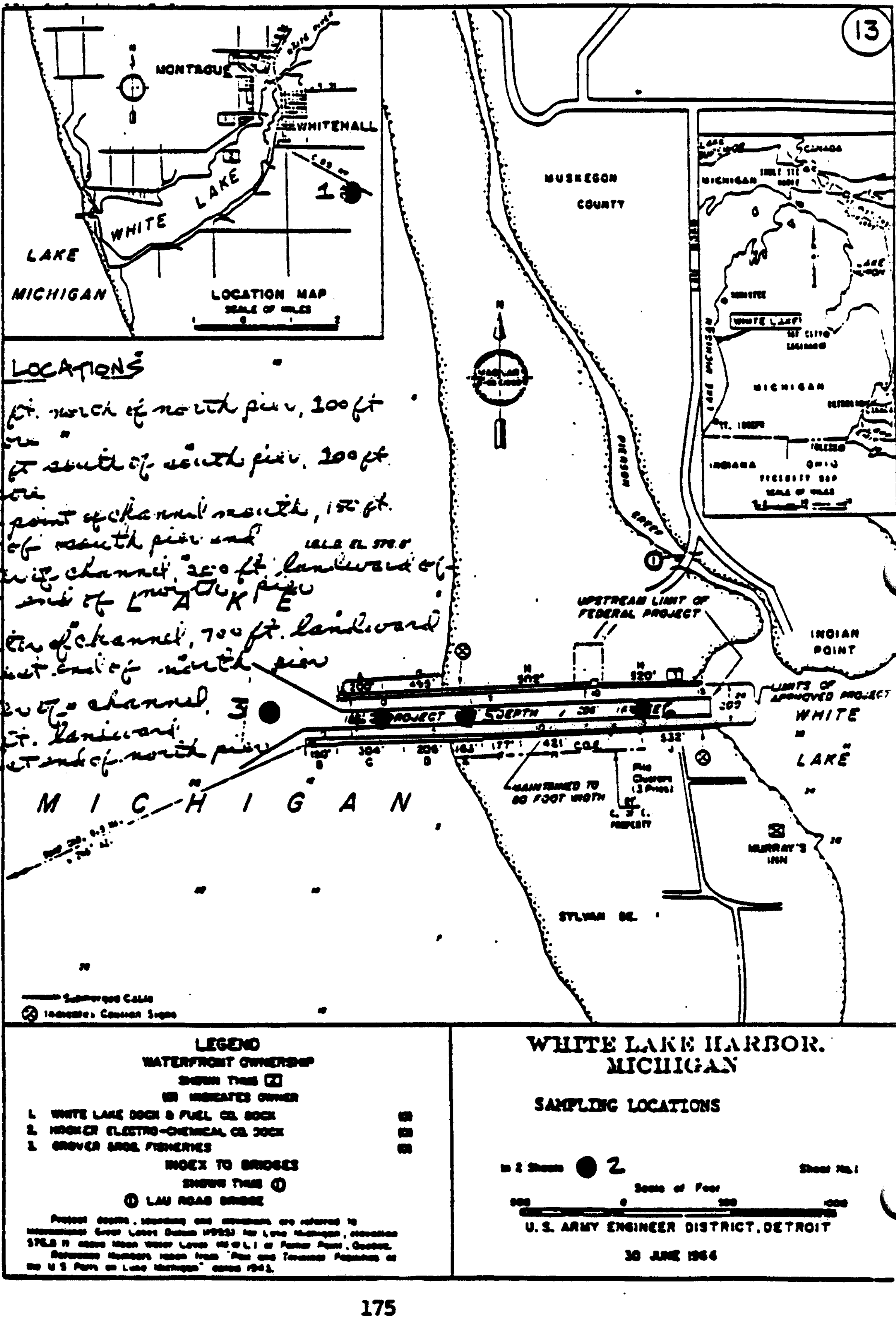

WHITE LAKE HARBOR, MICHIGAN
SAMPLING LOCATIONS
In 2 Sheets
Sheet No. 1
Scale of Feet
U.S. ARMY ENGINEER DISTRICT, DETROIT
30 JUNE 1966
LEGEND
WATERFRONT OWNERSHIP
INDEX TO BRIDGES
LOCATION MAP
MONTAGUE
WHITEHALL
WHITE LAKE
LAKE MICHIGAN
MUSKEGON COUNTY
INDIAN POINT
UPSTREAM LIMIT OF FEDERAL PROJECT
LIMITS OF APPROVED PROJECT
MAINTAINED TO 80 FOOT WIDTH
MURRAY'S INN
SYLVAN RD.
LOCATIONS
1 - 2000 ft. north of north pier, 100 ft offshore
2 - 3000 ft south of south pier, 200 ft offshore
3 - Mid point of channel mouth, 150 ft. west of south pier end
4 - Center of channel, 300 ft landward of west end of north pier
5 - center of channel, 700 ft. landward of west end of north pier
6 - center of channel, 1400 ft. landward of west end of north pier
13

TABLE 1

Results of physical and chemical analyses performed at each sampling site while in the field at White Lake, Michigan on November 13, 1979.

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Core Depth	Surface grab	Surface grab	Surface grab	Surface grab	Surface grab	Surface grab
Air Temperature (°C)	3	5	7	5	3	2
Water Temperature (°C)	6	6	6	6	6	6
Dissolved oxygen (mg/l)	11.4	12.0	12.0	11.5	11.2	11.2
pH (S.U.)	8.25	8.20	8.10	8.25	8.15	8.15
Water depth (m)	1.98	3.66	6.10	5.18	4.27	6.10
Secchi disc (m)	1.83	2.13	2.44	1.83	1.83	1.83
Redox potential	*	*	*	*	*	*
Sediments						
Color	Light brown	Light brown	Light brown	Light brown	Light brown	Light brown
Odor	None	None	None	None	None	None
Texture	Sand	Sand	Sand	Sand	Sand	Sand

*meter not operating

TABLE 2

Results of the benthic macroinvertebrate analyses for samples collected by Ponar grab from White Lake, Michigan on November 13, 1979.

Taxa	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Coelenterata						
Hydra sp.					50.9	
Turbellaria		6.4			63.7	
Nematoda					19.1	
Oligochaeta						
Tubificidae						
immature w/o capilliform chaetae	19.1			19.1	108.2	350.2
immature w/capilliform chaetae						31.8
Limnodrilus hoffmeisteri						12.7
Naididae		6.4			827.7	
Amphipoda						
Pontoporeia hoyi	6.4				6.4	
Gammarus sp.		25.5			184.6	248.3
Diptera						
Cryptochironomus sp.				6.4	127.3	89.1
Dicrotendipes sp.				6.4		
Chironomus sp.					12.7	6.4
Robackia sp.						6.4
Polypedilum sp.					6.4	
Cladotanytarsus sp.					31.8	57.3
Unidentifiable Chironomidae*	6.4	6.4	6.4	12.7	50.9	25.5
Total number/m^2	31.9	44.7	6.4	44.6	1489.7	827.7
Total taxa	3	4	1	4	12	9

*head capsule damaged or specimen too immature for identification beyond family level

**three grabs per site were taken

Results of water chemcial analyses (exluding chlorinated compounds) performed on samples collected from White Lake, Michigan on November 13, 1979.

Table 3

Site	Specific Conductance (μmhos)	Dissolved Solids (mg/l)	Total Suspended Solids (mg/l)	Chemical Oxygen Demand (mg/l)	Ammonia-Nitrogen (mg/l)	Total Kjeldahl Nitrogen (mg/l)
1	216	188	3	8.03	<0.02	0.29
2	209	190	<1	8.03	<0.02	0.46
3 & 4	249	214	<1	4.02	0.03	0.25
5 & 6	298	256	1	16.06	0.03	0.53

Site	Total Cyanide (mg/l)	Oil and Grease (mg/l)	Total Phosphorus (mg/l)	Total Dissolved Phosphorus (mg/l)	Phenols (μg/l)
1	<0.03	0.5	.004	.004	3
2	<0.03	0.3	.004	.004	3
3 & 4	<0.03	0.5	.019	.016	3
5 & 6	<0.03	2.3	.025	.016	3

Site	Total Arsenic (mg/l)	Total Cadmium (mg/l)	Total Chromium (mg/l)	Total Copper (mg/l)	Total Iron (mg/l)	Total Mercury (mg/l)
1	0.026	0.020	<0.001	0.006	0.039	<0.0002
2	0.014	0.023	<0.001	<0.001	0.136	<0.0002
3 & 4	0.034	0.025	<0.001	0.008	0.085	<0.0002
5 & 6	0.016	0.020	0.002	<0.001	0.122	<0.0002

Site	Total Manganese (mg/l)	Total Nickel (mg/l)	Total Lead (mg/l)	Total Zinc (mg/l)	Total Organic Carbon (mg/l)
1	0.003	0.012	0.003	<0.01	2.1
2	<0.001	<0.001	<0.001	<0.01	3.1
3 & 4	<0.001	0.010	<0.001	<0.01	2.9
5 & 6	0.001	0.008	<0.001	<0.01	[illegible]

TABLE 4

Results of the analyses of water samples for chlorinated compounds. Water samples were collected from White Lake, Michigan on November 13, 1979.

Parameter	Site 1	Site 2	Site 3 & 4	Site 5 & 6
PCB's (µg/l)	<0.01	<0.01	<0.01	<0.01
Lindane (µg/l)	0.098	0.076	0.054	0.088
Heptachlor (µg/l)	<0.003	0.020	0.013	0.021
Aldrin/Dieldrin (µg/l)	<0.003	<0.003	<0.003	<0.003
Heptachlor epoxide (µg/l)	<0.003	<0.003	<0.003	0.008
Methoxychlor (µg/l)	<0.003	<0.003	<0.003	<0.003
DDT, pp (µg/l)	0.170	<0.003	0.145	0.104
DDE (µg/l)	<0.003	<0.003	<0.003	<0.003

TABLE 5

Results of sediment chemical analyses performed on samples collected from White Lake, Michigan on November 13, 1979.

Site	Solids (%)	Total Volatile Solids (% Dry Solids)	Total Organic Carbon (mg/g)	Chemcial Oxygen Demand (mg/g)	Oil and Grease (% Dry Solids)	Total Cyanide (mg/l)
1	79.26	0.09	.67	47	0.16	<0.03
2	80.12	0.09	.70	24	0.05	<0.03
3	82.50	0.10	.74	15	0.07	<0.03
4	81.42	0.11	.89	16	0.08	<0.03
5	81.52	0.11	.64	16	0.15	<0.03
6	84.52	0.05	.39	34	.17	<0.03

Site	Total Arsenic (mg/kg)	Total Iron (mg/kg)	Total Cadmium (mg/kg)	Total Copper (mg/kg)	Total Chromium (mg/kg)	Total Nickel (mg/kg)
1	0.64	657	4.51	12.34	3.43	2.15
2	3.56	705	7.30	11.76	7.13	6.41
3	3.60	659	3.60	7.12	3.15	1.80
4	4.77	682	4.55	8.02	4.98	1.73
5	1.78	531	2.22	20.73	3.11	0.74
6	5.19	367	2.68	6.74	2.94	1.38

Table 5 (continued)

Site	Total Manganese (mg/kg)	Total Lead (mg/kg)	Total Zinc (mg/kg)	Total Mercury (mg/kg)
1	14.70	0.32	3.65	<0.020
2	14.25	1.59	4.99	<0.020
3	17.01	<0.1	<0.80	0.059
4	16.69	<0.1	<1.00	0.318
5	19.99	<0.1	<1.00	0.328
6	40.90	<0.1	4.58	0.141

Site	In Place Density	Total Phosphorus (mg/kg)
1	2.082	26
2	2.030	39
3	2.055	24
4	2.045	21
5	2.087	28
6	2.016	22

TABLE 6

Particle size composition of sediments collected from White Lake, Michigan on November 13, 1979. Tabular results are expressed as percent of dry weight retained per sieve.

	Sieve Opening (mm)*				
Site	2.000	0.850	0.250	0.075	Passed <0.075 (By Calculation)
1	<0.01	<0.01	63.03	35.13	1.84
2	<0.01	<0.01	37.80	61.91	<0.01
3	0.06	0.02	39.47	60.06	0.39
4	<0.01	0.02	31.05	67.27	1.66
5	<0.01	0.09	73.25	26.66	<0.01
6	0.05	0.25	93.11	5.18	1.41

Size (mm)	U.S. Standard Sieve No.	Classification
≥2.0	Retained by 10	granule, pebble cobble
.850 - 1.99	Retained by 20	very coarse sand
.250 - .849	Retained by 60	medium sand
.075 - 0.249	Retained by 200	fine and very fine sand
< 0.075	Passed through 200	silt and clay

TABLE 7

Results of elutriate water chemical analyses (excluding chlorinated compounds) performed on samples collected from White Lake, Michigan on November 13, 1979.

Site	Dissolved Solids (mg/l)	Oil and Grease (mg/l)	Total Cyanide (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Ammonia-Nitrogen (mg/l)	Total Arsenic (mg/l)
3	238	<0.10	<0.03	0.57	0.12	<0.001
4	237	8.4	<0.03	0.56	0.07	0.006
5	280	2.4	<0.03	0.69	0.11	0.008
6	247	<0.10	<0.03	1.02	0.19	<0.001

Site	Total Iron (mg/l)	Total Cadmium (mg/l)	Total Copper (mg/l)	Total Chromium (mg/l)	Total Nickel (mg/l)	Total Manganese (mg/l)
3	0.197	0.021	0.007	<0.001	0.014	0.002
4	0.094	0.033	<0.001	0.005	0.012	<0.001
5	0.091	0.028	0.036	0.004	0.008	<0.001
6	0.319	0.024	0.043	<0.001	0.010	0.010

Table 7 (continued)

Site	Total Lead (mg/l)	Total Mercury (mg/l)	Total Zinc (mg/l)	Total Organic Carbon (mg/l)
3	0.003	<0.0002	<0.010	6.2
4	0.014	0.0013	<0.010	3.9
5	0.014	0.0444	<0.010	5.6
6	<0.001	0.0012	<0.010	6.0

TABLE 8

Results of the analyses of elutriate water samples for chlorinated compounds. Water samples were collected from White Lake, Michigan on November 13, 1979.

Parameter	Site 3	Site 4	Site 5	Site 6
PCB's (µg/l)	<0.01	<0.01	14.22	<0.01
Lindane (µg/l)	<0.003	3.940	0.193	21.74
Heptachlor (µg/l)	<0.003	<0.003	0.173	<0.003
Aldrin/Dieldrin (µg/l)	<0.003	<0.003	<0.003	<0.003
Heptachlor epoxide (µg/l)	<0.003	<0.003	<0.003	<0.003
Methoxychlor (µg/l)	<0.003	<0.003	<0.003	<0.003
DDT, pp (µg/l)	<0.003	0.390	2.017	<0.003
DDE (µg/l)	<0.003	<0.003	2.144	<0.003

Chlorinated Hydrocarbons and Phenols in Sediments, Elutriate, and Water

Parameters	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Sediments (mg/kg)						
Total PCB's	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Lindane	0.086	0.066	0.056	0.090	0.085	0.102
Heptachlor	0.118	0.105	0.101	0.003	0.143	0.113
Aldrin/Dieldrin	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Heptachlor epoxide	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Methoxychlor	< 0.003	< 0.003	< 0.003	0.474	0.207	< 0.003
D D T	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.013
White Lake - Phenols						
Elutriate (ug/l)			4.4	3.2	7.7	5.5
Sediment (mg/kg)	0.8	0.5	0.4	0.2	0.1	0.7
Elutriate (ug/l)						
HCB			< 0.004	0.112	< 0.004	0.151
Mirex			0.036	0.049	0.136	0.009
C-56			< 0.005	< 0.005	< 0.005	< 0.005
Sediment (mg/kg)						
HCB	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
Mirex	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004
C-56	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006

Water (ug/l)	Site 1	Site 2	Site 3 & 4	Site 5 & 6
HCB	0.292	0.285	0.163	0.193 ; 0.200
Mirex	0.047	< 0.004	< 0.004	0.080 ; 0.064
C-56	< 0.005	< 0.005	< 0.005	< 0.005

APPENDIX 4.3 WHITE LAKE BENTHOS DATA
(Evans, no date)

Table 4. Macroinvertebrate species lists from petite ponar dredge samples in White Lake, Muskegon County, Michigan, June, 1972 and 1975.

	120 Samples 1972	18 Samples 1975
Colenterata		
Hydra		X
Turbellaria (flatworms)		
Dugesia	X	
Dalyellia	X	
Nematoda (roundworms)	X	X
Oligochaeta (aquatic earthworms)	X	X
Isopoda (sow bugs)		
Asellus militaris	X	X
Amphipoda (scuds)		
Gammarus	X	X
Hyallela azteca	X	
Ephemeroptera (mayflies)		
Caenis	X	
Hexagenia limbata	X	X
Tricorythodes		X
Odonata (dragonflies, damselflies)		
Coenagrionidae	X	
Trichoptera (caddisflies)		
Oecetis inconspicua	X	
Diptera (flies)		
Ceratopogonidae		X
Chaoboridae		
Chaoborus	X	X
Chironomidae (midges)		
Ablabesmyia	X	
Chironomus		X
C. fluviatilus gp.	X	
C. plumosus type	X	X
Cladotanytarsus	X	
Coelotanypus	X	X
Cryptochironomus digitatus	X	X
Cryptocladopelma		X
Dicrotendipes modestus	X	
Endochironomus	X	
Glyptotendipes	X	
Harnischia amachaerus	X	
Monodiamesa depectinata	X	
Parachironomus abortivus	X	
Polypedilum near *scalaenum*	X	
Procladius	X	X
Pseudochironomus	X	
Stictochironomus	X	
Tanytarsus (S.S.)	X	X
Tanypodinae		X
Pisces		
Larvae	X	

Table 8 Average density and percent oligochaetes of the White Lake macrobenthos from 1952 to 1980.

DENSITY (m²) OF OLIGOCHAETES AND TUBE DWELLING CHIRONOMIDS

Date:	Aug. 1952		May 1951		Aug. 1953	July 1967		June 1972		Aug. 1972		May 1973		Oct. 1973	
Depth (m):	<6	>6	<6	>6	>6	<6	>6	<6	>6	<6	>6	<6	>6	<6	>6
	339	190	3344	5676	483	3741	1333	602	434	387	2915	719	774	1436	7125
	657	4263	814	6658	2666	6493	817	559	690	523	466	1758	0	1021	775
	2067	2404	562	2596	6149	8630	645	415	860	19	19	795	378	0	19
	1335	849	1892	1232	2623	86	1505	916	474	76	694	116	529	373	321
	361	1249	1419	15840	3999	903	1634	768	473	587	1129	10	755	38	567
	3918	2024	836	7676	1247	3569	4128	402	538	558	722		1022	246	556
		1550	1144	6764	2279	760	3225	116	602		1449		1247		302
		2326	2166	860			43	817	434		1202		728		510
		1249	1364	4400			1805	1204	6106		1035		2603		2401
		2243	880	3316			960	817	3076		921		455		1641
				1652			6407	229	3025		1151		473		313
				1540				483	301		561		1721		227
								301	1433		226		1475		360
								961	2472		2062		3439		546
								1204	721		1586		57		5566
								645	72		352		5293		
								616	58		5756				
								1061	258						
								459	1219						
No. Samples/Station	1	1	1	1	2	2	2	3	3	2	2	2	2	2	2
N	6	10	10	12	7	7	11	19	16	6	17	5	16	6	15
x̄	1436	1642	1431	4792	2778	3450	2037	648	1133	358	1308	601	1286	520	1387
S.D.	1390	1116	847	4209	1860	3186	1862	311	1465	251	1349	695	1425	501	2052

PERCENT OLIGOCHAETES

Date:	Aug. 1952		May 1951		Aug. 1953	July 1967		June 1972		Aug. 1972		May 1973		Oct. 1973	
Depth (m):	<6	>6	<6	>6	>6	<6	>6	<6	>6	<6	>6	<6	>6	<6	>6
	16	67	63	72	91	15	55	81	65	25	91	45	66	66	99
	85	42	1	73	85	63	53	74	73	91	88	95	0	59	100
	22	72	10	20	89	43	53	75	57	0	0	64	70	0	100
	21	85	76	67	82	0	89	41	33	13	32	0	61	65	82
	84	0	72	1	94	48	71	38	43	48	72	100	83	0	100
	100	53	54	51	100	61	91	61	61		91		46	69	100
		76	63	40	94	78	71	77	86		34		85		100
		0	96	33			100	37	78		48		25		100
		0	32	30			85	57	100		59		75		96
			21	79			32	61	93		89		29		100
				31			95	19	46		49		32		94
				51				50	64		38		41		63
								50	95		54		22		75
								43	100		76		53		97
								56	0		61		100		96
								56	50		84		78		
								98	53		78				
								37	84						
								63							
x̄	54	45	51	60	91	45	72	59	66	35	62	61	54	43	95
S.D.	39	34	31	23	6	28	22	20	26	36	26	41	28	34	7

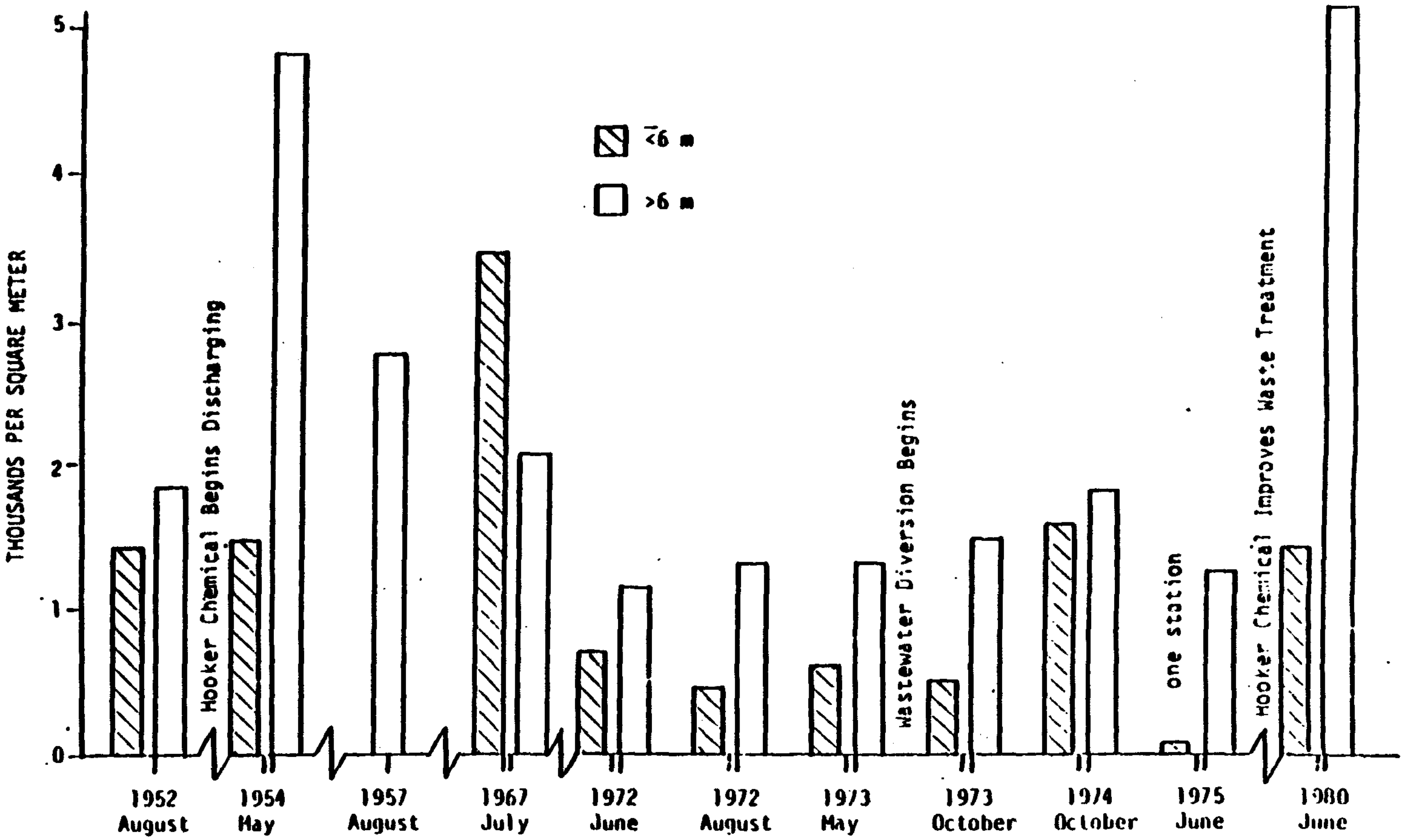


Figure 9. Estimated numbers of oligochaetes and tube dwelling chironomids per square meter in White Lake, Muskegon County, Michigan, 1952 to 1980 at depths equal to or less than six meters and at depths greater than six meters.

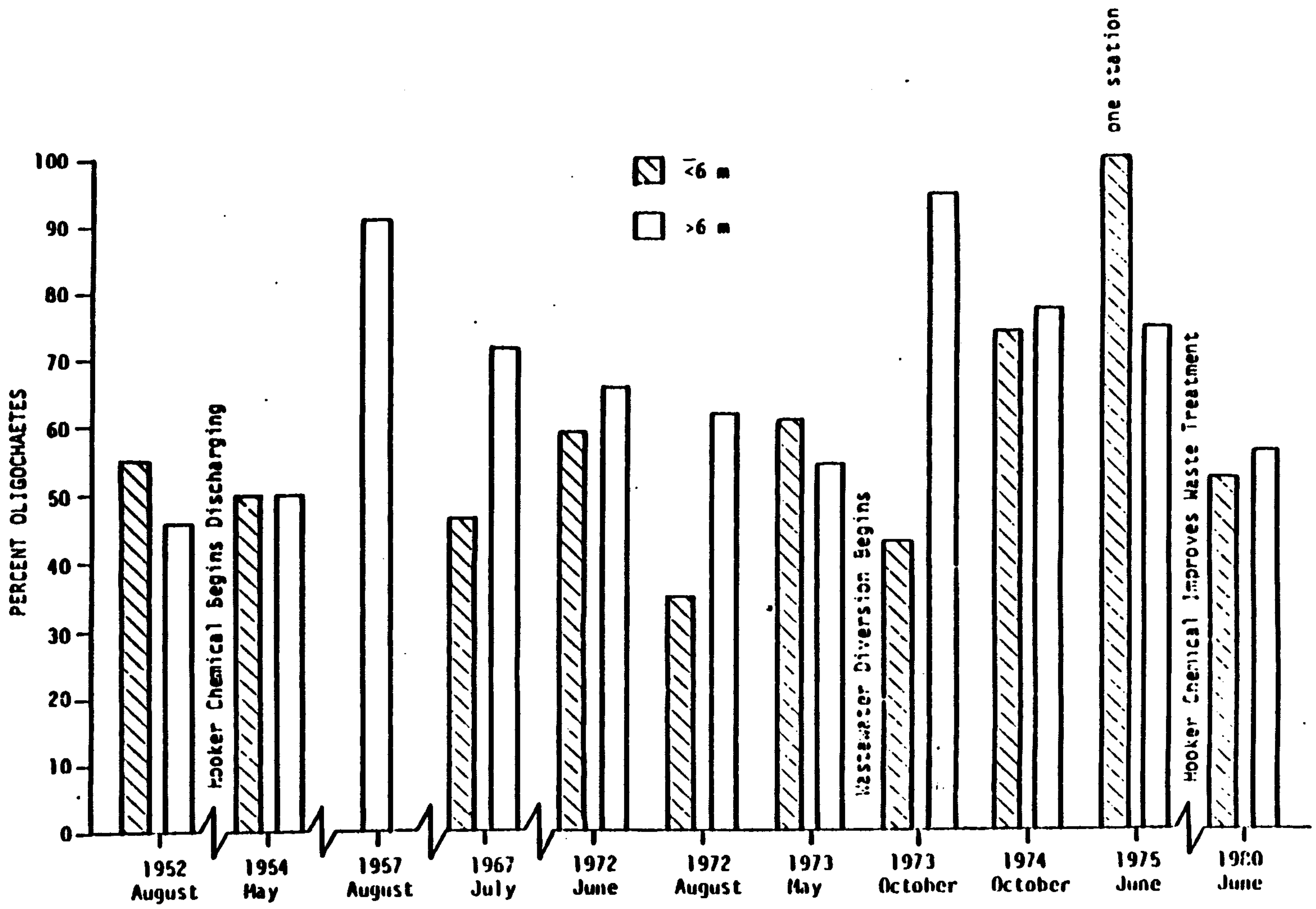


Figure 10. Percent oligochaetes of the oligochaetes and tube dwelling chironomid community in White Lake, Muskegon County, Michigan, 1952 to 1980 at depths equal to or less than six meters and depths greater than six meters.

APPENDIX 4.4 WHITE LAKE FISH SAMPLING DATA
(Forney, 1980 and Rossio, 1985)

1980

White Lake Fish Contamination

Michigan Department of Public Health
Division of Environmental Epidemiology
Position Paper
January 1980

Prepared by:

Harold E. B. Humphrey, Ph.D.
David Wade, Ph.D.
Daniel Williams, M.D.
Arthur Bloomer, M.S.

White Lake, which connects directly with Lake Michigan through a channel, has long been a popular area for catching sport fish endogenous to the lake itself as well as migratory species which enter from Lake Michigan.

Certain chemical contaminants have been detected in both Lake Michigan and White Lake fish. Polychlorinated biphenyls (PCB), dieldrin, DDT and DDE are typically found. However, the levels of these chemicals in White Lake fish are typically below those found in corresponding species in Lake Michigan and fall well within current and proposed FDA guideline tolerances for commercial sale. [Thus while PCB, dieldrin, DDT and DDE are found in White Lake fish, the quantities typically present are not sufficient to be of concern from a public health standpoint.]

Fish endogenous to White Lake itself such as northern pike, smallmouth bass, white sucker, bowfin, shad, bullhead, bluegill, pumpkinseed and perch have been examined from time to time in order to determine whether or not chemical manufacturing operations on the shores of the lake have caused contamination of this resource. In 1976 levels of hexachlorobenzene (HCB), hexachlorobutadiene (HCBD) and an unidentified compound were found at low levels in several species of fish. These results were not consistently confirmed by a second laboratory. The low levels of these compounds were not detected in fish collected and tested by the Department of Natural Resources in 1977 and 1978.

In 1979 the Michigan State University Pesticides Research Center announced that they had detected HCB and mirex in three species of White Lake fish which had been collected from a suspect area of the lake in October of 1978. The Michigan Department of Public Health Environmental Epidemiology Laboratory, using a very sensitive analytical methodology which had been developed in conjunction with the EPA, tested five of the specimens done at Michigan State

University. Although the presence of HCB and mirex were confirmed, the Michigan Department of Public Health did not agree with the quantities reported, instead finding them to be much lower. With the exception of one pike specimen which had 2 ppm, HCB was found at levels below 0.5 and mirex was found at levels no greater than 0.015 ppm.

Subsequently, another collection of 12 fish (3 northern pike, 1 bass, 1 shad, 2 white suckers, 2 bowfins and 3 perch) were obtained from various points in White Lake in August of 1979 and submitted to the laboratories at the Michigan Department of Public Health, Department of Natural Resources, Food and Drug Administration, and MSU Pesticides Center for testing. Tests included HCB and mirex as well as the previously mentioned contaminants PCB, DDT, DDE and dieldrin. Testing reports have been received from the MDPH, DNR, AND FDA laboratories and the results appear to be in reasonably good agreement. Mirex was found in 9 of the 12 fish at levels ranging from 0.001 ppm to 0.031 ppm (except for 3 perch, which had 0.018 to 0.031 ppm, mirex was found at only 0.002 or 0.003 ppm levels). HCB was found in 4 of the 12 fish at levels ranging from 0.002 to 0.014 ppm. Thus, the presence of these and other chemical contaminants have been confirmed in a variety of fish endogenous to White Lake but in quantities in the parts per billion range. It should be noted that 25% of the fish tested showed no detectable mirex and 66% of the fish tested showed no detectable HCB.

Mirex has been used primarily as an insecticide for the control of fire ants although its use as a fire retardant in plastics has also been described. The acute and chronic toxicities of this chemical in animal test systems have been reported by a number of investigators. The acute toxicity of mirex is very low, however, chronic administration has resulted in the development of cataracts in rats and tumor formation as well as other hepatotoxic effects in mice. These effects were only found at dose levels that greatly exceed the concentrations of mirex found in White Lake fish.

The Food and Drug Administration action level for mirex in regard to commercial sale of fish is 0.1 ppm. This value is from 3 to 5 times higher than the concentration found in the 3 fish containing the highest levels of the chemical and nearly 10 times higher than the average concentration of the 12 fish.

HCB has been widely used as a fungicide and is also a by-product in the manufacture of several chlorinated hydrocarbons. Its acute toxicity to humans was dramatically demonstrated by an epidemic of toxic porphyria in Turkey between 1955 and 1959 as the result of eating HCB-treated wheat seeds. The carcinogenicity of HCB has been demonstrated in several animal species however there are no epidemiological studies linking HCB to cancer in man. Again, as for mirex, the toxic effects of HCB were all found at dose levels much greater than those in White Lake fish.

An upper limit for human consumption of 0.6 ug HCB/kg/day was proposed by Food and Agricultural Organization/World Health Organization. Assuming the average human consumption of fish to be 11 lb/yr and that the average adult body weight is 70 kg, an individual would consume only 0.0027 ug/kg/day from eating fish containing the highest level of HCB found in the most recent fish collection. Even the so called "fish eater" surrounding the Lake who eat an average of 30 lbs of fish per year would consume only 0.0074 ug/kg/day. These values would be even lower if instead of using the highest contaminated fish for the estimate (which represents only 8% of the fish sample collected) the average HCB concentration were used.

The Food and Drug Administration has not, as yet, proposed an action level for HCB in fish. However, for cattle, sheep and goat fat a 0.3 ppm standard has been set. This action level is still 20 times higher than the highest concentration (0.014 ppm) of HCB found in the most recent fish collection and

and 70 times higher than the average of the HCB concentrations. Therefore, to eat an amount of White Lake fish equivalent to the 0.3 ppm action level, an individual would have to increase his or her fish consumption 70 fold.

Understanding the human significance of contaminants in White Lake fish requires consideration of several factors. First, we must accept the concept that modern analytical methods have allowed the detection of miniscule amounts of chemicals. The presence of chemicals in the environment including fish is to some extent unavoidable because it reflects the production and wide utilization of chemicals in our society. Obviously some spillage into the environment is inevitable and this can now be seen with modern sensitive instruments. The identification of man-made chemicals in fish represents only one of a variety of sources of exposure for modern man. The home, office, automobile and urban atmosphere represent other potential sources of exposure.

Second, fish as a significant source of human contamination becomes reduced in importance when one considers the relatively small (by world standards) amount of fish which Americans eat (about 11 pounds per year per capita). A 1974 study by the Michigan Department of Public Health of persons eating sport-caught fish, showed that most fishermen in Michigan ate only 24-35 pounds per year with 260 pounds being the highest consumption recorded. Thus, fish with miniscule amounts of a chemical which aren't eaten in vast quantity do not represent a major source of exposure to such chemicals.

Third, many of the chemical contaminants (including HCB, PCB, DDT and mirex) are associated with the fat of the fish. Appropriate preparation and cooking procedures which reduce the amount of fat will significantly affect the amount of such chemicals present in the meal which humans eat. This fact was demonstrated in the aforementioned 1974 study where the PCB levels of raw fish were shown to be significantly reduced when cooked. Thus proper food preparation procedures can further reduce the exposure of humans to the contaminants of interest in White Lake fish - possibly to non-detectable quantities.

Finally, it should be noted that all fish are not the same. The analytical tests to date on White Lake fish have shown that not all the fish are contaminated nor are all species equally contaminated. Thus, when one catches and eats a fish from the lake, there is a distinct possibility that it may not be contaminated with HCB or mirex at all. Further, it should be considered that large predator fish (pike, bass, lake trout and salmons) will tend to contain more of any given environmental contaminant because of feeding habits and fat content. Older, larger fish are generally found to be more contaminated than smaller fish of the same species or than fish of other species. Thus the nature of the catch will influence the degree of potential human exposure to a given chemical contaminant.

To summarize, we have a situation where chemical contaminants have been found in some fish from White Lake at relatively low levels. The highest contaminant concentration reported to date has been associated with a large predator species (pike) and fish eggs. The impact of a fish contaminant on humans will be influenced by the quantity of contaminant present, the size and species of fish eaten, the frequency of eating such fish, the method of cleaning and cooking used, and the total intake of fish from the lake over time.

It is the judgment of the Michigan Department of Public Health that the confirmed quantitative data generated to date (especially in the last 6 months) do not warrant the need for a ban on catching and eating fish endogenous to White Lake or fish migrating through the lake while spawning. While the presence of chemical contaminants in food are a matter of concern, their existence alone does not necessarily represent a health hazard. The concept of food quality and protection recognizes the dose-response principle of toxicology and the fact that certain contaminant levels can be tolerated in food without jeopardizing the safety of the public.

Therefore the Michigan Department of Public Health makes the following recommendations with respect to White Lake.

1. Residents and guests may use the waters for swimming and other aquatic recreational sports.

2. Residents may catch and eat endogenour fish species such as bluegill, bullhead, sucker, bowfin, shad, pumpkinseed, bass and pike.

3. Because predator species of larger size, such as pike and bass, have a greater possibility of contaminants, residents are advised not to use these fish as a major food source in the diet.

4. Migratory predator species found in Lake Michigan such as lake trout, steelhead, coho and other salmons should not be consumed at an annual avarage rate greater than one meal per week (1/2 lb.) and children, women who expect to bear children, and pregnant or nursing women should avoid eating these fish.

5. Tourists who sport fish in order to stock home freezers should observe recommendations #3 and #4.

6. Tourists vacationing and sport fishing for the vacation table have little to be concerned about but are advised to heed item #4 above and to calculate consumption (for the predator species shown in #3 and #4 above) during the vacation period on a basis which would not exceed a total of 26 pounds.

7. All persons are advised to clean, trim and cook fish in such a way that as much fat as possible is eliminated from the cooked meal.

8. The Department of Natural Resources is requested to carry out an annual fish testing program in order to monitor chemical contaminants such as HCB and mirex in White Lake fish and provide the results of such tests to the Michigan Department of Public Health for the purpose of updating this advisory.

ORGANIC CONTAMINANTS[a]
WHITE LAKE - MUSKEGON, MICHIGAN

Collected: July 1, 2, 1980 by District 9, Fisheries Division
Analysis: DNR - Environmental Services Division Laboratory
MDPH - Environmental Epidemiology Division Laboratory

SITE 1

Species	Length in Inches	Lab	%Lipid	Aroclor 1242 mg/kg	Aroclor 1254 mg/kg	Aroclor 1260 mg/kg	Dieldrin mg/kg	DDE p,p' mg/kg	DDT p,p' mg/kg	Oxychlordane mg/kg	Trans-Nonachlor mg/kg	HCB[1] mg/kg	HCP[2] mg/kg	UCP[3] mg/kg	Mirex mg/kg	PBB[4] mg/kg
Northern Pike	25.8	DNR	0.32	<0.10	<0.100	<0.100	----	0.080	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	---
		MDPH	0.30	----	0.062	----	<0.001(ND)	0.023	0.004	0.002	0.007	<0.001(ND)	<0.001	<0.001	<0.001(ND)	<0.001(ND)
Northern Pike	27.3	DNR	1.6	<0.10	1.2	0.53	----	0.35	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	--
		MDPH	1.3	----	0.740	----	0.012	0.256	0.036	0.009	0.050	0.002	<0.001(ND)	<0.001(ND)	0.011	<0.001(ND)
Northern Pike	32.5	DNR	0.24	<0.10	<0.100	<0.10	----	0.03	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	- -
		MDPH	3.2	----	0.020	----	0.003	0.044	0.006	0.002	0.011	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Largemouth Bass	17.1	DNR	0.49	<0.10	0.51	<0.10	----	0.12	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	---
		MDPH	0.40	----	0.220	----	<0.001(ND)	0.115	0.010	0.004	0.010	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Yellow Perch	11.0	DNR	0.08	<0.10	<0.100	<0.10	----	<0.010	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	--
		MDPH	0.30	----	0.064	----	<0.001(ND)	0.022	0.003	<0.001(ND)	0.002	<0.001(ND)	<0.001(ND)	<0.001(ND)	0.001	<0.001(ND)
Yellow Perch	10.5	DNR	0.09	<0.10	<0.100	<0.10	----	0.02	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.20	----	0.130	----	<0.001(ND)	0.035	0.003	0.001	0.005	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Carp	23.5	DNR	2.9	<0.10	0.53	0.20	----	0.14	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	1.5	----	0.025	----	0.003	0.100	0.003	0.002	0.017	0.002	<0.001(ND)	<0.001(ND)	0.001	<0.001(ND)
Carp	21.9	DNR	2.6	<0.10	0.28	0.17	----	0.09	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	4.4	----	0.510	----	<0.001(ND)	0.186	0.006	0.008	0.024	0.007	<0.001(ND)	<0.001(ND)	0.009	<0.001(ND)
Redhorse Sucker	17.1	DNR	0.43	<0.10	<0.100	<0.10	----	0.05	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	
		MDPH	0.30	----	0.062	----	<0.001(ND)	0.029	0.004	0.002	0.010	<0.001(ND)	<0.001(ND)	<0.001(ND)	0.001	<0.001(ND)

ORGANIC CONTAMINANTS*
WHITE LAKE - MUSKEGON, MICHIGAN

Collected: July 1, 2, 1980 by District 9, Fisheries Division
Analysis: DNR - Environmental Services Division Laboratory
MDPH - Environmental Epidemiology Division Laboratory

SITE 2

Species	Length in Inches	Lab	%Lipid	Aroclor 1242 mg/kg	Aroclor 1254 mg/kg	Aroclor 1260 mg/kg	Dieldrin mg/kg	DDE p,p' mg/kg	DDT p,p' mg/kg	Oxychlordane mg/kg	Trans-Nonachlor mg/kg	HCB[1] mg/kg	HCP[2] mg/kg	OCP[3] mg/kg	Mirex mg/kg	PBB[4] mg/kg
Largemouth Bass	14.5	DNR	0.20	<0.10	0.18	<0.10	----	0.06	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.10	----	0.25	----	<0.001(ND)	0.010	0.002	0.001	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Smallmouth Bass	15.4	DNR	0.81	<0.10	0.72	<0.10	----	0.09	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	--
		MDPH	2.3	----	0.200	----	<0.001(ND)	0.052	0.006	0.003	0.010	0.001	<0.001(ND)	<0.001(ND)	0.015	<0.001(ND)
Smallmouth	14.3	DNR	0.80	<0.10	0.72	<0.10	----	0.14	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.60	----	0.29	----	0.006	0.098	0.009	0.006	0.017	0.001	<0.001(ND)	<0.001(ND)	0.008	<0.001(ND)
Carp	23.9	DNR	4.5	0.10	2.6	N.D.	----	0.46	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	4.8	----	2.7	----	0.013	0.42	0.015	0.025	0.006	0.002	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Carp	22.7	DNR	3.0	0.10	1.5	N.D.	----	0.25	<0.050	----	----	0.025	<0.010	<0.010	<0.050	----
		MDPH	1.7	----	1.2	----	0.003	0.32	0.002	0.013	0.018	0.012	<0.001(ND)	<0.001(ND)	0.040	<0.001(ND)
Carp	26.7	DNR	0.61	<0.10	0.35	<0.10	----	0.05	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	7.3	----	2.10	----	<0.001(ND)	0.660	0.006	0.013	0.034	0.022	<0.001(ND)	<0.001(ND)	0.080	<0.001(ND)
Northern Pike	26.2	DNR	4.4	<0.10	1.2	N.D.	----	0.98	<0.050	----	----	<0.026	<0.010	<0.010	<0.020	----
		MDPH	0.40	----	0.25	----	<0.001(ND)	0.081	0.010	0.003	0.030	0.001	<0.001(ND)	<0.001(ND)	0.005	<0.001(ND)
Northern Pike	17.1	DNR	0.28	<0.10	<0.10	<0.10	----	0.020	<0.05	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.20	----	0.021	----	<0.001(ND)	0.014	0.003	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)

WHITE LAKE - MUSKEGON, MICHIGAN

Collected: July 1, 2, 1980 by District 9, Fisheries Division
Analysis: DNR - Environmental Services Division Laboratory
MDPH - Environmental Epidemiology Division Laboratory

SITE 3

Species	Length in Inches	Lab	%Lipid	Aroclor 1242 mg/kg	Aroclor 1254 mg/kg	Aroclor 1260 mg/kg	Dieldrin mg/kg	DDE p.p' mg/kg	DDT p.p' mg/kg	Oxychlordane mg/kg	Trans-Nonachlor mg/kg	HCB[1] mg/kg	HCP[2] mg/kg	OCP[3] mg/kg	Mirex mg/kg	PBB[4] mg/kg
White Sucker	21.1	DNR	1.1	<0.10	0.64	<0.10	----	0.15	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.30	----	0.120	----	<0.001(ND)	0.039	0.009	0.002	0.005	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Carp	25.5	DNR	3.9	<0.10	1.4	0.33	----	0.20	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	7.4	----	2.0	----	0.031	0.15	0.004	0.010	0.029	0.004	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Carp	25.2	DNR	6.6	<0.10	2.8	1.5	----	0.67	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	2.9	----	0.73	----	0.28	0.20	0.006	0.006	0.052	0.002	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Smallmouth Bass	9.9	DNR	0.33	<0.10	0.17	<0.10	----	0.05	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.30	----	0.045	----	<0.001(ND)	0.19	0.002	0.001	0.005	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Yellow Perch	11.1	DNR	0.10	<0.10	<0.100	<0.10	----	<0.010	<0.050	----	----	<0.010	<0.010	<0.010	0.020	----
		MDPH	0.10	----	<0.010(ND)	----	<0.001(ND)	0.001	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Yellow Perch	9.2	DNR	0.09	<0.10	<0.100	<0.10	----	<0.010	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.20	----	<0.010(ND)	----	<0.001(ND)	0.001	0.001	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Northern Pike	20.0	DNR	0.28	<0.10	0.30	<0.10	----	0.020	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.40	----	0.050	----	<0.001(ND)	0.018	0.002	<0.001(ND)	0.003	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)
Northern Pike	26.9	DNR	0.46	<0.10	0.57	<0.10	----	0.011	<0.050	----	----	<0.010	<0.010	<0.010	<0.020	----
		MDPH	0.20	----	0.093	----	<0.001(ND)	0.068	0.008	0.003	0.018	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)	<0.001(ND)

*Analysis run on skinless fillets

1 HCB - Hexachlorobenzene

2 HCP - Hexachlorocyclopentadiene

3 OCP - Octachlorocyclopentene

4 PBB - Polybrominated Byphenyl

N.D.- Not Detected

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: White Lake — STORET No.: 610236 — Collection Date: 07/24/84
Location: Montague — Grid No.: — Lab: MDNR

ID#	Species	Sex	Length (in)	Weight (lbs)	Sample Type	% Fat	% Fat (Replicate)	Comments
84001- 1	Northern Pike	M	25.00	3.34	Fs	0.30		
84001- 2	Northern Pike	M	25.24	3.74	Fs	0.45		
84001- 3	Northern Pike	M	25.51	3.96	Fs	0.25		
84001- 4	Northern Pike	M	24.02	2.77	Fs	0.20		
84001- 5	Northern Pike	M	27.01	4.40	Fs	0.45		
84001-21	Northern Pike	M	35.98	10.12	Fs	0.55		
84001-22	Carp	F	25.00	9.37	Fs	20.35		
84001-23	Carp		27.01	10.69	Fs	17.55		
84001-24	Carp	F	29.49	14.32	Fs	16.20		
84001-25	Carp	F	27.01	10.34	Fs	5.10		
84001-26	Carp	M	22.01	5.43	Fs	14.25		
84001-27	Carp	M	22.99	5.59	Fs	6.75		
84001-28	Carp	M	22.01	5.15	Fs	3.60		
84001-29	Carp	M	20.98	4.27	Fs	3.75		
84001-30	Northern Pike		29.02	5.72	Fs	1.50		
84001-31	Northern Pike	M	27.01	4.22	Fs	1.45		
84001-32	Northern Pike	F	28.90	5.15	Fs	1.20		
84001-33	Northern Pike	F	26.50	3.83	Fs	0.45		
84001-34	Walleye	F	19.49	2.93	F	2.00		
84001-35	Redhorse Sucker	F	19.02	2.20	F	1.90		
84001-36	Redhorse Sucker		18.50	2.42	F	0.70		
84001-37	Redhorse Sucker		17.48	1.83	F	11.25		
84001-38	Redhorse Sucker		16.50	1.67	F	1.55		
84001-39	Redhorse Sucker		16.50	1.64	F			
84001-44	Walleye		21.50	4.20	F	2.60		
84001-45	Walleye		18.50	2.73	F	2.15		
84001-46	Walleye		16.50	1.61	F	2.00		
84001-47	Smallmouth Bass	F	17.01	2.42	F	3.90		
84001-48	Redhorse Sucker	F	18.50	2.16	F	1.95		
84001-49	Redhorse Sucker		15.98	1.72	F	1.65		
84001-50	Redhorse Sucker		15.98	1.80	F	0.80		
84001-51	Redhorse Sucker		15.51	1.12	F	1.00		
84001-52	Redhorse Sucker		15.98	1.23	F	0.95		
84001-53	Redhorse Sucker		12.99	0.97	F	1.50		

F indicates skin-on fillet
Fs indicates skin-off fillet
E indicates egg sample only
W indicates whole fish
O indicates other sample type

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: White Lake
Location: Montague

Collection Date: 07/24/[illegible]

ID#	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	Arsenic (mg/kg)	Mercury (mg/kg)	Selenium (mg/kg)
84001- 1								0.400	
84001- 2								0.300	
84001- 3								0.200	
84001- 4								0.200	
84001- 5								0.200	
84001-21								0.300	
84001-22								0.100	
84001-23								K 0.100	
84001-24								0.200	
84001-25								0.200	
84001-26								0.100	
84001-27								0.200	
84001-28								0.200	
84001-29								0.200	
84001-30								0.500	
84001-31								0.600	
84001-32								0.200	
84001-33								0.300	
84001-34								0.400	
84001-35								0.400	
84001-36								K 0.100	
84001-37								0.100	
84001-38								K 0.100	

k indicates undetected at the detection level shown
t indicates substance was found at this level, which is below detection limit
m indicates substance was not found at the lowest quantifiable level indicated
lh indicates the actual level may be higher due to possible low recovery
ll indicates the actual level may be lower due to possible high recovery

IDB	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	Arsenic (mg/kg)	Mercury (mg/kg)	Selen (mg/k
84001-39								0.200	
84001-44								0.300	
84001-45								0.200	
84001-46								0.200	
84001-47								0.400	
84001-48								0.300	
84001-49								K 0.100	
84001-50								K 0.100	
84001-51								0.100	
84001-52								0.100	
84001-53								K 0.100	

k indicates undetected at the detection level shown
t indicates substance was found at this level, which is below detection limit
* indicates substance was not found at the lowest quantifiable level indicated
lh indicates the actual level may be higher due to possible low recovery
ll indicates the actual level may be lower due to possible high recovery

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: White Lake Collection Date: 07/24/84
Location: Montague

IDB	a-Chlordane (mg/kg)	g-Chlordane (mg/kg)	cis-Nonachlor (mg/kg)	trans-Nonachlor (mg/kg)	Oxy chlordane (mg/kg)	4,4'-DDD (mg/kg)	4,4'-DDE (mg/kg)	4,4'-DDT (mg/kg)
84001- 1	K 0.0130	K 0.0130	0.0300	0.0230	K 0.0130	0.0240	0.2100	0.0270
84001- 2	K 0.0130	K 0.0130	0.0230	0.0270	K 0.0130	0.0250	0.2100	0.0270
84001- 3	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	0.0740	K 0.0130
84001- 4	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	0.0660	K 0.0130
84001- 5	0.0230	K 0.0130	0.0690	0.0380	0.0140	0.0320	0.2100	0.0710
84001-21	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130
84001-22	0.1700	0.0840	0.6400	0.2900	0.0460	0.1700	3.0000	0.0640
84001-23	0.2000	0.1100	0.7100	0.1800	0.0360	0.2700	2.0000	0.0580
84001-24	0.0760	0.0350	0.4400	0.1100	0.0220	0.1000	1.8000	0.0200
84001-25	0.0700	0.0290	0.3100	0.1100	0.0200	0.0950	1.9000	0.0230
84001-26	0.0670	0.0390	0.2200	0.0730	0.0170	0.0880	0.5300	[illegible]
84001-27	0.0780	0.0350	0.3200	0.1100	0.0220	0.0930	1.3000	[illegible]
84001-28	0.0260	K 0.0130	0.0890	0.0380	K 0.0130	0.0340	0.3600	0.0180
84001-29	K 0.0130	K 0.0130	0.0760	K 0.0130	K 0.0130	0.0350	0.4200	K 0.0130
84001-30	0.0280	K 0.0130	0.0730	0.0700	0.0160	0.0670	0.5400	0.0650
84001-31	0.0310	K 0.0130	0.0710	0.0710	0.0300	0.0690	0.7500	0.0710
84001-32	0.0150	K 0.0130	0.0430	0.0250	K 0.0130	0.0290	0.1900	0.0460

J indicates an estimated value; value may not be accurate.
K indicates undetected at the detection level shown.
LH indicates the actual level may be higher due to possible low recovery.
LL indicates the actual level may be lower due to possible high recovery.
LP quality control indicates that the precision of the result may have been outside precision control limits.
PH indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been higher.
PL indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been lower.
PS indicates possible interference may have affected the accuracy of the laboratory result.
T indicates substance was found at this level, which is below detection level.
W indicates substance was not found at the lowest quantifiable level indicated.

ID#	a-Chlordane (mg/kg)	g-Chlordane (mg/kg)	cis-Nonachlor (mg/kg)	trans-Nonachlor (mg/kg)	Oxy chlordane (mg/kg)	4,4'-DDD (mg/kg)	4,4'-DDE (mg/kg)	4,4'-DDT (mg/kg)
84001-33	K 0.0130	K 0.0130	0.0210	0.0130	K 0.0130	0.0140	0.1000	0.0180
84001-34	K 0.0130	K 0.0130	0.0230	K 0.0130	K 0.0130	0.0170	0.0430	0.0210
84001-35	0.0130	K 0.0130	0.0250	0.0190	K 0.0130	0.0190	0.0840	0.0160
84001-36	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	K 0.0130	0.0610	K 0.0130
84001-37	K 0.0130	K 0.0130	0.0440	0.0130	K 0.0130	0.0150	0.0940	0.0340
84001-38	K 0.0130	K 0.0130	0.0230	0.0130	K 0.0130	0.0140	0.1200	0.0170
84001-44	0.0220	K 0.0130	0.0350	0.0380	K 0.0130	0.0360	0.1700	0.0380
84001-45	0.0140	K 0.0130	0.0230	0.0240	K 0.0130	0.0230	0.1000	0.0260
84001-46	K 0.0130	K 0.0130	K 0.0130	0.0130	K 0.0130	K 0.0130	0.0540	0.0170
84001-47	0.0410	0.0130	0.0860	0.0970	0.0290	0.1000	0.5300	0.1000
84001-48	K 0.0130	K 0.0130	0.0130	K 0.0130	K 0.0130	K 0.0130	0.0900	K 0.0130
84001-49	K 0.0130	K 0.0130	0.0370	0.0160	K 0.0130	0.0230	0.0870	0.0220
84001-50	K 0.0130	K 0.0130	0.0350	K 0.0130	K 0.0130	K 0.0130	0.0370	0.0350
84001-51	K 0.0130	K 0.0130	0.0210	K 0.0130	K 0.0130	K 0.0130	0.0420	0.0130
84001-52	K 0.0130	K 0.0130	0.0140	K 0.0130	K 0.0130	K 0.0130	0.0740	0.0140
84001-53	K 0.0130	K 0.0130	0.0140	K 0.0130	K 0.0130	K 0.0130	0.0170	K 0.0130

J indicates an estimated value; value may not be accurate.
K indicates undetected at the detection level shown.
LH indicates the actual level may be higher due to possible low recovery.
LL indicates the actual level may be lower due to possible high recovery.
LP quality control indicates that the precision of the result may have been outside precision control limits.
PH indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been higher.
PL indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been lower.
PS indicates possible interference may have affected the accuracy of the laboratory result.
T indicates substance was found at this level, which is below detection level.
W indicates substance was not found at the lowest quantifiable level indicated.

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: White Lake
Location: Montague

Collection Date: 07/24/84

IDN	Dieldrin (mg/kg)	Heptachlor-Epoxide (mg/kg)	Hexachloro-benzene (mg/kg)	Octachloro-Styrene (mg/kg)	PCB A-1248 (mg/kg)	PCB A-1254 (mg/kg)	PCB A-1260 (mg/kg)	2,3,7,8-TCDD (ng/kg)
84001- 1	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.4500	K 0.1300	
84001- 2	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.3800	K 0.1300	
84001- 3	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.2300	K 0.1300	
84001- 4	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.1800	K 0.1300	
84001- 5	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.6600	K 0.1300	
84001-21	K 0.0130	K 0.0130	K 0.0130		K 0.1300	K 0.1300	K 0.1300	
84001-22	0.0160	0.0350	K 0.0130		K 0.1300	2.1000	K 0.1300	
84001-23	0.2200	0.0820	K 0.0130		K 0.1300	5.0000	K 0.1300	
84001-24	K 0.0130	0.0250	K 0.0130		K 0.1300	1.9000	K 0.1300	
84001-25	K 0.0130	0.0130	K 0.0130		K 0.1300	2.9000	K 0.1300	
84001-26	0.1100	0.0420	K 0.0130		K 0.1300	3.4000	K 0.1300	
84001-27	K 0.0130	0.0140	K 0.0130		K 0.1300	3.5000	K 0.1300	
84001-28	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.9500	K 0.1300	
84001-29	K 0.0130	K 0.0130	K 0.0130		K 0.1300	1.2000	K 0.1300	
84001-30	K 0.0130	K 0.0130	K 0.0130		K 0.1300	1.3000	K 0.1300	
84001-31	K 0.0130	0.0130	K 0.0130		K 0.1300	2.3000	K 0.1300	
84001-32	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.7700	K 0.1300	
84001-33	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.3300	K 0.1300	

J indicates an estimated value; value may not be accurate.
K indicates undetected at the detection level shown.
LH indicates the actual level may be higher due to possible low recovery.
LL indicates the actual level may be lower due to possible high recovery.
LP quality control indicates that the precision of the result may have been outside precision control limits.
PH indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been higher.
PL indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been lower.
PS indicates possible interference may have affected the accuracy of the laboratory result.
T indicates substance was found at this level, which is below detection level.

ID#	Dieldrin (mg/kg)	Heptachlor-Epoxide (mg/kg)	Hexachloro-benzene (mg/kg)	Octachloro-Styrene (mg/kg)	PCB A-1248 (mg/kg)	PCB A-1254 (mg/kg)	PCB A-1260 (mg/kg)	2,3,7,8-TCDD (ng/kg)
84001-34	0.0220	K 0.0130	K 0.0130		K 0.1300	0.3200	K 0.1300	
84001-35	0.0130	K 0.0130	K 0.0130		K 0.1300	0.4500	K 0.1300	
84001-36	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.3600	K 0.1300	
84001-37	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.3200	K 0.1300	
84001-38	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.2700	K 0.1300	
84001-44	0.0240	K 0.0130	K 0.0130		K 0.1300	0.5800	K 0.1300	
84001-45	0.0150	K 0.0130	K 0.0130		K 0.1300	0.3000	K 0.1300	
84001-46	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.1700	K 0.1300	
84001-47	K 0.0130	K 0.0130	K 0.0130		K 0.1300	1.3000	K 0.1300	
84001-48	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.2600	K 0.1300	
84001-49	K 0.0130	K 0.0130	K 0.0130		K 0.1300	0.2800	K 0.1300	
84001-50	K 0.0130	K 0.0130	K 0.0130		K 0.1300	K 0.1300	K 0.1300	
84001-51	K 0.0130	K 0.0130	K 0.0130		K 0.1300	K 0.1300	K 0.1300	
84001-52	K 0.0130	K 0.0130	K 0.0130		K 0.1300	K 0.1300	K 0.1300	
84001-53	0.0140	K 0.0130	K 0.0130		K 0.1300	K 0.1300	K 0.1300	

J indicates an estimated value; value may not be accurate.
K indicates undetected at the detection level shown.
LH indicates the actual level may be higher due to possible low recovery.
LL indicates the actual level may be lower due to possible high recovery.
LP quality control indicates that the precision of the result may have been outside precision control limits.
PH indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been higher.
PL indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been lower.
PS indicates possible interference may have affected the accuracy of the laboratory result.
T indicates substance was found at this level, which is below detection level.
W indicates substance was not found at the lowest quantifiable level indicated.

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: White Lake
Location: Montague

Collection Date: 07/24/84

ID#	Hexachloro-butadiene (mg/kg)	Hexachloro-cyclopentadiene (mg/kg)	Octachloro-cyclopentene (mg/kg)	Pentachloro-benzene (mg/kg)	Hexachloro-ethane (mg/kg)
84001- 1					
84001- 2					
84001- 3					
84001- 4					
84001- 5					
84001-21					
84001-22					
84001-23					
84001-24					
84001-25					
84001-26					
84001-27					
84001-28					
84001-29					
84001-30					
84001-31					
84001-32					

J indicates an estimated value; value may not be accurate.
K indicates undetected at the detection level shown.
LH indicates the actual level may be higher due to possible low recovery.
LL indicates the actual level may be lower due to possible high recovery.
LP quality control indicates that the precision of the result may have been outside precision control limits.
PH indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been higher.
PL indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been lower.
PS indicates possible interference may have affected the accuracy of the laboratory result.
T indicates substance was found at this level, which is below detection level.
W indicates substance was not found at the lowest quantifiable level indicated.

ID#	Hexachloro-butadiene (mg/kg)	Hexachloro-cyclopentadiene (mg/kg)	Octachloro-cyclopentene (mg/kg)	Pentachloro-benzene (mg/kg)	Hexachloro-ethane (mg/kg)
84001-33					
84001-34					
84001-35					
84001-36					
84001-37					
84001-38					
84001-44					
84001-45					
84001-46					
84001-47					
84001-48					
84001-49					
84001-50					
84001-51					
84001-52					
84001-53					

J indicates an estimated value; value may not be accurate.
K indicates undetected at the detection level shown.
LH indicates the actual level may be higher due to possible low recovery.
LL indicates the actual level may be lower due to possible high recovery.
LP quality control indicates that the precision of the result may have been outside precision control limits.
PH indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been higher.
PL indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been lower.
PS indicates possible interference may have affected the accuracy of the laboratory result.
T indicates substance was found at this level, which is below detection level.
W indicates substance was not found at the lowest quantifiable level indicated.

FISH CONTAMINANT MONITORING PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Waterbody: White Lake
Location: Montague

IDB	Aldrin (mg/kg)		g-BHC (lindane) (mg/kg)		Heptachlor (mg/kg)		PBB (Firemaster BP-6) (mg/kg)		Terphenyl (mg/kg)	Toxaphene (mg/kg)	
84001- 1	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001- 2	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001- 3	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001- 4	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001- 5	K	0.0130	K	0.0130	K	0.0130		0.0790		K	0.0130
84001-21	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-22	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-23	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-24	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-25	K	0.0130	K	0.0130	K	0.0130		0.3900		K	0.0130
84001-26	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-27	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-28	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-29	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-30	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-31	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-32	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130

J indicates an estimated value; value may not be accurate.
K indicates undetected at the detection level shown.
LH indicates the actual level may be higher due to possible low recovery.
LL indicates the actual level may be lower due to possible high recovery.
LP quality control indicates that the precision of the result may have been outside precision control limits.
PH indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been higher.
PL indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been lower.
PS indicates possible interference may have affected the accuracy of the laboratory result.
T indicates substance was found at this level, which is below detection level.
W indicates substance was not found at the lowest quantifiable level indicated.

ID#	Aldrin (mg/kg)		g-BHC (lindane) (mg/kg)		Heptachlor (mg/kg)		PBB (Firemaster BP-6) (mg/kg)		Terphenyl (mg/kg)	Toxaphene (mg/kg)	
84001-33	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-34	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-35	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-36	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-37	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-38	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-44	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-45	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-46	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-47	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-48	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-49	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-50	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-51	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-52	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130
84001-53	K	0.0130	K	0.0130	K	0.0130	K	0.0130		K	0.0130

J indicates an estimated value; value may not be accurate.
K indicates undetected at the detection level shown.
LH indicates the actual level may be higher due to possible low recovery.
LL indicates the actual level may be lower due to possible high recovery.
LP quality control indicates that the precision of the result may have been outside precision control limits.
PH indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been higher.
PL indicates possible interference may have affected the accuracy of the laboratory result, and the actual level may have been lower.
PS indicates possible interference may have affected the accuracy of the laboratory result.
T indicates substance was found at this level, which is below detection level.
W indicates substance was not found at the lowest quantifiable level indicated.

APPENDIX 5.0
MICHIGAN'S NPDES PERMIT DEVELOPMENT
PROCEDURE

SURFACE WATER QUALITY DIVISION
PERMITS SECTION

Procedure No. 1

Title:. NPDES Permit Issuance Sequence

The NPDES permit issuance sequence below describes the several steps which must occur from the time a permit application is received until the permit is issued. The times allowed for various reviews are the best present estimates of the shortest realistic review periods. They assume a controlled rate of facilities entering the process. In other words, the response times could not be met if all permits on the expired backlog were put into the process at once. The NPDES permit issuance schedule, contained in Permits Section Procedure No. 2, explains the plan to systematically enter permits into this issuance sequence. Because of that procedure and current program plan priorities, processing of individual applications for permit reissuance may be delayed so that a controlled rate of permits enters the process. However, all new or increased use applications will be processed when received.

The following distinction is drawn between a "first draft permit", a "draft permit", and a "proposed permit" in this procedure:

"First draft permit" means the permit draft sent out for pre-public notice review under Step C-3.

"Draft permit" means the permit version which is public noticed.

"Proposed permit" means the permit version which is presented to the WRC with a recommendation to issue.

The steps in the permit issuance sequence are as follows:

A. Application Review

1. Applications are sent directly to the Permits Section by the applicants and are logged in. The appropriate Unit Supervisor will determine if the application is scheduled to be processed during the fiscal year in accordance with Procedure No. 2 and current program plan priorities. If not, the applicant will be informed under item 4(c), below.

2. If the application is to be processed, the Unit Supervisor will review it for administrative completeness. Concurrently, a copy of the application is sent to the appropriate SWQD District Office for review. The District Office has 20 days* to forward comments on the completeness and accuracy of the information in the application and to provide any additional comments on site acceptability, recommended special conditions for the permit or compliance problems that should delay permit action. District

comments should be put in writing; however, informal discussions that might expedite the process are encouraged. Note: District comments on compliance problems or site unacceptability may be followed by a division recommendation to the Water Resources Commission to deny the permit.

*All response times are in calendar days.

3. A monthly list of applications received is sent by the Permits Section secretarial staff to the Environmental Enforcement Division (EED). EED forwards comments to the Permits Section within 20 days on any enforcement actions/problems that should hold up permit action. Note: This may be followed by a division recommendation to the Water Resources Commission to deny the permit.

4. Within 30 days of receipt of the application, the Permits Section will notify the applicant as to the status of the application. The letter will state one of the following:

   a. The application is acknowledged as administratively complete and the applicant is informed that it has been assigned to the appropriate permit unit for processing. The applicant is also informed that during the processing of the permit additional information may be requested if it is deemed necessary to complete or correct deficiencies in the application. This letter starts the permit issuance "clock."

   b. The application is determined to be incomplete and the applicant is informed of the deficiencies and is requested to provide the necessary information by date certain.

   c. If, in step 1 above, the application cannot be immediately processed due to current program plan priorities, a cursory review is done to determine if sufficient information is provided for it to be considered an application for renewal. If so, a "delayed processing" letter is sent to the applicant informing him of when the permit is expected to be processed. A copy of the letter, along with the application is also sent to the district office.

B. Effluent Limit Development

1. Once the application has been acknowledged as administratively complete, the respective Unit Supervisor will review the application to determine if treatment technology-based effluent limits (TTBELs) and/or water quality based-effluent limits (WQBELs) are needed. For applications in the three industrial units, the Unit Supervisors will assign the application to their respective statewide specialists or other staff member for development of TTBELs. The appropriate technology-based recommendations will be provided by memo within 30 days, to the respective Unit Supervisor.

2. Concurrent with the development of the TTBELs, the respective Unit Supervisors will screen the application in accordance with the approved screening criteria to determine if it should be evaluated for WQBELs. The screening criteria will identify those groups of discharges that do not need formal WQBEL development because TTBELs will be more stringent or where it has been determined that standard WQBELs will be used. If it is determined that WQBELs are needed, the Unit Supervisor forwards a copy of the application, along with a WQBEL request memo indicating the request type and the priority, to the Planning & Special Programs Section-Water Quality Studies Unit. The WQBELs are due 30 days after receipt of the request memo. Note: An extra 20 days will be necessary if new low flow information is needed.

3. The completed WQBELs are forwarded to the appropriate Unit Supervisor who assigns the facility to one of his staff members for permit drafting.

C. Permit Drafting

1. The first draft permit is prepared by the unit staff member assigned to the facility within 15 days after receipt of the WQBEL and/or TTBEL recommendations. Permits Section staff will use its judgment to inform other staff members as appropriate of decisions being made during this time. For example, if the WQBEL or TTBEL recommendations require the inclusion of interim effluent limitations or compliance schedules, the Permits Section will informally review these first with the District before the draft permit is completed.

2. Upon completion of the draft permit, the permit processor prepares a Basis for Decision Memo for the permit development file. The memo indicates the reasons for the effluent limits and/or monitoring requirements being selected for inclusion into the draft permit as well as explaining any special conditions and schedules of compliance. If a recommended effluent limit or monitoring requirement is not included in the permit, the memo should state the reasons why the recommendation was not used.

3. The permit processor sends the first draft permit, along with the public notice and fact sheet (if a fact sheet is prepared), to the permittee. The first draft permit, public notice, fact sheet, and basis for decision memo are sent to the District Office and any sections which made WQBEL recommendations. EPA receives first draft permits for major dischargers only; the packet mailed to EPA should also include a copy of the application, any WQBEL or TTBEL recommendation memos, and the Basis for Decision Memo. Comments on the first draft permit are due back to the Permits Section within 20 days.

4. The Permits Section makes any needed changes to the permit and public notice/fact sheet within 10 days. Therefore, a draft permit for public notice is complete 75 days after the "clock" starts.

D. Public Notice

1. The draft permit is placed on public notice, with a public comment period of 30 days. (See Procedure #13 - Public Noticing of Permits)

2. The draft permit (with public notice and fact sheet) is sent at the same time to the permittee, the District, adjacent property owners listed in the permittee's application, and any names included on the mailing list for public notice. EPA receives a copy of the draft permit, the public notice, and the fact sheet for major dischargers only. Also, monthly lists of all permits public noticed and all permits issued are sent to EPA (these are from the monthly activity reports). For discharges to interstate waters, the draft permit and public notice is sent to any other states whose waters could be affected by the discharge.

E. Permit Issuance

1. The Permits Section resolves concerns raised during the public notice period and responds to comments received.

2. The permit processor prepares the proposed permit and WRC informational packets. The proposed permit is placed on the WRC agenda for action. (See Procedure #5 - Preparation of WRC Agenda)

3. The WRC takes action on permit issuance.

4. The approved permit document is signed by the WRC Executive Secretary. Copies of the signed original are sent to the permittee, the District Office and EPA (all permits).

F. Timing

There should be no delays in determining within 30 days whether the permit application is administratively complete. The permit issuance "clock" cannot start until the permit application is complete, because effluent limit development cannot proceed without complete information.

The permit drafting should be complete within 75 days unless new low flow information is needed or significant disagreements arise between the Department and the applicant that require additional time for negotiations. An additional 30 days are required for the public comment period.

There may be delays in the permit issuance step. This final step will take from 20 to 35 days depending upon when the public notice periods ends. (See Procedure #5 - Preparation of WRC Agenda).

Several situations could result in delays in permit issuance:

a. Based on comments received during the public notice period, the draft permit may require extensive revision. In some cases re-public noticing is needed.

b. A public hearing may be required, again depending on comments received during the public notice period.

c. The WRC could object to the permit proposed by staff.

d. The final effective date of the permit may be delayed indefinitely if a contested case hearing is granted by the WRC.

e. If EPA objects to the proposed permit and a compromise cannot be reached with DNR staff, permit issuance may be delayed for up to 180 days. In extreme cases, EPA has the authority to issue its own permit over DNR objection.

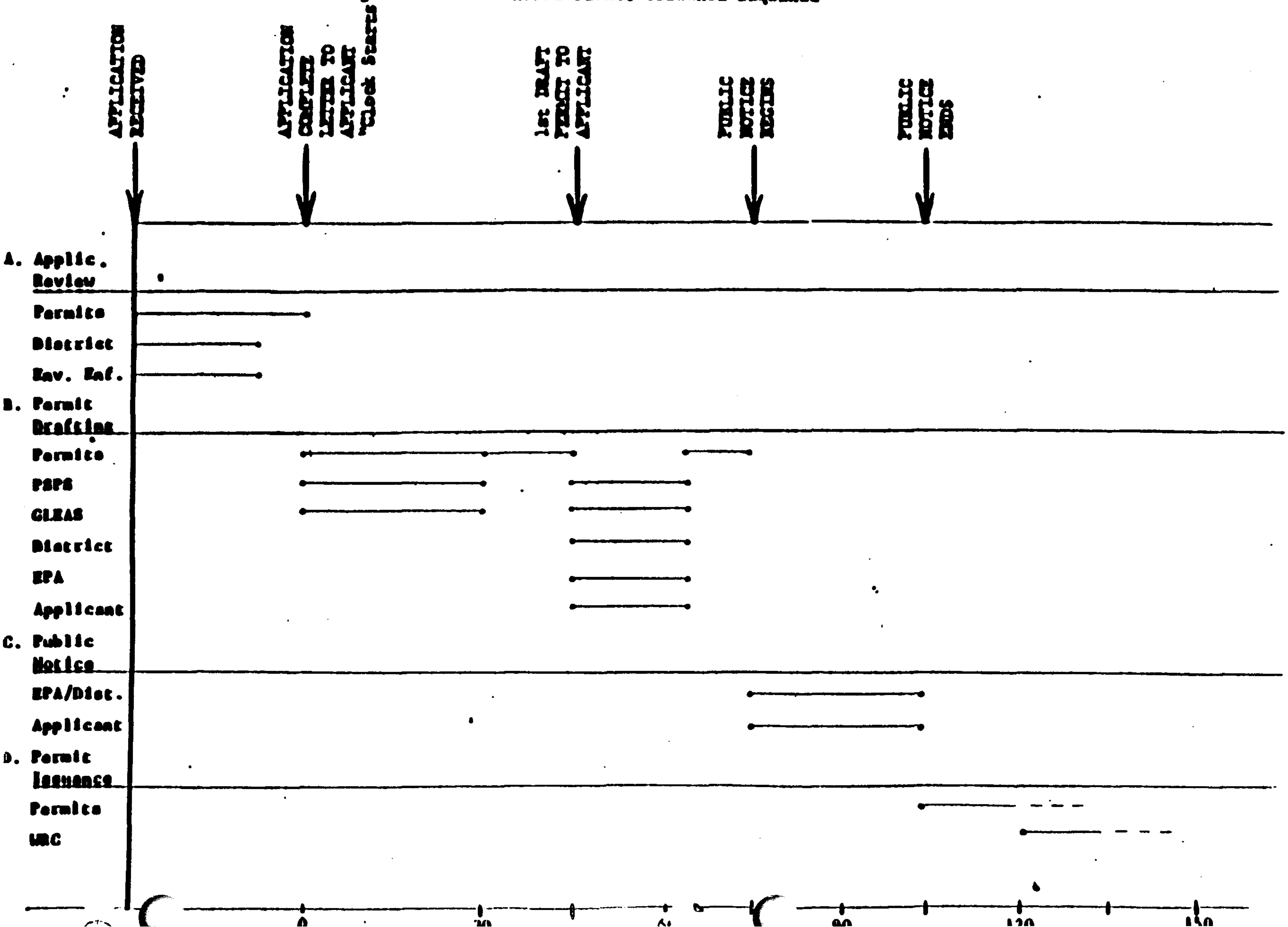
In summary, the total time from receipt of an application until issuance is approximately 180 days for a "non-controversial" permit. "Controversial" permits could, as outlined above, take much longer to issue. The permit issuance timing is represented graphically on the attached chart.

Approval:

William E. McCracken
Chief, Permits Section

November 24, 1986
Date

NPDES PERMIT ISSUANCE SEQUENCE



APPENDIX 7.1 PRIORITY LISTS FOR EVALUATION AND INTERIM RESPONSES AT SITES OF ENVIRONMENTAL CONTAMINATION PROPOSED (MDNR, 1986d)

PROPOSED PRIORITY LIST FOR EVALUATION AND INTERIM RESPONSE AT SITES OF ENVIRONMENTAL CONTAMINATION - SCORED SITES - 10/7/86

SAS Score	County and Date Scored	Common Site Name, Location Code, and Township[1]	Source of Contamination	Point of Release	Pollutant	Resource Affected	Resource Potentially Affected
0814	Muskegon 08-20-86	Whitehall Area 61-12N-17W-28AA Whitehall	Unknown	Unknown	Trichloroethane Dichloroethylene Perchloroethylene	Groundwater	Municipal Well Residential Well
0752	Muskegon 02-27-86	Muskegon Chemical 61-12N-17W-34CC Whitehall	Chem product manufacturing	Surface discharge	Dichloroethane Trichloroethylene Chlorobenzene	Surface Water Groundwater	Wetland Residential Well
0660	Muskegon 08-20-86	Tech Cast Area 61-12N-17W-29BC Montague	Unknown	Unknown	Tetrachloroethene Ethyl Benzene Benzene, Toluene	Groundwater	Surface Water
0565	Muskegon 08-19-85	White Lake LF Shellcast Area 61-12N-17W-27BB Whitehall	Landfill	Landfill	Domestic Comm Heavy manufacturing	Groundwater	Surface Water Air Soil
0498	Muskegon 09-28-84	E.I. DuPont deNemours 61-12N-18W-36AD White River	Chem product manufacturing	Barrel Landfill	Chem product manufacturing	Groundwater Soil	Surface Water Sediment Wetland Flora
0442	Muskegon 09-03-86	Res Well White Lake Dr. 61-11N-17W-04AA Fruitland	Unknown	Unknown	Benzene	Groundwater Residential Well	
0415	Muskegon 01-23-85	Hooker Chemical 61-12N-17W-31A Montague	Chem product manufacturing	Waste pile Lagoon Barrel	Chem product manufacturing	Surface Water Groundwater Soil	

B/592I/Disk #1/Doc #23

PROPOSED PRIORITY LIST FOR EVALUATION AND INTERIM RESPONSE AT SITES OF ENVIRONMENTAL CONTAMINATION - SCORED SITES - 10/7/86 (CONTINUED)

SAS Score	County and Date Scored	Common Site Name, Location Code, and Township[1]	Source of Contamination	Point of Release	Pollutant	Resource Affected	Resource Potentially Affected
0403	Muskegon 02-07-85	Muskegon Co. WMS No. 2 61-12N-17W-23DD Whitehall	Wastewater treatment	Surface discharge	Chloroethylether Chloroethoxyethane	Surface Water Groundwater, Soil Residential Well	
0292	Muskegon 08-20-86	San Juan Subdivision 61-11N-18W-01BD White River	Unknown	Unknown	Trichloroethane	Groundwater Residential Well	
0240	Muskegon 09-22-86	Howmet Corp. Plant No. 4 61-12N-17W-33DA Whitehall	Engine manufacturing	Lagoon Underground tank	Perchloroethylene Trichloroethane Chromium	Surface Water Groundwater	

Source: MDNR, 1986c

[1]The common site name represents site identification only and does not necessarily indicate a responsible party.

B/592I/Disk #1/Doc #24

PROPOSED PRIORITY LIST FOR EVALUATION AND INTERIM RESPONSE AT SITES OF ENVIRONMENTAL CONTAMINATION - SCREENED SITES - 10/7/86

SAS Screen	County and Date Screened	Common Site Name, Location Code, and Township[1]	Source of Contamination	Point of Release	Pollutant	Resource Affected	Resource Potentially Affected
08	Muskegon 10-07-85	Whitehall Leather 61-12N-17W-28CC City of Whitehall	Leather tanning	Lagoon	Light industrial	Surface Water	Groundwater Soil
06	Muskegon 08-23-85	Montague Municipal Well 61-12N-17W-29AD City of Montague	Unknown	Unknown	Trichloroethylene	Groundwater Municipal Well	
04	Muskegon 08-20-86	Res Well Holton Whitehall Rd. 61-12N-17W-25AC Montague	Unknown	Unknown	Tetrachloroethylene	Groundwater	Residential Well

Source: MDNR, 1986c

[1]The common site name represents site identification only and does not necessarily indicate a responsible party.

APPENDIX 9.0

A LISTING OF AGENCY CONTACTS AND CITIZENS INVOLVED IN THE DEVELOPMENT OF THE WHITE LAKE AREAS OF CONCERN REMEDIAL ACTION PLAN (AS OF OCTOBER 1987)

WHITE LAKE REMEDIAL ACTION PLAN

State Government Contacts

Michigan Dept. of Natural Resources

Karl Hosford Wildlife Division
6th Floor, Mason Bldg., Box 30028
Lansing, Michigan 48909
517-373-3911

Jack Bails
Fisheries Division
6th Floor, Mason Bldg., Box 30028
Lansing, Michigan 48909
517-373-3375

Tom Doyle
Fisheries Division
6th Floor, Mason Bldg., Box 30028
Lansing, Michigan 48909
517-373-6702

John Trimberger
Fisheries Division
Grand Rapids District Office 350 Ottawa NW
Grand Rapids, Michigan 49503
616-456-5071

Dave Smith
Fisheries Division
Grand Rapids District Office
350 Ottawa NW
Grand Rapids, Michigan 49503
616-456-5071

Terry Ringler
Grand Rapids Area Office
3319 Plainfield Ave., NE
Grand Rapids, Michigan 49505
616-456-2361

Rick Taszreak
Environmental Response Division
Box 30028
Lansing, Michigan 48909
517-373-8248

Roger Przybysz
Environmental Response Division
Grand Rapids District
350 Ottawa NW
Grand Rapids, Michigan 49503
616-456-5071

Ron Waybrant/Dale DeKraker
Waste Management Division
Grand Rapids District Office
350 Ottawa NW
Grand Rapids, Michigan 49503
616-456-5071

Irnie Jousma
Surface Water Quality Division
Grand Rapids District
350 Ottawa NW
Grand Rapids, Michigan 49503
616-456-5071

Denise Gruben
Environmental Response Division
Box 30028
Lansing, Michigan 49503
517-373-4807

Linn Duling
Surface Water Quality Division
Box 30028
Lansing, Michigan 48909
517-335-4188

Elwin Evans
Surface Water Quality Division
Box 30028
Lansing, Michigan 48909
517-335-4182

Diana Klemans
Surface Water Quality Division
Box 30028
Lansing, Michigan 48909
517-373-2758

Dave Kenaga
Surface Water Quality Division
Box 30028
Lansing, Michigan 48909
517-335-4314

Karen Gottlieb
Office of the Great Lakes
Box 30028
Lansing, Michigan 48909
517-373-3588

Thomas Martin
Office of the Great Lakes
Box 30028
Lansing, Michigan 48909
517-373-3588

Les Nichols
Recreational Facilities Division
Box 30028
Lansing, Michigan 48909
517-335-3588

Dan Morgan
Land and Water Management Division
Box 30028
Lansing, Michigan 48909
517-335-3183

Jack Butterfield
Parks Division Box 30028
Lansing, Michigan 48909
517-373-1270

Marlene Liestico
Geological Survey Division
Grand Rapids District
350 Ottawa NW
Grand Rapids, Michigan 49503
616-456-5071

Mike Cote
Geological Survey Division
Box 355
Plainwell, Michigan 49080
616-685-6851

Larry Karnes
Department of Transportation
Marine Transportation Planning Unit
State Transportation Building, Box 30050
Lansing, Michigan 48909
517-373-9058

James R. Bernard
Great Lakes & Water Resources
Planning Commission
Box 30028
Lansing, Michigan 48909
517-373-0014

Henry H. Webster
Forest Management Division
Box 30028
Lansing, Michigan 48909
517-373-6346

JoAnn Merrick
Environmental Enforcement
Box 30028
Lansing, Michigan 48909
517-373-3503

Jill Koebbe
Air Quality Division
Grand Rapids District
350 Ottawa, N.W.
Grand Rapids, Michigan 49503
616-456-5071

Jim Heinzman
Geological Survey Division
Secondary Complex
P.O. Box 30028
Lansing, Michigan 48909
517-322-1300

Michigan Dept. of Public Health

Harold Humphreys
3500 N. Logan
P.O. Box 30035
Lansing, Michigan 48909
517-335-8350

John Hesse
3500 N. Logan
P.O. Box 30035
Lansing, Michigan 48909
517-335-8350

David Timm
3500 N. Logan
P.O. Box 30035
Lansing, Michigan 48909
517-335-9186

Jan Koehler
3500 N. Logan
P.O. Box 30035
Lansing, Michigan 48909

NON-STATE GOVERNMENT CONTACTS

Muskegon County

Ted Baran
Environmental Health Sanitarian
1611 E. Oak Avenue
Muskegon, Michigan 49443
616-724-6244

Mike Vander Hauvel
Muskegon County Health Dept.
1611 E. Oak Avenue
Muskegon, Michigan 49443
616-724-6208

Dick Maher
County Planner
990 Terrace Street
Muskegon, Michigan 49443
616-724-6446

Dave Fisher
Muskegon County Dept. of Public Works
990 Terrace Street
Muskegon, Michigan 49443
616-724-6411

Frank Bednarek
Muskegon County Bldg.
990 Terrace St.
Muskegon, Michigan 49443
616-724-6211

Muskegon County Library
635 Ottawa
Muskegon, Michgian 49443

<u>City of Montague</u>

Mr. John Eilers
Superintendent
City of Montague
4525 Dowling St.
Montague, Michigan 49437

893-1155

Mayor B. Wayne Gillan
4848 Whitney Street
Montague, Michigan 49437

<u>City of Whitehall</u>

Mayor Else M. Anderson
City of Whitehall
405 East Colby
Whitehall, Michigan 49461-1101

Mr. David Boehm
City Manager
City of Whitehall
405 E. Colby
Whitehall, Michigan 49461-1101

Township Supervisors

Mr. David Johnson
Supervisor
Township of Whitehall
2904 Benston Rd.
Whitehall, Michigan 49461

Mr. Roger L. Simon
Supervisor
Township of Montague
8915 Whitbeck Rd.
Montague, Michigan 49437

Mr. Robert C. Wachernagel
Supervisor
Fruitville Rd.
Montague, Michigan 49437

U.S. Department of Agriculture

Greg Mund
Soil Conservation Service
940 Van Eyck Street
Muskegon, Michigan 49442
616-788-3492

U.S. Environmental Protection Agency - Region V

Pranus Pranckevicius
Great Lakes National Programs Office
230 S. Dearborn St.
Chicago, Illinois 60604
312-353-3612

Tom Glatzel
Water Division
WQA TUB 8 USEPA
230 S. Dearborn
Chicago, Illinois 60604

U.S. Army Corps of Engineers

Carol Deboise
Detroit District
Army Corps of Engineers
Box 1027
Detroit, Michigan 48231
616-788-3492

Pam Bedore
Detroit District
Army Corps of Engineers
Box 1027
Detroit, Michigan 48231

Mark Grazioli
Detroit District
Army Corps of Engineers
Box 1027
Detroit, Michigan 48231

U.S. Fish & Wildlife Services

Bob Pacific
East Lansing Field Office
1405 S. Harrison Rd.
East Lansing, Michigan 48823
517-337-6650

Margaret Kolar, Acting Field Supervisor
East Lansing Field Office
1405 S. Harrison Road
East Lansing, Michigan 48823
517-337-6650

Tim Kubiak
East Lansing Field Office
1405 S. Harrison Road
East Lansing, Michigan 48823
517-337-6650

Dave Best
East Lansing Field Office
1405 S. Harrison Rd.
East Lansing, Michigan 48823
517-337-6650

U.S. Coast Guard

Muskegon Lake
616-759-8581

International Joint Commission

John Hartig
Regional Office
Winsor, Ontario, Canada
313-226-2170

Great Lakes Fishery Commission

Carol Fetterolf, Exec. Sec.
1451 Green Road
Ann Arbor, Michigan 48105
313-763-3515

Dave Jude
Great Lakes Research Division
University of Michigan
2200 Bonisteel Boulevard
Ann Arbor, Michigan 48109
313-763-3515

Muskegon Conservation Club

Laurie Wasserman
3061 Idlewind Road
Muskegon, Michigan 49441
616-759-0546

Charles Rowdebush
160 Lakeshore Blvd.
Muskegon, Michigan 49441
616-737-2287

Michigan United Conservation Club

Carol Favero
Resource Specialist
P.O. Box 30235
Lansing, Michigan 48909

Mr. Steve Houseal
National Wildlife Federation
802 Monroe
Ann Arbor, Michigan 48104
313-769-3351

Muskegon Sport Fishing Association

C.C. Billinghurst
909 Tostenabe Lane
N. Muskegon, Michiggan 49445
616-744-1210

Muskegon Steelhead & Salmon Fishing Association

Stanley Peterson
1076 Francis Ave.
Muskegon, Michigan 49442
616-773-8258

W. Michigan Dive Center

Mark Hansen
2367 W. Sherman Blvd.
Muskegon, Michigan 49441
616-755-3771

<u>N. Branch Boat & Canoe Livery</u>

Larry De Con
400 Causeway
N. Muskegon, Michigan 49445
616-744-1119

Tom Hamilton
8770 Indian Bay Rd.
Montague, Michigan 49437
616-893-2175

John Koches
W. Michigan Shoreline Regional
Development Commission
137 Muskegon Mall
Muskegon, Michigan 49440-1192
616-722-7878

Kurt Lindland
Center for Great Lakes
435 N. Michigan
Suite 1408
Chicago, Ill 60611

Cameron Davis
Lake Michigan Federal
8 South Michigan Avenue, Suite 2010
Chicago, Illinois 60603
313-263-5550

Cindy Hughes
Science Application International Corporation
8400 Westpartk Drive
McLean, Virginia 22102
713-821-4711

Shari Schaftlein
West Michigan Environmental Action Council
1432 Wealthy, S.E.
Grand Rapids, Michigan 49506
616-451-3051

Dick Olsen
City of Grand Rapids
Chief Air Pollution
Grand Rapids, Michigan 49506
616-456-3148

Carla Bates
League of Women Voters
435 Mitzi St.
Muskegon, Michigan 49445
616-459-1504

Toby Dolinka
Center for Environmental Study
143 Bostwick, NE
Grand Rapids, Michigan 49503
616-456-4848

Brad Miller
Senator Riegle's Office
716 Federal Bldg.
110 Michigan Avenue, N.W.
Grand Rapids, Michigan 49503
616-456-2592

Joe Landis, V.P. of Region 8
Michigan Lakes and Streams
1642 Walnut Heights Drive
East Lansing, Michigan 48823
517-882-7399

Michigan House 96

M.L. Mickey Knight (R-Muskegon)
1450 Leaky St.
Muskegon, Michigan 49442
517-373-2646

Michigan Senate 33

Phil Arthurhultz (R-Whitehall)
6044 Murray Rd.
Whitehall, Michigan 49461
517-373-1635

U.S. Congress 9

Guy Vander Jagt
2409 Rayburn Bldg.
Washington, DC 20515

Jim Gibson and/or Karen Delaney
Rep. Guy Vander Jagt's Office
950 W. Morton Ave.
Muskegon, Michigan 49441
616-733-3131

Companies

E.I. duPont deNemours and Company
Plant Manager
Lamos and Wilkes Road
P.O. Box A
Montague, Michigan 49437

Howmet Turbine Components
Plant Manager
C & C Division
555 Benston Road
Whitehall, Michigan 49461

Mr. William Dodson
Howmet Turbine Components
Whitehall Castings Division
Misco Drive
Whitehall, Michigan 49461

Mr. Dave Martineze
Occidental Chemical Corp.
P.O. Box 295
Old Channel Trail
Montague, Michigan 49437

Mr. Norbert Woellhaf, Plant Manager
Whitehall Leather Company
900 S. Lake Street
Whitehall, Michigan 49461

<u>Individuals and Environmental Groups</u>

Don Winne
11262 Oak Ave.
Three Rivers, Michigan 49093
616-244-5336

Ken Sherburn
Muskegon Nature Club
1287 Peterson Rd.
Muskegon, Michigan 49445
616-744-9886

Mr. Greg Means
Editor
White Lake Beacon
116 S. Division
Whitehall, Michigan 49461

Mr. Dave Sheehan
WOTV CHANNEL - 8
120 College, S.E.
P.O. Box B
Grand Rapids, Michigan 49501
616-456-8888

John Lansing
WWMT TV - 3
280 Ann Street N.W.
Grand Rapids, Michigan 49504
616-388-3333

Rob Sanford
WWMT TV - 3
280 Ann Street, N.W.
Grand Rapids, Michigan 49504
616-784-4200

Mr. Jack Hogan
WZZM TV - 13
645 3-Mile Road, N.W.
Grand Rapids, Michigan 49510
616-784-4200

Mr. Ken Kolbe
WZZM TV - 13
645 3-Mile Road, N.W.
Grand Rapids, Michigan 49501
616-784-4200

Mr. Bill Betts
WZZM TV - 13
645 3-Mile Road, N.W.
Grand Rapids, Michigan 49501
616-784-4200

Mr. Dave Lorenz
WAVX - FM - 98.3 - THE WAVE
1826 Ruddiman Ave.
North Muskegon, Michigan 49445
616-744-2423

Mr. Tim Walters
WKBZ RADIO
592 Pontaluna Road
Muskegon, Michigan 49444
616-798-2141

Mr. Tim Breed
WGHN
P.O. Box 330
Grand Haven, Michigan 49417
616-842-8110
Mr. Bill Shoup
WABM - FM/WKJR - AM
6083 Martin Road
Muskegon, Michigan 49445
616-798-2115

Ms. Ann Vandermyde
WMUS FM/AM THE MUSIC STATION
517 West Giles Road
Muskegon, Michigan 49445
616-744-1671

Ms. Pam Roberts
WQWQ STERIO/WTRU SUNNY FM
873 Summit Avenue
Muskegon, Michigan 49444
616-798-2245

Ms. Connie Tripp
WCXT - FM
11 Diane Avenue
Muskegon, Michigan 49442
616-728-5333

Mr. Bob Burns
Muskegon Chronicle
Main Office 981-3
Muskegon, Michigan 49443
616-722-3161

Mr. John Steveson
Muskegon Chronicle
Main Office 981-3
Muskegon, Michigan 49443
616-722-3161

Mr. Dave Kolb
Muskegon Chronicle
Main Office 981-3
Muskegon, Michigan 49443
616-722-3161

The Honorable Carl Levin
Senate Office Bldg.
Washington, DC 20515

Mr. Lee Kernen
Chief of Great Lakes
Boundary Water & Great Lakes - DNR
P.O. Box 7921
Madison, Wisconsin 53707
608-266-2277

Dr. Dan Brazo - DNR
U.S. Naval Armory
Michigan City, Indiana 46360
219-879-8391

Dr. William Eger, Director
Intertribal Fisheries &
Assessment Program
206 Greenough St.
Sault Ste. Marie, Michigan 49783
906-632-6896

Mr. Richard Hess
Program Manager
Illinois Dept. of Conserv.
100 W. Randolph, Suite 4-300
Chicago, Illinois 60601
312-917-2070

Mr. Michael G. Walsh
Muskegon Chronicle
981 Third St., Box 59
Muskegon, Michigan 49443
616-722-3161

Mr. John R. Campbell
Muskegon Court House
County Commission
990 Terrace
Muskegon, Michigan 49440
616-773-9131

Mr. Mark S. Hill
7829 Cook St.
Montague, Michigan 49437

Mr. Greg Boughton
P.O. Box 62
Whitehall, Michigan 49461

Mr. Ken Mahoney
8029 Old Channel Trail
Montague, Michigan 49437

S. Hain
4214 W. White Lake Dr.
Whitehall, Michigan 49461

Mr. Ernie Stacy
7885 Whitehall Rd.
Whitehall, Michigan 49461

Mr. Clarence Highway
7504 Carefree Dr.
Whitehall, Michigan 49461

Ms. Evelyn E. White
4383 South Shore Dr.
Whitehall, Michigan 49461

Mr. Clark White
4383 South Shore Drive
Whitehall, Michigan 49461

Mr. K.J. Linton
2653 Fruitvale Rd.
Montague, Michigan 49437

Mr. Tim Westman
Rt. #2
Muskegon, Michigan 49446

Mr. Charles (Carl) Dentai
215 S. Division
Whitehall, Michigan 49461

Mr. Clark Rager
9049 Cook St.
Montague, Michigan 49437

B. Wayne Gillan D.D.
4848 Whitney
Montague, Michigan 49437

Ms. Jean E. Oliniski
304 S. Division #2
Whitehall, Michigan 49461

A.D. Engstrom M.D.
219 Country Rd.
Whitehall, Michigan 49461

B. Wiseley
4908 Bluff Rd.
Whitehall, Michigan 49461

J. Cousino
McFall Drive
Montague, Michigan 49437

R.E. Pikin
Box 69
Whitehall, Michigan 49461

Mr. Fred Loy
4752 Bluff Road
Whitehall, Michigan 49461

Ms. Rose Flynn
5505 Post Rd.
Montague, Michigan 49437

Mr. Paul Lukanu
5546 Channel View Dr.
Whitehall, Michigan 49461

Mr. Roger Holmstrom
7752 Old Channel Trail
Montague, Michigan 49437

Mr. Mike Bronsink
5912 Southshore
Whitehall, Michigan 49461

Mr. Tim Crawford
1869 Forest Park
Muskegon, Michigan 49441

Frances Nesbit
216 E. Alice
Whitehall, Michigan 49461

Mr. Tim Martin
7255 Blueberry Ridge Dr.
Montague, Michigan 49437

Mr. Stan Buxton
114 E. main
Whitehall, Michigan 49461

Mr. Bob Witte
Route # 1
Montague, Michigan 49437

Mr. Rick Hain
5858 Ducklane Rd.
Whitehall, Michigan 49461

Ms. Susan Lloyd
6907 Old Channel Trail
Montague, Michigan 49437

Mr. John Breuker Jr.
8042 Old Channel Trail
Montague, Michigan 49437

Mr. Bruce Krueger
4851 Dowling
Montague, Michigan 49437

Mr. Joe Landis
1642 Walnut Heights Drive
East Lansing, Michigan 48823

Ms. Ruth J. Galbreath
520 E. Hanson
Whitehall, Michigan 49461

Mr. Nimen G. Ullman
Box 52
524 E. Colby
Whitehall, Michigan 49461

Mr. Joseph Vihtelic
5900 Lamos Rd.
Whitehall, Michigan 49461

Mr. Thomas E. Hamilton
2785 Weesies Road
Montague, Michigan 49437

Gail & Gary Bohling
420 Spring Valley Lane
Whitehall, Michigan 49461

Ms. Mary McGee
6158 Murray Rd.
Whitehall, Michigan 49461

Ms. Maxine Cobb
5542 Channel View Dr.
Whitehall, Michigan 49461

Mr. and Mrs. Arland Newkirk
5530 Channel View Drive
Whitehall, Michigan 49461

Omel Hopkins
5490 Channel View Drive
Whitehall, Michigan 49461

R. Burns
2445 Hadden
Muskegon, Michigan 49441

R. Storm
208 S. Lake Street
Whitehall, Michigan 49461

R.C. Potter
5440 S. Shore Drive
Whitehall, Michigan 49461

H.L. Potter
5424 S. Shore
Whitehall, Michigan 49461

H.S. Santeford
8039 Old Channel Trail
Montague, Michigan 49437

R. Pitylof
603 Gibbs
Whitehall, Michigan 49461

Ms. Lynn L. Glaser
6900 Hill Street
Whitehall, Michigan 49461

J. Weesies
10132 Walsharp
Montague, Michigan 49437

Mr. Jim O'Brien
400 Mill Pond Rd.
Whitehall, Michigan 49461

Ms. Edna K. Blomdahl
115 W. Slocum
Whitehall, Michigan 49461

Mr. Greg Means
212 N. Baldwin
Whitehall, Michigan 49461

Mr. Robert C. Wackernagel
Fruitvale Road
Montague, Michigan 49437

Mr. Frank J. Oliniski
5000 S. Shore
Whitehall, Michigan 49461

Ms. Shari Schaftlein
West Michigan Environmental
Action Council
1432 Wealthy SE
Grand Rapids, Michigan 49506

Mr. Steve Britton
681 Lake Forest Ln Apt - 12
Muskegon, Michigan 49441

A. Winton Dahlstrom
116 E. Spring
Whitehall, Michigan 49461

Mr. Roger L. Simon
5800 Hancock
Montague, Michigan 49437

Ms. Edna K. Blomdahl
115 W. Slocum
Whitehall, Michigan 49461

Thomas E. Hamilton
2785 Weesies Road
Montague, Michigan 49437

Mr. Keith Griffin
9200 Dicey
Montague, Michigan 49437

Mr. Richard Parmer
5340 Anderson
Montague, Michigan 49437

Mr. & Mrs. Karl Schmitt
P.O. Box 384
Whitehall, Michigan 49461

Mr. & Mrs. Adolph P. Bushnick
119 Sunset Drive
Whitehall, Michigan 49461

Lloyd & Peggy Salacina
1654 Gardner Ave.
Newaygo, Michigan 49337

Mr. Charles O'Connell
220 S. Livingston
Whitehall, Michigan 49461

Ms. Sally Churchill
2101 Wood Street
P.O. Box 30235
Lansing, Michigan 48909

Mr. Ken Cabala
316 Lewis Street
Whitehall, Michigan 49461

Ms. Shelley Gleason
1242 W. Michillinda
Muskegon, Michigan 49445

Clarence Capek
5501 S. Shore Drive
Whitehall, Michigan 49461

Mr. Greg Boughton
5572 S. Shore Drive
Whitehall, Michigan 49461

Mr. Mark Hill
7829 Cook Street
Montague, Michigan 49437

Mr. Paul A. Carlson
4894 Hancock
Montague, Michigan 49437

Mr. John Dyer
P.O. Box 304
Montague, Michigan 49437-0272

Ms. Sue Herman
1837 Wyngarden Lane
East Lansing, Michigan 48823

Ms. Renee Feichtenbiner
West Michigan Env'tl Action Council
1432 Wealthy SE
Grand Rapids, Michigan 49506
616-451-3051

Ms. Arlene Esch
Muskegon Health Dept.
1611 Oak Ave.
Muskegon, Michigan 49442-2499
616-724-6311

Mr. Andrew Dumsch
14932 Old Millpond Road
Big Rapids, Michigan 49307

Mr. Ray A. Capek
2565 Michillinda
Whitehall, Michigan 49461

Ms. Eloise Baxter
4731 S. Shore Drive
Whitehall, Michigan 49461

Mr. Mike Skinner
712 S. Livingston Street
Whitehall, Michigan 49461

Mr. Darren Otto
306 Peach Street
Whitehall, Michigan 49461

Mr. Eric Pentland
7520 Easy Street
Whitehall, Michigan 49461

Mr. Mark Huber
932 S. Livingston Street
Whitehall, Michigan 49461

Mr. David Peabody
6002 S. Shore Drive
Whitehall, Michigan 49461

Mr. Mike Dawson
9232 Brookwood Circle
Montague, Michigan 49437

Ms. Charlotte Runnells
214 Woodside, N.E.
Grand Rapids, Michigan 49503

Mr. and Mrs. Chester Tchozewski
8712 Grant Street
Montague, Michigan 49437

Mr. Andrew P. Bonczyk
Route #1
P.O. Box 318
New Era, Michigan

Mr. Roy Wheeler
Muskegon County Emergency Service
Muskegon County Building
Muskegon, Michigan 49442

Mr. and Mrs. John Forester
410 E. Foster
Ludington, Michigan 49431

Mr. James Luttrull
8679 Meade Street
Montague, Michigan 49437

Mr. Charles Peabody
6002 S. Shore Drive
Whitehall, Michigan 49461

Mr. Eugene A. Roder
6008 S. Shore Drive
Whitehall, Michigan 49461

Mr. Bryon Anderson
7278 Pauline
Montague, Michigan 49437

Mr. Joseph Ferguson
603 E. Lewis Street
Whitehall, Michigan 49461

Ms. Shelley Gleason
6654 Blank Street
Whitehall, Michigan 49461

Mr. Jeffrey Bartholomy
WW Engineering and Science
P.O. Box 146
Montague, Michigan 49437

Mr. Clarence Capek
5501 S. Shore Drive
Whitehall, Michigan 49461

Mr. Paul Tomandl
17588-B Parkwood Drive
Spring Lake, Michigan 49456

APPENDIX 9.1 SURVEY FORM MDNR NONPOINT SOURCE ASSESSMENT

(MDNR, 1985a)

Date_____

Division_____

District or Region_____

NONPOINT WATERSHED INVENTORY DATA SHEET

WATERSHED NUMBER	WATERSHED NAME	ARE WATERS SIGNIFICANTLY IMPACTED FROM NONPOINT SOURCES (circle one)	LIST SPECIFIC SURFACE WATERS (streams, lakes, impoundments and Great Lakes) IMPACTED	IF WATERS IS AN IMPACT, LIST EFFECT(S) FROM TABLE A	IF WATERS IS AN IMPACT, LIST SOURCE(S) FROM TABLE B	IF WATERS IS NPS IMPAIRMENT, GIVE RELATIVE CONTRIBUTION PERCENTAGE (0,10,20,30, etc.) FOR EACH OF THE SOURCES INDICATED BELOW. POINT SOURCES	AGRICULTURE	URBAN	COMBINED SEWER OVERFLOWS	ARE WATERS LIKELY TO BE [illegible] (CIRCLE ONE)
		YES NO UNKNOWN	1. 2. 3. 4. 5.							YES NO UNKNOWN
		YES NO UNKNOWN	1. 2. 3. 4. 5.							YES NO UNKNOWN
		YES NO UNKNOWN	1. 2. 3. 4. 5.							YES NO UNKNOWN
		YES NO UNKNOWN	1. 2. 3. 4. 5.							YES NO UNKNOWN