Volume 1 - Report

Engineering Report

PENNSYLVANIA COASTAL ZONE MANAGEMENT PROGRAM

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

SEPTEMBER 1996
Project: 2758-001

CZM Project No.: CZ1:94.06PE

A REPORT OF THE PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION TO THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION PURSUANT TO NOAA AWARD NO. - NA47OZ0248

This project was financed through a Federal Coastal Zone Management Grant from the Pennsylvania Department of Environmental Protection with funds provided by the National Oceanic and Atmospheric Administration (NOAA). The views expressed herein are those of the author(s) and do not necessarily reflect the view of NOAA or any of its subagencies.

MALCOLM PIRNIE

ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

PENNSYLVANIA COASTAL ZONE MANAGEMENT PROGRAM

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WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

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1.0 INTRODUCTION

The Pennsylvania Lake Erie Watershed covers 330 square miles; has 14 large subwatersheds and more than 500 individual drainage areas; and encompasses all or portions of 25 municipalities, including 10 coastal municipalities, within Erie County, Pennsylvania.

The Coastal Zone Act Reauthorization Amendments, Section 6217, require that states with coastal programs develop a Coastal Nonpoint Source Control Program (CNPCP). Water quality information for watersheds within the federally assigned CNPCP management areas is needed to help quantify the effects of nonpoint source pollutants on coastal water, identify particular parameters of concern, and establish appropriate baseline conditions for future effectiveness monitoring of management measure implementation.

The Erie County Department of Planning (ECDP), in conjunction with the Pennsylvania Department of Environmental Protection (DEP - previously known as Department of Environmental Resources), Division of Coastal Programs and the Erie County Health Department (ECHD) retained Malcolm Pirnie, Inc. to conduct a water quality survey to be used as a baseline for the Lake Erie Watershed. This survey focuses on the Elk Creek, Walnut Creek, and Twelvemile Creek subwatersheds, which together comprise approximately 44.5 percent of the entire watershed that discharges to Lake Erie in the commonwealth of Pennsylvania.

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2.0 DESCRIPTION OF STUDY AREA

The study area is comprised of the following three creek subwatersheds:

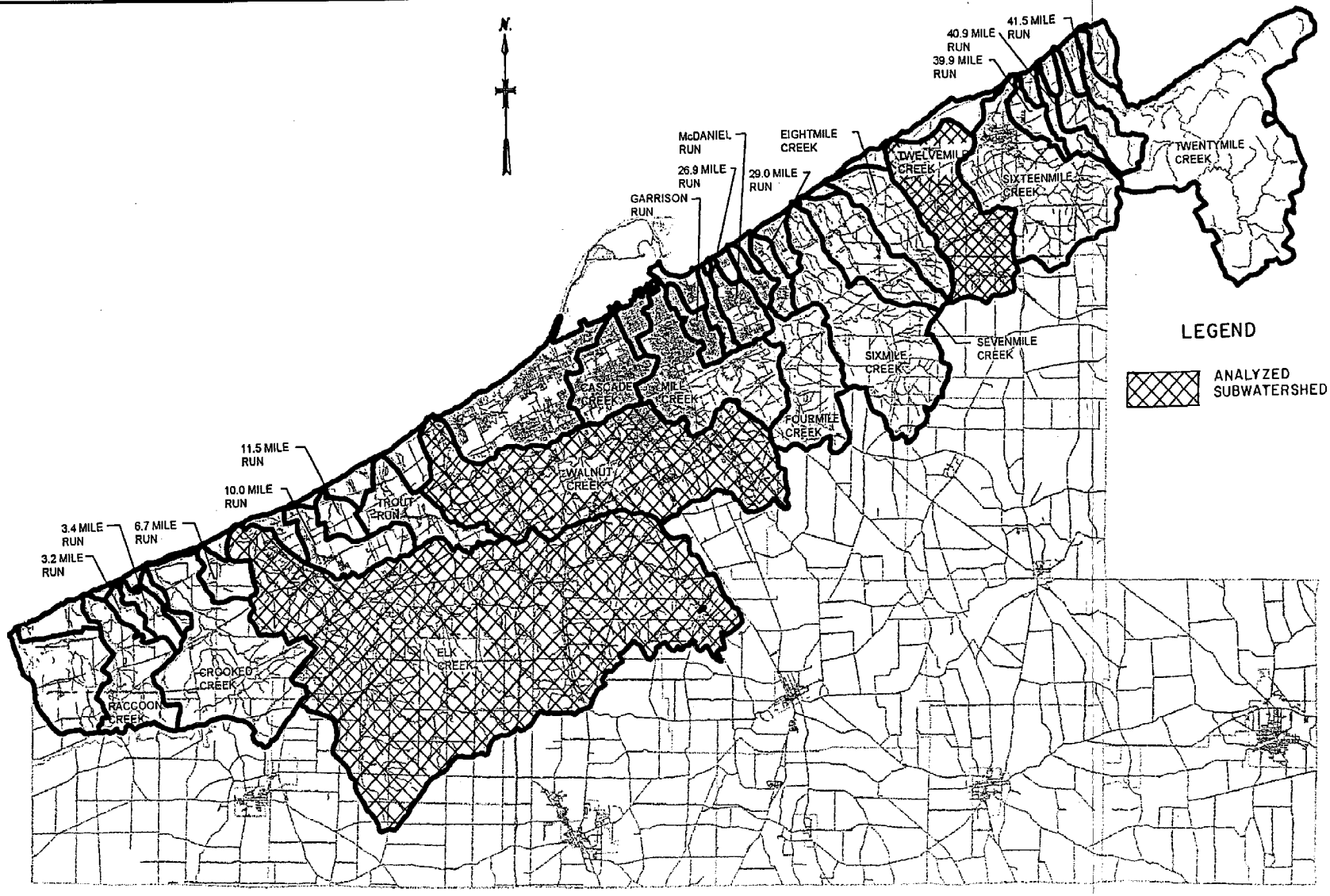
- Twelvemile Creek
- Walnut Creek
- Elk Creek

Presented on Figure 2-1 is a map showing the approximate location of the Twelvemile Creek subwatershed boundary. This creek begins south of Route 17 and travels north towards the township of North East. Flow is then northwesterly until discharging into Lake Erie north of the Route 5 crossing. Based on a review of the Erie County Land Cover / Land Use : 2nd Rendition Draft drawing, loaned to Malcolm Pirnie by the ECDP, this creek travels mostly through agricultural cropland and forested areas. A few "agricultural: other" and "urban: mixed" areas are also located in the proximity of the creek. One area east of Haskell Road and south of Route 20 is identified on the land use map as being "urban: industrial commercial complexes".

Presented on Figure 2-1 is also the approximate locations of the Walnut and Elk Creek subwatershed boundaries. Walnut Creek begins south of Route 90 near Old Waterford Road. This creek travels west, passing just north of the Millcreek Mall area and continuing to Fairview Township where the creek turns north and flows towards Lake Erie. The Erie County Land Cover / Land Use : 2nd Rendition Draft drawing indicates that this creek travels mostly through agricultural cropland and forested areas. There are also some "agricultural: other", "urban: mixed" and "urban: residential" areas located in the proximity of the creek. Two areas are identified as "urban: industrial commercial complexes". One is located near the Millcreek Mall area and the second is a small area near the Route 97 crossing. A tributary creek also appears to pass through an industrial commercial complex area that is bound by Routes 90 and 19, Hamot Road and Keystone Drive.

Elk Creek, the largest of the subwatersheds studied, begins in Waterford Township south of South Hill Road and east of Tamarack Road. The creek flows northwesterly until crossing Elk Creek Road, where the creek heads west. Elk Creek flows west through McKean and Fairview Townships before turning north when entering Girard Township at

FIGURE 2-1



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2758-SUBW

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED
SUBWATERSHED BOUNDARIES

COUNTY OF ERIE, PA SEPTEMBER 1996

approximately the Route 90 crossing. The creek discharges to Lake Erie after passing under Route 5. Major portions of this creek pass through agricultural cropland and forested areas. "Agricultural: other" land use designations are more prevalent along this creek than the other two. Limited "urban: mixed" areas and very few industrial commercial complexes are located in the proximity of Elk Creek, according tho the land use drawing. Elk Creek does pass to the west of two urban residential areas, namely Girard and Lake City Boroughs.

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3.0 HISTORICAL DATA / RELEVANT EXISTING INFORMATION

In July 1995, Malcolm Pirnie gathered historical relevant water quality information for Elk, Walnut, and Twelvemile Creeks at the ECHD. Several biological/chemical studies/surveys, Storm Water Management Plans, and water quality analyses were performed on the creeks. Listed below are summaries of studies reported for each of the creeks.

The Pennsylvania Department of Environmental Resources (DER) changed their name in June, 1995 to the Pennsylvania Department of Environmental Protection (DEP). In this section, when referring to historical information the regulatory agency will be referred to as the DER.

Elk Creek

- A November 10, 1971 study was performed by the DER and ECHD to determine the effects of wastes from the Lake City Sewerage Treatment Plant (STP) on water quality and aquatic life in Elk Creek. Two sampling stations were utilized in this study; one directly upstream and one directly downstream from the STP discharge to Elk Creek. Water quality was based on a single non-composite grab sample at each station. Benthic macroinvertebrates were also collected. The study concluded that water quality conditions upstream and downstream of the STP were good to excellent. However, a depression of benthic macroinvertebrate diversity along the right downstream bank indicated that the effluent had stratified. A strong chlorine odor indicated that chlorine residual was the cause of this depression. The study recommended that the Sanitary Engineer at the Meadville Regional Office of the DER contact the Lake City STP operator in order to determine if less chlorine could be used to achieve desired results.
- Results of a second DER and ECHD study were presented in a December 13, 1979 report. The study was conducted to investigate the influence of the Lake City and Girard STPs on Elk Creek's water quality. Grab samples were collected for chemical and bacteriological analyses at four Elk Creek stations: 1) Station #1 - upstream of the Girard STP outfall, 2) Station #2 - just below the Girard STP outfall and well

above the Lake City STP outfall, 3) Station #3 - well below the Girard STP outfall and just above the Lake City STP outfall, 4) Station #4 - below the Girard and Lake City STP outfalls on the north side of Route 5. The study concluded that all of the parameters tested for met DER Chapter 93 water quality standards and that there was not a serious water quality problem.

- In November 1982, the DER Bureau of Water Quality Management generated a report to justify effluent limitations for the Lake City and Girard STPs into Elk Creek. The report recommended using effluent limits determined using the EPA-DER Simplified Method instead of the 1980 NPDES issued permit limits. The EPA-DER method yielded a BOD_5 limit of 30 ppm and the 1980 NPDES permit set the BOD_5 limit at 30 ppm.

Walnut Creek

- A March 28, 1972 biological/chemical study was conducted by the ECHD to record water quality, stream conditions and determine the discharge effects from various upstream STPs on the water quality and aquatic life of Walnut Creek. Ten sampling stations were established on Walnut Creek from Zwilling Road downstream to Dutch Road. Chemical, bacteriological, and benthic macroinvertebrate samples were collected. The study concluded that, in general, water quality and stream conditions for the creek were good. However, a slight degradation existed from Millfair Road upstream to Zuck Road. In this section of the creek, macroinvertebrate species diversity was low. There was also a slightly elevated Biochemical Oxygen Demand (BOD_5) level of 3.5 compared to upstream (Rt. 19) and downstream (Zimmerly Road) BOD_5 levels of 1.0; possibly due to discharges from individual septic systems in this section. Additional sampling was recommended.
- On August 21, 1972, the ECHD performed a biological/chemical/bacteriological study to record existing water quality conditions and determine the effects of various discharges to Walnut Creek. Ten sampling stations were established on Walnut Creek from Zwilling Road downstream to Dutch Road. Macroinvertebrate and fish samples were collected at each of the ten stations. Seven chemical and eight bacteriological

samples were also collected. The study concluded that there was a problem area extending from Robison Road downstream to below Old French Road. Aquatic life was degraded in this region. The degradation was attributed to leachate discharges from the Jennings Landfill. Also, partially treated discharges from a malfunctioning Holiday Inn sewage treatment plant had been released into this section of Walnut Creek for a three week period prior to sampling. A fecal coliform count in excess of 2,000 was recorded at Zuck Road; possibly due to a large number of bathers present in a pool area directly upstream from the sampling point. The remaining seven stations exhibited little or no degradation of aquatic life. Chemical analysis at these stations was fair to good with the exception of the following fecal coliform counts; Dutch Road - 750 / 100 ml, Zimmerly Road and Cherry Street - 490 / 100 ml. No additional actions were recommended.

- Another study was conducted by the ECHD on February 6-9, 1973, to record existing water quality conditions, determine the effect of leachate from Jennings Landfill on Walnut Creek, locate existing or potential pollution problems, and to evaluate the extent to which STP effluent affected water quality. Twelve sampling stations were established from Zwilling Road to Dutch Road. Conclusions from the study indicated that water quality ranged from poor at Robison Road to very good at Dutch Road. Poor water quality was detected at Robison Road where leachate discharges from Jennings Landfill were suspected. Creek data at this location indicated elevated BOD_5 (4 mg/l), total iron (0.77 mg/l), NO_3-N (0.71 mg/l), and suspended solids (18 mg/l) compared with data collected from other sample locations in the study. Degradation in water quality near Cherry Street and Old French Road may have been influenced by a malfunctioning Holiday Inn sewage treatment plant. The study recommended stopping unpermitted leachate discharges from Jennings Landfill and closely monitoring permitted discharges. The study also recommended upgrading STPs that discharge to Walnut Creek in violation of their permits or the removal of these STPs.
- The ECHD also conducted a biological/chemical survey on June 24, 1976, to record existing water quality conditions and determine the effects of Jennings Landfill

leachate on Walnut Creek. Three sampling sites were selected on the creek and five additional discharge points were sampled. The five discharge points consisted of three tributaries to Walnut Creek located near Jennings Landfill, a discharge pipe from Popp's Trailer Court Sewage Plant, and at the end of the chlorine contact tank at the Standard Trailer Court Sewage Plant. Conclusions from the study indicated that during wet weather, discharge points at the Jennings Landfill contained BOD_5 (612 mg/l) and high iron (24,500 ug/l). However, Walnut Creek did not appear to be heavily polluted based on data collected from the three sampling sites. The study also indicated that the Standard Trailer Court Sewage Treatment Plant discharge added significant levels of ammonia-nitrogen (28.0 mg/l) and appeared to be the prime contributor of organic pollution during dry weather.

Twelvemile Creek

- There was no relevant biological/chemical study data available on Twelvemile Creek during Malcolm Pirnie's July 1995 ECHD water quality information review.

However, the ECHD has performed numerous water quality analyses on all three creeks. This information has regularly been provided to the United States Environmental Protection Agency (USEPA) by the ECHD and is available in a database named STORET. [This is a database of sampling sites and associated water quality data that is maintained by the USEPA.] STORET information was evaluated to determine "typical values" for streams in the region.

Attached as Plates 1 through 5, in the Appendix volume of this report, are spreadsheets identifying all STORET data received for water quality monitoring stations on Twelvemile, Walnut, Elk, Sixteenmile and Conneaut Creeks, respectively. STORET data was provided for the water quality network station numbers associated with each creek listed in Table 3-1. The Pennsylvania Water Quality Network (WQN) is a statewide, fixed station water quality sampling system operated by the Department of Environmental Protection, Bureau of Water Quality Management. The STORET spreadsheets are color coded to identify analytical parameters which have been identified as below detection limits, exceed

DEP Chapter 16 Water Quality Criteria (WQC) for both long-term protection (Criterion Continuous Concentration - CCC) and short-term protection (Criterion Maximum Concentration - CMC) and exceed DEP Chapter 93 WQC. We have summarized these spreadsheets as Tables 3-2 through 3-6.

TABLE 3-1

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

WATER QUALITY NETWORK STATIONS

CREEK	WATER QUALITY STATION NUMBER
TWELVEMILE	641
WALNUT	603
ELK	604
SIXTEENMILE	602
CONNEAUT	643

The following list identifies the summary table number, associated creek monitored, and dates of sample collection:

- Table 3-2 Twelvemile Creek (1988-Present)
- Table 3-3 Walnut Creek (1973-1987)
- Table 3-4 Elk Creek (1973-1987)
- Table 3-5 Sixteenmile Creek (1973-1987)
- Table 3-6 Conneaut Creek (1988-Present)

Included in the list above are the dates associated with sampling activities at each of the five creeks. Sample collection was conducted quarterly prior to 1988 and monthly since 1988. In addition, an Erie County Health Department biologist has collected samples subsequent to 1987 on Walnut, Elk and Sixteenmile Creeks.

Presented in Table 3-2 is the summarized STORET data for Twelvemile Creek. This is the only creek where Pesticide/PCB sample collection was reported. Most of the samples analyzed were flagged with a "K" denoting that the sample may not have been detected, or was detected below the value shown.

TABLE 3-2

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

SUMMARIZED STORET DATA

TWELVEMILE CREEK
(1988 - PRESENT)

PESTICIDES/PCBs

Date Time	minimum	maximum	number of data points
alpha-BHC (ppm)	0.009	0.009	1
beta-BHC			0
delta-BHC			0
gamma-BHC (Lindane)			0
Heptachlor (ppm)	0.044	0.044	1
Aldrin (ppm)	0.005K	-	1
Heptachlor epoxide (ppm)	0.005K	-	1
alpha-Endosulfan (I)			0
Dieldrin (ppm)	0.01K	-	1
4,4'-DDE			0
Endrin (ppm)	0.010K	-	1
beta-Endosulfan (II)			0
4,4'-DDD			0
Endosulfan sulfate			0
4,4'-DDT			0
alpha-Chlordane			0
beta-Chlordane			0
Toxaphene			0
Endrin Aldehyde			0

INORGANICS (total)

Date Time	minimum	maximum	number of data points
Aluminum (ug/L)	6	4,390	78
Antimony (ug/L)	0	1	25
Arsenic (ug/L)	0	2	24
Beryllium	0	0.14	24
Cadmium (ug/L)	0	0.09	25
Chromium Total (ug/L)	0	10	25
Chromium VI (ug/L)	1K	-	25
Copper (ug/L)	0.8	38	86
Iron (ug/L)	27	6,670	79
Lead (ug/L)	0	6	75
Manganese (ug/L)	3.5	249	87
Mercury (ug/L)	0.2K	0.2	24
Nickel (ug/L)	0	106	78
Selenium	0	2	24
Silver	0	0.1	24
Thallium	0.03	0.30	24
Zinc (ug/L)	0	39	79

ADDITIONAL PARAMETERS

Date Time	minimum	maximum	number of data points
Alkalinity (mg/L $CaCO_3$)	18	104	85
Chloride	20	62	85
Cyanide, free (ug/L)	1.000K	-	16
Grease & Oil Grab (mg/L)	2.00K	-	1
Ammonia-Nitrogen (mg/L)	0.020	0.080	85
Nitrite-Nitrogen (mg/L)	0.004	0.012	85
Nitrate-Nitrogen (mg/L)	0.300	4.600	84
$CBOD_5$ (mg/L)			0
BOD_5 (mg/L)			0
Chemical Oxygen Demand			0
Fecal Coliform (#/100mL)	0	6,900	15
Phosphorus, total (mg/L)	0.003	0.154	85
Total Suspended Solids	2	74	65
Hardness (mg/L $CaCO_3$)	37	193	85
pH (s.u.)	6.40	8.50	79
Temperature (°C)	0	24.8	88
Conductivity 25°C (micromho)	110	485	84
Dissolved Oxygen (mg/L O_2)	7.6	14.9	87

Note: K - Off-scale low. Actual value not known, but known to be less than value shown. Usually, used to indicate a failure to detect substance.

TABLE 3-3

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

SUMMARIZED STORET DATA

WALNUT CREEK
(1973 - 1987)

PESTICIDES/PCBs

Date Time	minimum	maximum	number of data points
alpha-BHC			0
beta-BHC			0
delta-BHC			0
gamma-BHC (Lindane)			0
Heptachlor			0
Aldrin			0
Heptachlor epoxide			0
alpha-Endosulfan (I)			0
Dieldrin			0
4,4'-DDE			0
Endrin			0
beta-Endosulfan (II)			0
4,4'-DDD			0
Endosulfan sulfate			0
4,4'-DDT			0
alpha-Chlordane			0
beta-Chlordane			0
Toxaphene			0
Endrin Aldehyde			0

INORGANICS (total)

Date Time	minimum	maximum	number of data points
Aluminum	10	500	11
Antimony			0
Arsenic (ug/L)	1K	-	11
Beryllium			0
Cadmium (ug/L)	3	3	12
Chromium Total (ug/L)	10	20	14
Chromium VI (ug/L)	0.2K	-	3
Copper (ug/L)	10	20	14
Iron (ug/L)	40	1,970	71
Lead (ug/L)	38	50	12
Manganese (ug/L)	10	30	10
Mercury (ug/L)	2	2	13
Nickel (ug/L)	20	30	9
Selenium	10K	-	2
Silver			0
Thallium			0
Zinc (ug/L)	10	50	12

ADDITIONAL PARAMETERS

Date Time	minimum	maximum	number of data points
Alkalinity (mg/L $CaCO_3$)	20	138	67
Chloride	7	264	67
Cyanide, free			0
Grease & Oil Grab			0
Ammonia-Nitrogen (mg/L)	0.010	0.850	67
Nitrite-Nitrogen (mg/L)	0.000	0.100	66
Nitrate-Nitrogen (mg/L)	0.020	1.850	59
$CBOD_5$ (mg/L)			0
BOD_5 (mg/L)			0
Chemical Oxygen Demand			0
Fecal Coliform (#/100mL)	10	1,700	28
Phosphorus, total (mg/L)	0.005	0.800	65
Total Suspended Solids	1	12	23
Hardness (mg/L $CaCO_3$)	12	238	67
pH (s.u.)	7.00	9.50	67
Temperature (°C)	0.0	26.1	70
Conductivity 25°C (micromho)	304	1,000	67
Dissolved Oxygen (mg/L O_2)	7.8	16.0	61

Note: K - Off-scale low. Actual value not known, but known to be less than value shown. Usually, used to indicate a failure to detect substance.

No Pesticide/PCB analytical results available in STORET database.

TABLE 3-4

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

SUMMARIZED STORET DATA

ELK CREEK
(1973 - 1987)

PESTICIDES/PCBs

Date / Time	minimum	maximum	number of data points
alpha-BHC (ppm)			0
beta-BHC			0
delta-BHC			0
gamma-BHC (Lindane)			0
Heptachlor (ppm)			0
Aldrin (ppm)			0
Heptachlor epoxide (ppm)			0
alpha-Endosulfan (I)			0
Dieldrin (ppm)			0
4,4'-DDE			0
Endrin (ppm)			0
beta-Endosulfan (II)			0
4,4'-DDD			0
Endosulfan sulfate			0
4,4'-DDT			0
alpha-Chlordane			0
beta-Chlordane			0
Toxaphene			0
Endrin Aldehyde			0

INORGANICS (total)

Date / Time	minimum	maximum	number of data points
Aluminum	50	2,180	16
Antimony			0
Arsenic (ug/L)	4K	-	9
Beryllium			0
Cadmium (ug/L)	0.2K	-	13
Chromium Total (ug/L)	10	20	14
Chromium VI (ug/L)	10K	-	2
Copper (ug/L)	10	20	14
Iron (ug/L)	60	3,290	72
Lead (ug/L)	25	25	12
Manganese (ug/L)	15	180	14
Mercury (ug/L)	0.2K	-	11
Nickel (ug/L)	10	40	14
Selenium	10K	-	1
Silver			0
Thallium			0
Zinc (ug/L)	10	140	14

ADDITIONAL PARAMETERS

Date / Time	minimum	maximum	number of data points
Alkalinity (mg/L $CaCO_3$)	15	134	69
Chloride	6	60	67
Cyanide, free			0
Grease & Oil Grab			0
Ammonia-Nitrogen (mg/L)	0.040	2.099	67
Nitrite-Nitrogen (mg/L)	0.002	0.280	67
Nitrate-Nitrogen (mg/L)	0.030	2.400	68
$CBOD_5$ (mg/L)			0
BOD_5 (mg/L)			0
Chemical Oxygen Demand			0
Fecal Coliform (#/100mL)	10	2,400	30
Phosphorus, total (mg/L)	0.010	0.990	68
Total Suspended Solids	1	90	25
Hardness (mg/L $CaCO_3$)	72	234	67
pH (s.u.)	6.41	9.08	65
Temperature (°C)	0.0	29	69
Conductivity 25°C (micromho)	177	500	68
Dissolved Oxygen (mg/L O_2)	6	14.6	71

Note: K - Off-scale low. Actual value not known, but known to be less than value shown. Usually, used to indicate a failure to detect substance.

No Pesticide/PCB analytical results available in STORET database.

TABLE 3-5

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

SUMMARIZED STORET DATA

SIXTEENMILE CREEK
(1973 - 1987)

PESTICIDES/PCBs

Date / Time	minimum	maximum	number of data points
alpha-BHC (ppm)			0
beta-BHC			0
delta-BHC			0
gamma-BHC (Lindane)			0
Heptachlor (ppm)			0
Aldrin (ppm)			0
Heptachlor epoxide (ppm)			0
alpha-Endosulfan (I)			0
Dieldrin (ppm)			0
4,4'-DDE			0
Endrin (ppm)			0
beta-Endosulfan (II)			0
4,4'-DDD			0
Endosulfan sulfate			0
4,4'-DDT			0
alpha-Chlordane			0
beta-Chlordane			0
Toxaphene			0
Endrin Aldehyde			0

INORGANICS (total)

Date / Time	minimum	maximum	number of data points
Aluminum (ug/L)	30	890	15
Antimony (ug/L)			0
Arsenic (ug/L)	4K	-	9
Beryllium			0
Cadmium (ug/L)	0.2K	-	14
Chromium Total (ug/L)	0	30	16
Chromium VI (ug/L)	10K	-	6
Copper (ug/L)	10	40	13
Iron (ug/L)	20	13,210	75
Lead (ug/L)	8	56	14
Manganese (ug/L)	10	430	15
Mercury (ug/L)	1.0K	-	14
Nickel (ug/L)	10	40	14
Selenium	10K	-	2
Silver			0
Thallium			0
Zinc (ug/L)	10	250	14

ADDITIONAL PARAMETERS

Date / Time	minimum	maximum	number of data points
Alkalinity (mg/L $CaCO_3$)	43	183	71
Chloride	9	107	72
Cyanide, free (ug/L)			0
Grease & Oil Grab (mg/L)			0
Ammonia-Nitrogen (mg/L)	0.000	1.260	71
Nitrite-Nitrogen (mg/L)	0.002	0.194	70
Nitrate-Nitrogen (mg/L)	0.042	13.200	69
$CBOD_5$ (mg/L)			0
BOD_5 (mg/L)	2	7	2
Chemical Oxygen Demand			0
Fecal Coliform (#/100mL)	20	5,300	30
Phosphorus, total (mg/L)	0.020	2.100	72
Total Suspended Solids	0.05	90	23
Hardness (mg/L $CaCO_3$)	80	266	71
pH (s.u.)	7.08	10.00	65
Temperature (°C)	0.0	25.5	67
Conductivity 25°C (micromho)	41	796	71
Dissolved Oxygen (mg/L O_2)	7.0	15.0	73

Note: K - Off-scale low. Actual value not known, but known to be less than value shown. Usually, used to indicate a failure to detect substance.

No Pesticide/PCB analytical results available in STORET database.

TABLE 3-6

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

SUMMARIZED STORET DATA

CONNEAUT CREEK
(1988 - PRESENT)

PESTICIDES/PCBs

Date Time	minimum	maximum	number of data points
alpha-BHC (ppm)			0
beta-BHC			0
delta-BHC			0
gamma-BHC (Lindane)			0
Heptachlor (ppm)			0
Aldrin (ppm)			0
Heptachlor epoxide (ppm)			0
alpha-Endosulfan (I)			0
Dieldrin (ppm)			0
4,4'-DDE			0
Endrin (ppm)			0
beta-Endosulfan (II)			0
4,4'-DDD			0
Endosulfan sulfate			0
4,4'-DDT			0
alpha-Chlordane			0
beta-Chlordane			0
Toxaphene			0
Endrin Aldehyde			0

INORGANICS (total)

Date Time	minimum	maximum	number of data points
Aluminum (ug/L)	135	11,110	81
Antimony (ug/L)			0
Arsenic (ug/L)			0
Beryllium			0
Cadmium (ug/L)			0
Chromium Total (ug/L)			0
Chromium VI (ug/L)			0
Copper (ug/L)	10	47	98
Iron (ug/L)	56	14,400	98
Lead (ug/L)	1	8	13
Manganese (ug/L)	11	630	91
Mercury (ug/L)	1.0K	-	1
Nickel (ug/L)	20	118	98
Selenium			0
Silver			0
Thallium			0
Zinc (ug/L)	11	74	98

ADDITIONAL PARAMETERS

Date Time	minimum	maximum	number of data points
Alkalinity (mg/L $CaCO_3$)	16	148	97
Chloride			0
Cyanide, free (ug/L)			0
Grease & Oil Grab (mg/L)			0
Ammonia-Nitrogen (mg/L)	0.020	0.240	90
Nitrite-Nitrogen (mg/L)	0.004	0.030	97
Nitrate-Nitrogen (mg/L)	0.040	4.580	97
$CBOD_5$ (mg/L)			0
BOD_5 (mg/L)			0
Chemical Oxygen Demand			0
Fecal Coliform (#/100mL)	60	60	1
Phosphorus, total (mg/L)	0.020	0.280	90
Total Suspended Solids	2	327	69
Hardness (mg/L $CaCO_3$)	28	177	97
pH (s.u.)	6.40	8.70	97
Temperature (°C)	0	28.3	98
Conductivity 25°C (micromho)	81	425	94
Dissolved Oxygen (mg/L O_2)	6.6	14.7	98

Note: K - Off-scale low. Actual value not known, but known to be less than value shown. Usually, used to indicate a failure to detect substance.

No Pesticide/PCB analytical results available in STORET database.

In each of the creeks a number of inorganic parameters were found. [Note that iron has historically been analyzed 3 to 12 times more frequently than other inorganic compounds.] Inorganic parameters such as iron, lead, nickel and zinc are present in samples from all five creeks. The WQC for lead, nickel and zinc vary depending on stream hardness. Mercury exceeds the WQC value in Walnut Creek, once during the 13 samples collected between 1973 and 1987.

Data from the additional parameter list indicate that fecal coliform colonies are present in each of the five creeks reporting information. These creeks contained fecal coliform colonies ranging from 0/100 ml to 6,900/100 ml. These data indicate that, historically, fecal coliform colonies have typically been found in the creeks and may be attributable to wildlife, humans, faulty sewage treatment plants or leaky septic systems. The latter two sources are less likely the source; however, since fecal coliform counts from these discharges would be expected to be significantly higher that those reported.

In addition to the past biological/chemical studies/surveys performed on the creeks, a fourteen volume Storm Water Management Plan was prepared by Erie County in 1981 for all of the watersheds in Erie County, Pennsylvania which drain into Lake Erie along the Pennsylvania shoreline, using funds provided by the Pennsylvania Coastal Zone Management Program and the Pennsylvania Bureau of Dams and Waterways Management. Only a small fraction of the 1981 plan was implemented, according to the ECDP (Volume 1: Technical Document and Volume 8: Sixteenmile Creek and Twentymile Creek watersheds). Planning, analysis methods, and basic approaches to watershed storm water management have changed since the 1981 plan was prepared. Because of this, a new Storm Water Management Plan has been prepared for the Lake Erie Watershed to address the Pennsylvania Storm Water Management Act 167. This plan was adopted by Erie County Council on June 18, 1996.

In 1985, the Erie County Conservation District (ECCD) performed a study to locate excessive phosphorus loading sources to Lake Erie from watersheds in Erie County, PA. The study determined that the most significant nonpoint source of phosphorus pollution to Lake Erie was soil erosion from agricultural cropland. Improper manure management, over fertilizing, and nutrient runoff were secondary sources. Nutrient overloaded acreage

information in the Elk, Walnut, and Twelvemile Creek subwatersheds obtained from this study are presented in Table 3-7. The table indicates that the Elk Creek subwatershed area is five times the area of the next largest subwatershed and has the greatest phosphorus loadings from agricultural sources.

The ECCD study also noted that many small sewage treatment plants (STPs) discharged phosphorus at levels considerably higher than permit levels required for larger plants in the Erie County subwatersheds. These small STPs, defined as operating at less than 1 mgd, were not required to meet effluent limitations of less than 1 mg/l phosphorus. Currently, these STPs are required to meet discharge limits of less than 1 mg/l phosphorus. The study noted that three small STPs were located on Elk Creek from Girard to Lake City.

TABLE 3-7

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

PHOSPHORUS LOADING STUDY SUMMARY

Sub Watershed	# of farms with 30 or more animals given access	Nutrient Overloaded Acreage			
		Over by Fertilizer	Over by Manure	Over by Both	Total
Elk Creek	15	48	164	386	598
Walnut Creek	3	50	0	50	100
Twelvemile Creek	1	0	0	0	0

Another study investigated for this report was conducted for the Crawford County Conservation District and is entitled "Conneaut Lake Water Quality and Land Use Study," November 1, 1989. While the Conneaut Lake watershed is outside the Coastal Nonpoint Program management area, the study contains useful information. The Conneaut Lake study addresses phosphorus loadings that contribute to the eutrophic condition of the lake. The study found that approximately half the phosphorus loading to the lake was from sediment release, groundwater, and precipitation. The other half was from surface runoff. No correlation between phosphorus concentrations in streams contributing to Conneaut Lake and agricultural use could be established in the study. Also, no significant relationship

between other land uses (residential and forest) and phosphorus concentrations could be established. The study recommended restrictive zoning and soil conservation programs to help reduce phosphorus loading runoff.

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4.0 SAMPLING / MONITORING

Malcolm Pirnie coordinated field sampling and analytical activities to establish a water quality baseline for the Erie County, Pennsylvania area of the Lake Erie Watershed. These activities were completed during the 12-month period of June 1995 through May 1996. All samples in this survey were collected and analyzed using the procedures described in the Field Sampling and Quality Assurance/Quality Control Plan (Volume 2 of this report) developed by Malcolm Pirnie for the Water Quality Monitoring Study for the Lake Erie Watershed, May 1995, revised June 1995. Laboratory analytical and sample collection activities were conducted by Church Laboratories, Inc. (Church), located in Fairview, Pennsylvania. Church is a certified full-service laboratory that also provides sample collection services. Field and analytical data recorded by laboratory personnel were used to evaluate flow characteristics and potential pollutant loadings. Throughout the course of the sampling activities, the objective was to identify those parameters having the greatest potential to affect pollutant loading to Lake Erie.

Malcolm Pirnie inspected each subwatershed to select precise sampling locations that would yield representative results. These sampling stations are situated near creek discharge points, upstream of Lake Erie influences. Specifically:

- The Twelvemile Creek sampling location was adjacent to a concrete retaining wall on the west side of the creek, approximately 500 yards north of the Route 5 and Twelvemile Creek crossing. Access was from Shorewood Drive across Route 5 from Moorheadville Road.
- The Walnut Creek monitoring location was from the south side of the bridge at the Dutch Road and Walnut Creek crossing.
- The Elk Creek sampling location was on the south side of the Route 5 and Elk Creek bridge crossing. Access was from Tomes Campground.

Listed in Table 4-1 is a summary of the dry and wet weather events monitored. Included are event numbers (including appropriate D for "dry" and W for "wet" designations), sampling dates, precipitation amounts and antecedent dry weather conditions.

MALCOLM PIRNIE

TABLE 4-1

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

SAMPLING SUMMARY

Event Number	Date	Precipitation (inches)	Antecedent Dry Period (days)
01D	June 14, 1995	NA	7.0
02W	Aug. 11, 1995	1.06	5.9
03W	Sept. 20, 1995	0.44	6.3
04D	Oct. 3, 1995	NA	11.0
05W	Oct. 5, 1995	1.67	2.0
06W	Nov. 7, 1995	0.52	2.6
07W	Nov. 11, 1995	1.92	3.0
08W	April 12, 1996	0.70	7.8
09W	April 30, 1996	0.71	1.0
10W	May 9, 1996	0.77	4.0

NA - Not Applicable *D = Dry Event* *W = Wet Weather Event*

As noted above, several different precipitation events were captured. Wet weather events monitored reflect approximately 0.5 inch, 0.75 inch, 1.0 inch, 1.5 inch and nearly 2.0 inch rainfalls. Even the three nearly 0.75 inch precipitation events differ due to the antecedent dry weather conditions. The day before event 09W, creek levels may have elevated slightly due to light shower activity. The antecedent dry weather periods between events 10W and 08W are nearly double. This data demonstrates that a wide range of precipitation events were captured during this study.

4.1 DRY WEATHER SAMPLING

Dry weather sampling activities were conducted utilizing procedures specified in the Field Sampling and Quality Assurance/Quality Control Plan developed by Malcolm Pirnie for this study. The Plan required a minimum of 48 to 72 hours of antecedent dry weather

conditions preceding the collection of these samples. As noted on Table 4-1, the antecedent dry period for the two dry weather sample events was 7 days (event 01D) and nearly 11 days (event 04D). The first dry weather event samples were analyzed for the Table 4-2 list of specified parameters. All analytical tests were performed on total analyte fractions. No dissolved samples were analyzed.

The water quality criteria for these parameters are listed in:

TITLE 25. RULES AND REGULATIONS
PART I. DEPARTMENT OF ENVIRONMENTAL RESOURCES
Subpart A. PRELIMINARY PROVISIONS
ARTICLE II. STATEMENTS OF POLICY

CHAPTER 16. WATER QUALITY TOXICS

and,

TITLE 25. RULES AND REGULATIONS
PART I. DEPARTMENT OF ENVIRONMENTAL RESOURCES
Subpart C. PROTECTION OF NATURAL RESOURCES
ARTICLE II. WATER RESOURCES

CHAPTER 93. WATER QUALITY STANDARDS

During the first dry weather sampling event, Malcolm Pirnie verified the accuracy of velocity meters that were to be used in this study. The travel times of flotation devices (i.e., oranges) over a predetermined known distance in the creek were recorded with a stopwatch. This information was then compared to the data obtained from velocity meters. Based on the results of this test, the floatation device method of measuring creek velocity was used throughout the study at all three creeks.

4.2 WET WEATHER SAMPLING

A minimum of 48 to 72 hours of antecedent dry weather conditions preceded all wet weather sampling activities except during event 09W. This event followed a day of light showers that was preceded by three days of antecedent dry weather conditions. Rainfall

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TABLE 4-2

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

ANALYTICAL PARAMETERS

Title 25. Rules and Regulations Part I. Department of Environmental Resources Subpart A. Preliminary Provisions Article II. Statements of Policy Chapter 16. Water Quality Toxics Test Parameters	**Title 25. Rules and Regulations Part I. Department of Environmental Resources Subpart C. Protection of Natural Resources Article II. Water Resources Chapter 93. Water Quality Standards Test Parameters**
Antimony Arsenic Beryllium Cadmium Chromium Total Chromium VI Copper Lead Mercury Nickel Selenium Silver Thallium Zinc Cyanide (free)	Aluminum Alkalinity Ammonia Nitrogen Bacteria/Fecal Coliform Hardness Iron Manganese Nitrite - Nitrogen Nitrate - Nitrogen Chloride Oil and Grease $CBOD_5$ Total Suspended Solids Phosphorus COD
Pesticides: Aldrin alpha-BHC beta-BHC gamma-BHC (Lindane) delta-BHC alpha-Chlordane gamma-Chlordane 4,4'-DDT 4,4'-DDE 4,4'-DDD Dieldrin alpha-Endosulfan beta-Endosulfan Endosulfan Sulfate Endrin Endrin Aldehyde Heptachlor Heptachlor Epoxide Toxaphene	**Field Measurements:** Dissolved Oxygen pH Temperature Conductivity

Note: All parameters analyzed are total analyte fractions.

intensity and duration, time of travel, and estimated flows were factors used to determine when wet weather sampling was conducted.

Event specific creek velocities were measured as described in the following section. Table 4-3 summarizes the average velocity and depth of flow for each monitored event at Twelvemile, Walnut and Elk Creeks.

TABLE 4-3

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

VELOCITY AND DEPTH SUMMARY

	Twelvemile Creek (7.8 miles)		Walnut Creek (16.9 miles)		Elk Creek (28.8 miles)	
Event	Average Velocity (ft./sec.)	Depth at Sample Station (ft.)	Average Velocity (ft./sec.)	Depth at Sample Station (ft.)	Average Velocity (ft./sec.)	Depth at Sample Station (ft.)
01D	0.50	0.73	2.47	0.51	1.41	0.71
02W	4.49	1.71	4.26	0.90	1.46	2.85
03W	0.73	0.69	2.14	0.42	1.02	NAM
04D	0.21	0.42	1.39	0.39	0.73	1.93
05W	3.22	1.25	4.45	1.45	2.81	2.54
06W	5.40	1.67	3.81	0.78	3.79	2.72
07W	10.20	3.17	7.07	2.09	8.50	5.64
08W	4.53	1.78	3.47	0.71	2.70	2.59
09W	7.17	2.50	6.10	1.73	6.50	6.17
10W	5.50	2.00	8.23	2.58	5.83	8.00

NA - Not Applicable *NAM - Not Able to Measure*

Note: Assumes uniform distribution of average rainfall, monitored by seven City of Erie precipitation gauges, across all three subwatersheds.

4.3 DEPTH AND VELOCITY MEASUREMENTS

Procedures for collecting depth and velocity measurements were developed following initial visits to the selected sample sites. Based on an evaluation of the sample collection location, the number of depth and velocity measurements required during each "round" of sampling was determined.

During each round of sampling, the orange velocity test was performed three times. The oranges were released in what visually appeared to be the "normal flow" section of each creek. We attempted to complete the flotation tests away from swirling eddys and quiescent areas of the creeks. The flotation test was conducted a series of three times. An average of the three measurements was assumed to be the representative velocity for the creek being sampled and is reported in Table 4-3.

Depth measurements were acquired from Twelvemile and Elk Creeks by setting a surveying rod on the creek bottom and measuring the water's depth each time grab samples were collected. The average of these three measurements was calculated and recorded in Table 4-3. A water level indicator was used to measure water surface elevation with respect to the Dutch Road bridge crossing at up to ten locations across Walnut Creek. Access at Twelvemile and Elk Creeks did not allow this type of measurement. A survey crew was hired to measure the distance between the creek bed and the bridge crossing at each station. The difference of these two measurements is the depth of the water. Measurements were collected during each of the three grab sample times for each event. The average depth is reported in Table 4-3.

4.4 INITIAL SAMPLING

Table 4-4 illustrates the overall sampling program approach utilized in this study. On June 14, 1995, three grab samples of equal volume were collected over a 6-hour period of time at each location, composited by the analytical laboratory, and tested for the complete parameter list (see Table 4-2), except as footnoted in Table 4-4. The approved USEPA methods and detection limits used by the laboratory to analyze the parameters are listed in

Table 4-5. The analytical results of this dry weather sampling event were used as a baseline for the study.

In addition, one round of wet weather samples were collected at all three monitoring locations and analyzed for the full list of parameters on August 11, 1995. Sample collection was conducted as described in section 4.2 during the storm events.

TABLE 4-4

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

INITIALLY PROPOSED SAMPLING APPROACH

Initial Monitoring (Spring and Summer Season):	
1 Event (dry)	6-hour composite - Full list of parameters
1 Event (wet)	6-hour composite - Full list of parameters
Intermediate Reduced Parameter Sampling (Spring and Summer Season):	
1 Event (dry)	6-hour composite - Initial parameters-of-interest
3 Events (wet)	6-hour composite - Initial parameters-of-interest
Reduced Parameter Sampling (Fall Season):	
4 Events (wet)	6-hour composite - Final parameters-of-interest

Note:

- *As detailed in field sampling and Quality Assurance/Quality Control Plan (Volume 2), one grab sample was collected during Round 2 of each event and analyzed for the following parameters:*
  - *Fecal Coliform*
  - *Oil and Grease*
  - *Cyanide (free)*
- *Three individual grab samples were collected during each of the three sample rounds of each event, analyzed and the results averaged to obtain the composite Chromium VI value.*
- *Three individual grab samples were collected during each of the three sample rounds of each event, composited in the laboratory and one single analysis performed on each composite for all other non-field tested parameters.*

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TABLE 4-5

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

Approved USEPA Analytical Methods and Detection Limits for Inorganics

Parameter	Analytical Method	Method Detection Limit mg/l
Aluminum	202.1	0.1
Antimony	204.2	0.003
Arsenic	206.2	0.001
Beryllium	210.1	0.005
Cadmium	213.2	0.0001
Chromium	218.1	0.05
Chromium, hexavalent	218.4	0.01
Copper	220.2	0.001
Iron	236.1	0.03
Lead	239.1/239.2	0.1/0.001
Manganese	243.1	0.01
Mercury	245.1	0.0002
Nickel	249.1	0.04
Selenium	270.2	0.002
Silver	272.2	0.0002
Thallium	279.1/279.2	0.1/0.001
Zinc	289.1	0.005

4.5 INTERMEDIATE PARAMETER SAMPLING

After the initial dry and wet weather event sampling and analysis, a meeting was held with representatives of the ECDP, DEP, ECDH and Malcolm Pirnie to evaluate parameter concentrations with respect to:

- Presence above detection limits.
- Historical presence above detection limits.
- Potential pollutant loading to Lake Erie.

The full parameter list was reduced based on these criteria. Pesticides, oil and grease and free cyanide were deleted from the list of parameters. All inorganic parameters remained on the analytical list pending further evaluation of analytical data by ECHD and DEP representatives.

4.6 REDUCED PARAMETER SAMPLING

Following the second wet weather sampling event another meeting was held with representatives of the ECDP, DEP, ECDH and Malcolm Pirnie to evaluate parameter concentrations with respect to:

- Frequency of presence above detection limits.
- Existing water quality standards.
- Potential pollutant loading to Lake Erie.

Based upon these criteria, the intermediate parameter list was further reduced for future sampling efforts. The objective was to concentrate sampling efforts on those parameters which have the greatest potential impact on pollutant loadings to Lake Erie. The inorganic parameters, Antimony, Beryllium, Chromium VI, Mercury, Selenium and Thallium were deleted from the analytical parameter list (see Table 4-6).

TABLE 4-6

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

ANALYTICAL PARAMETER LIST REDUCTIONS

Sampling Round	Sampling Event	Parameters Deleted from Full List
Initial	01D, 02W	N/A
Intermediate	03W	Pesticides, Oil & Grease, Free Cyanide
Final	04D, 05W, 06W, 07W, 08W, 09W, 10W	Pesticides, Oil & Grease, Free Cyanide, Antimony, Beryllium, Chromium VI, Mercury, Selenium, Thallium

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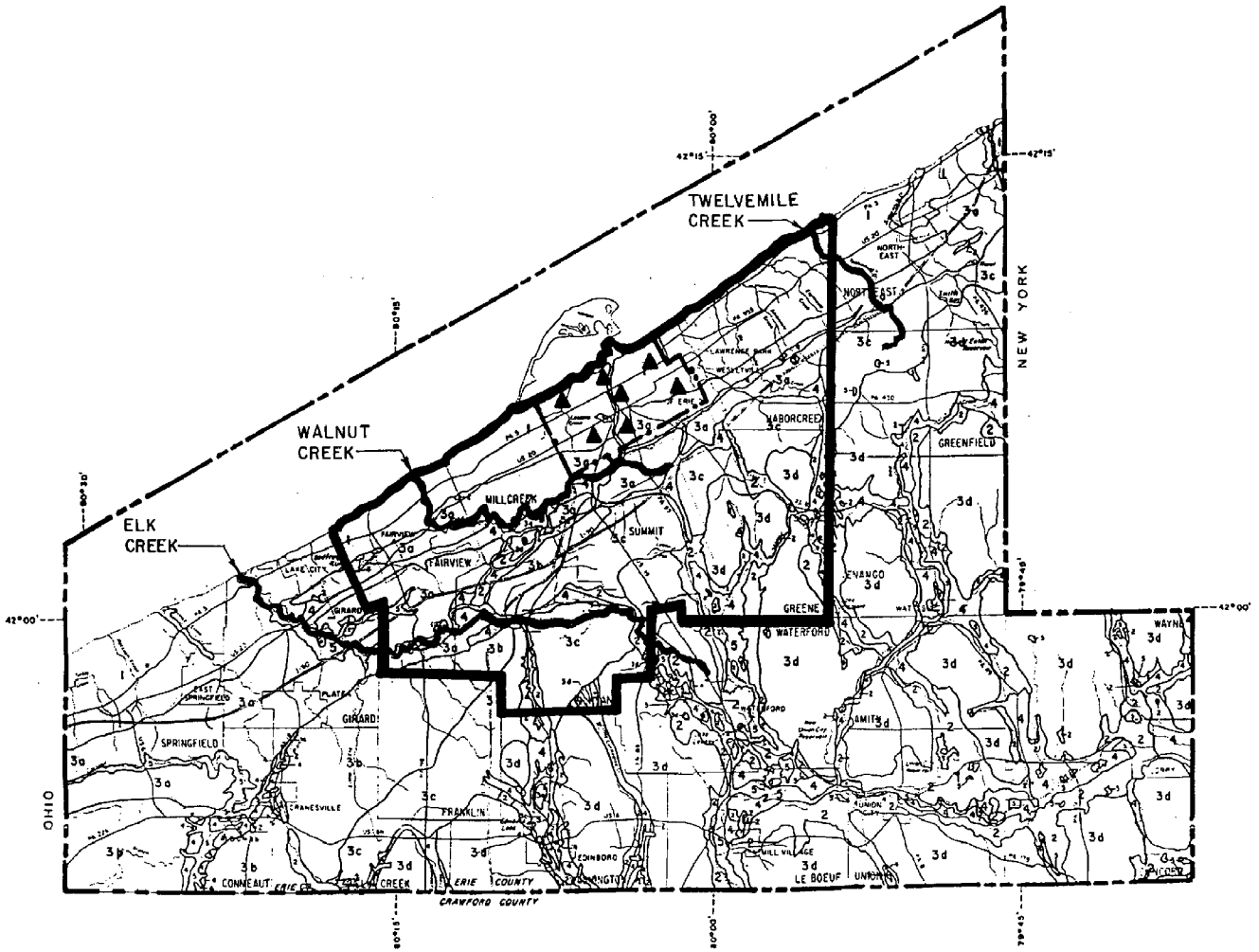
5.0 DATA EVALUATION

During the course of the sampling period, precipitation information was collected from seven rain gauges located throughout the City of Erie, Pennsylvania. These rain gauges were used to indicate the frequency and magnitude of storm events affecting flows in Twelvemile, Walnut and Elk Creeks. The precipitation monitor locations are identified on Figure 5-1 with respect to each creek location. Figure 5-2 is an enlargement of the City of Erie and illustrates specific rain gauge locations. A summary of each individual precipitation monitor rainfall is presented in Table 5-1. This information is presented in graphical format on an annual basis for each rain gauge in Appendix A of this report. Monthly precipitation tables for all rain gauges are also located in Appendix A. Precipitation data for all seven rain gauges are available in 15-minute tabular format at the City of Erie Publicly Owned Treatment Works (POTW). Table 5-2 illustrates this data at rain gauge 3 (RG3) for events 06W (November 7, 1995) and 07W (November 10-11, 1995). As shown in this table, precipitation during event 07W began late on November 10, 1995 and continued into November 11, 1995. Therefore, the sum of both days precipitation was added to reflect the total rainfall for the event.

The actual monitored precipitation associated with each wet weather event and the corresponding antecedent dry period is presented in Table 4-1. Antecedent dry periods were calculated by averaging the number of rain-free days prior to a wet weather sampling event at all seven rain gauges. The antecedent dry period for event 09W is listed as 1.0 day in Table 4-1. This event was preceded by one day of light rainfall which was preceded by three days of dry weather conditions.

Historical precipitation records from the Erie International Airport Weather Office were collected for a twenty year period starting in 1971. This information was collected for comparative purposes with actual monitored wet event precipitation and is presented in Table 5-3. This data is also presented graphically on Figure 5-3.

FIGURE 5-1



LEGEND

- ERIE METROPOLITAN AREA BOUNDARY
- COUNTY LINE
- TOWNSHIP OR BOROUGH BOUNDARY
- CITY OF ERIE BOUNDARY
- RAIN GAUGE LOCATION

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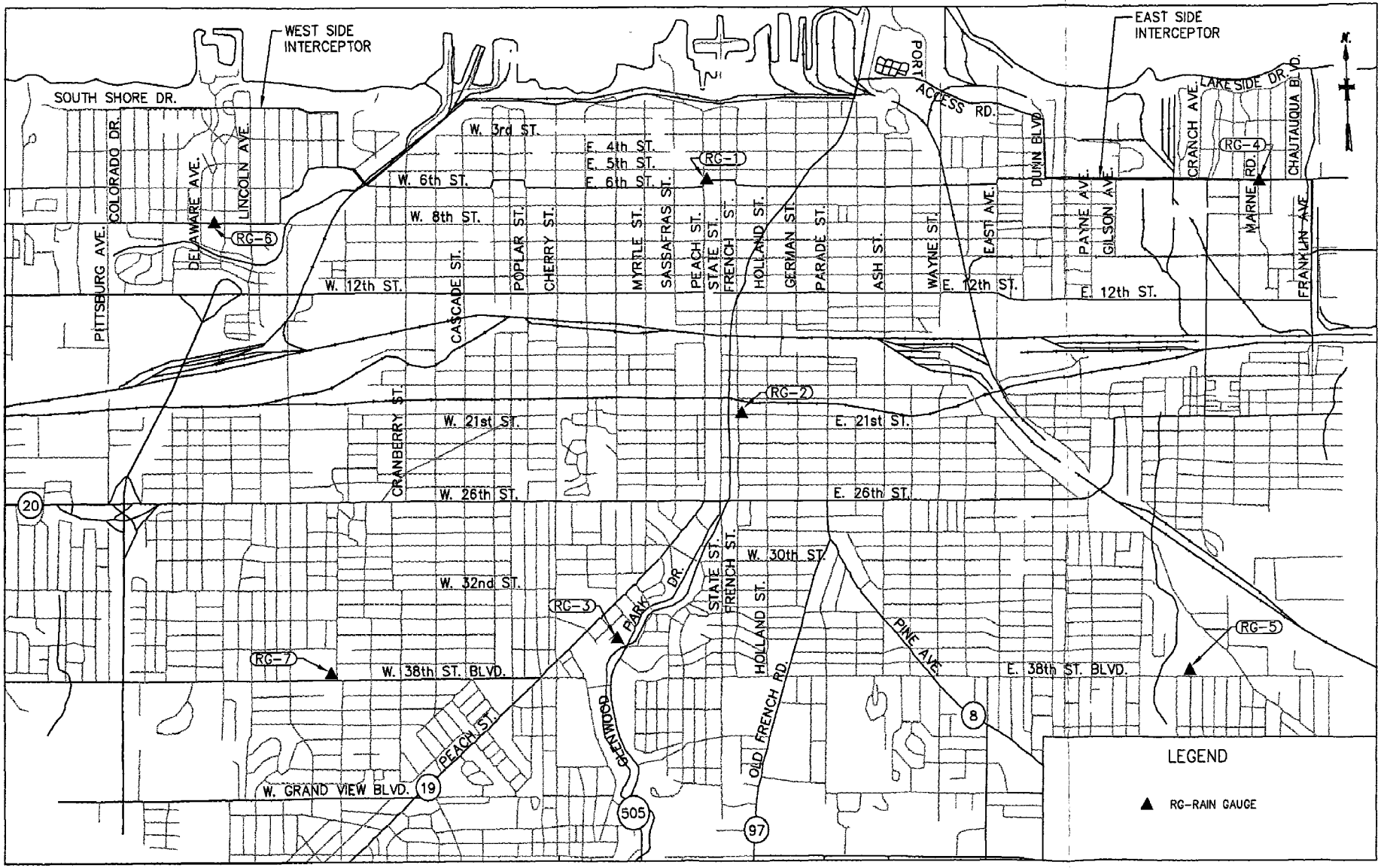
WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED
STUDY AREA

COUNTY OF ERIE, PA SEPTEMBER 1996

FIGURE 5-2



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WATER QUALITY MONITORING STUDY FOR
THE LAKE ERIE WATERSHED
PRECIPITATION MONITOR LOCATIONS

COUNTY OF ERIE, PA SEPTEMBER 1996

TABLE 5-1

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

RAINFALL SUMMARY

Rain Gauge	01D June 14, 1995 Rainfall (inches)	04D* Oct. 3, 1995 Rainfall (inches)	02W Aug. 11, 1995 Rainfall (inches)	03W Sept. 20, 1995 Rainfall (inches)	05W** Oct. 5, 1995 Rainfall (inches)	06W Nov. 7, 1995 Rainfall (inches)	07W# Nov. 10-11, 1995 Rainfall (inches)	08W April 12, 1996 Rainfall (inches)	09W April 30, 1996 Rainfall (inches)	10W May 9, 1996 Rainfall (inches)
1	0.00	0.00	0.93	0.47	1.67	0.51	1.61	0.65	0.51	0.87
2	0.00	0.00	0.98	0.43	1.44	0.49	1.80	0.87	0.67	n/a
3	0.00	0.00	1.25	0.44	1.76	0.50	2.12	0.59	0.77	0.81
4	0.00	0.00	0.94	0.00	1.76	0.59	2.14	0.86	0.73	0.64
5	0.00	0.00	0.92	0.37	1.64	0.52	2.03	0.59	0.92	0.62
6	0.00	0.00	1.13	0.49	1.75	0.54	1.87	0.63	0.68	0.81
7	0.00	0.00	1.27	0.43	1.67	0.49	1.89	n/a	0.69	0.85
average	0.00	0.00	1.06	0.44	1.67	0.52	1.92	0.70	0.71	0.77

Notes:

* Samples for dry weather event 04D were collected between 7:30 AM and 12:30 PM on Oct. 3, 1995.
The earliest rainfall activity occurred at 4:15 PM on Oct. 3, 1995 at the 7 rain gauges and averaged 0.62 inches.

** Rainfall event occurred on Nov. 10 and Nov. 11, 1995

Precipitation began late on Nov. 10 and sampling started early Nov. 11. Therefore, the total rainfall is the sum of rainfall for both days.

n/a - Rain gauge data not available.

TABLE 5-2

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

15 MINUTE RAINFALL DATA
RAIN GAUGE 3

	MONDAY 11/06/95	TUESDAY 11/07/95	WEDNESDAY 11/08/95	THURSDAY 11/09/95	FRIDAY 11/10/95	SATURDAY 11/11/95	SUNDAY 11/12/95
	RAIN (in)	RAIN (in)	RAIN (in)	RAIN (in)	RAIN (in)	RAIN (in)	RAIN (in)
0:00							
:15							
:30							
:45						0.01	
1:00						0.01	
:15							
:30						0.02	
:45						0.02	
2:00						0.03	
:15						0.03	
:30						0.04	
:45						0.01	
3:00						0.02	
:15						0.03	
:30							
:45						0.01	
4:00			0.01				
:15						0.01	
:30			0.01			0.01	
:45						0.01	
5:00		0.01				0.02	
:15		0.02				0.01	
:30		0.02				0.01	
:45		0.03				0.02	
6:00		0.04				0.01	
:15		0.03				0.04	
:30		0.03				0.04	
:45		0.02					
7:00		0.01					
:15		0.01	0.01			0.01	
:30		0.01					
:45		0.01					
8:00		0.01					
:15		0.03					
:30		0.03					
:45		0.03				0.02	
9:00		0.03				0.01	
:15		0.03					
:30		0.04				0.01	
:45		0.03				0.01	
10:00						0.01	
:15						0.01	
:30						0.02	
:45						0.01	
11:00						0.02	
:15						0.01	
:30						0.01	
:45						0.01	

TABLE 5-2

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

15 MINUTE RAINFALL DATA
RAIN GAUGE 3

	MONDAY 11/06/95	TUESDAY 11/07/95	WEDNESDAY 11/08/95	THURSDAY 11/09/95	FRIDAY 11/10/95	SATURDAY 11/11/95	SUNDAY 11/12/95
	RAIN (in)	RAIN (in)	RAIN (in)	RAIN (in)	RAIN (in)	RAIN (in)	RAIN (in)
12:00		0.01				0.03	
:15						0.02	
:30						0.02	
:45				0.01		0.03	
13:00		0.01		0.02		0.02	
:15						0.01	
:30		0.01		0.01		0.03	
:45				0.01		0.02	
14:00						0.02	
:15					0.01	0.03	
:30						0.02	
:45					0.02	0.03	
15:00						0.05	
:15					0.01	0.03	
:30					0.01	0.16	
:45					0.02	0.06	
16:00					0.02	0.03	
:15						0.04	
:30					0.02	0.03	
:45					0.03	0.02	
17:00					0.02	0.02	
:15					0.01	0.03	
:30					0.04	0.04	
:45						0.01	
18:00						0.01	
:15					0.01	0.01	
:30					0.05	0.01	
:45					0.04	0.01	
19:00					0.04		
:15					0.01	0.01	
:30							
:45							
20:00					0.03		
:15					0.03	0.01	
:30					0.01		
:45					0.01		
21:00							
:15					0.02		
:30					0.02		
:45					0.03		
22:00					0.05		
:15					0.06		
:30					0.05		
:45					0.02		
23:00							
:15							
:30							
:45							
TOTAL:		0.50	0.03	0.05	0.69	1.43	

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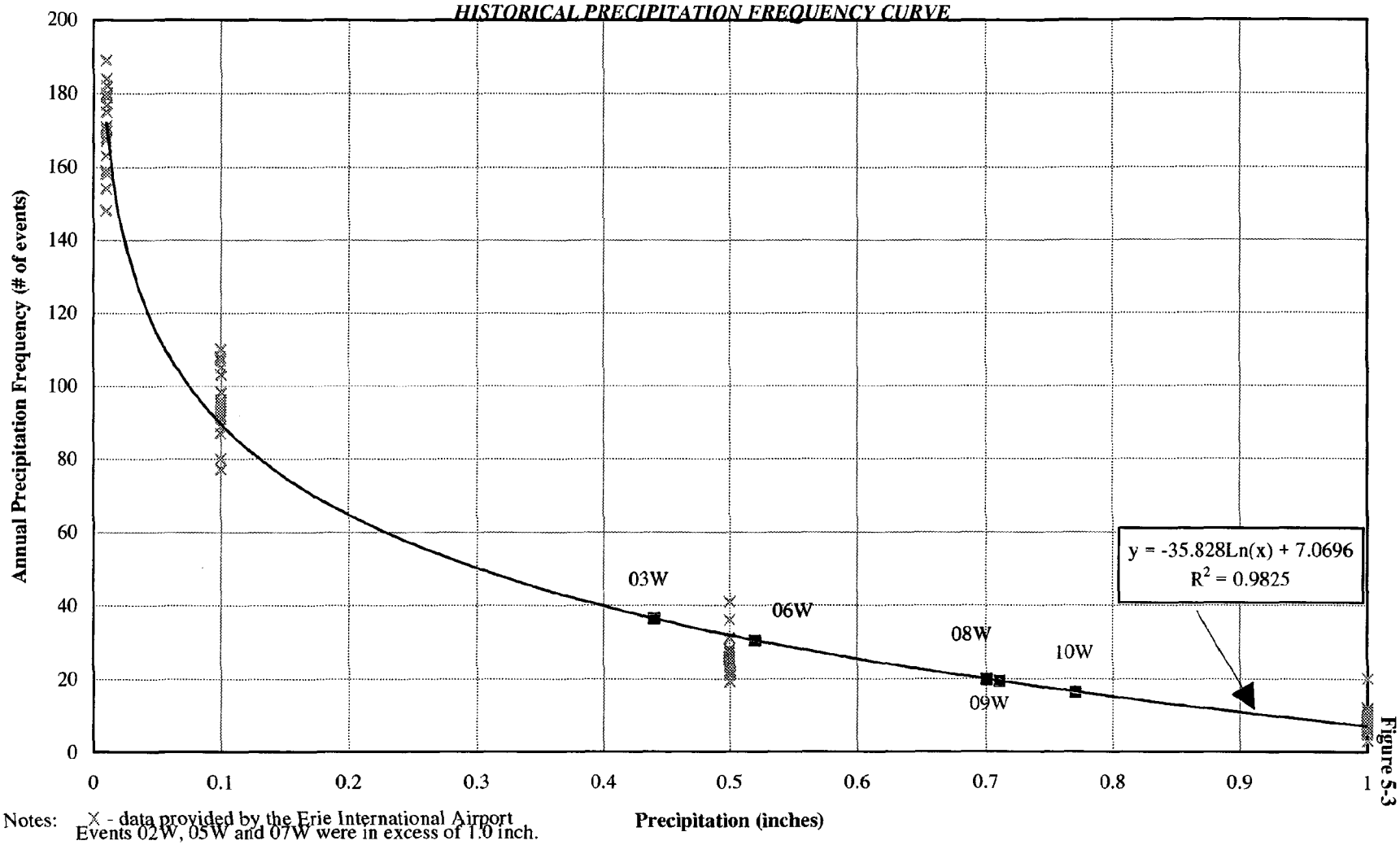
TABLE 5-3

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

HISTORICAL PRECIPITATION

WATER EQUIVALENT PRECIPITATION				
Year	**0.01" or more**	**0.1" or more**	**0.5" or more**	**1.0" or more**
1971	167	91	21	5
1972	177	96	25	10
1973	163	80	19	6
1974	182	107	22	6
1975	168	92	31	7
1976	175	98	26	9
1977	171	103	41	20
1978	154	77	24	5
1979	180	89	36	12
1980	159	95	28	11
1981	170	92	24	9
1982	171	110	24	10
1983	148	91	31	9
1984	179	96	24	3
1985	184	108	23	9
1986	177	93	26	9
1987	159	87	27	10
1988	171	94	21	7
1989	189	105	27	8
1990	158	98	31	12
Average	170.1	95.1	26.55	8.85
Variance	109.79	71.29	27.04	12.03
Std. Dev.	10.48	8.44	5.2	3.47
Maximum	189	110	41	20
Minimum	148	77	19	3

WATER QUALITY MONITORING STUDY
FOR THE LAKE ERIE WATERSHED



Notes: X - data provided by the Erie International Airport
Events 02W, 05W and 07W were in excess of 1.0 inch.

Figure 5-3

To determine the anticipated frequency of sampled wet weather events that occurred during the course of this study, the historical precipitation information collected at the Erie International Airport was plotted in terms of precipitation magnitude and event frequency (see Figure 5-1). The data points in Table 5-3 were fit to a second order logarithmic curve with an R^2=0.98, a lower limit of 0.01 inches of rain and an upper limit of 1.0 inches of rain. The precipitation magnitude for each sampled event was then plotted on the curve.

Figure 5-3 illustrates that a precipitation event with the same magnitude of 03W is expected to occur approximately 37 times every year. Likewise, an event with a similar magnitude to 06W may occur approximately 30 times and an event similar to events 08W, 09W and 10W may occur about 17 to 20 times a year. Wet weather events 02W, 05W and 07W are not illustrated on Figure 5-3 as precipitation associated with these events exceeded 1.0 inches. However, the figure does indicate that rainfall events with magnitudes similar to 02W, 05W and 07W are expected to occur approximately 7 or less times a year based on historical information.

5.1 WATER QUALITY EVALUATION

5.1.1 Dry Weather Conditions

Water Quality Criteria (WQC) and Water Quality Standards (WQS), as summarized in Table 5-4, were not exceeded for any parameter tested under dry weather conditions. As summarized in Table 5-5, data collected and analyzed for each of the three creeks monitored during two dry weather events indicates that there is no significant point or non-point sources of pollution along any of these creeks. The data reported during the two dry weather sampling events on June 14, 1995 and October 3, 1995 were one time grab samples. All parameters tested (i.e. pesticides/PCBs, inorganics and additional parameters) during dry weather conditions were either below detection limits or less than water quality criteria set by the DEP. Individual event specific data summaries are included in Appendix B.

Table 5-4

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

WATER QUALITY CRITERIA

PESTICIDES/PCBs	DEP CHPT 16 WQC		DEP CHPT 93 WQS	
	CCC	CMC	TABLE 3	
	(µg/l)	(µg/l)	(µg/l)	CU
alpha-BHC	n/a	n/a		
beta-BHC	n/a	n/a		
delta-BHC	n/a	n/a		
gamma-BHC (Lindane)			0.001 (X)	
Heptachlor			0.001 (X)	
Aldrin			0.001 (X)	
Heptachlor epoxide	0.1	0.8		
alpha-Endosulfan (I)	0.056	0.22		
Dieldrin			0.001 (X)	
4,4'-DDE	0.001	1.1		
Endrin			0.002 (X)	
beta-Endosulfan (II)	0.056	0.22		
4,4'-DDD	0.001	1.1		
Endosulfan sulfate	n/a	n/a		
4,4'-DDT	0.001	1.1		
alpha-Chlordane			* (X)	
gamma-Chlordane			* (X)	
Toxaphene			0.008 (X)	
Endrin Aldehyde	n/a	n/a		

NOTES:

DEP CHPT 16 WQC = Pennsylvania Department of Environmental Protection
Chapter 16 Water Quality Criteria for Toxic Substances
effective March 11, 1989, 19 Pa. B. 1059

DEP CHPT 93 WQS = Pennsylvania Department of Environmental Protection
Chapter 93 Water Quality Standards
effective March 11, 1989, 19 Pa. B. 1059

CCC - criterion continuous concentration (for long-term protection)

CMC - criterion maximum concentration (for short-term protection)

n/a - not applicable

* - limit for Chlordane = 0.06 µg/l (X)

(X) - Chapter 93 Water Quality Criteria Designated Water Use Drainage List - Lake Erie

Table 5-4

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

WATER QUALITY CRITERIA

INORGANICS	DEP CHPT 16 WQC		DEP CHPT 93 WQS	
	CCC	CMC	TABLE 3	
	(µg/l)	(µg/l)		CU
Aluminum			0.1(96hrLC$_{50}$)	1
Antimony	219	1,095		
Arsenic	190(As3+)	360(As3+)		
Beryllium	0.01(96hrLC$_{50}$)	0.05(96hrLC$_{50}$)		
Cadmium			0.01(96hr LC$_{50}$) (X)	
Chromium Total	11+EXP(0.819 (lnH)+1.561)	16+EXP(0.819 (lnH)+3.688)		
Chromium VI	11	16		
Copper	EXP(0.8545 (lnH)-1.465)	EXP(0.9422 (lnH)-1.464)		
Iron			0.3 mg/l * (X)	1
Lead	EXP(1.266 (lnH)-4.661)	EXP(1.266 (lnH)-1.416)		
Manganese			1 mg/l	2
Mercury			0.2 µg/l ** (X)	
Nickel	EXP(0.846 (lnH)+1.1645)	EXP(0.846 (lnH)+3.3612)		
Selenium			10 µg/l (X)	
Silver	0.2	EXP (1.72 (lnH)-6.52)		
Thallium	0.018	0.09		
Zinc	EXP(0.8473 (lnH)+0.7614)	EXP(0.8473 (lnH)+0.8604)		

NOTES:

DEP CHPT 16 WQC = Pennsylvania Department of Environmental Protection
Chpt 16 Water Quality Criteria for Toxic Substances
effective March 11, 1989, 19 Pa. B. 1059

DEP CHPT 93 WQS = Pennsylvania Department of Environmental Protection
Chapter 93 Water Quality Standards
effective March 11, 1989, 19 Pa. B. 1059

CCC - criterion continuous concentration (for long-term protection)

CMC - criterion maximum concentration (for short-term protection)

Table 3 - located on pages 93.7 through 93.15 of Chapter 93 Water Quality Standards

CU = Critical Use: 1) Aquatic Life; 2) Water Supply

LC_{50} = The concentration of pollutant in test waters that is lethal to 50% of test organisms over a specified time period.

H = Hardness

* This value or natural levels, whichever is greater.

** - in an unfiltered water sample

(X) - Chapter 93 Water Quality Criteria Designated Water Use Drainage List - Lake Erie

Table 5-4

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

WATER QUALITY CRITERIA

ADDITIONAL PARAMETERS	DEP CHPT 16 WQC		DEP CHPT 93 WQS	
	CCC	CMC	TABLE 3	
				CU
Alkalinity (mg/l $CaCO_3$)			minimum of 20	1
Chloride (mg/l)			250	2
Cyanide, free (µg/l)	5	22		
Grease & Oil Grab (mg/l)			2	2
Ammonia-Nitrogen			$(NH_3\text{-}N) \times (\log^{-1}[pK_T\text{-}pH]+1)$	
Nitrite-Nitrogen (mg/l)			$NO_2 + NO_3$=10	2
Nitrate-Nitrogen (mg/l)			(as nitrogen)	
$CBOD_5$				
Chemical Oxygen Demand				
Fecal Coliform (#/100ml)			BAC1 (X)	3
Phosphorus, total			(P) (X)	
Total Suspended Solids				
Hardness (mg/l $CaCO_3$)			max. monthly mean of 150	
pH (s.u.) * [field]			6.5 - 9.0 (X)	1
Temperature (°C) * [field]				1
Conductivity (mv/cm) * [field]				
Dissolved Oxygen (mg/l O_2) * [field]			minimum of 5.0	1

NOTES:

DEP CHPT 16 WQC = Pennsylvania Department of Environmental Protection
Chpt 16 Water Quality Criteria for Toxic Substances
effective March 11, 1989, 19 Pa. B. 1059

DEP CHPT 93 WQS = Pennsylvania Department of Environmental Protection
Chapter 93 Water Quality Standards
effective March 11, 1989, 19 Pa. B. 1059

CCC - criterion continuous concentration (for long-term protection)

CMC - criterion maximum concentration (for short-term protection)

Table 3 - located on pages 93.7 through 93.15 of Chapter 93 Water Quality Standards

CU = Critical Use: 1) Aquatic Life; 2) Water Supply; 3) Recreation

- colonies

BAC1 - MAX = geometric mean of 200/100ml based on not less than 5 samples taken over not more than a thirty-day period

*[field] - average of the 3 grab samples measured in the field

(P) - Concentrations should be limited to the extent necessary to prevent nuisance growths of algae, weeds, and slimes that are or may become injurious to any beneficial water use.

(X) - Chapter 93 Water Quality Criteria Designated Water Use Drainage List - Lake Erie

Table 5-5

WATER QUALITY MONITORING STUDY
FOR THE LAKE ERIE WATERSHED

POLLUTANT CONCENTRATION SUMMARY

PESTICIDES/PCBs

Event	01D			04D			02W			03W			05W			06W			07W			08W			09W			10W		
Date	June 14, 1995			Oct. 3, 1995			Aug. 11, 1995			Sept. 20, 1995			Oct. 5, 1995			Nov. 7, 1995			Nov. 11, 1995			April 12, 1996			April 30, 1996			May 9, 1996		
Creek	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk
Units	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
alpha-BHC	<0.02	<0.02	<0.02				<0.02	<0.02	<0.02																					
beta-BHC	<0.02	<0.02	<0.02				<0.02	<0.02	<0.02																					
delta-BHC	<0.02	<0.02	<0.02				<0.02	<0.02	<0.02																					
gamma-BHC (Lindane)	<0.02	<0.02	<0.02				<0.02	<0.02	<0.02																					
Heptachlor	<0.04	<0.04	<0.04				<0.04	<0.04	<0.04																					
Aldrin	<0.4	<0.4	<0.4				<0.4	<0.4	<0.4																					
Heptachlor epoxide	<0.02	<0.02	<0.02				<0.02	<0.02	<0.02																					
alpha-Endosulfan (I)	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01																					
Dieldrin	<0.5	<0.5	<0.5				<0.5	<0.5	<0.5																					
4,4'-DDE	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01																					
Endrin	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01																					
beta-Endosulfan (II)	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01																					
4,4'-DDD	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01																					
Endosulfan sulfate	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01																					
4,4'-DDT	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01																					
alpha-Chlordane	<0.2	<0.2	<0.2				<0.2	<0.2	<0.2																					
gamma-Chlordane	<0.2	<0.2	<0.2				<0.2	<0.2	<0.2																					
Toxaphene	<1.0	<1.0	<1.0				<1.0	<1.0	<1.0																					
Endrin Aldehyde	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01																					
Velocity (ft./sec.)$$	0.5	2.47	1.51	0.21	1.39	0.73	4.49	4.26	1.46	0.73	2.14	1.02	3.22**	4.45**	2.81**	5.40	3.81	3.79	10.2	7.1	8.5	4.5	3.5	2.7	7.2	6.1	6.5	5.5	8.2	5.8
Depth (ft.)$$	0.73	0.51	0.71	0.42	0.39	1.93	1.71	0.90	2.85	0.69	0.42	n/d	1.25**	1.45**	2.54**	1.67	0.78	2.72	3.17	2.09	5.64	1.78	0.71	2.59	2.50	1.73	6.17	2.00	2.58	8.00
Estimated Creek Flow (cfs)	3.72	51.8	18.5	0.55	17.6	29.5	127	220	99.6	4.96	29.8	n/f	55.6	213	162	147	147	222	830	1,110	2,150	137	122	160	387	875	1,910	202	1,750	2,810
Rainfall (inches) RF	0.00	0.00	0.00	0.00	0.00	0.00	1.06	1.06	1.06	0.44 &	0.44 &	0.44 &	1.67	1.67	1.67	0.52	0.52	0.52	1.92 &&	1.92 &&	1.92 &&	0.70 &	0.70 &	0.70 &	0.71	0.71	0.71	0.77 &	0.77 &	0.77 &
Antecedent Dry Period (days)	6.0	6.0	6.0	9.9	9.9	9.9	5.9	5.9	5.9	6.3	6.3	6.3	2.0	2.0	2.0	2.6	2.6	2.6	3.0	3.0	3.0	7.8	7.8	7.8	1.0 *R	1.0 *R	1.0 *R	4.0	4.0	4.0

Notes:

$$ - average of 3 measurements

** - average of 4 measurements

- analyte eliminated from sampling program

n/d - depth measurement not available

n/f - flow could not be estimated without depth measurement

& - Average of 6 rain gauge measurements collected in City of Erie

&& - Rainfall event occurred on Nov. 10 and Nov. 11, 1995

*R - Rainfall event preceded by 1 day of light rain preceded by 3 days antecedent dry conditions

- exceeds DEP Chapter 16 CCC limit

- exceeds DEP Chapter 16 CCC and CMC limits

CCC - for long-term protection

CMC - for short-term protection

Table 5-5

WATER QUALITY MONITORING STUDY
FOR THE LAKE ERIE WATERSHED

POLLUTANT CONCENTRATION SUMMARY

Table 5-5

INORGANICS

Event	01D			04D			02W			03W			05W			06W			07W			08W			09W			10W		
Date	June 14, 1995			Oct. 3, 1995			Aug. 11, 1995			Sept. 20, 1995			Oct. 5, 1995			Nov. 7, 1995			Nov. 11, 1995			April 12, 1996			April 30, 1996			May 9, 1996		
Creek	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk
Units	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Aluminum [total]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	13.8	38.5	1.28	0.21	<0.1	<0.1	0.59	<0.1	0.56	0.76	1.51	0.21	8.59	13.10	8.20	5.28	1.67	1.35	5.07	17.48	17.95	1.09	19.03	18.18
Antimony [total]	<0.003	<0.003	<0.003				<0.003	<0.003	<0.003	<0.003	<0.003	<0.003																		
Arsenic [total]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	0.010	0.003	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.002	0.002	0.002	0.004	0.006	0.004	0.001	<0.001	<0.001	0.007	0.003	0.002	0.001	0.002	0.003
Beryllium [total]	<0.005	<0.005	<0.005				<0.005	<0.005	<0.005	<0.005	<0.005	<0.005																		
Cadmium $ [total]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	0.0004	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0002	<0.0001
Chromium Total $	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.13	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.06
Chromium VI (ug/l)	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01																		
Copper $ [total]	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.021	0.033	0.0002	<0.001	<0.001	<0.001	0.002	0.008	0.001	0.004	0.004	<0.001	0.015	0.010	0.010	0.004	0.003	<0.001	0.002	0.001	0.003	<0.001	0.007	0.003
Iron [total]	0.62	0.38	0.47	<0.03	<0.03	0.06	19.50	35.50	0.82	0.15	0.13	0.09	3.14	14.40	2.23	1.63	2.54	0.23	6.92	10.22	7.49	6.95	2.16	1.95	7.12	25.87	35.64	1.29	20.22	19.87
Lead $ [total]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.003	<0.001	<0.001	<0.001	<0.001	0.001	0.008	0.003	0.002	0.005	<0.001	0.001	0.003	0.001	0.008	0.003	0.002	<0.001	0.002	0.001	0.002	0.014	0.009
Manganese [total]	<0.01	0.01	<0.01	0.01	0.02	0.03	0.08	0.08	0.06	0.04	0.03	0.03	0.49	0.80	0.26	0.20	0.21	0.05	0.65	0.79	0.50	0.15	0.07	0.05	0.13	0.45	0.42	0.05	0.30	0.25
Mercury [total]	<0.0002	<0.0002	<0.0002				<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002																		
Nickel $ [total]	<0.01	<0.01	<0.01	0.02	0.01	0.01	0.04	0.10	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.05	0.07	0.09	<0.01	0.02	0.02
Selenium [total]	<0.002	<0.002	<0.002				<0.002	<0.002	<0.002	<0.002	<0.002	<0.002																		
Silver $ [total]	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Thallium [total]	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001																		
Zinc $ [total]	<0.012	0.048	0.011	<0.005	<0.005	<0.005	0.200	0.670	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008	0.022	<0.005	0.050	0.089	0.045	0.028	0.032	<0.005	0.023	0.084	0.079	0.006	0.076	0.079
Velocity (ft./sec.)$$	0.5	2.47	1.51	0.21	1.39	0.73	4.49	4.26	1.46	0.73	2.14	1.02	3.22**	4.45**	2.81**	5.40	3.81	3.79	10.2	7.1	8.5	4.5	3.5	2.7	7.2	6.1	6.5	5.5	8.2	5.8
Depth (ft.)$$	0.73	0.51	0.71	0.42	0.39	1.93	1.71	0.90	2.85	0.69	0.42	n/d	1.25**	1.45**	2.54**	1.67	0.78	2.72	3.17	2.09	5.64	1.78	0.71	2.59	2.50	1.73	6.17	2.00	2.58	8.00
Estimated Creek Flow (cfs)	3.72	51.8	18.5	0.55	17.6	29.5	127	220	99.6	4.95	29.8	n/f	55.6	213	162	147	147	222	830	1,110	2,150	137	122	160	387	875	1,910	202	1,750	2,810
Rainfall (inches) RF	0.00	0.00	0.00	0.00	0.00	0.00	1.06	1.06	1.06	0.44 &	0.44 &	0.44 &	1.67	1.67	1.67	0.52	0.52	0.52	1.92 &&	1.92 &&	1.92 &&	0.70 &	0.70 &	0.70 &	0.71	0.71	0.71	0.77 &	0.77 &	0.77 &
Antecedent Dry Period (days)	6.0	6.0	6.0	9.9	9.9	9.9	5.9	5.9	5.9	6.3	6.3	6.3	2.0	2.0	2.0	2.6	2.6	2.6	3.0	3.0	3.0	7.8	7.8	7.8	1.0 *R	1.0 *R	1.0 *R	4.0	4.0	4.0

Notes:

$ - limit based on water hardness

$$ - average of 3 measurements

** - average of 4 measurements

- analyte eliminated from sampling program

n/d - depth measurement not available

n/f - flow could not be estimated without depth measurement

& - Average of 6 rain gauge measurements collected in City of Erie

&& - Rainfall event occurred on Nov. 10 and Nov. 11, 1995

*R - Rainfall event preceded by 1 day of light rain preceded by 3 days antecedent dry conditions

- exceeds DEP Chapter 16 CCC limit

- exceeds DEP Chapter 16 CCC and CMC limits

- exceeds DEP Chapter 93 limit

CCC - for long-term protection

CMC - for short-term protection

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

POLLUTANT CONCENTRATION SUMMARY

ADDITIONAL PARAMETERS

Event	01D			04D			02W			03W			05W			06W			07W			08W			09W			10W		
Date	June 14, 1995			Oct. 3, 1995			Aug. 11, 1995			Sept. 20, 1995			Oct. 5, 1995			Nov. 7, 1995			Nov. 11, 1995			April 12, 1996			April 30, 1996			May 9, 1996		
Creek	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk	12 Mile	Walnut	Elk
Units	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Alkalinity (mg/l $CaCO_3$) ALK1	81	140	100	88	122	108	44	165	105	79	104	98	53	122	75	30	75	55	[redacted]	40	31	44	97	70	33	62	40	43	45	30
Chloride	38	59	35	40	51	51	35	29	37	34	42	46	37	37	33	38	62	41	21	37	24	42	65	30	24	43	15	31	22	8.4
Cyanide, free	<0.005	<0.005	<0.005	[redacted]			<0.005	<0.005	<0.005	[redacted]			[redacted]			[redacted]			[redacted]			[redacted]			[redacted]			[redacted]		
Grease & Oil Grab *	1.2	1.3	1.6	[redacted]			0.5	2.0	0.4	[redacted]			[redacted]			[redacted]			[redacted]			[redacted]			[redacted]			[redacted]		
Ammonia-Nitrogen	0.05	0.04	0.09	<0.01	0.02	0.11	0.19	0.33	0.10	<0.01	0.05	0.07	0.02	0.02	0.08	0.01	0.05	0.02	0.08	0.0	0.06	0.20	0.12	0.11	0.04	0.12	0.16	0.42	0.09	0.07
Nitrite-Nitrogen	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.06	0.10	0.02	0.01	0.02	0.03	<0.01	0.05	0.01	0.01	0.04	<0.01	0.07	0.0	0.07	0.05	0.02	0.02	0.01	0.02	0.03	0.02	0.14	0.20
Nitrate-Nitrogen	2.45	0.41	0.97	1.95	0.10	2.40	3.28	0.59	1.27	2.85	0.70	1.87	1.37	0.56	0.88	0.97	0.95	1.22	1.16	1.17	1.36	2.05	0.71	1.16	1.02	0.47	0.54	2.98	0.44	0.47
$CBOD_5$	3	2	2	2	2	2	10	15	6	7	5	6	11	10	5	2	3	2	2	3	2	3	3	4	2	2	2	2	8	6
Chemical Oxygen Demand	<10	<10	10	<10	<10	<10	115	125	10	<10	10	10	30	50	20	35	20	15	60	60	50	20	10	<10	25	40	30	20	20	30
Fecal Coliform (#/100ml) BAC(X)	141	80	28	29	45	12	13,100	11,500	1,940	1,150	2,140	290	940	2,940	1,410	1,200	330	300	10,400	5,200	4,700	198	143	9	504	792	1,116	700	10,300	6,400
Phosphorus, total	<0.01	<0.01	0.01	<0.01	<0.01	0.08	0.89	1.74	0.04	0.01	<0.014	0.06	0.34	1.08	0.17	0.28	0.31	0.10	0.84	0.95	0.79	0.36	0.15	0.14	0.32	0.78	0.95	0.01	2.08	2.20
Total Suspended Solids	2	2	2	2	4	2	680	1,508	24	4	4	2	198	892	142	134	212	24	828	892	768	180	68	62	180	784	836	50	2,504	3,428
Hardness (mg/L $CaCO_3$) HRD1	157	209	154	198	220	226	112	144	184	186	144	222	164	144	200	106	176	156	72	104	102	116	158	132	70	100	80	90	74	55
pH (s.u.) * pH1	8.4	8.7	9.0	8.2	8.3	8.2	8.1	7.9	8.0	8.2	8.2	8.1	8.7	7.4	7.8	8.9	7.7	7.5	[redacted]	7.2	7.1	7.8	8.0	7.9	8.1	7.5	7.4	8.8	7.4	6.9
Temperature (°C) *	18.0	21.5	23.3	13.7	13.5	14.8	20.8	21.7	24.5	15.8	16.0	17.2	15.2	15.2	15.4	7.1	5.0	4.9	7.5	7.5	7.3	7.7	8.0	9.2	9.7	9.4	9.6	14.7	14.6	14.6
Conductivity (µS/cm) *	413	553	405	486	559	598	309	332	468	426	487	544	422	393	499	291	516	413	182	310	252	331	539	347	210	338	194	266	202	125
Dissolved Oxygen (mg/l O_2) * O_2	5.4@	5.4@	5.4@	6.7	10.1	10.1	4.6@	7.8	8.9	4.6@	11.3	12.4	7.4	9.7	10.0	10.6	11.4	11.3	12.5	13.0	10.9	12.8	10.6	10.2	10.8	9.1	8.9	7.6	8.2	8.6
Velocity (ft./sec.)SS	0.50	2.47	1.41	0.21	1.39	0.73	4.49	4.26	1.46	0.73	2.14	1.02	3.22**	4.45**	2.81**	5.40	3.81	3.79	10.20	7.07	8.50	4.53	3.47	2.70	7.17	6.10	6.50	5.50	8.23	5.83
Depth (ft.)SS	0.73	0.51	0.71	0.42	0.39	1.93	1.71	0.90	2.85	0.69	0.42	n/d	1.25**	1.45**	2.54**	1.67	0.78	2.72	3.17	2.09	5.64	1.78	0.71	2.39	2.50	1.73	6.17	2.00	2.58	8.00
Estimated Creek Flow (cfs)	3.72	51.8	18.5	0.55	17.6	29.5	127	220	99.6	4.96	29.8	n/f	55.6	213	162	147	147	222	830	1,110	2,150	137	122	160	387	875	1,910	202	1,750	2,810
Rainfall (inches) RF	0.00	0.00	0.00	0.00	0.00	0.00	1.06	1.06	1.06	0.44 &	0.44 &	0.44 &	1.67	1.67	1.67	0.52	0.52	0.52	1.92 &&	1.92 &&	1.92 &&	0.70 &	0.70 &	0.70 &	0.71	0.71	0.71	0.77 &	0.77 &	0.77 &
Antecedent Dry Period (days)	6.0	6.0	6.0	9.9	9.9	9.9	5.9	5.9	5.9	6.3	6.3	6.3	2.0	2.0	2.0	2.6	2.6	2.6	3.0	3.0	3.0	7.8	7.8	7.8	1.0 *R	1.0 *R	1.0 *R	4.0	4.0	4.0

Notes:

* - average of the 3 grab samples

SS - average of 3 measurements

** - average of 4 measurements

[redacted] - analyte eliminated from sampling program

@ - measurement considered an anomaly

n/d - depth measurement not available

n/f - flow could not be estimated without depth measurement

RF - Average of 7 rain gauge measurements collected in the City of Erie

& - Average of 6 rain gauge measurements collected in City of Erie

&& - Rainfall event occurred on Nov. 10 and Nov. 11, 1995

*R - Rainfall event preceded by 1 day of light rain preceded by 3 days antecedent dry conditions

DEP CHPT 16 & 93 Water Quality Criteria:

BAC(X) - Geometric mean of not less than 5 consecutive taken over not more than a 30 day period should not exceed 200/100ml fecal coliforms.

ALK1 - minimum alkalinity = 20 mg/l

HRD1 - max. monthly mean = 150 mg/l

pH1 - range = 6.5 to 9.0

O_2 - minimum = 5.0 mg/l

(X) - Chapter 93 Water Quality Criteria Designated Water Use Drainage List - List X - Lake Erie

[redacted] - exceeds DEP Chapter 16 CCC limit

[redacted] - exceeds DEP Chapter 16 CCC and CMC limits

[redacted] - exceeds DEP Chapter 93 limit

CCC - for long-term protection

CMC - for short-term protection

Table 5-5

5.1.2 Wet Weather Conditions

Pesticides/PCBs

Pesticides/PCBs were deleted from the parameter list following the first wet weather sampling event. Analyses of samples collected during the first wet weather event indicated that all of these compounds, if present, were less than detection limits. The analytical sample collection dates may not have coincided with typical pesticide application periods. Our initial sample date of June 14, 1995 may have missed the typical spring (February, March or April) pesticide application periods.

Inorganics

Total chromium was detected in Walnut Creek during sample event 02W at a level equal to a Criterion Continuous Concentration (CCC) for long-term protection. The WQC for this parameter, as defined in the Pennsylvania DEP Chapter 16 Water Quality Toxic Substances, is calculated based on hardness of the stream sampled. In this case, the analyte and the CCC are 0.29 mg/l. In all other samples at each of the three creeks, total chromium was either below detection levels or slightly above detection levels but not exceeding WQC.

Copper was detected above the CCC in Walnut Creek during wet weather event 07W. In this case, the copper concentration was determined to be 0.016 mg/l and the CCC value was 0.01223 mg/l based on a hardness in Walnut Creek of 104 mg/l. The Criterion Maximum Concentration (CMC) (for short-term protection) for this analyte was 0.0184 mg/l based on the same hardness value. As presented in Table 5-5, copper exceeded the CMC value at Twelvemile and Walnut Creeks during event 02W and at Twelvemile Creek during event 07W. These exceedances are not considered significant since they range from 0.0013 mg/l to 0.008 mg/l above the WQC limits.

Concentrations of iron were present in each wet weather sample collected from each creek. As presented in Table 5-4, the Chapter 93 Water Quality Standard in Table 3 for iron is 0.3 mg/l or natural levels, whichever is greater. Concentrations of iron exceeded the 0.3 mg/l value in every dry and wet weather sample, indicating that iron is naturally present in this area.

Lead was found to exceed the CCC WQC limit during the following events:

- Twelvemile Creek: 02W, 06W, 07W and 08W
- Walnut Creek: 02W, 05W, 07W and 10W
- Elk Creek: 07W and 09W

The lead concentrations that exceeded the CCC criteria were detected in a range from 0.004 mg/l to 0.049 mg/l. The CCC criteria for lead is based on hardness of the water in each stream during each wet weather event. Therefore, lead concentrations present in one sample may exceed CCC criteria for one event and the same concentrations may not exceed limits for another event. The Lead Criteria Continuous Concentrations Formula is:

$$\text{Exp}\,(1.266\,[\ln H] - 4.661)\ \text{ug/l}$$

In Twelvemile Creek during event O6W, a lead concentration at 6 ug/l is reported. The corresponding water hardness is 106 mg/l $CaCO_3$ which yields a CCC of 3.5 ug/l. If hardness for the same event in Twelvemile Creek were reported as 164 mg/l $CaCO_3$, the resulting CCC would be 6.0 ug/l and the reported O6W lead concentration would not exceed CCC criteria.

Manganese was detected above CMC limits during event 02W in both Twelvemile and Walnut Creeks. This compound has a Chapter 93 WQS limit of 1.0 mg/l. The Twelvemile Creek sample contained 1.34 mg/l and the Walnut Creek sample contained 2.44 mg/l manganese.

Silver was identified to be present in Twelvemile and Elk Creeks during event 02W. All other wet weather events reported a silver concentration less than the detection limit. This compound was detected at 0.0001 mg/l above the CCC limit of 0.0002 mg/l in Twelvemile Creek. In Elk Creek, silver was detected 0.0006 mg/l above the same CCC limit.

Zinc was detected once in each creek above the CMC value. This value was based on the hardness of the stream when sampled. The Twelvemile Creek concentration of zinc measured during event 02W is reported as 0.2 mg/l while the CMC is calculated to be 0.1288 mg/l. During the same wet weather event, the zinc concentration in Walnut Creek was measured to be 0.67 mg/l and the CMC was calculated at 0.1594 mg/l. Samples

collected at Elk Creek during wet weather event 10W contained zinc at a concentration of 0.079 mg/l and the CMC was calculated to be 0.071 mg/l.

Additional Parameters

Alkalinity was measured below the Chapter 93 minimum required 20 mg/l during sample event 07W at Twelvemile Creek (14 mg/l). All other samples were reported above the minimum required WQC value.

Fecal coliform colonies were present at each of the three creeks monitored during dry and wet weather events. During dry events, the range of fecal coliform colonies present was from 12 counts/100 ml to 141 counts/100 ml. During wet weather events, the range increased from 9 counts/100 ml to 13,100 counts/100 ml. These samples are individual grab samples. The Chapter 93 BAC1 standards are for a geometric mean of five consecutive samples. Therefore, these samples do not exceed the WQS limits based on a five-day geometric mean.

Elevated suspended solids concentrations were noted at Walnut Creek during events 02W (1,508 mg/l) and 10W (2,504 mg/l) and at Elk Creek during event 10W (3,428 mg/l). These two Walnut Creek events and the Elk Creek sample date coincide with highest recorded fecal coliform colonies in each creek during the study. In addition, event 10W represents the deepest creek flows recorded during the study.

During wet weather event 07W the pH in Twelvemile Creek was reported as 9.1 s.u. This value exceeds the Chapter 93 WQS for pH, which is between 6.5 - 9.0 s.u. The pH data reported for this creek during the October and November 1995 sample dates is suspect since an ECHD biologist recorded a pH in Twelvemile Creek of 7.6 s.u. on October 11, 1995 and 6.4 s.u. on November 13, 1995.

Chapter 93 WQS for dissolved oxygen is a minimum of 5 mg/l oxygen. During wet weather event 02W and 03W for Twelvemile Creek the dissolved oxygen level was reported to be 4.58 and 4.57 mg/l oxygen, respectively. We consider these data to be anomalies since the D.O. is anticipated to be much higher during wet weather events and considering the creek temperatures during these events. In addition, an ECHD biologist recorded D.O. readings of approximately 9.0 mg/l during these time periods. The average dissolved oxygen

measurements recorded in all three creeks during monitoring event O1D are also considered anomalies. Each week's D.O. average of 5.4 mg/l is considered low due to the creek's water temperature.

5.2 POLLUTANT LOADING SUMMARY

Presented in Appendix C are the cross-section surveys which were sent via facsimile to Malcolm Pirnie on May 30, 1996. We have calculated the estimated flows at each creek sampling point during each event. Pollutant loadings were calculated using these estimated flows and pollutant concentrations. Presented in Table 5-6 are the pollutant loadings for each of the three creeks studied.

The pollutant loading calculations should be considered best approximations due to the numerous assumptions and limitations of the monitoring methods used. Some of the assumptions used during this study include:

- The creek velocity was uniform across the entire cross section.
- Precipitation was uniform across the Erie County, Pennsylvania area of the Lake Erie Watershed.
- Depth of flow was accurately measured as swollen creek waters rapidly passed our monitoring station.

Review of the pollutant loading data indicates that there are four inorganic parameters consistently discharging to Lake Erie at elevated levels. These four parameters include aluminum, iron, manganese, and zinc. Each of these parameters discharge significantly less pollutants to Lake Erie during dry weather conditions as compared to wet weather conditions.

Summarized in Table 5-6 is the pollutant loading data for additional parameters analyzed. This data indicates that chloride, ammonia, $CBOD_5$, COD, phosphorus and TSS levels are elevated during wet weather conditions.

6.0 RECOMMENDATIONS AND CONCLUSIONS

Historically, pesticides and PCBs have not been analyzed on Twelvemile, Walnut or Elk Creeks. Based on a review of the data provided by STORET, only one sample, collected on August 25, 1993 from Twelvemile Creek, was analyzed for pesticides/PCBs. Identified in this sample was 0.009 mg/l of alpha-BHC and 0.044 mg/l of heptachlor. The other parameters analyzed (aldrin, heptachlor epoxide, dieldrin and endrin) were all reported with a qualifier used to indicate a failure to detect the substances. In comparison, all samples collected during the one dry and one wet weather sampling round during this study were identified as less than detection limits. During this study, the dry and wet weather sample dates, June 14 and August 11, 1995, respectively, may have been too long after typical spring pesticide application periods to measure any runoff containing pesticides/PCBs.

An analysis was conducted to compare historical STORET data and data collected during this study. A summary of this analysis is presented in Table 6-1. Illustrated in this table are the average concentrations of several inorganic and additional parameters for both STORET and this study's data. STORET data qualified with a "K" was not used when calculating averages. Data from this study qualified with a "less than" sign was also not used when calculating average concentrations. Also of note is that the STORET data typically has more data points than the study. In addition, the antecedent and sample day weather conditions are unknown for the STORET data group. The wet weather data was used to calculate average concentrations for this study's data.

A review of the inorganic parameters listed in Table 6-1 indicates that the average concentrations of aluminum and iron are significantly greater in this study than are reported in the STORET database. Other inorganic parameters remained approximately the same or increased slightly with lead being the only exception. Data for this parameter indicates a decrease in average concentrations of lead from this study's data in the three creeks studied.

As presented in Table 6-1, the average concentrations of additional parameters remained relatively constant except for noted increases in nitrite-nitrogen, fecal coliform counts and phosphorus concentrations.

TABLE 6-1
WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED
HISTORICAL DATA COMPARATIVE ANALYSIS

Parameter	TWELVEMILE				WALNUT				ELK			
	STORET		STUDY		STORET		STUDY		STORET		STUDY	
	Data Points	Average Concentration* (mg/l)	Data Points	Average Concentration** (mg/l)	Data Points	Average Concentration* (mg/l)	Data Points	Average Concentration** (mg/l)	Data Points	Average Concentration* (mg/l)	Data Points	Average Concentration** (mg/l)
Inorganic												
Aluminum	56	0.259	8	4.44	8	0.228	6	15.2	14	0.386	7	6.82
Copper	47	0.007	6	0.008	5	0.014	7	0.010	6	0.013	5	0.003
Iron	79	0.326	8	5.84	70	0.228	8	13.9	74	0.332	8	8.54
Lead	36	0.78	6	0.008	3	0.046	7	0.016	2	0.038	5	0.006
Manganese	66	0.19	8	0.38	8	0.018	8	0.636	14	0.042	8	0.203
Nickel	36	0.011	4	0.028	5	0.024	5	0.044	7	0.026	5	0.032
Zinc	41	0.005	6	0.053	7	0.023	6	0.162	13	0.035	3	0.068
Additional												
Alkalinity	78	57	8	42.5	68	98	8	88.8	71	80	8	63
Ammonia-Nitrogen	31	0.032	7	0.14	57	0.12	8	0.10	66	0.262	8	0.084
Nitrite-Nitrogen	30	0.006	7	0.033	35	0.016	8	0.06	41	0.03	7	0.05
Nitrate-Nitrogen	78	1.99	8	1.96	60	0.66	8	0.69	70	0.77	8	1.09
Fecal Coliform (#/ 100 ml)	13	1,055	8	3,524	23	214	8	4,143	25	423	8	2,021
Phosphorus	73	0.029	8	0.38	56	0.055	7	1.0	70	0.16	8	0.57

Note: Units (mg/l) except where noted
* *Average Concentration - Using all STORET data not qualified with a "K".*
** *Average Concentration - Using all study data not qualified with a "less than" sign.*

Based on the results presented in this report and in historical documents, we conclude that these three subwatersheds (namely: Twelvemile, Walnut and Elk) individually are not discharging significant pollutant concentrations to Lake Erie. However, the aggregate of the three subwatersheds may significantly impact the Erie County, Pennsylvania area of the Lake Erie Watershed. Based on the review of concentration data, there are a few elevated inorganic parameters, fecal coliform colonies, nitrate-nitrogen and phosphorus levels that warrant further evaluation. Historical accounts have confirmed that inorganics, such as iron, lead and zinc are indigenous to Erie and surrounding Pennsylvania counties soil. Data collected during this monitoring program indicate that during dry weather conditions, Twelvemile, Walnut and Elk Creeks do not contribute significant pollutants to the Erie County, Pennsylvania area of the Lake Erie Watershed. Increased pollutant levels during wet weather conditions indicates that a more in-depth, concentrated study should be completed.

We recommend that each creek be divided into representative areas and additional sampling be conducted in an effort to differentiate between potential point and nonpoint source(s). This most recent sampling program has yielded an updated database for each of the three creeks monitored. However, since only one water quality station along each creek was monitored, conclusions as to actual pollution point and nonpoint source(s) is difficult.

Additional sampling is recommended in an attempt to identify point and/or nonpoint source(s) of pollution. The following list includes potential source(s) along the three creeks monitored:

- Private on-lot septic systems.
- STPs.
- Wildlife.
- Agricultural land.
- Farm animals.

Suggested sampling points include the water quality locations monitored in this study and upstream and downstream of locations identified as "urban industrial and commercial complexes" at Twelvemile, Walnut at Elk Creeks. In addition, sampling should be

conducted upstream and downstream of Sewage Treatment Plants such as Girard and Lake City on Elk Creek and Popp's Trailer Court and Standard Trailer on Walnut Creek.

Listed in Table 6-2 are the recommended parameters to be analyzed in an attempt to differentiate between point and nonpoint pollution source(s)

TABLE 6-2

WATER QUALITY MONITORING STUDY FOR THE LAKE ERIE WATERSHED

FUTURE MONITORING ANALYTICAL PARAMETERS

Title 25. Rules and Regulations Part I. Department of Environmental Resources Subpart A. Preliminary Provisions Article II. Statements of Policy Chapter 16. Water Quality Toxics Test Parameters	**Title 25. Rules and Regulations Part I. Department of Environmental Resources Subpart C. Protection of Natural Resources Article II. Water Resources Chapter 93. Water Quality Standards Test Parameters**
Aluminum Iron Zinc	Alkalinity Ammonia Nitrogen Bacteria/Fecal Coliform Hardness Iron Nitrate - Nitrogen Total Suspended Solids Phosphorus CBOD
Additional Parameter: Commercial Fertilizer Test	**Field Measurements:** Dissolved Oxygen pH Temperature Conductivity

There are two different sample collection techniques that the ECDP, DEP and ECHD may employ for additional data gathering. One is a fast-tracked "short-term" investigative approach and the second is a "long-term" investigative approach. The short-term approach requires immediate commitment and use of financial and staff (or subcontractor) resources to locate water quality monitoring stations upstream and downstream of each of the areas listed above and conduct multiple sampling events in a short period of time. The stations

must be located far enough from another designated investigation area's upstream station to allow isolation of the effects of the upstream point or nonpoint source discharge.

Using the long-term approach, the agencies would allocate financial and staff resources over an extended period of time. Once the same water quality stations were located (as identified above), sampling events, using agency staff, may occur quarterly or semi-annually to isolate potential point and nonpoint pollution source(s) as well as to determine if any seasonal subwatershed impacts exist.

Malcolm Pirnie is available to assist the agencies develop either program to achieve the goals of the Coastal Nonpoint Source Control Program.