PRESQUE ISLE BAY

REMEDIAL ACTION PLAN

Prepared by the Pennsylvania Department of Environmental Resources

and

the Presque Isle Bay Public Advisory Committee

December 1992

Table of Contents

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107-4431

June 21, 1993

RECEIVED
JUN 23 1993
ENVIRONMENTAL RESOURCES
MEADVILLE REGIONAL OFFICE

Mr. James D. Rozakis
Assistant Regional Director
Pennsylvania Department of Environmental Resources
1012 Water Street
Meadville, PA 16335

Dear Mr. Rozakis:

The Environmental Protection Agency Region III (EPA) has reviewed the Presque Isle Bay Remedial Action Plan (RAP) which you submitted on January 15, 1993. The RAP was prepared as a result of the United States Department of State designation on January 30, 1991, of Presque Isle Bay as the 43rd Area of Concern (AOC) under the Great Lakes Water Quality Agreement. The Great Lakes Critical Programs Act of 1990 (GLCPA) required the RAP to be submitted to EPA within two years of designation. This statutory requirement has been satisfied, and we believe the RAP is generally ready to be submitted to the International Joint Commission (IJC) for its review.

We believe the RAP is a very well written, comprehensive plan to identify and in certain cases alleviate the pollution and resulting environmental impacts in Presque Isle Bay. We recognize there is a lack of data to adequately define several of the uses which could be or are impaired and several studies are ongoing which will fill in some of the data gaps. As you indicated in your letter of submittal, we expect the RAP to be a living document with periodic additions and revisions as resources allow studies to be completed and remedial actions undertaken.

Various members of our staff and the Great Lakes National Program Office (GLNPO) reviewed the RAP and have several comments and questions which are enclosed. Some questions regarding use impairments are raised due in part to a lack of information to fully define the cause, or degree of possible impairment. In a few cases, additional or different types of studies are suggested. If you are interested, we can attempt to get the reviewer to more specifically define his suggestion. Most of the questions raised concerning the use impairments should be addressed in future editions of the RAP.

Under the GLCPA the RAP must be submitted to the International Joint Commission (IJC) no later than six months after submittal to EPA. You should proceed to submit the RAP to the IJC at your convenience, but no later than July 15, 1993.

The GLCPA also requires that the Commonwealth include the RAP in the State water quality plan no later than one year after submitting it to the IJC.

If you have any questions concerning our comments on the RAP, please contact me. I can be reached at (215) 597-9096.

Sincerely,

Chuck Sapp

Charles W. Sapp
Great Lakes Coordinator

Enclosure

CC: Evelyn MacKnight (3WM12)
Victoria P. Binetti (3WM10)
Chris Grundler (GLNPO)

PRESQUE ISLE BAY
REMEDIAL ACTION PLAN
US ENVIRONMENTAL PROTECTION AGENCY
REGION III REVIEWERS' COMMENTS
JUNE 21, 1993

USE IMPAIRMENTS

1. Guideline #1 - Fish and Wildlife Consumption should be considered impaired. The RAP, through its evaluation of impaired beneficial uses, appears to contradict the Pennsylvania Fish Commission which in its latest fish consumption advisory listed chlordane and PCBs as reasons for limiting Lake Erie fish consumption. Although no differences are noted between Lake Erie and PIB fish, and the two pollutants are not listed as pollutants of concern in PIB, the sweeping conclusion that no impairment is noted in PIB may not be valid. Source evaluations in the food chain may be a better method of pinpointing bio-accumulation and magnification pathways. As long as Pennsylvania has an advisory in place in Erie County including the PIB, the Fish and Wildlife Consumption use should be listed as impaired.

   Most of the fish tissue data indicated higher levels of PCBs outside of PIB, but there was very little data on bottom feeders inside the PIB. Even the 1992 data showed no detectable levels in yellow perch from the PIB, however, channel catfish from the mouth of Sixmile Creek had levels over 4 ppm. Additional data on bottom feeders from PIB may be needed.

2. The RAP underestimates the effects of the millions of cubic yards of organic, metal laden muck that has been deposited on the bay bottom as a result of anthropogenic activity in the watershed. The muck limits the benthic fish and macroinvertebrate species that can inhabit the majority of the bay. Undoubtedly, the bottom dwelling community would be quite different if the substrate in the bay was sand and/or other glacially deposited materials. As a result of the apparent destruction of the natural substrate, guidelines #3 - Fish and Wildlife Populations, #6 - Degradation of Benthos, and #14 - Loss of Fish and Wildlife Habitat should be designated as impaired.

   The alteration to the substrate may have also been affected by upstream erosion of shales, coupled with the energy dynamics of the system, i.e., tributaries entering the Bay lose energy and deposit their loads of eroded shale. To accurately identify the sources contributing to the altered substrata cores would need to be taken and dated in order to determine if the artificial substrata is pre- or post-anthropogenic in origin or a combination of the two. This point may be moot, however, due to the scale of the impairment and the unlikelihood of any remedial activities occurring besides natural recovery.

3. Guideline #6 - Degradation of Benthos - Impairment is unknown due to lack of data, but would be suspected due to sediment contamination problems. Part of the goal of a Stage I RAP is to identify data gaps and areas that require further study. By identifying these needs, resources can be brought to bear, and this new information can be fed back into the RAP process to address data gaps and to drive remedial options to be recommended in the Stage II document. Sediment contamination in other Areas of Concern (AOCs) often contributes to and/or causes degradation of benthos. A lack of data is not a sufficient reason to determine an impairment does not exist. This is the antithesis of the RAP process. The Stage II document should be flexible enough to incorporate changes in remedial activities and resource allocation basd upon new findings. This has been one of the reasons for the lag time in the issuance of Stage II RAPs in some other AOCs.

4. In addressing guideline #8 - Eutrophication, the RAP summary stated "No significant, current cultural eutrophication problems are identified; no impairment is indicated." We believe that the trophic status of the bay is primarily a result of past, not "current cultural" activities. As a result of a 1990 study of the trophic status of Presque Isle Bay, Eric Obert, PADER, Meadville Regional Office, in a 1991 report classified the bay as "mesotrophic/eutrophic." [Other measures that indicate excessive enrichment are the more than ample fish population (as compared to oligotrophic communities) and the wide expanse of aquatic macrophytes in the littoral zone of the bay. In a shallow system, such as Presque Isle Bay, with deep light penetration, it is likely that the presence of macrophytes and large fish populations is a natural, expected and desirable outcome. We agree with Mr. Rozakis's statement that Presque Isle Bay probably always has been mesotrophic at best. There does not appear to be a eutrophication problem in the classic sense, i.e., blue-green algal blooms. In the western basin of Lake Erie, zebra mussels are filtering the water, leading to the return of macrophytes and associated fish population growth. EPA concurs that there is little evidence of eutrophication caused by human activities and beneficial uses should not be considered impaired due to eutrophication.

5. Use #14 - Loss of Fish and Wildlife Habitat - The PADER concern specifically deals with the sport fishery (mostly stocked) of the PIB. Concern has been raised regarding the protecting of fish propagation areas inside the PIB. What about habitat loss from the City of Erie development? This section could use more background information in Stage II.

GENERAL COMMENTS

6. Throughout the entire document, data was presented and cited for explaining the current state of the ecosystem. Some of the sweeping conclusions put forth in the "Impaired Beneficial Uses Evaluation" process were based on historic data gathered for studies which were not designed for those evaluation purposes. It is at best difficult to draw definitive conclusions on use impairments based on partial or missing data. Rather, it is preferable that the RAP authors err on the side of caution when drawing such conclusions.

7. Certain major issues were not addressed which would be of use in the evaluation of impacted beneficial use. The Zebra Mussel invasion was barely mentioned even though the potential effect on the PIB ecosystem in terms of fish populations, phyto/zooplankton dynamics, eutrophication, and benthic structure changes may be quite profound. Their effects should be documented although there are very few remedial options currently available and we realize this is part of a lake-wide problem rather than limited to PIB.

Stan Zagorski

In regard to benthos degradation, no mention was made of the Theoretical Bioaccumulation Potential (TBP) evaluation process which targets pollutants of concern. In addition, new organisms have been added to the list of effects-based biological testing of sediments. These tests increase the variety of end points which allow for a better evaluation of sediment effects on the aquatic community. When I obtain more information about these procedures I will forward it to you for consideration.

8. The RAP seems to struggle with the PAH in sediments issue. Some EPA programs have used a NOAA screening level of 4 ppm for low ecological effects and 35 ppm for moderate effects. The use of NOAA screening levels for PAHs is adequate for a gross level of assumptions such as the presence/absence of a potential PAH contamination problem. Its limited utility is due to the inclusion of only three of 16 PAH compounds in this protocol. As such, it should not be considered to have the level of detail needed to make a definitive conclusion on PAH contamination. Bioavailability of the PAHs should also be factored into the findings. In the absence of Great Lakes sediment quality values, these screening levels have been used in other AOCs, but only at these gross levels. A new set of PAH screening levels which will incorporate more compounds should be issued soon. The NOAA reference is "Technical Memorandum NOS OMA 52."

SPECIFIC COMMENTS

9. Tables 4.15, 4.16, and 4.17 - It is difficult to differentiate between regular type "non polluted" and bold type "moderately polluted".

10. Section 4.1.1.9, p. 41 - The last line indicates that normal lake currents are toward the east, away from the City of Erie water intakes. Are there any drinking water intakes on Lake Erie east of PIB which might be affected by contaminants discharged from PIB? No per T. Vogel

11. Chapter 4 - A couple pages seem to be out of order. Figure 4.5 is between pages 42 and 43, and figure 4.4 is after page 44.

12. Section 4.1.2, p. 51, second paragraph - The EPA regulations list six reasons why it may not be possible to attain certain beneficial uses. We suggest all six be listed or only the one of concern here - physical limitations.

    P. 52, third paragraph, line 4 - Change "Act" to "Federal regulations", line 7 - end sentence after "waterway". Again there are six reasons for non-attainment of use, physical condition of the waterway is one.

13. Figure 5.2 is difficult to read. On maps where a USGS, or other map, is used as a base for other information, it might be useful to reproduce the basic map using a light setting, then add the information in bolder type so there will be more contrast.

14. Section 5.2.2, and Figure 5.3 - Site summaries refer to numbers on Figure 5.3, these do not appear. See also comment 11 regarding contrast.

15. Section 8.5, p. 3, second paragraph - There is mention that a number of Erie industries have joined the voluntary 33/50 program. Our 33/50 coordinator had indicated there was a lack of interest from that area and he had no plans for any more follow-up activities. If you have a list of Erie industries that are involved in the 33/50 program, I would appreciate receiving it.

16. Section 9.1.3 - This section titled "New Programs" discusses existing programs. Mention could be made that the Clean Air Act Amendments (CAAA) will require more stringent controls on emissions, also under the Great Waterbodies program CAAA will require even more controls if air deposition is shown to preclude attainment of water quality standards.

17. ACRONYMS AND ABBREVIATIONS - PCB should be "Polychlorinated Biphenyls"

1.0 Executive Summary

The U. S. Department of State has designated Presque Isle Bay (PIB) as the 43rd Great Lakes Area of Concern (AOC). As an AOC, PIB will be the focus of prioritized ecosystem restoration and management activities conducted, coordinated and or sponsored by the Commonwealth of Pennsylvania Department of Environmental Resources (PADER). This document, the Remedial Action Plan or RAP, provides the framework under which these activities will be conducted. The primary goal of this project is the investigation of the types and causes of impaired beneficial uses of the ecosystem, and to develop alternative strategies for the restoration and protection of these uses. The PADER is joined in this effort by the U.S. Environmental Protection Agency (USEPA), the Erie County Department of Health (ECDH) acting as PADER's agent for water quality issues in Erie County, and by a Public Advisory Committee (PAC) comprised of representatives of local government, academic, industrial, environmental, recreational, and other interests who are the users of the Bay's resources.

The bay was designated as an AOC on January 30, 1991. However, in taking this action, no reasons were cited by the Department of State as the impetus for the designation. In order to focus future remedial investigations and actions, the RAP first identifies any impaired uses in the bay and the source(s) of the problem. The identification of impaired uses is based on the Guidelines for Recommending the Listing and Delisting of Great Lakes Areas of Concern, published by the International Joint Commission (IJC) in the March/April 1991 issue of the IJC's publication <u>Focus</u> (Volume 16, Issue 1, ISSN 0832-6673).

The Department of State described the PIB AOC as including "... Presque Isle Bay and the waters of Lake Erie in the immediate vicinity of Erie, Pennsylvania." However, based on a review of the available data and other information, PIB is seen as a sufficiently isolated ecosystem to be considered independently from the waters of Lake Erie outside of the Bay. Therefore, PADER, in consultation with the PAC, has determined that for the purpose of preparing this RAP, the AOC will consist of PIB and its tributary watershed areas. Other sources of pollution outside of the PIB drainage basin which add to or cause use impairments in the Bay will be identified and addressed in the appropriate sections of the RAP. In addition, PADER commits to investigating possible sediment contamination in the western portion of the Outer Harbor in conjunction with the sediment activities in the Bay. Based on that investigation, PADER and the PAC may consider possible expansion of the AOC.

Through the guidance of the IJC's Great Lakes Water Quality Board, and pursuant to the goals and objectives of the Great Lakes

Water Quality Agreement, an integrated "ecosystem approach" to the restoration and maintenance of the Great Lakes' aquatic resources has evolved. This approach has resulted in an assessment procedure for determining the nature of the impairments and for investigating cause-and-effect relationships between pollutant sources and ecosystem effects.

The IJC has adopted a system of tracking the progress of restoring AOCs, based on a logical sequence for problem solving and resolution, culminating with a demonstration that the full complement of beneficial uses has been restored, and subsequent delisting of the AOC. Based on the available data and other information, PIB is classified as a Category 3 AOC, signifying that the causative factors are largely known, but that a Remedial Action Plan has not been developed and remedial measures are not fully implemented.

This is the first stage in the development of a Remedial Action Plan for PIB, and provides a synthesis of the currently available data and other information. However, remedial action planning is a dynamic, flexible process, and new information will be synthesized as it becomes available. Consequently, while the focus of the RAP process for PIB, begun with the preparation of this report, will be on the currently identified impairments, new priorities may be recognized as existing problems are resolved, and as new information becomes available.

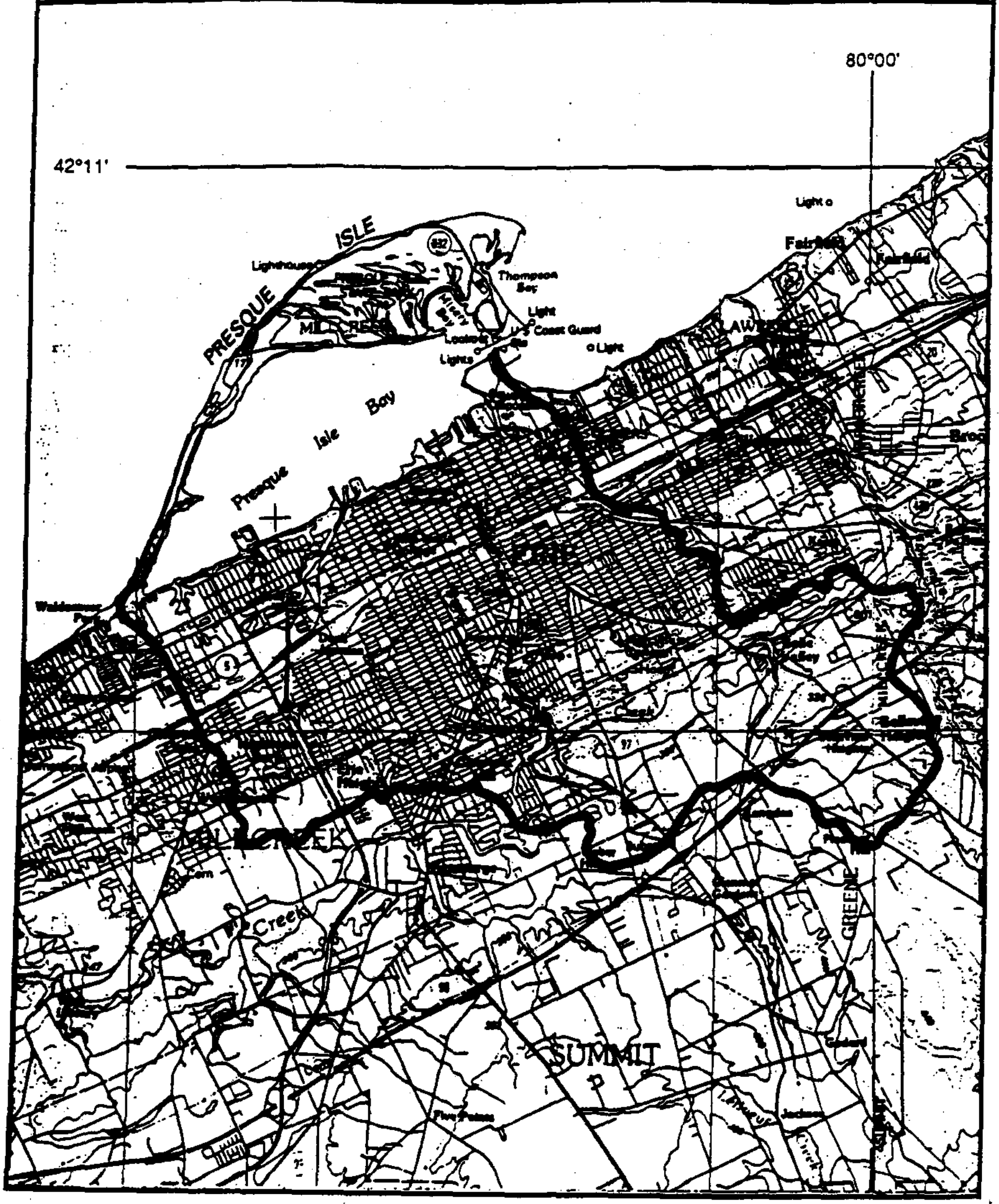
Beyond the data needs for completion of the impaired uses evaluations, additional data collection will be necessary to refine and confirm the pollutant source identification and loading rate estimates provided in this report, and for the process of formulating and screening remedial alternatives. The exact nature and extent of such additional information needs cannot be anticipated at this time. Ultimately, the quantity and quality of data needed to initiate the development, screening, and selection of the recommended remedial alternatives will be a judgement decision, and will be affected by many technical and political factors.

1.1 Study Area Description and Major Issues

The study area is located in the northwest corner of Pennsylvania on the southern shore of Lake Erie. The general location of PIB is depicted in Figure 1; the watershed area draining into PIB is also depicted in this figure. Presque Isle Bay is bounded by Presque Isle to the north and west, and the mainland and the City of Erie to the south and east.

1.1.1 Study Area

Figure 1. Location of Presque Isle Bay and drainage basin (approximate scale: 1"=8,333').



PIB is a shallow estuary (average depth of 13.1 feet) with a relatively small drainage basin (25 square miles) for the volume of the Bay (13,900 million gallons). Most of the watershed area lies within the City of Erie and Millcreek Township, however some of the more remote portions include parts of Summit, Greene, and Harborcreek Townships. The principal tributaries are Mill Creek (including Garrison Run) and Cascade Creek, which together account for approximately two thirds of the total water budget of the Bay. Additional inflow is received from precipitation directly on the Bay surface, Scott Run, combined sewer overflows (CSOs), groundwater discharge, and permitted wastewater discharges.

The Bay is a relatively closed system, and exchange of water with the outer harbor and Lake Erie is restricted by the small harbor opening and the low inflow to total volume ratio, resulting in a "flushing time" of almost 2.5 years. Consequently, biodegradation of wastes discharged to the Bay occurs almost entirely within the confines of the Bay, and does not significantly affect (and is not significantly affected by) the outer harbor or Lake Erie. However, because the Bay is completely mixed, thermal stratification does not occur, and conditions of dissolved oxygen depletion in bottom waters do not develop. Most of the Bay bottom is covered with fine, organic-rich sediments, however sand and a few larger rocks may be found in limited areas where currents have restricted the deposition of fine sediments.

Land use within the PIB watershed is approximately 80% urban and 20% rural. More than half of the total watershed (57%) is residential, followed by 16% open areas, 11% commercial, 8% public, and only 7% in industrial use. The highest concentration of industrial uses is located at the western edge of Erie, between 6th and 26th streets. A secondary concentration is located at the east edge, between 6th and 20th, and between 26th and 38th streets. A third industrial area is located on the Bayfront, at the southeast corner of the Bay. Commercial land use is concentrated in a north/south corridor from Sassafras to Holland Streets; smaller commercial land use concentrations (including shopping centers) occur throughout the City, but tend to concentrate along major east/west streets.

Almost all of the watershed is sewered, and served by the City's wastewater treatment plant which discharges to the outer harbor. In addition to the City itself, Erie's collection system also receives sewage from the metropolitan areas surrounding the City. Most of the industries located within the PIB watershed discharge wastewater to the City's collection system, however a few discharge cooling water to the Bay or its tributaries.

The City's wastewater collection system is complex, and many portions are combined sewers, receiving surface runoff during and after precipitation events. The inflow of surface runoff often exceeds the hydraulic capacity of many of these combined sewers, and untreated wastewater escapes to the Bay (either directly or indirectly) through dozens of CSOs.

1.1.2 Major Issues

PIB is the oldest U. S. Harbor on the Great Lakes; an 1824 appropriation from the national legislature for harbor improvements at Erie marked the beginning of Federal involvement in the construction of Great Lakes harbor facilities. The City of Erie, founded in 1792, has grown up around this port. Over time, much of the watershed draining to the Bay has become urbanized, with heavy manufacturing industries co-existing within the residential and commercial neighborhoods which these industries have historically supported. However, past waste disposal practices resulted in the discharge of industrial and domestic wastewater to the Bay, or to streams and tributaries leading to the Bay. While many of the pollutants which were released to the Bay from such past practices have decayed, through natural biodegradation processes, the conservative substances (such as primary metals) remain in the sediments.

Ironically, that physical feature which resulted in PIB being selected as a harbor - its sheltered, nearly enclosed natural basin - is a direct contributing cause to potential use impairments within the AOC. Because of the slow "flushing rate" of the Bay (almost 2.5 years), the Bay acts as a very efficient natural "settling basin", and most of the pollutants which enter the Bay as runoff become entrained in the Bay's sediment. Further, the shale bedrock in the Erie area is quite shallow (approximately 50 feet or less below the surface) and is exposed in stream valleys which have eroded through the alluvial layers overlying the shale. The eroded shale, in combination with the natural clay in the Erie area, results in a high suspended solids condition which encourages the precipitation and settling of metal ions and other pollutants in the Bay sediments. These natural erosion products (fine particles of shale and clay) contain very high concentrations of a variety of heavy metals.

In addition, because most of the PIB watershed is a developed, urban area, the Bay receives high concentrations of "nonpoint" pollutants from urban runoff, including untreated industrial/commercial/residential wastewater which escapes from combined sewer overflows (CSOs) in the City's sewer collection system. These pollutants may include polycyclic aromatic hydrocarbons (PAHs), oil and grease, volatile solids, BOD, COD, and nutrients (nitrogen and phosphorus), as well as pesticides, herbicides, and toxic organic compounds.

Degraded water quality issues have been reported in PIB since the early 1970s. These problems have typically been described as the readily recognizable symptoms of cultural eutrophication: algal "blooms", dissolved oxygen (DO) depletion, fish kills, malodorous conditions, reduced clarity, and excessive growths of aquatic macrophytes. While environmental conditions have shown gradual improvements over the past decade, many of the Bay's users have expressed continuing concern for possible health risks associated with remaining pollutant loads, particularly as regards possible fish flesh contamination and fecal coliform contamination of the water column. The RAP is intended to address these concerns.

1.2 Results of Impaired Beneficial Uses Evaluations

The evaluation of potentially-impaired uses is presented in Chapter 4 of this report. That chapter is the heart, or focal point, of the RAP, in that the identification of (1) impaired beneficial uses and (2) pollutants of concern are found there. This information is critical to the remainder of the RAP, but especially Chapters 5 and 6 (Pollutant Sources and Pollutant Loadings, respectively), which focus on the pollutants of concern identified in Chapter 4.

Impaired uses were identified by comparing available data and other information with the 14 use impairment identification guidelines developed by the IJC's Water Quality Board, based on Annex 2 of the 1978 Great Lakes Water Quality Agreement (GLWQA). Most of these guidelines are constructed as two-part tests of impairment, containing either/or conditional statements. Often, one part is based on specific, quantifiable measures while the second part is based on more subjective information. In completing the impaired uses evaluations, all relevant data were used, and the determination of whether a particular beneficial use is or is not impaired was based on the most compelling set of data, or the collective weight of multiple data sets in those instances where no single set was dominant. Generally, data from 1986 and earlier were not used, as such data do not represent current conditions in PIB. The results of the impaired uses evaluations, relative to the 14 IJC guidelines, are briefly summarized in Table 1. The Table 1 summaries are expanded in the following discussions.

Restrictions on Fish and Wildlife Consumption. Impairment of this guideline is indicated if (1) contaminant levels in fish or wildlife exceed current standards, or (2) if public health advisories against the consumption of fish or wildlife exist. The guideline further

Table 1. Summary of use impairments evaluations and identification of pollutants of concern.

	Guideline	Conclusions	Pollutants of Concern
# 1	Fish and Wildlife Consumption	For all regulated pollutants, levels in PIB fish are no different than background (Lake Erie) samples. No impairment is indicated.	None
# 2	Tainting	No evidence of tainted fish or wildlife flesh; no pattern of exceedances of tainting water quality standards. No impairment indicated.	None
# 3	Fish and Wildlife Populations	Productive, balanced fisheries present; no evidence of water column or sediment toxicity to fish. No impairment indicated.	None
# 4	Fish Tumors or Deformities	Liver tumors present. While PAHs are suspected of contributing to internal and external abnormalities, flesh levels are not elevated, and no standards exist.	Possibly PAHs
# 5	Bird Deformities	No reports of reproductive problems or deformities in fish-eating birds. No impairment indicated.	None
# 6	Degradation of Benthos	Difficulty in interpreting benthic community structure, but PIB sediment toxicity no different than background. No impairment indicated.	None
# 7	Restrictions on Dredging	All except PAHs chronically exceed USEPA dredged sediment disposal guidelines. No standards exist for PAHs, which are elevated in comparison with reference or background sites, but substantially below levels at sites where sediment PAHs have been linked to fish disorders.	As, Ba; Cd; Cr; Cu; Fe; Pb; Mn; Ni; Zn; COD; TKN; Total P; Cyanide; Oil & Grease; Volatile Solids; Possibly PAHs
# 8	Eutrophication	No significant, current cultural eutrophication problems are identified; No impairment is indicated.	None
# 9	Drinking Water	PIB is not used for drinking water. No impairment is indicated.	None
#10	Beach Closings	PIB meets water contact recreation standards in all areas other than Millcreek Tube. Limited impairment indicated.	Fecal Coliforms
#11	Aesthetics	No persistent problems known. No impairment indicated.	None
#12	Ag./Industrial Water Supply	No added treatment costs; no exceedances of industrial water supply criteria. No impairment indicated.	None
#13	Degradation of Phyto/Zooplankton	No current data on community structure; no current data on water column toxicity. Additional studies (bioassay tests) underway.	No Data
#14	L[illegible] of Fish and W[illegible]fe Habitat	PIB fisheries management goals ar[illegible]eing met. No impairment indicated.	None

JDR/sn/D54

stipulates that contaminant levels must be due to contaminant input from the watershed.

Reliable, available 1987-1990 data for PIB and Lake Erie fish were compiled and compared against the FDA "Action Levels" for 11 contaminants (or groups of related contaminants), including persistent organic pesticides, mercury, and PCBs. A total of 57 fish fillets data sets were evaluated (22 from PIB and 35 from Lake Erie).

As a result of this comparison, no impairment of the fish consumption AOC listing guideline is determined to exist. First, no violation of current FDA Action Levels is indicated, based on both PIB and Lake Erie fish flesh samples. Second, the concentrations of these monitored contaminants in PIB fish are no different than those of Lake Erie fish in the vicinity of Presque Isle, indicating that concentrations of the FDA-monitored contaminants in the PIB watershed are not greater than background levels in Lake Erie. Finally, while few data exist on wildlife contaminant levels, no impairment of the wildlife consumption AOC listing guideline is indicated.

Tainting of Fish and Wildlife Flavor. Impairment of this guideline is indicated if (1) water quality standards for tainting substances are being exceeded, or (2) tainting of fish or wildlife flavor has been determined through surveys. Water quality data for WQN-632 for the period 1985-1990 were examined, and compared with the PADER standards for taste and odor substances. Of the 14 taste and odor parameters in the PADER water quality standards, significant data are available for only copper and zinc. However, of the 22 copper and zinc data sets examined, no evidence of chronic violation of the taste and odor standards is indicated for these contaminants.

PIB fish samples have been tested for many of the same or similar organic compounds to those 12 other taste and odor parameters for which no comparative data are available, indicating that concentrations of these other parameters in PIB fish are not unusually high, compared with national averages. Therefore, while the available data and information are inadequate to support a complete, strict application of this AOC listing guideline, based on the available water quality criteria comparisons for tainting substances, and the fish flesh contamination testing results, no impairment of this use is implied or concluded.

Degradation of Fish and Wildlife Populations. This use is considered to be impaired when (1) fish and wildlife management programs have identified degraded fish and wildlife populations due to a cause within the watershed, or (2) significant sediment or water column biotoxicity exists. No evidence of degraded terrestrial wildlife populations exists, and fisheries management programs have not identified degraded fish populations due to a cause within the watershed (conversely, the PIB fishery is rated as "exceptional" by the Pennsylvania Fish Commission, based on angling success, survival of stocked fish, and population density). Regarding sediment or water column toxicity, no evidence of significant water column biotoxicity exists, and sediment tests have not identified significant biotoxicity.

Fish Tumors or Other Deformities. This guideline is considered to be impaired when (1) the incidence of fish tumors or other deformities exceed rates at unimpacted, control sites, or (2) when surveys have confirmed the presence of liver tumors in bullheads. Preliminary surveys have demonstrated the existence of liver tumors in PIB bullheads. More in depth analysis are currently in progress to determine the incidence rate and possible causes. Because liver tumors are currently attributed to chemical interference, the liver tumor test is the more reliable test of impairment, and indicates that this guideline is impaired. There is also a high incidence of external abnormalities found in PIB bullheads. There are no generally agreed upon background levels of external abnormalities which can be identified as representing "unimpacted control sites", and the observed incidence rates of external abnormalities in PIB bullheads cannot be reliably interpreted. Fisheries researchers hypothesize that the PIB bullheads are being attacked by a naturally-occurring viral agent, but that the susceptibility of the fish to viral attack is increased by chemically-induced environmental stress. In this theory, sediment contamination is indicated as the probable agent inducing the stress.

Bird or Animal Deformities or Reproductive Problems. This guideline is impaired when surveys confirm the existence of deformities or reproductive problems in wildlife species. While no formal surveys have been conducted, Presque Isle State Park is extensively visited by both amateur "bird watchers" and experienced ornithologists, and the avian populations of Presque Isle are therefore subject to an unusually intense level of observation, at all times of the year. Four key specialists were interviewed to determine if any evidence of deformities had been observed or reported in resident fish-eating birds (or animals) in the Park. In the aggregate, these specialists represent nearly 100 years of collective observations. No reports or other evidence of deformities or reproductive problems were identified by these specialists, and this guideline is not impaired.

Degradation of Benthos. This guideline is considered to be impaired when (1) the composition of the benthic macroinvertebrate community is significantly diminished from what would be normal for a comparable, unimpacted site, or (2) macroinvertebrate toxicity from sediment contaminants is higher than unimpacted (control) sites.

Because the physical conditions of PIB are so unique along the southern shore of Lake Erie, no fully-comparable site exists, and PIB benthos data cannot be reliably compared to other sites. However, within the Bay, the distribution pattern of pollution sensitive taxa does not correlate well with the pattern of sediment contamination, and the available data suggest that sediment contaminants are not the dominant influence on the PIB benthic community structure, which is fairly typical for an environment of fine, organic-rich sediments. Further, reliable bioassay test results indicate that the toxicity of PIB sediments on benthic macroinvertebrate test species is no different than the sediments at an unimpacted control site. Therefore, this guideline is not impaired.

Restrictions on Dredging Activities. This guideline is impaired when sediment contaminant levels exceed current standards. Sediment data from 1982, 1986, and 1990 were compared with the current, applicable standards (the USEPA Region V "guidelines"). This comparison resulted in the conclusion that PIB sediments are moderately to heavily polluted, for most parameters for which standards (i.e. guideline ranges) have been established. Specifically, the sediments were found to be contaminated for 10 metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc), nutrients (phosphorus and total kjeldahl nitrogen), COD, cyanide, oil & grease, and volatile solids. Although no current standards exist for PAHs, sediment levels of this group of contaminants may also be elevated, based on other data and observations (e.g. brown bullhead observations). This use is considered impaired pending the collection and analysis of additional sediment samples and/or the revision of the 1977 standards currently being used.

Eutrophication or Undesirable Algae. This guideline is considered impaired when there are persistent water quality problems attributable to "cultural eutrophication" (i.e. nutrient enrichment and related problems resulting from urbanization or other human sources of excess nutrients). Based on a recent (1990) trophic state study, PIB does not exhibit any of the classic symptoms of cultural eutrophication. No nuisance algal blooms, benthic oxygen depletion, or decreased water clarity problems are evident, and this guideline is not impaired.

Restrictions on Drinking Water Consumption, or Taste and Odor Problems. This guideline is considered to be impaired when (1) disease-causing or otherwise hazardous materials are present at levels exceeding applicable standards, (2) taste and odor problems exist, or (3) a level of treatment exceeding regional norms is required to adequately treat raw water. Because PIB is not used as a drinking water supply, this guideline is non-applicable. However, in any case, none of these problems exist in the City's water supply, which is drawn from Lake Erie northwest of Presque Isle, and this guideline is not impaired.

Beach Closings. This guideline is considered to be impaired when water quality standards for the protection of full water contact recreational activities (e.g. swimming) are exceeded. Although PADER has chosen not to establish public beaches at Presque Isle State Park in PIB, water contact recreation is a protected use in the Bay. A 1985 study determined that standards for the protection of this use are being met. More recent data (through 1990) indicate that these protective standards continue to be met, with the exception of the mouth of the Mill Creek Tube and other storm water discharge points. Therefore, there is a limited impairment of this guideline.

Degradation of Aesthetics. This guideline is considered to be impaired when a pollutant in the water results in a persistent, unnatural or objectionable condition. No evidence of unnatural or persistent discoloration of the water, or other sources of aesthetic impairment are known to occur. While turbid conditions exist after periods of heavy runoff, these conditions are natural for an urbanized area and are not persistent. Also, while a surface sheen is occasionally present at the mouth of Mill Creek, and while debris from urban runoff sources is common along portions of the south shore, these conditions are localized and do not significantly impact the Bay. Consequently, this guideline is not impaired.

Added Costs to Agriculture or Industry. This guideline is considered to be impaired when unusual treatment is required for water used for agricultural, industrial, or commercial purposes. With the closing of Penelec, PIB water is used by only one small-quantity user (an industry), which does not require special treatment of PIB water before use (the raw water is allowed to settle before use). Further, industrial water supply is a protected use in PIB, and the available water quality data indicate that the applicable standards for this use are being met. Therefore, this guideline is not impaired.

Degradation of Phytoplankton and Zooplankton Populations. This guideline is considered to be impaired when (1) the resident phytoplankton or zooplankton community structure is significantly different from comparable, unimpacted control sites, or (2) bioassays have confirmed that ambient waters are toxic to phytoplankton or zooplankton. The physical conditions of PIB are so unique along the southern shore of Lake Erie that no fully-comparable site exists for comparison purposes. Secondly, no recent data are available on the PIB phytoplankton or zooplankton community structure. Therefore, bioassay data were researched as the primary test of impairment. However, no reliable bioassay test data for potential water column toxicity exist, and other data and information are inadequate to support an inferred determination. Therefore, no reliable conclusion is possible for this guideline. Additional studies (i.e. water column biotoxicity testing) are being conducted to allow a determination regarding this impairment to be made.

Loss of Fish and Wildlife Habitat. This guideline is considered to be impaired when fish and wildlife management goals have not been met because of a loss of fish and wildlife habitat resulting from changes in the physical, chemical or biological conditions in the waterbody. The PFC manages PIB as a sport fishery, and conducts periodic fisheries assessments to evaluate the quality and quantity of fish stocks. Based on these assessments, the PFC's fisheries management goals are being met, and this guideline is not impaired.

Based on the impaired uses evaluations, pollutants of concern were identified as including only sediment contaminants. No water column or fish and wildlife impairments were indicated. Sixteen pollutants of concern were identified, including arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, zinc, phosphorus, TKN, COD, cyanide, oil & grease, and volatile solids. In addition, although no standards exist for PAHs, sediment level of these compounds were determined to be somewhat elevated, and sediment PAHs were therefore included as additional pollutants of concern.

1.3 Ecosystem Management Issues

Because of the long "flushing rate" of PIB, most pollutants discharged to the Bay from its watershed remain in this enclosed estuary, and are either biodegraded or deposited in the sediments. The natural shale bedrock in the Erie area contributes fine sediment particles which further encourage the precipitation of pollutants from the water column, and subsequent entrainment in the sediments. Consequently, environmental conditions in the Bay are especially sensitive to the pollution control practices employed in the watershed.

Estimates of the total annual loadings of pollutants of concern to PIB have been developed for continuous point sources, combined sewer overflows, and urban runoff/nonpoint sources. In addition, the volume of in-place sediment pollutants was also estimated. These calculated loadings are summarized in Table 2. No annual loadings were calculated for contaminated groundwater, as this was not found to be a potential source of significant quantities of pollutants of concern.

Table 2. Summary of PIB pollutants of concern estimates.

Pollutants	Point Sources (annual loading)	CSOs (annual loading)	Non-Point (annual loading)	In-Place (lbs/acre)
	Pollutants Sources and Quantities (pounds)			
Arsenic	<17	11	-(1)	72.6
Barium	313	17	-	699.3
Cadmium	<4	51	240	26.9
Chromium	<36	264	1,400	295.9
Copper	<139	264	2,500	511.0
Iron	<8,952	-	-	199,031.7
Lead	<198	119	11,000	591.8
Manganese	<281	-	-	3,227.5
Nickel	<65	494	12,000	322.8
Zinc	<922	519	-	1,963.4
COD	<43,361	-	4,800,000	591,716.0
TKN	<3,775	-	110,000	11,565.3
Total Phosphorus	<112	-	25,000	4,841.3
Cyanide	<32	383	-	10
Oil & Grease	<24,385	-	-	13,986.0
Volatile Solids	-	-	-	322,754.2
PAHs	-	<340	-	35.0

(1) Available data insufficient to calculate an estimate.

The estimates in Table 2 are developed from the best data currently available, and reliable estimation methodologies. However, it has been necessary to use a number of assumptions, to satisfy certain data gaps or inadequacies. Therefore, the loading rate estimates in Table 2 should be viewed as representative indicators of the potential loading rates from the various identified sources, and not as absolute rates.

Clearly, the loading estimates for point sources in Table 2 may be biased by the necessity to use certain assumptions (most are not truly quantified, and indicated as "less than" values). Further, it is emphasized that the in-place sediment contaminant quantities in Table 2 are total volumes, not annual loadings, and should not be directly compared to the annual loadings estimates for the other three contaminants sources (point sources, CSOs, and non-point).

It should be noted that only half of the in-place pollutants mass estimated in Table 2 are within the zone of bioturbation. The rates at which deeper chemicals may enter into the bioturbation zone, resulting from chemical migration (or physical forces) is unknown. Also, while 20 centimeters (eight inches) was selected as a sufficient depth to include both the zone of biological activity (bioturbation) and the zone of chemical migration, the actual depth is also unknown.

Because of these uncertainties, additional data and other information will be necessary to fully characterize the ecosystem management issues to be resolved in this RAP. Meaningful progress toward the development and screening of effective remedial action alternatives for the AOC cannot be achieved until these issues have been resolved, or at least clarified. Some of the informational gaps will be satisfied by the results of recently initiated studies, such as the Mill Creek Tube and Other Sources of Pollution studies being conducted by the City of Erie, sediment testing, phyto- and zooplankton toxicity tests, bullhead tumor evaluations, and other efforts by PADER and USEPA. Other informational needs will be identified and addressed as the RAP progresses.

In addition, there needs to be coordination with USEPA sources to monitor the development of new sediment evaluation criteria, and the application of these new criteria to re-evaluate PIB sediments. We need to look at risk-based sidiment management procedure to assist in determining the appropriate clean-up standards to be attained, and conduct conceptual level evaluations of alternative sediment remediation technologies (including custom applications of standard technologies) to identify cost-effective, feasible alternatives for achieving the selected clean-up standards.

Ultimately, the quantity and quality of data needed to initiate the development, screening, and selection of the recommended remedial alternatives will be a judgement decision, and will be affected by many technical and political factors. It is essential that the PAC, representing the "stakeholders" be directly involved with the evaluation and selection of those alternatives.

The overarching goal of the RAP is to restore those uses which we have identified as impaired and to protect the other uses from becoming impaired. In addition, we want to further interest and awareness of issues affecting the Bay and the Great Lakes in general through public education. We also want to promote the pollution prevention alternative wherever possible, to be consistent with the philosophy of "zero discharge" and the Basin-wide effort to virtually eliminate toxics from the system.

2.0 Introduction

The U. S. Department of State has designated Presque Isle Bay as the 43rd Great Lakes' Area of Concern (AOC). As an AOC, Presque Isle Bay (PIB, or Bay) will be the focus of prioritized ecosystem restoration and management activities conducted or sponsored by the Commonwealth of Pennsylvania Department of Environmental Resources (PADER). This document, the Remedial Action Plan or RAP, provides the framework under which these activities will be conducted. The primary goal of this project is the investigation of the types and causes of impaired beneficial uses of the ecosystem and to develop alternative strategies for the restoration and protection of these uses. The PADER is joined in this effort by the U. S. Environmental Protection Agency (USEPA), the Erie County Department of Health (ECDH) acting as PADER's agent for water quality issues in Erie County, and by a body of representatives of local governmental, academic, industrial, environmental, recreational, and other interests who are the users of the AOC's resources.

The Bay was designated as an AOC on January 30, 1991 (See Appendix A). However, in taking this action, no reasons were cited by the Department of State as the impetus for the designation. In order to focus future remedial investigations and actions, the RAP first identifies any impaired uses in the Bay and the source(s) of the problem. The identification of impaired uses is based on the Guidelines for Recommending the Listing and Delisting of Great Lakes Areas of Concern, published by the International Joint Commission (IJC) in the March/April 1991 issue of the IJC's Focus publication (Volume 16, Issue 1, ISSN 0832-6673).

In the designation, the Department of State described the PIB AOC as including "... Presque Isle Bay and the waters of Lake Erie in the immediate vicinity of Erie, Pennsylvania." However, based on a review of the available data and other information, PIB is seen as a sufficiently isolated ecosystem to be considered independently from the waters of Lake Erie outside of the Bay. Therefore, PADER, in consultation with the PIB Public Advisory Committee (PAC), has determined that for the purpose of preparing this RAP, the AOC will consist of PIB and its tributary watershed areas. Other sources of pollution outside of the PIB drainage basin which add to or cause use impairments will be identified and addressed in the appropriate sections of the RAP. In addition, PADER commits to investigating possible sediment contamination in the western portion of the Outer Harbor in conjunction with the sediment activities in PIB. Based on that investigation, PADER and the PAC may consider possible expansion of the AOC.

2.1 Background

PIB is the oldest U. S. Harbor on the Great Lakes. An 1824 appropriation from the national legislature for harbor improvements at Erie marked the beginning of Federal involvement in the construction of Great Lakes harbor facilities (Zagorski and Sampson, 1982). The establishment of a Federal harbor at Erie paralleled the events of the War of 1812: the American Fleet, which was built to combat the British on the Upper Lakes, would be built in Erie (City of Erie, 1986). However, a sand bar limited access to the harbor to shallow draft vessels, and the Federal appropriation was granted to deepen the entrance. The deepening of the harbor, and Federal guarantees to ensure that these improvements would be permanent, stimulated a shipbuilding and shipping industry in this improved port.

The City of Erie, founded in 1792, has grown up around this port. Over time, much of the area draining to the Bay has become urbanized, to the extent that agricultural/rural lands exist only in the most remote portions of the PIB watershed. As an older American city, Erie has experienced the growth and decline of the steel industry in the U.S., together with its related heavy manufacturing. As a result, Erie is a "working city", with heavy manufacturing industries co-existing within the residential and commercial neighborhoods which these industries have historically supported.

However, reflecting the waste disposal practices which were in vogue in the late 1800s and early 1900s, much of the wastewater from the City's heavy industries, as well as domestic sources, was discharged directly to the Bay, or to streams and tributaries leading to the Bay. Urban streams were looked at more as sewers than as natural resources, and much of PIB's largest tributary, Mill Creek, was converted to an enclosed, combined sewer (the "Mill Creek tube"). While many of the pollutants which were released to the Bay from such past practices have decayed, through natural biodegradation processes, the conservative substances (such as primary metals) remain in the sediments as a legacy of historical abuses.

Ironically, that physical feature which resulted in PIB being selected as a harbor - its sheltered, nearly enclosed natural basin - is a direct contributing cause to use impairments within the AOC. The very small channel opening, while providing excellent shelter to the port from Lake Erie storms, also restricts the exchange of water between the Bay and Lake Erie. Because the PIB watershed is very small, in comparison with the volume of the Bay (the ratio of PIB watershed area to the surface area of the Bay is only approximately 4.3:1), the "flushing rate" of the Bay is quite slow, on the order of once in every 2.45 years (by comparison, the theoretical flushing rate for Lake Erie is 2.6 years). Consequently, the Bay acts as a very efficient natural "settling basin", and most of the pollutants which enter the Bay as runoff become entrained in the Bay's sediment.

The shale bedrock in the Erie area is quite shallow, ranging from approximately 50 feet below the surface in the central portions of the watershed, to exposed outcrops near the Bay. The shale is also exposed in stream valleys which have eroded through the alluvial layers overlying the shale. The eroded shale, in combination with the natural clay in the Erie area, results in a high suspended solids condition which encourages the precipitation and settling of metal ions and other pollutants in the Bay sediments.

Degraded water quality issues have been reported in PIB since the 1960s. These problems have typically been described as the readily-recognizable symptoms of cultural eutrophication: algal "blooms", dissolved oxygen (DO) depletion, fish kills, malodorous conditions, reduced clarity, and excessive growths of aquatic macrophytes. While environmental conditions have shown gradual improvements over the past decade, many of the Bay's users have expressed continuing concern for possible health risks associated with remaining pollutant loads, particularly as regards possible fish flesh contamination and fecal coliform contamination of the water column.

2.1.1 Remedial Action Planning - An Historical Perspective

The Great Lakes Water Quality Agreement of 1978 represents a bi-national, U. S./Canadian commitment to the restoration and maintenance of the aquatic resources of the Great Lakes. Water quality management in the Great Lakes boundary waters has evolved over the past 10 to 20 years into an integrated approach for reversing conditions of environmental degradation. Conventional water quality management techniques (i.e. relating control programs to water quality objectives) have not proven adequate to ensure the restoration of environmental quality (IJC, 1985). The recognition of the importance of toxic substances within the Great Lakes, and their impact on human and environmental health, has led to the realization that effective water quality management requires consideration of many components of the ecosystem. The IJC's Great Lakes Water Quality Board (GLWQB) has termed this approach an "ecosystem perspective" and has identified 43 AOCs within the Great Lakes system based on environmental data from all media (sediment, biota, and water). The GLWQB determined the human health and environmental significance of the observed ecosystem quality of the AOCs, and identified probable cause-and-effect relationships between these conditions and the sources of envirônmental contaminants (IJC, 1985). This assessment procedure includes the following:

- assessment of the relative seriousness of the problem, including its extent and uses being impaired

- evaluation of the significance of toxic substances in the AOC

- consideration of the uncertainties related to remedial measures such as dredging of in-place pollutants, and the eventual response of the environment to the remedial measures

- priority for dealing with demonstrated problems, and

- progress of assessment and Remedial Action Plans (RAPs).

The GLWQB has supported the use of this ecosystem approach for remedial action planning in all AOCs.

2.1.2 Great Lakes Water Quality Management

The GLWQB is responsible for reporting water quality research activities and 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 43 identified AOCs in terms of environmental health. These categories represent a logical sequence for problem solving and resolution. The categories identify the status of the information base, programs that are underway to fill the information gaps, and the status of remedial efforts. Problem resolution is considered complete when evidence can be presented that the full complement of beneficial uses has been restored and the site can be removed from the AOC list (i.e.; "delisted"). The following categories form the described sequence:

(1) the causative factors are unknown and there is no investigative program underway to identify such causes

(2) the causative factors are unknown, but an investigative program is underway to identify the causes

(3) the causative factors are known, but a RAP has not been developed and remedial measures are not fully implemented

(4) the causative factors are known and a RAP has been developed, but remedial measures are not fully implemented

(5) the causative factors are known, a RAP has been developed and all remedial measures identified in the Plan have been implemented, and

(6) confirmation that the beneficial uses have been restored and deletion as an Area of Concern.

Based on the information presented in this report, PIB would be assigned to category 4.

2.2 Purpose and Objectives of the Remedial Action Planning Process

The purpose of the Remedial Action Planning process is to provide a systemwide (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, Presque Isle Bay. This approach requires an integration of currently available data on the Bay's environmental resource base, socioeconomic influences, and political/institutional frameworks.

The purpose of a RAP is to focus the data gathering and data synthesis efforts on resolution of the immediate problems which may be impairing the area's designated uses. Consequently, recommendations toward resolving the identified problems are based on the available data, and on the results of any additional studies specifically designed and targeted to complete the understanding of the cause-and-effect relationship between impaired uses and the pollutants causing such impairments. To ensure implementability, recommendations for remedial actions within the RAP must be structured, wherever possible, within the framework of existing environmental regulatory programs.

2.3 Intended Use

This report is intended as a technical management document providing a platform for current and future analyses and decision-making. It contains a review and synthesis of all relevant data and/or information on the AOC. Every attempt has been made to identify all of the major documents and data sources pertaining to the critical environmental issues affecting the area. However, the remedial action process is an open, iterative process, and new information will be synthesized as it is identified or otherwise becomes available. The process is sufficiently flexible that new priorities will be recognized and addressed, if warranted, while currently recognized problems are being resolved. Suggestions and additions are welcome, as they contribute to further definition and resolution of the use impairments affecting the AOC.

2.4 Summary

Presque Isle Bay (PIB) has been designated as the 43rd Great Lakes' Area of Concern (AOC) by the U. S. Department of State, however the reasons for this action were not cited in the designation. This RAP is intended to determine which actual and/or potential beneficial uses of PIB are impaired, based on the Guidelines for Recommending the Listing and Delisting of Great Lakes Areas of Concern, published by the IJC in the March/April 1991 issue of Focus. This report also seeks to identify the causes for the indicated impairments, to the extent possible within the limitations of the existing data base. While the AOC designation mentions both PIB and the adjacent waters of Lake Erie, PIB is seen as a sufficiently isolated ecosystem to be considered independently from the waters of Lake Erie outside of the Bay. The AOC has therefore been limited to the Bay and its immediate watershed area.

As an AOC, PIB is to receive priority attention from the PADER for the investigation of the causes of impaired beneficial uses of the ecosystem and for the development of alternative strategies for the restoration and protection of these uses. The PADER will coordinate with a representative group of local interests (Public Advisory Committee - PAC) who are the users of the AOC's resources.

The City of Erie was founded in 1792, and its harbor is the oldest U. S. Harbor on the Great Lakes, with a continuous history of commercial and industrial use dating from the early 1800s. With the growth and development of the City, much of the watershed draining to the Bay has become urbanized. This urbanization process resulted in the conversion of the watershed's major stream, Mill Creek, into an enclosed storm sewer. Historically, residential and industrial wastes as well as urban "nonpoint" runoff have been discharged into Mill Creek and other streams which drain to PIB. Because the Bay's watershed is small, in comparison with its volume, the "flushing rate" is slow, and contaminants introduced from the watershed settle out and become entrained in the Bay's sediments.

Water quality problems in PIB have been reported since the 1960s. These historic problems include the typical symptoms of nutrient enrichment, and are caused by biodegradable organic material. While the previous eutrophication-related problems have essentially disappeared from the Bay over the past decade, many of the Bay's users have expressed continuing concern for possible health risks associated with the remaining pollutant loads, particularly as regards conservative, non-biodegradable pollutants (heavy metals and persistent organics) and possible fish flesh contamination and other human health risks associated with such contaminants.

Through the guidance of the IJC's Great Lakes Water Quality Board, and pursuant to the goals and objectives of the Great Lakes Water Quality Agreement, an integrated "ecosystem approach" to the restoration and maintenance of the Great Lakes' aquatic resources has evolved. This approach has resulted in an assessment procedure for determining the nature of the impairments problems and for investigating cause-and-effect relationships between pollutant sources and ecosystem effects.

The IJC has adopted a system of tracking the progress of restoring AOCs, based on a logical sequence for problem solving and resolution, culminating with a demonstration that the full complement of beneficial uses has been restored, and subsequent de-listing of the AOC. Based on the available data and other information, PIB is currently classified as a Category 4 AOC, signifying that the causative factors are known, a Remedial Action Plan has been developed, but remedial measures are not fully implemented.

Remedial action planning is a dynamic, flexible process, and new information will be synthesized as it becomes available. Consequently, while the focus of the remedial action planning process for PIB will be on the currently-identified impairments, new priorities may be recognized as existing problems are resolved, and as new information becomes available.

3. Environmental Setting

The specific environmental characteristics of Presque Isle Bay and the land areas that drain into the Bay are included in this section. This information is presented for a background description of the AOC and as data that can be used for the evaluation of environmental problems and impairment of beneficial uses of the environment.

3.1 Location

The AOC is located in the northwest corner of Pennsylvania on the southern shore of Lake Erie. The general location of PIB is depicted in Figure 3.1, as is the watershed area draining into PIB.

3.1.1 Geographic Area

Presque Isle Bay is bounded by Presque Isle to the north and west, and the mainland and the City of Erie to the south and east. Physical characteristics of PIB are summarized as follows (PADER, 1991):

surface area:	3,718 acres
volume:	13,900 million gals
mean depth:	13.1 feet
maximum depth:	31.2 feet
shoreline length:	28.9 miles
maximum length:	4.75 miles
maximum width:	1.75 miles.

PIB is located predominantly within the Erie North, Pennsylvania 7.5' USGS quadrangle sheet (most recent edition is 1975). The southwest corner of the Bay is located within the Swanville, Pennsylvania quadrangle sheet (most recent edition is also 1975).

3.1.2 Political Jurisdictions

The PIB watershed is approximately 25 square miles in area, which includes much of the City of Erie as well as portions of Millcreek, Summit, Greene, and Harborcreek Townships (see Figure 3.1).

Most of the south shoreline of the Bay is fronted by the City of Erie; a small section to the west, near the base of the peninsula, is contained within Millcreek Township. The entire shoreline of Presque Isle, which constitutes the west and north shorelines, is Pennsylvania State Park lands.

3.2 Natural Features

This section describes the natural features of the AOC, including characteristics of the drainage basin and the associated aquatic ecosystems.

3.2.1 Drainage Basin Characteristics

Presque Isle Bay receives drainage from three small watersheds: Scott Run, Cascade Creek, and Mill Creek. Scott Run is the smallest tributary, only approximately 1.2 miles in length. Cascade Creek includes the main branch (3.0 miles) and the West Branch (2.2 miles). Mill Creek is by far the largest tributary, with a total length of 7.0 miles. The Mill Creek drainage system includes Garrison Run (2.0 miles), which discharges to Mill Creek near its mouth at the Bay. Cascade Creek has a drainage area of 5,158 acres (8.06 square miles), while Mill Creek has a drainage area of 8,358 acres (13.06 square miles). At the USGS gaging station an average discharge of: 9.7 cfs (6.3 MGD) and a minimum flow (seven day, ten year recurrence low flow) of 0.8 cfs (0.5 MGD) has been measured (PADER, 1976). However, because the gaging station is approximately 2 miles upstream from the outlet at PIB, it does not include the Garrison Run discharge and is an underestimation of the total contribution from Mill Creek to the Bay.

Average inflow to Presque Isle Bay from Cascade and Mill Creeks is estimated to be 11 mgd. Storm sewers contribute another 0.7 mgd to the Bay (PADER, 1976). Annual precipitation (adjusted for evaporation) contributes another 3.87 mgd (PADER, 1991). Water exchange between the Bay and Lake Erie occurs through the navigation channel at the northeast end of the Bay. Average outflow from the Bay to Lake Erie is estimated to be 15.57 mgd (PADER, 1991). However, it is documented that water exchange between the Bay and Lake Erie occurs in both directions and flow velocities from the Lake into the Bay have been measured as high as 100 feet per minute.

Until late 1990, the Pennsylvania Electric Company (Penelec) operated the Front Street Station on the southern shore of the eastern boat basin. The power plant was coal fired and used cooling water at a rate of approximately 127 mgd. The main intake was located in the east slip of the boat basin and an auxiliary intake was located east of the Duquesne Pier. Cooling water was discharged through an 8' by 8' underground channel which extended from the west side of the plant to the southeast corner of the west boat basin. An auxiliary discharge was located on the southern side of the east boat basin. This water use did not have any net effect on the water balance in the Bay since the withdrawal and discharge were equal in volume, and were both contained within the Bay.

3.2.2 Characteristics of Aquatic Ecosystems

Aquatic ecosystems in the AOC are dominated by the Bay itself. This ecosystem is a relatively quiescent body of water, with little current except near the entrance channel. Because of the relatively small inflow relative to volume, the mean hydraulic detention time of the Bay ("flushing rate") is 893 days (2.45 years). However, under certain lake seiche conditions, the rate of water exchange may be substantially accelerated (PADER, 1991). It should also be noted that while the mean hydraulic detention time is on the order of 2.45 years, much of the water entering the Bay does so via the Millcreek Tube near the mouth of the entrance channel. Western portions of the Bay may in fact have much longer retention times.

Because of the shallow nature of the Bay, the water column is completely mixed by wave energy and summer thermal stratification does not occur (PADER, 1991). As a result, oxic conditions exist throughout the water column, and dissolved oxygen (DO) is not a limiting factor.

Much of the bottom of the Bay is covered with fine, organic-rich sediments. In certain areas where currents are pronounced (e.g. at the mouths of tributaries and in the navigational channel), sand is the dominant substrate. Few large rocks or other solid substrate conditions occur.

Although not part of the Bay proper, a variety of sheltered pond environments exist in Presque Isle State Park which are connected to the Bay through channels. These ponds are natural refuges for fish and waterfowl, and exhibit a complete range of successional stages.

The PIB tributaries offer limited freshwater habitat, and are relatively insignificant when compared to the Bay itself. The largest tributary, Mill Creek, has been highly modified by past channelization projects, and offers little natural habitat. Cascade Creek is much more natural in physical condition, although the channel has been modified in many places by urbanization. Lake trout have been observed in Cascade Creek and, to a lesser extent, in the mouth of Mill Creek. Garrison Run and Scott Run are quite small, with very low summer flows, and offer little fisheries habitat. The PA Fish Commission conducts fish stocking activities in Cascade creek.

3.2.3 Air Quality

Air quality in Erie is influenced by the prevailing winds, which are generally from the southwest. When the winds are from a westerly or northerly direction, the lake has a moderating effect. When winds are from the south or east, air quality reflects the commercial/industrial activities of Erie and the rural nature of the areas surrounding the Erie metropolitan area. On average, air quality in Erie may best be described as "moderate", however no serious air quality problems occur in the Erie area. The 1990 Air Quality Report (PADER 1990) provides ambient air quality data for 13 parameters from 13 air basins in Pennsylvania, including four sampling sites in Erie. Generally, these data show that, for most parameters, air quality conditions in Erie are somewhat below average, in comparison with the other 12 Pennsylvania air basins (a 1991 Air Quality Report is in preparation, but is not yet available for review).

A Pollution Standards Index (PSI) is calculated daily for 17 areas within Pennsylvania, on the basis of recorded levels of five common air pollutants: CO, SO2, suspended particulates, ozone (03), and NO2. For 1990, the PSI for Erie was "good" for 283 days, "moderate" for 81 days. No "unhealthful" or "very unhealthful" or "hazardous" days were recorded (PADER, 1990). On the basis of the PSI scores, Erie was ranked #9 of 17 State-wide sampling locations in 1990 for "good" PSI scores (i.e 8 stations had more days in the "good" range than Erie).

3.3 Land Uses

This section describes the land uses within the AOC with particular attention to those that may affect the various measures of environmental quality and those that are directly related to the beneficial uses defined by the IJC and used as criteria for listing as an AOC.

3.3.1 Development Patterns

Erie is an older city, with most of the central areas fully developed. Significant new development is occurring only in the fringe areas which encircle the City to the west, south, and east (in Millcreek, Summit, and Harborcreek Townships). Within the City proper, medium to high-density residential uses are most prominent (City of Erie, 1986). The notable exceptions are the Bay waterfront, with concentrated industrial/commercial development along the northeast portion, and the industrialized Conrail/12th Street corridor. The highest concentration of industrial uses is located at the western edge of Erie, between 6th and 26th Streets. A secondary concentration is located at the east edge, between 6th and 20th, and between 26th and 38th Streets.

Commercial uses are concentrated in a north/south corridor from Sassafras to Holland Streets. Smaller commercial land use concentrations (including shopping centers) occur throughout the City, but tend to concentrate along major east/west streets (City of Erie, 1986).

Within the PIB watershed overall, land use is approximately 80% urban and 20% rural. The distribution of land uses within the watershed is 57% residential, 16% open areas, 11% commercial, 8% public, 7% industrial, and 1% agricultural (PADER, 1991). Rural land is concentrated in the southeast extreme of the watershed, in the Mill Creek headwaters.

3.3.2 Sewer Service Areas

Almost all of the PIB watershed is sewered; only the extreme southeast end of the watershed, in the Mill Creek headwaters, is without sanitary sewers. The most current sewer service area maps are found in the Comprehensive Water Quality Management Plan for the Erie area, prepared in 1976 (PADER, 1976).

The City of Erie operates a regional sewage treatment plant (STP) which receives sewage from the City as well as the urban areas surrounding the City (Millcreek, Harborcreek, Summit, and Fairview Townships, the Borough of Wesleyville and Lawrence Park). The STP discharges to the outer harbor. Local industries also discharge to the City's sewer system, and are regulated under an industrial user pretreatment program.

Portions of the City's sewer system consist of "combined" sewers, which receive both sanitary sewerage as well as surface runoff (stormwater). In addition, separate storm sewers exist throughout the City which convey surface runoff directly to the Bay, or to the tributary streams draining to PIB. The pattern of sanitary versus combined sewers is very complex; many sewers begin as separate, sanitary sewers, but become combined sewers further downstream.

A detailed mapping of the City's storm, combined, and sanitary sewers was prepared in a 1972 study (DDL, 1972). Although many changes have occurred since this study (especially as regards the removal of stormwater inflow from various combined sewers), the maps produced in the 1972 study have not been updated, and remain as the only comprehensive source of reliable information on sewer configurations.

3.3.3 Recreational Use Areas

Clearly, Presque Isle State Park is the dominant recreational use area in the PIB watershed. The park provides 3,202 acres of mixed-use recreational opportunities, including such diverse activities as swimming, boating, water skiing, sail boarding, picnicking, hunting, fishing, hiking, cross-country skiing, and nature study. Because of its unique geological and biological features, Presque Isle has been designated a National Natural Landmark by the National Park Service (PADER, 1978).

Presque Isle State Park offers nearly seven miles of sandy beaches on Lake Erie, and attracts over four million visitors annually (PADER, 1989b). Presque Isle State Park consistently ranks first among Pennsylvania's State Parks in annual attendance (PADER, 1986a).

Presque Isle was acquired by the State of Pennsylvania from the Federal Government in 1921 (PADER, 1978). The park boundaries extend 500 feet offshore into PIB and Lake Erie (PADER, 1989b). Other than Presque Isle State Park, few other significant recreational areas exist in the Erie area which offer sanctioned access to PIB or Lake Erie. Natural beaches along the Lake Erie shoreline east of the Bay (in the outer harbor) are reported to be used for swimming, although these are not sanctioned beach areas. West of the peninsula, waterfront access is provided at Waldameer Park, a privately-owned recreational park. Within the City, various neighborhood parks exist, some of which offer access to streams draining to PIB (e.g. Frontier Park, on Cascade Creek).

3.3.4 Agricultural Areas

As indicated earlier, only approximately 1% of the PIB watershed is agricultural in use (PADER, 1991). In the PIB watershed, agricultural land is concentrated in the extreme southeast portion of the watershed, in the Mill Creek headwaters.

3.3.5 Wildlife Habitat/Open Space

Presque Isle Peninsula, which forms the northern and western boundaries of PIB, is an exceptional natural area characterized by a wide variety of rich and unique plant and animal communities. Particularly noteworthy is the great habitat diversity, with successional continuity of vegetational types ranging from pioneer vegetation on newly formed land to fairly stable woodland communities on older areas. Successionally intermediate sites, such as highly productive marshlands, are also well represented and comprise the bulk of the Peninsula. An in-depth description and analysis of the wildlife habitat within the Park is provided in an Environmentally Sensitive Area Study prepared in 1986 (PADER, 1986b).

Other than the Park, the only other locations within the PIB watershed where significant areas of natural wildlife habitat or open space exist are in the Mill Creek headwaters (Millcreek, Summit, Greene, and Harborcreek Townships) and, to a much lesser extent, in the extreme southwest corner of the Bay, near where the peninsula meets the shoreline. Also, limited wildlife habitat exists in the lower portions of the Cascade Creek stream corridor, and near the mouth of Mill Creek, although these areas are significantly impacted by the surrounding urban land uses.

3.4 Water Uses

This section includes a description of the current beneficial uses of the PIB aquatic ecosystem, and a description of the quantity and/or quality of the environmental resources upon which these beneficial uses are based.

3.4.1 Fish and Wildlife Habitat

The PIB aquatic ecosystem offers habitat for both fish and non-fish species. Fish species include a variety of popular game and sport fish, as well as the non-sport, forage species which are utilized as food by the sport fish species. A comprehensive atlas of Great Lakes fish spawning and nursery areas, compiled by the FWS in 1982, listed 16 species of fish as spawning in PIB (Goodyear et al., 1982). That list, with the inclusion of some additional species, includes:

spotted gar	longnose gar
bowfin	gizzard shad
grass pickerel	northern pike
muskellunge	carp
spottail shiner	freshwater drum
bullhead spp.	largemouth bass
crappie spp.	yellow perch, and
walleye	emerald shiner
sunfish	bluegill
smallmouth bass	rock bass

A 1987 checklist reported 40 fish species from PIB (PFC, 1988). Of these species, more than 20 are pursued by fishermen (PFC, 1983), including:

yellow perch	pumpkinseed
black crappie	white bass
smallmouth bass	bluegill
largemouth bass	rock bass
coho salmon	rainbow trout
white crappie	northern pike
walleye	channel catfish
bullhead spp.	steelhead trout

muskellunge	chinook salmon
warmouth	white perch

The most abundant forage species in PIB are the emerald and spottail shiner, but at least six other species contribute to the forage base, which is rated as "very good and very adequate to support the game and panfish species present" (PFC, 1983).

In addition, many species of migratory waterfowl inhabit the open water and protected wetlands areas of the Bay, its shoreline areas, and the Park. Also, many species of amphibians and turtles may be found along the natural areas of the Park.

3.4.1.1 Fish Populations

The Pennsylvania Fish Commission (PFC) periodically assesses the quality and vitality of the sport fisheries resources of PIB. These assessments result in recommendations for adjustments in fish stocking practices (species stocked and numbers of fish introduced), daily catch (creel) limits, minimum size limits, duration of fishing seasons, and other fisheries management practices. The most recent "Fisheries Assessment" was conducted in 1986-1987 (PFC, 1988); the previous "Management Report" was prepared in 1983, based on 1982 sampling data (PFC, 1983). The next survey is scheduled for 1991, with a creel census anticipated to be completed in 1992, subject to the availability of funding (Billingsley, 1991).

A warmwater species hatchery was operated by the PFC on the Bay until the late 1950's, producing primarily yellow perch, walleye, blue pike, herring, and whitefish which were stocked for commercial purposes. The hatchery was acquired by the City of Erie in 1962, and is now used as the Chestnut Street water filtration plant. Smolt production by the PFC now occurs at the Tionesta, Fairview, and Linesville stations; the Fairview facility handles most of the egg taking program for Lake Erie salmon.

PIB has long been managed as a sport fishery by the PFC. Fish species stocked in PIB, by species and number stocked, are summarized in Table 3.1, for the eleven-year period 1971-1981.

As indicated in Table 3.1, over 2.7 million game or sport fish were stocked in PIB by the PFC over the eleven-year period from 1971-1981. Coho salmon were first introduced in 1975 in an effort to establish a coho fishery in the Bay.

3.4.1.1.1 1983 Management Report

An intensive, one-year creel survey was initiated in 1981 (including over 9000 angler interviews), comparing fish harvest

Table 3.1. Fish species stocked in Presque Isle Bay: 1971-1981 (adapted from PFC, 1983).

Year	Species	Size (inches)	Number Stocked
1971	Muskellunge	9-11	1,200
	Northern Pike	11-13	1,200
1972	Muskellunge	7-9	2,000
1973	Muskellunge	6-11	2,000
	Northern Pike	fry	245,000
1974	Northern Pike	fry	245,000
	Channel Catfish	2-4	150,000
1975	Muskellunge	6-9	4,000
	Coho salmon	4-6	90,000
1976	Muskellunge	6-8	3,500
	Walleye	14-23	26
	Yellow perch	13	1
	Black crappie	11-13	16
	Bluegill	8-10	15
	Sucker	18-19	2
	Carp	22	1
	Coho salmon	4-8	70,640
1977	Coho salmon	4-5	140,000
1978	Muskellunge	7-14	4,410
	Northern pike	fry	250,000
	Coho salmon	4-9	1,190,528
1979	Muskellunge	5-9	5,700
	Northern pike	2-8	16,135
	Largemouth bass	2-4	11,500
	Coho salmon	5-6	10,000
1980	Muskellunge	5-7	5,700
	Northern pike	6-8	9,950
	Largemouth bass	2-4	11,500
	Coho salmon	4-7	138,000
1981	Northern pike	2-4	15,205
	Coho salmon	4-6	84,000
		Total	2,707,229
		(average)	246,112

characteristics in PIB to the areas immediately east and west of the Bay (Young, 1982). In 1982, trapnetting and electrofishing techniques were used to assess the fish stocks in PIB.

The results of these investigations were that PIB is an "exceptional" and "very diverse" fishery, which supports and sustains "extremely high fishing pressure" (PFC, 1983). The 1981 creel census reported 625,000 hours of fishing pressure, consisting of 283,700 hours of shore angling, 255,900 hours of boat angling, and 85,400 hours of ice angling. The total catch from PIB, as reported from the 1981 creel census, was 952,200 fish (614,900 harvested), equating to 1.52 fish caught/hour (0.98 fish harvested/hour), or 257 fish caught/acre (166/acre harvested).

The 1982 sampling (trapnetting and electrofishing) results indicated that, as a group, panfish were the most significant fishery in the Bay, and yellow perch was the most abundant species sampled. Other significant species included white perch, white crappie, white bass, rock bass, bluegill, pumpkinseed, and black crappie. Brown bullheads were also sampled, 98% of which were "desirably sized". Numerous forage species were also noted during the 1982 sampling, but no effort was made to quantify these species. In all, 40 separate fish species were recorded during the survey.

Major game species collected during the 1982 sampling included five warmwater species and four coldwater (salmonid) species. The warmwater species included northern pike, muskellunge, largemouth bass, smallmouth bass, and walleye. Salmonids included coho salmon, chinook salmon, steelheads, and palomino trout. As evident in Table 3.1, the PFC did not stock appreciable numbers of walleye in the Bay in the 1971-1981 period, however limited numbers were stocked by sportsmen's cooperative nurseries. While an estimated harvest of 1,600 walleyes was reported from the creel census, the sampling program results indicated that walleye do not spawn in the Bay, and the PFC did not consider PIB as naturally-preferable walleye habitat, in comparison with Lake Erie.

The salmonid fishery in PIB was relatively new at the time of the 1982 survey (coho salmon stocking of the Bay by the PFC began in 1975). Although coho salmon were the only salmonids stocked in the Bay, the 1981 creel census reported angler harvests of chinook, steelhead, coho, lake trout, and palomino trout. The creel census indicated a catch of 1,600 coho by shore anglers and 8,100 from boats, and were the dominant salmonid caught. It was observed that the harvest of coho from the Bay, on a weight basis, was second only to yellow perch. It was concluded that the coho fishery in PIB was significant, and represented an excellent management and utilization of a fishery resource. The high return of stocked smolts (25% of the PFC coho are stocked in PIB, and 23.4% of the coho harvest is from

PIB) indicates that, during the 1975-1981 period, PIB provided a high quality habitat for coho salmon production. All management recommendations in the 1983 report were based on improving the productive use of the PIB fishery, from a recreational perspective; no indications of pollution-related impairment of fisheries potential were noted.

3.4.1.1.2 1988 Fisheries Assessment

This assessment was a follow-up to the more extensive 1981-1982 studies reported in section 3.4.1.1.1 above. The 1988 assessment reports on the results of sampling efforts in 1986 and 1987. The primary focus of the 1986 sampling was on determining the status of the walleye fishery, while the 1987 effort was oriented to the overall fishery of PIB. No creel census data were collected for use in the 1988 report. Sampling techniques included gill netting, electrofishing, trapnetting, and seine netting. Aquatic vegetation conditions were also assessed, and limited chemical analyses were performed.

Significant fisheries management practices which occurred between the 1983 and 1988 reports included:

- establishment of a daily creel limit (six) and a minimum size limit (15") for walleye, in 1982

- establishment of a daily creel limit (50) for panfish, in 1982

- initiation of steelhead trout stocking in PIB, in 1984

- significant stocking of walleye fry by the PFC occurred in 1983 and 1984, and was continued, on an annual basis, by co-op nurseries, and

- a largemouth bass season from June 12 to the first day of trout season was established in 1987 (the existing 12" minimum size and six fish creel limits remained unchanged).

The 1988 report evaluated the effects of these changes, and recommended additional adjustments in PIB fisheries management practices.

Based on the 1986-1987 sampling results, the principal conclusions in the 1988 assessment were:

- overall, PIB continues to be an "exceptional fishery", and both panfish and game species are doing well (with the exception of walleye and smallmouth bass, which appear to be transients from Lake Erie), and are described as "quality populations"

- PIB had a "high quality" fishery for northern pike, muskellunge, brown bullhead, rockbass, pumpkinseed, bluegill, and largemouth bass in 1986-1987

- the salmonid fishery has become more significant since the initiation of direct stocking of steelhead smolts into the Bay, and

- the stocking of walleye fry into the Bay appears to have no effect on walleye populations.

An additional observation was the high incidence of "redspot" on northern pike (49% of the population). Although this problem is normal consequence of crowding (the northern pike population was very high in the 1986-1987 sampling), concern was expressed for the unexplained high incidence of black "blotches" reported in largemouth bass (17.6% of the population), and the "high number" of brown bullheads which had either black blotches or open sores on the mouth or skin.

Fish species stocked in PIB, by species and number stocked, are summarized in Table 3.2, for the five-year period 1982-1986.

Comparing the PFC 1971-1981 stocking record (Table 3.1) with the 1982-1986 stocking record in Table 3.2, it may be seen that the average number of fish stocked in PIB in the 1982-1986 period is six times that of the 1971-1981 period. However this statistic is biased by the high number of walleye fry experimentally introduced in 1984 (7,000,000). Excluding this stocking, the average for 1982-1986 is 322,992 fish/year, or 1.3 times that of the 1971-1981 period.

In addition to the PFC walleye stocking, it is reported that co-op nurseries stocked 10,000 walleye fry in PIB in 1983, and approximately 600,000/year thereafter in an attempt to establish walleye fishery in the Bay. However, the 1988 report, like its 1983 predecessor, concluded that the Bay is not natural habitat for walleye. While walleye were caught in the Bay in both sampling efforts, it was concluded that the Bay is not used for spawning, and the presence of walleye in the Bay is due to seasonal migration from Lake Erie. Based on the limited chemical data collected, it was concluded that summer water temperatures in PIB (24 C) are approximately 5 degrees Centigrade higher than the maximum summer temperatures naturally preferred by walleye.

Table 3.2. Fish species stocked in Presque Isle Bay: 1982-1986 (adapted from PFC, 1988).

Year	Species	Size (inches)	Number Stocked
1982	Muskellunge	fingerling	5,393
	Northern Pike	fingerling	10,287
	Coho salmon	fingerling	188,500
1983	Northern Pike	fingerling	28,260
	Coho salmon	fingerling	275,000
	Walleye	fry	10,000
1984	Muskellunge	fingerling	18,500
	Northern Pike	fingerling	20,800
	Coho salmon	fingerling	227,500
	Steelhead	fingerling	144,000
	Walleye	fry	7,000,000
1985	Northern Pike	fingerling	6,315
	Coho salmon	fingerling	295,000
	Steelhead	fingerling	128,000
	Chinook salmon	fingerling	175,000
1986	Coho salmon	fingerling	128,400
	Steelhead	fingerling	277,000
		Total	8,937,955
		(average)	(1,489,659/year)

Table 3.3. Summary of 1991 fishing regulations for Presque Isle Bay (from PFC, 1991).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Trout/Salmon *†	9"-3/day				9"-8/day					9"-3/day		
Muskellunge and Hybrids †	30"-2/day		15					30"-2/day				
Northern Pike	24"-2/day		15					24"-2/day				
Walleye						15"-6/day						
Bass: Largemouth Smallmouth †	15"-4/day			13		14		15"-4/day				
Sturgeon		N O		O P	E	N	S	E	A	S O	N	
Panfish †				No minimum size-50/day								
Baitfish Fishbait †				No minimum size-50/day								

* Limit 2 lake trout/day

† Daily creel limits for combined species

The limited salmonid data from the 1986-1987 sampling (no creel census data were available for this period) indicate that PIB continues to offer a productive coldwater species fishery. The capture rate for both coho and steelhead increased over the 1982 sampling period.

Additional fisheries management recommendations were made as a result of the 1988 assessment. These recommendations were again based on improving the recreational use of the PIB fishery. No indications of pollution-induced impairments of the fishery were noted, however concern was expressed for the unexplained blotches and sores on largemouth bass and brown bullheads.

3.4.1.1.3 Fishing Regulations

Laws and regulations governing fishing in Pennsylvania are published in the Pennsylvania Bulletin, and summarized in annual booklets published by the PFC. These regulations establish the dates of open seasons, by species and water body, as well as the minimum size standards and daily creel limits. These management regulations are established to implement the fisheries management objectives for specific waterbodies, as based on recommendations resulting from the periodic fisheries assessment studies.

Until 1982, management regulations for PIB were the same as those for Lake Erie, and were different from inland waters. However, in 1982, a daily creel limit of 50 was established for panfish in PIB, and a walleye daily creel limit of six, with a minimum size of 15", was added. Current (1991) regulations for PIB are provided in Table 3.3. No distinction is drawn between PIB and Lake Erie under the current regulations, which are different from inland water regulations.

"Panfish", as used in the PFC regulations (Table 3.3), includes Sunfish, Yellow Perch, Crappies, Catfish, Rock Bass, Suckers, Eels, Carp, and White Bass. Further, the Emerald Shiner and Great Lakes Spottail Shiner are the only species of "minnows" which may be taken from PIB (including the Bay itself as well as the peninsular ponds and lagoons), and they may be taken from boats and docks only. The 15" minimum size limit for Bass in the regulations is higher than the Pennsylvania inland waters limit (12" for lakes and ponds, and 10" for rivers and streams), and has been imposed in an effort to develop a trophy bass fishery in PIB.

3.4.1.2 Other Aquatic Species

Presque Isle State Park is maintained to provide opportunities for both recreational enjoyment and natural preservation. Recreational opportunities range from passive, aesthetic pursuits to active, consumptive pursuits such as hunting and fishing. In contrast, other areas are set aside for preservation of natural ecosystems and scientific study. Park management practices seek to preserve and protect the species diversity which supports this wide variety of park uses, balancing consumptive demands against conservation needs.

In a report released in 1989, the environmental features of Presque Isle were surveyed, and environmentally sensitive areas were identified (PADER, 1989). In this survey, an environmentally sensitive area was defined as:

> ...an area which contains an ecosystem whose biological and physical integrity, as well as its ecological processes, should be maintained, and protected. Within a park, they are the <u>most</u> significant and sensitive natural sites. They require special consideration in the determination of management actions because of the sensitive features that they contain.

The survey identified environmentally sensitive areas based on the following eight factors, or "criteria":

- species of special concern (vulnerable, rare, threatened or endangered species)

- unusual and/or high quality community (natural communities with limited representation in the Park, State, or country)

- high diversity (unusually high species diversity)

- ecological function (the ecological function of the area is vital to the healthy maintenance of a natural system beyond its boundaries)

- large areas (the area is sufficiently large to provide habitat for species which require extensive blocks of suitable habitat)

- landform (area is a distinctive and unusual natural landform)

- scientific research (area is significant for scientific research), and

- aesthetic area (combination of natural landforms and biological communities is of high aesthetic value).

Environmentally sensitive areas were then delineated on computer overlay maps, and a composite map was created to identify the most significant areas within the Park. Management recommendations were then developed for these environmentally sensitive area "hot spots".

The results of the overlay analyses included identification of a wide variety of aquatic species habitats within the Park and the Park boundary areas of PIB. These areas were identified on the basis of physical habitat, and water quality (chemistry) information was not included. Significant aquatic species of "special concern" for which potential habitats were identified included:

- Eastern Sand Darter (a review candidate for listing as an endangered species at the federal level)

- juvenile Lake Sturgeon (State level significance)

- Iowa Darter (Park level significance)

- Spotted Gar, or Bowfin (Park level significance)

- four naiad mollusks considered to rare/endangered at the State level (fragile paper-shell, eastern pond-mussel, pink heel-splitter, and maple-leaf), and

- Blandings Turtle (State level significance).

Many of the habitat areas for these aquatic species are located in ponds or other water bodies which are within the Park, or on the Lake Erie or Outer Harbor shoreline. Significant habitat areas identified on PIB or open water areas which are in direct circulation with the Bay included:

- Lake Sturgeon Channel; the navigation channel south of the Coast Guard station, which is habitat for Lake Sturgeon

- Misery Bay Mollusk Bed; an area along the west shore of the central portion of Misery Bay, and

- Crystal Point Mollusk Bed; an area in PIB along the south shore of Crystal Point (ending at the Perry monument).

Management recommendations for these areas included minimization or elimination of dredging or construction during critical life cycles, and "interagency management required". Additional management recommendations for the two mollusk beds included maintaining submerged vegetation and substrate, and protection of water quality, substrate and host fish.

Significant aquatic habitat areas which are located within the Park included a wide variety of ponds, marshes, and other wetlands.

Two open water habitats outside PIB included the Thompson Bay shoreline (Outer Harbor), and the Lake Erie shoreline from the lighthouse to the eastern end of the peninsula. These two habitats are identified as environmentally sentitive areas for various darter species.

In recent years, the Zebra Mussel has been introduced into the Great Lakes. Large numbers of these mussels are found in PIB, as well as the surrounding Lake Erie waters. In addition to causing problems in water intake lines, the mussels will have an effect on the Bay ecosystem. There are already indications that the water clarity has increased significantly due to the mussels' filter feeding activities, with a concurrent increase in littoral vegetation. Competition with other mollusks and fish for planktonic food and habitat may alter the existing system and community structure, as may the effects of deeper light penetration (due to increased clarity) and the direct effects of the mussels attaching to other mollusks, turtles and plants. It will be important, when evaluating the conditions in the Bay, to separate the impact of the Zebra Mussel from other environmental factors.

3.4.1.3 Wildlife

Relatively little natural wildlife habitat area exists along the south shore of PIB. Some natural habitat exists at the mouth of Cascade Creek and Mill Creek, however these areas have been altered by human activities. In contrast, the peninsula offers a range of wildlife habitats which is unique in Pennsylvania, and uncommon in the Great Lakes system. The wetlands and upland habitats in the Park provide a compressed series of successional ecological stages, ranging from sand beaches through ponds and marshes to mature hardwoods.

The wetlands areas offer valuable habitat for a variety of waterfowl species, including both swimming and wading birds (ducks and herons). The Park is also an important stop for many species of migratory birds, including both waterfowl and other species (e.g. songbirds). Finally, a large population of resident ducks and seagulls inhabits the City of Erie and Park shoreline areas, and has become accustomed to (and in some measure dependent upon) human presence.

As a State Park, Presque Isle supports and maintains a variety of uses, from ecological observation to hunting, fishing, and boating. While duck hunting is permitted during the duck season from authorized blinds along the PIB shoreline, a large section of the Park's interior is set aside as an ecological reservation and provides habitat for many species of wildlife which may not acclimate to the high levels of human presence in the Bay and Bay shoreline areas.

3.4.2 Water Supply

PIB is not used as a source of drinking water. Although the City or Erie at one time drew water from PIB, these intakes were moved to Lake Erie, northwest of Presque Isle. The only known industrial water withdrawal is the Quin-T corporation, located near the intersection of 16th and French streets. Water is pumped from an intake near the Litton docks. After settling, the water is used in the manufacture of asbestos gaskets; wastewater is discharged to the City sewer. The daily or annual volume of water used is not known.

3.4.3 Sport Fishing

PIB is extensively used by sport fishermen. As part of a comprehensive survey performed in 1982, it was reported that the Bay received 625,000 hours of fishing pressure that year, consisting of 283,700 hours of shore fishing, 255,900 hours of boat fishing, and 85,400 hours of ice fishing (PFC, 1983). As part of this survey, a catch rate of 1.52 fish/hour of fishing was derived (0.98 fish/hour kept), for a yield of 257 fish/acre caught (166/acre harvested).

Fisheries assessments by the PFC have consistently shown PIB to be a highly productive sport fishery, with excellent returns of stocked sport species (see previous §§3.4.1.1 and 3.4.1.2). The Bay is rated as a "high quality fishery" for many warmwater species, including northern pike, muskellunge, brown bullhead, rock bass, pumpkinseed, bluegill, and largemouth bass; also, the coldwater species (salmonid) fishery is becoming significant since the initiation of the practice of stocking steelhead smolts directly into the Bay (PFC, 1988).

3.4.4 Water Contact Recreation

Prior to 1985, water contact recreation was not a designated use for PIB. However, a detailed review of water quality conditions was conducted in 1985 (PADER, 1986a) which determined that water quality standards for full water contact recreation were being met, and water contact recreation was added to the protected uses of PIB (see §4.1.1.10 for additional information on this study). Monitoring data collected since 1985 have shown PIB to consistently meet the applicable standards for this protected use.

Although swimming (water contact recreation) is a protected use in PIB, most swimmers prefer the sandy beaches along the lakeshore side of the peninsula. Also, PADER State Parks has decided not to develop beaches on the Bay side of the peninsula, and water access is limited. In addition, water contact recreation is not a protected use in the harbor basin or entrance channel, and water skiing is prohibited within 500 feet of the Park shoreline. As a result, swimming from shore is predominantly pursued along the lakefront of the Park; the forms of full-body water contact recreation in PIB are primarily water skiing, swimming from boats, and more recently, sail boarding.

3.4.5 Navigation and Commerce

Erie Harbor has been a Federal harbor since 1824 when the first improvements were authorized. At Erie Harbor, the major percentage of total commerce is made up of receipts. The primary commercial receipts include sand and gravel, domestic limestone, domestic salt, Canadian sand and gravel, iron, and fabricated metal products. The harbor also handles lesser amounts of gasoline, residual fuel oil, lumber, logs, distillate fuel oil, non-ferrous ores, and iron and steel scrap. Between 1975 and 1984, annual shipments through the harbor averaged 861,695 tons. Table 3.4 shows the variation in annual rates during those years (COE, 1987).

3.4.6 Drainage

Presque Isle Bay receives surface runoff from an approximately 25 square mile watershed area, as depicted in Figure 3.1 (see §3.2.1 for additional information on surface runoff volumes from this area). In addition, PIB receives shallow groundwater from those areas immediately proximal to the Bay; further inland, shallow groundwater contributes to streamflow. On the peninsula, the exact delineation of surface and groundwater flow regimes is not known. The low relief of the land surface and the highly permeable nature of the sandy soils limits surface runoff and encourages groundwater recharge. It is expected that shallow groundwater along the lakeshore drains toward Lake Erie, and that much of the rest of the peninsula drains to the complex series of inland ponds and marshes, and eventually to the Bay.

3.4.7 Waste Disposal

Presque Isle Bay is not generally used for wastewater disposal. The only permitted wastewater treatment plant point source discharge to the Bay is Presque Isle State Park (NPDES permit #PA0032549), with a maximum discharge of 0.0175 mgd. However, several point sources discharge treated wastewater to streams within the PIB watershed, and a number of sources discharge cooling water or other non-process wastewater directly to the Bay, or to streams or storm sewers leading

Table 3.4. Commodity tonnage at Erie Harbor
(adapted from COE, 1987).

Year	Total Tonnage
1984	828,904
1983	606,690
1982	624,432
1981	754,698
1980	508,075
1979	833,707
1978	1,129,985
1977	954,672
1976	1,157,637
1975	1,218,153
Average	861,695

to the Bay. In addition, more than 50 combined sewer overflows from the City of Erie's wastewater collection system discharge to the Bay or its tributaries.

Most Erie area industries discharge process wastewater to the City's sewer system. The City's wastewater treatment plant discharges to the outer harbor, at an average flow of 45 mgd. At least three other cooling water discharges, and several additional, combined sewer overflows (CSOs), also discharge to the outer harbor. Prior to 1991, the largest volume discharge to PIB, by far, was Penelec's Front Street power station. This facility discharged an average of 125 mgd of condensor cooling water into the west slip of the public dock. This cooling water discharge did not contain process wastewater, and the primary pollutant was heat. This discharge was discontinued in early 1991.

Additional information on point and nonpoint source loadings to PIB is provided in Chapters 5 and 6.

3.4.8 Recreational Boating

In 1981, over 1,500 recreational boats were based in Erie Harbor; small craft with drafts of 12 feet or less account for over 80 percent of all trips made in and out of the harbor (COE, 1987). A boater use survey conducted in 1982 determined that "...over 90% of the recreational boating hours recorded in Pennsylvania-bound Lake Erie were for Presque Isle Bay/Outer Erie Harbor" (PADER, 1986a).

In addition to the pleasure boats moored in the harbor, sixteen marinas and nine public boat launching facilities exist in PIB and the outer harbor. Presque Isle State Park offers six boat launching ramps, in four separate areas, and a 498 slip marina, as well as a livery for canoe, rowboat, and motorboat rentals (PADER, 1978). Major marinas on the south shore of PIB include the Erie Yacht Club and facilities at the public docks. The Lampe marina, located in the outer harbor, offers additional recreational boating opportunities.

3.5 Environmental Quality Standards and Applicable Beneficial Uses

There are numerous measures of environmental quality that are applicable, or relevant and appropriate, to the conditions within the AOC which can be used for the evaluation of the data presented in this report. These measures include specific standards for environmental resources in the Bay, guidelines that have been developed for similar resources, and objectives set for the resources and their uses which were developed by the USEPA, the IJC, and the Commonwealth of Pennsylvania. This section summarizes those quality standards, objectives, or guidelines that will be used to evaluate the existing environmental quality data from PIB, in order to (1) determine the presence or absence of impairments and (2) develop recommendations, as necessary, for additional data collection.

3.5.1 Water Quality Criteria

Water quality criteria that apply to PIB have been established by the PADER and the IJC. The PADER standards are dependent upon the protected uses that are defined by the DER, and are preeminent.

3.5.1.1 Protected Uses

The Pennsylvania Code of Regulations, Title 25, Chapter 93 establishes water quality standards, defines protected water uses, and identifies the protected uses for the water resources within the State. Protected uses are defined in five categories: Aquatic Life, Water Supply, Recreation, Special Protection, and Other.

Presque Isle Bay has identified protected uses in the Aquatic Life, Water Supply and Recreation categories. Within the Bay/Outer Harbor area, protected uses are defined for two specific zones: (1) the harbor basin and the central channel, and (2) all other areas of the Bay and the outer harbor area (see Figure 4.5; §4.1.1.10).

The harbor basin and channel have the following protected uses as defined in The Pennsylvania Code of Regulations, Chapter 93, Water Quality Standards:

AQUATIC LIFE

Warm Water Fishes - Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.

WATER SUPPLY

Potable Water Supply - Use by the public as defined by the Federal Safe Drinking Water Act or other water uses that require a permit from the Department under the Pennsylvania Safe Drinking Water Act after conventional treatment, for drinking, culinary, and other domestic purposes, such as inclusion into foods (either directly or indirectly).

Industrial Water Supply - Use by industry for inclusion into nonfood products, processing and cooling.

Livestock Water Supply - Use by livestock and poultry for drinking and cleansing.

Wildlife Water Supply - Use for waterfowl habitat and for drinking and cleansing by wildlife.

Irrigation - Used to supplement precipitation for growing crops.

RECREATION

Boating - Use of the water for power boating, sail boating, canoeing, and rowing for recreational purposes when surface water flow or impoundment conditions allow.

Fishing - Use of the water for the legal taking of fish.

Esthetics - Use of the water as an esthetic setting to recreational pursuits.

The areas of the Bay outside of the harbor basin and harbor channel have the following additional protected use:

RECREATION

Water Contact Sports - Use of the water for swimming and related activities.

The deletion of the Water Contact Sports use from the harbor basin and channel area is not specifically a water quality concern but more of a safety issue related to the commercial shipping traffic in that area (see §4.1.1.10).

Cascade Creek and Mill Creek also have the following additional protected use:

AQUATIC LIFE

Migratory fishes - Passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which ascend to flowing waters to complete their life cycle.

3.5.1.2 Water Quality Standards

"Water quality standards" are defined in Title 25, Chapter 93 as "the combination of water uses to be protected and the water quality criteria necessary to protect those uses". The uses to be protected are summarized in 3.5.1.1; criteria for the protection of these uses are established in Title 25, Chapter 93. The PADER has established both general and specific water quality criteria.

The general water quality criteria (Title 25, Chapter 93; §93.6) stipulate that:

(a) Water may not contain substances attributable to point or nonpoint source waste discharges in concentrations or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life.

(b) In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances which produce color, tastes, odors, turbidity or settle to form deposits.

The specific criteria are primarily comprised of two tables, or lists. The first is a listing of waters of the Commonwealth for which specific criteria (relating to designated uses) have been established (Title 25, Chapter 93, 93.9). The second is a table of specific water quality criteria (Title 25, Chapter 93, §93.7, Table 3). A third section (Title 25, Chapter 93, 93.8) describes the procedure to be followed for developing "safe concentration values" for those pollutants for which no criteria exists. Sections 93.7-93.9 are reproduced in Appendix A (only that portion of the list of drainage basins applicable to PIB has been included).

Finally, water quality criteria for toxic substances are included in Title 25, Chapter 16. Water quality criteria for toxic substances are "...designed to protect the water uses listed in Chapter 93". The PADER has developed toxic criteria for 127 pollutants, based on the Clean Water Act 307(a) priority pollutants. Human health and aquatic life criteria used by the PADER in development of effluent limits in NPDES discharge permits are also included in Appendix A.

3.5.2 Sediment Classification Criteria

Sediment classification criteria applicable to PIB are those developed by the USEPA, Region V. Technically, these are guidelines and not criteria. However they are the applicable tests of sediment quality on the U.S. side of the Great Lakes, and are routinely used to distinguish between those sediments which may be disposed of by open lake dumping and those which must be disposed of in a controlled manner (typically; a confined disposal area).

The USEPA <u>Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments</u> (USEPA, 1977a) includes guideline values for 19 parameters, including 11 metals and eight other conventional, nonconventional, and toxic organic pollutants. These guidelines have three concentration ranges, and a particular sediment sample may be rated as "unpolluted", "moderately polluted", or "highly polluted" against any of the 19 guideline parameters.

The USEPA Guidelines for sediment classification are presented in Chapter 4, §4.1.1.7.

3.5.3 Wildlife Criteria

Criteria for the contamination of fish have been established by both the IJC and the U. S. Food and Drug Administration (FDA). In the case of PIB, the FDA "Action Levels" are the applicable standards. The Action Levels are "...limits at or above which FDA will take legal action to remove adulterated products from the market" and "...are established based on the unavoidability of the poisonous or deleterious substance". Action Levels "are established and revised according to criteria specified in [21 CFR 109 and 509] and are revoked when a regulation establishing a tolerance for the same substance and use becomes effective" (FDA, 1987). Technically, the Action Levels apply to marketed food products (i.e. sold in commercial outlets) and do not apply to food products which are harvested directly by the consumer (i.e. do not enter the commercial distribution system). However, the Action Levels often serve as the basis for fish consumption advisories issued by State agencies, and are the de facto applicable criteria for determining the safety of fish and wildlife harvested for human consumption.

Action Levels for fish flesh are for the "edible portion", denoting fillets. To date, Action Levels for fish have been established for 10 contaminants (or groups of related contaminants), including one metal (mercury), eight bioaccumulative organo-pesticides, and PCBs (the current PCBs Action Level is found in 21 CFR §109.30). The Action Levels are presented in Chapter 4, §4.1.1.1. There is currently a multi-state fish advisory task force that is reviewing the existing criteria and will be proposing a basinwide system for issuing fish advisories.

The IJC has also established "objectives" for contaminant levels in fish (IJC, 1989). However, the IJC objectives are primarily focused on the protection of aquatic organisms and fish-consuming birds and animals. Consequently, the IJC objectives are based on levels in whole fish, rather than the "edible portion" (fillets) approach used by the FDA, where protection of human consumers is the focus. IJC objectives have been established for four of the same contaminants for which FDA Action Levels exist (DDT and metabolites, PCBs, mercury, and mirex), as well as one additional contaminant (lindane) for which, no counterpart Action Level has been set.

3.6 Summary

PIB is a shallow estuary (average depth of 13.1 feet) with a relatively small drainage basin (25 square miles) for the volume of the Bay (13,900 million gallons). Most of the watershed area lies within the City of Erie and Millcreek Township, however some of the more remote portions include parts of Summit, Greene, and Harborcreek Townships. The principal tributaries are Mill Creek (including Garrison Run) and Cascade Creek, which together account for approximately two thirds of the total water budget of the Bay. Additional inflow is received from precipitation directly on the Bay surface, Scott Run, CSOs, groundwater discharge, and permitted wastewater discharges.

The Bay is a relatively closed system, and exchange of water with the outer harbor and Lake Erie is restricted by the small harbor opening and the low inflow to total volume ratio, resulting in a "flushing time" of almost 2.5 years. Consequently, biodegradation of wastes discharged to the Bay occurs almost entirely within the confines of the Bay, and does not significantly affect (and is not significantly affected by) the outer harbor or Lake Erie. However, because the Bay is completely mixed, thermal stratification does not occur, and conditions of dissolved oxygen depletion in bottom waters do not develop. Most of the Bay bottom is covered with fine, organic-rich sediments, however sand and a few larger rocks may be found in limited areas where currents have restricted the deposition of fine sediments.

Land use within the PIB watershed is approximately 80% urban and 20% rural, however only approximately 1% of the rural land is in agricultural use, which is concentrated in the Mill Creek headwaters. More than half of the total watershed (57%) is residential, followed by 16% open areas, 11% commercial, 8% public and only 7% in industrial use. The highest concentration of industrial uses is located at the western edge of Erie, between 6th and 26th Streets. A secondary concentration is located at the east edge, between 6th and 20th, and between 26th and 38th Streets. A third industrial area is located on the Bayfront, at the southeast corner of the Bay. Commercial land use is concentrated in a north/south corridor from Sassafras to Holland Streets; smaller commercial land use concentrations (including shopping centers) occur throughout the City, but tend to concentrate along major east/west streets.

Almost all of the watershed is sewered, and served by the City's wastewater treatment plant which discharges to the outer harbor. In addition to the City itself, Erie's collection system also receives sewage from the metropolitan areas surrounding the City. Most of the industries located within the PIB watershed discharge wastewater to the City's collection system, however a few discharge cooling water to the Bay or its tributaries. The wastewater collection system is complex, and many portions are combined sewers, receiving surface runoff during and after precipitation events. The inflow of surface runoff exceeds the hydraulic capacity of many of the combined sewers, and untreated wastewater escapes to the Bay (either directly or indirectly) through dozens of CSOs.

Presque Isle State Park is the most heavily visited park in Pennsylvania, attracting more than four million visitors annually. A wide variety of outdoor recreational opportunities are provided by the Park and the Bay, however little recreational access exists along the Bay's south shore, fronting the City. While some limited areas of wildlife habitat exist within the City, the Park is the dominant concentration of open space and wildlife habitat within the PIB system.

Predominant water uses in PIB include fish and wildlife habitat, water supply, sport fishing, water contact recreation, navigation and commerce, drainage, waste disposal, and recreational boating. Protected uses managed by the PADER include aquatic life, water supply, and recreation (including water contact activities). Water quality standards for the protection of these uses are established in Title 25, Chapter 93 of the Pennsylvania Code. The primary guidelines for the assessment of sediment quality are established by the USEPA and are intended to distinguish between those dredged sediments which may be disposed of through open lake dumping and those which must be deposited in confined disposal locations. Applicable criteria for the consumption of fish and wildlife ("Action Levels") are established by the Food and Drug Administration, for 10 contaminants or groups of related contaminants. In addition, the IJC has also established "objectives" for contaminant levels in fish, however these are primarily targeted for the protection of fish-eating wildlife rather than human health.

PIB provides habitat for a wide variety of sport and forage fish species, including at least 16 which spawn in the Bay. More than 40 fish species may be found in the Bay, of which more than 20 are pursued by fishermen. The Bay is managed as a sport fishery by the PFC, which stocks both warmwater and coldwater species. The Bay is described as an "exceptional fishery", providing high quality populations of northern pike, muskellunge, brown bullhead, rockbass, pumpkinseed, bluegill, and largemouth bass as well as salmonids (steelheads). The PFC discontinued direct stocking of walleyes into the Bay in 1985, after a determination that summer water temperatures were higher than the naturally-preferred range for this species. However, the Cooperative Sportsmen's Club continues to hatch eggs at the Chestnut Street hatchery. The eggs are provided by the PFC, and the fry are stocked by sportsmen in the Bay.

PIB is extensively used as a sport fishery, supporting an estimated annual total of well over 500,000 hours of fishing pressure. Recreational boating is also very popular, with well over 1,500 recreational craft based in the harbor. Because no protected beaches exist on the Bay side of the peninsula, and because more than seven miles of protected beaches exist on the Lake Erie side, relatively little swimming occurs in the Bay. While water skiing is restricted within 500 feet of the Park, it is reported that the sheltered waters of the Bay provide excellent opportunities for both water skiing and, more recently, sail boarding.

4. PROBLEM DEFINITION

This chapter is the heart, or focal point, of the Remedial Action Plan, drawing upon information from previous chapters, and providing the technical foundation for subsequent chapters. In the first part of this chapter, available environmental data are compared to the IJC's AOC Listing Guidelines (Appendix C) to identify impaired beneficial uses (§4.1). The pollutants of concern (§4.2) are then defined, based on the impairments described in §4.1. The sources of these pollutants, and the mechanisms by which they are transported from the source areas to the impact areas, are summarized in Chapter 5.

4.1 Conflicts with Beneficial Uses

In this section, the most current available data and information from Presque Isle Bay are compared with specific guidelines for identifying and listing Areas of Concern, based on the impairment of beneficial uses. These guidelines have been developed by the IJC's Water Quality Board, pursuant to Annex 2 of the 1978 GLWQA (see Section 2.2 for additional information on the GLWQA and the AOC listing/delisting process). Section 1.(c) of Annex 2 defines "impairment of beneficial use(s)" as a change in the chemical, physical or biological integrity of an aquatic system sufficient to cause any of the 14 effects listed in §1.(c)(i)-(xiv) of Annex 2.

4.1.1 Impaired Uses Analyses

The following discussion is formatted to coincide with the 14 use impairment identification guidelines developed by the IJC's Water Quality Board. The 14 individual Annex 2 use impairments are the headings for the following 14 sections (§§4.1.1.1 through 4.1.1.14). For each impairment, the IJC's listing guideline is first quoted, followed by a comparative summary of the relevant data, and conclusions.

4.1.1.1 Restrictions on Fish and Wildlife Consumption

> "When contaminant levels in fish and wildlife populations exceed current standards, objectives or guidelines, or public health advisories are in effect for human consumption of fish or wildlife. Contaminant levels in fish and wildlife must be due to contaminant input from the watershed."

Public health advisories against the consumption of certain species of fish and wildlife harvested from the Pennsylvania waters of Lake Erie have been issued since the 1970s. For example, an advisory was issued by the Governor in 1970 against consumption of walleye, smallmouth bass, white bass, and sheepshead due to mercury (Hg) levels exceeding the U. S. Food and Drug Administration (FDA) action levels. In addition, consumption advisories for PCBs and chlordane have been issued on multiple occasions by Pennsylvania, most recently in 1991 (it should be noted that once issued, advisories remain in effect until rescinded).

The fish and wildlife consumption advisories issued to date apply generally to the Pennsylvania waters of Lake Erie rather than any specific locations (e.g. PIB), and are derived from lakewide data. By definition, restrictions on consumption of fish and wildlife (i.e. "advisories") only qualify as an AOC use impairment if the elevated levels of the offending contaminants result from input from the AOC's watershed. Therefore, the focus of the following discussions is on PIB fish and wildlife, and the lakewide advisories (which reflect lakewide water quality management issues) are only briefly summarized, as background information.

4.1.1.1.1 Lake Erie Fish

Lakewide advisories for consumption of Lake Erie fish caught in Pennsylvania waters have been issued on many occasions, from 1970 through the 1980s. The focus of these advisories has been on mercury (Hg) and PCBs/pesticides. The early advisories included a variety of sport fish species, however the more recent advisories have focused on carp and channel catfish, based on continuing programs of fish tissue analysis.

Mercury. The earliest known Pennsylvania fish consumption advisory was issued in 1970, and was based on fish sampling data which revealed Hg levels of 0.04-1.43 ppm in edible portions of fish collected from the Pennsylvania waters of Lake Erie, with the highest concentrations found in the top predators (walleye, smallmouth bass, white bass, and fresh water drum). A range of 0.34-0.46 ppm was observed in coho salmon (Frey, 1984). At that time, a 0.5 ppm guideline was used as the level of concern for Hg (interim FDA limit). This level was subsequently raised to the current 1.0 ppm FDA level.

In 1984, a summary of the available Hg data from Pennsylvania Lake Erie fish was prepared, for comparison with applicable Hg limits (Frey, 1984). Data from 1969-1971 included 113 Hg measurements, ranging from 0.003-1.43 ppm, with an average value of 0.297 ppm. Of these 113 measurements, 17 (15%) exceeded the 0.5 ppm interim limit, and 3 (2.7%) exceeded the current 1.0 ppm limit. Data from 1976-1984 were then tabulated for comparison with the 1969-1971 data set. These data included 26 measurements, ranging from <0.002 to 0.28 ppm, with an average of 0.124 ppm.

None of these measurements exceeded or even approached the 1.0 ppm limit, and no further Hg advisories were issued.

PCBs/Pesticides. In 1986, Pennsylvania issued health advisories against eating channel catfish and carp taken from the Pennsylvania waters of Lake Erie because of elevated levels of chlordane and PCBs. This advisory was repeated in 1987 and 1991. The PADER carp/channel catfish advisories emphasized that samples of trout and salmon collected from Lake Erie consistently showed these fish to be safe for consumption. Coho salmon samples were collected from Trout Run, a Lake Erie tributary approximately 10 miles southwest of Erie. These samples were analyzed for a variety of pesticides and PCBs, and were all found to be "... well below FDA Action Levels" (Frey, 1987). For example:

- total DDT values were within a range of 0.13-0.14 ppm, or <3% of the DDT Action Level

- total chlordane values were within a range of 0.05-0.07 ppm, or 17-23% of the chlordane Action Level, and

- total PCBs values were within a range of 0.27-0.44 ppm, or 14-22% of the PCBs Action Level.

Based on the results of the continued sampling and analysis program, an additional fish advisory for Lake Trout was issued in 1992, due to a PCB level of 1.9 ppm.

4.1.1.1.2 Presque Isle Fish

Because of the historic Lake Erie fish consumption advisories, a variety of sampling efforts have been initiated in PIB. Unfortunately, these sampling efforts have yielded conflicting results, particularly if older sampling data (i.e. before 1987) are considered. For example, when aliquots of a single (homogenized) channel catfish sample collected in 1986 were sent to three separate laboratories for analysis (one private, one State, and one Federal), the results were widely different, as follows:

- the first lab found both PCB and chlordane levels to exceed FDA limits

- the second lab found PCB levels in excess of the FDA limit, but did not detect chlordane, and

- the third lab found both PCB and chlordane levels to be below the FDA limits.

Clearly, these discrepancies resulted from differences in analytical technique and quality assurance/quality control (QA/QC) procedures between the different laboratories. Other examples of conflicting data also exist, and are attributable to differences in sample collection technique (e.g. whole fish versus fillets); variations in analytical protocol (e.g. wet weight versus dry weight) and QA/QC procedures between laboratories; and other variables (e.g. sample location, sampling time, and species sampled).

Because of the discrepancies in the data base on fish flesh contamination, it would be possible to selectively "sample" the available data and alternatively demonstrate that PIB fish are or are not contaminated. The purpose of the RAP is to provide an objective appraisal of the current condition of PIB fish, in comparison with the AOC listing criteria. Consequently, the most recent data available, from 1987-1990, have been assembled for comparison with the AOC impairment assessment guidelines. These data have been reviewed for QA/QC issues, which are identified (where appropriate) in the following discussion. Because "contaminant levels in fish ... must be due to contaminant input from the watershed", available Lake Erie fish flesh data are also summarized and presented for comparison.

The available 1987-1990 data sets are identified in Tables 4.1 and 4.2. In these tables, the data sets are aggregated according to sample year and location. Presque Isle Bay data sets are indicated by a "PIB" number; Lake Erie data sets are identified with an "LE" number. Where possible, the sample number used by the generating agency is also included, above the PIB or LE number. The following descriptive information is provided for each data set:

- species
- date of collection
- collection location
- laboratory performing the analysis
- whether the sample collected was a fillet or whole fish,
- supplemental observations on sampling, analysis, or data reporting circumstances.

Data sets for the period 1989-1990 are identified in Table 4.1; data sets for 1987-1988 are identified in Table 4.2.

Data from the sets identified in Tables 4.1 and 4.2 are presented in four tables, as follows:

Table 4.3. 1990 PIB and Lake Erie fish data vs FDA Action Levels

Table 4.4. 1989 Lake Erie fish data vs FDA Action Levels

Table 4.5. 1988 PIB and Lake Erie fish data vs FDA Action Levels, and

Table 4.6. 1987 PIB and Lake Erie fish data vs FDA Action Levels.

As seen in these tables, only one PIB fish data set is available from 1990, and no PIB data sets are available from 1989. Collectively, a total of 57 fish fillet data sets (22 from PIB and 35 from Lake Erie) are summarized in Tables 4.3-4.6.

In presenting the available PIB and Lake Erie fish flesh contaminant testing data in Tables 4.3 through 4.6, certain of the FDA instructions for data comparison were ignored, in order to adopt the most conservative possible approach to evaluating the available data (i.e. investigate the "worst-case" scenario). These specific instructions are reflected in the "notes" below each of Tables 4.3-4.6. For example, the FDA instructions stipulate that any results for DDT, TDE, and DDE that are reported at levels <0.2 ppm should not be included in deriving the total DDT/DDE/TDE value ("DDT & metabolites" in Tables 4.3-4.6) for comparison against the 5.0 ppm Action Level. However, to provide the most conservative possible comparison, all quantitated DDT/DDE/TDE values, including those <0.2 ppm, were included in deriving the total DDT & metabolites values. This same conservative approach was used for endrin, chlordane residues, and mercury (see notes 2, 3, and 4). Finally, while no FDA Action Level for benzene hexachloride (BHC) exists for fish (the existing standard applies only to frog legs; see note 5), all reported BHC data were also included for information, even though these data cannot be directly compared to the existing BHC Action Level.

As evident in Tables 4.3-4.6, a high percentage of "trace amount" or "not detected" results are reported. In all such cases, the detection limits used are at least one or two orders of magnitude below the FDA Action Level. For example:

- the Action Level for aldrin and dieldrin is 0.3 ppm, while the analytical detection limits used for these contaminants was typically 0.01 or 0.02 ppm, or an order of magnitude less than the Action Level
- for endrin, the Action Level is 0.3 ppm, while the detection limit was typically 0.005, or two orders of magnitude below the Action Level, and

Table 4.4. 1989 Lake Erie fish data vs FDA Action Levels.

parameter	Action Level (ppm)	note	Sample numbers and results (ppm) LE1	LE2	LE3	LE4	LE5	LE6	LE7	LE8	LE9	LE10	LE11	LE12	LE13
aldrin & dieldrin	0.3		ND	ND	0.033	0.036	ND	0.005	ND	0.035	0.07	0.02	0.03	0.02	0.035
DDT & metabolites	5	[1]	0.03	ND	0.152	0.204	ND	0.009	ND	0.631	0.03	0.1	0.1	0.11	0.631
endrin	0.3	[2]	ND	ND	ND	ND	ND	ND	ND	ND	T	T	T	T	<0.02
heptachlor/heptachlor epoxide	0.3		ND	ND	ND	ND	ND	ND	ND	ND	0.01	T	T	T	<0.01
PCBs	2		0.22	ND	0.97	1.4	ND	0.118	ND	0.76	0.94	0.61	0.6	0.61	0.76
toxaphene	5		NT	NT	NT	NT	NT	NT	NT	NT	<0.25	<0.25	<0.25	<0.25	NT
chlordane residues	0.3	[3]	ND	ND	0.114	0.118	ND	0.007	ND	0.118	0.2	0.05	0.05	0.05	0.118
mercury	1	[4]	*	*	*	*	*	NR	*	*	NT	NT	NT	NT	NT
mirex	0.1		NT	NT	NT	NT	NT	ND	NT	NT	NT	NT	NT	NT	NT
chlordecone (Kepone)	0.3		NT	NT	NT	NT	NT	NR	NT	NT	NT	NT	NT	NT	NT
[BHC (benzene hexachloride)]	[0.3]	[5]	ND	ND	ND	ND	ND	ND	ND	ND	T	T	T	T	<0.01

Notes:

[1] For fish, do not count DDT, TDE, and DDE levels below 0.2 ppm.

[2] For fish, do not count heptachlor or heptachlor epoxide levels below 0.1 ppm.

[3] Includes residues of chlordane, including heptachlor and its epoxide, cis and trans chlordane, cis and trans nonachlor, oxychlordane (octachlor epoxide), alpha, beta and gamma chlordane and chlordene. Levels of individual components must be quantitated at 0.02 ppm or above and confirmed in order to be added into the "chlordane" column.

[4] As methyl mercury.

[5] Limit is for frog legs - no fish limit currently exists.

ND = not detected
NT = not tested
NR = no results
T = trace amount
* = data not yet available (4/1/91)

Table 4.5. 1988 PIB and Lake Erie fish data vs FDA Action Levels.

parameter	Action Level (ppm)	note	PIB sample numbers and results (ppm) 276 PIB1	277 PIB2	284 PIB3	273 PIB4	280 PIB5	281 PIB6	282 PIB7	283 PIB8	285 PIB9	286 PIB10	287 PIB11	288 PIB12	289 PIB13	272 PIB14	278 PIB15
aldrin & dieldrin	0.3		ND	ND	ND	ND	ND	ND	0.013	ND	ND	ND	ND	ND	NR	ND	ND
DDT & metabolites	5	[1]	ND	0.13	ND	ND	0.071	ND	0.052	0.279	0.37	0.24	0.07	0.03	NR	ND	ND
endrin	0.3	[2]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND
heptachlor/heptachlor epoxide	0.3		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND
PCBs	2		ND	0.69	ND	ND	0.27	ND	0.17	1.2	0.92	1	0.19	ND	NR	ND	ND
toxaphene	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND
chlordane residues	0.3	[3]	ND	0.23*	ND	ND	ND	ND	0.17*	0.53*	0.72*	0.56*	0.22*	0.32*	NR	ND	ND
mercury	1	[4]	<0.1	<0.1	0.108	<0.1	0.125	0.135	0.1	<0.1	0.18	0.205	<0.1	<0.1	0.141	0.108	0.17
mirex	0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	ND	ND
chlordecone (Kepone)	0.3		NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
[BHC (benzene hexachloride)]	[0.3]	[5]	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

parameter	Action Level (ppm)	note	Lake Erie sample numbers and results (ppm) 291 LE1	168(s) LE2	168(m) LE3	168(l) LE4
aldrin & dieldrin	0.3		ND	T	0.01	0.01
DDT & metabolites	5	[1]	ND	0.05	0.06	0.06
endrin	0.3	[2]	ND	T	T	T
heptachlor/heptachlor epoxide	0.3		ND	T	T	T
PCBs	2		ND	0.27	0.26	0.28
toxaphene	5		ND	<0.25	<0.25	<0.25
chlordane residues	0.3	[3]	ND	0.02	0.03	0.03
mercury	1	[4]	0.112	NT	NT	NT
mirex	0.1		ND	NT	NT	NT
chlordecone (Kepone)	0.3		NT	NT	NT	NT
[BHC (benzene hexachloride)]	[0.3]	[5]	NT	ND	ND	ND

ND = not detected
NT = not tested
NR = no results
T = trace amount
shaded values exceed Action Levels
* These results, while reported here, have been shown to be substantial overestimations of the actual chlordane residues levels, through split sampling QA/QC procedures.

Notes:

[1] For fish, do not count DDT, TDE, and DDE levels below 0.2 ppm.

[2] For fish, do not count heptachlor or heptachlor epoxide levels below 0.1 ppm.

[3] Includes residues of chlordane, including heptachlor and its epoxide, cis and trans chlordane, cis and trans nonachlor, oxychlordane (octachlor epoxide), alpha, beta and gamma chlordane and chlordene. Levels of individual components must be quantitated at 0.02 ppm or above and confirmed in order to be added into the "chlordane" column.

[4] As methyl mercury.

[5] Limit is for frog legs - no fish limit currently exists.

Table 4.6. 1987 PIB/Lake Erie fish data vs FDA Action Levels.

parameter	Action Level (ppm)	note	PIB sample numbers and results (ppm)					
			266	267	268	269	-	-
			PIB1	PIB2	PIB3	PIB4	PIB5	PIB6
aldrin & dieldrin	0.3		ND	ND	ND	ND	T	T
DDT & metabolites	5	[1]	0.021	0.02	ND	ND	ND	0.017
endrin	0.3	[2]	ND	ND	ND	ND	NT	NT
heptachlor/heptachlor epoxide	0.3		ND	ND	ND	ND	NT	NT
PCBs	2		0.13	ND	ND	ND	ND	0.11
toxaphene	5		ND	ND	ND	ND	NT	NT
chlordane residues	0.3	[3]	0.061*	ND	ND	ND	ND	0.03
mercury	1	[4]	0.253	<0.1	<0.1	<0.1	ND	ND
mirex	0.1		ND	ND	ND	ND	ND	ND
chlordecone (Kepone)	0.3		NT	NT	NT	NT	NT	NT
[BHC (benzene hexachloride)]	[0.3]	[5]	NT	NT	NT	NT	NT	NT

ND = not detected
NT = not tested
NR = no results
T = trace amount
shaded values exceed Action Levels
* These results, while reported here, have been shown to be substantial overestimations of the actual chlordane residues levels, through split sampling QA/QC procedures.

parameter	Action Level (ppm)	note	Lake Erie sample numbers and results (ppm)												
			270	271	260	261	262	263	264	265	-	-	-	-	187
			LE1	LE2	LE3	LE4	LE5	LE6	LE7	LE8	LE9	LE10	LE11	LE12	LE14
aldrin & dieldrin	0.3		ND	0.12	ND	0.15	T	ND	0.003	ND	ND	ND	NR	NR	0.03
DDT & metabolites	5	[1]	0.095	0.102	ND	0.091	0.083	0.058	0.51	0.09	ND	ND	NR	NR	0.15
endrin	0.3	[2]	ND	ND	ND	ND	ND	ND	ND	ND	NT	NT	NT	NT	T
heptachlor/heptachlor epoxide	0.3		ND	ND	ND	ND	ND	ND	ND	ND	NT	NT	NT	NT	T
PCBs	2		0.44	0.24	ND	0.21	0.35	0.46	1.25	0.24	ND	ND	NR	NR	0.65
toxaphene	5		ND	ND	ND	ND	ND	ND	ND	ND	NT	NT	NT	NT	<0.25
chlordane residues	0.3	[3]	0.28*	0.18*	ND	0.22*	0.16*	0.15*	1.0*	0.32*	ND	ND	NT	NT	0.06
mercury	1	[4]	<0.1	0.178	0.197	0.171	0.306	0.121	NR	<0.1	0.14	NR	NR	NR	NT
mirex	0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NR	NT
chlordecone (Kepone)	0.3		NT	NT	NT	NT	NT	NT	NT	NT	NT	NR	NR	NR	NT
[BHC (benzene hexachloride)]	[0.3]	[5]	NT	NT	NT	NT	NT	NT	0.012	NT	NT	NT	NT	NT	T

Notes:

[1] For fish, do not count DDT, TDE, and DDE levels below 0.2 ppm.

[2] For fish, do not count heptachlor or heptachlor epoxide levels below 0.1 ppm.

[3] Includes residues of chlordane, including heptachlor and its epoxide, cis and trans chlordane, cis and trans nonachlor, oxychlordane (octachlor epoxide), alpha, beta and gamma chlordane and chlordene. Levels of individual components must be quantitated at 0.02 ppm or above and confirmed in order to be added into the "chlordane" column.

[4] As methyl mercury.

[5] Limit is for frog legs - no fish limit currently exists.

- the detection limits for PCBs were typically 0.1 or 0.2 ppm, or an order of magnitude below the 2 ppm Action Level for PCBs.

Consequently, no instances occurred wherein a parameter was not reported (or a potential violation of the Action Level overlooked) because the analytical detection limit used was not sufficiently sensitive.

The restricted fish consumption AOC listing guideline contains two tests, or components. In the first test, a use impairment is determined when contaminant levels "... exceed current standards, objectives or guidelines". Based on the available data, contaminant levels in PIB fish do not exceed the applicable standards (i.e. the FDA Action Levels). While the available data from 1987-1990 indicate that the FDA Action Level for residues of chlordane was exceeded in four PIB fish samples in 1988, and two Lake Erie fish samples in 1987 (see Tables 4.5 and 4.6), it was later discovered (through split sampling with the U.S. EPA and Michigan State Department of Health) that those 1987 and 1988 PIB and Lake Erie chlordane results generated by the PADER laboratory were overestimated, by as much as four times the actual values (ECDH, 1989b). Following this discovery, the PADER laboratory which performed the analyses reviewed and revised its analytical procedures for chlordane analysis (for additional details, see ECDH, 1989b). Based on this information, the apparent exceedances of the chlordane Action Level in Tables 4.5 and 4.6 are not reliable. While these data points have not been excluded from the tables, they are not interpreted as a credible indication of a use impairment, and no chlordane problems are indicated in the 1989 or 1990 data. With the exception of these aberrant chlordane results, no other samples from either PIB or Lake Erie fish exceeded any FDA Action Levels.

The second test in the restricted fish consumption AOC listing guideline states that "contaminant levels in fish and wildlife must be due to contaminant input from the watershed". Although the sample results from PIB fish do not exceed the FDA Action Levels, the PIB data were compared with the Lake Erie fish data, to determine if PIB fish exhibit elevated levels of monitored contaminants, relative to Lake Erie fish. In this comparison, the Lake Erie fish are used as the control, to evaluate for the possible addition of contaminants from the PIB watershed (i.e. to determine if contaminant levels in PIB fish are significantly higher than background, or Lake Erie, fish samples).

The PIB/Lake Erie fish data are compared in Table 4.7, in which any quantifiable data measurements from the 1987-1990 data base discussed above are summarized (i.e. Table 4.7 summarizes all

Table 4.7. Summary of PIB/Lake Erie fish data.

Sample	LE ald/diel.	PIB ald/diel.	LE DDT	PIB DDT	LE endrin	PIB endrin	LE hept.	PIB hept.
1990 1	0.02		0.1125					
1990 2	0.02		0.14					
1990 3	0.02		0.12					
1990 4	0.04		0.24				0.01	
1990 5								
1989 1			0.03					
1989 2								
1989 3	0.033		0.152					
1989 4	0.036		0.204					
1989 5								
1989 6	0.005		0.009					
1989 7								
1989 8	0.035		0.631					
1989 9	0.07		0.03				0.0100	
1989 10	0.02		0.1					
1989 11	0.03		0.1					
1989 12	0.02		0.11					
1989 13	0.035		0.631					
1988 1								
1988 2			0.05	0.13				
1988 3	0.01		0.06					
1988 4	0.01		0.06					
1988 5				0.071				
1988 6								
1988 7		0.013		0.052				
1988 8				0.279				
1988 9				0.37				
1988 10				0.24				
1988 11				0.07				
1988 12				0.03				
1988 13								
1988 14								
1988 15								
1987 1			0.095	0.021				
1987 2	0.12		0.102	0.02				
1987 3								
1987 4	0.15		0.091					
1987 5			0.083					
1987 6			0.058	0.017				
1987 7	0.003		0.51					
1987 8			0.09					
1987 9								
1987 10								
1987 11								
1987 12								
1987 14	0.03		0.15					
# values	19	1	25	11	0	0	2	0
mean	0.0372	0.0130	0.1583	0.1182	N/A	N/A	0.0100	N/A

Table 4.7. Summary of PIB/Lake Erie fish data (cont.).

Sample	LE PCBs	PIB PCBs	LE toxa.	PIB toxa.	LE chlor.	PIB chlor.	LE merc.	PIB merc.
1990 1	0.6				0.05			
1990 2	0.63				0.05			
1990 3	0.56				0.05			
1990 4	0.85				0.16			
1990 5								
1989 1	0.22							
1989 2								
1989 3	0.97				0.114			
1989 4	1.4				0.118			
1989 5								
1989 6	0.118				0.007			
1989 7								
1989 8	0.76				0.118			
1989 9	0.094				0.2			
1989 10	0.61				0.05			
1989 11	0.6				0.05			
1989 12	0.61				0.05			
1989 13	0.76				0.118			
1988 1							0.112	
1988 2	0.27	0.69			0.02	0.23*		
1988 3	0.26				0.03			0.108
1988 4	0.28				0.03			
1988 5		0.27						0.125
1988 6								0.135
1988 7		0.17				0.17*		0.1
1988 8		1.2				0.53*		
1988 9		0.92				0.72*		0.18
1988 10		1				0.56*		0.205
1988 11		0.19				0.22*		
1988 12						0.32*		
1988 13								0.141
1988 14								0.108
1988 15								0.17
1987 1	0.44	0.13			0.28*	0.061*		0.253
1987 2	0.24				0.18*		0.178	
1987 3							0.197	
1987 4	0.21				0.22*		0.171	
1987 5	0.35				0.16*		0.306	
1987 6	0.46	0.11			0.15*	0.03	0.121	
1987 7	1.25				1.0*			
1987 8	0.24				0.32*			
1987 9							0.14	
1987 10								
1987 11								
1987 12								
1987 14	0.65				0.06			
# values	25	9	0	0	17	1	7	10
mean	0.5373	0.5200	N/A	N/A	0.0750	0.0300	0.1750	0.1525

* These data were shown to be unreliable and were excluded from numerical comparisons (see text).

Table 4.7. Summary of PIB/Lake Erie fish data (cont.).

Sample	LE mirex	PIB mirex	LE Kepone	PIB Kepone	LE BHC	PIB BHC
1990 1						
1990 2						
1990 3						
1990 4					0.01	
1990 5						
1989 1						
1989 2						
1989 3						
1989 4						
1989 5						
1989 6						
1989 7						
1989 8						
1989 9						
1989 10						
1989 11						
1989 12						
1989 13						
1988 1						
1988 2						
1988 3						
1988 4						
1988 5						
1988 6						
1988 7						
1988 8						
1988 9						
1988 10						
1988 11						
1988 12						
1988 13						
1988 14						
1988 15						
1987 1						
1987 2						
1987 3						
1987 4						
1987 5						
1987 6						
1987 7					0.012	
1987 8						
1987 9						
1987 10						
1987 11						
1987 12						
1987 14						
# values	0	0	0	0	2	0
mean	N/A	N/A	N/A	N/A	0.0110	N/A

Table 4.1. Fish flesh data sets: 1989-1990.

1990

agency #	#083	#084	#085	#086	-	-	
PHE #	LE1	LE2	LE3	LE4	LE5	PIB1	Total Data Sets:
species	coho salmon	coho salmon	coho salmon	lake trout	yellow perch	yellow perch	5 L. Erie fillets
sample date	11/14/90	11/14/90	11/14/90	8/21/90	10/16/90	10/17/90	No L. Erie whole
location	Trout Run	Trout Run	Trout Run	Lake Erie*	WQN 622	WQN 632	1 PIB fillets
lab	FDA	FDA	FDA	FDA	DER	DER	No PIB whole
notes	fillets (small)	fillets (med.)	fillets (large)	fillets	fillets	fillets	
	Lake Erie trib.	Lake Erie trib.	Lake Erie trib.	*location not specified			

1989

agency #	-	-	-	-	-	-	-
PHE #	LE1	LE2	LE3	LE4	LE5	LE6	LE7
species	walleye	yellow perch	channel catfish	channel catfish	yellow perch	freshwater drum	walleye
sample date	9/19/89	8/1/89	9/18/89	8/1/89	8/1/89	6/6/89	10/24/89
location	Lake Erie	WQN 601	WQN 601	WQN 622	WQN 622	Lake Erie	Lake Erie
lab	DER	DER	DER	DER	DER	USEPA*	DER
notes	fillets	fillets	fillets	fillets	fillets	fillet	fillets
	off Wilkins Run					outer harbor at POTW outfall	off Shades Beach

1989

Table 4.1. Fish flesh data sets: 1989-1990 (cont.).

1989

LE8	LE9	LE10	LE11	LE12	LE13	LE14	Total Data Sets:
-	FDA #072	FDA #073	FDA #074	FDA #075	-	-	
lake trout	lake trout	rainbow trout	rainbow trout	rainbow trout	lake trout	white sucker	13 L. Erie fillets
10/24/89	1989	1989	1989	1989	1989	6/6/89	1 L. Erie whole
Lake Erie	Lake Erie*	Trout Run	Trout Run	Trout Run	Lake Erie*	Lake Erie	No PIB fillets
DER	FDA	FDA	FDA	FDA	DER	USEPA	No PIB whole
fillets	fillets	fillets	fillets	fillets	fillets	whole fish	
off Shades Beach	* location not specified	small specimens	medium specimens	large specimens	* location not specified	outer harbor at POTW outfall	

Table 4.2. Fish flesh data sets: 1987-1988.

1988							1988
agency #	276	277	284	273	280	281	282
PHE #	PIB1	PIB2	PIB3	PIB4	PIB5	PIB6	PIB7
species	white sucker	brown bullhead	yellow perch	yellow perch	smallmouth bass	muskellunge	white perch
sample date	5/4/88	5/4/88	6/22 & 30/88	2/17/88	5/12/88	5/12/88	5/12/88
location	PIB	PIB	PIB	PIB	PIB	PIB	PIB
lab	DER	DER	DER	DER	DER	DER	DER
notes	fillets off Cascade Cr.	fillets off Cascade Cr.	fillets off Cascade Cr.	fillets west end of Bay	fillets off Cascade Cr.	fillets off Cascade Cr.	fillets off Cascade Cr.

1987							1987
agency #	266	267	268	269	-	-	270
PHE #	PIB1	PIB2	PIB3	PIB4	PIB5	PIB6	LE1
species	walleye	northern pike	yellow perch	black crappie	yellow perch	brown bullhead	rainbow trout (#1)
sample date	10/20/87	10/20/87	10/20/87	10/20/87	9/2/87	9/2/87	11/19/87
location	PIB	PIB	PIB	PIB	PIB	PIB	Trout Run
lab	DER	DER	DER	DER	DER	DER	DER
notes	fillets Cascade Cr. area	fillets Cascade Cr. area	fillets Cascade Cr. area	fillets Cascade Cr. area	fillets data from sample custody sheets and a PADER data summary	fillets data from sample custody sheets and a PADER data summary	fillets Lake Erie trib.

Table 4.2. Fish flesh data sets: 1987-1988 (cont.).

1988 283 PIB8	285 PIB9	286 PIB10	287 PIB11	288 PIB12	289 PIB13	272 PIB14	1988 278 PIB15
gizzard shad	channel catfish	carp	walleye	largemouth bass	bluegill	bluegill	sunfish
5/12/88	6/30/88	6/22/88	5/12/88	5/4/88	5/4/88	3/2/88	5/4/88
PIB	PIB	PIB	PIB	PIB	PIB	PIB	PIB
DER	DER	DER	DER	DER	DER	DER	DER
fillets	fillets	fillets	fillets	fillets	fillets	fillets	fillets
off Cascade Cr.	off Cascade Cr.	off Cascade Cr.	off Cascade Cr.	off Cascade Cr.	off Cascade Cr.	west end of Bay	off Cascade Cr.

1987 271 LE2	260 LE3	261 LE4	262 LE5	263 LE6	264 LE7	265 LE8	1987 - LE9
rainbow trout (#2)	yellow perch	walleye	smallmouth bass	sheepshead	lake trout (#1)	lake trout (#2)	yellow perch
11/19/87	10/20/87	10/20/87	10/20/87	10/20/87	10/20/87	10/20/87	1987
Trout Run	Lake Erie	Lake Erie	Lake Erie	Lake Erie	Lake Erie	Lake Erie	WQN 601
DER	DER	DER	DER	DER	DER	DER	DER
fillets	fillets	fillets	fillets	fillets	fillets	fillets	fillets
Lake Erie trib.	off Shades Beach	off Shades Beach	off Shades Beach	off Shades Beach	off Shades Beach	off Shades Beach	summary data from a PADER data summary

Table 4.2. Fish flesh data sets: 1987-1988 (cont.).

1988

291 LE1	188 (s) LE2	188 (m) LE3	188 (l) LE4	Total Data Sets:
yellow perch	coho salmon	coho salmon	coho salmon	4 L. Erie fillets
7/8/88	10/26/88	10/26/88	10/26/88	No L. Erie whole
Lake Erie	Trout Run	Trout Run	Trout Run	15 PIB fillets
DER	FDA	FDA	FDA	No PIB whole
fillets	fillets (small)	fillets (medium)	fillets (large)	
off Shades Beach	Lake Erie trib.	Lake Erie trib.	Lake Erie trib.	

1987

- LE10	- LE11	- LE12	- LE13	#187 LE14	Total Data Sets:
walleye	channel catfish	carp	yellow perch	rainbow trout	13 L. Erie fillets
1987	1987	1987	1987	1987	1 L. Erie whole
Lake Erie*	Lake Erie*	Lake Erie*	WQN 601	Trout Run	6 PIB fillets
DER	DER	DER	DER	FDA	No PIB whole
fillets	fillets	fillets	whole fish	fillets	
summary data from a PADER data summary	summary data from a PADER data summary	summary data from a PADER data summary	summary data from a PADER data summary	Lake Erie trib.	
* location not specified	* location not specified	* location not specified			

Table 4.3. 1990 PIB and Lake Erie fish data vs FDA Action Levels.

parameter	Action Level (ppm)	note	LE1	LE2	LE3	LE4	LE5	PIB1
			Sample numbers and results (ppm)					
aldrin & dieldrin	0.3		0.02	0.02	0.02	0.04	ND	ND
DDT & metabolites	5	[1]	0.11	0.14	0.12	0.24	ND	ND
endrin	0.3	[2]	ND	T	T	T	ND	ND
heptachlor/heptachlor epoxide	0.3		T	T	T	0.01	ND	ND
PCBs	2		0.6	0.63	0.56	0.85	ND	ND
toxaphene	5		<0.25	<0.25	<0.25	<0.25	NT	NT
chlordane residues	0.3	[3]	0.05	0.05	0.05	0.16	ND	ND
mercury	1	[4]	NT	NT	NT	NT	*	*
mirex	0.1		NT	NT	NT	NT	NT	NT
chlordecone (Kepone)	0.3		NT	NT	NT	NT	NT	NT
[BHC (benzene hexachloride)]	[0.3]	[5]	ND	ND	ND	0.01	ND	ND

Notes:

[1] For fish, do not count DDT, TDE, and DDE levels below 0.2 ppm.

[2] For fish, do not count heptachlor or heptachlor epoxide levels below 0.1 ppm.

[3] Includes residues of chlordane, including heptachlor and its epoxide, cis and trans chlordane, cis and trans nonachlor, oxychlordane (octachlor epoxide), alpha, beta and gamma chlordane and chlordene. Levels of individual components must be quantitated at 0.02 ppm or above and confirmed in order to be added into the "chlordane" column.

[4] As methyl mercury.

[5] Limit is for frog legs - no fish limit currently exists.

ND = not detected
NT = not tested
NR = no results
T = trace amount
* = data not yet available (4/1/91)

numerical data from Tables 4.3-4.6, but excludes "not detected", "trace amount", "not tested", or "not reported" entries). The number of quantifiable measurements for each parameter are indicated near the bottom of Table 4.7 ("# values" row), followed by the mean value for each parameter. As seen in this table, significant amounts of quantifiable data are reported only for five parameters: aldrin/deildrin, DDT and metabolites, PCBs, chlordane, and mercury. For the other six parameters, the results were dominated by "not detected" or "not tested" entries (compare Tables 4.3-4.6 with Table 4.7). However, it should be noted that any "not detected" and "trace amount" results are nevertheless valid measurements of the possible presence of contamination and should not be ignored, even though they cannot be used in quantitative comparisons.

For all five parameters for which a significant number of quantified data points exist, the mean Lake Erie fish flesh contaminants concentrations exceeded the PIB means for all parameters. Specifically, the Lake Erie mean concentrations for aldrin/dieldrin, DDT, PCBs, mercury, and chlordane exceeded the PIB means. However, while the Lake Erie mean values exceeded the PIB means in all five comparisons, it should be noted that these differences are not statistically significant. Therefore, it should be concluded that the PIB contaminant levels are no different than the Lake Erie contaminant levels, rather than concluding that they are lower than the Lake Erie levels, as a comparison of means would suggest.

For chlordane, it should be noted that a series of PIB and Lake Erie sample results were determined to be unreliable when subjected to Quality Assurance/Quality Control (QA/QC) split sampling procedures and were excluded from numerical comparison (i.e. those 1987 and 1988 PIB and Lake Erie samples designated with a 200-series number in Tables 4.5 and 4.6). The PIB mean chlordane value is based on a single, quantified measurement. Based on this limited numerical comparison, the mean Lake Erie chlordane value is 0.075, or more than twice the PIB value of 0.03. However, as noted above, "not detected" and/or "trace amount" PIB chlordane results are nevertheless valid measurements of the possible presence of chlordane contamination, even if they cannot be treated quantitatively. Including both the quantitative and unquantifiable results (i.e. any numerical results as well as any "not detected" and "trace amount" results), a total of 33 Lake Erie chlordane results are represented in the 1987-1990 data base, of which 27% were too low to be quantified. By comparison, 21 PIB chlordane results are represented over the same time period, of which a much higher percentage (57%) were too low to be quantified. These data also suggest that PIB fish flesh chlordane levels are lower than those of Lake Erie.

Although a series of 1987 and 1988 chlordane results were compromised by analytical problems, and cannot be compared quantitatively, the other 1987 and 1988 PIB and Lake Erie chlordane results in Tables 4.5 and 4.6 (i.e. the non-200 series sample numbers) were generated by laboratories other than PADER. No chlordane analytical QA/QC problems are evident, and these results, as well as all 1988-1990 chlordane results, are believed reliable. Therefore, despite the chlordane QA/QC issue discussed above, the data are interpreted to indicate that, with respect to those fish flesh contaminants for which standards exist, the PIB fish flesh contaminant levels are at least no greater than (and probably less than) those of Lake Erie fish.

Based on a review of the reliable fish flesh contamination data for the period 1987-1990, it is probable that no impairment of the AOC listing guideline for fish consumption exists. First, no violation of current FDA Action Levels is indicated, based on both PIB and Lake Erie fish flesh samples. Second, the concentrations of these monitored contaminants in PIB fish are no different than those of Lake Erie fish in the vicinity of Presque Isle, indicating that concentrations of the monitored contaminants in the PIB watershed are not greater than background levels in Lake Erie.

In order to confirm this belief, PADER will do additional sampling of both PIB and Lake Erie fish during the next several years. The species and numbers of fish to be sampled will be determined in conjunction with advice from the PA Fish Commission and the RAP Public Advisory Committee.

4.1.1.1.3 Waterfowl

In 1988, the PADER issued an advisory against consumption of the red-breasted merganser (also known as "sheldrake", "fish duck", or "sawbill") and the common goldeneye ("whistlers"). This advisory was the result of samples collected from three birds taken during the 1987 hunting season "in the Erie area" which revealed elevated levels of PCBs.

The PCB levels listed in the advisory, based on concentrations in fat, were 8 ppm in the Goldeneye, and 13.6 ppm in the Red-breasted Merganser (PADER, 1988c). These levels both exceed the FDA Action Level of 3 ppm (fat basis), but are substantially less than a geometric mean value of 24 ppm PCBs in 34 Goldeneyes collected in the Niagara River, New York (data from a page copied from a NY State consumption advisory; exact reference unknown).

Both of these species are migratory ducks, and are believed to reflect contaminant levels from outside the Erie area where they were harvested. This assumption is supported by the results of:

(1) the PIB and Lake Erie fish flesh data evaluations discussed above (§4.1.1.1.2), which show PCB levels in PIB fish to be no different from those of fish from Lake Erie, and

(2) the sediment data evaluations discussed in §4.1.1.7, which reveal PIB sediment PCB levels to be quite low, in comparison to sediment guidelines and other PIB sediment contaminants.

The PCB levels in these ducks is a genuine, and continuing, health concern (as noted earlier, advisories remain in effect until specifically rescinded). However, based on the observations above, there is no indication that the observed contaminant levels are due to input from the PIB watershed, and no impairment is indicated or concluded.

4.1.1.2 Tainting of Fish and Wildlife Flavor

> "When ambient water quality standards, objectives, or guidelines, for the anthropogenic substance(s) known to cause tainting, are being exceeded or survey results have identified tainting of fish or wildlife flavor."

This impairment assessment guideline includes the following two components, or tests. The first test is whether water quality standards for tainting substances are being exceeded. The second test is whether tainting of fish or wildlife flavor has been determined through surveys. Each of these tests are discussed in the following sections.

4.1.1.2.1 Water Quality Standards for Tainting Substances

Available, current water quality data for PIB were retrieved from the USEPA STORET data base. In order to identify all data for PIB and the Presque Isle area (including waters adjacent to PIB), STORET data were retrieved for a rectangular polygon which ranged from 42°05'00"N/80 00'00"E, at the southeast corner, to 42°12'30"N/80 15'00"E at the northwest corner.

Data were retrieved for the period 1985-1990. Older data were not retrieved, for two reasons. First, experience has shown that earlier STORET data were not consistently scrutinized (i.e. quality control was not consistent), and are not always reliable. Second, older data are not representative of current conditions in

PIB, and are therefore not a valid basis for comparison with applicable standards.

PIB water quality data were dominated by data collected by PADER, at water quality network (WQN) monitoring station #632. The DER utilizes consistent and reliable sample collection and handling procedures, and laboratory protocols and QA/QC measures. In addition, much of the data have been collected by the same sampling personnel, reducing the possibility of sampling bias resulting from the use of different sample collection procedures over time. The WQN 632 data are therefore believed to be accurate, reliable measures of ambient water quality conditions in the Bay.

Water quality data were compared with the taste and odor parameters of the Pennsylvania water quality criteria (Pennsylvania Code, Title 25, Chapter 16, Section 16.51), which are the applicable standards for PIB for tainting substances. The Pennsylvania water quality criteria include 14 taste and odor parameters, as follows:

- copper
- phenolics (total phenols)
- 2,4-dichlorophenol
- p-chloro-m-cresol
- phenol
- anenaphthene
- naphthalene, and
- 2-chlorophenol
- 2,4-dimethylphenol
- pentachlorophenol
- chlorobenzene
- hexachlorocyclopentadiene
- nitrobenzene.

Of these 14 parameters, ambient water quality data are available for only copper and zinc. In addition, "odor" is also periodically reported, however there is no criterion for this parameter.

Available data for copper, zinc, and odor for the period 1985-1990 are summarized in Table 4.8, in comparison with the current criteria for these parameters. As seen in Table 4.8, three criteria values are provided for each of the parameters for which standards have been established. The first, "criteria continuous concentration", is a "chronic" exposure criteria, intended to protect aquatic life against adverse effects based on "indefinite" (four day duration) exposure. The "criteria maximum concentration" is an "acute" exposure criteria, intended to protect aquatic life against adverse effects based on "short-term" (one hour duration) exposure. The "human health criteria" is the level below which no adverse human health effects are expected (based on current toxicological studies), including a margin of safety.

The continuous and maximum criteria for copper and zinc are hardness-dependant, and vary according to the hardness value at the time of sample collection. The criteria ranges presented in Table

Table 4.8. PIB ambient water quality data vs tainting standards.

PA Water Quality Standards / Sampling Dates and Results (µg/l)

Parameter	Units	Criteria Continuous Conc. (µg/l)	Criteria Maximum Conc. (µg/l)	Human Health Crit. (µg/l)	8/12/85	5/20/86	8/12/86	8/3/87	2/15/88	5/11/88
Cu, total	µg/l	11.9-14.3*	17.9-21.9*	1,000	10 K	-	**50** K	**50** K	10 K	10 K
Zn, total	µg/l	107-128*	118-141*	5,000	20	-	10 K	20	12	10 K
odor	severity	N/A	N/A	N/A	0	0	0	0	-	-

Parameter	Units	Criteria Continuous Conc. (µg/l)	Criteria Maximum Conc. (µg/l)	Human Health Crit. (µg/l)	6/21/88	7/18/88	8/9/88	9/27/88	9/27/88	10/20/88
Cu, total	µg/l	11.9-14.3*	17.9-21.9*	1,000	12	18 (shaded)	10 K	11	10 K	10 K
Zn, total	µg/l	107-128*	118-141*	5,000	26	11	10 K	47	16	10 L
odor	severity	N/A	N/A	N/A	-	-	-	-	-	-

Parameter	Units	Criteria Continuous Conc. (µg/l)	Criteria Maximum Conc. (µg/l)	Human Health Crit. (µg/l)	6/21/89	7/12/89	9/12/89	10/5/89	11/8/89	4/18/90
Cu, total	µg/l	11.9-14.3*	17.9-21.9*	1,000	10 K	10 K	10 K	10 K	10 K	11
Zn, total	µg/l	107-128*	118-141*	5,000	12	10 K	10 K	10 K	10 K	10 K
odor	severity	N/A	N/A	N/A	-	-	-	-	-	-

Parameter	Units	Criteria Continuous Conc. (µg/l)	Criteria Maximum Conc. (µg/l)	Human Health Crit. (µg/l)	5/15/90	6/5/90	7/10/90	8/14/90	9/4/90
Cu, total	µg/l	11.9-14.3*	17.9-21.9*	1,000	10 K	10 K	19 (shaded)	10 K	24 (shaded)
Zn, total	µg/l	107-128*	118-141*	5,000	14	19	19	10	10 K
odor	severity	N/A	N/A	N/A	-	-	-	0	-

Parameter	Criteria Continuous Conc. formula	Criteria Maximum Conc. formula	min. hard.	max. hard.
Cu	EXP(0.8545*LN(hardness)-1.465)	EXP(0.9422*LN(hardness)-1.464)	101	125
Zn	EXP(0.8473*LN(hardness)+0.7614)	EXP(0.8473*LN(hardness)+0.8604)	"	"

* Criteria are hardness related; see text for explanation and discussion.

Bold values are possible exceedences of indicated criteria-see text.

Shaded values are actual exceedences of indicated criteria-see text.

4.8 are the result of applying the formulae for these criteria (given near the bottom of the table) to the range (minimum/maximum) of hardness values reported for the 22 individual copper/zinc data sets which are available for the period 1985-1990.

Data points which are potential violations of the criteria are indicated in bold type in Table 4.8. As indicated, six copper values are apparent violations of either the continuous or maximum criteria (no copper values exceed the human health criteria, and no zinc values exceed any criteria). However, two of these six copper values are conditioned with a "k" qualifier in the STORET data base. This qualifier indicates that the parameter was detected in the analytical procedure, but at a concentration too low to be quantified, and the actual value is much less than the default value shown. Clearly, the analytical capability exists to quantify copper at concentrations below the 50 μg/l (50 ppb) default value entered in STORET, and many other values are quantified as low as 10 μg/l. Because the actual analytical detection limit for copper is at least as low as 10 μg/l, and because 10 μg/l is less than either of the criteria concentration limits for copper, the two 50 μg/l values in Table 4.8 are interpreted as artifacts of an inappropriate default value rather than actual violations of the criteria.

Excluding the two 50 μg/l copper values which resulted from the application of an elevated STORET default value, four other values in Table 4.8 are indicated as potential violations of one or more criteria. The last value (24 μg/l, on 9/4/90) exceeds both the continuous and maximum criteria, and is a violation of the Pennsylvania water quality standards. The remaining three values (6/21/88, 7/18/88, and 7/10/90) fall within the hardness-dependant criteria ranges. Consequently, it is necessary to calculate the criteria individually for each of these three samples, based on the hardness reported for each sampling date, to assess which criteria are actually exceeded. The first of these three values is 12 μg/l, on 6/21/88, which is a potential violation of the criteria continuous concentration, depending on the actual criteria value for that sampling date. The hardness on this date was 114 mg/l. Applying the criteria continuous formula (see the bottom of Table 4.8), the applicable criteria continuous concentration for this date is 13.22 μg/l, and the 12 μg/l result is not a violation of the criteria. The second of these three is 18 μg/l, on 7/18/88. This value exceeds the continuous criteria range, but falls within the maximum criteria range. Applying the criteria maximum concentration formula (see Table 4.8) to the 114 mg/l hardness value for that sampling date, the resulting criteria maximum is 20.05 μg/l, and no violation of the criteria maximum concentration is indicated. Similarly, the third value (19 μg/l; 7/10/90) exceeds the criteria continuous concentration range, but falls within the criteria maximum range. Applying the criteria maximum concentration formula and a hardness of 116 mg/l for the sampling date, the resulting criteria maximum concentration is 20.39 μg/l, and the 19 μg/l result is not a violation of the criteria maximum concentration standard.

Based on application of the hardness-dependant criteria formula to the copper/hardness data, only three copper results exceed the ambient water quality criteria. These results are indicated as shaded values in Table 4.8. Even though these values exceed the criteria, the margin of violation in all cases is small. For example, the 18 μg/l result on 7/18/88, and the 19 μg/l result on 7/10/90, are 136 and 142 %, respectively, of the criteria continuous concentration standards for those dates; and the 24 μg/l result on 9/24/90 is 128% of the criteria maximum concentration standard for that date. Finally, five "odor" values exist in the STORET data base for the 1985-1990 period of record summarized in Table 4.8. No standard exists for this taste and odor parameter, and the measurement units are given as "severity". As indicated in the table, all odor results were zero.

In summary, of the 14 taste and odor parameters for which Pennsylvania water quality standards exist, data are available only for two: copper and zinc. Twenty-two copper/zinc data sets are available in STORET for the period 1985-1990. From these 22 data sets, no violations of the criteria continuous or criteria maximum concentration or human health standards for zinc are indicated. One copper result exceeded both the criteria continuous and criteria maximum concentration standards for copper, and two other results exceeded the criteria continuous concentration standard (these are indicated as shaded values in Table 4.8).

It should be noted that the relative magnitude of the three excedences of the taste and odor water quality parameters are small. STORET data are available for a third taste and odor indicator, "odor", however no ambient water quality standards exist for this parameter. All five "odor" results for the period 1985-1990 were zero.

4.1.1.2.2 Tainting Surveys

No surveys are known to have been conducted for fish or wildlife tainting. However, no indication of the potential existence of tainting problems exists in the data base. Further, none has been indicated in the numerous communications conducted with PADER and ECDH personnel pursuant to the preparation of this report, or with any of the other Federal agency and private citizen (e.g. Erie Harbor Improvement Council, or EHIC) contacts established.

Many of the 12 taste and odor parameters for which no ambient water quality data are available are the same or similar compounds to those tested in PIB fish (flesh and bile) by the Fish and Wildlife Service. The results of this testing indicated that the concentrations of these parameters was not unusually high, in comparison with national average fish flesh concentration levels (FWS, 1986; FWS, 1987). These results, while they do not constitute a true organoleptic "survey", imply that the findings of such a survey, if conducted, would be negative.

4.1.1.2.3 Discussion and Conclusions

This use is considered impaired when (1) ambient water quality standards for tainting substances are being exceeded, or (2) surveys have identified tainting of fish or wildlife flavor. Reliable water quality data are available for only two of the 14 taste and odor parameters for which Pennsylvania ambient water quality criteria exist. Water quality data for these two parameters, copper and zinc, were examined for the period 1975-1990, totaling 22 data sets. Of these 22 measurements, none of the zinc results exceeded any of the three categories of criteria (continuous exposure, maximum exposure, and human health), and none of the copper results exceeded the human health criteria. One copper result (4.5%, or one of 22) exceeded the criteria maximum concentration standard (an "acute" exposure standard), while three values (13.6%) exceeded the criteria continuous concentration standard (a "chronic" exposure standard). The relative magnitudes of the three exceedances were small, ranging from 128-142% of the applicable standard.

No pattern of taste and odor standards violation is indicated in the copper and zinc results. Although four criteria exceedances were identified in the six year period of record examined, this rate of criteria exceedances does not indicate a chronic condition. Further, in addition to the copper and zinc results, the 1985-1990 ambient water quality data base includes six measurements of "odor". Although no ambient water quality standard exists for this parameter, all measurements were zero.

Finally, PIB fish samples have been tested for many of the same or similar organic compounds to those 12 other taste and odor parameters for which no comparative data are available. The results of this testing, while not a true tainting survey, indicate that concentrations of these other parameters are not unusually high, compared with national averages.

The available data and information are inadequate to support a complete, strict application of this AOC listing guideline. However, based on the available water quality criteria comparisons for tainting substances, and the fish flesh contamination testing results, no impairment of this use is implied or concluded.

4.1.1.3 Degradation of Fish and Wildlife Populations

"When fish and wildlife management programs have identified degraded fish or wildlife populations due to a cause within the watershed. In addition, this use will be considered impaired when relevant, field-validated, fish or wildlife bioassays with appropriate quality assurance/quality control confirm significant toxicity from water column or sediment contaminants."

This impairment assessment guideline includes the following two components, or tests:

(1) fish or wildlife populations have been degraded due to a cause within the watershed, or

(2) fish or wildlife bioassays confirm significant toxicity from water column or sediment contaminants.

Each of these components are discussed individually in the following subsection.

4.1.1.3.1 Degradation of Fish or Wildlife Populations

As discussed in §4.1.1.5, the available data base contains no evidence of degradation of terrestrial wildlife populations in PIB, and none is suspected. Consequently, the focus of the following discussion is on fish populations.

It should be noted that this use impairment assessment guideline is oriented toward evaluation of the productivity and health of fish <u>populations</u>, rather than individual fish. At the population level, critical factors include the size of the standing crop (i.e. fish density, or total numbers of fish present), growth rates, reproductive success, community structure, and yield (angler success). Issues associated with the health or physical condition of individual members of the population are addressed in §4.1.1.4.

Presque Isle Bay has long been managed as a sport fishery by the PFC. As discussed in §3.4.1.1 (see Chapter 3), more than 11.6 million fish have been stocked in the Bay by the PFC from 1971-1986, averaging more than 700,000 fish/year. Additional fish (primarily walleyes) have also been stocked by cooperative nurseries.

The PFC conducts periodic evaluations of the quality and vitality of fish populations of PIB, for the purposes of identifying any problems in the structure of the fish communities and evaluating the need for alternative management practices. The two most recent evaluations were performed in 1982 and 1986-1987 (PFC, 1983 and PFC, 1988, respectively). The next evaluation is scheduled to be performed in 1992 or 1993.

The 1982 assessment concluded that PIB is an "exceptional" and "very diverse" fishery, which supports and sustains "extremely high fishing pressure". The results of the 1986-1987 survey were that PIB continues to be an "exceptional" and "high quality" fishery, supporting "quality populations" of a variety of panfish and warmwater game species, including northern pike, muskellunge, brown bullhead, rockbass, pumpkinseed, bluegill, and largemouth bass.

The 1986-1987 survey further concluded that PIB continues to sustain a productive coldwater species fishery as well, and that the salmonid fishery has become more significant since the initiation of direct stocking of steelhead smolts into the Bay in 1984. The capture rates of both steelheads and coho increased between the 1982 and the 1986-1987 surveys.

The_only game species which were not of comparable quality were walleyes and smallmouth bass, which appear to be transients from the lake. The failure of previous walleye stocking programs to establish a productive walleye fishery in PIB is attributed to this species' natural preference for colder summer water temperatures than those which prevail in the Bay. Although walleyes were collected during both surveys, and are occasionally caught by PIB fishermen, they appear to be migrants from the lake.

High populations of minnows (particularly emerald shiners) and other species of smaller fish are present and provide food for the game fish populations. The high return on stocked fish, as well as the high natural populations of forage species indicate that PIB is an effective fisheries nursery area, and no evidence of degraded fisheries conditions exists with respect to productivity, at the population level. This conclusion is supported by the success of the salmonid smolts stocking program, demonstrating that PIB is an effective fisheries nursery area for both warmwater as well as the more sensitive, coldwater species.

4.1.1.3.2 Biotoxicity of Water Column or Sediment Contaminants

As stated above, PIB is an "exceptional ... very diverse ... high quality" fishery, supporting "quality populations" of a variety of panfish as well as warmwater and coldwater game species, and high natural populations of forage species. These observations indicate that PIB is an effective fisheries nursery area, and no evidence or suggestion of water column biotoxicity exists. Consequently, the following discussion focuses on the potential for toxicity from sediment contaminants.

Little sediment biotoxicity test data are available for PIB sediments. The known data are limited to two Corps of Engineers studies, performed in 1982 and 1986 (COE, 1982; COE, 1986a). Both of these studies utilized acceptable QA/QC procedures and are considered reliable measures of sediment biotoxicity, however the results of the 1986 study were compromised by unexplained interference, and a retest was performed (COE, 1986b).

The 1982 and 1986 studies utilized similar test species, test methods, and sampling sites, as summarized in Table 4.9. Locations of sampling sites are depicted in Figure 4.1.

Both studies utilized replicate test chambers and control sediments. The control sediment component was used to identify and separate that mortality which occurred as a result of the test procedure (e.g. handling of the organisms) from that mortality which occurred as a result of contaminants in the test sediments. The control sediments were obtained from the natural habitat locations where the *Hexagenia limbata* test organisms were collected (Custar, Michigan in the 1982 study, and the Pere Marquette River, Mason County, Michigan in the 1986 study).

The 1982 study utilized five replicates for all tests; the 1986 study utilized three replicates. In the 1982 study, a 72 hour pre-test bioassay of the control sediments (three replicates) was performed, and two control bioassays were performed simultaneous to the test sediment bioassays. In the 1986 study, a 96 hour bioassay of the control sediments (three replicates) was performed simultaneous to the test sediment bioassays.

In the 1986 study, the *Daphnia magna* test was terminated at 48 hours; all other tests in both studies were for the full 96 hours. Both studies utilized the same sediment pollution classification scheme, in which sediment is classified according to three levels of toxicity to the test organisms (per Prater and Anderson, 1977). In this classification scheme, sediments which result in <10% mortality to the test organisms are "nonpolluted"; sediments which result in 10-50% mortality are "moderately polluted"; and sediments which result in >50% mortality are "heavily polluted".

Table 4.9. Comparison of 1982 and 1986 COE bioassay study methods.

Study	Test Method	Test Species	Sampling Sites
COE, 1982	96-hour, continuous flow, acute bioassay (following the procedure described in Prater and Anderson, 1977)	• *Daphnia magna* (a crustacean, commonly called "water fleas") • *Hexagenia limbata* (a burrowing mayfly) • *Pimephales promelas* (fathead minnow)	Outer Harbor: Sites 1-3 Outer Harbor: Site 4 Inner Harbor: Sites 7-9 Inner Harbor: Sites 10-12 Dumping Area: Site 15 Reference Site: Site 16
COE, 1986a; 1986b	96-hour, continuous flow, acute bioassay (following the procedure described in Prater and Anderson, 1977)	• *Daphnia magna* • *Hexagenia limbata* • *Pimephales promelas*	Outer Harbor: Sites 1-4 Inner Harbor: Sites 5-8, 10, 11 Dumping Area: Site 15 Reference Site: Site 16

Table 4.11. Summary of biotoxicity pollution classification of PIB and area sediments.

	1982			1986		
Sites	Daph.(1)	Pime.(1)	Hexa.(1)	Daph.(2)	Pime.(2)	Hexa.(3)
Outer Harbor	non-poll.	non-poll.	non-poll.	non-poll.	non-poll.	mod-poll.
Inner Harbor(4)	non-poll.	non-poll.	non-poll.	mod-poll.	non-poll.	mod-poll.
Harbor Basin(4)	mod-poll.	non-poll.	non-poll.	mod-poll.	non-poll.	non-poll.
Disp. Area	mod-poll.	non-poll.	non-poll.	mod-poll.	non-poll.	non-poll.
Lake Ref.	mod-poll.	non-poll.	non-poll.	mod-poll.	non-poll.	mod-poll.

(1) From COE, 1982
(2) From COE, 1986a
(3) From COE, 1986b
(4) PIB sites

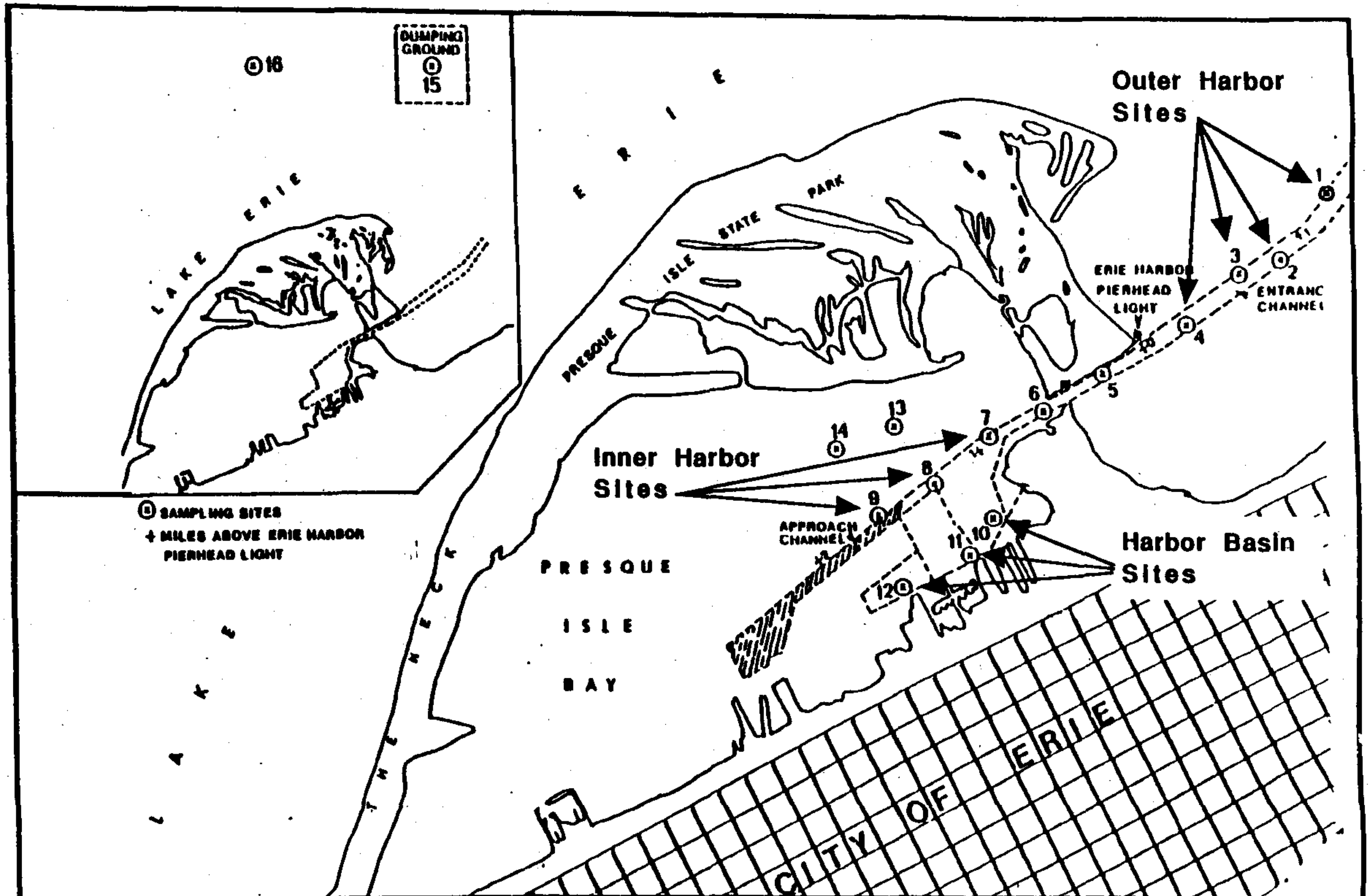


Figure 4.1. Locations of Corps of Engineers sediment sampling sites (from COE, 1982 and COE, 1986a).

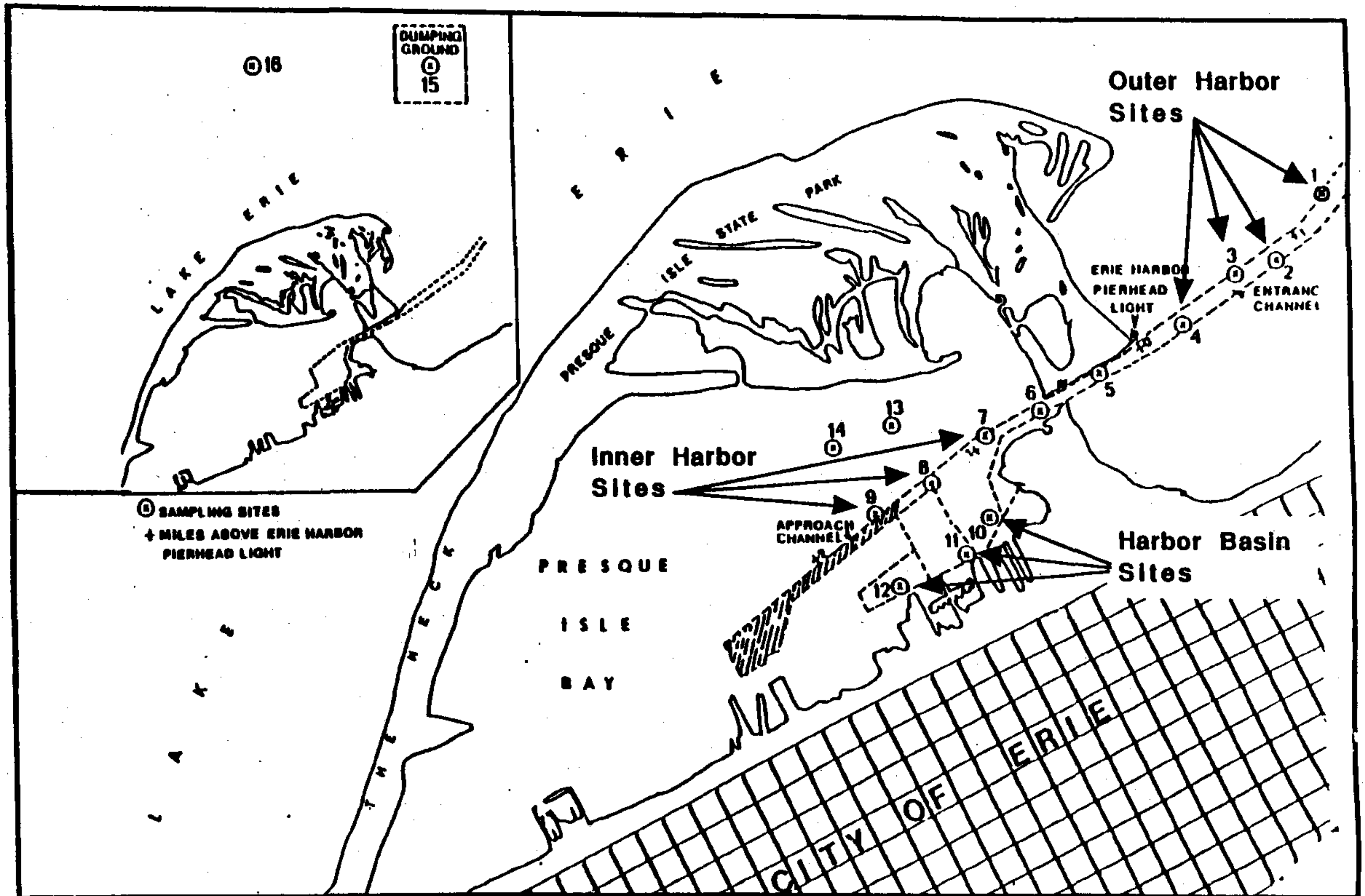


Figure 4.1. Locations of Corps of Engineers sediment sampling sites (from COE, 1982 and COE, 1986a).

Table 4.10. Comparison of COE 1982 and 1986 bioassay results.

	% mortality, by species and year						
	1982			1986			1986 retest
Sampling Locations	Daph.	Pime.	Hexa.	Daph.	Pime.	Hexa.	Hexa.
Outer Harbor (sites 1-4)	1.0	0.0	7.0	9.5	0.0	86.6	20.8
adjusted for control	-5.0	-1.0	3.0	1.8	0.0	**28.3**	**10.8**
PIB Inner Harbor (sites 7-9)	2.0	0.0	6.0	25.7	0.0	75.0	26.7
adjusted for control	-4.0	-1.0	2.0	**18.0**	0.0	**16.7**	**16.7**
PIB Harbor Basin (sites 10-12)	38.0	2.0	2.0	52.3	1.7	91.7	11.7
adjusted for control	**32.0**	1.0	-2.0	**44.6**	1.7	**33.4**	1.7
Disposal Area (site 15)	34.0	0.0	4.0	19.0	0.0	78.3	15.0
adjusted for control	**28.0**	-1.0	0.0	**11.3**	0.0	**20.0**	5.0
Lake Reference (site 16)	44.0	0.0	2.0	30.0	1.7	63.3	28.3
adjusted for control	**38.0**	-1.0	-2.0	**22.3**	1.7	5.0	**18.3**
Control I	4.0	2.0	2.0	7.7	0.0	58.3	10.0
Control II	8.0	0.0	6.0	-	-	-	-
controls average	6.0	1.0	4.0	7.7	0.0	58.3	10.0
Pre-test bioassay	9.0	0.0	7.0	-	-	-	-

notes:

Bold numbers indicate "moderately polluted" conditions (10-50% mortality).

Shaded numbers indicate "heavily polluted" conditions (>50% mortality).

"Daph."= *Daphnia magna*
"Pime."= *Pimephales promelas*
"Hexa."= *Hexagenia limbata*

"% mortality" is expressed as the mean value for all replicates at each site, for each species.

"adjusted" values for each test were derived by subtracting the mean % mortality of the controls from the raw results at each site.

Table 4.10. Comparison of COE 1982 and 1986 bioassay results.

	% mortality, by species and year						
	1982			1986			1986 retest
Sampling Locations	Daph.	Pime.	Hexa.	Daph.	Pime.	Hexa.	Hexa.
Outer Harbor (sites 1-4)	1.0	0.0	7.0	9.5	0.0	86.6	20.8
adjusted for control	-5.0	-1.0	3.0	1.8	0.0	**28.3**	**10.8**
PIB Inner Harbor (sites 7-9)	2.0	0.0	6.0	25.7	0.0	75.0	26.7
adjusted for control	-4.0	-1.0	2.0	**18.0**	0.0	**16.7**	**16.7**
PIB Harbor Basin (sites 10-12)	38.0	2.0	2.0	52.3	1.7	91.7	11.7
adjusted for control	**32.0**	1.0	-2.0	**44.6**	1.7	**33.4**	1.7
Disposal Area (site 15)	34.0	0.0	4.0	19.0	0.0	78.3	15.0
adjusted for control	**28.0**	-1.0	0.0	**11.3**	0.0	**20.0**	5.0
Lake Reference (site 16)	44.0	0.0	2.0	30.0	1.7	63.3	28.3
adjusted for control	**38.0**	-1.0	-2.0	**22.3**	1.7	5.0	**18.3**
Control I	4.0	2.0	2.0	7.7	0.0	58.3	10.0
Control II	8.0	0.0	6.0	-	-	-	-
controls average	6.0	1.0	4.0	7.7	0.0	**58.3**	10.0
Pre-test bioassay	9.0	0.0	7.0	-	-	-	-

notes:

Bold numbers indicate "moderately polluted" conditions (10-50% mortality).

Shaded numbers indicate "heavily polluted" conditions (>50% mortality).

"Daph."= *Daphnia magna*
"Pime."= *Pimephales promelas*
"Hexa."= *Hexagenia limbata*

"% mortality" is expressed as the mean value for all replicates at each site, for each species.

"adjusted" values for each test were derived by subtracting the mean % mortality of the controls from the raw results at each site.

indicate that the observed toxicity cannot be concluded to be the result of a cause solely within the PIB watershed. Further, with specific regard to this AOC listing guideline, no significant toxicity to fish was observed in either the 1982 or 1986 tests.

4.1.1.3.3 Summary and Conclusions

This impairment guideline includes two components, or tests. The first test is whether fish and wildlife management programs have identified degraded fish and wildlife populations due to a cause within the watershed. The second test is whether significant sediment or water column biotoxicity exists. Each of these tests are addressed below.

Degraded fish and wildlife populations. No evidence of degraded terrestrial wildlife populations exists, and none is suspected. Further, fisheries management programs have not identified degraded fish populations due to a cause within the watershed. Conversely, the PIB fishery is rated as "exceptional" by the PFC, based on angling success (catch per unit effort), survival of stocked fish (both warmwater and coldwater species), and population density.

Strictly speaking, the focus of this AOC listing criteria is on fisheries productivity, at the population rather than individual level. In fact, the counterpart AOC delisting criteria states that this use will be considered restored "When environmental conditions support healthy, self-sustaining communities of desired fish and wildlife at predetermined levels of abundance that would be expected from the amount and quality of suitable physical, chemical and biological habitat present." This delisting criteria is met, based on the results of the PFC sampling efforts. The delisting criteria further states that "... this use will be considered restored when fish and wildlife bioassays confirm no significant toxicity from water column or sediment contaminants." Again, this delisting criteria is met, based on the results of the COE fathead minnow bioassays, and no impairment of this beneficial use is indicated, based on a strict application of the criteria.

Sediment or water column biotoxicity. The second component or test in this impairment assessment guideline is whether fish or wildlife bioassays have confirmed significant toxicity from water column or sediment contaminants. PIB is an effective fisheries nursery area, with good survival of even sensitive, coldwater species stocked as fry. Also, high natural populations of minnows and other game fish forage species exist. Consequently, no evidence of significant water column biotoxicity exists, and none is suspected.

Sediment biotoxicity tests on fish were performed in 1982 and 1986, using the fathead minnow (*Pimephales promelas*) as the test species. Neither study identified significant sediment toxicity (>98% of the test fish survived a 96-hour test). Consequently, no evidence of significant sediment biotoxicity exists.

Based on the results of these observations and findings, no impairment of this AOC listing guideline is indicated.

4.1.1.4 Fish Tumors or Other Deformities

"When the incidence rates of fish tumors or other deformities exceed rates at unimpacted control sites or when survey data confirm the presence of neoplastic or preneoplastic liver tumors in bullheads or suckers."

In previous §4.1.1.3, the focus of the impairment evaluations was at the population level, examining the overall dynamics of the fish community (such as diversity, standing crop, and yield). For this impairment guideline, the focus is on the individual members of the overall fish community.

The primary sources of information available to assess this AOC listing guideline include surveys conducted in 1984 and 1985 by the FWS, and data collected in 1991 by the ECDH and DER, in cooperation with the PFC. Each of these sources are discussed below.

4.1.1.4.1 1984 FWS Study

In 1984, numerous PIB fishermen reported the presence of external sores and lesions on Brown bullheads (<u>Ictalurus nebulosus</u>) caught in the Bay. Because such external abnormalities may be indications of cancer-inducing chemical contaminants, the FWS (State College, PA Field Office) collected and examined 46 brown bullheads from PIB in 1984 (FWS, 1986). It was reported that:

(1) "almost all" of these fish exhibited some degree of fin erosion

(2) barbels were "frequently eroded", and

(3) red areas or dark patches on the skin were observed "less frequently".

A "high incidence" of mouth sores and/or lumps around the outside of the mouth was also reported. All of the abnormal skin lesions, and samples from the livers and other internal organs, were examined by FWS pathologists. From the original 46 fish, six bullhead specimens were selected as exhibiting apparent "tumors". These six samples were provided to a tumor specialist at the Smithsonian Institution (Washington, D. C.) for diagnosis. Of the six fish samples examined, four were diagnosed as benign skin tumors (epidermal papillomas), the fifth sample was diagnosed as a non-neoplastic thickening of the skin (epidermal hyperplasia), and the sixth was diagnosed as a physical injury. No neoplastic or preneoplastic liver tumors were identified in any of the 46 fish collected in this investigation.

Chemical analyses were performed on a number of fish, in an effort to identify a potential chemical agent which could be contributing to the skin disorders. Because of demonstrated relationships between sediment PAH levels and brown bullhead neoplasms in other locations, the FWS analyzed flesh samples for PAHs and other organic and inorganic contaminants. The resulting PAH levels were not considered to be of sufficient concentrations to support a cause-and-effect relationship with the observed abnormalities in the PIB bullheads, and no other potential chemical agent was identified. Because viruses have been conclusively linked to tumors in some fish species (but not yet demonstrated in bullheads), the possibility of a viral agent was also suggested as another possible cause.

4.1.1.4.2 1985 FWS Study

A second FWS survey of PIB brown bullheads was initiated in 1985 (FWS, 1987). The approach was similar to the 1984 survey. Bullheads were collected from various locations in PIB and examined for lesions and other external abnormalities. Most of any such lesions noted were excised and preserved for later histopathologic evaluation. Liver and bile samples were collected from all bullheads, and were also preserved for histopathologic evaluation. Flesh samples were again analyzed for organic and inorganic contaminants, including PAHs.

In the 1985 survey, 37 of 93 fish examined (40%) exhibited oral or skin abnormalities. Results of histopathologic examinations of the external abnormalities were provided for 23 of the original 37 fish exhibiting such abnormalities (results were not available for 14 specimens because of missing or unuseable slides, no diagnosis, or no sample collected). Of these 23 specimens, nine cases of oral neoplasm and two cases of skin neoplasm were diagnosed; nine cases of epidermal hyperplasia (a non-neoplastic thickening of the skin) were diagnosed; and the remaining three specimens were diagnosed as non-neoplastic or normal. In total, of the 79 fish for which results were provided (the original 93 examined less the 14 for which no results were available), 11 were diagnosed as exhibiting external neoplasms, for an incidence rate of 14%. No liver neoplasms were diagnosed in any of the 93 fish collected, and PAH levels in the bile samples were "low" in comparison with samples from areas of known PAH contamination (FWS, 1991).

The results of the chemical analysis of flesh samples revealed somewhat elevated levels of copper, lead, and PCBs. However, like the 1984 study, the 1985 investigation did not identify any chemical agent in sufficiently elevated concentration to be identified as a probable or likely cause of the observed skin abnormalities. The possibility of a viral agent as the source of the external abnormalities was again discussed.

4.1.1.4.3 1991 ECDH/DER/PFC Survey

Following the 1984 and 1985 FWS surveys, no quantitative data were collected to determine whether the observed external abnormalities represented a temporary phenomenon or chronic problem, or to assess any trends in the development of the condition, at the population level. Between 1985 and 1990, the only known record is a qualitative observation by the PFC, during the 1986-1987 Fisheries Assessment survey of PIB (PFC, 1988), that a "high number" of brown bullheads were found to be exhibiting blotches or sores on the mouth or skin. Because the most recent quantitative data were more than five years old, the ECDH and DER, in cooperation with the PFC, agreed to examine brown bullheads netted from PIB in March and April, 1991.

Brown bullheads are routinely, but unintentionally, collected by the PFC during spring nettings of northern pike for egg harvesting. Typically, the bullheads are separated from the northern pike and returned to the Bay. During the March/April, 1991 egg harvesting program, ECDH and DER personnel examined the bullheads caught in the PFC nets for the presence of external abnormalities, and recorded these observations. In addition, livers and other internal organs were examined for gross (visual) evidence of tumors, and liver samples were collected and preserved for histopathologic examination.

The March/April 1991 survey was conducted in two phases. In the first phase, a total of 64 brown bullheads were examined for external abnormalities (Wellington, 1991b). All were large, mature fish (typically 10-11 inches), and all appeared robust and healthy. During this survey, approximately 85% of the 64 fish examined exhibited some form of external abnormality. Thirty-nine percent exhibited sores in the mouth region, while 22% exhibited sores in other parts of the head and body, and 34% exhibited areas of black skin pigmentation. In the second phase, 10 worst-case fish were selected, which exhibited the most extreme involvement of external abnormalities. Livers from these 10 specimens were examined visually for evidence of tumors. However, no gross evidence of tumors was observed in any of 10 livers examined. The 10 liver samples were preserved and provided to Dr. Eric May, a specialist in fish tumor identification at the University of Maryland, for a more detailed, histopathologic examination. The results of this examination found that four of the ten livers had tumors. These results were confirmed with Dr. Harshbarger at the Smithsonian Institution.

The existence of liver tumors in brown bullheads is considered an impaired use if the incidence exceeds 2% of the population. While the 1991 study showed that liver tumors existed in Presque Isle Bay bullheads, it did not allow a calculation of the incidence in the population. In order to address that question, PADER initiated a more comprehensive study of the bullheads in conjunction with the Cornell University College of Veterinary Medicine, the ECDH, and the PA Fish Commission. During Spring 1992, 2000+ brown bullheads captured in PIB were examined for the existence of external abnormalities, weighed, measured, photographed, tagged and released. In addition, Cornell obtained 100 livers from randomly selected fish for histological examination, fish flesh chemical analysis and age and growth evaluation. Cornell also took 100 live fish for continued observation of external tumor development. More than 50% of the fish examined had external growths or lesions, or exhibited abnormal pigmentation. In addition to the analysis being performed by Cornell, Texas A&M researchers are analyzing liver and bile samples from bullheads for the presence of PAH's.

Hopefully, this study will not only determine the incidence of tumors in the bullheads, but will shed light on the causative agent(s). If environmental contaminants are indicated, the tag/release/recapture activities may help to locate "hot spots" where remediation should occur.

4.1.1.4.4 Discussion and Conclusions

This AOC listing guideline includes two tests. The first test is whether the incidence rates of fish tumors or other deformities exceed rates at unimpacted, control sites. The second test is whether surveys have confirmed the presence of liver tumors.

Most fish researchers agree that <u>internal</u> (i.e. liver) tumors in brown bullheads are an indication of the action of chemical carcinogens, and that essentially any incidence rate over 1-2% is abnormal (Baumann, 1991). Conversely, there is no uniform agreement on what incidence rates of <u>external</u> tumors are considered as positive indicators of the action of chemical agents, because viral agents acting alone or chemical/viral agents acting in combination may induce external abnormalities. However, tumor incidence rates in excess of 10-12% are believed to be an indication of the action of some chemical agent (Baumann, 1991).

A significant percentage of the PIB brown bullhead population is affected by external abnormalities, characterized by pigment "blotches", eroded fins and barbels, lesions, sores, and growths. Inadequate quantitative data are available to assess trends in the progression of this malady, however the condition was first reported in 1984, and has apparently persisted through the present. The relative percentage of the population affected has exhibited dramatic short term fluctuation, ranging from "almost all" in a 1984 survey to 40% one year later. However, a "high number" of fish were found to be affected in a 1986-1987 survey, and an incidence rate of 85% was observed in a 1991 survey, indicating that the condition is chronic.

The external lesions and sores were examined to determine if they are cancerous. Results from the 1984 and 1985 surveys revealed the presence of benign tumors in a few of the sampled fish (FWS, 1991); the incidence rate of external neoplasms in the 1985 survey was 14%. However, "fish tumor researchers do not believe that fish skin tumors necessarily imply the action of a chemical carcinogen [and] liver tumors are considered to be stronger evidence of a carcinogen" (FWS, 1991). Consequently, liver samples were examined from the 1984, 1985, and 1991 sampling events, and are currently being examined for the 1992 event. A zero incidence of liver tumors resulted from the 1984 and 1985 surveys. Liver tumors were identified from the 1991 survey, however these results did not allow the determination of incidence rates for the PIB bullhead population. A more comprehensive examination of livers is currently being done on fish collected in 1992.

In the 1984 and 1985 surveys, tissue samples were analyzed for heavy metals, pesticides, PCBs, and PAHs. In addition, bile samples were analyzed for levels of PAH compounds. Neither study identified a chemical agent in sufficiently elevated levels to be identified as a probable cause, and natural causes (i.e. viral infections) were considered as alternative explanations. These findings are supported by the 1987-1990 fish flesh contaminants data, which showed concentrations of monitored contaminants in PIB fish to be no different than background levels in Lake Erie fish (see §4.1.1.1). In addition, the concentrations of PAHs in PIB sediments have been found to be only one-third to one-tenth (or less) of the levels at other sites where fish disorders (neoplasia) have been identified and linked to sediment PAHs (see §6.4).

The cause of the degraded bullhead population has never been established. Based on recent discussions with leading researchers in this field (Baumann, 1991; Mac, 1991), a consensus opinion is that the tumors may be the result of viral or other infectious agents, but that the bullheads' susceptibility to attack by such agents is increased by sublethal exposure to stressful environmental chemicals.

The possible role of environmental chemicals in increasing the susceptibility of fish populations to attack by infectious biological agents is widely recognized by fish researchers, who have demonstrated that several environmental contaminants may "... act in concert with oncogenic viruses to induce neoplasia" (Sonstegard, 1977). These researchers speculate that bottom feeders (e.g. bullheads and white suckers) are more prone to mechanical abrasion, which could facilitate the transmission of viruses.

In summary, this AOC listing guideline is based on whether (1) "incidence rates of fish tumors or other deformities exceed rates at unimpacted control sites", or (2) "survey data confirm the presence of ... liver tumors in bullheads". Surveys have demonstrated the existence of liver tumors in PIB bullheads, but the incidence rate is unknown. Because there are no generally-agreed background levels of external abnormalities which fish researchers identify as representing "unimpacted control sites", the observed incidence rates of external abnormalities in PIB bullheads cannot be reliably interpreted. Fisheries researchers hypothesize that the PIB bullheads may be being attacked by a naturally-occurring viral agent, but that the susceptibility of the fish to viral attack is increased by chemically-induced environmental stress.

Consequently, this use is tentatively concluded to be impaired, based on the listing guideline. This impairment will be re-evaluated when the results of the 1992 study are available. Depending on the percentage of the bullhead population which demonstrates liver tumors, this decision may have to be revised. As to the external abnormalities, it is probable that elevated levels of certain chemicals in the environment (i.e. PAHs) are at least contributing to the chronic condition in PIB bullheads.

4.1.1.5 Bird or Animal Deformities or Reproduction Problems

"When wildlife survey data confirm the presence of deformities (e.g. cross-bill syndrome) or other reproductive problems (e.g. egg-shell thinning) in sentinel wildlife species."

No formal wildlife survey data are known to exist which could either confirm or deny the presence of deformities or reproductive problems in sentinel wildlife species. However, Presque Isle State Park attracts a wide diversity of migratory birds, and is home to an unusually large number of resident species, including many waterfowl. Further, the Park is extensively visited by both amateur "bird watchers" and experienced ornithologists, and the avian populations of Presque Isle are therefore subject to an unusually intense level of observation, at all times of the year.

Because no formal survey data exist, and since there are no colonies of nesting birds in the AOC which could be directly investigated, direct inquiries were made to the following key individuals with extended periods of direct ornithological observations on Presque Isle:

Jean Stull; Waterford, PA; observations since the 1950's, and banding studies since the 1960's

Bob Leberman; Carnegie Museum; banding studies from the mid-1950's to 1961

Ron Leberman; Meadville, PA; 40 years of banding studies experience, and

Jerry McWilliams; PFC-Union City; observations since 1977, and Chairman of the Presque Isle birds records committee for the Audubon Society.

These individuals have been involved in banding studies and other formal, scientific endeavors which involve careful observations of birds. In particular, as Chairman of the Presque Isle birds records committee for the Audubon Society, Mr. McWilliams is aware of all official sighting records for Presque Isle.

Although most of their studies do not involve observations of birds for the purposes of this impairment assessment guideline, these four individuals possess nearly 100 years of collective, anecdotal observations. Based on communications with these key individuals, no instances of deformities or reproductive disorders in fish-eating birds have ever been observed on Presque Isle. In particular, Mr. McWilliams reports that the double-breasted cormorant has been specifically observed in recent years, as this species is becoming more abundant. No deformities have been reported as a result of the observations of this species, which is a fish-eating bird.

Given the sustained, high levels of ornithological observation which occur in the Park, the lack of any reports of avian disorders is interpreted as an indication that no such problems exist within the AOC. This interpretation is supported by the results of fish tissue analyses discussed in section 4.1.1.1 (see above). Because consumption of contaminated fish would be the primary source of contaminant exposure and subsequent deformities in wildlife species, contamination of PIB fish would logically suggest that fish-eating wildlife may be threatened. However, as discussed in Section 4.1.1.1, contaminant levels of bioaccumulative organic pollutants in PIB fish are no different than corresponding levels in Lake Erie fish.

Research has demonstrated that long term exposure to even low levels of certain contaminants may result in subtle impacts which are not readily detected (Jacobsen, et al., 1989; Jacobsen, et al., 1990a and 1990b; Humphrey, 1988; Humphrey, 1991). Consequently, the reported contaminants levels of PIB fish may represent an unrecognized risk to the health of indigenous, fish-eating wildlife. However, because the levels of bioaccumulative pollutants in PIB fish are no different than those of Lake Erie fish, any such potential problems are a lakewide rather than an AOC issue.

Even though this use is considered not impaired, additional efforts will be made to determine the health of birds nesting in the AOC, through discussions with the Presque Isle Audubon Society, Park personnel, and others.

4.1.1.6 Degradation of Benthos

> "When the benthic macroinvertebrate community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when toxicity (as defined by relevant, field validated, bioassays with appropriate quality assurance/quality controls) of sediment associated contaminants at a site is significantly higher than controls."

This AOC listing guideline contains two components, or tests. The first test is whether the composition of the benthic macroinvertebrate community is significantly diminished from what would be normal for a comparable, unimpacted site. The second test is whether macroinvertebrate toxicity from sediment contaminants is higher than unimpacted (control) sites. Each of these tests are addressed separately in the following discussions.

4.1.1.6.1 Benthic Macroinvertebrate Community Structure

The structure of the PIB macrobenthos and zooplankton communities has been investigated in a number of early studies, from the late 1960's through the mid to late 1970s (Zagorski and O'Toole, 1970; Penelec, 1973; Zagorski and Wilcox, 1973; GLRI, 1974a and 1974c; Masteller et al., 1976; USEPA, 1979a). These studies provide species lists and relative density statistics for sites in PIB, the outer harbor, and Lake Erie in the vicinity of Erie.

Overall, these early studies show the PIB benthos community to be fairly similar to the non-PIB sites, with the exception of far fewer "pollution-sensitive" species and/or fewer individuals in the Bay. However, these studies showed the densities (standing crop) of the remaining species to be quite high in PIB, relative to Lake Erie sites. The high numbers of certain "pollution-tolerant" organisms in PIB (e.g. Oligochaetes, Chironomids, Isopods, Gastropods, and Pelecypods) was attributed to the reduced predation resulting from the elimination of pollution-sensitive predator species (GLRI, 1974a).

Generally, these early studies showed the PIB benthic community to be dominated by worms (Oligochaeta), followed by midges (Chironomidae), clams (Pelecypoda), snails (Gastropoda) and leeches (Hirudinea); far fewer amphipods (scuds, or sideswimmers) were observed (Zagorski and Wilcox, 1973), and isopods (aquatic sow bugs) were rare (Penelec, 1973). The Penelec study concluded that the composition and density of the benthic species reflected hypereutrophic conditions along the southern shoreline, grading to eutrophic toward the northern shoreline (i.e. the Park).

Although the species diversity (numbers of species) was lower in PIB than in open lake sites, the standing crop (numbers of organisms) was considerably higher. For the pollution sensitive species, the standing crop was lower in sites with sandy substrates. The population density of the pollution tolerant species was found to be related to the organic content of the sediments, with the highest standing crop in the outer harbor, followed by PIB sites.

Because these studies are one to two decades old, they are no longer representative of current conditions in PIB. In response to this "hole" in the data base, a benthos study of the Bay was initiated in 1990 by Mercyhurst College (Campbell, 1991). The 1990 study was initiated specifically to address this AOC listing (use impairment) guideline.

The pattern of benthic taxa observed in the 1990 study was similar to that of the earlier studies discussed above, and the observed community structure in this study is predictable for a lentic, freshwater environment with high concentrations of organic-rich, fine sediments. However, an important finding in this study was that it is not possible to identify "... unimpacted control sites of comparable physical and chemical characteristics". Because the physical conditions of PIB are so unique along the southern shore of Lake Erie, no fully-comparable site exists. The nearest physically-comparable site would be so removed, geographically, so as to no longer be chemically-comparable.

Another finding in the 1990 Mercyhurst College study was that the distribution pattern of pollution sensitive taxa does not correlate well with the pattern of sediment contamination resulting from the parallel FWS study. To demonstrate this finding, the 16 sites sampled in the 1990 FWS study (FWS, 1991) were ranked, according to the relative severity of contamination, and compared to the macrobenthos distribution determined in the Mercyhurst College sampling.

The relative ranking of the FWS sediment sampling sites was accomplished through the following procedure:

(1) each site was rank ordered (from 1-16) according to total PCB concentrations, with site #1 being the most heavily contaminated

(2) each site was again rank ordered, according to total PAHs

(3) each site was then rank ordered, according to each of the 11 metals for which applicable dredge sediment disposal guidelines exist (per USEPA, 1977a), resulting in 11 additional rankings, and

(4) the 13 individual sets of site rankings were combined to derive a final site ranking.

The results of this procedure are summarized in Table 4.12, including the 13 individual rankings and the final, summary ranking. The data used to complete this scoring process are presented in more detail in the following section (§4.1.1.7).

The sites ranking procedure summarized in Table 4.12 is intended only to provide some indication of the relative degree of

Table 4.12. Comparative ranking of PIB sediment sampling sites.

Site #	PCBs	PAHs	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Zn	Totals	Rank	Group	Alt.* Rank	Alt.* Group
1	11	4	13	13	7	12	13	13	3	13	11	13	13	139	11	C	8	B
2	9	5	14	6	9	14	7	14	12	14	5	14	8	131	10	B	7	B
3	8	13	12	14	13	13	14	10	14	12	14	12	14	163	13	C	11	C
4	7	7	2	2	2	4	2	3	4	6	4	5	3	51	2	A	5	A
5	3	3	8	1	3	3	5	8	5	11	7	3	5	65	4	A	2	A
6	14	15	16	15	15	15	15	15	15	15	15	15	15	195	14	C	14	C
7	13	10	7	5	6	8	11	7	13	9	3	9	6	107	7	B	10	B
8	16	6	5	11	5	9	6	9	8	7	9	8	9	108	8	B	10	B
9	15	8	10	12	12	10	12	12	11	10	13	11	12	148	12	C	12	C
10	5	2	6	9	14	11	10	11	7	8	12	10	11	116	9	B	4	A
11	1	1	1	8	8	6	1	6	6	5	6	7	4	60	3	A	1	A
12	12	11	9	10	11	5	8	5	10	4	8	4	7	104	6	B	9	B
13	2	14	11	7	10	7	9	4	9	3	10	6	10	102	5	A	7	B
14	4	9	4	3	4	2	4	2	2	2	1	2	2	41	1	A	3	A
15	10	12	3	4	1	1	3	1	1	1	2	1	1	41	1	A	6	B
16	6	16	15	16	15	16	16	16	16	16	16	16	16	196	15	C	13	C

Notes:
Sampling sites are per FWS, 1991.
Rankings are relative; see text for explanation and interpretation.
* Alternate rankings use a single, collective score for metals (see text).

sediment contamination between sites, based on bulk sediment chemistry. The numerical values have no absolute significance. Also, because such factors as total organic carbon and sediment partitioning coefficients have not been considered, the ranking scores cannot necessarily be directly correlated with potential toxicity to benthic organisms. Recognizing these procedural limitations, sites were placed into groups, according to their final ranking scores, in order to dampen any bias in the scoring process. Sites were grouped according to 5-point ranges, with regard to severity of contamination. Sites with a final ranking score of 1-5 were placed in Group A, sites with a final score of 6-10 were placed in Group B, and sites with final scores of 11-16 were placed in Group C.

This ranking process assumes (numerically) that total PCBs, total PAHs, and each of the 11 metals are individually but directly comparable, and that there is no priority between any of these 13 parameters with regard to the potential severity of benthic toxicity. An alternate ranking was performed in Table 4.12 in which a single, combined score was derived for metals, and then compared with the PCB and PAH rankings. This alternate score assumes that total PCBs, total PAHs, and all 11 metals, as a single group, are of equal importance (i.e. the alternate score is based on three rather than 13 sets of rank scores). As seen in Table 4.12, the final severity group assignment of the sampling sites is not strongly affected by the alternate scoring approach (only four sites are affected).

The results of the sediment site contamination ranking process presented in Table 4.12 are depicted in Figure 4.2, in which each of the 16 FWS sediment sampling sites are assigned a contamination severity group code from Table 4.12 (the alternate rank score groupings from Table 4.12 are shown in parentheses in Figure 4.2). In order to compare the FWS study results with those of the Mercyhurst College benthos study, benthos quality codes were added to Figure 4.2 on the basis of the preliminary results of that study (Campbell, 1991).

Because the results of the Mercyhurst College study were not yet complete at the time of this analysis (the taxonomic identification of the Chironomids and Oligochaetes is continuing), benthos quality codes could be assigned only on the following basis:

+ general associations of pollution sensitive taxa present

+ + high numbers of amphipods (a specific, pollution sensitive organism) present

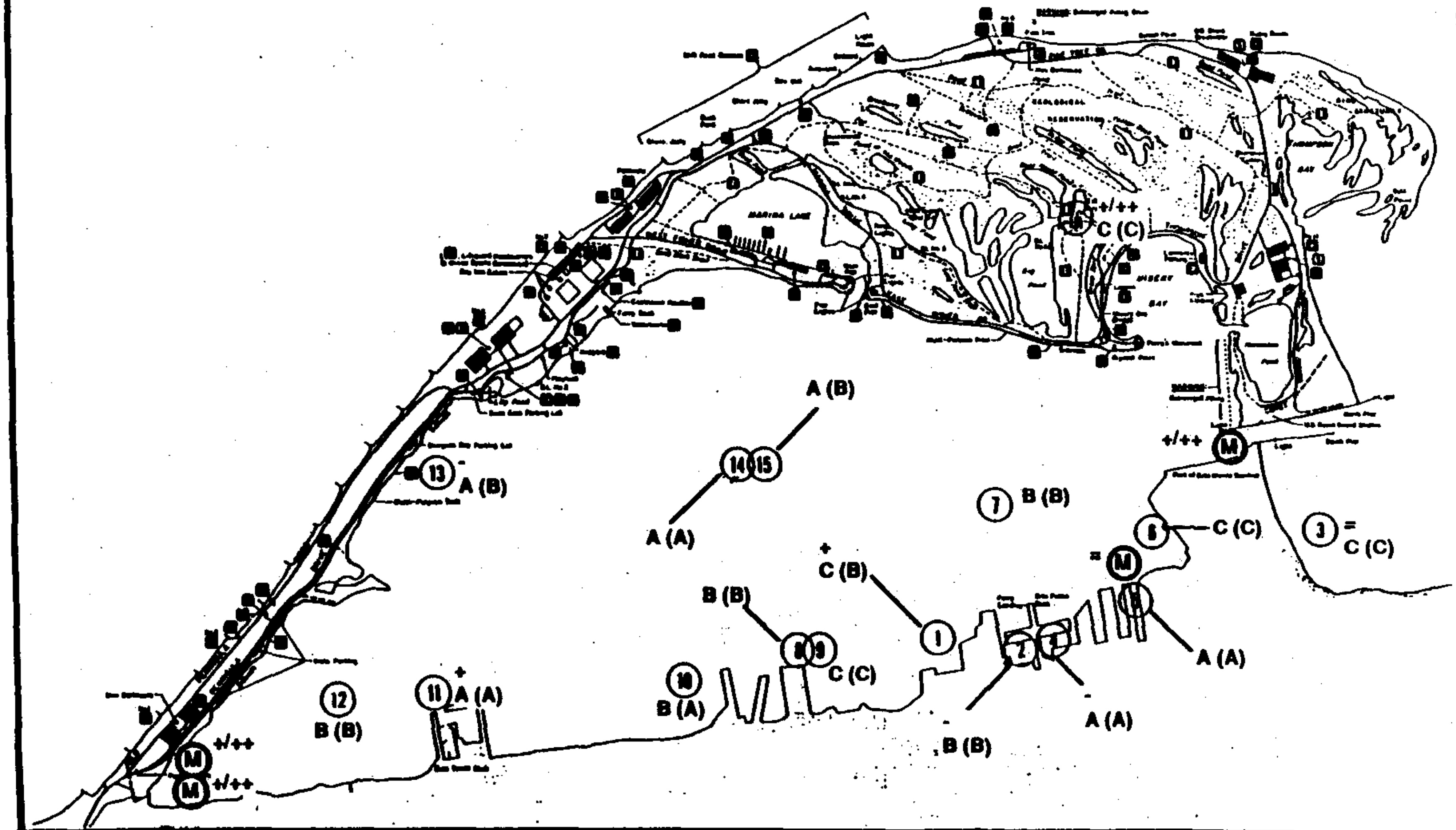


Figure 4.2. Comparison of sediment contamination severity with benthos quality (adapted from FWS, 1991).

(1) = FWS sediment sampling site (M) = Mercyhurst College benthos sampling site

- few or no pollution sensitive taxa present, and

- - high numbers of oligochaetes (a pollution tolerant organism) present.

Although all FWS sampling sites were sampled in the Mercyhurst College study, benthos quality codes could be assigned only to selected sites due to the incomplete nature of the benthos study results. Benthos quality codes were added to all the PIB sites in Figure 4.2 where this was possible (based on the current information), regardless of whether the site was a FWS or Mercyhurst College sampling location.

As seen in Figure 4.2, the pattern of benthos distribution does not correlate well with the severity of sediment contamination. For example, sites 3 and 16, while both placed in Group C (least contaminated), are widely different with regards to benthic communities. Similarly, sites 11 and 13, which are both placed in Group A (most contaminated), are quite different with regards to benthic communities. This lack of correlation between pollution severity and benthic community quality was attributed to the benthos exhibiting a higher preference for physical habitat type than chemical quality (Campbell, 1991). The overshadowing importance of physical habitat over chemical quality, even over an extreme range of ambient water quality conditions, has been demonstrated in other studies (Kay, 1975).

In addition to the difficulty in identifying a comparable but unimpacted control site for comparison, another factor complicating the interpretation of the available benthic community descriptive data is that harbor areas very seldom support a well balanced benthos population (USEPA, 1977a). This is a function of the naturally high organic content and fine grain size of harbor sediments, and relates to the natural preferences of benthic organisms for certain substrate types, as discussed above. In general:

- the absence of organisms from harbor sediments (or very reduced numbers) may indicate toxic conditions

- high populations of pollution tolerant organisms indicates organic contamination, but does not necessarily preclude open lake disposal of the sediment, and

- moderate populations of oligochaetes or other tolerant organisms in harbor sediments frequently signifies that the sediments are acceptable for open lake disposal.

In addition, drifting sands provide poor habitat and support few organisms, while substrates comprised of silty material usually provide good habitats for sludgeworms, leeches, fingernail clams, and perhaps amphipods (USEPA, 1977a). The results of the PIB benthos sampling correlate well with these general expectations for harbor sediments.

Based on these observations, it may be seen that the distribution of benthic macroinvertebrates in PIB does not necessarily correlate well with the severity of contamination. However, the data are not adequate to ascertain whether this apparent lack of correlation is because:

(1) the severity of contamination is generally lower than some threshold level needed to overshadow the strong natural preference of benthic species for habitat type over chemical quality, or

(2) the extent of contamination is sufficiently uniform that whatever differences exist between sites are not reflected in the benthos distribution patterns, which are responding to other factors.

In either case, the available data seem to suggest that the structure of the benthic community is not impaired by the chemical quality of the sediment, but these data are insufficient to determine this with certainty. The available data are also inadequate to determine whether the PIB benthic community is impaired, relative to other comparable sites. However, the structure of PIB benthic community is not atypical of a lenthic freshwater habitat with a high concentration of fine, organic rich sediments.

4.1.1.6.2 Sediment Toxicity to Benthos

The second test in this AOC listing guideline is whether macroinvertebrate toxicity from sediment contaminants is higher than unimpacted (control) sites. The two primary data sources available to apply this test to are the results of sediment biotoxicity tests performed by the COE in 1982 and 1986 (COE, 1982; COE, 1986a). These results have been discussed in previous section 4.1.1.3 and are only briefly summarized here.

The macroinvertebrate test species used in the 1982 and 1986 COE toxicity tests was the burrowing mayfly, Hexagenia limbata. Results of the two tests are summarized in Table 4.10 (see §4.1.1.3). As seen in this table, the toxicity of PIB sediments to the test benthic organism was not significantly different from the "lake reference" control site, in either year (note that for Hexagenia limbata results, the "1986 retest" column in Table 4.10 takes precedence). Consequently, no impairment of this use is implied in the results of this test (i.e. the toxicity of sediment associated contaminants is not significantly higher than controls).

4.1.1.6.3 Discussion and Summary

Given the problems associated with applying the first test in this guideline (whether benthic community structure significantly diverges from unimpacted control sites), the second test (sediment toxicity to benthos) may be the more meaningful with regard to the evaluation of potential use impairments. The results of sediment toxicity bioassay tests conducted with reliable test methods and a macroinvertebrate benthic species have shown no significant differences between PIB sites and an unimpacted control site.

In summary, current data on the community structure of the PIB benthos suggest that the pattern of distribution of benthic species does not correlate well with the distribution of sediment contaminants. These results suggest that sediment contaminants are not the dominant influence on the PIB benthic community structure (physical habitat differences may be the primary influence). Second, reliable bioassay test results indicate that the toxicity of PIB sediments are no different than an unimpacted control site. Third, the high fisheries productivity of PIB (see §4.1.1.3) would not be possible if the benthic macroinvertebrate community (and the zooplankton/phytoplankton communities) was significantly impaired.

Consequently, based on the currently available data and information, no significant impairment of this beneficial use is indicated or concluded. In order to bolster this determination, PADER and USEPA will attempt to conduct additional sediment toxicity testing during the summer of 1992.

4.1.1.7 Restrictions on Dredging Activities

> "When contaminants in sediment exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities."

Applicable guidelines for assessing restrictions on dredging activities applicable to PIB sediments are described in Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments, prepared by the USEPA Region V (USEPA, 1977a), and summarized in Table 4.13. Although other standards, criteria, or guidelines have been developed by other political jurisdictions in

Table 4.13. Guidelines for evaluating the severity of sediment contamination.

	Pollution Classifications and Contaminant Ranges[1]		
Parameter	Nonpolluted	Moderately Polluted	Heavily Polluted
Arsenic (As)	<3	3 - 8	>8
Barium (Ba)	<20	20-60	>60
Cadmium (Cd)	lower limits not established	lower limits not established	>6
Chromium (Cr)	<25	25-75	>75
Copper (Cu)	<25	25-50	>50
Iron (Fe)	<17,000	17,000-25,000	>25,000
Lead (Pb)	<40	40-60	>60
Manganese (Mn)	<300	300-500	>500
Mercury (Hg)	≥1 not acceptable for open lake disposal	≥1 not acceptable for open lake disposal	>1
Nickel (Ni)	<20	20-50	>50
Zinc (Zn)	<90	90-200	>200
Chemical Oxygen Demand (COD)	<40,000	40,000-80,000	>80,000
Total Kjeldahl Nitrogen (TKN)	<1,000	1,000-2,000	>2,000
Ammonia (NH_3)	<75	75-200	>200
Total Phosphorus (P)	<420	420-650	>650
Cyanide	<0.10	0.10-0.25	>0.25
Oil and Grease (%)	<1,000	1,000-2,000	>2,000
Volatile Solids (%)	<5	5 - 8	>8
Total Polychlorinated Biphenyls (PCBs)	≥10 not acceptable for open lake disposal	≥10 not acceptable for open lake disposal	≥10

[1] All concentrations in mg/kg dry weight, unless otherwise noted.

the Great Lakes (e.g. States and Provinces), the guidelines in Table 4.13 are the only currently-available applicable and appropriate measures of dredging restrictions with which sediment quality data may be effectively compared.

A variety of sediment sampling results are available, from a wide range of sources. These are identified in Table 4.14. Many of these data sets were collected for narrowly-defined objectives, or from isolated locations, and do not reflect overall conditions in the Bay. Further, some data sets do not include data which may be directly compared to the dredging impairment guidelines. In addition, some data sets lack QA/QC information and other sample collection, handling, and analysis specifics which limit their utility for comparison with other data sets. After reviewing the data sets described in Table 4.14, the following three sources were selected to form the basis for evaluation of this impairment guideline:

(1) Chemical, Physical and Bioassay Analysis of Sediment Samples, Erie Harbor, Erie, Pennsylvania (COE, 1982)

(2) The Analysis of Sediments from Erie Harbor; Erie, PA (COE, 1986a)

(3) Chemical Analysis of Sediments from Presque Isle Bay, Erie, Pennsylvania (FWS, 1991).

These three data sets have the common attributes of reliable QA/QC and broad geographic coverage in sampling locations. Each of these data sets are described individually in the following discussions (§§4.1.1.7.1-4.1.1.7.3), followed by a discussion and conclusions section (§4.1.1.7.4).

4.1.1.7.1 Chemical, Physical and Bioassay Analysis of Sediment Samples, Erie Harbor, Erie, Pennsylvania (COE, 1982)

Sediment sampling was conducted at 16 locations in PIB, the harbor entrance channel, the outer harbor, and Lake Erie north of Presque Isle. Sampling locations are depicted in Figure 4.1 (see §4.1.1.3); no samples were collected from Sites 5 and 6 because of hard substrate. Sampling was conducted in August, 1982. Samples were analyzed in accordance with USEPA analytical procedures.

Analytical results are summarized in Table 4.15. For purposes of discussion, sample locations are grouped according to the following scheme:

- outer harbor: Sites 1-4

Table 4.14. Summary of existing Presque Isle Bay sediment sampling data.

Source	Sampling Date	Laboratory	Location	Notes
Fish and Wildlife Service, chemical analysis of PIB sediments (FWS, 1991)	4/24 and 4/25/90	FWS Contract Lab	16 locations within PIB	Metals, PCBs/pesticides, and PAHs; QA/QC procedures; metals correlated with grain size
PADER sample #0690016	9/20/90	DER	Mill Creek storm sewer	Only TOC and MBAS for organics
PADER sample #2634043	5/8/90	PADER	Confined disposal area	EP toxicity and lead only
PADER sample #2634044	5/8/90	PADER	Confined disposal area	EP toxicity and lead only
Joint Permit Application for waterfront maintenance activities, and associated correspondences and lab. analysis data sheets (Erie-Western Pennsylvania Port Authority, 1989-1990)	8/24/89	Microbac	Lampe Marina	Volatiles, some semi-volatiles (PAHs), and iron and manganese
	8/24/89	Microbac	East Avenue Boat Ramp	Volatiles, some semi-volatiles (PAHs), iron and manganese
PADER sample #2634021	10/18/89	PADER	Confined disposal area	EP toxicity metals only
PADER sample #2634022	10/18/89	PADER	Confined disposal area	EP toxicity metals only
PADER sample #2634023	10/18/89	PADER	Confined disposal area	EP toxicity metals only
PADER sample #2634020	10/18/89	PADER	Confined disposal area	PAH, semi-volatiles
PADER sample #2634019	10/18/89	PADER	Confined disposal area	PAH, pemi-volatiles
PADER sample #2634017	9/21/89	PADER	Lampe Marina	Metals, phenols
PADER sample #2634016	9/21/89	PADER	Lampe Marina	Metals, phenols

Table 4.14. Summary of existing Presque Isle Bay sediment sampling data (cont.).

Source	Sampling Date	Laboratory	Location	Notes
Corps of Engineers, Buffalo District, environmental evaluation of repairs to North Pier (COE, 1988)	N/A	N/A	N/A	Cites sediment and elutriate results for nutrients, metals, conv./non-conv. pollutants from COE, 1986 (AquaTech) report
PAHs in streams draining to Lake Erie in and near Erie (Plowchalk and Zagorski, 1986)	1985	?	3 sites within PIB 6 sites outside PIB	PAHs
Erie County Dept. Health, priority pollutants analyses (ECDH, 1985)	1985	DER	26 sampling locations (15 within PIB)	Semi-volatiles, pesticides and PCBs, volatiles, and EP toxicity metals (not all parameters tested at all sites)
Corps of Engineers, Buffalo District: chemical, physical and bioassay analysis of sediment samples (COE, 1982)	8/23/82	Applied Biology, Inc.	Samples 1-5: outer channel Samples 6 - 14: inner harbor Sample 15: open lake disposal area Sample 16: lake reference area (background)	Procedures and detection limits described. Metals, nutrients, phenols, pesticides, PCBs, bioassay QA/QC including duplicate samples and % recovery
Proposed disposal of dredge materials (Erie-Western Pennsylvania Port Authority, 1979?)	?	?	Lampe Marina	Only one data set reported. It may be a summary of several samples although that is not explained.
Water pollution investigation of Erie area (USEPA, 1975)	1973	Betz Environmental Engineers	12 sites within PIB	BOD, Sulfides, COD, Oil & Grease, and Nutrients

Table 4.14. Summary of existing Presque Isle Bay sediment sampling data (cont.).

Source	Sampling Date	Laboratory	Location	Notes
Corps of Engineers, Buffalo District, environmental evaluation of annual beach nourishment (COE, 1991)	1980 through 1990	?	13 sources of beachfill (background data)	Metals, pesticides, PCBs, conv./non-conv. pollutants
Public Notice, misc. correspondences, and lab. data sheets associated with a permit application for expansion of the Presque Isle Yacht Club Marina (Presque Isle Yacht Club, 1988-1989)	11/88?	Microbac	11 Samples of fill behind existing pier which was to be removed	PCBs
	5/88?	Microbac	1 composite sample of existing fill	EP toxicity for metals and pesticides/PCBs
Corps of Engineers, Buffalo District, environmental evaluation of operation and maintenance dredging (COE, 1987)	N/A	N/A	N/A	Cites data from COE, 1986 (AquaTech) report
Corps of Engineers, Buffalo District, analysis of Erie Harbor sediments (COE, 1986)	5/86	Aqua Tech Environmental Consultants, Melmore, Ohio	Samples 1-5: outer harbor channel Samples 6 - 14: inner harbor Sample 15: open lake disposal area Sample 16: lake reference area (background)	Metals, pesticides, PCBs, phthalate esters, purgeable halocarbons, purgeable aromatics, PAHs, elutriate test for metals and nutrients, QA/QC data, bioassays Same locations as in COE, 1982

Table 4.15. Metals and selected chemical parameters in PIB and Erie area sediments - 1982.†

Sediment Sampling Locations and Concentrations.

Parameter	Outer Harbor Sites 1	Outer Harbor Sites 2	Outer Harbor Sites 3	Outer Harbor Sites 4	Presque Isle Bay Sites: "Inner Harbor" Sites 7	"Inner Harbor" Sites 8	"Inner Harbor" Sites 9	"Harbor Basin" Sites 10	"Harbor Basin" Sites 11	"Harbor Basin" Sites 12	"PIB background" 13	"PIB background" 14	Disposal Area 15	Lake Ref. 16
Arsenic (As)	1.11	1.54	1.87	1.79	1.10	2.06	2.03	1.40	2.47	1.93	2.74	2.55	1.61	1.70
Cadmium (Cd)	2.30	2.78	3.85	5.35	3.34	7.86	8.96	6.53	11.95	6.32	9.41	11.16	3.40	3.13
Chromium (Cr)	3.70	**28.40**	**36.20**	**41.90**	**23.90**	57.50	61.50	77.84	71.72	49.29	67.98	79.18	40.29	37.98
Copper (Cu)	**35.52**	**43.47**	**39.39**	**39.63**	**34.31**	59.53	79.56	62.69	88.42	52.75	76.06	94.03	44.79	38.74
Iron (Fe)	**15,981**	**21,455**	25,881	26,045	**12,042**	**24,865**	26,754	**19,072**	27,400	**16,678**	29,195	32,085	**18,830**	**18,510**
Lead (Pb)	**42.7**	**52.3**	66.7	78.6	**51.2**	131.7	148.8	197.81	179.65	122.70	167.15	194.53	76.49	66.67
Manganese (Mn)	**289.42**	**345.06**	**439.5**	**486**	263.76	**451.6**	**391.5**	**306.94**	**376.71**	**375.47**	**399.43**	**460.31**	**315.8**	**340.87**
Mercury (Hg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (Ni)	**26.98**	80.28	**40.3**	**46.6**	**26.92**	65.7	**31.11**	116.5	56.87	**47.95**	57.29	63.99	**47.63**	**37.73**
Zinc (Zn)	**90.0**	**100.0**	**120.5**	**147.9**	**194.0**	351.8	300.9	288.55	319.64	217.53	318.24	363.58	**159.7**	**184.36**
COD	26,888	**39,658**	**71,286**	**73,823**	**31,474**	197,188	131,788	128,046	154,762	89,624	131,737	107,613	**35,530**	17,519
TKN	**156**	**262**	**342**	**616**	**222**	**728**	**723**	**797**	**810**	**909**	**898**	**937**	**500**	**361**
Ammonia-N	**65**	**75**	**46**	**80**	35	**98**	**111**	**85**	**119**	**63**	**67**	**105**	**82**	**64**
Total Phosphorus	79	99	88	134	71	142	125	139	174	1043	142	137	108	64
Cyanide	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
Oil and Grease	0.022	0.051	0.068	0.101	0.051	0.789	0.173	0.418	0.178	0.181	0.157	0.312	0.054	0.072
Volatile Solids (%)	1.96	3.12	4.06	4.94	2.88	7.7	7.53	8.95	8.22	7.1	8.38	10.38	4.49	2.58
# nonpolluted:	13	9	9	8	12	6	6	6	6	7	7	6	9	10
# mod. polluted:	4	8	8	9	5	11	11	11	11	10	10	11	8	7
# heavily polluted:	0	1	2	2	0	6	6	8	8	6	8	11	1	1

Notes:

Bold : Indicates values which fall within the USEPA "moderately-polluted" guideline.

Shaded : Indicates values which exceed the USEPA "heavily-polluted" guideline.

Sites 1 - 4 are outer harbor channel locations.

Sites 7 - 14 are in Presque Isle Bay.

Site 15 is an open lake disposal area.

Site 16 is an open lake "reference" (background) location.

All concentrations are in mg/kg dry weight unless otherwise noted.

† From COE, 1982a.

- PIB "background": Sites 13-14
- PIB "inner harbor": Sites 7-9
- PIB "harbor basin": Sites 10-12
- Lake Erie dumping site: Site 15, and
- open lake control ("reference") site: Site 16.

Again, no samples were obtained from Sites 5 and 6 (the entrance channel).

The artificial segregation of PIB sample sites according to three geographic subgroups was done to facilitate inspection of the sample data for possible correlations between contaminant concentrations and proximity to possible contaminant sources. Sites 10-12 are located immediately offshore of the industrialized waterfront area of Erie, including the area of the mouth of Mill Creek. Sites 7-9 are further offshore, but still within the area directly affected by commercial and industrial traffic. Both the harbor basin and inner harbor sites (#s 10-12 and 7-9, respectively) are subject to periodic dredging. Sites 13-14 are in an area of PIB which receives little commercial and industrial traffic, and represents more natural, background conditions within the Bay (i.e. these sites are not dredged). Site 15 is the Lake Erie disposal (dumping) site, and Site 16 is an open lake control site.

The results of the 1982 sampling in Table 4.15 were compared with the USEPA guidelines presented in Table 4.13. To illustrate the results of this comparison, those sample results in Table 4.15 which fall within the "moderately polluted" guideline range are indicated in bold type; those values which fall within the "heavily polluted" guideline range are indicated in bold, shaded type ("nonpolluted" values are indicated in normal type). The total number of parameters falling in the "nonpolluted", "moderately polluted", and "heavily polluted" guideline category ranges for each sample site are indicated at the bottom of the table. Because no Barium results were provided for the 1982 samples, and all PCB analysis results were below the detection limit (<2 mg/kg dry weight), these parameters are omitted from Table 4.15. Also, although all cyanide values are indicated as "nonpolluted", the detection limit used (0.63 mg/kg) is more than twice the 0.25 mg/kg "highly polluted" guideline level.

4.1.1.7.2 The Analysis of Sediments from Erie Harbor; Erie, PA. (COE, 1986a)

Sediment sampling was conducted at 16 locations in PIB, the harbor entrance channel, the outer harbor, and Lake Erie north of Presque Isle. Sampling locations were the same as used in COE, 1982 and are depicted in Figure 4.1 (see §4.1.1.3). Sampling was conducted in May, 1986. Samples were analyzed in accordance with USEPA analytical procedures.

Analytical results are summarized in Table 4.16. For purposes of comparison, sample locations are grouped according to the same general scheme used in presenting the 1982 COE results:

- outer harbor: Sites 1-4
- PIB "background": Sites 13-14
- PIB "inner harbor": Sites 7-9
- PIB "harbor basin": Sites 10-12
- Lake Erie dumping site: Site 15, and
- open lake control ("reference") site: Site 16.

The 1986 report includes results from Sites 5 and 6 (the "entrance channel"), which were not available in the 1982 report. The reasons for the artificial segregation of PIB sample sites according to geographic subareas are described in §4.1.1.7.1, above.

The results of the 1986 sampling in Table 4.16 were compared with the USEPA guidelines presented in Table 4.13. To illustrate the results of this comparison, those sample results in Table 4.16 which fall within the "moderately polluted" guideline range are indicated in bold type; those values which fall within the "heavily polluted" guideline range are indicated in bold, shaded type ("nonpolluted" values are indicated in normal type). The total number of parameters falling in the "nonpolluted", "moderately polluted", and "heavily polluted" guideline category ranges for each sample site are indicated at the bottom of the table.

Although analytical results for barium were not available in the 1982 report, the 1986 report includes this parameter, and barium results are included in Table 4.16. PCB analysis results were all below the detection limit used in the 1982 report (<2 mg/kg dry weight) and were omitted from the 1982 analysis results summary (Table 4.15). In the 1986 report, all PCB analysis results except Site 9 were also below the 0.10 mg/kg detection limit, and PCB results were not included in the 1986 analysis results summary

Table 4.16. Metals and selected chemical parameters in PIB and Erie area sediments - 1986†.

Parameter	Outer Harbor Sites 1	1 Dup.	2	3	4	"Entrance Channel" 5	6	Disposal Area 15	Lake Ref. (background) 16	16 Dup.
Arsenic (As)	12	11	13	17	7	5	3	10	9	8
Barium (Ba)	18	21	26	21	25	10	13	37	26	22
Cadmium (Cd)	1	1	<0.5	<0.5	2	<0.5	1.5	1.5	0.8	0.8
Chromium (Cr)	9	9	10	9	12	5	5	18	11	9.2
Copper (Cu)	25	25	25	25	24	7.5	9	32	18	16
Iron (Fe) (x1,000)	20	20	22.9	24.1	16.9	8.08	6.3	18.5	16.3	15.4
Lead (Pb)	14	12	12	14	18	7.5	9	28	16	16
Manganese (Mn)	260	250	260	290	260	124	110	210	220	217
Mercury (Hg)	<0.04	0.05	<0.04	0.03	0.06	0.05	<0.05	0.12	0.06	0.07
Nickel (Ni)	19	18	19	19	19	9	8	23	21	18
Zinc (Zn)	74	74	74	75	97	34	150	150	85	82
COD (x1000)	37.4	46.3	40.1	36.7	54.1	<1.4	6.8	53.8	33.1	40
TKN	906	1310	1010	815	1480	27	211	887	1030	1500
Ammonia-N	21.2	20.6	26.9	18.5	54.2	7.24	9.47	23	19.5	18.6
Total Phosphorus	633	633	618	573	496	348	257	527	500	501
Cyanide	0.31	0.31	0.33	0.22	0.34	0.33	0.54	1.82	0.39	0.48
Oil and Grease	327	293	284	937	870	108	257	600	373	316
Volatile Solids (%)	2.48	2.83	2.32	2.25	3.4	0.63	1.04	3.14	2.33	2.62
# nonpolluted:	13	10	10	12	11	16	15	9	12	12
# mod. polluted:	5	8	8	6	7	2	3	9	6	6
# heavily polluted:	2	2	2	2	1	1	1	2	2	1

Parameter	Presque Isle Bay Sites: "Inner Harbor" Sites 7	8	9	"Harbor Basin" Sites 10	11	12	"PIB Background" 13	14
Arsenic (As)	10	15	16	15	14	15	17	18
Barium (Ba)	61	53	55	51	66	71	62	66
Cadmium (Cd)	3.2	5.2	8	6.1	6.3	4.8	7.4	7.8
Chromium (Cr)	16	24	34	31	27	24	37	45
Copper (Cu)	35	54	78	70	72	60	81	88
Iron (Fe) (x1,000)	17.2	21.3	24.5	21.7	20.1	20.1	25.3	30.4
Lead (Pb)	49	82	120	97	86	94	120	140
Manganese (Mn)	300	370	360	360	410	300	390	390
Mercury (Hg)	0.18	0.24	0.50	0.34	0.38	0.39	0.53	0.72
Nickel (Ni)	27	39	46	55	49	35	47	51
Zinc (Zn)	200	260	340	360	288	220	280	370
COD (x1000)	67.7	88.6	122	140	131	113	173	152
TKN	1870	2430	2730	2300	2460	3020	2580	3330
Ammonia-N	61.8	72.3	70.8	109	100	50.8	55.1	46.2
Total Phosphorus	885	864	1226	982	867	1160	1120	1520
Cyanide	0.56	0.57	1.06	0.75	0.47	0.54	3.7	1.62
Oil and Grease	1330	2150	3230	3980	2640	2110	3770	3700
Volatile Solids (%)	3.92	6.68	7.52	8.33	8.3	7.16	8.65	8.73
# nonpolluted:	5	4	2	1	1	4	2	2
# mod. polluted:	13	14	16	17	17	14	16	16
# heavily polluted:	5	5	10	12	12	10	13	13

Notes:

Bold : indicates values falling within the USEPA "moderately-polluted" guideline.

Shaded : indicates values which exceed the USEPA "heavily-polluted" guideline.

Sites 1 - 4 are outer harbor channel locations. Sites 5-6 are in the entrance channel.

Sites 7 - 14 are in Presque Isle Bay. Site 15 is an open lake disposal area.

Site 16 is an open lake "reference" (background) location.

All concentrations in mg/kg dry weight, unless otherwise noted.

† From COE, 1986a.

(the PCB value from Site 9 was 1.7 mg/kg, or 17% of the ≥10.0 mg/kg threshold guideline for impairment of dredging from PCBs).

4.1.1.7.3 Chemical Analysis of Sediments from Presque Isle Bay, Erie, Pennsylvania (FWS, 1991)

Sediment sampling was conducted at 16 locations in PIB, the outer harbor, and Big Pond (Presque Isle State Park) by the FWS, in April, 1990. Sampling locations are depicted in Figure 4.3. These locations are substantially different from those used in the COE, 1982 and 1986a studies; the only sites which are essentially coincident are COE Site 9 and FWS Site 7 (compare Figures 4.1 and 4.3). Rigorous QA/QC procedures were employed by the laboratories analyzing the samples. While the specific analytical procedures were generally not identified, it is believed that all samples were analyzed in accordance with USEPA analytical procedures or their equivalents.

Analytical results are summarized in Table 4.17. For purposes of comparison, sample locations are grouped according to the following general scheme:

- PIB "Erie nearshore": Sites 1-2, 4-6, and 8-12
- PIB "inner harbor": Site 7
- PIB "central basin": Sites 14-15
- PIB "peninsula nearshore": Site 13, and
- Big Pond (Presque Isle State Park): Site 16.
- outer harbor: Site 3

Because the FWS study did not include results for COD, TKN, NH_3, total phosphorus, cyanide, oil and grease, or volatile solids, these parameters are not included in Table 4.17, and cannot be compared with the USEPA dredging impairment guidelines.

The results of the 1990 sampling in Table 4.17 were compared with the USEPA guidelines presented in Table 4.13. To illustrate the results of this comparison, those sample results in Table 4.17 which fall within the "moderately polluted" guideline range are indicated in bold type; those values which fall within the "heavily polluted" guideline range are indicated in bold, shaded type ("nonpolluted" values are indicated in normal type). The total number of parameters falling in the "nonpolluted",

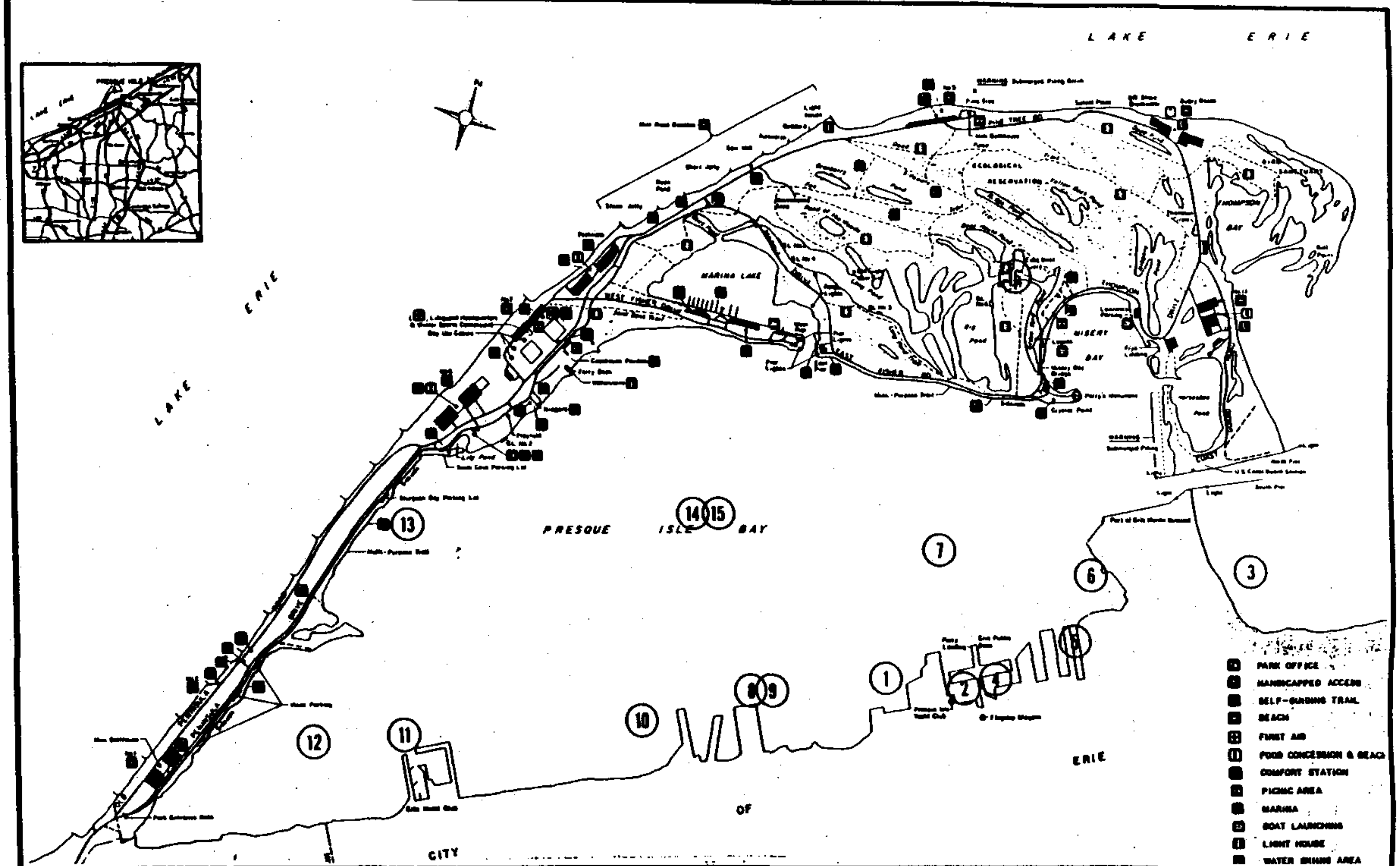


Figure 4.3. Locations of Fish and Wildlife 1990 sediment sampling sites (from FWS, 1991).

"moderately polluted", and "heavily polluted" guideline category ranges for each sample site are indicated at the bottom of the table.

4.1.1.7.4 Discussion and Conclusions

Clearly, this use is impaired, based on the USEPA guidelines. In fact, as may be seen from comparing Tables 4.16 and 4.17, PIB sediments are moderately to heavily polluted for most of the USEPA guideline parameters. However, it is interesting to note that one parameter which does not exceed the guideline value is mercury; this result is corroborated by the results of the fish flesh contaminants evaluations (see §4.1.1.1) which showed the mercury levels in PIB fish to be no different than those of Lake Erie fish. It is also interesting to note that while arsenic levels exceeded the guidelines in most PIB sites, high arsenic levels were also recorded from the unimpacted lake reference site (Table 4.16), and moderate levels were recorded from the isolated site in Big Pond (Table 4.17). Further, based on the most recent (1990) data, the only PIB site which was not contaminated, for any guideline parameter, was the site at the mouth of Mill Creek. Finally, it is noted that no discernible pattern of contamination is readily apparent, and no contaminant "hot spots" are immediately recognizable in the available data. These observations do not modify the conclusion that this use is impaired, but relate more to the sources of pollution and pollutant dispersion pathways, and are discussed in more detail in §4.2 and Chapters 5 and 6.

No current standard or guideline value exists for sediment PAH levels. Therefore, PAHs are not included with the problem contaminants identified through the application of the current guidelines to the available data. However, PAH levels are considered to be elevated, based on other Great Lakes sites, and are " ... one to three orders of magnitude higher than unpolluted reference sites" (FWS, 1991). In addition, the results of fish studies, while not conclusive, implicate PAHs as possible contributors to (but not directly causing) the external abnormalities observed in PIB brown bullheads. Therefore, PAHs are included in the sediment contaminants of concern, as a precaution.

At present, the USEPA guidelines are the applicable standards with which to evaluate this AOC listing guideline. However, it should be noted that these guidelines are nearly 15 years old and do not reflect current scientific knowledge regarding the extrapolation of human health and aquatic life risks from sediment contaminant levels. In fact, the current guidelines were simply derived through a process in which the levels of selected parameters from multiple lake sites were averaged, in order to establish background contaminant levels. The logic was that

Table 4.17. Metals and selected characteristics of PIB sediments - 1990.†

	PIB - "Erie Nearshore"										"inner harbor"	"central basin"		"penin. n-shore"	Big Pond	outer harbor
Parameter	1	2	4	5	6	8	9	10	11	12	7	14	15	13	16	3
Arsenic	9.08	8.84	37.13	8.80	2.19	19.72	17.68	19.19	39.06	18.01	18.96	22.61	23.61	13.54	4.06	12.67
Barium	55.85	137.83	296.44	441.60	14.32	86.83	88.42	92.54	98.28	87.40	188.08	227.39	226.84	101.34	6.16	43.24
Cadmium	4.92	3.57	10.59	10.26	ND	6.77	3.16	1.71	3.75	3.38	6.32	8.91	11.47	3.49	ND	2.20
Chromium	26.77	17.35	65.15	66.10	4.13	36.01	30.95	29.64	52.19	52.73	49.73	103.64	105.19	49.78	2.30	18.75
Copper	76.46	108.16	214.01	162.71	8.97	109.17	81.68	92.11	225.09	107.40	86.54	182.61	182.68	180.44	3.92	48.31
Iron (1,000)	17.69	15.14	48.86	37.61	5.03	31.88	29.90	38.49	48.66	42.12	37.81	65.22	66.23	44.10	3.71	30.57
Lead	178.46	94.22	182.87	159.54	6.39	118.38	94.32	128.78	162.81	109.97	86.54	222.61	223.61	110.04	ND	23.65
Manganese	358.46	328.23	674.27	618.87	68.90	612.39	536.94	611.94	740.83	765.27	593.41	1017.4	1021.6	803.49	65.09	510.14
Mercury	0.302	0.621	0.655	0.516	0.045	0.335	0.269	0.286	0.619	0.363	0.657	0.722	0.680	0.328	ND	0.211
Nickel	26.62	26.36	73.96	81.48	9.10	58.58	46.74	48.19	68.94	73.31	57.87	164.78	112.99	62.54	3.38	30.41
Zinc	261.56	269.84	679.39	476.89	41.61	456.38	294.74	314.09	490.42	285.85	396.35	602.61	603.98	338.43	18.81	161.66
Total PCBs	0.34	0.41	0.42	0.46	<0.26	0.22	0.24	0.45	0.56	<0.30	<0.28	<0.46	<0.40	<0.47	<0.43	<0.42

# non.:	3	5	2	2	12	2	3	3	3	3	2	2	2	3	11	5
# mod.:	9	7	10	10	0	10	9	9	9	9	10	10	10	9	1	7
# heavily:	4	5	9	9	0	8	7	7	8	8	8	10	10	8	0	3

Moisture (%)	35.00	41.20	69.30	64.90	22.50	56.40	52.50	53.10	68.00	68.90	63.60	77.00	76.90	77.10	26.10	40.80
TOC (%)	7.81	8.64	10.53	5.82	0.24	4.92	4.14	4.67	5.55	3.70	3.40	5.30	5.05	3.00	0.21	1.52
Silt/clay (%)	58.00	64.43	97.65	96.22	44.79	84.97	80.33	89.68	97.23	96.24	95.11	99.70	99.72	96.27	44.16	93.25
Sand (%)	42.00	35.57	2.35	3.77	55.22	16.03	19.67	10.32	3.78	3.76	4.89	0.30	0.28	3.72	55.84	6.75

<u>Notes:</u>

Bold : Indicates values which fall within the USEPA "moderately-polluted" guideline.
Shaded : Indicates values which exceed the USEPA "heavily-polluted" guideline.
Site 3 is in the outer harbor.
Site 16 is in Big Pond on Presque Isle.
All other sites are within Presque Isle Bay.
These sites do not correspond with the Corps of Engineers (1982 and 1986a) sites.
All concentrations are in mg/kg dry weight unless otherwise noted.
† From FWS, 1991.

sediments with contaminant levels no higher than background levels could be deposited in open lake disposal areas with no significant adverse effects, because the contaminant levels would be compatible. However, these averaged values do not reflect regional differences in natural background levels. Although the existence of these guideline values tend to encourage simple comparisons with bulk sediment chemistry, such additional factors as elutriate test results, contamination sources, benthos populations, particle size distribution, and sediment color and odor are also intended to be considered in evaluating the pollution status of sediments.

The above observations do not modify the basic observation that this use is impaired, based on the currently-applicable guidelines. However, many practical and technical issues exist which limit the applicability of at least some of these guideline values to PIB. The USEPA is currently developing new guidelines and criteria to be used when evaluating sediment contamination. These new guidelines will replace the 1977 guidelines which were used in this analysis, and therefore a new evaluation will need to be made to determine the status of this impairment when the new guidelines are released. These issues affect the identification of pollutants of concern and pollutant dispersion pathways, and are discussed in §4.2 and Chapters 5 and 6.

4.1.1.8 Eutrophication or Undesirable Algae

"When there are persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication."

Very little information exists regarding the trophic status of PIB. Significant historical studies are based on water quality information which is more than 15 years old (PADER, 1976; Penelec, 1973). These sources generally conclude that the Bay is eutrophic. However, these data do not reflect the recent advances in pollution control in PIB, and are not representative of current conditions in the Bay.

In 1985, the DER conducted a Priority Water Body Survey on PIB, to determine its suitability to support water contact recreation (PADER, 1986). This survey concluded that PIB was suitable for water contact recreation, and recommended that this use be added to the Bay, as an additional protected use (see §4.1.1.10). At that time, both PIB and Lake Erie were rated as "eutrophic" (PADER, 1986). However, this assessment was apparently subjective, as the survey focused primarily on the characterization of bacteriological water quality and did not involve collection and analysis of data on other parameters common to a trophic state assessment.

In 1990, the DER conducted a "Trophic State Analysis" of PIB (PADER, 1991), specifically designed to determine the trophic state of the Bay. The lack of appropriate historical information on the trophic status of PIB was cited as one of the reasons for conducting this study. In accordance with §95.6 of the Pa. Code, a trophic state analysis involves (1) a systematic evaluation of trophic status, and (2) development of point and nonpoint source controls recommendations for nutrients sufficient to provide the appropriate level of protection or water quality improvement. In this analysis, three PIB locations were sampled in 1990. Three sampling events were conducted at each sampling location, corresponding to the times of spring overturn (mid-April), summer stratification (mid-August), and fall overturn (late-October). A computer model was then used to evaluate the sampling data and derive a "trophic state index". This index is based on productivity, and includes consideration of such key variables as DO, water transparency, phosphorus, chlorophyll a, and pH.

Key findings of the 1990 DER study may be summarized as follows:

(1) No nuisance algal blooms or other excessive growths of algal or aquatic macrophyte species were identified (although such conditions existed in PIB in the early 1960s, they essentially disappeared following a program of sewage discharge controls).

(2) No dissolved oxygen depletion of bottom waters was observed. DO levels during the summer stratification period, when benthic DO levels are typically lowest, were only slightly less than surface levels (>=78% of surface concentrations), and always at least 2.0 mg/l above the 5.0 mg/l ambient water quality standard).

(3) Water clarity has improved dramatically in recent years. This increase is common to entire portions of Lake Erie, and is evident in PIB as well. Decreases in nutrients loading may be a primary reason for this observed increase in water clarity (as related to diminished growth of planktonic algal species), however the recent appearance of large populations of the filter-feeding zebra mussel (*Dreissena polymorpha*) is cited as another potential contributing factor.

(4) The results of the computer-based tropic state analysis place PIB in a "mesotrophic" category. A Trophic State Index (TSI) of 53.2 was derived as a result of the DER analysis, which places PIB within the 45-55 mesotrophic range (a TSI of <45 is oligotrophic; a TSI of >55 is eutrophic).

This analysis concluded that the trophic status of PIB is primarily driven by non-point loads of nutrients (i.e. phosphorus), and that further point source reductions would result in <5% change in the TSI. Consequently, no additional point source controls are recommended in this analysis.

The conclusions of the DER Trophic State Analysis regarding DO levels are based on three sampling events during 1990. For comparison, available ambient water quality data from the Bay sampling station maintained by the DER (WQN 632) for the period 1985-1990 were retrieved from STORET and reviewed. The STORET data supported the conclusions of the DER Trophic State Analysis. A total of 23 DO results were retrieved for the 1985-1990 time period, with an average of 8.9 mg/l. Only one DO value in the six year period of record reviewed fell below the 6.0 mg/l DO standard (5.7 mg/l, on 6/21/89). The second lowest DO was 6.7 mg/l (7/12/89), and all other recorded DO values were >= 7.0 mg/l.

As discussed above, PIB does not exhibit any of the classic symptoms of cultural eutrophication. No nuisance algal blooms, benthic oxygen depletion, or decreased water clarity problems are evident. Consequently, no impairment of this guideline is indicated or concluded.

4.1.1.9 Restrictions on Drinking Water Consumption, or Taste and Odor Problems

> "When treated drinking water supplies are impacted to the extent that: 1) densities of disease-causing organisms or concentrations of hazardous or toxic chemicals or radioactive substances exceed human health standards, objectives or guidelines; 2) taste and odor problems are present; or 3) treatment needed to make raw water suitable for drinking is beyond the standard treatment used in comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection)."

PIB is not used as a source of drinking water. Potable water for the City of Erie and Presque Isle is drawn from Lake Erie, through two intakes northwest of the peninsula (see Chapter 3). These intakes are on the opposite side of the peninsula from the PIB outlet, and normal lake currents are toward the east, which would carry any contaminants discharged from PIB in the opposite direction from the water intakes.

Treatment consists primarily of filtration, for the removal of suspended solids (a coagulant increases settling efficiency), followed by chlorination for bacterial control. During certain times of the year, activated carbon and potassium permanganate are added for taste and odor control.

The City does not experience any problems meeting drinking water standards, and is not required to provide a level of treatment which exceeds the standard practices used in other Lake Erie locations. Because PIB is not used as a source of drinking water, and because no indication of any problems in the City's drinking water supplies is apparent, no impairment of this beneficial use is indicated.

4.1.1.10 Beach Closings

> "When waters, which are commonly used for total-body contact or partial-body contact recreation, exceed standards, objectives, or guidelines for such use."

As discussed in Chapter 3, water contact recreation is a designated and protected use for most of PIB. This use is not protected for the navigational channel, or that portion of the Bay north of the public dock which is identified on navigational charts as the "inner basin" and/or "harbor basin" (see Figure 4.5).

Water contact recreation may include total-body contact activities such as swimming, sail boarding, and water skiing, or partial-body contact activities such as boating and fishing. PIB is not extensively used for swimming, for two primary reasons. First, no public beaches exist within the Bay, and swimming is prohibited within 500 feet of the shoreline within the jurisdiction of Presque Isle State Park. Second, 11 guarded public beaches are maintained along the Lake Erie margin of the peninsula (Beach 11 is located in the outer harbor). However, the Bay is heavily used for sail boarding, water skiing, boating, and fishing (water skiing is prohibited within 500 feet of the shoreline within the jurisdiction of the Park). Therefore, PIB is commonly used for water contact recreational activities.

Based on the water contact recreation protected use, the applicable standard is bacteriological, defined in DER's Water Quality Standards (Chapter 93, §93.7) as follows:

> "During the swimming season (May 1 through September 30), the maximum fecal coliform level shall be a

geometric mean of 200 per 100 milliliters (ml) based on five consecutive samples each sample collected on different days; for the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2,000 per 100 milliliters (ml) based on five consecutive samples collected on different days."

In addition to the geometric mean standard, water contact recreation is considered to be impaired when any single fecal coliform count exceeds 1,000/100 ml (ECDH, 1990a).

In 1985, the DER conducted a detailed review of water quality conditions in PIB for the express purpose of determining if conditions were appropriate for designation of water contact recreation as a protected use for the Bay (PADER 1986a). Prior to the 1985 DER study, water contact recreation was not an intended or protected use of PIB, reflecting the degraded water quality conditions which existed in the Bay in the 1970s and into the early 1980s. The DER review included evaluation of fecal coliform data collected from 11 PIB locations. Five of these 11 stations were sampled by the DER, over a five-consecutive-day period during the 1985 swimming season. These data were compared with the 200 fecal coliforms/100 ml standard.

Two of the 11 PIB stations were sampled by the City of Erie's Bureau of Sewers, and the remaining five stations were sampled by the ECDH. The Bureau of Sewers samples were collected on six non-consecutive days during the 1985 swimming season. Because these data were collected on non-consecutive days, they should be compared with only the 1,000 fecal coliforms/100 ml single-measurement standard, however a geometric mean of these data was also calculated for comparison with the 200 fecal coliforms/100 ml standard. The ECDH samples were collected during the 1984 and 1985 swimming seasons. While these samples were individual measurements, and no geometric means could be developed, the sample results were also compared with geometric mean standard (this is a conservative approach, in that the geometric mean standard is much lower than the instantaneous measurement standard, which would be the applicable criterion).

Results of the 1984-1985 PIB fecal coliform sampling efforts are depicted in Table 4.18. The corresponding sampling locations are depicted in Figure 4.4. As represented in Table 4.18, no violations of either the geometric mean or single measurement standards occurred in sampling locations 1-5 or 13-16. The two sampling locations where violations were observed were at the mouth of Mill Creek (location #7) and at the exit of the Bay at the navigational channel (location #8). These locations reflect the CSO discharges to Mill Creek.

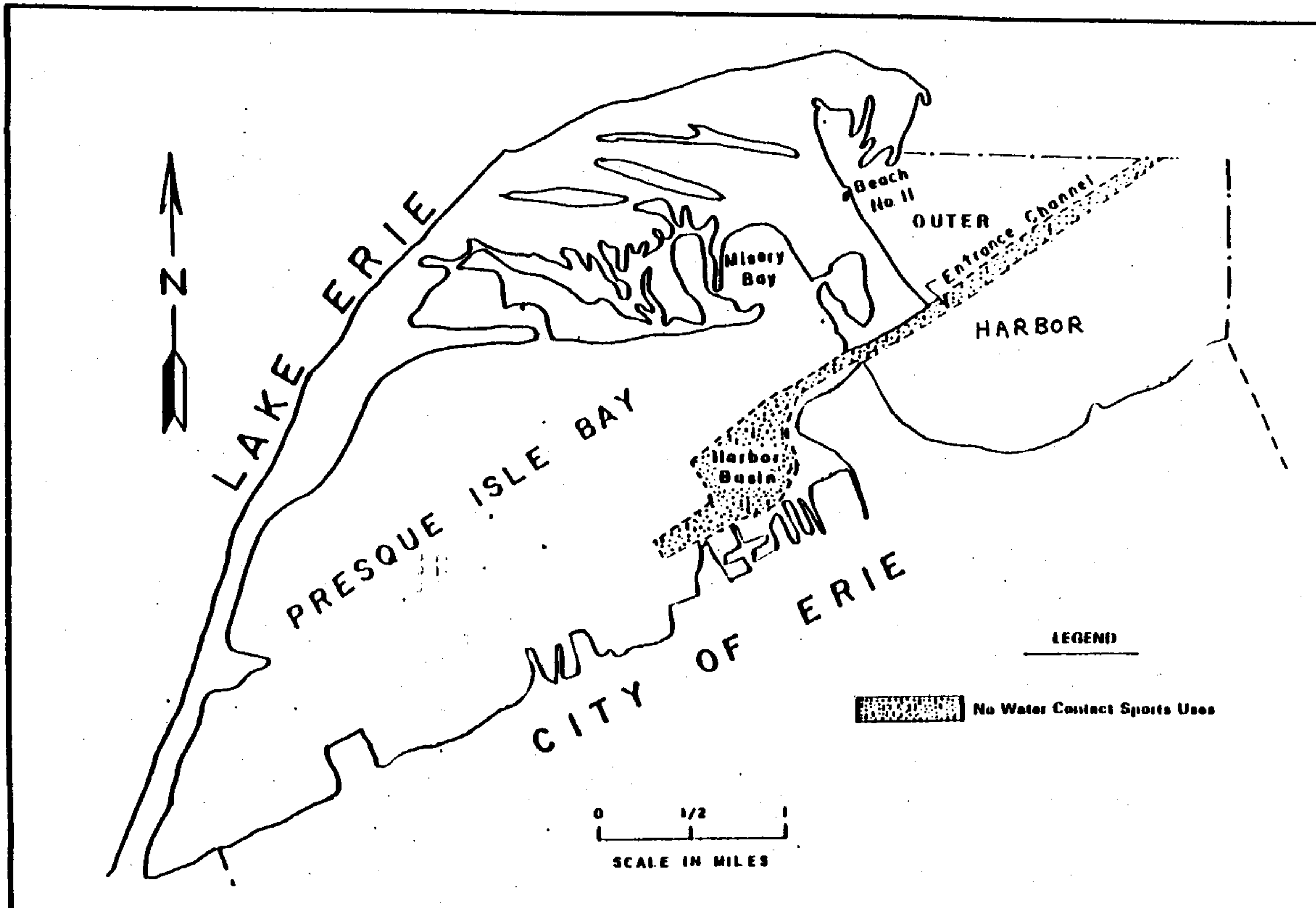


Figure 4.5. Delineation of recommended (1986) water contact recreation use area within PIB (from PADER, 1986a).

Table 4.18. 1984-1985 PIB fecal coliform sampling data.

Sampling Location	Sample Numbers and Numbers of Fecal Coliform Colonies/100 ml						Geometric Mean[(1)]
	1	2	3	4	5	6	
1	3	1	1	2	78	-	3
2	3	2	1	0	1	-	2
3	7	0	1	1	0	-	2
4	3	1	0	0	0	-	2
5	50	23	23	148	20	-	38
7	1,400	2,200	1,500	60,000	2,900	2,600	4,313[(2)]
8	720	150	1,070	4,000	32	360	375[(2)]
13-16	#13: <10	#14: <10	#15: 80	#16a: <10	#16b: <10	-	-[(3)]

(1) Sampling dates are September 16-20, 1985 for sampling locations 1-5; for locations 7 and 8, the dates are May 29, July 11 and 24, and August 1, 14, and 22, 1985; dates for locations 13-16 are 7/25/85 for #13, 5/15/84 for #14, 5/7/84 for #15, and 5/15 and 25/84 for #16a and 16b (two samples were recorded from location 16).

(2) The geometric means for sampling locations 7, 8 and 10 are based on the last five dates (sample numbers 2-6).

(3) No geometric mean is possible, as only one samples is available from each location (two samples were collected at location #16).

Table 4-20. PIB ambient water quality data vs industrial water supply criteria (all values in mg/l).

Parameter	Number of samples	Average	Maximum	Criteria
residue	4	161	176	500 ave. (max. 750)
nitrate & nitrite	22	0.05	0.13	10
chloride	4	18.25	21	250
sulfate	23	28.79	53	250
iron	22	0.227	0.672	1.5
manganese	22	0.037	0.100	1.0

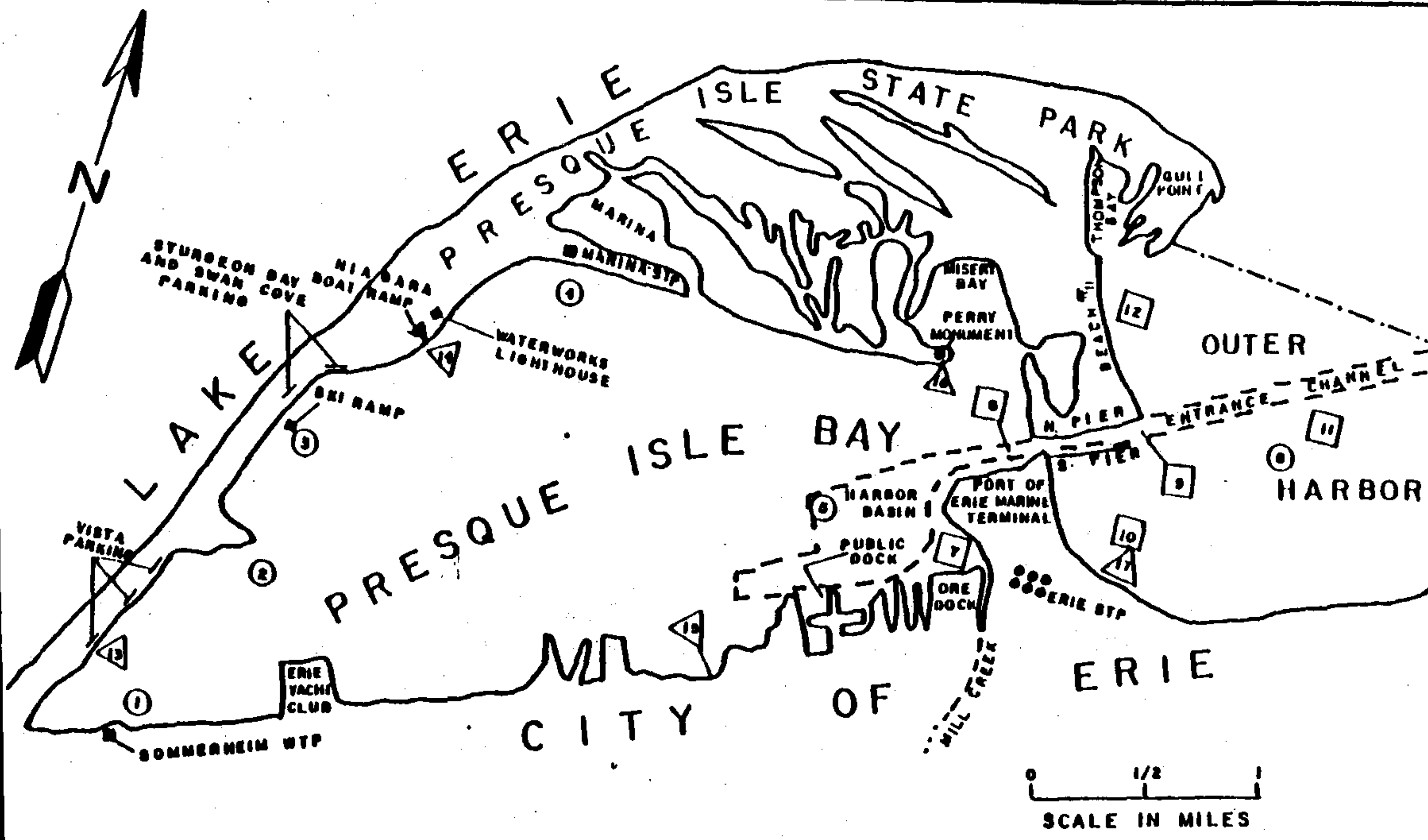


Figure 4.4. Locations of 1984-1985 PIB fecal coliform sampling sites (from PADER, 1986a).

(1) — (6) PADER sampling sites (september 16-20, 1985).

[7] — [12] Erie Bureau of Sewers sampling sites (May 29-August 22, 1985)

△13 — △17 Erie County Dept. of Health sampling sites (May, 1984-August, 1985)

Based on the results of the 1985 survey, the DER added water contact recreation to the protected uses of PIB. Recognizing the dangers to water contact sports from commercial traffic in the harbor basin and navigational channel, water contact recreation was not designated as a protected use in this portion of the Bay.

Fecal coliform data from 1984 and 1985 indicated that PIB met the applicable standards for the protection of water contact recreation. Another intensive fecal coliform sampling effort on PIB was completed by the ECDH in 1990. The results of this sampling are provided in Table 4.19 (ECDH, 1990). Sampling sites from which the Table 4.19 data were collected are depicted in Figure 4.6. These locations represent those PIB locations where shore-based water contact recreation activities are most likely to occur (i.e. sites where water access is readily available from the shore). Consequently, these sites are highly relevant locations to act as indicators of the suitability of PIB for water contact recreational use.

Based on the 1990 ECDH data, as well as the findings of the 1985 DER review, no major impairment of the water contact recreation designated use of PIB exists, but there is limited impairment at the mouth of the Mill Creek Tube and possibly at other creek and stormwater inputs to the Bay. Since there is some use of these areas, albeit illegal, for water recreation, and therefore a potential health concern, this use will be considered partially impaired pending the completion of the City's program to correct CSO's. It will be re-evaluated at that time.

4.1.1.11 Degradation of Aesthetics

> "When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum)."

At certain times, a thin oil film (a surface "sheen") may be observed in the waters of Mill Creek, near its mouth at PIB. However, this effect appears to be limited to the immediate area of the mouth of Mill Creek and is not reported to extend into the Bay for any appreciable distance, or persist for unusual or unanticipated durations. While the sources of this film are not well defined, this effect is typical of urban runoff, and the degree or extent of the Mill Creek phenomenon does not appear to be unusual or atypical for urban settings.

During and following rainfall events, turbid runoff is discharged to the Bay from tributaries in the watershed, including Mill Creek, Cascade Creek, and smaller streams, as well as CSOs and

Table 4.19. 1990 PIB fecal coliform sample results.

Sampling Date	Sample Sites and Results (fecal coliforms/100 ml)				
	1	2	3	4	5
5/9/90	70	<10	20	<10	1,000
5/15/90	70	<10	10	<10	20
5/22/90	20	10	30	<10	40
5/30/90	- -	<10	<10	10	80
5/31/90	<10	- -	- -	- -	- -
6/1/90	10	- -	- -	- -	- -
6/6/90	160	30	120	<10	10
6/13/90	250	10	50	<10	<10
6/28/90	300	40	<10	20	10
7/3/90	20	100	<10	20	20
7/11/90	300	<10	20	10	10
7/18/90	- -	<10	20	<10	<10
7/25/90	20	<10	<10	<10	10
8/1/90	110	<10	<10	<10	<10
8/8/90	110	<10	20	20	50
8/15/90	100	<10	60	<10	50
8/21/90	70	- -	30	- -	- -
8/22/90	40	50	10	70	<10
8/22/90	50	- -	<10	20	<10
Geometric means	53.5	3.8	8.4	3.7	10.8

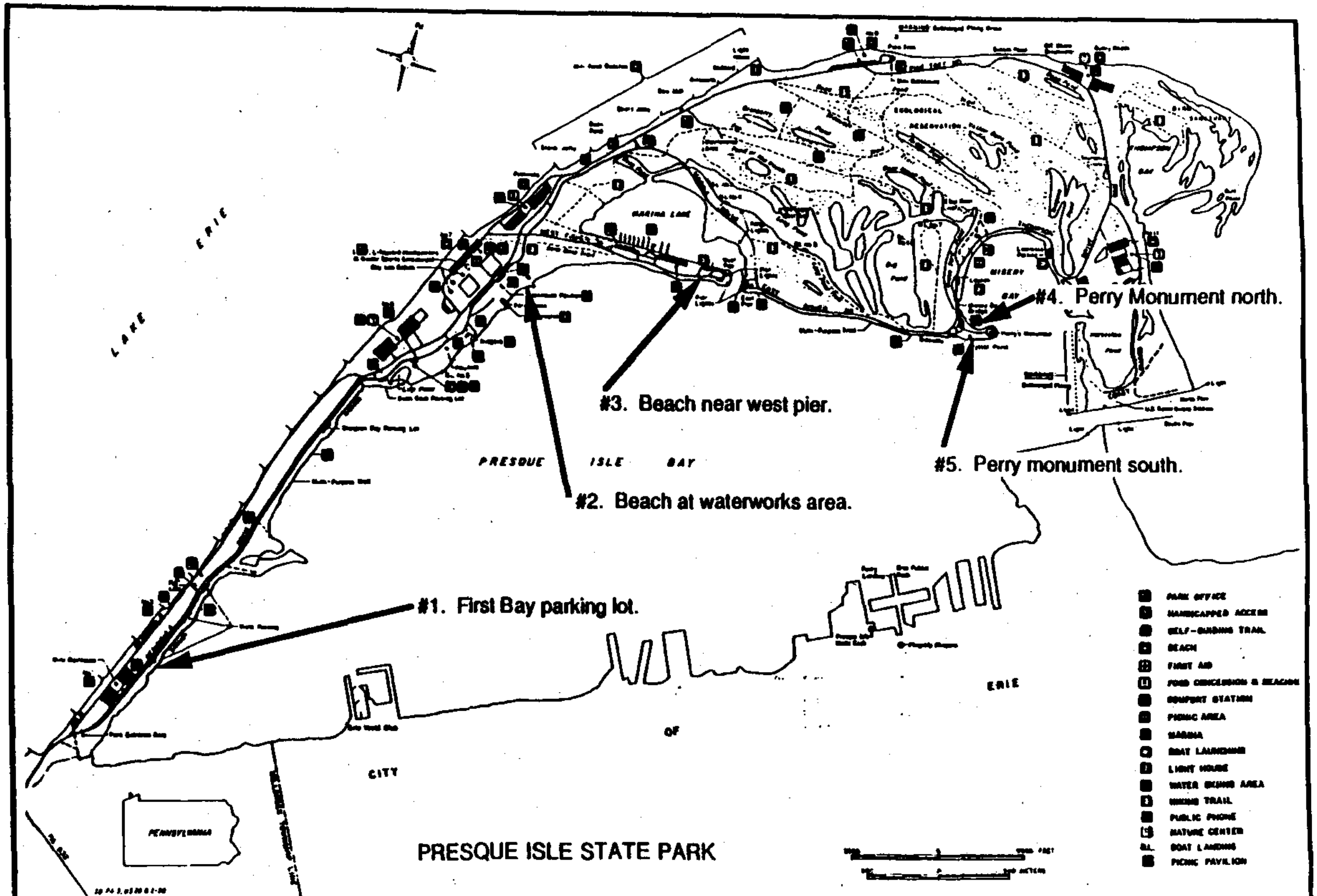


Figure 4.6. Locations of ECDH 1990 fecal coliform sampling sites in PIB (adapted from ECDH, 1990b).

storm sewers. It is reported that a plume of more turbid water may sometimes be observed in the Bay following rainfall events, originating in the central harbor basin (near the mouth of Mill Creek) and exiting the Bay through the navigational channel. Such turbidity results from sediment carried into the Bay from erosional processes in the watershed. While the rates of natural erosion are accelerated by urban development, the periodic presence of nearshore turbidity following rainfall events is not unusual for an urban setting. There is no indication that the observed turbidity along the urbanized south shore of PIB is unusually severe or persistent, or otherwise atypical.

At the mouths of Mill Creek, Cascade Creek and various storm sewers, various man-made objects (which can generally be categorized as trash, debris, or junk) may be observed, ranging from pieces of discarded furniture to empty food containers (bottles, cans, and the ubiquitous fast food packaging materials). These objects, which are often referred to as "floatables", are common components of urban runoff. The distribution of floatables appears to be concentrated in the urbanized south shore of PIB, from which they originate, and is apparently not a significant aesthetics issue in the Bay in general.

As noted above, the south shoreline of the Bay and the central basin are impacted by periodic incidences of turbid water and floating debris of urban origin, and a surface sheen is frequently visible in the mouth of Mill Creek. However, the extent or severity of these problems is apparently not atypical of, or unusually severe for, an urbanized watershed, and is an unfortunate but natural consequence of urban runoff. The increased turbidity results from erosional processes in the watershed and does not persist for unusually long periods following rainfall events. Generally, these aesthetics problems (1) occur in industrial/commercial areas of naturally limited aesthetics, (2) are localized in their extent, and (3) are directly related to runoff episodes and are not unusually persistent. No other evidence of unnatural or persistent discoloration of the water, or other sources of aesthetic impairment are known to occur. From the perspective of the overall PIB resource, which offers unique visual amenities, these localized problems are not considered to be significant and this beneficial use of the Bay is not considered to be impaired.

4.1.1.12 Added Costs to Agriculture or Industry

> "When there are additional costs required to treat the water prior to use for agricultural purposes (i.e. including, but not limited to, livestock watering, irrigation and crop spraying) or industrial purposes (i.e.

intended for commercial or industrial applications and noncontact food processing)."

With the closing of the Pennelec generating station, PIB is not used extensively for industrial, commercial, or agricultural water supplies. However, it is reported that one small industrial user continues to use water from PIB for process water (Vogel, 1991). This user, Quin-T, occupies an old GAF plant near the intersection of 16th and French streets and manufactures asbestos gaskets and related products. Water is pumped to the plant from an intake near the Litton docks. At the plant, the water is allowed to gravity settle; clear water is used in the manufacturing process, and the settleable solids are discharged to the City sewer. No water treatment processes or additional costs are required, and no impairment of this listing guideline is indicated.

Industrial water supply is a protected use in PIB. Pennsylvania water quality criteria and standards for this use are promulgated in Title 25, Chapter 93 of the Pennsylvania Code. Criteria exist for coliforms, chloride, color, fluoride, iron, manganese, nitrate plus nitrite, phenolics, sulfate, and total dissolved solids (residue). Water quality data for WQN 632 for the period 1985-1990 were retrieved from STORET for comparison with these criteria.

STORET data were available for seven of the 10 parameters for which water quality standards for industrial water supply exist. A brief summary of the STORET data is provided in Table 4-20 for six of these seven parameters. Data for the seventh parameter, coliform bacteria, are summarized and discussed in previous §4.1.1.10 and are not repeated here (no violations of the 5,000/100 ml coliform criterion are indicated). As seen in Table 4-20, no exceedances of the applicable water quality criteria for industrial water supply were indicated in the 1985-1990 STORET data-base.

The results of the water quality data comparison in Table 4-20 confirm that the industrial water supply use of PIB is being met, and no impairment of this AOC listing guideline is indicated or concluded.

4.1.1.13 Degradation of Phytoplankton and Zooplankton Populations

"When phytoplankton or zooplankton community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when relevant, field-validated, phytoplankton or zooplankton

Table 4-20. PIB ambient water quality data vs industrial water supply criteria (all values in mg/l).

Parameter	Number of samples	Average	Maximum	Criteria
residue	4	161	176	500 ave. (max. 750)
nitrate & nitrite	22	0.05	0.13	10
chloride	4	18.25	21	250
sulfate	23	28.79	53	250
iron	22	0.227	0.672	1.5
manganese	22	0.037	0.100	1.0

bioassays (e.g. Ceriodaphnia; algal fractionation bioassays) with appropriate quality assurance/quality controls confirm toxicity in ambient waters."

This AOC listing guideline contains two tests. The first is whether the resident phytoplankton or zooplankton community structure is significantly different from unimpacted control sites. A second or alternate test is whether bioassays have confirmed that ambient waters are toxic to phytoplankton or zooplankton. Each of these tests are addressed separately in the following discussions.

4.1.1.13.1 Phytoplankton/Zooplankton Community Structure

Few studies are known to exist which describe the structure of the PIB phytoplankton and zooplankton community. The primary known references (Zagorski and O'Toole, 1970; Penelec, 1973) are approximately two decades old, and can no longer be considered representative of current conditions in PIB.

In addition to the relative age of the available PIB phytoplankton/ zooplankton data, another significant problem in applying this test is the difficulty in identifying another site with "comparable physical and chemical characteristics". In a recent attempt to assess the structure of the PIB macrobenthos community, it was concluded that the physical conditions of PIB are so unique along the southern shore of Lake Erie that no fully-comparable site exists (Campbell, 1991). The nearest physically-comparable site would be so removed, geographically, so as to no longer be chemically-comparable.

A third complicating factor is the recent appearance of large populations of the zebra mussel (Dreissena polymorpha) in PIB. The zebra mussel is an effective filter-feeder, and may remove large numbers of plankton from the water column. Investigators have speculated that recent increases in the water clarity (transparency) of PIB may be the result of the feeding habits of the zebra mussel (PADER, 1991). Therefore, in addition to the requirement that an "unimpacted control site" would have to be both chemically and physically similar, any such site would also have to exhibit a comparable water-volume-to-zebra-mussel-density ratio to negate any bias introduced by the presence of large populations of a filter-feeder within the nearly-enclosed PIB system.

In summary, no current data are known to exist which describe the community structure of the phytoplankton and zooplankton populations of PIB. Further, even if such data were available, significant problems would be encountered in identifying an unimpacted control site for comparison.

4.1.1.13.2 Phytoplankton/Zooplankton Bioassays

This is the second of the two tests in this AOC listing guideline. In this test, impairment is demonstrated when reliable bioassays have demonstrated ambient water column toxicity to phytoplankton or zooplankton test species. No such test results are known to exist. The closest such information available is from bioassays of sediment toxicity, performed for the COE in 1982 and 1986 (COE, 1982; COE, 1986a).

The COE bioassay test results have been previously described, in §4.1.1.3. Because these tests were on sediment rather than water column toxicity, no direct comparison of the COE bioassay results with this AOC listing guideline is possible. However, given the lack of any ambient water column toxicity test data, the sediment toxicity test data are reviewed here as anecdotal indications of possible water column toxicity problems (i.e. if the sediments are toxic to zooplankton or phytoplankton, it is possible that contaminants may leach from the sediments to the overlying water column in sufficient concentrations to cause water column toxicity).

The copepod *Daphnia magna* (a planktonic crustacean) was the test organism used in the COE sediment toxicity bioassays. Results of the 1982 and 1986 *Daphnia magna* bioassay studies are summarized in Table 4.10 (see §4.1.1.3). These results indicated that PIB sediments were found to range from "nonpolluted" to "moderately polluted" with regard to *Daphnia magna* in the 1982 study, and "moderately polluted" in the more recent, 1986 study (mortality rates ranged from essentially zero to 32% in 1982, and from 18 to 45% in 1986).

However, it may also be seen in Table 4.10 that comparable mortality (22 to 38%) was also observed in the open lake reference site (#16) in both studies. This site was used as a local control, and is not suspected of being contaminated. Consequently, whatever agent(s) is causing the observed PIB sediment toxicity apparently also exists in unimpacted areas of the lake, and the observed toxicity cannot be concluded to be strictly AOC-related issue (i.e. is not due to a cause solely within the AOC watershed).

It was noted in §4.1.1.3 that the high fisheries productivity of PIB (including the high rate of reproductive success of indigenous forage species as well as the high survival rate of stocked fry) is an indication that no significant sediment of water column toxicity to fish is occurring. In fact, sediment bioassays revealed no significant toxicity to a test fish species. It might be argued that the high natural rate of fisheries productivity in PIB is a clear indication of the existence of healthy populations of those organisms which form the foundation of the aquatic food pyramid (plankton and macroinvertebrates), and that potential water column toxicity to planktonic species is inferentially discounted. However, the high populations of benthic macroinvertebrates in PIB might provide an effective, alternate food source for resident fish species, and a diminished planktonic community may actually exist, but might therefore not be apparent. Consequently, the high fisheries productivity of PIB cannot be interpreted as a reliable indicator of a healthy planktonic community.

4.1.1.13.3 Summary and Conclusions

No current descriptive studies of PIB phytoplankton or zooplankton community structure are known to exist (the primary known sources of such information are approximately two decades old and are no longer relevant). Further, because of the unique nature of PIB, it would be very difficult to impossible to identify a truly comparable control site even if such data were developed. Consequently, it is not possible to apply the first of the two tests comprising this AOC listing guideline (i.e. phytoplankton/zooplankton community structure diverges significantly from unimpacted control sites of comparable physical and chemical characteristics).

A second or alternate test in this listing guideline is whether reliable bioassays have confirmed water column toxicity to relevant test organisms. Again, no such data exist, and it is not possible to apply this test either.

In the lack of water column toxicity test results, sediment toxicity test data for *Daphnia magna* were reviewed. Although these results are only anecdotal, and cannot be directly applied to this guideline, it is reasoned that significant sediment toxicity may be indicative of the potential for water column toxicity problems, in that sediment contaminants leach to the overlying water column. Although the bioassay results revealed significant levels of toxicity from PIB sediments, these results also indicated that the toxicity of PIB sediments to the zooplankton test organisms is not recognizably different from the toxicity of unimpacted control site sediments to the same species.

In summary, no current data are known to exist with which to apply this AOC listing guideline. However such data, if collected, would be difficult to evaluate because of problems in identifying a truly comparable control site (the feeding habits of the zebra mussel alone could diminish the PIB planktonic community and bias comparisons). Further, while PIB sediments exhibit significant zooplankton toxicity, comparable toxicity was observed in sediments from an unpolluted lake reference site, indicating that the observed sediment toxicity cannot be concluded to be the result of a cause solely within the PIB watershed. Finally, the existence of a high fisheries productivity in PIB cannot be interpreted as an indication that water column toxicity to phytoplankton or zooplankton is not occurring, due to the very high standing crops of certain benthic macroinvertebrates, which might compensate for a diminished planktonic food supply to fish.

Although indications are that no impacts exist in PIB, no conclusion can be drawn at this time regarding this impairment. The PADER and USEPA will be conducting a plankton bioassay during the summer of 1992 to resolve this issue.

4.1.1.14 Loss of Fish and Wildlife Habitat

> "When fish and wildlife management goals have not been met as a result of loss of fish and wildlife habitat due to a perturbation in the physical, chemical, or biological integrity of the Boundary Waters, including wetlands."

"Boundary Waters" are defined in the 1909 Boundary Waters Treaty and include those Great Lakes waterbodies through which a U. S./Canada international boundary passes. Therefore Lake Erie is, by definition, Boundary Waters. The IJC interprets any waters which are directly connected to Boundary Waters (including wetlands, embayments, etc.) to also meet the test of Boundary Waters. Consequently, this AOC listing guideline applies to PIB.

This listing guideline includes elements of several earlier guidelines which individually focused on the physical, chemical, or biological integrity of the AOC. However the focus of this guideline is on any potential inability to realize fish and wildlife management goals, as the result of diminished fish and wildlife habitat caused by pollution or other impacts on the AOC.

The PFC is the only identified agency which is involved in setting fish and wildlife management goals for PIB. As discussed in §4.1.1.3, PIB is managed as a sport fishery. The PFC conducts periodic assessments of the quality and vitality of PIB fish populations, for the purposes of identifying any problems in the structure of the fish communities and evaluating the need for alternative management practices. The two most recent evaluations were performed in 1982 and 1986-1987; the next evaluation is scheduled to be performed in 1992.

The 1982 and 1986-87 assessments concluded that PIB is an exceptional, very diverse and high quality fishery, which supports and sustains extremely high fishing pressure. The PIB fishery was found to support "quality populations" of a variety of panfish and warmwater/coldwater game species, as well as high populations of minnows and other species of smaller fish which provide food for the game fish populations.

In summary, the PFC maintains PIB as a sport fishery. These goals are being met; PIB offers exceptional sport fishing opportunities, and no impairment of this use is indicated. Even so, habitat enhancements will be considered where possible and practical, and included in the RAP.

4.1.2 Use Attainability Considerations

The Pennsylvania water quality management process is based on the Federal Clean Water Act (CWA; 33 U.S.C.A. §§1251-1387), which requires that all waters achieve "fishable/swimmable" use objectives wherever possible. All State water quality goals, objectives, and standards are oriented toward improving and maintaining water quality at levels sufficient to support the fishable/swimmable goals of the CWA. In Pennsylvania, as in other States, water quality standards are set at levels necessary to protect the specified or "designated" uses of each waterbody within the State's jurisdiction.

Section 303(c) of the CWA requires that States periodically (at least one every three years) review the existing standards for all waters, and to upgrade use designations/criteria/standards as appropriate. However, the CWA implementing regulations recognize that it may not be possible to attain certain beneficial uses in all waterbodies, due to physical limitations or socioeconomic considerations (40 CFR §131.10(g)). Consequently, in certain waterbodies (or portions thereof), States may designate and protect uses which are less than the full fishable/swimmable goals of the CWA, after conducting a "use attainability" analysis.

The DER conducted a detailed review of the designated uses and protective standards for PIB in 1986 (PADER, 1986). This "Priority Water Body Survey" was necessary because, prior to 1986, water contact recreation (the "swimmable" portion of the CWA's overall fishable/swimmable goals) was not a protected (designated) use for the Bay. This survey concluded that ambient water quality and other physical conditions in the Bay had improved to the extent that water contact recreation should be added to the designated uses for PIB (see §4.1.1.10). In completing this survey, however, the DER recognized that it would not be possible, as a practical matter, to achieve water contact recreation uses in all portions of PIB, as a result of certain physical and socioeconomic considerations.

Specifically, the DER survey concluded that water contact recreational uses could not (or should not) be attained in that portion of the PIB in the harbor basin and entrance channel, due to commercial shipping traffic. The area in which water contact uses are restricted is depicted in Figure 4.5 (see §4.1.1.10).

The physical limitations are, from a practical perspective, irreversible constraints on the attainment of water contact recreational uses in the affected portion of PIB. Consequently, there is no expectation that such uses will be attainable in all portions of PIB, and no attempt to establish these uses in such areas is appropriate.

In summary, the CWA requires that, as a general goal, all waters of the U. S. be suitable for swimmable/fishable beneficial uses, and requires States to establish suitable water quality standards to attain and protect such uses. However, the Act also recognizes that such uses are not attainable in certain waters, because of irreversible changes in the physical condition of the waterway and its banks, or because of other socioeconomic limitations. The DER has conducted a use attainability analysis of PIB, for the purposes of determining if the Bay is capable of supporting water contact recreation. As a result of this survey, the DER has concluded that all appropriate portions of the Bay are supporting the full fishable/swimmable goals of the Act, and has exempted a portion of the Bay because of conflicting uses and other irreversible limitations preventing the attainment of water contact uses in this area.

4.1.3 Other Concerns

At various places in the impaired uses evaluations, an impairment was determined not to exist if certain applicable standards or guidelines were not exceeded (this was particularly true for the FDA fish flesh contamination guidelines in §4.1.1.1). Because such guidelines and standards are the result of an often cumbersome governmental regulatory process, they are not always up-to-date and do not always reflect the most current information and knowledge on chronic exposure health effects. For this reason, in addition to comparisons with such guidelines and standards, PIB data have also been compared with Lake Erie data (where applicable), to analyze for contaminant levels significantly in excess of "background" levels. While it may be argued that current scientific information suggests that such "background" levels nevertheless contain a risk to human health and aquatic life, such issues are lakewide planning issues rather than an AOC-specific issues.

The RAP process is intended to restore environmental conditions in AOCs to levels which ensure that the AOC users are not subjected to unusual health risks resulting from normal uses of the AOC. In practice, this unusual health risk exposure test is generally accomplished by comparing AOC contaminant levels with those of "background" levels. For example, four of the 14 AOC listing guidelines include specific comparisons of AOC conditions with unimpacted/control/background conditions. Also, five additional guidelines include comparisons with standards, objectives, or guidelines. Such standards are based on a public health risk management approach, in which the standards are set at risk levels which exceed zero, but are determined to be acceptable through a governmental standards-setting process which balances risks against costs. Consequently, these standards are also approximations of background, rather than zero, risk levels.

4.2 Pollutants of Concern

The overall purpose of the RAP process is to identify those pollutants or other factors which result in impairments of the beneficial uses of an AOC, and to then focus on the reduction or elimination of such pollutants, and on the eventual restoration of such beneficial uses. The 14 AOC listing criteria discussed in §4.1.1 are only guidelines; they are not meant to be all-inclusive, nor are they intended to be static. That is, pollutants of concern may be identified by criteria not specifically included in the 14 current guidelines. Further, in that the 14 current guidelines are based on regulatory standards or comparative background levels, they are dynamic and may change as the standards or background levels change.

A second important aspect of the RAP process is that it encourages the initiation of problem solving (i.e. restoration) activities in parallel with the identification of AOC issues. This process recognizes that it is not necessary to define all ecosystem problems before initiating the problem solving process. It also recognizes that as the initial problems are solved, new problems may become recognizable, whereupon the focus of the RAP may shift toward the newly-recognized problems.

Based on the currently-available information, it not possible to conclusively apply all 14 AOC listing guidelines. However, not all of these listing guidelines contribute toward the identification of pollutants of concern. More importantly, the available information is sufficient to present a reasonably clear indication of the nature of the problems in the AOC. Consequently, it is not necessary to complete additional studies before initiating ecosystem restoration activities in the AOC. While such studies may be necessary to formulate, evaluate, and select the appropriate remedial alternatives, the available information provides a sufficient foundation upon which to initiate the remedial planning process.

PIB pollutants of concern are identified in Table 4-21, on the basis of the evaluations described in §4.1.1 (and the considerations summarized above). The following three sections (pollutants of concern in water quality, sediment, and biota) are derived from this table.

4.2.1 Water Quality

The AOC listing guidelines which involve direct or indirect water quality comparisons and evaluations include numbers 2, 3, 8, 9, 10, 12, and 13. As indicated in Table 4-21, no direct or indirect evidence exists to indicate significant impairment of the water column in PIB, and no water column pollutants of concern are identified.

For several AOC listing guidelines, the existing data are not sufficient to test all parameters. For example, adequate water quality data are available for only two of the 14 taste and odor parameters (guideline #2) for which Pennsylvania water quality standards exist. However, the available data do not indicate the presence of significant problems with these parameters, and all "odor" results (an additional tainting indicator for which there is no corresponding water quality standard) were zero. Further, no reports or other evidence of fish flesh tainting exists. Consequently, no indirect (water quality data) or direct (fish flavor) evidence of the existance of tainting problems exists, and none are suspected.

Most of the AOC listing guidelines include both direct and indirect tests for the presence of problem pollutants, as typified in the example above. In evaluating the available water column data, indirect indicators were evaluated in parallel with the direct (water quality) indicators, particularly where limited water quality data were available. No evidence of significant water column problems resulted from these evaluations, and no water column pollutants of concern were identified.

4.2.2 Sediment

The AOC listing guidelines which involve direct or indirect sediment quality comparisons and evaluations include numbers 3, 6, and 7. No evidence of elevated (i.e. higher than background) sediment toxicity to fish (guideline #3) or benthos (guideline #6) is indicated in the available data. However, in comparison with the USEPA dredged sediment disposal guidelines, PIB sediments are

Table 4-21. Identification ( )ollutants of concern.

	Guideline	Indicated Pollutants	Observations
# 1	Fish and Wildlife Consumption	None	For all regulated pollutants, levels in PIB fish are no different than background.
# 2	Tainting	None	No reports of tainted flesh; no pattern of exceedances of tainting water quality standards.
# 3	Fish and Wildlife Populations	None	Productive, balanced fisheries present; no evidence of water column or sediment toxicity to fish.
# 4	Fish Tumors or Deformities	Possibly PAHs	Liver tumors present; contaminants (e.g. PAHs) suspected of contributing to internal and external abnormalities, but fish flesh levels not elevated; no standards.
# 5	Bird Deformities	None	No reports of reproductive problems or deformities in fish-eating birds.
# 6	Degradation of Benthos	None	Difficulty in interpreting benthic community structure, but PIB sediment toxicity no different than background.
# 7	Restrictions on Dredging	As, Ba; Cd; Cr; Cu; Fe; Pb; Mn; Ni; Zn; COD; TKN; Total P; Cyanide; Oil & Grease; Volatile Solids; Possibly PAHs	All except PAHs chronically exceed USEPA dredged sediment disposal guidelines. No standards for PAHs, but suspected of being elevated.
# 8	Eutrophication	None	No significant cultural eutrophication problems identified.
# 9	Drinking Water	None	PIB not used for drinking water, but would meet standards.
#10	Beach Closings	Fecal Coliforms	PIB meets water contact recreation standards in most areas with exception of Millcreek Tube.
#11	Aesthetics	None	No persistent problems known.
#12	Ag./Industrial Water Supply	None	No added treatment costs; no exceedances of industrial water supply criteria.
#13	Degradation of Phyto/Zooplankton	No Data	No current data on community structure; no current data on water column toxicity.
#14	Loss of Fish and Wildlife Habitat	None	PIB fisheries management goals are being met.

JDR/sn/D54

moderately to heavily contaminated with respect to 10 metals and six other conventional and unconventional pollutants (see Table 4-21).

Although no guidelines or standards exist for sediment PAH levels, PIB sediments exhibit elevated levels of a wide variety of PAHs, which are also suspected to be sediment pollutants of concern. Other organics (pesticides, PCBs, etc.) were not different from background levels and are not indicated or suspected of being sediment pollutants of concern.

4.2.3 Biota

The AOC listing guidelines which involve direct or indirect biota comparisons and evaluations include numbers 1, 2, 3, 4, 5, 6, 13, and 14. From a public health perspective, the most significant of these guidelines is #1; fish and wildlife consumption. For all regulated fish flesh contaminants, no violations of the FDA Action Levels are indicated in the available data, and contaminant levels in PIB fish are no different than background (Lake Erie) levels.

No direct indication of biota contamination exists in the available data. No evidence of fish flesh tainting (guideline #2) exists, and toxicity testing has failed to indicate evidence of sediment or water column toxicity to fish (guideline #3). Although PAHs are suspected of being a sediment pollutant of concern (see above), PAH levels in PIB fish were not unusually high, compared with a national database (see §4.1.1.4). However, fish researchers implicate PAHs as a possible contributing factor in the chronic condition of external sores/lesions in PIB brown bullheads. Consequently, PAHs are considered a contaminant of concern for fish, even though there is no direct evidence of PAH contamination of fish flesh.

No evidence of reproductive problems or other deformities is reported from decades of observations of fish-eating birds on Presque Isle (guideline #5), and sediment toxicity to benthic test species (guideline #6) is no different than background levels. Data are insufficient to assess the possibility for water column toxicity to phytoplankton or zooplankton (guideline #13), however the very high fisheries productivity of PIB suggests a healthy community structure of phytoplankton/zooplankton species, which are at the foundation of the aquatic food chain. Finally, fisheries management goals for PIB (guideline #14) are being met.

4.3 Summary

This chapter is the heart, or focal point, of the Remedial Action Plan, in that the identification of (2) impaired beneficial uses and (2) pollutants of concern occur in this chapter. This information is critical to the remainder of the Plan, but especially Chapters 5 and 6 (Pollutant Sources and Pollutant Loadings, respectively), which focus on the pollutants of concern identified in this chapter.

Impaired uses were identified by comparing available data and other information with the 14 use impairment identification guidelines developed by the IJC's Water Quality Board, based on Annex 2 of the 1978 GLWQA. Most of these guidelines are constructed as two-part tests of impairment, containing either/or conditional statements. Often, one part is based on specific, quantifiable measures while the second part is based on more subjective information. In completing the impaired uses evaluations, all relevant data were used, and the determination of whether a particular beneficial use is or is not impaired was based on the most compelling single set of data, or the collective weight of multiple data sets in those instances where no single set was dominant. Generally, data from 1986 and earlier were not used, as such data do not represent current conditions in PIB. The results of the impaired uses evaluations, relative to the 14 IJC guidelines, are summarized below, and in Table 4.22.

Restrictions on Fish and Wildlife Consumption. Impairment of this guideline is indicated if (1) contaminant levels in fish or wildlife exceed current standards, or (2) if public health advisories against the consumption of fish or wildlife exist. The guideline further stipulates that contaminant levels must be due to contaminant input from the watershed.

Reliable, available 1987-1990 data for PIB and Lake Erie fish were compiled and compared against the FDA "Action Levels" for 11 contaminants (or groups of related contaminants), including persistent organic pesticides, mercury, and PCBs. A total of 57 fish fillets data sets were evaluated (22 from PIB and 35 from Lake Erie). As a result of this comparison, it appears that no impairment of the fish consumption AOC listing guideline is determined to exist. First, no violation of current FDA Action Levels is indicated, based on both PIB and Lake Erie fish flesh samples. Second, the concentrations of these monitored contaminants in PIB fish are no different than those of Lake Erie fish in the vicinity of Presque Isle, indicating that concentrations of the FDA-monitored contaminants in the PIB watershed are not greater than background levels in Lake Erie. Finally, while few data exist on wildlife contaminant levels, no impairment of the wildlife consumption AOC listing guideline is indicated. Further fish flesh analysis will be conducted to reach a more conclusive determination on this impairment.

Tainting of Fish and Wildlife Flavor. Impairment of this guideline is indicated if (1) water quality standards for tainting substances are being exceeded, or (2) tainting of fish or wildlife flavor has been determined through surveys. Water quality data for WQN-632 for the period 1985-1990 were examined, and compared with the PADER standards for taste and odor substances. Of the 14 taste and odor parameters in the PADER water quality standards, significant data are available for only copper and zinc. Of the 22 copper and zinc data sets examined, no evidence of chronic violation of the taste and odor standards is indicated for these contaminants. Also, PIB fish samples have been tested for many of the same or similar organic compounds as those 12 other taste and odor parameters for which no comparative data are available, indicating that concentrations of these other parameters in PIB fish are not unusually high, compared with national averages. Therefore, while the available data and information are inadequate to support a complete, strict application of this AOC listing guideline, based on the available water quality criteria comparisons for tainting substances, and the fish flesh contamination testing results, no impairment of this use is implied or concluded.

Degradation of Fish and Wildlife Populations. This use is considered to be impaired when (1) fish and wildlife management programs have identified degraded fish and wildlife populations due to a cause within the watershed, or (2) significant sediment or water column biotoxicity exists. No evidence of degraded terrestrial wildlife populations exists, and fisheries management programs have not identified degraded fish populations due to a cause within the watershed (conversely, the PIB fishery is rated as "exceptional" by the PFC, based on angling success, survival of stocked fish, and population density). Regarding sediment or water column toxicity, no evidence of significant water column biotoxicity exists, and sediment tests have not identified significant biotoxicity.

Fish Tumors or Other Deformities. This guideline is considered to be impaired when (1) the incidence of fish tumors or other deformities exceed rates at unimpacted, control sites, or (2) when surveys have confirmed the presence of liver tumors in more than 2% of the bullhead population. Surveys have demonstrated the existence of liver tumors in PIB bullheads, but the incidence level has not yet been determined. Because liver tumors are considered the best indication of chemical interference, the liver tumor test is the more reliable test of impairment, and indicates that this guideline may be impaired. There are no generally agreed upon background levels of external abnormalities which can be identified as representing "unimpacted control sites", and the observed incidence rates of external abnormalities in PIB bullheads cannot be reliably interpreted. Fisheries researchers hypothesize that the PIB bullheads are being attacked by a naturally-occurring viral agent, but that the susceptibility of the fish to viral attack is increased by chemically-induced environmental stress. In this theory, sediment PAHs are indicated as the possible chemical agents inducing the stress.

Bird or Animal Deformities or Reproduction Problems. This guideline is impaired when surveys confirm the existence of deformities or reproductive problems in wildlife species. While no formal surveys have been conducted, Presque Isle State Park is extensively visited by both amateur "bird watchers" and experienced ornithologists, and the avian populations of Presque Isle are therefore subject to an unusually intense level of observation, at all times of the year. Four key specialists were interviewed to determine if any evidence of deformities had been observed or reported in resident fish-eating birds (or animals) in the Park. In the aggregate, these specialists represent nearly 100 years of collective observations. There are no colonies of nesting birds in the AOC, and no reports or other evidence of deformities or reproductive problems were identified by these specialists. Therefore, this guideline is not impaired.

Degradation of Benthos. This guideline is considered to be impaired when (1) the composition of the benthic macroinvertebrate community is significantly diminished from what would be normal for a comparable, unimpacted site, or (2) macroinvertebrate toxicity from sediment contaminants is higher than unimpacted (control) sites. Because the physical conditions of PIB are so unique along the southern shore of Lake Erie, no fully-comparable site exists, and PIB benthos data cannot be reliably compared to other sites. However, within the Bay, the distribution pattern of pollution sensitive taxa does not correlate well with the pattern of sediment contamination, and the available data suggest that sediment contaminants are not the dominant influence on the PIB benthic community structure, which is fairly typical for an environment of fine, organic-rich sediments. Further, reliable bioassay test results indicate that the toxicity of PIB sediments on benthic macroinvertebrate test species is no different than the sediments at an unimpacted control site, and this guideline is not impaired.

Restrictions on Dredging Activities. This guideline is impaired when sediment contaminant levels exceed current standards. Sediment data from 1982, 1986, and 1990 were compared with the current, applicable standards (the USEPA Region V "guidelines"). This comparison resulted in the conclusion that PIB sediments are moderately to heavily polluted, for most parameters for which standards (i.e. guideline ranges) have been established. Specifically, the sediments were found to be contaminated for 10 metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc), nutrients (phosphorus and total kjeldahl nitrogen), COD, cyanide, oil & grease, and volatile solids. Although no current standards exist for PAHs, sediment levels of this group of contaminants may also be elevated, based on other data and observations (e.g. brown bullhead observations). When the new sediment guidelines are released by USEPA, this impairment will be re-evaluated with that criteria.

Eutrophication or Undesirable Algae. This guideline is considered impaired when there are persistent water quality problems attributable to "cultural eutrophication" (i.e. nutrient enrichment and related problems resulting from urbanization or other human sources of excess nutrients). Based on a recent (1990) trophic state study, PIB does not exhibit any of the classic symptoms of cultural eutrophication. No nuisance algal blooms, benthic oxygen depletion, or decreased water clarity problems are evident, and this guideline is not impaired.

Restrictions on Drinking Water Consumption, or Taste and Odor Problems. This guideline is considered to be impaired when (1) disease-causing or otherwise hazardous materials are present at levels exceeding applicable standards, (2) taste and odor problems exist, or (3) a level of treatment exceeding regional norms is required to adequately treat raw water. Because PIB is not used as a drinking water supply, this guideline is non-applicable. However, in any case, none of these problems exist in the City's water supply, which is drawn from Lake Erie northwest of Presque Isle, and this guideline is not impaired.

Beach Closings. This guideline is considered to be impaired when water quality standards for the protection of full water contact recreational activities (e.g. swimming) are exceeded. Although no public beaches are established in PIB, water contact recreation is a protected use in the Bay. A 1985 study determined that standards for the protection of this use are being met. More recent data (through 1990) indicate that these protective standards continue to be met. Due to concerns about the use of the mouth of the Mill Creek Tube for recreation, this use is considered partially impaired, pending the completion of the City of Erie's CSO correction project, at which time it will be re-evaluated.

Degradation of Aesthetics. This guideline is considered to be impaired when a pollutant in the water results in a persistent, unnatural or objectionable condition. No evidence of unnatural or persistent discoloration of the water, or other sources of aesthetic impairment are known to occur. While turbid conditions exist after periods of heavy runoff, these conditions are natural for an urbanized area and are not persistent. Also, while a surface sheen is occasionally present at the mouth of Mill Creek, and while debris from urban runoff sources is common along portions of the south shore, these conditions are localized and do not significantly impact the Bay. Consequently, this guideline is not impaired.

Added Costs to Agriculture or Industry. This guideline is considered to be impaired when unusual treatment is required for water used for agricultural, industrial, or commercial purposes. With the closing of Penelec, PIB water is used by only one small-quantity user (an industry), which does not require special treatment of PIB water before use (the raw water is allowed to settle before use). Further, industrial water supply is a protected use in PIB, and the available water quality data indicate that the applicable standards for this use are being met. Therefore, this guideline is not impaired.

Degradation of Phytoplankton and Zooplankton Populations. This guideline is considered to be impaired when (1) the resident phytoplankton or zooplankton community structure is significantly different from comparable, unimpacted control sites, or (2) bioassays have confirmed that ambient waters are toxic to phytoplankton or zooplankton. The physical conditions of PIB are so unique along the southern shore of Lake Erie that no fully-comparable site exists for comparison purposes. Secondly, no recent data are available on the PIB phytoplankton or zooplankton community structure. Therefore, bioassay data were researched as the primary test of impairment. However, no reliable bioassay test data for potential water column toxicity exist, and other data and information are inadequate to support an inferred determination. Therefore, while indications are that no impairment exists for this use, a reliable conclusion is not possible for this guideline, and additional studies (i.e. water column biotoxicity testing) are recommended and currently being conducted.

Loss of Fish and Wildlife Habitat. This guideline is considered to be impaired when fish and wildlife management goals have not been met because of a loss of fish and wildlife habitat resulting from changes in the physical, chemical or biological conditions in the waterbody. The PFC manages PIB as a sport fishery, and conducts periodic fisheries assessments to evaluate the quality and quantity of fish stocks. Based on these assessments, the PFC's fisheries management goals are being met, and this guideline is not impaired. Habitat enhancement projects will be encouraged wherever possible and practical.

Based on the impaired uses evaluations, pollutants of concern were identified as including only sediment contaminants. No water column impairments were indicated. Fish impairments (i.e. liver tumors in bullheads), if environmentally caused, are probably related to the sediment contamination. Sixteen pollutants of concern were identified, including arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, zinc, phosphorus, TKN, COD, cyanide, oil & grease, and volatile solids. In addition, although no standards exist for PAHs, sediment levels of these compounds were determined to be somewhat elevated, and sediment PAHs were therefore included as additional pollutants of concern.

5. Pollutant Sources and Transport Mechanisms

The purpose of the previous chapter was to first determine which beneficial uses are impaired in PIB, and then to determine what pollutants are causing the impairment(s). That information is critical to both this chapter (Chapter 5) and the following chapter (Chapter 6).

Use impairments and conflicts with beneficial uses of PIB were described in §4.1. Pollutants of concern were identified in §4.2, based on the use impairments identified in §4.1. The purpose of this chapter is to determine (1) the sources of the pollutants causing the impairments, and (2) the means by which the problem pollutants are transported from their sources to the impact areas.

PIB pollutants of concern are identified in Table 4-21, based on the results of the evaluations conducted in Chapter 4. These pollutants include 10 metals, five conventional/nonconventional pollutants, and (probably) PAHs. These pollutants are determined to be primarily confined to the sediments, and do not appear to be significantly accumulating in (or adversely affecting) biota or the water column, although it is theorized that PAHs may act in association with a naturally-occurring virus to cause the external lesions observed in PIB brown bullheads.

5.1 Primary Sources of Pollutants of Concern

Typically, the primary or major sources of pollutants of concern in AOCs are point source discharges, or other "direct" pollutant inputs. Therefore, NPDES point source discharge files were reviewed to attempt to "spot" candidate sources of the PIB pollutants of concern identified in Chapter 4. Based on this review, five significant NPDES-permitted point sources were identified which discharge directly to PIB, and an additional four permitted point sources were identified which discharge to storm sewers or tributaries within approximately 1.3 miles of the Bay (generally, north of 19th Street, or the Norfolk and Western rail line). These point sources are summarized in Table 5.1; their locations are depicted in Figure 5.1.

In addition, numerous CSOs exist within the City's combined sewer system. These outfalls are individually numbered as point source outfalls in the City's NPDES permit. The locations of the CSO discharge points are depicted in Figure 5.2. As seen in Figure 5.2, the CSOs in the Mill Creek drainage system are fairly well distributed throughout the urbanized portion of the watershed, with some as much as two to three miles upstream from the Bay, while others are located within 0.5 miles of the mouth of Mill Creek. Of the CSOs in the City's sewer system, 47 (84%) discharge directly to

Table 5.1 Summary of significant NPDES-permitted outfalls to PIB.*

Permittee	Discharge Location (longitude/latitude)	Wastewater Source	Effluent Levels	Comments
Pennsylvania Electric Company (Penelec)	• 001: public dock (42°03'24"/80°05'15")	coal pile runoff, ash transport water, low volume wastes	TSS(1): 30/70 mg/l(2) O&G(3): 15/20 mg/l PCBs: not known (special condition 2)(4) pH: 6.0-9.0 flow: estimated 1 mgd	Discharge discontinued in early 1991. Permit expires 12/22/92.
	• 002: public dock; W. slip (42°08'08"/80°05'24") • 003: public dock (42°8'16"/80°5'21")	cooling water from steam electric generation(7)	TSS: 30/70 mg/l O&G: 15/20 mg/l TRC(5): 0.2 mg/l(6) (special condition 1)(4) Temp.: $\leq$°5 F over ambient pH: 6.0-9.0 flow: est. 100 mgd (combined 002/003)	Discharge discontinued in early 1991. Permit expires 12/22/92.
Erie Forge & Steel, Inc.	• 001: Cascade Creek (42°06'37"/80°06'24")	vacuum degassing effluent from ladle refining furnace and steam degasser, and effluent from heat treatment quench operation; ladle refining furnace cooling(7); electric furnace cooling(7); oil quench heat exchanger(7); forge press & miscellaneous area cooling(7)	Currently being established. flow: 0.889 mgd	#s 101, 201, & 301 discharge through 0[illegible] 101-vacuum degassing 201-water quench 301-boiler blowdown Permit expiration date not known.
AND	• 002: Cascade Creek (42°06'32"/80°06'23")	stormwater runoff (estimated at 35,000 gpd)		Outfall 002 is stormwater only. Permit expiration date not known.
National Forge Company	• 003: Drainage Ditch to Cascade Creek (42°06'20"/80°06'59")	refining of steel by an electroslag remelt furnace	Currently being established. flow: 0.07 mgd (0.02 mgd - evaporative cooler flushing; 0.05 mgd - ground dewatering)	Permit expiration date not known.

Table 5.1 Summary of significant NPDE… …rmitted outfalls to PIB (cont.)*

Permittee	Discharge Location (longitude/latitude)	Wastewater Source	Effluent Levels	Comments
nited Erie, Inc.	• 001: storm sewer draining to PIB (42°07'02"/80°05'23")	boiler blowdown and kettle jacket cooling water (0.054 MGD)	TSS: Monitor Only Iron, Total: Monitor Only Aluminum: Monitor Only O&G: 15/30 mg/l Temp.: Monitor Only ph: 6.0-9.0	Permit expires 9/19/9(
yramid Industries, Inc.	• 001: storm sewer discharging to West Branch Cascade Creek (42°06'36"/80°07'23")	contact cooling water from thermo-plastic extrusion of polyethylene and polyvinyl chloride pipe flow: 0.066 MGD design average flow	TSS: 19 mg/l (Max. Daily) O&G: 15/30 mg/l BOD_5: 26 mg/l (Max. Daily) pH: 6.0-9.0	Permit expires 7/14/9(
	• 002: storm sewer discharging to West Branch Cascade Creek (42°06'36"/80°07'23")	Manhole inside building that collects flow from the floor drains.	TSS: Monitor Only O&G: Monitor Only BOD_5: Monitor Only pH: 6.0-9.0	
rick Foundry Company	• 001: Poplar Street storm sewer (42°06'58"/80°05'36") • 002A, 002B: Cherry St. storm sewer (42°06'58"/80°05'36")	foundry non-contact cooling water from cupola wall, air compressor, and shell core machines and storm water runoff (est. annual flow #001 - 0.048; #002 (A&B) - 0.013 mgd)	TSS: Monitor Only Iron: Monitor Only Aluminum: Monitor Only Zinc: Monitor Only Temp.: Monitor Only pH: 6.0-9.0 (All 3 Outfalls)	Permit expires 9/19/9(
hestnut Street Water Treatment Plant	• 001: PIB (42°08'10"/80°05'50")	filter backwash from drinking water filtration	TSS: 30/75 mg/l Iron: 2.0/5.0 mg/l Aluminum: 4.0/10.0 mg/l Manganese: 1.0/2.5 mg/l pH: 6.0-9.0	Permit expires 5/21/9' No longer use this di charge as they convey it to the City sanita system.

Table 5.1 Summary of significant NPDES-permitted outfalls to PIB (cont.)*

Permittee	Discharge Location (longitude/latitude)	Wastewater Source	Effluent Levels	Comments
est Filtration Plant ("Sommerheim")	• 003: PIB (42°06'55"/80°08'40")	filter backwash from drinking water filtration	TSS: 30/75 mg/l Iron: 2.0/5.0 mg/l Aluminum: 4.0/10.0 mg/l Manganese: 1.0/2.5 mg/l pH: 6.0-9.0 flow: 0.5 mgd (mo. ave.)	Permit expires 5/24/95
AF Building Materials Corporation	• 001: PIB via Sassafras Street storm sewer (42°08'02"/80°05'34") • 002: PIB via Sassafras Street storm sewer (42°08'04"/80°05'35") • 003: PIB via Sassafras Street storm sewer (42°08'05"/80°05'36") • 004: PIB via Sassafras Street storm sewer (42°08'09"/80°05'40")	boiler blowdown, stormwater runoff, vacuum pump cooling water(7), and roofing machine cooling water(7)	001: O&G: 15/30 mg/l pH: 6.0-9.0 002: O&G: 15/30 mg/l pH: 6.0-9.0 003: TSS: 21/42 mg/l O&G: 15/30 mg/l pH: 6.0-9.0 flow: .263 mgd (ave. flow) 004: no sampling required (all storm water)	Permit expires 5/14/97 Boiler additives used
ity of Erie CSOs	• various (47) total: PIB and PIB via Mill Creek, Garrison Run, Cascade Creek, and sewer outfalls (see text for locations)	combined sewer overflows (approx. 3.1 mg to PIB during an average storm, from 20 outfalls)	none	Permit expires 10/3/96
resque Isle State Park	• 001: PIB (42°09'30"/80°08'00")	treated sanitary wastewater	BOD_5: 25/50 mg/l TSS: 30/60 mg/l fecal coliforms: 200/100 ml (limits applies May 1 - September 30) pH: 6.0-9.0 flow: 0.0175 mgd (mo. ave.)	Permit expires 8/16/95

*see text for determination of "significant"
(1)total suspended solids
(2)average/maximum
(3)oil and grease
(4)details not known
(5)total residual chlorine
(6)instantaneous maximum
(7)non-contact cooling water

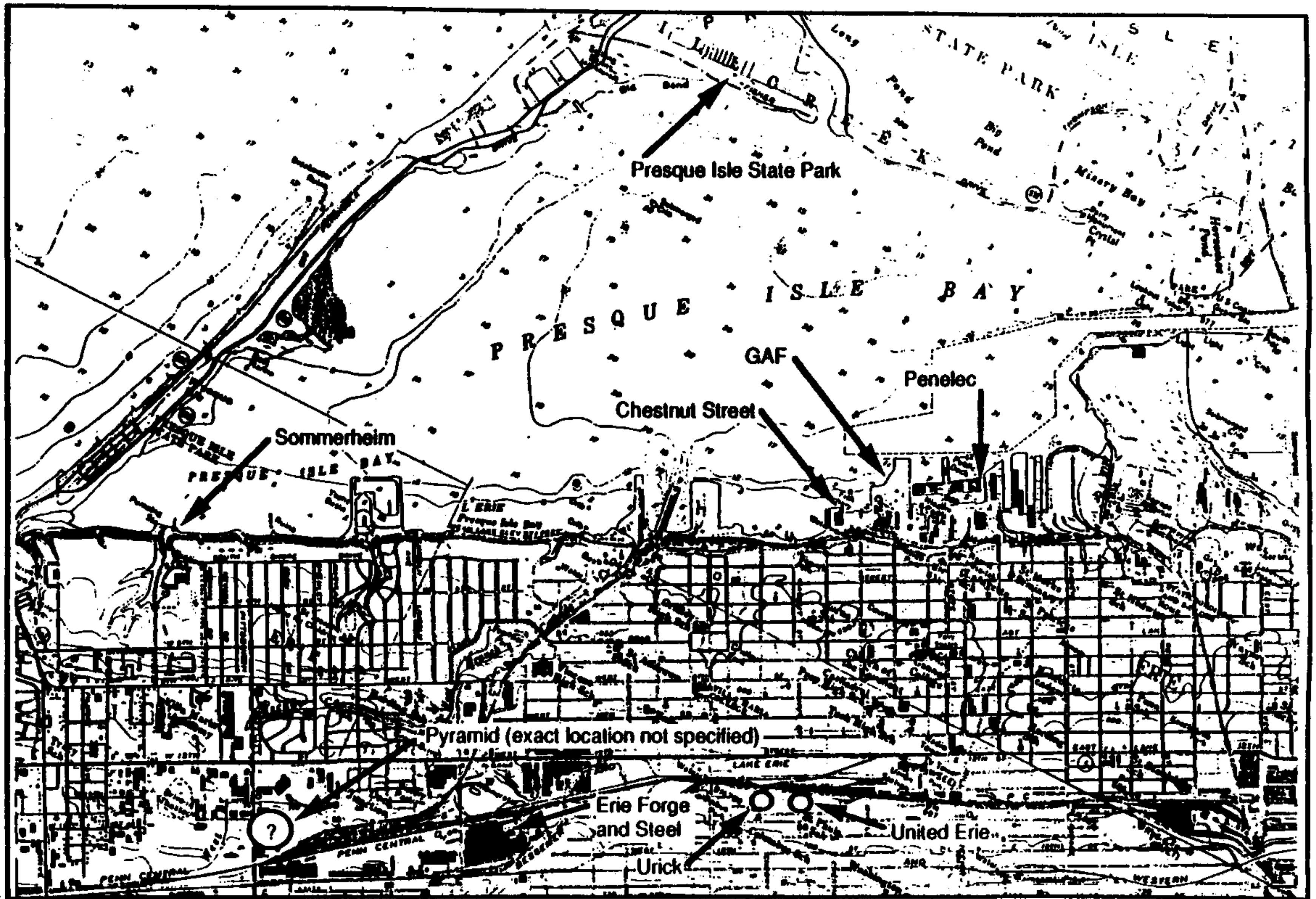


Figure 5.1. Locations of selected NPDES outfalls discharging to PIB.

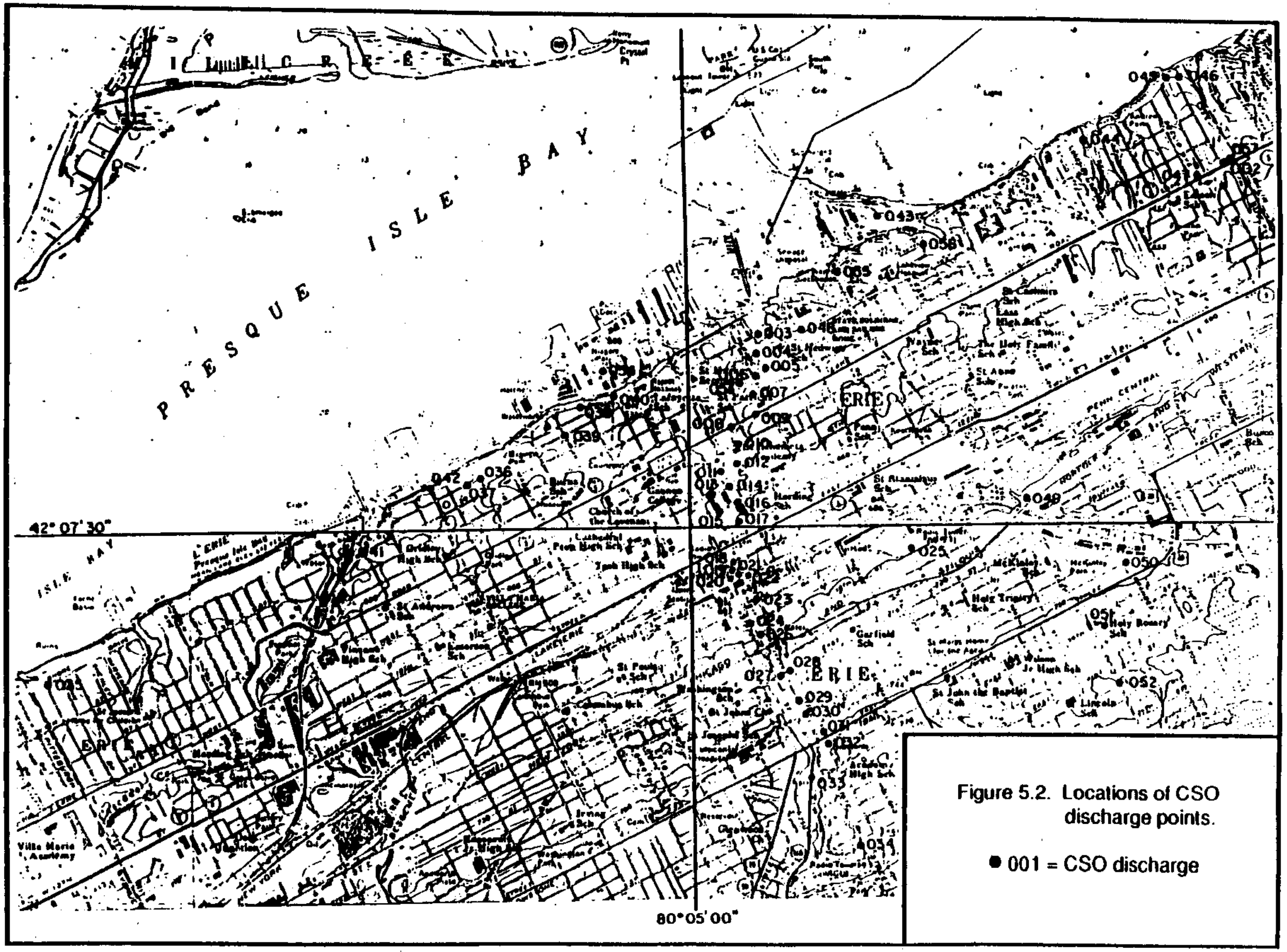


Figure 5.2. Locations of CSO discharge points.

PIB, or indirectly, through streams or sewer outfalls leading to the Bay. These 47 additional point sources are included in summary fashion in Table 5.1. Of the 47 CSOs discharging directly or indirectly to PIB, 38 (81%) discharge to the Mill Creek/Garrison Run drainage system, one discharges to Cascade Creek, and eight discharge to the Bay via small, unnamed tributaries, drainageways, or outfall sewer lines.

The CSOs release raw sanitary sewage to the Bay during overflow events. In addition, because most of Erie's industries discharge their process wastewater to the City's sewer system, untreated industrial effluent is also released through these CSOs. The City's NPDES permit lists 39 industries which contribute >50,000 gallons/day and/or toxic materials to the sewer system. Based on the permit file data, an estimated 18.6 mgd of industrial effluent is discharged to the sewer, on an average daily basis, from these 39 industrial users.

Of the point sources listed in Table 5.1, the largest by far is Penelec, which ceased operations in early 1991. With the exception of the CSOs, the remainder of the point sources in Table 5.1 contribute <1.0 mgd to the Bay. While a significant percentage of the 3.1 million gallons discharged from the CSOs during an average storm is industrial effluent, the City operates an industrial user program, and industrial effluents are therefore primarily limited to those which are amenable to biological treatment (industries are generally prohibited from introducing bioaccumulative or persistent toxics to the sewer system).

A review of the permit limits in Table 5.1 does not result in the identification of any significant candidate sources of the PIB pollutants of concern identified in Chapter 4. In order to examine these point sources more closely, available discharge monitoring data for the pollutants of concern were retrieved from the NPDES permit files. These data are summarized in Table 5.2.

Comparing Tables 5.1 and 5.2, it is seen that monitoring data are not available in the NPDES files for all Table 5.1 direct dischargers. Also, because of inconsistencies in the manner in which data are reported in the files, some of the annual loading values (i.e. "#/year") in Table 5.2 may be significant overestimates. For example, it is not always clear whether the reported monitoring results in the "conc." column are based on (1) the total flow volume for that outfall, or (2) an internal, contributing waste stream of substantially less relative flow volume, which discharges through the same outfall. This potential source of error is most significant for those industries discharging large volumes of non-contact cooling water (e.g. Erie Forge), because the #/year values are the product of flow volume

Table 5.2

Estimated annual pollutant loadings from significant NPDES direct dischargers.

Pollutants of Concern(1)	National Forge Co. (0.07 mgd)		Erie Forge & Steel, Inc. (0.889 mgd)		U.-Erie #001 (0.054 mgd)	
	conc.(2)	#/year	conc.(2)	#/year	conc.(2)	#/year
Arsenic	<0.002	<0.426	<0.002	<5.410	<0.005	<0.820
Barium	0.040	8.520	0.100	270.600	0.025	4.100
Cadmium	<0.005	<1.065	0.00023	0.620	<0.0004	<0.066
Chromium	<0.010	<2.130	<0.010	<27.060	<0.002	<0.329
Copper	0.010	2.130	0.039	105.500	0.010	1.640
Iron	<0.070	<14.920	1.580	4276.000	0.257	42.200
Lead	<0.003	<0.640	0.042	113.700	<0.010	<1.640
Manganese	0.010	2.130	0.070	189.400	0.008	1.320
Nickel	<0.020	<4.260	<0.020	<54.100	<0.002	<0.330
Zinc	<0.017	<3.620	0.258	698.200	0.014	2.300
COD	<6.670	<1421.000	<5.000	<13531.000	<10.000	<1644.000
TKN(4)	--	--	<0.360	<974.000	0.700	115.000
Total Phosphorus	<0.010	<2.130	<0.017	<46.000	0.100	16.400
Cyanide	<0.010	<2.130	<0.010	<27.060	<0.001	<0.160
Oil & Grease	<1.670	<356.000	<2.000	<5412.000	4.600	756.000
Total Volatile Solids	--	--	NT	--	NT	--
PAHs(5)	--	--	ND	--	NT	--

(1)Metals and cyanide are reported as total.
(2)Longest term average concentrations cited used; all concentrations in mg/l.
(3)#/year values were calculated on the basis of the flow values given in the permit.
(4)Values with an (*) are based on total organic nitrogen (TKN value not available).
(5)ND=tested for, but not detected; NT=not tested for.

Table 5.2

Estimated annual pollutant loadings from significant NPDES direct discharges.

Pollutants of Concern(1)	Urick #001 (0.048 mgd)		Urick #002A (0.013 mgd)		Urick #002B (0.00076 mgd)	
	conc.(2)	#/year	conc.(2)	#/year	conc.(2)	#/year(3)
Arsenic	<0.005	<0.730	<0.005	<5.540	<0.005	<0.010
Barium	0.028	4.090	0.027	1.070	0.023	0.050
Cadmium	<0.002	<0.290	<0.002	<2.370	<0.002	<0.005
Chromium	<0.002	<0.290	<0.002	<2.370	<0.002	<0.005
Copper	0.030	4.380	<0.002	<2.370	<0.002	<0.005
Iron	1.420	207.300	1.160	1286.000	<0.004	<0.009
Lead	<0.010	<1.460	<0.010	<11.100	<0.010	<0.020
Manganese	0.019	2.770	0.017	19.000	<0.0004	<0.0009
Nickel	<0.002	<0.290	<0.002	<2.370	<0.002	<0.005
Zinc	0.040	5.840	0.183	202.600	0.082	0.190
COD	12.000	1,752.000	11.000	12189.000	<10.000	<23.000
TKN(4)	1.690	246.700	1.110	1230.000	0.640	1.470
Total Phosphorus	<0.008	<1.170	0.020	22.200	<0.008	<0.018
Cyanide	0.007	1.020	<0.001	<1.190	<0.001	<0.002
Oil & Grease	10.000	1,460.000	8.000	8864.000	7.000	16.100
Total Volatile Solids	NT	--	NT		NT	--
PAHs(5)	NT	--	NT		NT	--

(1)Metals and cyanide are reported as total.
(2)Longest term average concentrations cited used; all concentrations in mg/l.
(3)#/year values were calculated on the basis of the flow values given in the permit.
(4)Values with an (*) are based on total organic nitrogen (TKN value not available).
(5)ND=tested for, but not detected; NT=not tested for.

Table 5.2

Estimated annual pollutant loadings from significant NPDES direct discharges.

Pollutants of Concern(1)	Sommerheim (0.5 mgd)		GAF #003 (0.263 mgd)		
	conc.(2)	#/year	conc.(2)	#/year	
Arsenic	NT	--	<0.005	<4.000	
Barium	NT	--	0.031	24.800	
Cadmium	NT	--	<0.001	<0.800	
Chromium	NT	--	<0.005	<4.000	
Copper	0.014	21.300	<0.002	<1.600	
Iron	0.840	1278.000	2.310	1848.000	
Lead	0.030	45.600	<0.030	<24.000	
Manganese	NT	--	0.083	66.400	
Nickel	NT	--	<0.005	<4.000	
Zinc	NT	--	<0.012	<9.600	
COD	NT	--	16.000	12801.000	
TKN(4)	NT	--	1.510	1208.000	
Total Phosphorus	NT	--	<0.030	<24.000	
Cyanide	NT	--	<0.001	<0.800	
Oil & Grease	NT	--	9.400	7521.000	
Total Volatile Solids	NT	--	NT		
PAHs(5)	NT	--	NT		

(1)Metals and cyanide are reported as total.
(2)Longest term average concentrations cited used; all concentrations in mg/l.
(3)#/year values were calculated on the basis of the flow values given in the permit.
(4)Values with an (*) are based on total organic nitrogen (TKN value not available).
(5)ND=tested for, but not detected; NT=not tested for.

times pollutant concentration. Consequently, the data in Table 5.2 may be considered as worst-case loading estimates, based on the file data.

The 47 CSOs from the City's sewer system are not included in Table 5.2. Because of the discontinuous nature of these discharges and the limited available data, it is not possible to calculate annual pollutant loadings from the 47 individual CSOs. The City of Erie is currently collecting data on the volume and quality of effluent from CSOs, but a final report is not yet available. A summary of preliminary data is included in Appendix C and complete analysis will be provided in the future and included in this RAP as needed. However, a crude estimate of annual pollutants loadings may be calculated from the estimated total overflow volume to PIB, and the characteristics of the wastewater influent at the treatment plant (both of which are known). This approach assumes that (1) the characteristics of the wastewater at that point at which it enters the treatment plant are representative of those characteristics at the individual CSO outfall locations, and (2) the plant influent wastewater characteristics at the time of sample collection are representative of those characteristics prevailing during CSO events.

The total volume of annual CSO discharges to PIB is estimated at 0.7 mgd (PADER, 1991). Based on this flow rate, and the wastewater characteristics data in the NPDES file, annual loadings of the pollutants of concern to PIB from CSOs are estimated in Table 5.3. The NPDES file data used in developing Table 5.3 are reasonably current (5/19/86 PRC lab report to ECHD) and a wide variety of toxic organic pollutants were tested for, in addition to metals and cyanide. The second "Pollutants" column in Table 5.3 includes a variety of the more common PAH compounds, most of which have been reported from the sediments of PIB (FWS, 1991).

As seen in Table 5.3, all of the PAHs were reported as <10 μg/l, which is assumed to have been the detection limit used in the analysis. As a result, all PAHs are estimated at the same annual loading rate (21.28 #/year), which is an obvious overestimation of the true values. In addition to the inorganics (metals), a total of 112 other parameters were tested for in the 1986 data report, comprised primarily of pesticides and other toxic organics. These 112 additional parameters included cyanide, 29 volatile organics, 11 acid-extractable organics, 46 base neutral organics, 18 organic pesticides, and seven PCBs. Of these 112 parameters, 110 (98%) were listed as "<" ("less than") results, indicating their concentrations to be less than the detection limits used in the analytical procedure.

Table 5.3. Estimated annual loading of pollutants of concern from CSOs.

Pollutants	Conc. (mg/l)	Loadings (#/year)	Pollutants	Conc. (µg/l)	Loadings (#/year)
Arsenic	0.005	10.64	Naphthalene	<10	<21.28
Barium	0.008	17.03	Phenanthrene	<10	<21.28
Cadmium	0.024	51.10	Pyrene	<10	<21.28
Chromium	0.124	264.00	Acenaphthene	<10	<21.28
Copper	0.124	264.00	Acenaphthylene	<10	<21.28
Iron	NT	-	Anthracene	<10	<21.28
Lead	0.056	119.23	Benzo[a]anthracene	<10	<21.28
Manganese	NT	-	Benzo[a]pyrene	<10	<21.28
Nickel	0.232	493.94	3,4-Benzofluoranthene	<10	<21.28
Zinc	0.244	519.49	Benzo[ghi]perylene	<10	<21.28
COD	NT	-	Benzo[k]fluoranthene	<10	<21.28
TKN(4)	NT	-	Chrysene	<10	<21.28
Total phosphorus	NT	-	Dibenzo[a,h]anthracene	<10	<21.28
Cyanide	0.18	383.23	Fluoranthene	<10	<21.28
Oil & grease	NT	-	Fluorene	<10	<21.28
Total volatile solids	NT	-	Indeno[1,2,3-cd]pyrene	<10	<21.28

The results of the organics testing of the wastewater treatment plant influent (98% less than detection limits) indicates that raw wastewater in the City's sewer lines does not carry large volumes of potentially toxic organics. These data also suggest, therefore, that normal sanitary and industrial wastewater escaping from CSOs is not a major potential source of toxic organics to PIB.

Comparing Tables 5.2 and 5.3, it may be seen that, at least for the metals, the CSOs are significant contributors of pollutants of concern to PIB, relative to other NPDES-permitted point sources. However, while these CSOs include untreated industrial effluent, they also include "nonpoint" pollutants carried in large volumes of urban runoff which enters the sewer system through surface inlets (storm drains, roof leaders, foundation drains, etc.) during runoff events, causing the overflows. Therefore, it cannot be concluded that the pollutants loadings in Table 5.3 are wholly derived from industrial users. Pollutant loadings from urban nonpoint runoff are discussed in the following section.

5.2 Secondary Sources of Pollutants of Concern

Typically, the major sources of pollutants of concern in AOCs are direct discharges from municipal and industrial wastewater treatment plants, and overflows from combined sewer systems. These sources are discussed in the previous section. Secondary or minor sources of pollutants of concern in AOCs are typically contaminated surface and groundwater runoff, air deposition, and other nonpoint or "indirect" sources of pollutant inputs. These potential sources are discussed in the following sections.

5.2.1 Surface Runoff

Because PIB is a nearly-enclosed embayment with a low "flushing" rate (see §3.2.2), any contaminants introduced into the Bay, regardless of the source, tend to accumulate in the ecosystem. Further, because such a large percentage of the PIB watershed is urbanized, nonpoint pollution from urban runoff is a significant potential source of PIB pollutants of concern. In addition, groundwater discharges can enter the Bay as surface runoff when intercepted by stream valleys. (Richards, et al, 1987)

However, nonpoint pollutant loading rates have not been systematically investigated in the PIB watershed, and no reliable estimates of the quantity and quality of urban nonpoint runoff exist in the available data base. Consequently, this topic is addressed by drawing inferences and comparisons with other urban areas in which such data have been generated. Because of the importance of this potential contaminants source, this topic is dealt with in some detail in the following discussion.

5.2.1.1 Background

The nationwide significance of pollution caused by storm-generated discharges was first identified in the 1964 U. S. Public Health Service's publication: "Pollutional Effects of Stormwater and Overflows from Combined Sewer Systems" (Lager and Smith, 1974). Congress, in recognizing this problem, authorized funds under the Federal Water Pollution Control Act of 1965 and, through Section 62 of the Water Quality Act of 1965 (P.L. 89-234), authorized the Federal government to make grants for the purpose of "... assisting in the development of any project which will demonstrate a new or improved method of controlling the discharge into any water of untreated or inadequately treated sewage or other waste from sewerage which carry storm water or both storm water and sewerage or other waste".

The 1972 Amendments placed new and stronger emphasis on urban runoff as a source of pollution. The 1972 amendments stressed "An accelerated effort ... to develop, refine, and achieve practical application of waste management methods applicable to nonpoint sources of pollutants to eliminate the discharge of pollutants including, but not limited to, elimination of runoff of pollutants". Construction grant applications (§201 of the Act) and areawide or basin wastewater treatment management plans (§208 of the Act) were encouraged to include "... the necessary waste water collection and urban storm water runoff systems" for the control and treatment of storm-generated pollution.

As a result of Section 208 of the Act, State and local water quality management agencies were designated to integrate water quality management activities. As funds for the construction and upgrading of municipal sewage treatment plants were granted, and both municipal and industrial point source discharges were increasingly brought under control, the significance of nonpoint sources (including urban runoff) as potential contributors to water quality degradation became more apparent, and a program of investigative and research studies was initiated.

However, as these studies progressed, uncertainties arose over the local nature and extent of urban runoff water quality problems, the effectiveness of possible management and control measures, and the affordability of these control measures in comparison with benefits to be derived. Studies in the 1970's concluded that essentially every metropolitan area of the United States has a stormwater problem, whether served by a combined sewer system or a separate sewer system (Lager and Smith, 1974). However, the unknowns were so great and certain control cost estimates were so high that the Clean Water Act of 1977 (P.L.

95-217) deleted Federal funding for the treatment of separate stormwater discharges. The Congress felt that there was simply not enough known about urban runoff loads, impacts, and controls to warrant making major investments in physical control systems (USEPA, 1983a).

In 1978, EPA Headquarters reviewed the results of work on urban runoff by the technical community and the various 208 Areawide Agencies and determined that additional, consistent data were needed. The National Urban Runoff Program (NURP) was implemented to build upon pertinent prior work and to provide practical information and insights to guide the planning process, including policy and program development and implementation. The NURP program included 28 projects, conducted separately at the local level, but centrally reviewed, coordinated, and guided (USEPA, 1983b).

The U. S. EPA's Storm and Combined Sewer Research Program has continued to sponsor urban runoff studies, including several long-term research projects that are concerned with urban receiving-water problems. Current research efforts stress identifying the sources of pollutants and controlling their discharge. Even so, recent papers (e.g. Field and Pitt, 1990) continue to note problems encountered in the application and use of existing, available data because of differences in sampling procedures and the practice of pooling data from various sites. These papers cite the need for comprehensive, carefully designed, long-term studies to investigate urban storm runoff problems on a site-specific basis. Sediment transport, deposition, and chemistry play key roles in urban receiving water behavior and need additional research. Biological conditions in receiving waters need to be studied to support laboratory bioassays.

It has been noted (Field and Pitt, 1990) that studies of receiving-water effects are needed to examine beneficial water uses directly instead of relying on published water quality criteria and water column measurements alone. Published criteria are usually not applicable to urban runoff because of the intermittent nature of urban runoff, the unique chemical speciation of its components, the transport patterns of contaminated runoff solids, and the potential impacts that polluted urban sediments may have on beneficial water uses.

5.2.1.2 Water Quality Impacts of Stormwater Runoff

Both toxic heavy metals and organic pollutants are responsible for urban receiving-water problems caused by stormwater runoff. Most beneficial water uses, including shellfish harvesting, fish and aquatic-life propagation, drinking water, and recreation, have been shown to be adversely affected by urban runoff.

The urban stormwater impacts problem is a nationwide rather than a regional or local issue. In one example, studies on the Saddle River near Lodi, New Jersey, found higher sediment enrichment of heavy metals in the urban, lower Saddle River than in the more rural, upper Saddle River (Wilbur & Hunter, 1980). The increase in heavy metal concentrations caused by urbanization ranged from about 3 mg/l for zinc and copper to more than 5 mg/l for lead, chromium, and cadmium (Field & Pitt, 1990). In another study near Champaign-Urbana, Illinois, lead concentrations in the sediments of an urban stream were found to be almost 400 ppm; this same study also found greater plant and animal diversity in rural streams than in the urban streams (Rolfe and Reinbold, 1977).

Even in those urban areas where untreated sewage discharges are an issue, urban runoff represents a significant portion of the heavy metal loadings to the receiving waters. This is illustrated in example urban runoff data presented in Table 5.4. As seen in this table, the percentage contributions of surface runoff derived heavy metals to the total metals loadings in runoff of a major urban area currently range from 63% for zinc to 32% for nickel.

In Erie, a major effort has been made to transmit all collected wastes from the City, Peninsula, and Bay watershed to the City's Sewage Treatment Plant. The treated effluent from the plant is not discharged to PIB and thus does not contribute any waste components to the Bay's loading. Effluent is discharged to Lake Erie within the boundaries of the Outer Harbor.

If it is assumed that the untreated wastewater component percentage of New York Harbor's loading is representative of the untreated wastewater effluent reaching PIB and that future treatment will remove 90% of that load, then runoff would be responsible for the following percentage contribution to Bay loadings in the future: copper, 95%; chromium, 92%; nickel, 94%; zinc, 98%; and cadmium, 95%. Also, if the above assumptions are correct, presently the runoff waste load contributions would equal 67% of copper, 55% of chromium, 60% of nickel, 82% of zinc, and 65% of cadmium. Clearly, if a table similar to Table 5.4 were prepared for PIB, the "Treated effluent" loads would be insignificant compared to the non-point loads.

Table 5.4. Metals loadings to New York Harbor from various sources (from USEPA, 1979; Field and Turkeltaub, 1981).

	Metals Concentrations (mg/l)				
Metals Sources	Copper	Chromium	Nickel	Zinc	Cadmium
Treated effluent	1,410	780	930	2,520	95
Runoff(1)(2)	1,990	690	650	6,920	110
Untreated wastewater	980	570	430	1,500	60
Total loading (#/day)	4,380	2,050	2,010	10,940	265
Ave. concentrations (mg/l)	0.25	0.12	0.11	0.62	0.015
% of total from runoff	45	34	32	63	42
% assuming 90% treatment of untreated wastewater sources	57	45	40	72	52

(1) In reality, shockload discharges are much greater.

(2) Runoff data includes separate storm sewer discharges as well as wet weather CSOs.

Three key factors which are important in understanding the magnitude of the stormwater runoff problem and the complex water quality management issues involved are discussed below.

Time Delay. Many of the adverse effects of stormwater runoff associated with organic and toxic pollutants are expressed only over long time frames, and are not recognizable from individual runoff events. Over time, small repetitive doses of contaminants from individual runoff episodes result in large accumulations of sediment contaminants, and numerous examples of heavy metal and nutrient accumulations in urban sediments are available in the technical literature. In-place sediment pollutants affect the water column in urban streams usually by the resuspension of previously deposited materials. Resuspension occurs under the highly variable flow conditions that are common to urban streams. Large quantities of sediment may be transported in the stream system by deposition, resuspension, and subsequent redeposition. This repetitive process causes polluted solids to pass slowly through an urban stream. The transport of pollutants, therefore, is difficult to relate to specific runoff events, as much of the suspended material during a high storm flow may actually be resuspended sediment material deposited during previous storms (Field & Pitt, 1990).

An example of the time delay factor is provided in the results of a study in San Jose, California, which found that urban runoff BOD affecting Coyote Creek exerted increased oxygen demand, as much as tenfold, 10 to 20 days after a rain event, rather than during the first few days after the rain event. Therefore, sediments having high BODs can substantially affect overlaying DO concentrations many days after they are deposited by a specific storm. Another study found more critical oxygen deficits located much farther downstream than predicted because of the resuspension of contaminated sediments during high flows (Meinholz et al., 1979).

Variation in Toxicity. Preliminary toxicity results have found that urban runoff varies widely in its relative toxicity, depending on sample location. A residential roof-runoff sample was found to be the most toxic of all samples examined to date, possibly because of the high concentrations of soluble heavy metals, especially zinc, that may have leached from galvanized metal roof gutters and downspouts. This sample also contained the highest concentration of DDT. Other samples that had relatively high toxicities were from automobile-service facilities, unpaved industrial parking and storage area, and paved industrial streets (Field & Pitt, 1990).

The relative toxicities of various urban runoff source samples are presented in Table 5.5. As seen in this table, the category having the largest percentage of extremely toxic samples was combined sewer overflows. The urban creeks and detention ponds had the largest percentage of samples that can be considered not toxic. The source areas that had the greatest toxic responses were the parking and storage areas (Pitt & Field, 1990).

No Appropriate Standards. Urban stormwater runoff behaves in a different manner than typical municipal or industrial wastewater discharges, for which many standards have been developed. Urban storm runoff occurs for relatively short periods of time. Therefore, toxicant concentration standards developed for continuous exposures are not directly applicable for these short-term discharges. Monitored mass loadings show that great quantities of toxic compounds are being discharged in urban storm runoff. Additional long-term receiving-water studies have found that aquatic organism surveys indicate significant toxicity problems in many areas. Urban runoff leads to habitat destruction by causing high flow rates, sediment accumulation, and the presence

Table 5.5. Relative toxicity groupings of various urban runoff source samples (from Field & Pitt, 1990).

Sampling Locations	Toxicity Classifications (%) Extremely	Moderately	Non-toxic	# samples
Roofs	8	58	33	12
Parking areas	19	38	44	16
Storage areas	25	50	25	8
Streets	0	67	33	6
Loading docks	0	67	33	3
Vehicle service areas	0	40	60	5
Landscaped areas	17	33	50	6
Urban creeks	0	12	88	19
Detention ponds	10	10	80	12
Combined sewer overflows	65	30	5	20

of toxic chemicals in those sediments. Because of the time delay issues, few short-term problems, such as fish kills, have been associated with specific urban storm-runoff events (Field & Pitt, 1990), and the conventional standards setting process has not been adaptable to stormwater runoff.

Few well documented cases of the detrimental effects of urban storm runoff on receiving water quality exist in the literature. Urban stormwater runoff impacts are difficult to observe in urban areas because of pre-existing poor water quality and the lack of pollution sensitive organisms. Fish kills may indicate urban stormwater runoff problems. However, researchers have stated that one of the complications in determining the causes of fish kills related to heavy metals is that the fish mortality may lag behind the first toxic exposure by many days, and therefore usually occurs many miles downstream from the discharge location. The actual concentrations of the constituents that caused the kill may be diluted beyond detection limits, making the sources of the toxic materials impossible to determine (Field & Pitt, 1990).

5.2.1.3 Impacts to Aquatic Organisms

A 3-year monitoring study on an urbanized watershed in California (Coyote Creek) evaluated the sources of urban stormwater runoff, and the impact on water quality and aquatic organisms as the stream passed through San Jose (Pitt & Bozeman, 1982). Coyote Creek is a small stream, only a few meters wide and less than a meter deep during dry weather. It drains a large watershed of about 80,000 hectares (197,680 acres) that contains two reservoirs in the rural upstream reaches. Upstream is a wilderness area that is free of almost all pollutant sources. The flows coming from the upstream areas are regulated and quite clean, but the downstream urban flows are highly variable and polluted.

Forty-one stations were monitored in both urban and rural perennial-flow stretches of the Creek. Short- and long-term sampling techniques were used to evaluate the effects of urban runoff on water quality, sediment properties, fish, macroinvertebrates, attached algae, and rooted aquatic vegetation. Information collected during this study implied that the effects of toxic organics and heavy metals in the water and sediment were responsible for the adverse biological conditions. Within the urban area, many pollutants were found in significantly greater concentrations during wet weather than dry weather, including organic nitrogen, lead, zinc, copper, cadmium, mercury, iron, and nickel (Field & Pitt, 1990).

Water quality upstream of the urbanized area was fairly consistent from site to site, but the quality changed markedly as sweeping. Removal efficiencies were calculated on the basis of (1) the effectiveness of street sweeping equipment for removal of differing sized particles, and (2) the fractionation of pollutants among these particle size ranges. The distribution of general categories of urban runoff pollutants, according to varying particle size ranges, is provided in Table 5.8. The distribution of individual heavy metals, according to the same particle size ranges, is provided in Table 5.9.

Finally, based on the information in Tables 5.8 and 5.9, the calculated efficiency of street sweeping for removing typical categories of urban runoff pollutants is summarized in Table 5.10. As may be seen in Table 5.10, from approximately one-fourth to one-half of common street pollutants may be effectively removed through an efficient program of street sweeping. Somewhat higher pollutants removal rates may be achieved with more efficient sweeping systems, which remove a higher percentage of "fines".

As may be seen in Table 5.8, the distribution of pollutant loads in urban runoff is markedly skewed toward the smaller particle sizes (the "fines"). For example, more than 50% of the volatile solids, BOD5, COD, nutrients (nitrogen, nitrates, and phosphates), heavy metals, and pesticides are carried by particles smaller than 250μ ("fine sand"; <0.01 inches), and approximately 25-50% of the total volumes of these same pollutants are actually associated with particles smaller than 43μ ("silts" and "clays"; <0.0017 inches). This relationship extends to the individual heavy metals as well. For example, it may be seen in Table 5.9 that 41-87% of the chromium, copper, zinc, nickel, mercury, and lead are carried by particles of <250μ, and that 19-44% of these same metals are carried by particles of <43μ.

More recent research has shown that there are important sources of heavy metals in addition to streets. Table 5.11 summarizes heavy metal observations from other urban area sources. The data summarized in this table yielded some surprising results. For example, roof runoff had the highest concentrations of zinc (probably associated with galvanized metal), parking areas had the highest nickel concentrations, vehicle service areas had the highest cadmium and lead concentrations, and streets had high aluminum concentrations. Surprisingly, landscaped areas had the highest chromium and urban creeks had the highest copper concentrations (Pitt & Field, 1990).

Many observations of filterable metals were also made and are also summarized on Table 5.11. Except for storage areas, most of the zinc was associated with the filterable sample partitions (i.e. that portion which is not removed by filtration, including dissolved solids). In contrast, very little of the nickel was found in the filterable sample partitions. Nickel, and most other metals, were also found associated with the nonfilterable residue (i.e. the suspended solids removed through filtration). Therefore, solids separation processes would be very effective in removing heavy metals from these source areas, with the exception of zinc. If these metals are not removed before discharge, they are likely to contribute to polluted sediments in the receiving waters (Pitt & Field, 1990).

Other studies have also shown high percentages of heavy metals associated with the solids fraction, ranging from 97% for aluminum to 64% for zinc and copper. These observations are summarized in Table 5.12.

Clearly, as seen in the previous tables, the bulk of the heavy metals in urban runoff are associated with the smallest-sized particulates in the suspended sediment load. The sources of these metals loads are discussed in the following section.

5.2.1.4.2 Sources of Heavy Metals on Urban Roadways

Roadways are unquestionably a major source of heavy metals in urban runoff. Historically, much of this lead resulted from combustion of leaded gasoline, although some was deposited with leaking motor oil, in that combustion of leaded gasoline introduces considerable quantities of lead into engine oil. Despite the phase-out of leaded gasoline, leaking motor oil and transmission fluid continue to be sources of lead, because they become contaminated with wear metals, including lead from babbitt metal bearings. Other engine wear metals include:

* copper; from wear of thrust bearings, bushings, and bearing metals

* chromium; from wear of metal plating, rocker arms, crankshafts and rings

* zinc; as an ingredient of oil additives, and

* phosphorus; also an oil additive.

In addition to lubricants as metals sources, zinc, lead and other metallic oxides are used as fillers in the manufacture of rubber tires and are deposited on roadways as tires are abraded. Nickel and chromium abraded from roadway surface materials and from the corrosion of steel motor vehicle parts also contribute to the heavy metal load of street surface contaminants. Both nickel and chromium are present in brake lining materials. Asbestos in dust and dirt is produced by abrasion of clutch plates and brake

Table 5.8. Fraction of pollutant load (% by weight) associated with various particle size ranges (from Sartor and Boyd, 1972).

Contaminants	Particle Size Ranges (μ) >2,000	840-2,000	246-840	104-246	43-104	<43
Total solids	24.4	7.6	24.6	27.8	9.7	5.9
Volatile solids	11.0	17.4	12.0	16.1	17.9	25.6
BOD_5	7.4	20.1	15.7	15.2	17.3	24.3
COD	2.4	4.5	13.0	12.4	45.0	22.7
Kjeldahl nitrogen	9.9	11.6	20.0	20.2	19.6	18.7
Nitrates	8.6	6.5	7.9	16.7	28.4	31.9
Phosphates	0	0.9	6.9	6.4	29.6	56.2
Total heavy metals	16.3	17.5	14.9	23.5	27.8[1]	
Total pesticides	0	16.0	26.5	25.8	31.7[1]	

[1] Combined value for 43-104 and <43μ size ranges.

Table 5.9. Fraction of heavy metals (% by weight) associated with various particle size ranges (from Sartor and Boyd, 1972).

Metal	Particle Size Ranges (μ) >2,000	840-2,000	246-840	104-246	<104
Chromium	26.1	13.6	16.3	16.3	27.7
Copper	22.5	20.0	16.5	19.0	22.0
Zinc	4.9	25.9	16.0	26.6	26.6
Nickel	26.2	14.2	15.3	17.2	27.1
Mercury	16.4	28.8	16.4	19.2	19.2
Lead	1.7	2.6	8.7	42.5	44.5
Average	16.3	17.5	14.9	23.5	27.8

Table 5.10. Projected efficiency of street sweeping for removal of selected pollutants (from Sartor and Boyd, 1972).

Particle Size (μ)	Sweeper Efficiency (%)	Pollutants and Projected % Removals: Total Solids	BOD5	COD	Kjeldahl Nitrogen	Phos-phates	Total Heavy Metals	Total Pesticides
>2,000	79	19.3	5.8	1.9	7.8	0	12.9	0
840-2,000	66	5.0	13.3	3.0	7.7	0.6	11.6	10.0
246-840	60	14.8	9.4	7.8	12.0	4.1	8.9	15.9
104-246	48	13.3	7.3	6.0	9.7	3.1	11.3	12.4
43-104	20	1.9	3.5	9.0	3.9	5.9	5.6	6.3
<43	15	0.9	3.6	3.4	2.8	8.4	-	-
Totals	-	55.2	42.9	31.1	43.9	22.1	50.3	44.7

Table 5.12. Total versus particulates mass from Seattle storm sewer overflow point (from USEPA, 1979).

Pollutant	Total Mass (pounds)	Particulate Mass (pounds)	% Particulate
Suspended solids	4,924	4,924	-
Copper	2.55	1.64	64
Lead	13.29	11.7	88
Zinc	6.03	3.87	64
Aluminum	213.8	207	97
Organic Carbon	658	370	-
Total Phosphorus	19.2	8.93	-
Oils and Greases	249	not applicable	-
Chlorinated Hydrocarbons	not determined	0.854	-

Source Area Runoff	Aluminum non filt.	Aluminum filt.	Cadmium non filt.	Cadmium filt.	Chromium non filt.	Chromium filt.	Copper non filt.	Copper filt.	Lead non filt.	Lead filt.	Nickel non filt.	Nickel filt.	Zinc non filt.	Zinc filt.
roofs														
detection frequency	11/12	9/12	11/12	8/12	7/12	2/12	11/12	7/12	12/12	1/12	10/12	0/12	12/12	12/12
median	270	13	0.82	0.23	7	<1	17	1.2	13	<1	5.1	<1	100	80
maximum	8370	1550	30	0.95	510	2.3	900	8.7	170	1.1	70	<1	1580	1550
% filt. (range, median)	2→100	(15%)	1→69	(50%)	6→14	(10%)	4→87	(20%)	7	(<10%)	(<20%)		57→100	(90%)
parking areas														
detection frequency	12/12	10/10	11/12	4/10	11/12	4/12	12/13	9/12	13/13	5/13	11/13	1/13	13/13	13/13
median	1550	360	0.72	<0.1	10	<1	20	1.8	30	<1	40	<1	30	23
maximum	22,500	2890	70	1.0	310	2.4	770	9.2	130	2.5	130	1.6	150	88
% filterable	1→100	(20%)	<1→53	(20%)	2→82	(35%)	<1→40	(15%)	1→45	(10%)	(<5%)		15→100	(75%)
storage areas														
detection frequency	6/6	1/7	7/7	4/7	7/7	4/7	7/7	5/7	7/7	6/7	7/7	0/7	6/6	6/6
median	975	<1	2.4	0.27	60	1.1	30	1.0	30	1.6	30	<1	66	9
maximum	6990	37	10	1.3	340	32	300	1.7	330	5.7	90	<1	290	103
% filterable	(1%)		3→13	(10%)	3→46	(10%)	1→18	(3%)	2→50	(10%)	(<3%)		3→100	(15%)
streets														
detection frequency	4/4	4/4	6/6	5/6	5/6	4/6	6/6	5/6	6/6	4/6	5/6	0/6	5/5	5/5
median	4,000	200	0.76	0.18	3.3	1.3	15	1.9	30	1.3	3.0	<1	58	23
maximum	10,040	4,380	220	0.57	30	2.7	1250	11.4	150	3.9	70	<1	130	76
% filterable	1→44	(20%)	12→91	(50%)	9→60	(30%)	<1→57	(10%)	4→100	(20%)	(<30%)		8→100	(60%)
loading docks														
detection frequency	3/3	1/3	3/3	3/3	3/3	0/3	3/3	2/3	3/3	1/3	3/3	1/3	2/2	2/2
medium	810	<1	1.2	0.5	0.9	<1	20	2.6	60	<1	7.0	<1	55	33
maximum	930	<1	2.4	0.6	40	<1	30	15	80	2.3	8.1	1.3	79	62
% filterable	(<5%)		23→41	(40%)	(<10%)		9→100	(10%)	(<5%)		(<10%)		13→78	(50%)
vehicle service areas														
detection frequency	4/4	3/3	4/4	2/4	4/4	0/4	4/4	3/3	4/4	1/4	4/4	0/4	4/4	4/4
medium	920	200	8	<0.2	19	<1	8.3	2.1	75	<1	35	<1	67	18
maximum	1370	410	30	0.34	320	<1	580	6.3	110	1.4	70	<1	130	83
% filterable	<1→87	(30%)	1→16	(<5%)	(<5%)		<1→95	(20%)	(<5%)		(<5%)		10→100	(40%)
landscaped areas														
detection frequency	4/4	4/4	3/5	1/5	5/ 5	4/5	4/4	4/4	5/5	1/5	3/5	0/5	5/5	5/5
medium	2500	1600	0.04	<0.1	100	1.5	80	2.0	9.4	<1	30	<1	32	32
maximum	4610	1860	1.0	1.0	250	4.1	300	8.3	70	1.7	130	<1	1160	670
% filterable	34→93	(50%)	(<25%)		2→68	(10%)	3→20	(3%)	(<10%)		(<5%)		58→100	(100%)
New York CSOs														
detection frequency	19/19	-	20/20	20/20	20/20	1/20	20/20	16/20	20/20	14/20	20/20	19/20	20/20	20/20
medium	720		1.6	0.25	17.6	<1	70	9.1	40	1.8	11.3	5.5	96	34
maximum	23,830		10	5.1	130	18	340	30	120	7.5	48.2	48.2	390	80
% filt.	?		2→100	(35%)	(<5%)		2→100	(20%)	2→100	(15%)	12→100	(50%)	3→100	(35%)
urban creeks														
detection frequency	4/4	4/4	4/4	0/4	4/4	0/4	4/4	3/4	4/4	0/4	3/4	0/4	4/4	4/4
medium	1600	240	5	<0.1	6.8	<1	160	1.2	38	<1	20	<1	24	19
maximum	3250	500	30	<0.1	30	<1	440	1.4	100	<1	70	<1	32	23
% filterable	13→42	(15%)	(<1%)		(<15%)		<1→23	(20%)	(<3%)		(<5%)		53→100	(80%)
detention ponds														
detection frequency	4/4	4/4	4/4	1/4	3/4	0/4	4/4	0/4	4/4	0/4	3/4	0/4	4/4	4/4
medium	550	200	0.24	<0.1	5.5	<1	47	<1	1.9	<1	20	<1	22	22
maximum	1350	330	1.0	<0.1	230	<1	210	<1	8.8	<1	70	<1	25	25
% filterable	6→100	(60%)	(<5%)		(<20%)		(<2%)		(<25%)		(<5%)		(all 100%)	

Table 5.11. Metals concentrations in runoff from various urban source areas (from Pitt and Field, 1990).

linings. Copper wire is added to brake linings for increased mechanical strength and to provide better heat transfer properties. Brake linings contain large amounts of copper (>= 3%), and it is probable that much copper on urban roadways originates from this source. However, calculation of copper emissions from brake lining wear yields a value approximately one order of magnitude higher than the deposition rate found in field studies (Shaheen, 1975). This observation is interpreted as supporting the finding that much of the products of brake wear are retained by the motor vehicle (Jacko & DuCharme, 1973).

5.2.1.5 Estimated Stormwater Pollutant Loading Rates to PIB

It is emphasized that reliable data from which to calculate pollutant loading rates to PIB from stormwater do not exist. However, for purposes of comparison, estimates of annual stormwater loading rates for pollutants of concern were derived, based on runoff characteristics from other studies (as summarized in the preceding discussions and tables) and PIB watershed characteristics. These estimates are summarized in Table 5.13.

Key assumptions and data soures used in developing the loading estimates in Table 5.13 include (1) PIB drainage basin = 25 $mi.^2$; (2) the basin is 11% commercial, 7% industrial, and 82% residential and all other, and (3) annual rainfall = 40 inches. Key references used in developing Table 5.13 include Sartor and Boyd, 1972; USEPA, 1983b.

It should be noted that the NURP report (USEPA, 1983b) was the primary source of the loadings data used in developing Table 5.13. This report provided loading rates (in kg/hectare/year) for residential and commercial areas, assuming an annual rainfall of 40 inches. Based on the description of residential areas in this report, the residential areas loading rate was used for all non-commercial or non-industrial areas in the PIB watershed. Unfortunately, this source does not include loading factors for industrial land. However, based on data reported in other sources (Sartor and Boyd, 1972; USEPA, 1979b; Field and Turkeltaub, 1981), loading rates for industrial land were assumed to be 30% greater than those of commercial land. Some heavy metals not included in the NURP reports were added by comparison to prior studies. The annual loading rates were multiplied by the drainage area sizes to calculate total loads.

5.2.1.6 Background Sources of PIB Stormwater Pollutants

The NURP studies (USEPA, 1983) found that the heavy metals consistently found in urban runoff were copper, zinc, and lead. Other heavy metals were also found, but not consistently at all

Table 5.13. Estimated PIB stormwater pollutant loading rates.

Pollutants	Loading Rate (pounds/year)
Cadmium	240
Chromium	1,400
Copper	2,500
Lead	11,000
Mercury[1]	1,200
Nickel	12,000
BOD[1]	7.1×10^5
COD	4.8×10^6
Total phosphorus	25,000
Total kjeldahl nitrogen	110,000
Nitrite/Nitrate nitrogen[1]	51,000
Total suspended solids[1]	1.0×10^7

[1] Not a PIB pollutant of concern

locations. This would indicate that copper, zinc, and lead are generated by common activities and land uses in urban areas. Typical anthropogenic sources of urban runoff contaminants include automotive, industrial, commercial, and residential activities. Other heavy metals may be present due to such unique factors such as particular industries, past dumping, or unusual soil conditions. Soil conditions, as sources of heavy metals in runoff, are discussed below.

Surface runoff includes soil erosion products (minerals, ions, etc.) which are of natural origin, resulting from the parent geological materials of the area. The underlying geological material in the Erie area is shale, which in general has fairly high concentrations of various heavy metals. Table 5.14 summarizes typical concentrations of heavy metals found naturally in five different rock types, including granite, basalt, sandstone, limestone, and shale.

Compared with the four other types of parent geologic material in Table 5.14, shale exhibits:

(1) the highest natural levels of arsenic, cadmium, lead, and mercury

(2) the second highest natural levels of barium, chromium, copper, nickel, zinc, and

(3) the third highest natural levels of manganese.

Shale has the highest overall concentration of heavy metals as compared to other rock types.

The influence of the parent bedrock (shale) in the Erie area on metals levels in soil material is reflected in the high concentrations of arsenic and other metals found in a variety of local quarries which were identified as alternative sources of Presque Isle beachfill material for the COE's beach nourishment program (COE, 1991). This information is summarized in Table 5.15. For comparison purposes, the ranges of mean contaminant concentrations from Lake Erie dredging projects (1980-1984) are summarized in Table 5.16, segregated according to substrate types (ranging from silty/clay to class"B" sand). The ranges of maximum contaminant concentrations from Lake Erie dredging projects are provided in Table 5.17.

It is noted that the data in Tables 5.16 and 5.17 are based on differing numbers of individual dredged sediment data sets, ranging from only one for silt, to nine for silty clay. Therefore, because of the small sample size, the average values may be biased

Table 5.14. Typical concentrations of selected metals in rocks (from Turekian, 1971a; Drever, 1982).

Metals	Rock Type and Concentrations (mg/kg)				
	Granite	Basalt	Shale	Sandstone	Limestone
Chromium	10	170	90	35	11
Manganese	450	1,500	850	50	1,100
Iron	major	major	major	major	major
Nickel	10	130	68	2	20
Copper	20	87	45	2	4
Zinc	50	105	95	16	20
Arsenic	2	2	13	1	1
Cadmium	0.13	0.2	0.3	-	0.03
Barium	600	330	580	-	10
Mercury	0.03	0.01	0.4	0.03	0.04
Lead	17	6	20	7	9

Table 5.15. Metals concentrations in Presque Isle peninsula beachfill sources (from COE, 1991).

Metals	Concentrations (mg/kg)			
	Maximum	Minimum	Median	Mean
Arsenic	16	4	11	10.9
Barium	55	10	37	34.3
Cadmium	0.8	0.4	0.6	0.6
Chromium	9	2	5	4.8
Copper	34	2	23	20
Iron	18,900	2,600	14,300	11,800
Lead	11	1	4	4.8
Manganese	410	140	320	307
Mercury	0.03	<0.02	<0.02	<0.02
Nickel	16	5	11	11.2
Zinc	73	8	48	45.7

Table 5.16. Ranges of mean metals concentrations in 1980-1984 Lake Erie dredging projects (from IJC, 1990).

Metals	Substrate Types and Concentrations (mg/kg dry weight)				
	Silty/Clay	Silt	Sandy/Clay	Silty Sand	Class "B" Sand
Arsenic	0.0002-17.2	4.3	10.0	1.7-10.4	1.8-9.0
Cadmium	0.36-287	0.47	1.6	0.8-6.0	1.0
Chromium	4.4-104	6.8	17.5-42.2	16.3-45.2	5-108
Copper	18.4-159.4	25.4	15.8-20.2	21.7-170	3-61.5
Lead	12.8-156	13.6	26.0-36.3	7.7-106.2	2-101
Mercury	0.12-0.29	0.10	0.10	0.001-1.05	0.0-0.90
Nickel	18.8-57.6	25.4	34.3-83.8	14.3-52.9	5-33.3
Zinc	44.6-576	61.1	55.1-120	147-491	19.3-340
No. Projects	9	1	2	6	8

Table 5.17. Ranges of maximum metals concentrations in 1980-1984 Lake Erie dredging projects (from IJC, 1990).

Metals	Substrate Types and Concentrations (mg/kg dry weight)				
	Silty/Clay	Silt	Sandy/Clay	Silty Sand	Class "B" Sand
Arsenic	0.002-21.6	8.1	13.8	1.8-20	1.8-9.0
Cadmium	0.6-8,600	0.70	3.0	0.8-12.0	1.0-1.5
Chromium	6.0-310	9.0	42.0-68.0	19.0-77.8	5-139
Copper	26.0-600	39.0	30.0-36.0	25.0-250	3-66
Lead	15.0-227	20.0	43.0-50.0	9.7-188	2-150
Mercury	0.2-0.4	0.10	0.27	0.001-2.0	0.0-2.6
Nickel	25.0-120	37.0	65.0-228	26-117	5.0-73.0
Zinc	55-1,600	88.0	111-150	184-626	7.0-470
No. Projects	9	1	2	6	8

in either direction, by a particularly "clean" or unusually "dirty" sediment sample. However, it is noted that the mean and maximum ranges for Class "B" sand, which would most closely resemble the parent geologic materials of its origin, were extremely similar for all metals. For comparison purposes, Table 5.18 has been prepared to contrast the following information:

* the typical concentrations of various metals in shale (see Table 5.14)

* the maximum and mean concentrations of these metals in Presque Isle beachfill sources (see Table 5.15), and

* the observed range of concentrations of these metals in Lake Erie dredging projects (see Tables 5.16 and 5.17).

As evident in Table 5.18, the mean metals concentrations in Presque Isle peninsula beachfill sources (from Table 5.15) are remarkably similar to the mean metals concentrations in class "B" sand in Lake Erie dredging projects (from Table 5.16), for all metals. Further, the average metals concentrations for shale are within the ranges of the concentrations of these same metals reported from beachfill sources and Lake Erie dredging projects. Based on these observations, it is possible that the metals concentrations in the sand component of sediments throughout Lake Erie may be dominated by the mineralogic nature of the bedrock in this basin.

To complete this comparison, concentrations of heavy metals in PIB sediments were compared with those of Lake Erie in general (Table 5.16). Because there may be significant variability over time in reported pollutant concentrations at a given site, and because the available IJC data are based on the period 1980-1984, the 1982 PIB sediment data (from COE, 1982; see Table 4.15) were used in this comparison. Also, because PIB sediments contain significant concentrations of silts and other organic rich "fines", the Lake Erie class "B" sands concentrations were not used in this comparison.

Based on this comparison, all of the Lake Erie sediment concentrations for mercury exceeded the PIB mercury concentrations, and 90% of the Lake Erie dredging projects exhibited higher arsenic concentrations than PIB sediments. Thirty percent of the Lake Erie chromium, copper, and zinc concentrations exceeded PIB concentrations, and 10% of the Lake Erie cadmium, lead, and nickel concentrations were higher than PIB concentrations of these same metals. Because the dredging locations from which the Lake Erie sediment were collected are not known, further comparisons with PIB are not prudent, however it may be seen that many sites exceed PIB

Table 5.18. Comparison of metals levels in shale, beachfill sources, and Lake Erie dredging projects in general.

Metals	Substrate Types and Concentrations (mg/kg)			
	Shale	Beachfill Sources Maximum	Beachfill Sources Mean	Range of L. Erie Dredging Projects
Arsenic	13	16	10.9	0.002-17.2
Barium	580	55	34.3	N/A
Cadmium	0.3	0.8	0.6	0.36-287
Chromium	90	9	4.8	4.4-108
Copper	45	34	20.0	3.0-170
Iron	major	18,900	11,800	N/A
Lead	20	11	4.8	2.0-156
Manganese	850	410	307	N/A
Mercury	0.4	0.03	<0.02	0.000-1.05
Nickel	68	16	11.2	5.0-83.8
Zinc	95	73	45.7	19.3-576

sediment metal contamination levels, for at least some metals.

5.2.1.7 Influence of Particle Size on Contaminant Transport and Fate

As discussed earlier, urban runoff contaminants are strongly associated with the finer sized particles in the sediment load. When 1990 FWS sediment sampling data for metals are compared with the corresponding percent sand values, a strong inverse relationship is found to exist for arsenic, copper, lead, manganese, and zinc. In general, the sandiest sediment samples exhibited the lowest overall metals levels. Site #6, which is at the mouth of Mill Creek, would be expected to be one of the most polluted sampling sites. However, this site exhibits a high percentage of sand, and its contaminant levels closely resemble Site #16, which is an unimpacted site in Presque Isle State Park.

As has been discussed previously (see §4.1.1.6), the distribution of contaminants in PIB sediments does not appear to follow any readily recognizable pattern, based on the locations of pollutant sources (Mill Creek, CSOs, storm sewer outfalls, etc.). Instead, the most striking pattern is the inverse correlation with sand content, implying that the fate of introduced contaminants (in this case, metals) is closely tied to the dispersion dynamics and fate of the fine sediments.

Because the finer components of the suspended solids load tend to settle out very slowly, and because large percentages of the total contaminants are found to be associated with these fine particulates, high contaminant levels may be found in quiescent areas, even though these areas are quite removed from contaminants sources (e.g. site numbers 13, 14, and 15). Conversely, comparatively lower contaminant levels may be found in areas quite near pollutant sources (e.g. site #6, at the mouth of Mill Creek), where higher velocities prevent settling of the fine sediments. In these areas, only the coarser particles are found, and the sediment quality tends to resemble the chemical characteristics of the parent geologic materials. The influence of particle size is further demonstrated by examination of the data in Tables 5.15 and 5.16, which show the silty/clay dredged materials to be noticeably more contaminated than the class "B" sand.

Most of the available data focus on the heavy metals, and comparatively little is available for organics and nutrients. However, these contaminants tend to associate quite strongly with the organic content of the suspended solids load. In general, the finer sediments exhibit the highest organic content. Therefore, while the data are inadequate to determine the relationship with certainty, the distribution and fate of organics and nutrients is expected to also be biased toward the "fines". When the 1990 FWS sediment data are evaluated on this basis, an inverse relationship is generally found to exist between total organic content (TOC) and % sand for most sites. However, sites 1, 2, and 4 have higher TOCs than would be expected, based on their % and levels. These sites are located in heavily industrialized areas, and may reflect localized influences from unusual contaminanant sources.

5.2.1.8 Contaminant Levels in PIB Tributaries

Water quality samples were collected from five PIB tributaries in August, 1989 and analyzed for a variety of pollutants, including the majority of the identified pollutants of concern for PIB. The results of this sampling, for the PIB pollutants of concern, are summarized in Table 5.19.

Sampled tributaries included four streams and one storm sewer. All tributary samples reported in Table 5.19 were collected at or near the mouths of the indicated streams.

As seen in Table 5.19, the results for cyanide and most of the toxic metals (arsenic, cadmium, chromium, copper, lead, and nickel) were found to be below the analytical detection limit. The observed concentrations of zinc, manganese, iron, and barium are not surprising, based on the natural, background concentrations of these elements in the Erie area (see Table 5.18). The COD and nutrients (TKN and total phosphorus) results are not unusual for runoff from an urban area.

No attempt has been made to estimate annual loadings of pollutants of concern to PIB from the Table 5.19 tributaries, for the following reasons:

* these results are based on a single sample, which does not represent annual conditions

* the flow rates at the time of sampling are not known

* the annual flow volumes of these tributaries are not known

* most results are not quantifiable (i.e. below the analytical detection limits), and much of the pollutant load from those Table 5.19 parameters which were reported at quantifiable levels are already accounted for (i.e. included) in the Table 5.13 stormwater runoff pollutant loading estimates.

However, the fact that quantifiable levels of zinc, maganese, iron, and barium were found in all five tributaries is another indication

Table 5.19. Concentrations of pollutants of concern in PIB tributaries.

Pollutant	Sampling Sites and Ambient Water Column Concentrations				
	Garrison Run	Cascade Creek	Scott Run	Myrtle St. Storm Sewer	Mill Creek
Arsenic (µg/l)	<4.0	<4.0	<4.0	<4.0	<4.0
Barium (µg/l)	58.0	37.0	141	29.0	61.0
Cadmium (µg/l)	0.38	<0.2	<0.20	0.66	<0.2
Chromium (µg/l)	<50.0	<50.0	<50.0	<50.0	<50.0
Copper (µg/l)	<10.0	<10.0	<10.0	<10.0	<10.0
Iron (µg/l)	480	584	567	185	236
Lead (µg/l)	<50.0	<50.0	<50.0	<50.0	<50.0
Manganese (µg/l)	155	71.0	103	32.0	38.0
Nickel (µg/l)	<25.0	<25.0	<25.0	<25.0	<25.0
Zinc (µg/l)	50	10.0	11.0	18.0	51.0
COD (mg/l)	12.0	<10.0	<10.0	16.0	26.0
TKN (mg/l)	1.3	0.25	0.35	0.40	1.83
Total phosphorus (mg/l)	0.06	0.03	0.03	0.04	0.36
Cyanide (mg/l)	<0.001	<0.001	<0.001	<0.001	0.002

of the potential significance of background sources to the total metals loading to PIB.

5.2.2 Groundwater Contamination

The depth to bedrock is quite shallow in the Erie area. Surficial deposits of glacial drift yield useable groundwater, but such sources are shallow, limited by the underlying shale. Potable groundwater in the Erie area is reported to be produced at depths of approximately 25 to 50 feet below the surface (USEPA, 1985b; 1987b). Because of the shallow groundwater in the Erie area, direct groundwater discharge to the PIB is limited to areas directly adjoining the Bay. Further inland, shallow groundwater is intercepted by stream valleys, and enters the Bay as surface runoff, which is discussed in the previous section (§5.2.1).

To investigate the potential for significant contamination of PIB from groundwater sources, hazardous waste site investigation files were reviewed to identify those sites within a reasonable distance of the Bayfront. Generally, sites within two miles of the Bay (north of 26th Street) were selected for review. Based on this review, 10 sites were identified at which significant groundwater investigations had been performed. These sites are located in Figure 5.3, and are identified and described in the following summaries.

Kimmel Site (West 18th and Filmore; Millcreek Township-Site #1 in Figure 5.3). This is an approximately 10 acre site used as an illegal dump from the mid-1960s to the early 1980s. Soil samples from this site indicated significant levels of PCBs, PAHs, arsenic, cadmium, chromium, lead, mercury, and nickel. On-site groundwater samples indicated significant levels of lead, arsenic and cadmium, and lesser levels of other metals. However, off-site groundwater samples indicated that no migration of the contaminants beyond the site had occurred (USEPA, 1988; Harrison, 1984; Geary, 1983).

Currie Landfill (West 16th and Indiana Drive; Millcreek Township-Site #2 in Figure 5.3). This landfill site is located immediately east of the Kimmel Site (see above). The site is bounded on the east by the West Branch of Cascade Creek. The site was sampled in June, 1984 by the NUS Corporation (a USEPA Superfund contractor).

Sampling at the Currie Landfill site included on-site soil and surface water, upstream and downstream (West Branch Cascade Creek) surface water and sediment, and surface water runoff (drainage ditch leading to West Branch Cascade Creek); no groundwater data were reported. The upstream/downstream West Branch Cascade Creek surface water sample results were compared to

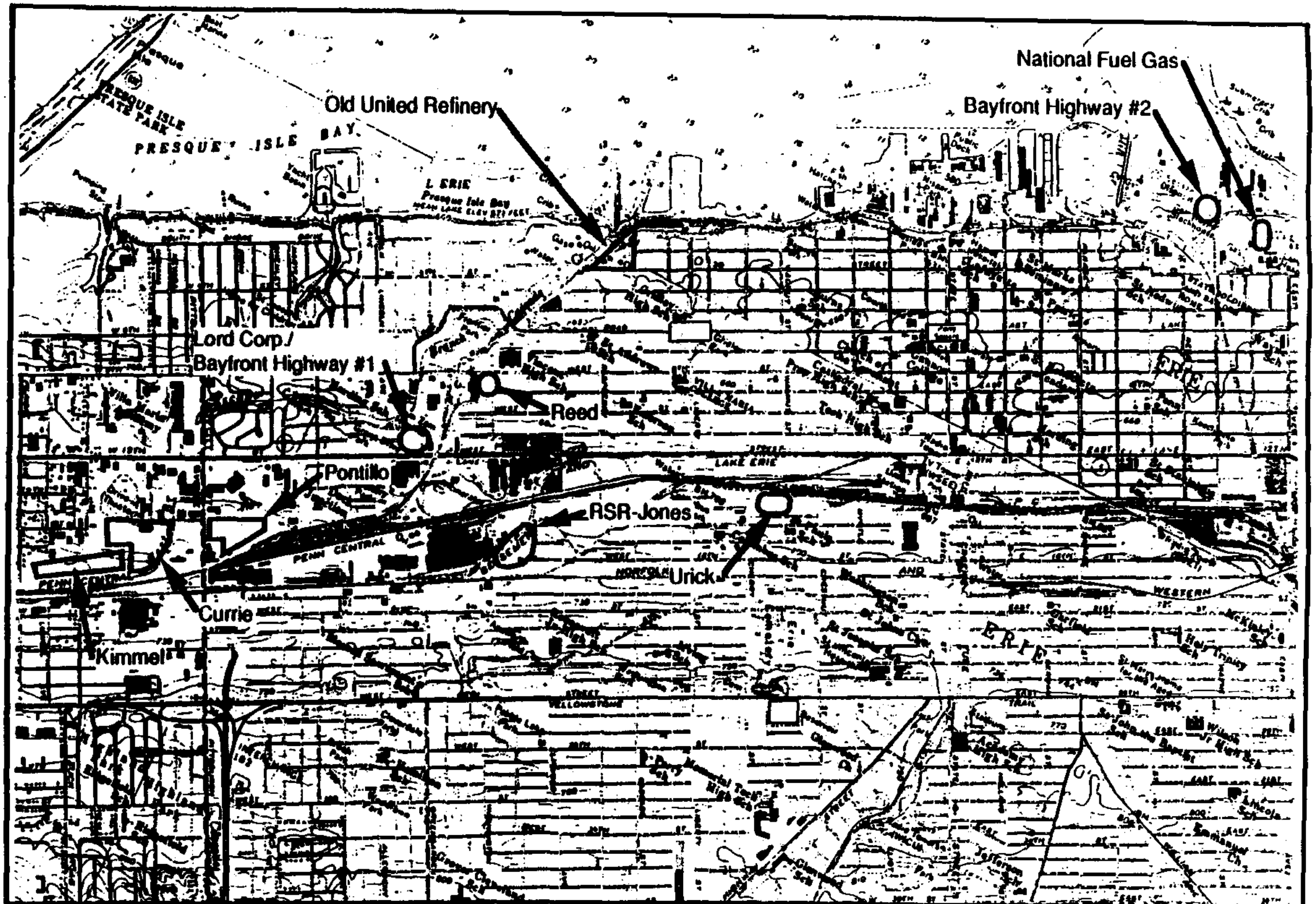


Figure 5.3. Locations of significant potential groundwater contamination sites.

determine the existence of contaminants migration. The results of this comparison indicated minor amounts (18-150 μg/l) of volatile organics (trans-1,2 dichloroethene, tetrachloroethene and vinyl chloride) in the downstream samples, however these amounts would be expected to volatilize before reaching the Bay. The downstream water samples also reflected increases in iron and manganese (2.5% and 145% increases, respectively), and the downstream sediment samples reflected increases in aluminum (21%), barium (2%), chromium (27%), iron (53%), manganese (61%), and zinc (19%). The samples from the drainage ditch, which were collected nearer the source, exhibited a generally similar pattern of contamination, but at higher concentrations.

The current status of this site is not known. However, the site is not suspected of being a major contributor of pollutants of concern because (1) the site is more than a mile from the Bay, (2) rapid attenuation of contaminant levels is evident with downstream direction, and (3) the site is near the headwaters of the West Branch of Cascade Creek, where flow volume is quite low (mass loading = concentration x flow). Because flow volume in the West Branch of Cascade Creek was not included with the contaminants sampling data, mass loading estimates could not be derived.

Pontillo Landfill (a.k.a. Baldwin-Pontillo: West 16th and Pittsburgh Avenue; Erie-Site #3 in Figure 5.3). This site is immediately east of the Currie Landfill Site (see above), and is approximately 20 acres in area. The site was apparently used as a landfill in the late 1960s. Because of the very shallow depth to the shale bedrock under this area (55-60 feet), and the presence of partial aquicludes at various depths, most leachate generated from the landfill is collected and discharged through a pipe at the north edge of the landfill, at an estimated annual rate of approximately 2.5 gallons per minute (1.3 million gallons per year). Landfill leachate discharges to a storm sewer which discharges to the West Branch of Cascade Creek, near West 8th Street and Delaware Avenue (see Harrison, 1988, and Water Quality Protection Report: BWM/Baldwin-Pontillo Site Leachate Discharge Evaluation [author unknown]; submitted to Ricardo Gilson of the PADER Bureau of Waste Management on February 13, 1987).

To provide a basis for evaluation of the leachate quality monitoring data, surrogate discharge "limits" for the leachate discharge were calculated in the Water Quality Protection Report cited above, using the same process that would be used if this source were applying for an NPDES permit for direct discharge of treated wastewater to the West Branch of Cascade Creek. Based on the leachate characteristics, 13 discharge "limits" were calculated, including nine volatile organics (vinyl chloride, 1,1 dichloroethane, 1,2 dichloroethylene, benzene, chlorobenzene, 1,1

The RAP process is intended to restore environmental conditions in AOCs to levels which ensure that the AOC users are not subjected to unusual health risks resulting from normal uses of the AOC. In practice, this unusual health risk exposure test is generally accomplished by comparing AOC contaminant levels with those of "background" levels. For example, four of the 14 AOC listing guidelines include specific comparisons of AOC conditions with unimpacted/control/background conditions. Also, five additional guidelines include comparisons with standards, objectives, or guidelines. Such standards are based on a public health risk management approach, in which the standards are set at risk levels which exceed zero, but are determined to be acceptable through a governmental standards-setting process which balances risks against costs. Consequently, these standards are also approximations of background, rather than zero, risk levels.

4.2 Pollutants of Concern

The overall purpose of the RAP process is to identify those pollutants or other factors which result in impairments of the beneficial uses of an AOC, and to then focus on the reduction or elimination of such pollutants, and on the eventual restoration of such beneficial uses. The 14 AOC listing criteria discussed in §4.1.1 are only guidelines; they are not meant to be all-inclusive, nor are they intended to be static. That is, pollutants of concern may be identified by criteria not specifically included in the 14 current guidelines. Further, in that the 14 current guidelines are based on regulatory standards or comparative background levels, they are dynamic and may change as the standards or background levels change.

A second important aspect of the RAP process is that it encourages the initiation of problem solving (i.e. restoration) activities in parallel with the identification of AOC issues. This process recognizes that it is not necessary to define all ecosystem problems before initiating the problem solving process. It also recognizes that as the initial problems are solved, new problems may become recognizable, whereupon the focus of the RAP may shift toward the newly-recognized problems.

Based on the currently-available information, it not possible to conclusively apply all 14 AOC listing guidelines. However, not all of these listing guidelines contribute toward the identification of pollutants of concern. More importantly, the available information is sufficient to present a reasonably clear indication of the nature of the problems in the AOC. Consequently, it is not necessary to complete additional studies before initiating ecosystem restoration activities in the AOC. While such studies may be necessary to formulate, evaluate, and select the appropriate remedial alternatives, the available information provides a sufficient foundation upon which to initiate the remedial planning process.

PIB pollutants of concern are identified in Table 4-21, on the basis of the evaluations described in §4.1.1 (and the considerations summarized above). The following three sections (pollutants of concern in water quality, sediment, and biota) are derived from this table.

4.2.1 Water Quality

The AOC listing guidelines which involve direct or indirect water quality comparisons and evaluations include numbers 2, 3, 8, 9, 10, 12, and 13. As indicated in Table 4-21, no direct or indirect evidence exists to indicate significant impairment of the water column in PIB, and no water column pollutants of concern are identified.

For several AOC listing guidelines, the existing data are not sufficient to test all parameters. For example, adequate water quality data are available for only two of the 14 taste and odor parameters (guideline #2) for which Pennsylvania water quality standards exist. However, the available data do not indicate the presence of significant problems with these parameters, and all "odor" results (an additional tainting indicator for which there is no corresponding water quality standard) were zero. Further, no reports or other evidence of fish flesh tainting exists. Consequently, no indirect (water quality data) or direct (fish flavor) evidence of the existance of tainting problems exists, and none are suspected.

Most of the AOC listing guidelines include both direct and indirect tests for the presence of problem pollutants, as typified in the example above. In evaluating the available water column data, indirect indicators were evaluated in parallel with the direct (water quality) indicators, particularly where limited water quality data were available. No evidence of significant water column problems resulted from these evaluations, and no water column pollutants of concern were identified.

4.2.2 Sediment

The AOC listing guidelines which involve direct or indirect sediment quality comparisons and evaluations include numbers 3, 6, and 7. No evidence of elevated (i.e. higher than background) sediment toxicity to fish (guideline #3) or benthos (guideline #6) is indicated in the available data. However, in comparison with the USEPA dredged sediment disposal guidelines, PIB sediments are

Table 4-21. Identification of pollutants of concern.

	Guideline	Indicated Pollutants	Observations
#1	Fish and Wildlife Consumption	None	For all regulated pollutants, levels in PIB fish are no different than background.
#2	Tainting	None	No reports of tainted flesh; no pattern of exceedances of tainting water quality standards.
#3	Fish and Wildlife Populations	None	Productive, balanced fisheries present; no evidence of water column or sediment toxicity to fish.
#4	Fish Tumors or Deformities	Possibly PAHs	Liver tumors present; contaminants (e.g. PAHs) suspected of contributing to internal and external abnormalities, but fish flesh levels not elevated; no standards.
#5	Bird Deformities	None	No reports of reproductive problems or deformities in fish-eating birds.
#6	Degradation of Benthos	None	Difficulty in interpreting benthic community structure, but PIB sediment toxicity no different than background.
#7	Restrictions on Dredging	As, Ba; Cd; Cr; Cu; Fe; Pb; Mn; Ni; Zn; COD; TKN; Total P; Cyanide; Oil & Grease; Volatile Solids; Possibly PAHs	All except PAHs chronically exceed USEPA dredged sediment disposal guidelines. No standards for PAHs, but suspected of being elevated.
#8	Eutrophication	None	No significant cultural eutrophication problems identified.
#9	Drinking Water	None	PIB not used for drinking water, but would meet standards.
#10	Beach Closings	Fecal Coliforms	PIB meets water contact recreation standards in most areas with exception of Millcreek Tube.
#11	Aesthetics	None	No persistent problems known.
#12	Ag./Industrial Water Supply	None	No added treatment costs; no exceedances of industrial water supply criteria.
#13	Degradation of Phyto/Zooplankton	No Data	No current data on community structure; no current data on water column toxicity.
#14	Loss of Fish and Wildlife Habitat	None	PIB fisheries management goals are being met.

DR/sn/D54

moderately to heavily contaminated with respect to 10 metals and six other conventional and unconventional pollutants (see Table 4-21).

Although no guidelines or standards exist for sediment PAH levels, PIB sediments exhibit elevated levels of a wide variety of PAHs, which are also suspected to be sediment pollutants of concern. Other organics (pesticides, PCBs, etc.) were not different from background levels and are not indicated or suspected of being sediment pollutants of concern.

4.2.3 Biota

The AOC listing guidelines which involve direct or indirect biota comparisons and evaluations include numbers 1, 2, 3, 4, 5, 6, 13, and 14. From a public health perspective, the most significant of these guidelines is #1; fish and wildlife consumption. For all regulated fish flesh contaminants, no violations of the FDA Action Levels are indicated in the available data, and contaminant levels in PIB fish are no different than background (Lake Erie) levels.

No direct indication of biota contamination exists in the available data. No evidence of fish flesh tainting (guideline #2) exists, and toxicity testing has failed to indicate evidence of sediment or water column toxicity to fish (guideline #3). Although PAHs are suspected of being a sediment pollutant of concern (see above), PAH levels in PIB fish were not unusually high, compared with a national database (see §4.1.1.4). However, fish researchers implicate PAHs as a possible contributing factor in the chronic condition of external sores/lesions in PIB brown bullheads. Consequently, PAHs are considered a contaminant of concern for fish, even though there is no direct evidence of PAH contamination of fish flesh.

No evidence of reproductive problems or other deformities is reported from decades of observations of fish-eating birds on Presque Isle (guideline #5), and sediment toxicity to benthic test species (guideline #6) is no different than background levels. Data are insufficient to assess the possibility for water column toxicity to phytoplankton or zooplankton (guideline #13), however the very high fisheries productivity of PIB suggests a healthy community structure of phytoplankton/zooplankton species, which are at the foundation of the aquatic food chain. Finally, fisheries management goals for PIB (guideline #14) are being met.

4.3 Summary

This chapter is the heart, or focal point, of the Remedial Action Plan, in that the identification of (2) impaired beneficial uses and (2) pollutants of concern occur in this chapter. This information is critical to the remainder of the Plan, but especially Chapters 5 and 6 (Pollutant Sources and Pollutant Loadings, respectively), which focus on the pollutants of concern identified in this chapter.

Impaired uses were identified by comparing available data and other information with the 14 use impairment identification guidelines developed by the IJC's Water Quality Board, based on Annex 2 of the 1978 GLWQA. Most of these guidelines are constructed as two-part tests of impairment, containing either/or conditional statements. Often, one part is based on specific, quantifiable measures while the second part is based on more subjective information. In completing the impaired uses evaluations, all relevant data were used, and the determination of whether a particular beneficial use is or is not impaired was based on the most compelling single set of data, or the collective weight of multiple data sets in those instances where no single set was dominant. Generally, data from 1986 and earlier were not used, as such data do not represent current conditions in PIB. The results of the impaired uses evaluations, relative to the 14 IJC guidelines, are summarized below, and in Table 4.22.

Restrictions on Fish and Wildlife Consumption. Impairment of this guideline is indicated if (1) contaminant levels in fish or wildlife exceed current standards, or (2) if public health advisories against the consumption of fish or wildlife exist. The guideline further stipulates that contaminant levels must be due to contaminant input from the watershed.

Reliable, available 1987-1990 data for PIB and Lake Erie fish were compiled and compared against the FDA "Action Levels" for 11 contaminants (or groups of related contaminants), including persistent organic pesticides, mercury, and PCBs. A total of 57 fish fillets data sets were evaluated (22 from PIB and 35 from Lake Erie). As a result of this comparison, it appears that no impairment of the fish consumption AOC listing guideline is determined to exist. First, no violation of current FDA Action Levels is indicated, based on both PIB and Lake Erie fish flesh samples. Second, the concentrations of these monitored contaminants in PIB fish are no different than those of Lake Erie fish in the vicinity of Presque Isle, indicating that concentrations of the FDA-monitored contaminants in the PIB watershed are not greater than background levels in Lake Erie. Finally, while few data exist on wildlife contaminant levels, no impairment of the wildlife consumption AOC listing guideline is indicated. Further fish flesh analysis will be conducted to reach a more conclusive determination on this impairment.

Tainting of Fish and Wildlife Flavor. Impairment of this guideline is indicated if (1) water quality standards for tainting substances are being exceeded, or (2) tainting of fish or wildlife flavor has been determined through surveys. Water quality data for WQN-632 for the period 1985-1990 were examined, and compared with the PADER standards for taste and odor substances. Of the 14 taste and odor parameters in the PADER water quality standards, significant data are available for only copper and zinc. Of the 22 copper and zinc data sets examined, no evidence of chronic violation of the taste and odor standards is indicated for these contaminants. Also, PIB fish samples have been tested for many of the same or similar organic compounds as those 12 other taste and odor parameters for which no comparative data are available, indicating that concentrations of these other parameters in PIB fish are not unusually high, compared with national averages. Therefore, while the available data and information are inadequate to support a complete, strict application of this AOC listing guideline, based on the available water quality criteria comparisons for tainting substances, and the fish flesh contamination testing results, no impairment of this use is implied or concluded.

Degradation of Fish and Wildlife Populations. This use is considered to be impaired when (1) fish and wildlife management programs have identified degraded fish and wildlife populations due to a cause within the watershed, or (2) significant sediment or water column biotoxicity exists. No evidence of degraded terrestrial wildlife populations exists, and fisheries management programs have not identified degraded fish populations due to a cause within the watershed (conversely, the PIB fishery is rated as "exceptional" by the PFC, based on angling success, survival of stocked fish, and population density). Regarding sediment or water column toxicity, no evidence of significant water column biotoxicity exists, and sediment tests have not identified significant biotoxicity.

Fish Tumors or Other Deformities. This guideline is considered to be impaired when (1) the incidence of fish tumors or other deformities exceed rates at unimpacted, control sites, or (2) when surveys have confirmed the presence of liver tumors in more than 2% of the bullhead population. Surveys have demonstrated the existence of liver tumors in PIB bullheads, but the incidence level has not yet been determined. Because liver tumors are considered the best indication of chemical interference, the liver tumor test is the more reliable test of impairment, and indicates that this guideline may be impaired. There are no generally agreed upon background levels of external abnormalities which can be identified as representing "unimpacted control sites", and the observed incidence rates of external abnormalities in PIB bullheads cannot be reliably interpreted. Fisheries researchers hypothesize that the PIB bullheads are being attacked by a naturally-occurring viral agent, but that the susceptibility of the fish to viral attack is increased by chemically-induced environmental stress. In this theory, sediment PAHs are indicated as the possible chemical agents inducing the stress.

Bird or Animal Deformities or Reproduction Problems. This guideline is impaired when surveys confirm the existence of deformities or reproductive problems in wildlife species. While no formal surveys have been conducted, Presque Isle State Park is extensively visited by both amateur "bird watchers" and experienced ornithologists, and the avian populations of Presque Isle are therefore subject to an unusually intense level of observation, at all times of the year. Four key specialists were interviewed to determine if any evidence of deformities had been observed or reported in resident fish-eating birds (or animals) in the Park. In the aggregate, these specialists represent nearly 100 years of collective observations. There are no colonies of nesting birds in the AOC, and no reports or other evidence of deformities or reproductive problems were identified by these specialists. Therefore, this guideline is not impaired.

Degradation of Benthos. This guideline is considered to be impaired when (1) the composition of the benthic macroinvertebrate community is significantly diminished from what would be normal for a comparable, unimpacted site, or (2) macroinvertebrate toxicity from sediment contaminants is higher than unimpacted (control) sites. Because the physical conditions of PIB are so unique along the southern shore of Lake Erie, no fully-comparable site exists, and PIB benthos data cannot be reliably compared to other sites. However, within the Bay, the distribution pattern of pollution sensitive taxa does not correlate well with the pattern of sediment contamination, and the available data suggest that sediment contaminants are not the dominant influence on the PIB benthic community structure, which is fairly typical for an environment of fine, organic-rich sediments. Further, reliable bioassay test results indicate that the toxicity of PIB sediments on benthic macroinvertebrate test species is no different than the sediments at an unimpacted control site, and this guideline is not impaired.

Restrictions on Dredging Activities. This guideline is impaired when sediment contaminant levels exceed current standards. Sediment data from 1982, 1986, and 1990 were compared with the current, applicable standards (the USEPA Region V "guidelines"). This comparison resulted in the conclusion that PIB sediments are moderately to heavily polluted, for most parameters for which standards (i.e. guideline ranges) have been established. Specifically, the sediments were found to be contaminated for 10 metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc), nutrients (phosphorus and total kjeldahl nitrogen), COD, cyanide, oil & grease, and volatile solids. Although no current standards exist for PAHs, sediment levels of this group of contaminants may also be elevated, based on other data and observations (e.g. brown bullhead observations). When the new sediment guidelines are released by USEPA, this impairment will be re-evaluated with that criteria.

Eutrophication or Undesirable Algae. This guideline is considered impaired when there are persistent water quality problems attributable to "cultural eutrophication" (i.e. nutrient enrichment and related problems resulting from urbanization or other human sources of excess nutrients). Based on a recent (1990) trophic state study, PIB does not exhibit any of the classic symptoms of cultural eutrophication. No nuisance algal blooms, benthic oxygen depletion, or decreased water clarity problems are evident, and this guideline is not impaired.

Restrictions on Drinking Water Consumption, or Taste and Odor Problems. This guideline is considered to be impaired when (1) disease-causing or otherwise hazardous materials are present at levels exceeding applicable standards, (2) taste and odor problems exist, or (3) a level of treatment exceeding regional norms is required to adequately treat raw water. Because PIB is not used as a drinking water supply, this guideline is non-applicable. However, in any case, none of these problems exist in the City's water supply, which is drawn from Lake Erie northwest of Presque Isle, and this guideline is not impaired.

Beach Closings. This guideline is considered to be impaired when water quality standards for the protection of full water contact recreational activities (e.g. swimming) are exceeded. Although no public beaches are established in PIB, water contact recreation is a protected use in the Bay. A 1985 study determined that standards for the protection of this use are being met. More recent data (through 1990) indicate that these protective standards continue to be met. Due to concerns about the use of the mouth of the Mill Creek Tube for recreation, this use is considered partially impaired, pending the completion of the City of Erie's CSO correction project, at which time it will be re-evaluated.

Degradation of Aesthetics. This guideline is considered to be impaired when a pollutant in the water results in a persistent, unnatural or objectionable condition. No evidence of unnatural or persistent discoloration of the water, or other sources of aesthetic impairment are known to occur. While turbid conditions exist after periods of heavy runoff, these conditions are natural for an urbanized area and are not persistent. Also, while a surface sheen is occasionally present at the mouth of Mill Creek, and while debris from urban runoff sources is common along portions of the south shore, these conditions are localized and do not significantly impact the Bay. Consequently, this guideline is not impaired.

Added Costs to Agriculture or Industry. This guideline is considered to be impaired when unusual treatment is required for water used for agricultural, industrial, or commercial purposes. With the closing of Penelec, PIB water is used by only one small-quantity user (an industry), which does not require special treatment of PIB water before use (the raw water is allowed to settle before use). Further, industrial water supply is a protected use in PIB, and the available water quality data indicate that the applicable standards for this use are being met. Therefore, this guideline is not impaired.

Degradation of Phytoplankton and Zooplankton Populations. This guideline is considered to be impaired when (1) the resident phytoplankton or zooplankton community structure is significantly different from comparable, unimpacted control sites, or (2) bioassays have confirmed that ambient waters are toxic to phytoplankton or zooplankton. The physical conditions of PIB are so unique along the southern shore of Lake Erie that no fully-comparable site exists for comparison purposes. Secondly, no recent data are available on the PIB phytoplankton or zooplankton community structure. Therefore, bioassay data were researched as the primary test of impairment. However, no reliable bioassay test data for potential water column toxicity exist, and other data and information are inadequate to support an inferred determination. Therefore, while indications are that no impairment exists for this use, a reliable conclusion is not possible for this guideline, and additional studies (i.e. water column biotoxicity testing) are recommended and currently being conducted.

Loss of Fish and Wildlife Habitat. This guideline is considered to be impaired when fish and wildlife management goals have not been met because of a loss of fish and wildlife habitat resulting from changes in the physical, chemical or biological conditions in the waterbody. The PFC manages PIB as a sport fishery, and conducts periodic fisheries assessments to evaluate the quality and quantity of fish stocks. Based on these assessments, the PFC's fisheries management goals are being met, and this guideline is not impaired. Habitat enhancement projects will be encouraged wherever possible and practical.

Based on the impaired uses evaluations, pollutants of concern were identified as including only sediment contaminants. No water column impairments were indicated. Fish impairments (i.e. liver tumors in bullheads), if environmentally caused, are probably related to the sediment contamination. Sixteen pollutants of concern were identified, including arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, zinc, phosphorus, TKN, COD, cyanide, oil & grease, and volatile solids. In addition, although no standards exist for PAHs, sediment levels of these compounds were determined to be somewhat elevated, and sediment PAHs were therefore included as additional pollutants of concern.

5. Pollutant Sources and Transport Mechanisms

The purpose of the previous chapter was to first determine which beneficial uses are impaired in PIB, and then to determine what pollutants are causing the impairment(s). That information is critical to both this chapter (Chapter 5) and the following chapter (Chapter 6).

Use impairments and conflicts with beneficial uses of PIB were described in §4.1. Pollutants of concern were identified in §4.2, based on the use impairments identified in §4.1. The purpose of this chapter is to determine (1) the sources of the pollutants causing the impairments, and (2) the means by which the problem pollutants are transported from their sources to the impact areas.

PIB pollutants of concern are identified in Table 4-21, based on the results of the evaluations conducted in Chapter 4. These pollutants include 10 metals, five conventional/ nonconventional pollutants, and (probably) PAHs. These pollutants are determined to be primarily confined to the sediments, and do not appear to be significantly accumulating in (or adversely affecting) biota or the water column, although it is theorized that PAHs may act in association with a naturally-occurring virus to cause the external lesions observed in PIB brown bullheads.

5.1 Primary Sources of Pollutants of Concern

Typically, the primary or major sources of pollutants of concern in AOCs are point source discharges, or other "direct" pollutant inputs. Therefore, NPDES point source discharge files were reviewed to attempt to "spot" candidate sources of the PIB pollutants of concern identified in Chapter 4. Based on this review, five significant NPDES-permitted point sources were identified which discharge directly to PIB, and an additional four permitted point sources were identified which discharge to storm sewers or tributaries within approximately 1.3 miles of the Bay (generally, north of 19th Street, or the Norfolk and Western rail line). These point sources are summarized in Table 5.1; their locations are depicted in Figure 5.1.

In addition, numerous CSOs exist within the City's combined sewer system. These outfalls are individually numbered as point source outfalls in the City's NPDES permit. The locations of the CSO discharge points are depicted in Figure 5.2. As seen in Figure 5.2, the CSOs in the Mill Creek drainage system are fairly well distributed throughout the urbanized portion of the watershed, with some as much as two to three miles upstream from the Bay, while others are located within 0.5 miles of the mouth of Mill Creek. Of the CSOs in the City's sewer system, 47 (84%) discharge directly to

Table 5.1 Summary of significant NPDES-permitted outfalls to PIB.*

Permittee	Discharge Location (longitude/latitude)	Wastewater Source	Effluent Levels	Comments
nsylvania lectric Company Penelec)	• 001: public dock (42°03'24"/80°05'15")	coal pile runoff, ash transport water, low volume wastes	TSS(1): 30/70 mg/l(2) O&G(3): 15/20 mg/l PCBs: not known (special condition 2)(4) pH: 6.0-9.0 flow: estimated 1 mgd	Discharge discontinueo in early 1991. Permit expires 12/22/92.
	• 002: public dock; W. slip (42°08'08"/80°05'24") • 003: public dock (42°8'16"/80°5'21")	cooling water from steam electric generation(7)	TSS: 30/70 mg/l O&G: 15/20 mg/l TRC(5): 0.2 mg/l(6) (special condition 1)(4) Temp.: <°5 F over ambient pH: 6.0-9.0 flow: est. 100 mgd (combined 002/003)	Discharge discontinuec in early 1991. Permit expires 12/22/92.
ie Forge & Steel, Inc.	• 001: Cascade Creek (42°06'37"/80°06'24")	vacuum degassing effluent from ladle refining furnace and steam degasser, and effluent from heat treatment quench operation; ladle refining furnace cooling(7); electric furnace cooling(7); oil quench heat exchanger(7); forge press & miscellaneous area cooling(7)	Currently being established. flow: 0.889 mgd	#s 101, 201, & 301 discharge through 0(101-vacuum degassing 201-water quench 301-boiler blowdown Permit expiration date not known.
AND				
	• 002: Cascade Creek (42°06'32"/80°06'23")	stormwater runoff (estimated at 35,000 gpd)		Outfall 002 is stormwater only. Permit expiration date not known.
tional Forge Company	• 003: Drainage Ditch to Cascade Creek (42°06'20"/80°06'59")	refining of steel by an electroslag remelt furnace	Currently being established. flow: 0.07 mgd (0.02 mgd - evaporative cooler flushing; 0.05 mgd - ground dewatering)	Permit expiration date not known.

Table 5.1 Summary of significant NPDE[illegible] [illegible]rmitted outfalls to PIB (cont.)*

Permittee	Discharge Location (longitude/latitude)	Wastewater Source	Effluent Levels	Comments
‌ited Erie, Inc.	• 001: storm sewer draining to PIB (42°07'02"/80°05'23")	boiler blowdown and kettle jacket cooling water (0.054 MGD)	TSS: Monitor Only Iron, Total: Monitor Only Aluminum: Monitor Only O&G: 15/30 mg/l Temp.: Monitor Only ph: 6.0-9.0	Permit expires 9/19/9‌
‌ramid Industries, Inc.	• 001: storm sewer discharging to West Branch Cascade Creek (42°06'36"/80°07'23")	contact cooling water from thermo-plastic extrusion of polyethylene and polyvinyl chloride pipe flow: 0.066 MGD design average flow	TSS: 19 mg/l (Max. Daily) O&G: 15/30 mg/l BOD_5: 26 mg/l (Max. Daily) pH: 6.0-9.0	Permit expires 7/14/9‌
	• 002: storm sewer discharging to West Branch Cascade Creek (42°06'36"/80°07'23")	Manhole inside building that collects flow from the floor drains.	TSS: Monitor Only O&G: Monitor Only BOD_5: Monitor Only pH: 6.0-9.0	
‌ick Foundry Company	• 001: Poplar Street storm sewer (42°06'58"/80°05'36") • 002A, 002B: Cherry St. storm sewer (42°06'58"/80°05'36")	foundry non-contact cooling water from cupola wall, air compressor, and shell core machines and storm water runoff (est. annual flow #001 - 0.048; #002 (A&B) - 0.013 mgd)	TSS: Monitor Only Iron: Monitor Only Aluminum: Monitor Only Zinc: Monitor Only Temp.: Monitor Only pH: 6.0-9.0 (All 3 Outfalls)	Permit expires 9/19/9‌
‌estnut Street Water Treatment Plant	• 001: PIB (42°08'10"/80°05'50")	filter backwash from drinking water filtration	TSS: 30/75 mg/l Iron: 2.0/5.0 mg/l Aluminum: 4.0/10.0 mg/l Manganese: 1.0/2.5 mg/l pH: 6.0-9.0	Permit expires 5/21/9‌ No longer use this di‌ charge as they convey it to the City sanita‌ system.

Table 5.1 Summary of significant NPDES-permitted outfalls to PIB (cont.)*

Permittee	Discharge Location (longitude/latitude)	Wastewater Source	Effluent Levels	Comments
: Filtration lant 'Sommerheim")	• 003: PIB (42°06'55"/80°08'40")	filter backwash from drinking water filtration	TSS: 30/75 mg/l Iron: 2.0/5.0 mg/l Aluminum: 4.0/10.0 mg/l Manganese: 1.0/2.5 mg/l pH: 6.0-9.0 flow: 0.5 mgd (mo. ave.)	Permit expires 5/24/95
Building aterials orporation	• 001: PIB via Sassafras Street storm sewer (42°08'02"/80°05'34") • 002: PIB via Sassafras Street storm sewer (42°08'04"/80°05'35") • 003: PIB via Sassafras Street storm sewer (42°08'05"/80°05'36") • 004: PIB via Sassafras Street storm sewer (42°08'09"/80°05'40")	boiler blowdown, stormwater runoff, vacuum pump cooling water(7), and roofing machine cooling water(7)	001: O&G: 15/30 mg/l pH: 6.0-9.0 002: O&G: 15/30 mg/l pH: 6.0-9.0 003: TSS: 21/42 mg/l O&G: 15/30 mg/l pH: 6.0-9.0 flow: .263 mgd (ave. flow) 004: no sampling required (all storm water)	Permit expires 5/14/97 Boiler additives used
y of Erie CSOs	• various (47) total: PIB and PIB via Mill Creek, Garrison Run, Cascade Creek, and sewer outfalls (see text for locations)	combined sewer overflows (approx. 3.1 mg to PIB during an average storm, from 20 outfalls)	none	Permit expires 10/3/96
sque Isle State ark	• 001: PIB (42°09'30"/80°08'00")	treated sanitary wastewater	BOD_5: 25/50 mg/l TSS: 30/60 mg/l fecal coliforms: 200/100 ml (limits applies May 1 - September 30) pH: 6.0-9.0 flow: 0.0175 mgd (mo. ave.)	Permit expires 8/16/95

see text for determination of "significant"
(1)total suspended solids
(2)average/maximum
(3)oil and grease
(4)details not known
(5)total residual chlorine
(6)instantaneous maximum
(7)non-contact cooling water

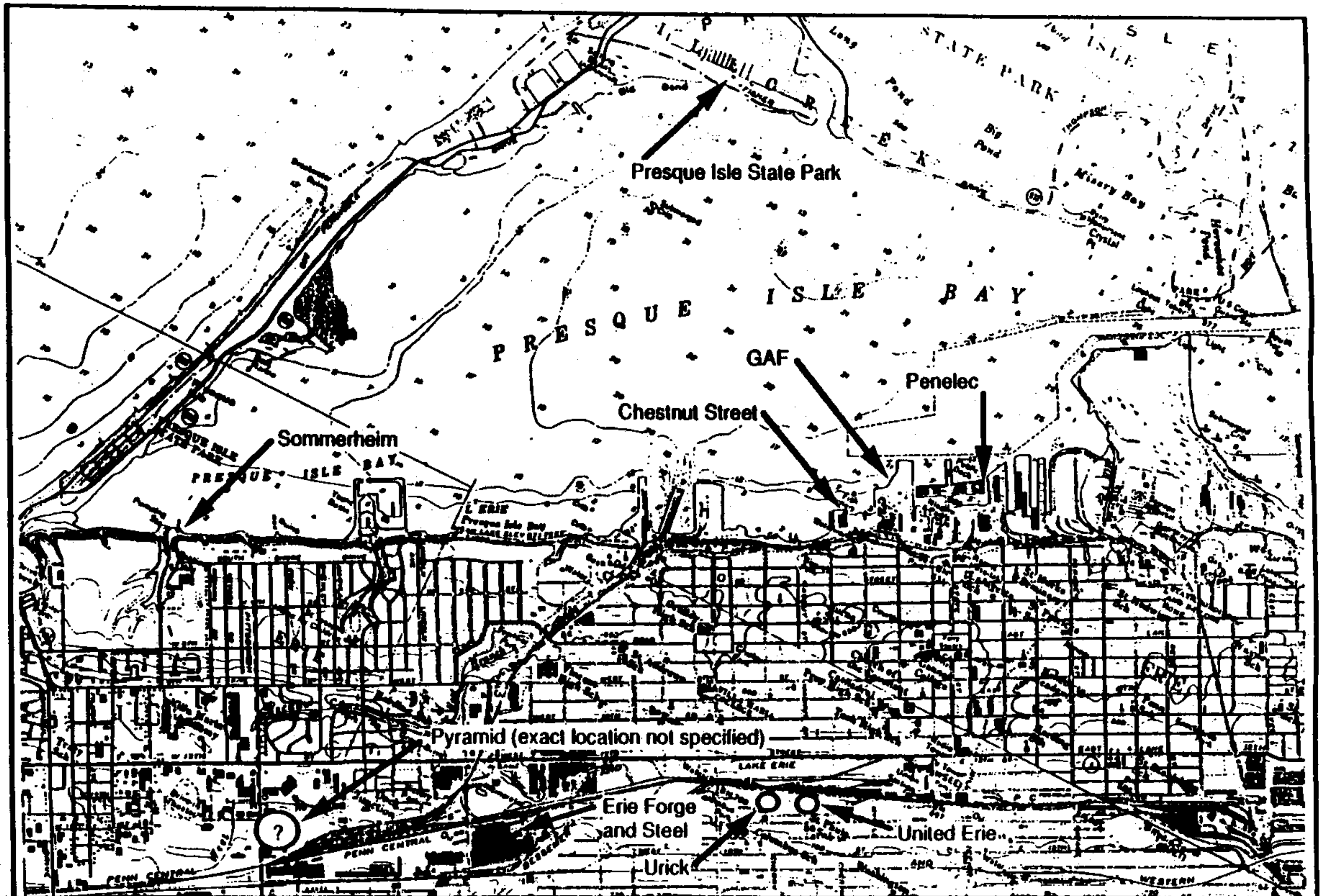


Figure 5.1. Locations of selected NPDES outfalls discharging to PIB.

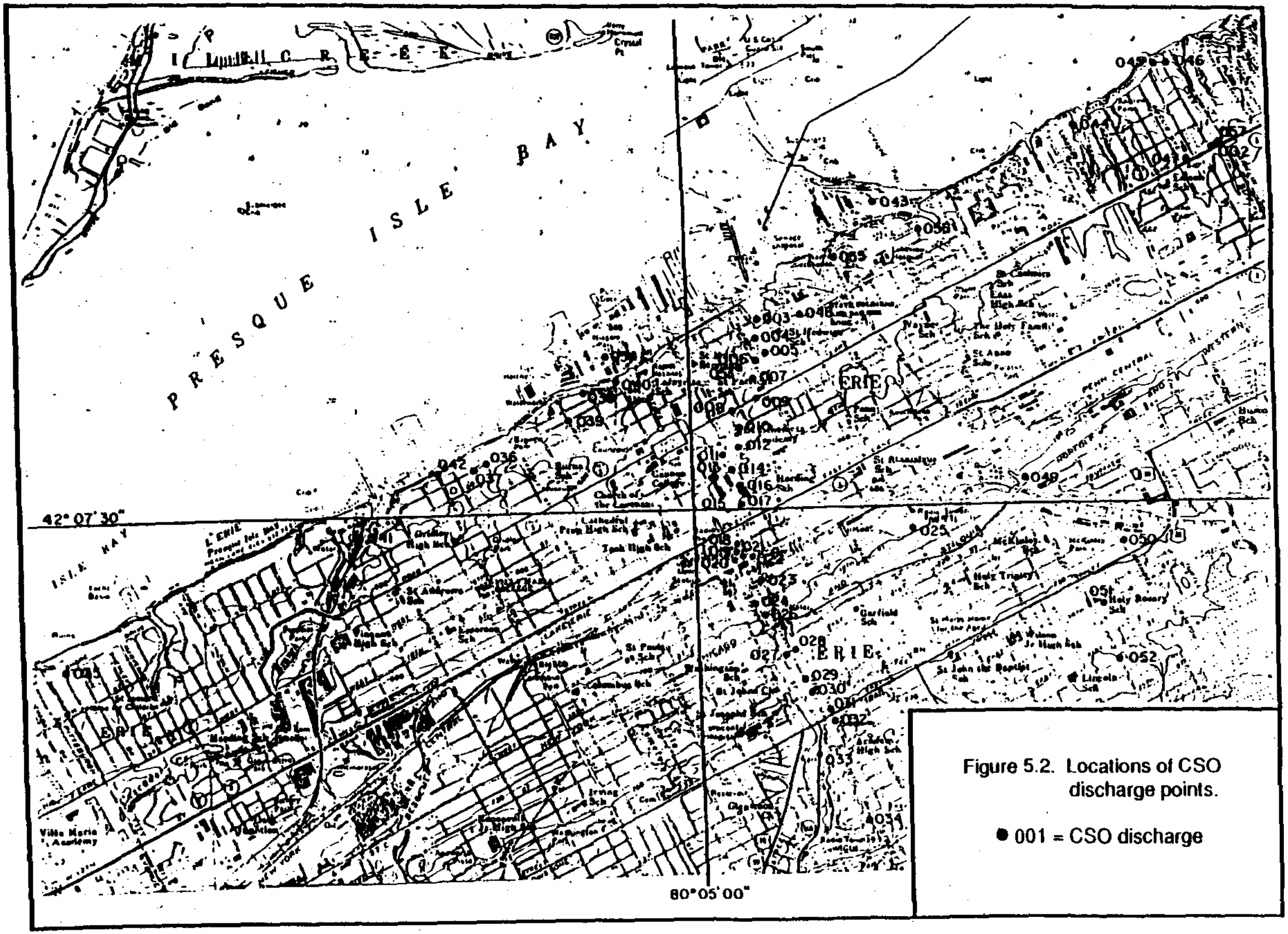


Figure 5.2. Locations of CSO discharge points.

● 001 = CSO discharge

PIB, or indirectly, through streams or sewer outfalls leading to the Bay. These 47 additional point sources are included in summary fashion in Table 5.1. Of the 47 CSOs discharging directly or indirectly to PIB, 38 (81%) discharge to the Mill Creek/Garrison Run drainage system, one discharges to Cascade Creek, and eight discharge to the Bay via small, unnamed tributaries, drainageways, or outfall sewer lines.

The CSOs release raw sanitary sewage to the Bay during overflow events. In addition, because most of Erie's industries discharge their process wastewater to the City's sewer system, untreated industrial effluent is also released through these CSOs. The City's NPDES permit lists 39 industries which contribute >50,000 gallons/day and/or toxic materials to the sewer system. Based on the permit file data, an estimated 18.6 mgd of industrial effluent is discharged to the sewer, on an average daily basis, from these 39 industrial users.

Of the point sources listed in Table 5.1, the largest by far is Penelec, which ceased operations in early 1991. With the exception of the CSOs, the remainder of the point sources in Table 5.1 contribute <1.0 mgd to the Bay. While a significant percentage of the 3.1 million gallons discharged from the CSOs during an average storm is industrial effluent, the City operates an industrial user program, and industrial effluents are therefore primarily limited to those which are amenable to biological treatment (industries are generally prohibited from introducing bioaccumulative or persistent toxics to the sewer system).

A review of the permit limits in Table 5.1 does not result in the identification of any significant candidate sources of the PIB pollutants of concern identified in Chapter 4. In order to examine these point sources more closely, available discharge monitoring data for the pollutants of concern were retrieved from the NPDES permit files. These data are summarized in Table 5.2.

Comparing Tables 5.1 and 5.2, it is seen that monitoring data are not available in the NPDES files for all Table 5.1 direct dischargers. Also, because of inconsistencies in the manner in which data are reported in the files, some of the annual loading values (i.e. "#/year") in Table 5.2 may be significant overestimates. For example, it is not always clear whether the reported monitoring results in the "conc." column are based on (1) the total flow volume for that outfall, or (2) an internal, contributing waste stream of substantially less relative flow volume, which discharges through the same outfall. This potential source of error is most significant for those industries discharging large volumes of non-contact cooling water (e.g. Erie Forge), because the #/year values are the product of flow volume

Table 5.2

Estimated annual pollutant loadings from significant NPDES direct dischargers.

Pollutants of Concern(1)	National Forge Co. (0.07 mgd) conc.(2)	#/year	Erie Forge & Steel, Inc. (0.889 mgd) conc.(2)	#/year	U.-Erie #001 (0.054 mgd) conc.(2)	#/year
Arsenic	<0.002	<0.426	<0.002	<5.410	<0.005	<0.820
Barium	0.040	8.520	0.100	270.600	0.025	4.100
Cadmium	<0.005	<1.065	0.00023	0.620	<0.0004	<0.066
Chromium	<0.010	<2.130	<0.010	<27.060	<0.002	<0.329
Copper	0.010	2.130	0.039	105.500	0.010	1.640
Iron	<0.070	<14.920	1.580	4276.000	0.257	42.200
Lead	<0.003	<0.640	0.042	113.700	<0.010	<1.640
Manganese	0.010	2.130	0.070	189.400	0.008	1.320
Nickel	<0.020	<4.260	<0.020	<54.100	<0.002	<0.330
Zinc	<0.017	<3.620	0.258	698.200	0.014	2.300
COD	<6.670	<1421.000	<5.000	<13531.000	<10.000	<1644.000
TKN(4)	--	--	<0.360	<974.000	0.700	115.000
Total Phosphorus	<0.010	<2.130	<0.017	<46.000	0.100	16.400
Cyanide	<0.010	<2.130	<0.010	<27.060	<0.001	<0.160
Oil & Grease	<1.670	<356.000	<2.000	<5412.000	4.600	756.000
Total Volatile Solids	--	--	NT	--	NT	--
PAHs(5)	--	--	ND	--	NT	--

(1)Metals and cyanide are reported as total.
(2)Longest term average concentrations cited used; all concentrations in mg/l.
(3)#/year values were calculated on the basis of the flow values given in the permit.
(4)Values with an (*) are based on total organic nitrogen (TKN value not available).
(5)ND=tested for, but not detected; NT=not tested for.

Table 5.2

Estimated annual pollutant loadings from significant NPDES direct discharges.

Pollutants of Concern(1)	Urick #001 (0.048 mgd)		Urick #002A (0.013 mgd)		Urick #002B (0.00076 mgd)	
	conc.(2)	#/year	conc.(2)	#/year	conc.(2)	#/year(3)
Arsenic	<0.005	<0.730	<0.005	<5.540	<0.005	<0.010
Barium	0.028	4.090	0.027	1.070	0.023	0.050
Cadmium	<0.002	<0.290	<0.002	<2.370	<0.002	<0.005
Chromium	<0.002	<0.290	<0.002	<2.370	<0.002	<0.005
Copper	0.030	4.380	<0.002	<2.370	<0.002	<0.005
Iron	1.420	207.300	1.160	1286.000	<0.004	<0.009
Lead	<0.010	<1.460	<0.010	<11.100	<0.010	<0.020
Manganese	0.019	2.770	0.017	19.000	<0.0004	<0.0009
Nickel	<0.002	<0.290	<0.002	<2.370	<0.002	<0.005
Zinc	0.040	5.840	0.183	202.600	0.082	0.190
COD	12.000	1,752.000	11.000	12189.000	<10.000	<23.000
TKN(4)	1.690	246.700	1.110	1230.000	0.640	1.470
Total Phosphorus	<0.008	<1.170	0.020	22.200	<0.008	<0.018
Cyanide	0.007	1.020	<0.001	<1.190	<0.001	<0.002
Oil & Grease	10.000	1,460.000	8.000	8864.000	7.000	16.100
Total Volatile Solids	NT	--	NT		NT	--
PAHs(5)	NT	--	NT		NT	--

(1)Metals and cyanide are reported as total.
(2)Longest term average concentrations cited used; all concentrations in mg/l.
(3)#/year values were calculated on the basis of the flow values given in the permit.
(4)Values with an (*) are based on total organic nitrogen (TKN value not available).
(5)ND=tested for, but not detected; NT=not tested for.

Table 5.2

Estimated annual pollutant loadings from significant NPDES direct discharges.

Pollutants of Concern[1]	Sommerheim (0.5 mgd)		GAF #003 (0.263 mgd)	
	conc.[2]	#/year	conc.[2]	#/year
Arsenic	NT	--	<0.005	<4.000
Barium	NT	--	0.031	24.800
Cadmium	NT	--	<0.001	<0.800
Chromium	NT	--	<0.005	<4.000
Copper	0.014	21.300	<0.002	<1.600
Iron	0.840	1278.000	2.310	1848.000
Lead	0.030	45.600	<0.030	<24.000
Manganese	NT	--	0.083	66.400
Nickel	NT	--	<0.005	<4.000
Zinc	NT	--	<0.012	<9.600
COD	NT	--	16.000	12801.000
TKN[4]	NT	--	1.510	1208.000
Total Phosphorus	NT	--	<0.030	<24.000
Cyanide	NT	--	<0.001	<0.800
Oil & Grease	NT	--	9.400	7521.000
Total Volatile Solids	NT	--	NT	
PAHs[5]	NT	--	NT	

(1) Metals and cyanide are reported as total.
(2) Longest term average concentrations cited used; all concentrations in mg/l.
(3) #/year values were calculated on the basis of the flow values given in the permit.
(4) Values with an (*) are based on total organic nitrogen (TKN value not available).
(5) ND=tested for, but not detected; NT=not tested for.

times pollutant concentration. Consequently, the data in Table 5.2 may be considered as worst-case loading estimates, based on the file data.

The 47 CSOs from the City's sewer system are not included in Table 5.2. Because of the discontinuous nature of these discharges and the limited available data, it is not possible to calculate annual pollutant loadings from the 47 individual CSOs. The City of Erie is currently collecting data on the volume and quality of effluent from CSOs, but a final report is not yet available. A summary of preliminary data is included in Appendix C and complete analysis will be provided in the future and included in this RAP as needed. However, a crude estimate of annual pollutants loadings may be calculated from the estimated total overflow volume to PIB, and the characteristics of the wastewater influent at the treatment plant (both of which are known). This approach assumes that (1) the characteristics of the wastewater at that point at which it enters the treatment plant are representative of those characteristics at the individual CSO outfall locations, and (2) the plant influent wastewater characteristics at the time of sample collection are representative of those characteristics prevailing during CSO events.

The total volume of annual CSO discharges to PIB is estimated at 0.7 mgd (PADER, 1991). Based on this flow rate, and the wastewater characteristics data in the NPDES file, annual loadings of the pollutants of concern to PIB from CSOs are estimated in Table 5.3. The NPDES file data used in developing Table 5.3 are reasonably current (5/19/86 PRC lab report to ECHD) and a wide variety of toxic organic pollutants were tested for, in addition to metals and cyanide. The second "Pollutants" column in Table 5.3 includes a variety of the more common PAH compounds, most of which have been reported from the sediments of PIB (FWS, 1991).

As seen in Table 5.3, all of the PAHs were reported as <10 μg/l, which is assumed to have been the detection limit used in the analysis. As a result, all PAHs are estimated at the same annual loading rate (21.28 #/year), which is an obvious overestimation of the true values. In addition to the inorganics (metals), a total of 112 other parameters were tested for in the 1986 data report, comprised primarily of pesticides and other toxic organics. These 112 additional parameters included cyanide, 29 volatile organics, 11 acid-extractable organics, 46 base neutral organics, 18 organic pesticides, and seven PCBs. Of these 112 parameters, 110 (98%) were listed as "<" ("less than") results, indicating their concentrations to be less than the detection limits used in the analytical procedure.

Table 5.3. Estimated annual loading of pollutants of concern from CSOs.

Pollutants	Conc. (mg/l)	Loadings (#/year)	Pollutants	Conc. (µg/l)	Loadings (#/year)
Arsenic	0.005	10.64	Naphthalene	<10	<21.28
Barium	0.008	17.03	Phenanthrene	<10	<21.28
Cadmium	0.024	51.10	Pyrene	<10	<21.28
Chromium	0.124	264.00	Acenaphthene	<10	<21.28
Copper	0.124	264.00	Acenaphthylene	<10	<21.28
Iron	NT	-	Anthracene	<10	<21.28
Lead	0.056	119.23	Benzo[a]anthracene	<10	<21.28
Manganese	NT	-	Benzo[a]pyrene	<10	<21.28
Nickel	0.232	493.94	3,4-Benzofluoranthene	<10	<21.28
Zinc	0.244	519.49	Benzo[ghi]perylene	<10	<21.28
COD	NT	-	Benzo[k]fluoranthene	<10	<21.28
TKN(4)	NT	-	Chrysene	<10	<21.28
Total phosphorus	NT	-	Dibenzo[a,h]anthracene	<10	<21.28
Cyanide	0.18	383.23	Fluoranthene	<10	<21.28
Oil & grease	NT	-	Fluorene	<10	<21.28
Total volatile solids	NT	-	Indeno[1,2,3-cd]pyrene	<10	<21.28

The results of the organics testing of the wastewater treatment plant influent (98% less than detection limits) indicates that raw wastewater in the City's sewer lines does not carry large volumes of potentially toxic organics. These data also suggest, therefore, that normal sanitary and industrial wastewater escaping from CSOs is not a major potential source of toxic organics to PIB.

Comparing Tables 5.2 and 5.3, it may be seen that, at least for the metals, the CSOs are significant contributors of pollutants of concern to PIB, relative to other NPDES-permitted point sources. However, while these CSOs include untreated industrial effluent, they also include "nonpoint" pollutants carried in large volumes of urban runoff which enters the sewer system through surface inlets (storm drains, roof leaders, foundation drains, etc.) during runoff events, causing the overflows. Therefore, it cannot be concluded that the pollutants loadings in Table 5.3 are wholly derived from industrial users. Pollutant loadings from urban nonpoint runoff are discussed in the following section.

5.2 Secondary Sources of Pollutants of Concern

Typically, the major sources of pollutants of concern in AOCs are direct discharges from municipal and industrial wastewater treatment plants, and overflows from combined sewer systems. These sources are discussed in the previous section. Secondary or minor sources of pollutants of concern in AOCs are typically contaminated surface and groundwater runoff, air deposition, and other nonpoint or "indirect" sources of pollutant inputs. These potential sources are discussed in the following sections.

5.2.1 Surface Runoff

Because PIB is a nearly-enclosed embayment with a low "flushing" rate (see §3.2.2), any contaminants introduced into the Bay, regardless of the source, tend to accumulate in the ecosystem. Further, because such a large percentage of the PIB watershed is urbanized, nonpoint pollution from urban runoff is a significant potential source of PIB pollutants of concern. In addition, groundwater discharges can enter the Bay as surface runoff when intercepted by stream valleys. (Richards, et al, 1987)

However, nonpoint pollutant loading rates have not been systematically investigated in the PIB watershed, and no reliable estimates of the quantity and quality of urban nonpoint runoff exist in the available data base. Consequently, this topic is addressed by drawing inferences and comparisons with other urban areas in which such data have been generated. Because of the importance of this potential contaminants source, this topic is dealt with in some detail in the following discussion.

5.2.1.1 Background

The nationwide significance of pollution caused by storm-generated discharges was first identified in the 1964 U. S. Public Health Service's publication: "Pollutional Effects of Stormwater and Overflows from Combined Sewer Systems" (Lager and Smith, 1974). Congress, in recognizing this problem, authorized funds under the Federal Water Pollution Control Act of 1965 and, through Section 62 of the Water Quality Act of 1965 (P.L. 89-234), authorized the Federal government to make grants for the purpose of "... assisting in the development of any project which will demonstrate a new or improved method of controlling the discharge into any water of untreated or inadequately treated sewage or other waste from sewerage which carry storm water or both storm water and sewerage or other waste".

The 1972 Amendments placed new and stronger emphasis on urban runoff as a source of pollution. The 1972 amendments stressed "An accelerated effort ... to develop, refine, and achieve practical application of waste management methods applicable to nonpoint sources of pollutants to eliminate the discharge of pollutants including, but not limited to, elimination of runoff of pollutants". Construction grant applications (§201 of the Act) and areawide or basin wastewater treatment management plans (§208 of the Act) were encouraged to include "... the necessary waste water collection and urban storm water runoff systems" for the control and treatment of storm-generated pollution.

As a result of Section 208 of the Act, State and local water quality management agencies were designated to integrate water quality management activities. As funds for the construction and upgrading of municipal sewage treatment plants were granted, and both municipal and industrial point source discharges were increasingly brought under control, the significance of nonpoint sources (including urban runoff) as potential contributors to water quality degradation became more apparent, and a program of investigative and research studies was initiated.

However, as these studies progressed, uncertainties arose over the local nature and extent of urban runoff water quality problems, the effectiveness of possible management and control measures, and the affordability of these control measures in comparison with benefits to be derived. Studies in the 1970's concluded that essentially every metropolitan area of the United States has a stormwater problem, whether served by a combined sewer system or a separate sewer system (Lager and Smith, 1974). However, the unknowns were so great and certain control cost estimates were so high that the Clean Water Act of 1977 (P.L.

95-217) deleted Federal funding for the treatment of separate stormwater discharges. The Congress felt that there was simply not enough known about urban runoff loads, impacts, and controls to warrant making major investments in physical control systems (USEPA, 1983a).

In 1978, EPA Headquarters reviewed the results of work on urban runoff by the technical community and the various 208 Areawide Agencies and determined that additional, consistent data were needed. The National Urban Runoff Program (NURP) was implemented to build upon pertinent prior work and to provide practical information and insights to guide the planning process, including policy and program development and implementation. The NURP program included 28 projects, conducted separately at the local level, but centrally reviewed, coordinated, and guided (USEPA, 1983b).

The U. S. EPA's Storm and Combined Sewer Research Program has continued to sponsor urban runoff studies, including several long-term research projects that are concerned with urban receiving-water problems. Current research efforts stress identifying the sources of pollutants and controlling their discharge. Even so, recent papers (e.g. Field and Pitt, 1990) continue to note problems encountered in the application and use of existing, available data because of differences in sampling procedures and the practice of pooling data from various sites. These papers cite the need for comprehensive, carefully designed, long-term studies to investigate urban storm runoff problems on a site-specific basis. Sediment transport, deposition, and chemistry play key roles in urban receiving water behavior and need additional research. Biological conditions in receiving waters need to be studied to support laboratory bioassays.

It has been noted (Field and Pitt, 1990) that studies of receiving-water effects are needed to examine beneficial water uses directly instead of relying on published water quality criteria and water column measurements alone. Published criteria are usually not applicable to urban runoff because of the intermittent nature of urban runoff, the unique chemical speciation of its components, the transport patterns of contaminated runoff solids, and the potential impacts that polluted urban sediments may have on beneficial water uses.

5.2.1.2 Water Quality Impacts of Stormwater Runoff

Both toxic heavy metals and organic pollutants are responsible for urban receiving-water problems caused by stormwater runoff. Most beneficial water uses, including shellfish harvesting, fish and aquatic-life propagation, drinking water, and recreation, have been shown to be adversely affected by urban runoff.

The urban stormwater impacts problem is a nationwide rather than a regional or local issue. In one example, studies on the Saddle River near Lodi, New Jersey, found higher sediment enrichment of heavy metals in the urban, lower Saddle River than in the more rural, upper Saddle River (Wilbur & Hunter, 1980). The increase in heavy metal concentrations caused by urbanization ranged from about 3 mg/l for zinc and copper to more than 5 mg/l for lead, chromium, and cadmium (Field & Pitt, 1990). In another study near Champaign-Urbana, Illinois, lead concentrations in the sediments of an urban stream were found to be almost 400 ppm; this same study also found greater plant and animal diversity in rural streams than in the urban streams (Rolfe and Reinbold, 1977).

Even in those urban areas where untreated sewage discharges are an issue, urban runoff represents a significant portion of the heavy metal loadings to the receiving waters. This is illustrated in example urban runoff data presented in Table 5.4. As seen in this table, the percentage contributions of surface runoff derived heavy metals to the total metals loadings in runoff of a major urban area currently range from 63% for zinc to 32% for nickel.

In Erie, a major effort has been made to transmit all collected wastes from the City, Peninsula, and Bay watershed to the City's Sewage Treatment Plant. The treated effluent from the plant is not discharged to PIB and thus does not contribute any waste components to the Bay's loading. Effluent is discharged to Lake Erie within the boundaries of the Outer Harbor.

If it is assumed that the untreated wastewater component percentage of New York Harbor's loading is representative of the untreated wastewater effluent reaching PIB and that future treatment will remove 90% of that load, then runoff would be responsible for the following percentage contribution to Bay loadings in the future: copper, 95%; chromium, 92%; nickel, 94%; zinc, 98%; and cadmium, 95%. Also, if the above assumptions are correct, presently the runoff waste load contributions would equal 67% of copper, 55% of chromium, 60% of nickel, 82% of zinc, and 65% of cadmium. Clearly, if a table similar to Table 5.4 were prepared for PIB, the "Treated effluent" loads would be insignificant compared to the non-point loads.

Table 5.4. Metals loadings to New York Harbor from various sources (from USEPA, 1979; Field and Turkeltaub, 1981).

Metals Sources	Metals Concentrations (mg/l) Copper	Chromium	Nickel	Zinc	Cadmium
Treated effluent	1,410	780	930	2,520	95
Runoff(1)(2)	1,990	690	650	6,920	110
Untreated wastewater	980	570	430	1,500	60
Total loading (#/day)	4,380	2,050	2,010	10,940	265
Ave. concentrations (mg/l)	0.25	0.12	0.11	0.62	0.015
% of total from runoff	45	34	32	63	42
% assuming 90% treatment of untreated wastewater sources	57	45	40	72	52

(1) In reality, shockload discharges are much greater.

(2) Runoff data includes separate storm sewer discharges as well as wet weather CSOs.

Three key factors which are important in understanding the magnitude of the stormwater runoff problem and the complex water quality management issues involved are discussed below.

Time Delay. Many of the adverse effects of stormwater runoff associated with organic and toxic pollutants are expressed only over long time frames, and are not recognizable from individual runoff events. Over time, small repetitive doses of contaminants from individual runoff episodes result in large accumulations of sediment contaminants, and numerous examples of heavy metal and nutrient accumulations in urban sediments are available in the technical literature. In-place sediment pollutants affect the water column in urban streams usually by the resuspension of previously deposited materials. Resuspension occurs under the highly variable flow conditions that are common to urban streams. Large quantities of sediment may be transported in the stream system by deposition, resuspension, and subsequent redeposition. This repetitive process causes polluted solids to pass slowly through an urban stream. The transport of pollutants, therefore, is difficult to relate to specific runoff events, as much of the suspended material during a high storm flow may actually be resuspended sediment material deposited during previous storms (Field & Pitt, 1990).

An example of the time delay factor is provided in the results of a study in San Jose, California, which found that urban runoff BOD affecting Coyote Creek exerted increased oxygen demand, as much as tenfold, 10 to 20 days after a rain event, rather than during the first few days after the rain event. Therefore, sediments having high BODs can substantially affect overlaying DO concentrations many days after they are deposited by a specific storm. Another study found more critical oxygen deficits located much farther downstream than predicted because of the resuspension of contaminated sediments during high flows (Meinholz et al., 1979).

Variation in Toxicity. Preliminary toxicity results have found that urban runoff varies widely in its relative toxicity, depending on sample location. A residential roof-runoff sample was found to be the most toxic of all samples examined to date, possibly because of the high concentrations of soluble heavy metals, especially zinc, that may have leached from galvanized metal roof gutters and downspouts. This sample also contained the highest concentration of DDT. Other samples that had relatively high toxicities were from automobile-service facilities, unpaved industrial parking and storage area, and paved industrial streets (Field & Pitt, 1990).

The relative toxicities of various urban runoff source samples are presented in Table 5.5. As seen in this table, the category having the largest percentage of extremely toxic samples was combined sewer overflows. The urban creeks and detention ponds had the largest percentage of samples that can be considered not toxic. The source areas that had the greatest toxic responses were the parking and storage areas (Pitt & Field, 1990).

No Appropriate Standards. Urban stormwater runoff behaves in a different manner than typical municipal or industrial wastewater discharges, for which many standards have been developed. Urban storm runoff occurs for relatively short periods of time. Therefore, toxicant concentration standards developed for continuous exposures are not directly applicable for these short-term discharges. Monitored mass loadings show that great quantities of toxic compounds are being discharged in urban storm runoff. Additional long-term receiving-water studies have found that aquatic organism surveys indicate significant toxicity problems in many areas. Urban runoff leads to habitat destruction by causing high flow rates, sediment accumulation, and the presence

Table 5.5. Relative toxicity groupings of various urban runoff source samples (from Field & Pitt, 1990).

Sampling Locations	Toxicity Classifications (%) Extremely	Moderately	Non-toxic	# samples
Roofs	8	58	33	12
Parking areas	19	38	44	16
Storage areas	25	50	25	8
Streets	0	67	33	6
Loading docks	0	67	33	3
Vehicle service areas	0	40	60	5
Landscaped areas	17	33	50	6
Urban creeks	0	12	88	19
Detention ponds	10	10	80	12
Combined sewer overflows	65	30	5	20

of toxic chemicals in those sediments. Because of the time delay issues, few short-term problems, such as fish kills, have been associated with specific urban storm-runoff events (Field & Pitt, 1990), and the conventional standards setting process has not been adaptable to stormwater runoff.

Few well documented cases of the detrimental effects of urban storm runoff on receiving water quality exist in the literature. Urban stormwater runoff impacts are difficult to observe in urban areas because of pre-existing poor water quality and the lack of pollution sensitive organisms. Fish kills may indicate urban stormwater runoff problems. However, researchers have stated that one of the complications in determining the causes of fish kills related to heavy metals is that the fish mortality may lag behind the first toxic exposure by many days, and therefore usually occurs many miles downstream from the discharge location. The actual concentrations of the constituents that caused the kill may be diluted beyond detection limits, making the sources of the toxic materials impossible to determine (Field & Pitt, 1990).

5.2.1.3 Impacts to Aquatic Organisms

A 3-year monitoring study on an urbanized watershed in California (Coyote Creek) evaluated the sources of urban stormwater runoff, and the impact on water quality and aquatic organisms as the stream passed through San Jose (Pitt & Bozeman, 1982). Coyote Creek is a small stream, only a few meters wide and less than a meter deep during dry weather. It drains a large watershed of about 80,000 hectares (197,680 acres) that contains two reservoirs in the rural upstream reaches. Upstream is a wilderness area that is free of almost all pollutant sources. The flows coming from the upstream areas are regulated and quite clean, but the downstream urban flows are highly variable and polluted.

Forty-one stations were monitored in both urban and rural perennial-flow stretches of the Creek. Short- and long-term sampling techniques were used to evaluate the effects of urban runoff on water quality, sediment properties, fish, macroinvertebrates, attached algae, and rooted aquatic vegetation. Information collected during this study implied that the effects of toxic organics and heavy metals in the water and sediment were responsible for the adverse biological conditions. Within the urban area, many pollutants were found in significantly greater concentrations during wet weather than dry weather, including organic nitrogen, lead, zinc, copper, cadmium, mercury, iron, and nickel (Field & Pitt, 1990).

Water quality upstream of the urbanized area was fairly consistent from site to site, but the quality changed markedly as the stream passed through the urbanized area. Urban reach DO concentrations were about 20% less than those in the rural reach. Lead concentrations in the urban sediments were greater than those in the rural sediments by a factor of about six. Large differences were also found between the urban and rural concentrations of both sulfate and phosphate. Seasonal and yearly changes in the urban reach sediment constituents were significant (Field & Pitt, 1990).

Evidence of bioaccumulation of lead and zinc was found in samples of algae, crayfish, and cattails. The concentrations of the metals in some of the organisms exceeded concentrations in the sediments by six times. Concentrations of lead and zinc in the organisms exceeded water-column concentrations by a factor of about 100 to 500 times. However, although urban lead and zinc concentrations were two to three times higher than rural samples, lead and zinc concentrations in fish tissue were not noticeably different between the urban and rural samples (Field & Pitt, 1990).

5.2.1.4 Urban Runoff Contaminants and Loading Rates

The following discussion is presented to (1) typify the sources and quantities of heavy metals and other common contaminants in urban runoff, and (2) estimate the loading rates of these pollutants of concern to PIB from this source. In estimating the loading rates, "background" sources of heavy metals are identified and compared with anthropogenic sources.

5.2.1.4.1 Heavy Metal Runoff Rates and Transport Mechanisms

Prior studies have shown that heavy metal loadings in street runoff vary from city to city. These variations are typified in the data provided in Table 5.6.

As seen in Table 5.6, the most variable heavy metal was chromium, which varied by a factor of 136 (i.e. the highest loading rate was 136 times the lowest). The least variable was nickel, but this metal still showed a variation factor of 12. Some of this variation is due to meteorology and other site factors, while some is due to different mixes of land use.

The effect of different land uses on heavy metal loading rates is illustrated in Table 5.7. As illustrated in this table, heavy metals loading rates from industrial land use are 33% higher than those from residential land use, and 370% higher than commercial land use.

Sartor and Boyd (1972) analyzed the effectiveness of street sweeping in removing pollutants from street runoff. Slightly more than 50% of the heavy metals were projected to be removed by street

Table 5.6. Heavy metals loading rates (pounds/curb mile) in selected cities (from Sartor and Boyd, 1972).

City	Cr	Cu	Zn	Ni	Hg	Pb	Cd[1]	Totals
	Average Heavy Metals Loading Rates Per Storm Event							
San Jose I	0.2	0.5	1.4	0.13	0.30	1.9	0.0033	4.5
San Jose II	0.14	0.02	0.28	0.085	0.085	0.90	0.0031	1.5
Phoenix	0.029	0.058	0.36	0.038	0.022	0.12	0.0031	0.63
Milwaukee	0.047	0.59	2.1	0.032	0.082	1.5	0.0032	4.5
Baltimore	0.45	0.33	1.3	0.077	0.082	0.47	0.0026	2.8
Seattle	0.081	0.075	0.37	0.028	0.034	0.50	0.0031	1.09
Atlanta	0.011	0.066	0.11	0.021	0.023	0.077	0.0031	0.31
Tulsa	0.0033	0.032	0.062	0.011	0.019	0.030	0.0031	0.16
Weighted Average	0.11	0.20	0.65	0.05	0.073	0.57	-	1.6
Range Factor[2]	136	30	34	12	16	63	N/A	-

(1) Most cadmium estimates were based on other observations.

(2) Range between the highest and lowest loading rates (i.e.; highest rate divided by the lowest).

Table 5.7. Distribution of stormwater runoff contaminant loads by land use categories (from Sartor and Boyd, 1972).

Contaminants	Residential	Industrial	Commercial
	Contaminants Loadings, by Land Use Categories (pounds/curb mile/day)[1][2]		
Total solids	590	1,400	180
Volatile solids	44	77	14
BOD_5	3.6	7.2	0.99
COD	20	81	5.7
Kjeldahl nitrogen	0.60	1.2	0.12
Nitrates	0.019	0.055	0.055
Phosphates	0.37	1.1	0.10
Total heavy metals	1.2	1.6	0.34

sweeping. Removal efficiencies were calculated on the basis of (1) the effectiveness of street sweeping equipment for removal of differing sized particles, and (2) the fractionation of pollutants among these particle size ranges. The distribution of general categories of urban runoff pollutants, according to varying particle size ranges, is provided in Table 5.8. The distribution of individual heavy metals, according to the same particle size ranges, is provided in Table 5.9.

Finally, based on the information in Tables 5.8 and 5.9, the calculated efficiency of street sweeping for removing typical categories of urban runoff pollutants is summarized in Table 5.10. As may be seen in Table 5.10, from approximately one-fourth to one-half of common street pollutants may be effectively removed through an efficient program of street sweeping. Somewhat higher pollutants removal rates may be achieved with more efficient sweeping systems, which remove a higher percentage of "fines".

As may be seen in Table 5.8, the distribution of pollutant loads in urban runoff is markedly skewed toward the smaller particle sizes (the "fines"). For example, more than 50% of the volatile solids, BOD5, COD, nutrients (nitrogen, nitrates, and phosphates), heavy metals, and pesticides are carried by particles smaller than 250μ ("fine sand"; <0.01 inches), and approximately 25-50% of the total volumes of these same pollutants are actually associated with particles smaller than 43μ ("silts" and "clays"; <0.0017 inches). This relationship extends to the individual heavy metals as well. For example, it may be seen in Table 5.9 that 41-87% of the chromium, copper, zinc, nickel, mercury, and lead are carried by particles of <250μ, and that 19-44% of these same metals are carried by particles of <43μ.

More recent research has shown that there are important sources of heavy metals in addition to streets. Table 5.11 summarizes heavy metal observations from other urban area sources. The data summarized in this table yielded some surprising results. For example, roof runoff had the highest concentrations of zinc (probably associated with galvanized metal), parking areas had the highest nickel concentrations, vehicle service areas had the highest cadmium and lead concentrations, and streets had high aluminum concentrations. Surprisingly, landscaped areas had the highest chromium and urban creeks had the highest copper concentrations (Pitt & Field, 1990).

Many observations of filterable metals were also made and are also summarized on Table 5.11. Except for storage areas, most of the zinc was associated with the filterable sample partitions (i.e. that portion which is not removed by filtration, including dissolved solids). In contrast, very little of the nickel was found in the filterable sample partitions. Nickel, and most other metals, were also found associated with the nonfilterable residue (i.e. the suspended solids removed through filtration). Therefore, solids separation processes would be very effective in removing heavy metals from these source areas, with the exception of zinc. If these metals are not removed before discharge, they are likely to contribute to polluted sediments in the receiving waters (Pitt & Field, 1990).

Other studies have also shown high percentages of heavy metals associated with the solids fraction, ranging from 97% for aluminum to 64% for zinc and copper. These observations are summarized in Table 5.12.

Clearly, as seen in the previous tables, the bulk of the heavy metals in urban runoff are associated with the smallest-sized particulates in the suspended sediment load. The sources of these metals loads are discussed in the following section.

5.2.1.4.2 Sources of Heavy Metals on Urban Roadways

Roadways are unquestionably a major source of heavy metals in urban runoff. Historically, much of this lead resulted from combustion of leaded gasoline, although some was deposited with leaking motor oil, in that combustion of leaded gasoline introduces considerable quantities of lead into engine oil. Despite the phase-out of leaded gasoline, leaking motor oil and transmission fluid continue to be sources of lead, because they become contaminated with wear metals, including lead from babbitt metal bearings. Other engine wear metals include:

* copper; from wear of thrust bearings, bushings, and bearing metals

* chromium; from wear of metal plating, rocker arms, crankshafts and rings

* zinc; as an ingredient of oil additives, and

* phosphorus; also an oil additive.

In addition to lubricants as metals sources, zinc, lead and other metallic oxides are used as fillers in the manufacture of rubber tires and are deposited on roadways as tires are abraded. Nickel and chromium abraded from roadway surface materials and from the corrosion of steel motor vehicle parts also contribute to the heavy metal load of street surface contaminants. Both nickel and chromium are present in brake lining materials. Asbestos in dust and dirt is produced by abrasion of clutch plates and brake

Table 5.8. Fraction of pollutant load (% by weight) associated with various particle size ranges (from Sartor and Boyd, 1972).

Contaminants	Particle Size Ranges (μ) >2,000	840-2,000	246-840	104-246	43-104	<43
Total solids	24.4	7.6	24.6	27.8	9.7	5.9
Volatile solids	11.0	17.4	12.0	16.1	17.9	25.6
BOD_5	7.4	20.1	15.7	15.2	17.3	24.3
COD	2.4	4.5	13.0	12.4	45.0	22.7
Kjeldahl nitrogen	9.9	11.6	20.0	20.2	19.6	18.7
Nitrates	8.6	6.5	7.9	16.7	28.4	31.9
Phosphates	0	0.9	6.9	6.4	29.6	56.2
Total heavy metals	16.3	17.5	14.9	23.5	27.8[1]	
Total pesticides	0	16.0	26.5	25.8	31.7[1]	

[1] Combined value for 43-104 and <43μ size ranges.

Table 5.9. Fraction of heavy metals (% by weight) associated with various particle size ranges (from Sartor and Boyd, 1972).

Metal	Particle Size Ranges (μ) >2,000	840-2,000	246-840	104-246	<104
Chromium	26.1	13.6	16.3	16.3	27.7
Copper	22.5	20.0	16.5	19.0	22.0
Zinc	4.9	25.9	16.0	26.6	26.6
Nickel	26.2	14.2	15.3	17.2	27.1
Mercury	16.4	28.8	16.4	19.2	19.2
Lead	1.7	2.6	8.7	42.5	44.5
Average	16.3	17.5	14.9	23.5	27.8

Table 5.10. Projected efficiency of street sweeping for removal of selected pollutants (from Sartor and Boyd, 1972).

Particle Size (μ)	Sweeper Efficiency (%)	Pollutants and Projected % Removals: Total Solids	BOD5	COD	Kjeldahl Nitrogen	Phos-phates	Total Heavy Metals	Total Pesticides
>2,000	79	19.3	5.8	1.9	7.8	0	12.9	0
840-2,000	66	5.0	13.3	3.0	7.7	0.6	11.6	10.0
246-840	60	14.8	9.4	7.8	12.0	4.1	8.9	15.9
104-246	48	13.3	7.3	6.0	9.7	3.1	11.3	12.4
43-104	20	1.9	3.5	9.0	3.9	5.9	5.6	6.3
<43	15	0.9	3.6	3.4	2.8	8.4	-	-
Totals	-	55.2	42.9	31.1	43.9	22.1	50.3	44.7

Table 5.12. Total versus particulates mass from Seattle storm sewer overflow point (from USEPA, 1979).

Pollutant	Total Mass (pounds)	Particulate Mass (pounds)	% Particulate
Suspended solids	4,924	4,924	-
Copper	2.55	1.64	64
Lead	13.29	11.7	88
Zinc	6.03	3.87	64
Aluminum	213.8	207	97
Organic Carbon	658	370	-
Total Phosphorus	19.2	8.93	-
Oils and Greases	249	not applicable	-
Chlorinated Hydrocarbons	not determined	0.854	-

Source Area Runoff	Aluminum		Cadmium		Chromium		Copper		Lead		Nickel		Zinc	
	non filt.	filt.	non filt.	filt.	non filt.	filt.	non filt.	filt.	non filt.	filt.	non filt.	filt.	non filt.	filt.
roofs														
detection frequency	11/12	9/12	11/12	8/12	7/12	2/12	11/12	7/12	12/12	1/12	10/12	0/12	12/12	12/12
median	270	13	0.82	0.23	7	<1	17	1.2	13	<1	5.1	<1	100	80
maximum	8370	1550	30	0.95	510	2.3	900	8.7	170	1.1	70	<1	1580	1550
% filt. (range,median)	2→100	(15%)	1→69	(50%)	6→14	(10%)	4→87	(20%)	7	(<10%)	(<20%)		57→100	(90%)
parking areas														
detection frequency	12/12	10/10	11/12	4/10	11/12	4/12	12/13	9/12	13/13	5/13	11/13	1/13	13/13	13/13
median	1850	360	0.72	<0.1	18	<1	20	1.8	30	<1	40	<1	30	23
maximum	22,500	2890	70	1.0	310	2.4	770	9.2	130	2.5	130	1.6	150	88
% filterable	1→100	(20%)	<1→53	(20%)	2→82	(35%)	<1→40	(15%)	1→45	(10%)	(<5%)		15→100	(75%)
storage areas														
detection frequency	6/6	1/7	7/7	4/7	7/7	4/7	7/7	5/7	7/7	6/7	7/7	0/7	6/6	6/6
median	975	<1	2.4	0.27	60	1.1	30	1.0	30	1.6	30	<1	66	9
maximum	6990	37	10	1.3	340	32	300	1.7	330	5.7	90	<1	290	103
% filterable	(3%)		3→13	(10%)	3→46	(10%)	1→15	(3%)	2→50	(10%)	(<3%)		3→100	(15%)
streets														
detection frequency	4/4	4/4	6/6	5/6	5/6	4/6	6/6	5/6	6/6	4/6	5/6	0/6	5/5	5/5
median	4,000	200	0.76	0.18	3.3	1.3	15	1.9	30	1.3	3.0	<1	58	23
maximum	10,040	4,380	220	0.57	30	2.7	1250	11.4	150	3.9	70	<1	130	76
% filterable	1→44	(20%)	12→91	(50%)	9→60	(30%)	<1→57	(10%)	4→100	(20%)	(<30%)		8→100	(60%)
loading docks														
detection frequency	3/3	1/3	3/3	3/3	3/3	0/3	3/3	2/3	3/3	1/3	3/3	1/3	2/2	2/2
medium	810	<1	1.2	0.5	8.9	<1	20	2.6	60	<1	7.8	<1	55	31
maximum	930	<1	2.4	0.6	40	<1	30	15	80	2.3	8.1	1.3	79	62
% filterable	(<5%)		23→41	(40%)	(<10%)		9→100	(10%)	(<5%)		(<10%)		13→78	(50%)
vehicle service areas														
detection frequency	4/4	3/3	4/4	2/4	4/4	0/4	4/4	3/3	4/4	1/4	4/4	0/4	4/4	4/4
medium	920	200	8	<0.2	19	<1	8.3	2.1	75	<1	35	<1	67	18
maximum	1370	410	30	0.34	320	<1	580	6.3	110	1.4	70	<1	130	83
% filterable	<1→87	(30%)	1→16	(<5%)	(<5%)		<1→95	(20%)	(<5%)		(<5%)		10→100	(40%)
landscaped areas														
detection frequency	4/4	4/4	3/5	1/5	5/5	4/5	4/4	4/4	5/5	1/5	3/5	0/5	5/5	5/5
medium	2500	1600	0.04	<0.1	100	1.5	80	2.0	9.4	<1	30	<1	32	32
maximum	4610	1860	1.0	1.0	250	4.1	300	8.3	70	1.7	130	<1	1160	670
% filterable	34→93	(50%)	(<25%)		2→68	(10%)	3→20	(3%)	(<10%)		(<5%)		58→100	(100%)
New York CSOs														
detection frequency	19/19	-	20/20	20/20	20/20	1/20	20/20	16/20	20/20	14/20	20/20	19/20	20/20	20/20
medium	720		1.6	0.25	17.6	<1	70	9.1	40	1.8	11.3	5.5	96	34
maximum	23,030		10	5.1	130	18	340	30	120	7.5	48.2	48.2	390	80
% filt.	?		2→100	(35%)	(<5%)		2→100	(20%)	2→100	(15%)	12→100	(50%)	3→100	(35%)
urban creeks														
detection frequency	4/4	4/4	4/4	0/4	4/4	0/4	4/4	3/4	4/4	0/4	3/4	0/4	4/4	4/4
medium	1600	240	5	<0.1	6.8	<1	160	1.2	38	<1	20	<1	24	19
maximum	3250	500	30	<0.1	30	<1	440	1.4	100	<1	70	<1	32	23
% filterable	13→42	(15%)	(<1%)		(<15%)		<1→23	(20%)	(<3%)		(<5%)		53→100	(80%)
detention ponds														
detection frequency	4/4	4/4	4/4	1/4	3/4	0/4	4/4	0/4	4/4	0/4	3/4	0/4	4/4	4/4
medium	550	200	0.24	<0.1	5.5	<1	47	<1	1.9	<1	20	<1	22	22
maximum	1350	330	1.0	<0.1	230	<1	210	<1	8.8	<1	70	<1	25	25
% filterable	6→100	(60%)	(<5%)		(<20%)		(<2%)		(<25%)		(<5%)		(all 100%)	

Table 5.11. Metals concentrations in runoff from various urban source areas (from Pitt and Field, 1990).

linings. Copper wire is added to brake linings for increased mechanical strength and to provide better heat transfer properties. Brake linings contain large amounts of copper (>= 3%), and it is probable that much copper on urban roadways originates from this source. However, calculation of copper emissions from brake lining wear yields a value approximately one order of magnitude higher than the deposition rate found in field studies (Shaheen, 1975). This observation is interpreted as supporting the finding that much of the products of brake wear are retained by the motor vehicle (Jacko & DuCharme, 1973).

5.2.1.5 Estimated Stormwater Pollutant Loading Rates to PIB

It is emphasized that reliable data from which to calculate pollutant loading rates to PIB from stormwater do not exist. However, for purposes of comparison, estimates of annual stormwater loading rates for pollutants of concern were derived, based on runoff characteristics from other studies (as summarized in the preceding discussions and tables) and PIB watershed characteristics. These estimates are summarized in Table 5.13.

Key assumptions and data soures used in developing the loading estimates in Table 5.13 include (1) PIB drainage basin = 25 $mi.^2$; (2) the basin is 11% commercial, 7% industrial, and 82% residential and all other, and (3) annual rainfall = 40 inches. Key references used in developing Table 5.13 include Sartor and Boyd, 1972; USEPA, 1983b.

It should be noted that the NURP report (USEPA, 1983b) was the primary source of the loadings data used in developing Table 5.13. This report provided loading rates (in kg/hectare/year) for residential and commercial areas, assuming an annual rainfall of 40 inches. Based on the description of residential areas in this report, the residential areas loading rate was used for all non-commercial or non-industrial areas in the PIB watershed. Unfortunately, this source does not include loading factors for industrial land. However, based on data reported in other sources (Sartor and Boyd, 1972; USEPA, 1979b; Field and Turkeltaub, 1981), loading rates for industrial land were assumed to be 30% greater than those of commercial land. Some heavy metals not included in the NURP reports were added by comparison to prior studies. The annual loading rates were multiplied by the drainage area sizes to calculate total loads.

5.2.1.6 Background Sources of PIB Stormwater Pollutants

The NURP studies (USEPA, 1983) found that the heavy metals consistently found in urban runoff were copper, zinc, and lead. Other heavy metals were also found, but not consistently at all

Table 5.13. Estimated PIB stormwater pollutant loading rates.	
Pollutants	Loading Rate (pounds/year)
Cadmium	240
Chromium	1,400
Copper	2,500
Lead	11,000
Mercury[1]	1,200
Nickel	12,000
BOD[1]	7.1×10^5
COD	4.8×10^6
Total phosphorus	25,000
Total kjeldahl nitrogen	110,000
Nitrite/Nitrate nitrogen[1]	51,000
Total suspended solids[1]	1.0×10^7

[1] Not a PIB pollutant of concern

locations. This would indicate that copper, zinc, and lead are generated by common activities and land uses in urban areas. Typical anthropogenic sources of urban runoff contaminants include automotive, industrial, commercial, and residential activities. Other heavy metals may be present due to such unique factors such as particular industries, past dumping, or unusual soil conditions. Soil conditions, as sources of heavy metals in runoff, are discussed below.

Surface runoff includes soil erosion products (minerals, ions, etc.) which are of natural origin, resulting from the parent geological materials of the area. The underlying geological material in the Erie area is shale, which in general has fairly high concentrations of various heavy metals. Table 5.14 summarizes typical concentrations of heavy metals found naturally in five different rock types, including granite, basalt, sandstone, limestone, and shale.

Compared with the four other types of parent geologic material in Table 5.14, shale exhibits:

(1) the highest natural levels of arsenic, cadmium, lead, and mercury

(2) the second highest natural levels of barium, chromium, copper, nickel, zinc, and

(3) the third highest natural levels of manganese.

Shale has the highest overall concentration of heavy metals as compared to other rock types.

The influence of the parent bedrock (shale) in the Erie area on metals levels in soil material is reflected in the high concentrations of arsenic and other metals found in a variety of local quarries which were identified as alternative sources of Presque Isle beachfill material for the COE's beach nourishment program (COE, 1991). This information is summarized in Table 5.15. For comparison purposes, the ranges of <u>mean</u> contaminant concentrations from Lake Erie dredging projects (1980-1984) are summarized in Table 5.16, segregated according to substrate types (ranging from silty/clay to class"B" sand). The ranges of <u>maximum</u> contaminant concentrations from Lake Erie dredging projects are provided in Table 5.17.

It is noted that the data in Tables 5.16 and 5.17 are based on differing numbers of individual dredged sediment data sets, ranging from only one for silt, to nine for silty clay. Therefore, because of the small sample size, the average values may be biased

Table 5.14. Typical concentrations of selected metals in rocks (from Turekian, 1971a; Drever, 1982).

Metals	Rock Type and Concentrations (mg/kg)				
	Granite	Basalt	Shale	Sandstone	Limestone
Chromium	10	170	90	35	11
Manganese	450	1,500	850	50	1,100
Iron	major	major	major	major	major
Nickel	10	130	68	2	20
Copper	20	87	45	2	4
Zinc	50	105	95	16	20
Arsenic	2	2	13	1	1
Cadmium	0.13	0.2	0.3	-	0.03
Barium	600	330	580	-	10
Mercury	0.03	0.01	0.4	0.03	0.04
Lead	17	6	20	7	9

Table 5.15. Metals concentrations in Presque Isle peninsula beachfill sources (from COE, 1991).

Metals	Concentrations (mg/kg)			
	Maximum	Minimum	Median	Mean
Arsenic	16	4	11	10.9
Barium	55	10	37	34.3
Cadmium	0.8	0.4	0.6	0.6
Chromium	9	2	5	4.8
Copper	34	2	23	20
Iron	18,900	2,600	14,300	11,800
Lead	11	1	4	4.8
Manganese	410	140	320	307
Mercury	0.03	<0.02	<0.02	<0.02
Nickel	16	5	11	11.2
Zinc	73	8	48	45.7

Table 5.16. Ranges of mean metals concentrations in 1980-1984 Lake Erie dredging projects (from IJC, 1990).

Metals	Substrate Types and Concentrations (mg/kg dry weight)				
	Silty/Clay	Silt	Sandy/Clay	Silty Sand	Class "B" Sand
Arsenic	0.0002-17.2	4.3	10.0	1.7-10.4	1.8-9.0
Cadmium	0.36-287	0.47	1.6	0.8-6.0	1.0
Chromium	4.4-104	6.8	17.5-42.2	16.3-45.2	5-108
Copper	18.4-159.4	25.4	15.8-20.2	21.7-170	3-61.5
Lead	12.8-156	13.6	26.0-36.3	7.7-106.2	2-101
Mercury	0.12-0.29	0.10	0.10	0.001-1.05	0.0-0.90
Nickel	18.8-57.6	25.4	34.3-83.8	14.3-52.9	5-33.3
Zinc	44.6-576	61.1	55.1-120	147-491	19.3-340
No. Projects	9	1	2	6	8

Table 5.17. Ranges of maximum metals concentrations in 1980-1984 Lake Erie dredging projects (from IJC, 1990).

Metals	Substrate Types and Concentrations (mg/kg dry weight)				
	Silty/Clay	Silt	Sandy/Clay	Silty Sand	Class "B" Sand
Arsenic	0.002-21.6	8.1	13.8	1.8-20	1.8-9.0
Cadmium	0.6-8,600	0.70	3.0	0.8-12.0	1.0-1.5
Chromium	6.0-310	9.0	42.0-68.0	19.0-77.8	5-139
Copper	26.0-600	39.0	30.0-36.0	25.0-250	3-66
Lead	15.0-227	20.0	43.0-50.0	9.7-188	2-150
Mercury	0.2-0.4	0.10	0.27	0.001-2.0	0.0-2.6
Nickel	25.0-120	37.0	65.0-228	26-117	5.0-73.0
Zinc	55-1,600	88.0	111-150	184-626	7.0-470
No. Projects	9	1	2	6	8

in either direction, by a particularly "clean" or unusually "dirty" sediment sample. However, it is noted that the mean and maximum ranges for Class "B" sand, which would most closely resemble the parent geologic materials of its origin, were extremely similar for all metals. For comparison purposes, Table 5.18 has been prepared to contrast the following information:

* the typical concentrations of various metals in shale (see Table 5.14)

* the maximum and mean concentrations of these metals in Presque Isle beachfill sources (see Table 5.15), and

* the observed range of concentrations of these metals in Lake Erie dredging projects (see Tables 5.16 and 5.17).

As evident in Table 5.18, the mean metals concentrations in Presque Isle peninsula beachfill sources (from Table 5.15) are remarkably similar to the mean metals concentrations in class "B" sand in Lake Erie dredging projects (from Table 5.16), for all metals. Further, the average metals concentrations for shale are within the ranges of the concentrations of these same metals reported from beachfill sources and Lake Erie dredging projects. Based on these observations, it is possible that the metals concentrations in the sand component of sediments throughout Lake Erie may be dominated by the mineralogic nature of the bedrock in this basin.

To complete this comparison, concentrations of heavy metals in PIB sediments were compared with those of Lake Erie in general (Table 5.16). Because there may be significant variability over time in reported pollutant concentrations at a given site, and because the available IJC data are based on the period 1980-1984, the 1982 PIB sediment data (from COE, 1982; see Table 4.15) were used in this comparison. Also, because PIB sediments contain significant concentrations of silts and other organic rich "fines", the Lake Erie class "B" sands concentrations were not used in this comparison.

Based on this comparison, all of the Lake Erie sediment concentrations for mercury exceeded the PIB mercury concentrations, and 90% of the Lake Erie dredging projects exhibited higher arsenic concentrations than PIB sediments. Thirty percent of the Lake Erie chromium, copper, and zinc concentrations exceeded PIB concentrations, and 10% of the Lake Erie cadmium, lead, and nickel concentrations were higher than PIB concentrations of these same metals. Because the dredging locations from which the Lake Erie sediment were collected are not known, further comparisons with PIB are not prudent, however it may be seen that many sites exceed PIB

Table 5.18. Comparison of metals levels in shale, beachfill sources, and Lake Erie dredging projects in general.

Metals	Substrate Types and Concentrations (mg/kg)			
	Shale	Beachfill Sources Maximum	Beachfill Sources Mean	Range of L. Erie Dredging Projects
Arsenic	13	16	10.9	0.002-17.2
Barium	580	55	34.3	N/A
Cadmium	0.3	0.8	0.6	0.36-287
Chromium	90	9	4.8	4.4-108
Copper	45	34	20.0	3.0-170
Iron	major	18,900	11,800	N/A
Lead	20	11	4.8	2.0-156
Manganese	850	410	307	N/A
Mercury	0.4	0.03	<0.02	0.000-1.05
Nickel	68	16	11.2	5.0-83.8
Zinc	95	73	45.7	19.3-576

sediment metal contamination levels, for at least some metals.

5.2.1.7 Influence of Particle Size on Contaminant Transport and Fate

As discussed earlier, urban runoff contaminants are strongly associated with the finer sized particles in the sediment load. When 1990 FWS sediment sampling data for metals are compared with the corresponding percent sand values, a strong inverse relationship is found to exist for arsenic, copper, lead, manganese, and zinc. In general, the sandiest sediment samples exhibited the lowest overall metals levels. Site #6, which is at the mouth of Mill Creek, would be expected to be one of the most polluted sampling sites. However, this site exhibits a high percentage of sand, and its contaminant levels closely resemble Site #16, which is an unimpacted site in Presque Isle State Park.

As has been discussed previously (see §4.1.1.6), the distribution of contaminants in PIB sediments does not appear to follow any readily recognizable pattern, based on the locations of pollutant sources (Mill Creek, CSOs, storm sewer outfalls, etc.). Instead, the most striking pattern is the inverse correlation with sand content, implying that the fate of introduced contaminants (in this case, metals) is closely tied to the dispersion dynamics and fate of the fine sediments.

Because the finer components of the suspended solids load tend to settle out very slowly, and because large percentages of the total contaminants are found to be associated with these fine particulates, high contaminant levels may be found in quiescent areas, even though these areas are quite removed from contaminants sources (e.g. site numbers 13, 14, and 15). Conversely, comparatively lower contaminant levels may be found in areas quite near pollutant sources (e.g. site #6, at the mouth of Mill Creek), where higher velocities prevent settling of the fine sediments. In these areas, only the coarser particles are found, and the sediment quality tends to resemble the chemical characteristics of the parent geologic materials. The influence of particle size is further demonstrated by examination of the data in Tables 5.15 and 5.16, which show the silty/clay dredged materials to be noticeably more contaminated than the class "B" sand.

Most of the available data focus on the heavy metals, and comparatively little is available for organics and nutrients. However, these contaminants tend to associate quite strongly with the organic content of the suspended solids load. In general, the finer sediments exhibit the highest organic content. Therefore, while the data are inadequate to determine the relationship with certainty, the distribution and fate of organics and nutrients is expected to also be biased toward the "fines". When the 1990 FWS sediment data are evaluated on this basis, an inverse relationship is generally found to exist between total organic content (TOC) and % sand for most sites. However, sites 1, 2, and 4 have higher TOCs than would be expected, based on their % and levels. These sites are located in heavily industrialized areas, and may reflect localized influences from unusual contaminanant sources.

5.2.1.8 Contaminant Levels in PIB Tributaries

Water quality samples were collected from five PIB tributaries in August, 1989 and analyzed for a variety of pollutants, including the majority of the identified pollutants of concern for PIB. The results of this sampling, for the PIB pollutants of concern, are summarized in Table 5.19.

Sampled tributaries included four streams and one storm sewer. All tributary samples reported in Table 5.19 were collected at or near the mouths of the indicated streams.

As seen in Table 5.19, the results for cyanide and most of the toxic metals (arsenic, cadmium, chromium, copper, lead, and nickel) were found to be below the analytical detection limit. The observed concentrations of zinc, manganese, iron, and barium are not surprising, based on the natural, background concentrations of these elements in the Erie area (see Table 5.18). The COD and nutrients (TKN and total phosphorus) results are not unusual for runoff from an urban area.

No attempt has been made to estimate annual loadings of pollutants of concern to PIB from the Table 5.19 tributaries, for the following reasons:

* these results are based on a single sample, which does not represent annual conditions

* the flow rates at the time of sampling are not known

* the annual flow volumes of these tributaries are not known

* most results are not quantifiable (i.e. below the analytical detection limits), and much of the pollutant load from those Table 5.19 parameters which were reported at quantifiable levels are already accounted for (i.e. included) in the Table 5.13 stormwater runoff pollutant loading estimates.

However, the fact that quantifiable levels of zinc, maganese, iron, and barium were found in all five tributaries is another indication

of the potential significance of background sources to the total metals loading to PIB.

5.2.2 Groundwater Contamination

The depth to bedrock is quite shallow in the Erie area. Surficial deposits of glacial drift yield useable groundwater, but such sources are shallow, limited by the underlying shale. Potable groundwater in the Erie area is reported to be produced at depths of approximately 25 to 50 feet below the surface (USEPA, 1985b; 1987b). Because of the shallow groundwater in the Erie area, direct groundwater discharge to the PIB is limited to areas directly adjoining the Bay. Further inland, shallow groundwater is intercepted by stream valleys, and enters the Bay as surface runoff, which is discussed in the previous section (§5.2.1).

To investigate the potential for significant contamination of PIB from groundwater sources, hazardous waste site investigation files were reviewed to identify those sites within a reasonable distance of the Bayfront. Generally, sites within two miles of the Bay (north of 26th Street) were selected for review. Based on this review, 10 sites were identified at which significant groundwater investigations had been performed. These sites are located in Figure 5.3, and are identified and described in the following summaries.

Kimmel Site (West 18th and Filmore; Millcreek Township-Site #1 in Figure 5.3). This is an approximately 10 acre site used as an illegal dump from the mid-1960s to the early 1980s. Soil samples from this site indicated significant levels of PCBs, PAHs, arsenic, cadmium, chromium, lead, mercury, and nickel. On-site groundwater samples indicated significant levels of lead, arsenic and cadmium, and lesser levels of other metals. However, off-site groundwater samples indicated that no migration of the contaminants beyond the site had occurred (USEPA, 1988; Harrison, 1984; Geary, 1983).

Currie Landfill (West 16th and Indiana Drive; Millcreek Township-Site #2 in Figure 5.3). This landfill site is located immediately east of the Kimmel Site (see above). The site is bounded on the east by the West Branch of Cascade Creek. The site was sampled in June, 1984 by the NUS Corporation (a USEPA Superfund contractor).

Sampling at the Currie Landfill site included on-site soil and surface water, upstream and downstream (West Branch Cascade Creek) surface water and sediment, and surface water runoff (drainage ditch leading to West Branch Cascade Creek); no groundwater data were reported. The upstream/downstream West Branch Cascade Creek surface water sample results were compared to

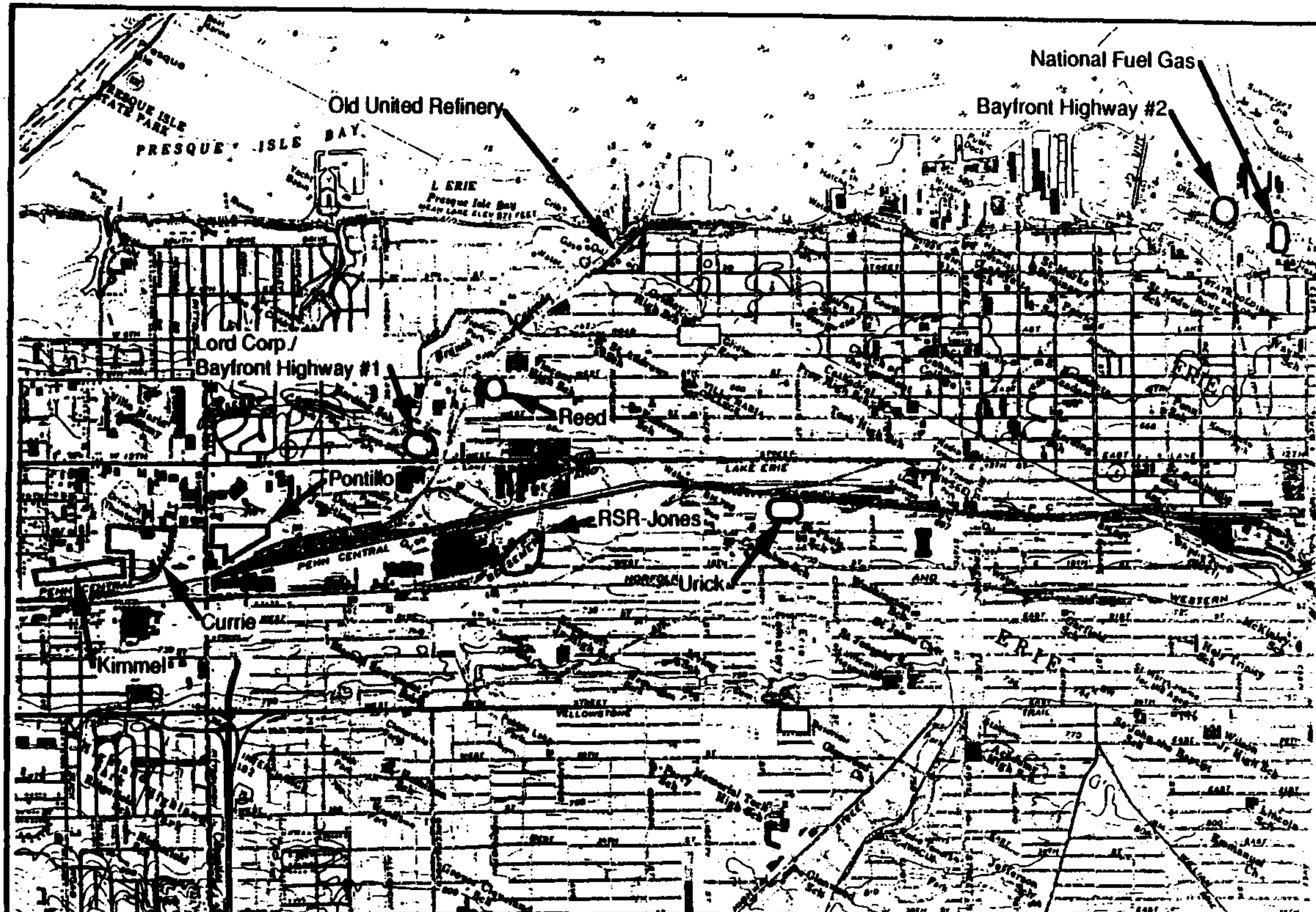


Figure 5.3. Locations of significant potential groundwater contamination sites.

determine the existence of contaminants migration. The results of this comparison indicated minor amounts (18-150 $\mu g/l$) of volatile organics (trans-1,2 dichloroethene, tetrachloroethene and vinyl chloride) in the downstream samples, however these amounts would be expected to volatilize before reaching the Bay. The downstream water samples also reflected increases in iron and manganese (2.5% and 145% increases, respectively), and the downstream sediment samples reflected increases in aluminum (21%), barium (2%), chromium (27%), iron (53%), manganese (61%), and zinc (19%). The samples from the drainage ditch, which were collected nearer the source, exhibited a generally similar pattern of contamination, but at higher concentrations.

The current status of this site is not known. However, the site is not suspected of being a major contributor of pollutants of concern because (1) the site is more than a mile from the Bay, (2) rapid attenuation of contaminant levels is evident with downstream direction, and (3) the site is near the headwaters of the West Branch of Cascade Creek, where flow volume is quite low (mass loading = concentration x flow). Because flow volume in the West Branch of Cascade Creek was not included with the contaminants sampling data, mass loading estimates could not be derived.

Pontillo Landfill (a.k.a. Baldwin-Pontillo: West 16th and Pittsburgh Avenue; Erie-Site #3 in Figure 5.3). This site is immediately east of the Currie Landfill Site (see above), and is approximately 20 acres in area. The site was apparently used as a landfill in the late 1960s. Because of the very shallow depth to the shale bedrock under this area (55-60 feet), and the presence of partial aquicludes at various depths, most leachate generated from the landfill is collected and discharged through a pipe at the north edge of the landfill, at an estimated annual rate of approximately 2.5 gallons per minute (1.3 million gallons per year). Landfill leachate discharges to a storm sewer which discharges to the West Branch of Cascade Creek, near West 8th Street and Delaware Avenue (see Harrison, 1988, and Water Quality Protection Report: BWM/Baldwin-Pontillo Site Leachate Discharge Evaluation [author unknown]; submitted to Ricardo Gilson of the PADER Bureau of Waste Management on February 13, 1987).

To provide a basis for evaluation of the leachate quality monitoring data, surrogate discharge "limits" for the leachate discharge were calculated in the Water Quality Protection Report cited above, using the same process that would be used if this source were applying for an NPDES permit for direct discharge of treated wastewater to the West Branch of Cascade Creek. Based on the leachate characteristics, 13 discharge "limits" were calculated, including nine volatile organics (vinyl chloride, 1,1 dichloroethane, 1,2 dichloroethylene, benzene, chlorobenzene, 1,1 dichloroethylene, chloroform, chloroethane, and 1,2 dichloroethane), two metals (iron and manganese), pH, and ammonia (NH3N). When monitoring data from 1983-1987 are compared with these surrogate "limits", exceedances are found for vinyl chloride, 1,2 dichloroethylene, total iron, and NH3N. Of these parameters, the two volatile organics would be expected to volatilize before reaching the Bay, and most of the NH3N would be nitrified. Only the iron is a conservative substance and could be expected to reach the Bay. At an average 1987 concentration of 24.03 mg/l, and an average leachate discharge of 16,712 gallons/day (6.1 million gallons per year), the calculated loading to the Bay from this source (assuming that all the iron reached the Bay, which would not occur), would be 1,223 pounds/year. However, this amount would enter as surface runoff, not contaminated groundwater.

RSR-Jones Chemicals Site (west end of West 18th Street; Erie-Site #4 in Figure 5.3). This site, which is approximately one mile east of the Pontillo Site (see above), is approximately 6.5 acres in surface area and includes a 1.5 acre alum sludge disposal pit and multiple surface spill sites. Surface runoff from this site discharges to a small, unnamed, intermittent tributary to a piped section of Cascade Creek, approximately 1.4 miles from PIB. The tributary is believed to intersect the shallow groundwater table downgradient (northwest) of the site, and Cascade Creek, which is deeper, intersects additional groundwater flow. Shallow groundwater at the site lies between approximately six and 14-18 feet below the ground surface. A deeper aquifer, separated from the shallow water table aquifer by an 8-12 foot sandy silt aquitard, overlies the bedrock, starting at a depth of 24-29 feet below grade and ending at bedrock, approximately 30 feet below the surface (see AES, 1985 and PADER, 1986b).

Monitoring results indicated several volatile organics in on-site surface water, soils, and groundwater at very low to moderate concentrations (trichloroethene exhibited the highest concentrations, followed by 1,1,1 trichloroethane, 1,2 dichloroethene, and tetrachloroethene). Downgradient of the site, only trichloroethene was reliably detected in Cascade Creek. No other hazardous chemicals were reliably detected in off-site samples. This site is not determined to be a significant contributor of pollutants of concern to PIB because (1) Cascade Creek is believed to intercept most shallow groundwater from the site, (2) deeper groundwater is not impacted, and (3) only low levels of one contaminant (trichloroethene) were detected in Cascade Creek, downstream of the site. Trichloroethene is a volatile compound, and the low levels observed would be expected to volatilize before reaching the Bay.

Urick Foundry Site (West 15th Street and Walnut Avenue; Erie-Site #5 in Figure 5.3). This site is located approximately one mile northeast of the RSR-Jones Site described above. This site consisted of a calcium carbide desulfurization slag waste pile, and concern for possible off-site migration of arsenic resulted from high arsenic levels in on-site soils (up to 500 mg/kg dry weight). The waste was removed, and the site closed, in accordance with PADER hazardous waste regulations, in 1988. Four groundwater wells were installed to monitor the effectiveness of the closure (one upgradient and three downgradient). Based on the characteristics of the waste at this site, the wells were monitored quarterly for arsenic, cyanide, field conductivity, field pH, total organic carbon (TOC), and total organic halides (TOH). In accordance with PADER regulations for site closure, the monitoring well data were subjected to statistical analysis to evaluate potential groundwater impacts (see RMT, 1989, and quarterly monitoring well results from RMT, from September, 1988 through September, 1990).

Available monitoring data were reviewed for sampling events in 1988 (two), 1989 (two), and 1990 (three). Four replicate samples were analyzed for each well, for each sampling event. Including the replicates, 28 data points were available in the file for each of the four wells (seven sampling events x four replicates/event). Most of the results were listed as "<" (less than detection limit) for the upgradient well #1 (71% "<") and for downgradient well #3 (82% "<"). However, detectable arsenic levels were recorded in 75% of the samples from Well #2, and from 100% of the samples from Well #4. Comparing the mean arsenic value for the upgradient well (0.004 mg/l) with the mean values from the three downgradient wells (0.0053, 0.0094, and 0.0155) indicates that arsenic is migrating from this site in the shallow groundwater. The direction of groundwater flow from this site is toward PIB, and although the site is approximately one mile from the Bay, no large stream valleys exist between the site and the Bayfront. Therefore, it is possible that this site is contributing arsenic to the Bay, through contaminated groundwater (arsenic has been identified as a PIB pollutant of concern). Data necessary to confirm this possibility (groundwater plume tracking), or to estimate the potential annual loading rate from this site (volume of plume and groundwater flow rate) are unavailable.

Lord Corp./Erie Bayfront Highway Site 1 (West 9th Street and Greengarden Avenue; Erie-Site #6 in Figure 5.3). This site is located on the south bank of the West Branch of Cascade Creek, approximately 0.8 miles from the Bay. The site consists of the margin of the Lord Corporation parking lot, and the right-of-way or the Erie Bayfront Highway. Because it was alleged that the parking lot was used in the past for disposal of industrial wastes, and because the highway construction activities intersected the base of the hill below the parking lot, numerous investigations of potential on-site contamination were initiated. These studies determined that on-site subsurface materials were contaminated with a variety of metals (copper, nickel, lead, and zinc), PAHs, phthalates, pesticides, and PCBs. Based on test pits excavated in the parking lot fill material, it was determined that the observed contaminants resulted from slag, ash, cinders, scrap steel, reinforced concrete, and metal debris, but no evidence of chemical dumping was found (see PennDOT, 1989a; PennDOT, 1990b; PennDOT, 1990c; Lobins, 1990).

Results from eight on-site monitoring wells indicated that the shallow groundwater beneath the site showed contamination with copper, lead, nickel, zinc, and phthalates. However, groundwater from this site discharges to Cascade Creek, at the bottom of a steep grade, immediately northwest of the site. Upstream/downstream sampling in Cascade Creek showed evidence of elevated levels of only one compound which could be attributed to this site. This contaminant, tetrachloroethylene, was detected at 1 $\mu g/l$ in Cascade Creek (PennDOT, 1990b). However this concentration is essentially insignificant (the drinking water standard is 5 $\mu g/l$), and would be expected to volatilize before reaching the Bay.

Reed Manufacturing Site (West 8th Street and Weschler Avenue; Erie-Site #7 in Figure 5.3). This site is located on a hillside overlooking the main branch of Cascade Creek, approximately 0.75 miles from the Bay. This site is located approximately 0.4 miles northeast of the Lord Site (see above), and is similar to the Lord Site in that the right-of-way for the Erie Bayfront Highway construction intercepted a groundwater flow at the toe of the grade. The site was investigated by the ECDH and PADER, and a limited cleanup of soils in the right-of-way was performed. Off-site investigations are continuing, under the direction of the ECDH (and in conjunction with the PADER).

Site drainage is complicated, with discharges routed separately to the storm sewer and sanitary sewer. A "small trickle" of flow was found emanating from a clay pipe at this site, which was identified as "drainage". This sample revealed elevated levels of four volatile organics: 1,1,1 trichloroethane, trichloroethene, trans 1,2 dichloroethene, and cis 1,2 dichloroethene. This drainage is routed to the sanitary sewer and does not enter the Bay (see Boyle, 1990; Gilson, 1990a, b, and c). This site is not currently believed to represent a significant potential source of groundwater contaminants loading to PIB, because (1) shallow groundwater from this site is expected to be intercepted by Cascade Creek, (2) these materials are highly volatile (suggestive of a fuel spill), and (3) the discharge rate is small. A groundwater remediation project was initiated in the fall of 1991, and is continuing. At present, no indication exists that this site is contributing contaminated groundwater to the Bay, however ECDH/PADER studies are continuing and potential impacts will be re-evaluated when that project is completed.

Old United Tank Farm Site (West 3rd Street and Cascade Avenue; Erie-Site #8 in Figure 5.3). This site is located on a hillside overlooking the west bank of Cascade Creek, approximately 0.1 to 0.2 miles from the mouth of Cascade Creek. The site is approximately 0.5 mile downstream from the Reed Manufacturing Site (see above). This site is similar to the two previously-described sites (Lord Corp. and Reed), in that right-of-way construction for the Erie Bayfront Highway intercepted a groundwater flow at the toe of the grade. Widespread soil contamination from releases of petroleum products (primarily #2 and #6 fuel oils) from the former tank farm was identified, and contaminated soil was removed for off-site disposal at CECOS, in New York State. Fuel oil levels in the contaminated soil ranged from 360 to 90,782 ppm, however no PCBs, and no volatile organics in the lighter molecular weight range indicative of gasoline, were detected.

Fuel oil contamination was detected in on-site groundwater which filled test pits. Although monitoring wells were not installed, the results of the on-site investigations were interpreted to indicate that "wide-spread groundwater contamination" has occurred at this site. A remedial action alternative was selected which included removal of contaminated soil (>=500 ppm), placement of a clay cap over the soil surface to limit infiltration through the remaining soil, and confinement of surface water flow to an impervious channel to further limit infiltration (see Gilson, 1990b; PennDOT, 1989b). Groundwater from this site is expected to be intercepted by Cascade Creek. Therefore, and because no PIB pollutants of concern were identified, this site is not anticipated to be a source of groundwater contamination to the Bay (however this site may continue to contribute hydrocarbons contamination to the Bay through surface sources).

Bayfront-Port Access Road Site 2 (foot of Wayne Avenue; Erie-Site #9 in Figure 5.3). This site is located at the foot of the bluff overlooking the Bay, immediately west of the City's wastewater treatment plant. Because the Bayfront-Port Access Road had intercepted at least two other contaminated sites within the construction right-of-way (see Reed Manufacturing Site and Old United Tank Farm Site, above), soil samples were collected along the entire length of the proposed highway alignment. At this site, evidence of contamination with gasoline-related volatile organics was detected in the field, but not confirmed in laboratory analyses. The laboratory analyses did, however, reveal potential lead contamination, and a more detailed study was undertaken in 1988-1989. The results of this study (PennDOT, 1990a) revealed that much of the site is underlain by ash/cinder/slag fill material, and on-site soils are contaminated with numerous metals, some volatile organics, and petroleum hydrocarbons. However, these compounds were not found to be leaching in significant quantities, and on-site groundwater contamination is largely limited to petroleum hydrocarbons. Consequently, and because this site is within 0.5 miles of the Bayfront, this site is potentially contributing groundwater contaminated with petroleum hydrocarbons to the Bay. However, the existing data do not suggest that this site is a major potential contributor of the identified pollutants of concern to the Bay (again, ECDH/PADER studies are ongoing).

National Fuel Gas Site (East 3rd Street and Wayne Avenue; Erie-Site #10 in Figure 5.3). This site is approximately three acres in area, and is located at the top of the bluff overlooking the Bay, immediately east of the Bayfront-Port Access Road Site 2 described above. This site slopes to the north, toward the Bay. Depth to the white shale bedrock is approximately 30-40 feet, depending on site location. Drainage from this site is complicated: most surface runoff drains to Garrison Run, and hence to the Bay, although some runs onto Erie Coke property; groundwater flows N 16° W, and hence to the Outer Harbor; a storm sewer passing through the east side of the site (which may be corroded, allowing contaminated groundwater to enter by infiltration) discharges to the Outer Harbor; and an abandoned six-inch tile sanitary sewer pipe which originates and discharges on the site, emptying into the Garrison Run drainage system.

This site was investigated in an attempt to identify the source of cyanide appearing in the Outer Harbor, near the Kopper's Coke Plant thermal effluent outfall. The site was operated by Pennsylvania Gas Company from 1926-1960, during which time wastes from coke gas purification were deposited on-site, filling two ravines. Five on-site monitoring wells were installed and sampled in 1981 by Ecology and Environment, Inc., as a contractor to the National Fuel Gas Company. The results of this sampling determined that the buried wastes contained varying amounts of PAHs, cyanides, and various metals (including iron, arsenic, lead, and mercury), and were of low pH (2-3). Groundwater samples indicated detectable concentrations (1.02-5.08 μg/l) of beryllium and cadmium, and significant concentrations (often in the 100s of μg/l) of arsenic, chromium, copper, iron, lead, mercury, nickel, and zinc. High concentrations of total cyanide (104 μg/l) were detected from one of the five on-site wells.

Analysis of the well locations, sampling data, and direction of groundwater movement resulted in the conclusion that groundwater entering the site is already contaminated with lead, mercury, and arsenic, but that the concentrations of these contaminants is increased as the groundwater passes through the site. However, groundwater from this site discharges to the Outer Harbor, and is not a source of pollutants of concern to PIB. The report indicated that PAHs in Garrison Run sediments were low in comparison with those of the storm sewer outfall area (3-85 mg/kg), however no data were available on the quality of surface runoff, which enters the Bay through Garrison Run.

5.2.3 Air Deposition

Pollutants discharged through air emissions from both stationary and mobile point sources may represent potential sources of water pollution through (1) settling of suspended particulates, and (2) rain scour. Investigations in other AOCs have identified a contaminants "rain shadow" effect downwind of primary air emission sources.

Very little information is available with which to evaluate this potential source of contaminants to PIB. However, because the predominant winds are generally from the southwest (PADER, 1976), and because more than 50 stationary air pollution sources are permitted in Erie, a potential exists for air pollutants in the Erie area to be deposited in PIB. Direct air monitoring will be undertaken by the PADER in Spring 1993 to try and determine the impact of air deposition on the Bay, as well as the possible contribution from City of Erie sources.

It is estimated that the annual mean concentrations of aluminum, lead, and zinc in rainfall in western Pennsylvania (as measured at M. K. Goddard State Park, in Mercer County) are 9.8, 1.3, and 30 $\mu g/l$, respectively (Lynch et al., 1989). Two of these metals, lead and zinc, are pollutants of concern in PIB. Converting the mean lead and zinc concentrations in rainfall (1.3 and 30 $\mu g/l$, respectively) to annual loadings of these contaminants to PIB, an estimated annual load of 40 pounds/year lead, and 933 pounds/year zinc is derived (the aluminum loading rate is 305 pounds/year). These loading rates are based only on direct deposition on the surface of PIB (3,718 acres surface area) and do not include additional input from surface runoff within the watershed. Precipitation derived inputs of lead and zinc from surface runoff within the watershed is already included in the nonpoint/urban runoff calculations presented in §5.2.1.

The lead and zinc loadings data derived above are based on a monitoring location in Mercer County. While these rates do not include any local (Erie area) inputs, and may therefore be underestimates, it is also possible that attenuation may occur between the M. K. Goddard State Park sampling location and PIB, in which case the calculated PIB loadings may be overestimates. Information on stationary air emissions sources in the Erie area are available in the **PADER's** Emission Inventory Report (PADER, 1988A). However, this source includes data for only particulates, SOx, NOx, CO, and VOC and does not provide emissions data for the PIB pollutants of concern. Data on suspended particulate levels for lead (as µg/m3) and benzo[a]pyrene (as ng/l) are available for Erie (PADER, 1989a); however these data are reported only as ambient concentrations and cannot be converted to loadings rates (deposition rates not provided).

It is known that the Erie wastewater treatment plant sludge incinerator flue gas contains arsenic, cadmium, chromium, lead, and nickel. Although the current atmospheric loading rates from this source are not known, pilot scale testing of an emissions reduction system (wet electrostatic precipitation) was conducted in August, 1989 which demonstrated the capability to reduce the loadings of these metals by 74.1% for nickel, and 96.6-98.5 % for the remaining metals (PEI, 1989). PIB pollutants of concern loading rate information for other major air emission sources on the Bay waterfront are similarly lacking. In order to fill some of the data gaps, PADER will be conducting air sampling in PIB in the spring of 1993.

5.3 Summary

Typically, the primary or major sources of pollutants of concern in AOCs are point source discharges, or other "direct" pollutant inputs. A review of the NPDES files resulted in the identification of five existing point sources which discharge directly into PIB, and four additional point sources which discharge to tributaries within approximately 1.3 miles of the Bay (generally, north of 19th Street). These point sources discharge either small quantities of wastewater, or cooling water only. Based on a review of the permitted effluent limits and discharge monitoring reports in the permit files, annual loadings of pollutants of concern to PIB could be calculated for eight of these nine point sources. Annual loadings for metals from one of these sources (Erie Forge) were calculated in the 10s to 100s of pounds, and annual loadings of COD, TKN, and oil & grease were in the 1,000s of pounds. However, many of these calculated values result from the extrapolation of monitoring results which are reported as less-than-detection-limit ("<") values, multiplied by very large annual flow volumes, and are certainly overestimates. Much lower loading estimates (typically, a few pounds or less for metals) were derived for the other NPDES dischargers.

In addition, 47 CSOs from the City's sewer collection system discharge to the Bay or its tributaries. Thirty-eight of these 47 discharges are dispersed throughout the Mill Creek/ Garrison Run drainage system, one discharges to Cascade Creek, and the remaining eight discharge to the Bay through small, unnamed tributaries, drainageways, or outfall sewer lines. Based on an estimated annual CSO volume of 0.7 mgd, and sampling data collected at the influent to the wastewater treatment plant, annual loadings of pollutants of concern to PIB from CSOs were calculated. The calculated annual CSO loadings for all pollutants of concern except PAHs were in the 10s to 100s of pounds range; PAH loadings were all <21.28 pounds/year, reflecting the detection limit used in the analytical procedure for PAHs.

Typical secondary sources of pollutants of concern to AOCs include surface runoff, groundwater discharges, and air deposition. Very limited data are available to estimate air deposition rates; lead and zinc are the only two pollutants of concern for which annual loading rates could be calculated. The estimated annual loading rate for lead is 40 pounds/year and the zinc rate is 933 pounds/year. These estimates are based on several assumptions and are provided for reference only. Additional data collection will be conducted by the PADER in spring of 1993 to allow better estimates of air deposition impacts in the Bay.

The water table aquifer in the Erie area is quite shallow (typically 25-50 feet below the surface), and is intercepted by stream valleys, where it becomes a constituent of surface water flows. Direct discharge of groundwater to PIB is limited to areas directly adjoining the Bay. To investigate the potential for significant contamination of PIB from groundwater sources, hazardous waste site investigation files were reviewed to identify those sites within a reasonable distance of the Bayfront. Ten sites were identified within two miles of the Bay (north of 26th Street) at which significant groundwater investigations had been performed. Based on a review of groundwater monitoring file data and other information for these projects, none were identified as being significant potential contributors of pollutants of concern to PIB via groundwater discharges, however the data were incomplete or inconclusive for one site (Urick Foundry).

No reliable data exist from which to estimate the annual loadings of pollutants of concern to PIB as a result of contaminated surface water runoff. However, it is known that surface runoff may contribute very high annual loadings of a wide variety of pollutants. The sources of these pollutants may include contaminated groundwater which has discharged to stream valleys, point source discharges to tributaries, air deposition over the watershed, and a broad range of "non-point" sources typical of urban areas. Because of the potential significance of this secondary source of pollutants of concern, annual loadings were estimated on the basis of literature values, matched as closely as possible with the local (Erie area) conditions within the PIB watershed. Because these estimates are not derived from actual monitoring data, they were developed for reference purposes only. However, it is evident from the runoff ranges and mean values in the literature that the quantity of annual loading of pollutants of concern to PIB from stormwater is in the 100s of pounds for cadmium, and in the 1,000s of pounds for chromium, copper, lead, mercury, and nickel. The annual loading of BOD from this source is estimated at approximately 0.7 million pounds, and the COD loading is estimated at nearly five million pounds per year. Total phosphorus and total kjeldahl nitrogen loadings are estimated at 25,000 and 110,000 pounds per year, respectively.

Significant annual loadings of a variety of metals are derived from natural, background sources, and result from the geologic parent material (shale) from which area soil materials are formed. This is confirmed in the results of a series of samples collected from upland sand and gravel quarries which were evaluated by the COE as alternative sources of Presque Isle peninsula beachfill. Naturally-occurring metals levels in these upland sources are quite high, and would be classified as moderately to heavily polluted for arsenic, barium, copper, and manganese if evaluated against the existing, USEPA dredged sediment disposal guidelines.

Based on comparisons of PIB sediment samples with samples of dredged sediment from other locations throughout Lake Erie, it is apparent that many sites exceed PIB sediment metal contamination levels, for at least some metals. It is also apparent that naturally high background levels of many metals are found throughout Lake Erie, as reflected in the strong similarity between the metals analysis results from the Presque Isle peninsula upland beachfill sand sources and sand samples from various Lake Erie dredging projects.

Research has demonstrated that urban runoff contaminants are strongly associated with the finer sized particles in the sediment load, and a strong, inverse relationship was found to exist between PIB sediment concentrations of several metals (arsenic, copper, lead, manganese, and zinc) and the % sand of the sample. In general, the sandiest sediment samples exhibited the lowest overall metals levels. Based on examination of the FWS 1990 sediment sampling data, it is concluded that the metals component of the pollutants of concern are closely associated with the finer components of the suspended solids load (the "fines"), which tend to settle out very slowly. As a result, contaminants are carried throughout the Bay on the fine particulates; in general, sediment quality is influenced more by conditions which restrict the deposition of fine particulates (strong currents) than by proximity to pollutants sources. Less is known about the organics component of the pollutants of concern, however, these contaminants tend to associate quite strongly with the organic content of the suspended solids load. Because the finer sediments tend to exhibit the highest organic content, the distribution and fate of organics and nutrients is also expected to be biased toward the sediment "fines".

6. Pollutant Loadings

Primary and secondary sources of pollutants of concern in PIB were described in previous Chapter 5. In describing these sources, pollutants loading information was also included. This information on pollutants loading is summarized in this chapter, and placed in context with in-place pollutants.

6.1 Continuous Point Sources

At least 10 NPDES-permitted point sources discharge wastewater to the PIB watershed. However, most of these sources are small, discharge only cooling water, and are not located in the immediate proximity of the Bay (most of the industrial process wastewater generated within the PIB watershed is discharged to the City's sewer system). The only source discharging treated wastewater directly to the Bay is the wastewater treatment plant in Presque Isle State Park. This is a very small source (0.0175 mgd), treating only sanitary wastewater on a seasonal basis from April to October, and is not suspected of being a significant contributor of pollutants of concern.

Seven other continuous point sources are located within approximately 1.3 miles of the Bay, discharging primarily cooling water directly to the Bay or to tributaries and storm sewers which empty into the Bay. Characteristics of these continuous point sources have been summarized in Table 5.1, and loading estimates for the PIB pollutants of concern from these sources have been summarized in Table 5.2, to the extent that this information is available in the NPDES permit files. An eighth continuous point source described in Table 5.1, Penelec, is included only for historical reference; this source was discontinued in early 1991.

6.2 Intermittent Point Sources

Many of the point sources described in the previous section ("continuous point sources") discharge cooling water on a cyclical rather than a truly continuous basis. However, their discharge characteristics are sufficiently predictable that they were included as continuous point sources.

By far, the most significant intermittent point sources discharging to PIB are the 47 CSOs from the City's combined sewer system. These sources are described in Table 5.1; their locations are depicted in Figure 5.1. These overflows discharge during and after significant rainfall (or snowmelt) events, when the volume of surface runoff entering the sewer system exceeds the hydraulic capacity of the sewer lines. The City of Erie is currently collecting data on the quantity and quality of the effluent from the CSOs.

A comprehensive sampling of the wastewater influent to the wastewater treatment plant was conducted in 1986. Based on the results of this sampling (which are summarized in Table 5.3), the CSOs are not a major source of toxic organics to the Bay (98% of the 112 parameters tested were less than the detection limits). However, significant loadings of cyanide and several metals to PIB are derived from the CSOs.

6.3 Nonpoint Sources

No reliable data exist from which to determine the annual loading of pollutants of concern to PIB from stormwater runoff. However, research has shown that urban runoff contributes significant quantities of a variety of pollutants to receiving waters. Based on typical runoff rates from literature sources, and the land use characteristics of the PIB watershed, very high annual loadings of pollutants of concern to PIB are predicted. Estimates of the annual loading of pollutants of concern from urban runoff are provided in Table 5.13. It should be noted that a large but unquantifiable fraction of the total metals loadings in Table 5.13 are the result of natural, background levels of these metals in the soil materials of the Erie area.

A series of samples were collected in 1989 from five PIB tributaries. However, the concentrations of most pollutants of concern in these samples were below the analytical detection limit. Those metals which were quantifiable appear to correlate well with the natural, background geological conditions of the watershed. For several reasons, no attempt was made to quantify the annual loadings of contaminants of concern from these tributaries; a major reason is that the bulk of any such contributions is already captured in the urban runoff estimates.

6.4 In-Place Pollutants

The available records do not allow an estimation of the historical loadings of PIB pollutants of concern which have occurred from past industrial and municipal discharges to the Bay and its tributaries. Clearly, much of the biodegradable organic fraction of any such historical discharges has decayed and is no longer an issue. However, conservative substances, such as the metals, do not decay and accumulate in the sediments.

For several reasons, the volume of the in-place sediment pollutants reservoir cannot be accurately calculated on the basis of the available information. First, comprehensive determinations of the areal distributions of pollutants within the sediments are not available. Second, accurate determinations of the pollutant concentrations with various depths do not exist. Third, the effective depth of biological activity within the sediments is not known.

The third problem is an especially significant factor in developing remedial alternatives, because only those contaminants which are in flux with the surficial zone of biological activity are contributing to use impairments and potential health risks. Below a certain but unknown depth within the sediments, pollutants are not in chemical, hydrological, or biological contact with the biotic processes of PIB, and are therefore not cycled within the ecosystem (they are effectively "sealed" in the sediment). It should be realized, however, that dredging or other activities which expose these buried sediment contaminants effectively re-introduce these pollutants to the Bay's ecosystem.

The depth of biological activity within PIB's sediments (i.e. the depth to which sediment-dwelling organisms burrow) is not known, however a depth of 10 centimeters (four inches) is generally accepted as the typical range of bioturbation for freshwater benthos. If this depth is extended an additional 10 centimeters (another 4 inches) to allow for chemical migration of additional contaminants from below the biologically-active surficial layer, a total depth of eight inches (20 centimeters) is estimated as the effective reservoir of in-place contaminants of concern.

Based on an assumed eight inch depth of cycled sediment contaminants, a crude estimate of the total quantity of in-place pollutants of concern in PIB sediments may be derived, using the following three additional assumptions:

(1) pollutants of concern are essentially equally distributed throughout the PIB sediments, including both the horizontal and vertical axes (which is almost certainly not true)

(2) the average concentration of sediment contaminants of concern is represented by sediment samples collected in the center of the Bay, and

(3) one cubic foot of wet sediment weighs approximately 160 pounds (the density of wet sediment is typically 2.5-2.6 times the weight of water).

Based on the above assumptions, and the sampling data from the 1990 FWS sampling (FWS, 1991), the total reservoir of in-place sediment contaminants is estimated in Table 6.1. The sediment contaminant concentrations used in Table 6.1 are the average concentrations from sampling locations 13, 14, 15, and 7 in the 1990 FWS sampling (see Figure 4.3), which are located along the approximate centerline of the Bay.

Table 6.1. Estimated quantity of in-place pollutants of concern in PIB sediment.

Pollutants of Concern	Mean Conc. (mg/kg dry weight)	Sediment Load (lbs/acre in top 20 cm)
Arsenic	19.7	72.6
Barium	188	699.3
Cadmium	7.55	26.9
Chromium	76.9	295.9
Copper	138	511.0
Iron	53,400	199031.7
Lead	160.8	591.8
Manganese	859	3227.5
Nickel	84.6	322.8
Zinc	526	1963.4
COD	162,500	591716.0
TKN	3,100	11565.3
Total Phosphorus	1,320	4841.3
Cyanide	2.66	10.0
Oil & Grease	3,735	13986.0
Volatile Solids	8.7%	322754.2
PAHs	9.36	35.0

Because the 1990 FWS study did not include analytical testing for COD, TKN, total phosphorus, cyanide, oil & grease, and volatile solids, the in-place sediment loads of these contaminants in Table 6.1 were calculated on the basis of the 1986 COE sediment sample results. COE sample sites 13 and 14 were selected as representative sample locations. These sites are located near the Bay centerline, yet are outside of the area influenced by dredging activities and large vessel traffic.

The data in §4.1.1.7 provided a summary of the concentrations of selected contaminants in PIB sediments. Data in Table 6.1 (above) provide a rough estimate of the total quantity of pollutants of concern in PIB sediments which may, under normal circumstances, be reasonably expected to be a source of interference or influence on the biological systems of the PIB ecosystem. In order to provide a basis for comparison of PIB sediment contamination levels with other estuaries, data representing the median and 95th percentile values (i.e. those values which are higher than 95% of all observations) for selected contaminants from locations throughout the U. S. (regardless of whether such sites are or are not recognized as "contaminated") are summarized in Table 6.2, compared with the ranges of these contaminants found in the FWS 1990 sampling of PIB.

Table 6.2. Comparison of PIB sediment contamination levels with nationwide statistics (concentrations in mg/kg).

	Concentrations in U. S. Sites(1)		
Pollutants	Median	95th Percentile	PIB Average(2)
Arsenic	4.0	39	18.47
Cadmium	1.0	12	5.59
Copper	4.0	32	123.42
Lead	16	199	131.34
Nickel	13	99	60.16
Zinc	41	379	397.20
Acenaphthalene	0.6	4.3	0.095
Anthracene	0.5	4.5	0.368
Benzo[a]anthracene	0.01	0.014	0.832
Fluorene	0.6	4.5	0.186
Phenanthrene	0.6	5.6	1.482

(1) From USEPA, 1987a.

(2) Based on the 14 sediment sampling sites within PIB, as reported in FWS, 1991.

As may be seen in Table 6.2, and based on the most recent sampling, the concentrations of all PIB sediment metals compared were above the national median, and copper and zinc exceeded the national 95th percentile value. The average values for arsenic, cadmium, lead, and nickel were 47-66% of the respective 95th percentile values. However, it should be noted that the background levels of these metals in the Erie area are naturally high, and the results of the comparison in Table 6.2 do not necessarily reflect anthropogenic sources (see §5.2.1.6).

For the five PAHs for which national median and 95th percentile levels are provided in Table 6.2, the average PIB sediment levels of two species (benzo[a]anthracene and phenanthrene) exceeded the national median, and one (benzo[a]anthracene) exceeded the national 95th percentile value. The average values for the other four PAHs were 2-26% of the respective 95th percentile values. Table 6.3 provides a comparison of the concentrations of selected PIB sediment PAH levels with other Great Lakes/freshwater sites, including (1) sites where fish disorders (epizootics of neoplasia) have been identified and linked to sediment PAHs, and (2) background, or reference, locations.

Based on the data in Table 6.3, the average PIB sediment levels of the selected PAHs were 24-45 times the reference (background) levels for the first seven PAHs, and 90 times the background level for benzo(a)pyrene. However, when compared to other sites where fish disorders have been identified and linked to sediment PAHs, the PIB sediment levels of the selected PAHs were generally much lower. This is seen by comparing the average PIB PAH concentrations with the averages of four of the five sites where fish disorders have been identified (the values for the Black River were excluded from this comparison, as the PAH levels at this site are disproportionately high, and would unreasonably bias the comparison). From this comparison, it is seen that the PIB PAH levels were <= 20% of the other sites averages for seven PAHs, and 32% of the other sites average for the eighth PAH (benzo(k)fluoranthene).

6.5 Summary

Estimates of the total annual loadings of pollutants of concern to PIB have been developed for continuous point sources, combined sewer overflows, and urban runoff/nonpoint sources. In addition, the volume of in-place sediment pollutants was also

Table 6.3. Comparison of PIB sediment PAH levels with contaminated and reference sites (adapted from FWS, 1991).

Locations	PAHs and Concentrations (ppm dry weight)							
	Phenanthrene	Fluoranthene	Pyrene	Chrysene	Benz(a)-anthra.	Benzo(b)-fluoran.	Benzo(k)-fluoran.	Benzo(a)-pyrene
Smokes Creek	0.93	7.6	2.0	18	1.5	1.9	0.73	1.6
Union Ship Canal	7.5	33	24	14	7.1	11	3.4	6.4
Buffalo River	23	28	38	9.5	7.5	6.5	3.4	6.8
Black Rock Canal	3.4	9.9	11	2.7	3.2	3.8	2.4	3.4
Average of Above:	8.7	19.6	18.8	11.0	4.8	5.8	2.5	4.6
Presque Isle Bay[1]	1.6	2.6	2.2	1.1	0.9	1.0	0.8	0.9
Black River	390	220	140	51	51	-	-	3
Lake Ontario[2]	-	0.28	0.06	0.22	-	-	-	-
Buckeye Lake[2]	0.04	0.11	0.07	0.03	0.02	-	-	0.01

[1] PIB sample sites 6, 16, and 17 were omitted (see Figure 4.3 for locations of sampling sites).

[2] Reference (background) sites.

estimated. These calculated loadings are summarized in Table 6.4. No annual loadings were calculated for contaminated groundwater, as this was not found to be a potential source of significant quantities of pollutants of concern.

The estimates in Table 6.4 are developed from the best data currently available, and reliable estimation methodologies. However, it has been necessary to use a number of assumptions, to satisfy certain data gaps or inadequacies. These assumptions are described in the text, or footnoted on the tables, in Chapter 5.

It is emphasized that the in-place sediment contaminant quantities in Table 6.4 are total volumes, not annual loadings, and should not be directly compared to the annual loadings estimates for the other three contaminants sources (point sources, CSOs, and non-point). It is also noted that only half of the in-place pollutants are within the zone of bioturbation. The rates at which deeper chemicals may enter into the bioturbation zone, resulting from chemical migration (or physical forces) is unknown. Also, while 20 centimeters (eight inches) was selected as a sufficient depth to include both the zone of bioturbation and the zone of chemical migration, the actual depth is also unknown.

The total quantities of in-place sediment contaminants of PIB pollutants of concern are based on data from the FWS 1990 sediment sampling program. When these data were averaged, and compared with mean sediment quality data from U. S. estuaries, it was found that all six metals for which comparison data are available (arsenic, cadmium, copper, lead, nickel, and zinc) exceeded the U. S. median, and two metals (copper and zinc) exceeded the national 95th percentile value. However, background metals levels are naturally high in the Erie area, and the observed sediment metals levels do not necessarily reflect anthropogenic sources.

When compared with national median PAH levels and other freshwater lake reference sites, the PIB sediment PAH levels are clearly elevated. However, when compared to the national 95th percentile values, the PIB sediment PAH levels are generally much lower. Also, when compared to other sites where fish disorders (neoplasia) have been identified and linked to sediment PAHs, the PIB sediment PAH levels were one-third to one-tenth (or less) of the average levels at these other sites, and one to two orders of magnitude lower than the worst sites.

Table 6.4. Summary of PIB pollutants of concern estimates.

Pollutants	Point Sources (annual loading)	CSOs (annual loading)	Non-Point (annual loading)	In-Place (lbs/acre)
	Pollutants Sources and Quantities (in pounds)			
Arsenic	<17	11	-(1)	72.6
Barium	313	17	-	699.3
Cadmium	<4	51	240	26.9
Chromium	<36	264	1,400	295.9
Copper	<139	264	2,500	511.0
Iron	<8,952	-	-	199,031.7
Lead	<198	119	11,000	591.8
Manganese	281	-	-	3,227.5
Nickel	<65	494	12,000	322.8
Zinc	<922	519	-	1,963.4
COD	<43,361	-	4,800,000	591,716.0
TKN	<3,775	-	110,000	11,565.3
Total Phosphorus	<112	-	25,000	4,841.3
Cyanide	<32	383	-	10
Oil & Grease	<24,385	-	-	13,986.0
Volatile Solids	-	-	-	322,754.2
PAHs	-	<340	-	35.0

(1) Available data insufficient to calculate an estimate.

JDR/sn/D54

Table 6.4. Summary of PIB pollutants of concern estimates.

	Pollutants Sources and Quantities (in pounds)			
Pollutants	Point Sources (annual loading)	CSOs (annual loading)	Non-Point (annual loading)	In-Place (lbs/acre)
Arsenic	<17	11	-(1)	72.6
Barium	313	17	-	699.3
Cadmium	<4	51	240	26.9
Chromium	<36	264	1,400	295.9
Copper	<139	264	2,500	511.0
Iron	<8,952	-	-	199,031.7
Lead	<198	119	11,000	591.8
Manganese	281	-	-	3,227.5
Nickel	<65	494	12,000	322.8
Zinc	<922	519	-	1,963.4
COD	<43,361	-	4,800,000	591,716.0
TKN	<3,775	-	110,000	11,565.3
Total Phosphorus	<112	-	25,000	4,841.3
Cyanide	<32	383	-	10
Oil & Grease	<24,385	-	-	13,986.0
Volatile Solids	-	-	-	322,754.2
PAHs	-	<340	-	35.0

(1) Available data insufficient to calculate an estimate.

storm water and combined sewer flows, and the installation of new air pollution equipment in the incinerators to meet the new clean air regulations.

In addition, from 1979 to 1986, seven CSOs discharging to PIB were eliminated from the sewage collection system, and an additional 4 were eliminated in 1990. Finally, an indeterminate number of industrial point sources were eliminated, through plant closures or connection to the City's sewage collection system, and the City has implemented a pretreatment program to regulate all industrial discharges to the City's system. It is important to note that the City's outfall discharges to Lake Erie and not to PIB. Therefore, many discharges that previously may have gone to the Bay, now go to the treatment plant and are removed from the Bay system.

7.1.2 Costs and Funding Sources

The estimated cost of the 1975 upgrading and expansion projects of the City's wastewater treatment plant was $20 million. The funds were derived from the USEPA's Construction Grants Program, authorized and operated under §201 of the Clean Water Act, and an Erie Sewer Authority bond issue.

The accumulated costs for the past and continuing CSO separation efforts are not known, however approximately $350,000 was spent in 1990/1991 to eliminate 4 CSOs discharging to PIB and for the abatement of dry weather overflows to the Mill Creek Tube. An additional $75,000 was spent on metering equipment at other CSOs. The funds were derived from sewer use fees ("sewer rentals").

7.1.3 Benefits Realized

The available data base is inadequate to develop a reliable correlation between the completed pollution control efforts described above and resultant improvements in water quality and ecosystem health. One notable improvement which has been observed over the past decade is the achievement of full-body water contact recreation standards in most of the Bay. It is probable that this benefit is the principal result of the City's CSO reduction efforts, including the elimination of dry weather overflows to the Bay.

7.2 Actions in Progress

The City is continuing to work toward the elimination of additional CSOs. In addition, the ECDH and PADER are continuing to review and tighten NPDES point source discharge permit limits, as existing permits are renewed and as applications for new discharges are processed. However, the most significant new initiatives are the Mill Creek Tube study, which will result in the identification and eventual elimination of the most significant sources of pollution to the Mill Creek drainage system, and a similar effort (the "Other Sources of Pollution" study) for Cascade Creek and other drainage systems.

7.2.1 Descriptions of Programs and Individual Projects

The City of Erie has been progressively eliminating CSOs from its collection system for at least 10 years (the number of mapped CSOs discharging to PIB was reduced from 54, in a 1979 map, to 47, in a 1986 map), and eliminated 4 as recently as 1990. Because the elimination of CSOs requires that additional hydraulic capacity be provided in the collection system, either through the reduction in other sources of flow, or through the construction of additional sewers, these CSO eliminations have been accomplished to the extent possible within the limitations of hydraulic capacity and available funds. However, the 1989 Consent Decree between the Commonwealth of Pennsylvania and the City of Erie has resulted in the imposition of a court-ordered timeframe for the City to develop and implement measures to address CSOs (as well as other significant pollutant discharges) to PIB from the Mill Creek system, as well as a companion effort for the other PIB tributaries.

In response to the Consent Decree, the City has undertaken a program to identify and eliminate dry weather discharges to the Mill Creek Tube, and has initiated (Spring, 1991) a contract with Malcolm Pirnie Engineers to identify all significant sources of pollutants in the Mill Creek Tube system, and to develop structural and non-structural control alternatives. This study ("Comprehensive Evaluation of the Mill Creek Tube") is being undertaken as a condition of the Consent Decree.

In the Spring of 1992, PADER and the City revised the Consent Decree. The second consultant contract (Other Sources of Pollution study) to identify sources of pollutants to the Bay from sources other than those tributary to the Mill Creek system (e.g. Cascade Creek and other tributaries, and CSOs and storm sewer discharges not connected to the Mill Creek system) was delayed while the City conducted additional flow monitoring and water analysis. It was felt that this additional analysis would enable a better plan of work to be developed for the second study. Currently, PADER and the City are discussing the possibility of the City itself conducting this second study, rather than contracting for services. Malcolm Pirnie would provide technical oversight to the City on this second phase of the project. This study will be similar to the ongoing Mill Creek Tube study, and will result in the development of structural and non-structural alternatives for the control of pollutant loadings to the Bay. Finally, the City has constructed a treatment plant for the drinking water filter backwash discharge to PIB. Sludge from this plant is sent to the City's wastewater treatment plant and the liquid is put into the intake line or returned to the Bay.

Erie County is currently involved in the development of a non-point source pollution study for the Lake Erie coastal areas. Bids have been solicited for this study, but a successful contractor has not yet been selected.

In addition to the activities described above, the ECDH and PADER have aggressively investigated a variety of real and potential pollution sources, including hazardous materials disposal and spill sites throughout the Erie area (ten individual project examples have been described in Chapter 5). The Erie Conservation District has initiated programs to reduce the amount of non-point source pollution reaching the Lake and Bay, primarily from agricultural activities. Federal Clean Water Act grant money has been used for those projects.

7.2.2 Costs and Funding Sources

The contract value of the Mill Creek Tube study is approximately $900,000. These funds were derived from sewer use fees. Because this study is not yet complete, no estimates of the costs of recommended remedial alternatives are currently available.

It is estimated that the cost of the Other Sources of Pollution study will be in the $450,000 range. The funds will derive from sewer use fees. No projections of the costs of recommended remedial alternatives are currently possible.

7.2.3 Projected Benefits

Until the Mill Creek Tube and Other Sources of Pollution studies are completed, no reliable projections of the types of contaminants which will be controlled, and the quantities of such reductions, can be developed. Consequently, the resulting water quality and aquatic ecosystem benefits cannot be projected. However, because water quality conditions in PIB meet current standards (except near the mouth of Mill Creek Tube), the greatest water quality benefits will be realized in this area.

Sediment quality improvements will be realized throughout the Bay. Sources which previously discharged contaminants from the City to the Bay, where they were mixed by currents and distributed in the water column throughout the Bay before settling into the sediment, will be directed to the waste treatment plant or eliminated. However, because of the large quantities of in-place sediment contaminants, the rate of improvement in sediment quality will be slow.

Because no evidence of direct impairment of PIB fish stocks exists, benefits to fish and wildlife will be limited. Theoretically, reductions in PAH and other contaminant loading rates could eventually result in the reduction or elimination of the chronic condition of external lesions and liver tumors observed in PIB brown bullheads.

7.3 Summary

The existing data base is inadequate to gauge the incremental benefits of past and ongoing pollution control projects in the PIB watershed. Consequently, it is not possible to identify the categories of activities which resulted in the greatest improvements.

One past pollution control action which is significant is the upgrading and expansion of the City's wastewater treatment plant, which was completed in 1975 at an estimated cost of $20 million. Another significant past action has been the ongoing efforts toward CSO elimination. From 1979 to 1990, approximately one dozen CSOs have been eliminated, including 4 which were eliminated in 1990, as part of a $350,000 project. Funding for these projects has been derived from Federal grant programs and sewer use fees.

Actions in progress include the continuation of the CSO elimination efforts, a continued program of review and revision in NPDES direct discharge permits, and the recently-initiated Mill Creek Tube study. The Mill Creek Tube study has been initiated to identify all significant sources of pollution to Mill Creek, including CSOs. A future action is the Other Sources of Pollution Study (a companion study to the Mill Creek Tube study, with similar objectives), addressing Cascade Creek and other PIB tributaries outside of the Mill Creek watershed. Funding for the Mill Creek Tube study ($900,000), which will identify measures to eliminate additional CSOs as well as other significant pollutant sources to the Mill Creek system, is derived from sewer use fees. The Other Sources of Pollution Study was initiated and remediation begun in 1992.

No reliable projections of the anticipated benefits to water or sediment quality from the actions in progress, or planned future actions, are available. Because the Bay currently meets water quality standards for protected uses, the greatest water quality benefits are anticipated to be realized in nearshore areas along the south shore of the Bay, at the discharge locations of CSOs, point sources, tributaries, and storm sewers. Sediment quality improvements will be more widespread, because sediment contaminants are most closely associated with the sediment "fines", which are dispersed throughout the Bay during settling. Benefits to fish and wildlife will be more limited, because no significant impairment of aquatic species has been conclusively demonstrated by the available data.

8. Restoration Goals, Objectives, and Milestones

One of the most fundamental aspects of any remedial strategy is a determination of the goals and objectives to be met, and the establishment of milestones at which progress may be assessed, and appropriate "mid-course corrections" introduced, if warranted. However, to be effective, any such set of goals and objectives must be supported by all the users of the resource being managed. For an ecosystem which is shared by such a diverse array of user groups as Presque Isle Bay, selection of the restoration and maintenance goals and objectives must result from an open and interactive process, involving public, industry, government, recreation, commerce, navigation and other interest groups. These interest groups represent the "stakeholders" and the membership of the Public Advisory Committee reflects this cross-section of opinions.

8.1 Uses to be Restored, Maintained, or Discontinued

Of the 14 beneficial uses specified by the IJC for consideration (see Chapter 4), the available data indicate two clearly impaired uses (dredging and fish tumors), one uncertain use (phyto- and zooplankton), and one limited impairment (beach closing/recreation restriction). Ten other uses are either (1) being met, or (2) not indicated as impaired, based on the currently available data and other information. Therefore, we wish to restore the Bay to a condition where there is unrestricted dredging (as defined by USEPA and Corp of Engineers guidelines), tumor free fish, and unrestricted recreation. At the same time, we want to maintain the other 10 beneficial uses. No potential but non-attained uses have been identified which are to be discontinued.

The specific objectives of the remedial action planning process for PIB will continue to parallel the general PADER objectives: maintenance of aquatic life, water supply, and recreation. To this end, the Bay will continue to be held to the water quality criteria and standards established by the PADER for the protection of such uses. As any such criteria and standards are modified (for example, in response to the Great Lakes Water Quality Initiative), or as any new criteria and standards are added, conditions in the Bay will be re-assessed, and new objectives established, as appropriate.

8.2 Goals for Biota and Habitat Restoration

The available data indicate that concentrations of monitored contaminants in PIB fish are no different than comparable levels in Lake Erie fish, and no indication of wildlife impairment exists. Further, no evidence of sediment or water column toxicity to PIB fish exists. However, it is hypothesized that elevated PAH or other contaminant levels in the sediments are responsible for or contributing to the existence of external lesions and deformities, and liver tumors in resident Brown Bullheads. Therefore, although no direct cause and effect relationship has been established, it is theorized that the chronic malady affecting the bullhead population would diminish under conditions of reduced contaminant exposure. Consequently, a goal of the remedial action planning process will be to restore the PIB fisheries habitat to conditions which support normal populations of all resident fish species, while maintaining the current high productivity of these fish stocks. Clearly, if it is later determined that problems with fish are related to lakewide conditions, they will need to be addressed by the Lakewide Management Plan (LAMP) that will be developed in 1993.

8.3 Water Use and Quality Objectives

Based on the available information, PIB currently supports all relevant water use and quality objectives, with the limited exception of the mouth of the Mill Creek Tube being unsuitable for water recreation. A goal of the RAP will be the completion of the City of Erie's project to investigate and correct CSOs and other sources of pollution and to continue to maintain these uses and objectives, and to maintain a sufficient monitoring program to ensure that this goal continues to be met. It is a goal of the RAP that the programs outlined in §9.1.1 be implemented.

8.4 Sediment Quality Objectives

Contaminant levels in PIB sediments exceed levels which permit their disposal in open lake dump sites (see §4.1.1.7). Consequently, any sediments dredged from the Bay must be disposed of in confined disposal sites, or other controlled disposal areas where isolation of the sediment can be assured, and incidental release to the environment prevented. At present, the objectives will be to restore the sediment quality to conditions which do not necessitate special handling. However, the current standards (actually "guidelines") are almost 15 years old, and may be inappropriate for some parameters. A new set of sediment disposal standards is currently under development by the U. S. EPA and are expected to be released in the near future. At such time as these new standards are released, the sediment quality objectives for PIB will be revised to reflect these new standards.

8.5 Other Goals of the Remedial Action Process

In addition to the specific activities cited above, there are a number of general goals which may be achieved using the RAP process.

It is the committee's intent that the RAP spark heightened public awareness of, and interest in environmental issues concerning PIB and the Great Lakes in general. To that end, an important component of the RAP process will be educating the public through meetings, publications, reports, etc. Wherever possible, RAP activities should be coordinated with the local media to focus attention on the importance of the project and the benefits to be obtained from its successful completion. In April of 1992, the Erie Earth Day Coalition sponsored the "I Promise Campaign" which requested local industries to identify programs or activities they have undertaken to protect and improve the environment and plans for future improvements. The RAP will hopefully support these types of efforts in the future.

Another goal of the RAP process will be to instill the concept of pollution prevention into our environmental management of PIB. This will include not only evaluating industrial practices, but also the habits of homeowners and individuals living in the AOC. This effort will go hand in hand with the public education effort mentioned above. There are a number of Erie industries that have joined the voluntary 33/50 program initiated by the USEPA to reduce the discharge of toxic pollutants. Again, the RAP process seeks to support these efforts and increase participation in these types of programs. The philosophy of "zero discharge" should be used wherever possible in selecting remedial alternatives and solutions to existing problems. Our efforts should support and be consistent with the Basin's ultimate goal of virtually eliminating toxic inputs to the Great Lakes.

8.6 Summary

Presque Isle Bay is shared by a diverse array of "stakeholder" or user groups, including public, industry, government, recreation, commerce, navigation, and other interests. These stakeholder groups comprise the Public Advisory Committee and will coordinate with the PADER to develop a consensus set of goals and objectives for the restoration and maintenance of the Bay.

There are two clearly impaired uses, dredging and fish tumors, and one limited impairment, recreation restrictions, which are therefore to be restored. Ten other uses are either being met and/or exhibit no evidence of actual or potential impairment. For the remaining use, phytoplankton/zooplankton productivity, the collection of additional data is required in order to complete the evaluation of potential impairment. No uses are to be discontinued. The PADER will continue to pursue its broad ecosystem management objectives of maintenance of aquatic life, water supply, and recreation, and will continue to apply the water quality criteria and standards developed to protect these broad categories of protected uses.

Although no direct evidence of fisheries impairment exists, sediment contaminant levels are theorized to be contributing to the external abnormalities and liver tumors observed in the PIB Brown Bullhead population. Consequently, a goal of the remedial action planning process will be to restore the PIB fisheries habitat to conditions which support normal populations of all resident fish species, while maintaining the current high productivity of these fish stocks. Because the available information indicates that PIB currently supports all relevant water use and quality objectives, with the exception of the mouth of the Mill Creek Tube, no restoration needs are apparent, and a water quality management goal will be to simply continue to maintain these uses and objectives, including maintaining an adequate monitoring program. Another water quality goal will be the completion of the City of Erie's project to investigate and correct CSOs and other sources of pollution contributing to the problems associated with the Mill Creek Tube. For contaminated sediments, the present objectives will be to restore the sediment quality to conditions which do not necessitate special handling. However, a new set of sediment standards is anticipated to be developed in the near future, and the sediment quality objectives for PIB will be revised to reflect these new standards.

A general goal of the RAP process will be the continued education of the public and regulated community on issues important to the successful completion of this project. Pollution prevention practices should be encouraged wherever possible. The "zero discharge" philosophy should guide our selection of remedial alternatives and we should support the goal of virtually eliminating toxic discharges to the Lakes.

9. Programs and Participants

The purpose of this chapter is to identify the existing pollution control and environmental management programs which are available to implement the Remedial Action Plan (RAP) which will be developed for Presque Isle Bay. A final determination of the relevant pollution control programs and implementing authorities can occur only after consensus on the ecosystem restoration and maintenance goals and objectives has been reached (see Chapter 8), and the development of selected alternatives to meet these goals and objectives has been completed. Since we are currently in the information gathering stage for some of the uses and have not yet selected remedial alternatives, the following information is presented as initial background information and guidance which will be supplemented an d expanded as alternatives are identified.

9.1 Regulatory and Administrative Programs

A variety of Federal programs exist to control the introduction of pollutants into surface waters, and to manage the quality of aquatic resources. These programs are focused on the Clean Water Act (CWA), and manifested through a series of permit activities. However, the authorities of other regulatory programs (e.g. the Safe Drinking Water Act, the Great Lakes Critical Programs Act, the Clean Air Act, the Resource Conservation and Recovery Act, the Underground Injection Control Act, etc.) may be selectively invoked to accomplish a specific pollution abatement objective or need. These Federal programs are sufficiently flexible that the determined resource manager may apply their broad powers to achieve the prevention of ecosystem damage, wherever a clear link can be established between a polluting activity and a risk to public health or the environment.

These Federal programs usually have direct State-level counterpart programs, which are required to be no less strict than the Federal model (they may be more strict, however, at the State's discretion). In the absence of a State counterpart program, the Federal program takes precedence.

9.1.1 Current Programs

Clearly, for the PIB AOC, the most significant existing program is the National Pollutant Discharge Elimination System (NPDES) permit program, established under the authority of the CWA, and conducted under Pennsylvania's Clean Streams Law. Through this program, the quality and quantity of direct wastewater discharges to the Bay and its tributaries may be controlled, through the requirement that any discharges to surface waters obtain an NPDES permit. NPDES permit authorities are very broad; permits are required for essentially any discharge of any pollutants to any surface waters. NPDES permit authorities are used to control CSO discharges and municipal and industrial stormwater runoff. The Great Lakes Water Quality Initiative is a program currently under development which will significantly impact the NPDES program in the Lakes. Contaminants being discharged will be subject to stricter standards than were previously accepted.

In addition, the Pretreatment program (actually, another form of NPDES permit authority) is used by municipalities to control the quantity and quality of industrial wastewater discharged to municipal sewer systems. Under the pretreatment program, which is developed as an element of the municipality's NPDES permit, all industrial and commercial users are subject to general and specific prohibitions on the types and quantities of pollutants that may be discharged. These limitations are developed to protect both the treatment works as well as the receiving waters.

As an adjunct to the Commonwealth's NPDES authorities, court-ordered consent decrees may be used to cause a particular discharger to implement specific corrective measures, within a specified timeframe. The current Mill Creek Tube study is being performed under the purview of a consent decree; elimination of the discharge of filter backwash to PIB from the City's two water filtration plants was also accomplished under the same consent decree.

Controls on the release of hazardous substances to the environment, whether to the air, soil, groundwater, or surface water, are authorized by RCRA authorities, and conducted under Pennsylvania's Solid Waste Management Act. These authorities apply to the management and disposal of hazardous wastes as well as the storage of hazardous chemicals which could, if spilled, contribute to pollution of environmental media. For past spills where no clearly-responsible party may be identified, or where the polluting entity no longer exists or is incapable of funding a clean-up effort, "Superfund" authorities (Comprehensive Environmental Response, Compensation and Liability Act/Superfund Amendments and Reauthorization Act, or CERCLA/SARA) may be invoked to effect a clean-up. The Superfund process requires that a site be scored above a certain level to be eligible for funding; the site scoring process is based on the relative level of actual or potential risk to human health and the environment represented by the contamination.

As a supplement to CERCLA/SARA, the State Hazardous Substance Cleanup Act (HSCA) provides a mechanism to effect restorations at sites which do not score above the CERCLA/SARA threshold. The management of non-hazardous wastes, including wastes from industrial sources, is regulated by the State Solid Waste Management Act.

The discharge of contaminants to the groundwater, through the underground injection of wastes, is controlled through the authorities of the Underground Injection Control Act. The permit authorities of this act apply to any underground placement of fluids for the purposes of disposal. These authorities extend to all wells used for underground injection, including any dug hole whose depth exceeds its greatest surface dimension, if used for the disposal of fluids, as well as certain types of septic tanks.

The release of pollutants to the air is regulated under the authority of the Clean Air Act. Specific discharge limitations apply to hazardous or toxic substances as well as the conventional air pollutants. Additional limitations exist which are related to the type of industrial activity from which the emissions originate. A PADER operating permit is required for all significant emissions sources. The recently enacted Clean Air Act Amendments tighten control of toxics in air emmissions and have specific provisions regarding impacts in the Great Lakes region.

Finally, the dredging of sediment, as well as the placement of fill or any structure in "navigable waters", requires a permit from the COE, again under the authority of the CWA. The dredge and fill permit program includes an EPA review and approval component. Dredge and fill permit requirements extend to any physical alterations of the floodplain as well as to the stream channel itself.

9.1.2 Implementing Authorities

Because Pennsylvania is an NPDES-authorized state, the PADER is the implementing authority for NPDES permits. This permit authority includes surface water discharges of treated wastewater and cooling water, CSOs, and stormwater runoff. Municipal pretreatment programs for indirect (industrial) dischargers is also included under PADER's NPDES authorities. In Erie County, the ECDH acts as PADER's agent for NPDES enforcement and permitting activities, however the PADER may exercise its authority in conjunction with, or independently of, the ECDH.

The PADER is also the RCRA permitting authority, exercising permit controls over the management and disposal of hazardous wastes. Although any Superfund (or CERCLA/SARA) cleanups are under the authority of the U. S. EPA (in this case Region III), the PADER may exercise a broad range of RCRA response actions at RCRA-permitted facilities. PADER hazardous waste management permit authority extends to both public (e.g. municipal or other governmental) and private facilities, and includes such activities as on-site storage and/or treatment and/or disposal of hazardous wastes, including landfilling, incineration, chemical/physical/biological treatment, surface impoundments, land treatment ("land application"), and thermal treatment.

A Federal permit, obtained from the U. S. EPA, Region III is required for the underground injection of wastes. Although Pennsylvania exercises limited permit authority for the underground injection of oil and gas wastewaters, the Federal underground injection control program has not been delegated to Pennsylvania, and an EPA permit is required for all non-oil and gas activity injections. All pre-existing as well as new or proposed injection wells are required to obtain permits, and closed wells are required to meet strict closure standards for closure integrity and financial liability in the event of failure.

The PADER has authority for the issuance of air discharge permits in Pennsylvania. Permit requirements extend to new as well as existing sources.

Finally, the COE (Buffalo District) is the authorized permit authority for dredge and permit activities. However, the EPA Region III retains review and veto power over COE permit actions, and may deny the use of any disposal site under the authority of §404(c) of the CWA.

9.1.3 New Programs

Existing permit programs and authorities (as summarized above) provide for the control of the following types of pollutant discharges:

* industrial and municipal wastewater discharges to surface waters
* industrial and commercial wastewater discharges to municipal wastewater treatment plants
* combined sewer overflows
* industrial and municipal stormwater runoff
* hazardous waste releases to any environmental media
* non-hazardous waste releases
* discharge of pollutants to groundwater
* release or discharge of pollutants to the air, and

* dredge and fill activities in surface waters.

These existing authorities are primarily focused in the PADER but shared with the COE (dredge and fill), the ECDH (NPDES permitting), and the U. S. EPA (underground injection control).

As seen above, existing regulatory program authorities extend to virtually any form of pollutant release to any environmental media. Consequently, existing regulatory programs provide adequate authorities to effect any necessary pollution controls, and new control programs are not necessary. Detailed reviews of regulatory capabilities performed in other AOCs have concluded that more vigorous and focused applications of existing regulatory authorities, rather than the creation of additional or new authorities, is adequate to achieve the restoration of impaired uses (USEPA, 1985a). However, the application of existing regulatory authorities is complicated, because (1) the ecosystem problems in AOCs are typically multi-media (affecting or involving air, water, groundwater, biota, etc.), and (2) most environmental statutes and regulatory programs are single-media in focus and orientation.

The PAC wishes to note that, since the cleanup of the Lakes is an international effort, it is important that our Canadian partners implement regulatory regimes which are as strict or stricter as those used in the United States.

9.2 Local Programs

The only existing viable local programs presenting alternatives for reducing pollutant loads to the Bay are the sanitary sewage transport and treatment systems. The transport system is wholly under the direction of the City of Erie, except for the Eastside and Westside Interceptors. The treatment plant and two Interceptors are controlled by the Erie Sewer Authority. All other municipalities located in the PIB drainage basin are required by agreements to deliver all of their sanitary wastes to the Erie treatment plant.

9.2.1 Current Programs

The present Erie transportation system removes all waste deposited in it from the PIB basin, except for storm event overflows. The waste includes industrial and sanitary wastes, as well as some street waste from the combined sewer system during low intensity storms and some first flush flows during higher intensity, long duration events. These flows are delivered to the Erie Wastewater Treatment Plant whose treated effluent is discharged to the Lake outside of the boundaries of the Bay.

9.2.2 Implementing Authorities

The maintenance, use, and expansion of the sanitary waste transportation and treatment system is the responsibility of the City of Erie and/or the Erie Sewer Authority. Its adaptation or expansion to incorporate additional waste flows or eliminate existing overflows will be the responsibility of these two entities.

9.3 Public Involvement

Essentially all significant permit actions in Federal or Federally-delegated permit programs (e.g. NPDES, hazardous waste management, air permitting, dredge and fill, underground injection, etc.) include a public notice and comment period requirement. In the event that significant public comment or controversy results from the proposed permit action, the permitting agency is required to investigate and resolve any valid scientific and technical issues associated with the proposed action prior to the issuance of a permit and commencement of the discharge activity. This investigative effort may include preparation of an Environmental Impact Statement.

In the restoration of an AOC, however, the need for public involvement is necessarily interwoven into the remedial action planning process. Because the resources of the AOC are shared by a variety of user groups (see Chapter 8), a consensus must be reached between these often diverse "stakeholder" interest groups on the best resource utilization and management approaches for the AOC. Because the ecosystem problems in AOCs are complex, and typically expensive to correct, a balance is needed between the staggering costs of complete remediation and the remaining risks to human health and the environment associated with partial remediation. As an inevitable consequence of urbanization, some degree of pollution of surface and groundwaters is inevitable. Consequently, the issue is no longer risk elimination, but risk management. Therefore, the public involvement process is necessary to determine what level of relative risk is acceptable, and what costs are associated with alternative risk levels.

To facilitate public involvement in the Remedial Action Plan for PIB, a Public Advisory Committee (PAC) has been established. This group necessarily includes representatives of the various AOC user interest groups, ranging from strictly conservationist interests on the one extreme, to purely consumptive use interests on the other, as well as municipal and other governmental officials. The membership roster is included as Appendix D. It is essential that this group reflect all AOC user interests, so that the final RAP may present a solution which can be endorsed and supported by the entire community. Because of the flexibility available to the regulatory authorities in administering environmental management programs, it is the responsibility of the PAC to negotiate a compromise solution that meets the environmental restoration and maintenance needs of the AOC while being sensitive to the economic realities, public health concerns, and needs of the local business community.

9.4 Political Implementability

As indicated above, any recommended solution for the AOC will be a compromise between the divergent interests and needs of the various AOC user groups. In theory, such a compromise will reflect environmental as well as economic limitations, and will enjoy broad political and public support.

Remediation of AOCs is typically expensive, and requires a relatively long timeframe to complete. Therefore, it is important that all interest groups understand the costs and tradeoffs of the alternative solutions, and that the selected alternative receive the continuing support of the majority of these interest groups.

9.5 Summary

Identification of the relevant pollution control programs and implementing authorities which will be instrumental in implementing the Remedial Action Plan for the PIB AOC will occur after the final consensus selection of the goals and objectives for the restoration and maintenance of the PIB ecosystem, and the identification of remedial activities to be taken is complete.

A wide variety of Federal/State programs exist to control the introduction of pollutants into surface waters, and to manage the quality of aquatic resources. Therefore, it is likely that any remedial actions will be implementable through existing regulatory authorities and administrative programs.

For the PIB AOC, the NPDES permit program (established under the authority of the Clean Water Act) will be the most significant regulatory program. NPDES permits are required for essentially any discharge of any pollutants to any surface waters. NPDES permit authorities are used to control surface water discharges of treated wastewater and cooling water, CSOs, and municipal and industrial stormwater runoff. In addition, the quantity and quality of industrial wastewaters discharged to the municipal sewer system are controlled through pretreatment programs, which are another form of NPDES authority. In addition to normal NPDES program authorities, court orders and consent decrees may also be imposed under the powers of the Clean Water Act, and used in conjunction with the NPDES permit program. The NPDES program in Pennsylvania is administered by the PADER; in Erie, the ECDH administers the NPDES program, acting as local agents for the PADER.

The existing sanitary wastewater treatment programs within the Presque Isle Bay drainage basin are under the control of either the City of Erie or the Erie Sewer Authority. These two agencies must be looked upon to implement any programs which call for the use of the existing facilities.

Controls on the release of hazardous substances are implemented through RCRA authorities, and the "Superfund" is available for cleanup of hazardous chemicals where a responsible party no longer exists. The PADER is the RCRA permitting authority, and any Superfund cleanups are under the authority of the U. S. EPA, Region III. In addition, a PADER cleanup program exists for sites which are not eligible for Superfund response. Controls on the underground injection of wastes are exercised through a permit program established under the authority of the Underground Injection Control Act, as administered by the U. S. EPA, Region III (Pennsylvania operates a limited program for oil and gas activities only). All significant air discharges require air discharge permits under a program administered by the PADER. Finally, the COE (Buffalo District) is the authorized permit authority for dredge and permit activities.

Existing regulatory program authorities extend to virtually any form of pollutant release to any environmental media, including industrial and municipal wastewater discharges to surface waters, industrial and commercial wastewater discharges to municipal wastewater treatment plants, combined sewer overflows, industrial and municipal stormwater runoff, hazardous waste releases to any environmental media, discharge of pollutants to groundwater, release or discharge of pollutants to the air, and dredge and fill activities in surface waters. Consequently, new regulatory programs are not anticipated to be necessary, and adequate controls are possible through focused applications of existing regulatory authorities.

The public involvement program is an integral part of the remedial action planning process for PIB. The most fundamental goal of the program is to serve as a forum for negotiating the consensus set of goals and objectives which meet the needs of the various stakeholder groups which are the users of the AOC's resources. Active participation of all affected user groups is essential to ensure that the restoration goals and objectives, and selected remedial action alternatives, enjoy both the initial as well as continuing support of the AOC's users. The Public Advisory Committee has been established to fulfill this role.

REFERENCES

The following references include those sources cited in the Background Report. Selected, additional sources are also included in the following listing. These additional sources were reviewed in preparation of the report, but were not directly referenced or cited. These sources are included here to provide an indication of the universe of relevant information with direct or indirect bearing on the environmental conditions of Presque Isle Bay and the surrounding areas.

AES, 1985. Soil and Water Analyses for Project #1483, Jones Chemicals, Erie Facility. Advanced Environmental Systems, Inc. February 26, 1985. Report prepared for Conestoga-Rovers & Associates, Ltd.

Baumann, P. C., 1991. Ohio State University, Department of Zoology. Personal communications.

Baumann, P. C., and Whittle, D. M., 1988. The Status of Selected Organics in the Laurentian Great Lakes: An Overview of DDT, PCBs, Dioxins, Furans, and Aromatic Hydrocarbons. Aquatic Toxicology, 11 (1988) 241-257. ©1988 Elsevier Science Publishers B. V.

Baumann, P. C., Harshbarger, J. C., and K. J. Hartman, 1990. Relationship Between Liver Tumors and Age in Brown Bullhead Populations from Two Lake Erie Tributaries. The Science of the Total Environment, 94 (1990) 71-87. ©Elsevier Science Publishers B. V.

Baumann, P. C., Smith, W. D., and W. K. Parland, 1987. Tumor Frequencies and Contaminant Concentrations in Brown Bullheads from an Industrialized River and a Recreational Lake. Transactions of the American Fisheries Society 116:79-86, 1987.

BEE, 1976. Draft Water Quality Study of Outer Harbor of Presque Isle Bay; Erie, Pennsylvania. Prepared for the U. S. Environmental Protection Agency, Region III, Philadelphia, Pennsylvania, by Betz Environmental Engineers, Inc. September, 1976

Billingsley, C., 1991. Area 1 Biologist, Pennsylvania Fish Commission. Personal communication.

Black, J., [date?]. Epidermal Hyperplasia and Neoplasia in Brown Bullheads (Ictalurus nebulosus) in Response to Repeated Applications of a PAH Containing Extract of Polluted River Sediment. In: Polynuclear Aromatic Hydrocarbons: Formation, Metabolism and Measurement, Seventh International Symposium, edited by Marcus Cooke and Anthony J. Dennis.

Bolton, H. S., Breteler, R. J., Vigon, B. W., Scanlon, J. A., and S. L. Clark, 1985. National Perspective on Sediment Quality. U. S. Environmental Protection Agency, Criteria and Standards Division, Office of Water Regulations and Standards, Washington, D. C. EPA Contract No. 68-01-6986. May, 1985.

Boyle, 1990. Erie Bayfront Highway Lord/Reed Surface Sites CERCLIS. Letter from A Patrick Boyle, Regional Monitoring and Compliance Manager, PADER Bureau of Waste Management to Thomas Teets, Chairman Erie County Environmental Coalition. March 15, 1990.

Brigham, C., 1991. Student, Biology Department, Mercyhurst College. Presque Isle Bay Benthic Macroinvertebrates. Unpublished, draft data.

Campbell, M., 1991a. Associate Professor, Biology Department, Mercyhurst College. Correspondence to C. Rice, U. S. Fish and Wildlife Service; State College, Pennsylvania.

Campbell, M., 1991b. Associate Professor, Biology Department, Mercyhurst College. Personal communications.

City of Erie, 1986. Waterfront Comprehensive Plan - Erie, Pennsylvania. Prepared for the City of Erie by Land Design/Research, Inc. and Morton Hoffman and Company, Inc. May, 1986.

COE, 1979 (?). Final Environmental Impact Statement; Permit Application by United States Steel Corp.-Proposed Lake Front Steel Mill-Conneaut, Ohio. Prepared by the U. S. Army Corps of Engineers, Army Engineer District Buffalo. undated. Four Volumes.

COE, 1982. Chemical, Physical and Bioassay Analysis of Sediment Samples, Erie Harbor, Erie, Pennsylvania. Prepared for the U. S. Army Corps of Engineers, Buffalo District by Applied Biology, Inc. December, 1982.

COE, 1986a. The Analysis of Sediments from Erie Harbor; Erie, PA. Prepared for the U. S. Army Corps of Engineers, Buffalo District by AquaTech Environmental Consultants, Inc. (Technical Report #G0176-07; Contract #DACW49-86-D-001). June, 1986.

COE, 1986b. Results of 96-hour Sediment Bioassay Retests of Sediment from Dunkirk Harbor, N. Y. and Erie Harbor, PA. Prepared for the U. S. Army Corps of Engineers, Buffalo District by AquaTech Environmental Consultants, Inc. (Supplement to Technical Report #G0176-07; Contract #DACW49-86-D-0001). October, 1986.

COE, 1987. Erie Harbor, Pennsylvania; Operations and Maintenance; Dredging, Confined Disposal, and Open-Lake Disposal; Environmental Assessment, Finding of No Significant Impact, and Section 404(b)(1) Evaluation. U. S. Army Corps of Engineers, Buffalo District. July, 1987.

COE, 1988. Erie Harbor; North Pier Stone Repair; Erie County Pennsylvania; Finding of No Significant Impact and Environmental Assessment. U. S. Army Corps of Engineers, Buffalo District. June, 1988.

COE, 1991. Annual Beach Nourishment; Presque Isle State Park; Erie County, Pennsylvania; Public Notice, Preliminary 404(b)(1) Evaluation, and Finding of Compliance. U. S. Army Corps of Engineers, Buffalo District. January 28, 1991.

DDL, 1972. Engineering Report on Combined Sewer Study for Erie, Pennsylvania. Dalton•Dalton•Little. January, 1972.

Drever, J. I., 1982. The Geochemistry of Natural Waters. Prentice-Hall, Inc. Englewood Cliffs, NJ. 388 pp.

ECDH, 1970. Fact Sheet on Lake Erie Pollution Control. Erie County Department of Health. February 12, 1970.

ECDH, 1985. Priority Pollutants, Lake Erie and Presque Isle Bay, 1985. Erie County Department of Health. 1985.

ECDH, 1989a. Presque Isle State Park Bathing Beach Contamination Report. Erie County Department of Health. June, 1989.

ECDH, 1989b. The Lake Erie/Presque Isle Bay Fish Flesh Study 1987-1988. Erie County Department of Health. December, 1989.

ECDH, 1990a. Presque Isle State Park Bathing Beach Contamination Investigation Year 2 - Final Report. Erie County Department of Health. February, 1990.

ECHD, 1990b. Unpublished fecal coliform sampling data from 1990 collections at five Presque Isle Bay locations. Erie County Department of Health.

ECHD, 1975. Lake Erie Basin Water Quality; Erie County, Pennsylvania. 1975 Annual Report. Erie County Health Department, Division of Sanitary Engineering.

ECHD, 1977. Lake Erie Basin Water Quality; Erie County, Pennsylvania. 1976-77 Annual Report. Erie County Health Department, Division of Water Quality and Land Protection.

ECHD, 1979. Lake Erie Basin Water Quality; Erie County, Pennsylvania. 1978-79 Annual Report. Erie County Health Department, Division of Water Quality and Land Protection.

Erie Sewer Authority, 1988. Wastewater Treatment Plant Outfall Sewer Study. Report to the Erie Sewer Authority by Consoer, Townsend & Associates, Inc. November, 1988.

Erie-Western Pennsylvania Port Authority, 1979 (?). Proposed Disposal of Dredge Materials; The Captain John E. Lampe Marina; Erie, Pennsylvania (technical analysis of disposal options prepared for the Erie-Western Pennsylvania Port Authority by D'Appolonia).

Erie-Western Pennsylvania Port Authority, 1989-1990. Joint Permit Application and related correspondences and laboratory analysis data sheets. Permit application submitted by the Erie-Western Pennsylvania Port Authority to the U. S. Army Corps of Engineers, Buffalo District (application prepared by Challenge Engineering Consultants, Inc.).

Fabacher, D. L., Schmitt, C. J., Besser, J. M., and M. J. Mac, 1988. Chemical Characterization and Mutagenic Properties of Polycyclic Aromatic Compounds in Sediment from Tributaries of the Great Lakes. U. S. Fish and Wildlife Service; National Fisheries Contaminant Research Center (D. L. Fabacher, C. J. Schmitt, and J. M Besser) and National Fisheries Center-Great Lakes (M. J. Mac). Environmental Toxicology and Chemistry, Vol. 7, pp. 529-543, 1988. Pergamon Press.

FDA, 1987. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. U. S. Department of Health and Human Services, Food and Drug Administration, Center for Food Safety and Applied Nutrition.

Field, R. and Pitt, R. E., 1990. Urban Storm-Induced Discharge Impacts. Water Environment and Technology, August 1990, pp. 64-69.

Field, R., and Turkeltaub, R., 1981. Urban Runoff Receiving Water Impacts: Program Overview, Journal of the Environmental Engineering Division, ASCE, Vol. 107, No. EE1, Feb., 1981, pp. 83-100.

Frey, R., 1984. Internal memo from Robert Frey, PADER Division of Water Quality, Bureau of Water Quality Management, entitled: "Subject: 1986 Coho Salmon Results". October 14, 1987; with attachments.

Frey, R., 1984. Internal memo from Robert Frey, PADER Division of Water Quality, Quality Assessment Unit, entitled: "Subject: Mercury in Lake Erie Fish". December 20, 1984; with attachments.

FWS, 1986. A Preliminary Survey of Tumors in Brown Bullheads in Presque Isle Bay, Lake Erie, Erie, Pennsylvania. U. S. Fish and Wildlife Service, State College, PA Field Office (C. Rice, D. Putnam, F. Plewa, and C. Kulp). Resource Contaminant Assessment Report No. 86-1.

FWS, 1987. Preliminary Report: Results of 1985 Survey of Tumors in Brown Bullheads From Presque Isle Bay, Lake Erie, Erie, Pennsylvania. U. S. Fish and Wildlife Service, State College, PA Field Office (C. Rice, D. Putnam, and C. Kulp). Environmental Contaminants Report No. 87-8. May, 1987.

FWS, 1991. Chemical Analysis of Sediments from Presque Isle Bay, Erie, Pennsylvania. U. S. Fish and Wildlife Service, State College, PA Field Office (C. Rice, and C. Kulp). Special Project Report 91-2. February, 1991.

Geary, J. T., 1983. Report on the Results of Chemical Analyses of Soil and Water Samples Taken from the Property of Ben Kimmel, West 18th and Filmore, Erie, Pennsylvania. Prepared by John T. Geary, chemist. December 6, 1983.

Gilson, 1990a. Bay Front Access Road City of Erie, Erie County. Memo to file from Ricardo F. Gilson, Regional Solid Waste Operations Supervisor, PADER Bureau of Waste Management. February 27, 1990.

Gilson, 1990b. Bay Front Access Road/Old United Tank Farm/Reed Manufacturing City of Erie, Erie County. Memo to file from Ricardo F. Gilson, Regional Operations Supervisor, PADER Bureau of Waste Management. December 27 1989.

Gilson, 1990c. Bay Front Access Road/Reed Manufacturing City of Erie, Erie County. Memo to file from Ricardo F. Gilson, Solid Waste Supervisor, PADER Bureau of Waste Management. January 24, 1990.

GLRI, 1972. Selected Analysis and Monitoring of Lake Erie Water Quality; 1972 Annual Report. Great Lakes Research Institute (report prepared for the Commissioners of Erie County, Pennsylvania on behalf of the Erie County Health Department). December 31, 1972.

GLRI, 1973. Selected Analysis and Monitoring of Lake Erie Water Quality; 1973 Annual Report. Great Lakes Research Institute (report prepared for the Commissioners of Erie County, Pennsylvania on behalf of the Erie County Health Department). December 31, 1973.

GLRI, 1974a. Interim Report to Erie County Health Department for the Commissioners of Erie County, Pennsylvania on Limnology of the Benthos of Presque Isle Bay Summer 1974 (Supplementary Work Related to the 1974 Water Quality Study; Report No. 45, Samples 508 through 519). Great Lakes Research Institute. October 15, 1974.

GLRI, 1974b. Report to Erie County Health Department, Bureau of Environmental Health on Selected Analysis and Monitoring of Lake Erie Water Quality. Great Lakes Research Institute. Report No. 40-A. June 25, 1974.

GLRI, 1974c. Selected Analysis and Monitoring of Lake Erie Water Quality; 1974 Annual Report. Great Lakes Research Institute (report prepared for the Commissioners of Erie County, Pennsylvania on behalf of the Erie County Health Department). December 31, 1974.

Goodyear, C. S., T. A. Edsall, D. M. Ormsby Dempsey, G. D. Moss, and P. E. Polanski, 1982. Atlas of the Spawning and Nursery Areas of Great Lakes Fishes. Volume Nine: Lake Erie. U. S. Fish and Wildlife Service, Washington, D. C. Publication FWS/OBS-82/52. September, 1982.

Harrison, S., 1984. Quarterly Sampling, July 22, 1984, Kimmel Site. Report on the sampling and groundwater flow at the Kimmel Site prepared by Sam Harrison, Certified Professional Geologist. October 7, 1984.

Harrison, S., 1988. Preliminary Hydrogeological Assessment of the Pontillo Landfill, W. 16th St. and Pittsburgh Ave., Erie, PA. Prepared by Samuel S. Harrison, Ph. D., Certified Professional Geologist/Certified Ground Water Professional, November 26, 1988.

Hebert, P., and Schwartz, S., 1983. Great Lakes Dredging in an Ecosystem Perspective-Lake Erie. A Report submitted to the Dredging Subcommittee of the International Joint Commission Water Quality Board by the Great Lakes Institute of the University of Windsor, Ontario. June, 1983.

Howison, R., 1989. A Summary of Water Quality Data from Presque Isle Bay, Lake Erie, Erie, Pennsylvania. International Joint Commission, Great Lakes Regional Office. March, 1989.

Humphrey, E., 1988. Chemical Contaminants in the Great Lakes: The Human Health Aspect. In: Toxic Contaminants and Ecosystem Health; A Great Lakes Focus (Marlene S. Evans, ed.). © John Wiley & Sons, Inc., 1988.

Humphrey, E., 1991. Michigan's Cohort Studies; The "Crown Jewels" of Environmental Epidemiology". Harold E. B. Humphrey, Ph. D. Center for Environmental Health Sciences, Michigan Department of Public Health. unpublished.

IJC, 1983a. 1983 Annual Report; Report of the Aquatic Ecosystem Objectives Committee. International Joint Commission, Great Lakes Science Advisory Board. November, 1983.

IJC, 1983b. A Review of the Municipal Pollution Abatement Programs in the Great Lakes Basin. International Joint Commission, Great Lakes Water Quality Board, Water Quality Programs Committee, Municipal Abatement Task Force. November, 1983 (eighth draft).

IJC, 1983c. Dredging Subcommittee Report. Appendix to the 1983 Report on Great Lakes Water Quality. International Joint Commission, Great Lakes Water Quality Board. August, 1983.

IJC, 1983d. Evaluation of Dredged Material Disposal Options for Two Great Lakes Harbours Using the Water Quality Board Dredging Subcommittee Guidelines. Report of the Dredging Subcommittee to the Great Lakes Water Quality Board, International Joint Commission. April, 1983.

IJC, 1985. 1985 Report on Great Lakes Water Quality. International Joint Commission; Great Lakes Water Quality Board.

IJC, 1986a. 1985 Annual Report; Committee on the Assessment of Human Health Effects of Great Lakes Water Quality. International Joint Commission, Great Lakes Water Quality Board/Great Lakes Science Advisory Board, Revision of October. 1986.

IJC, 1986b. A Forum to Review Confined Disposal Facilities for Dredged Materials in the Great Lakes. Report of the Dredging Subcommittee to the Great Lakes Water Quality Board. International Joint Commission, Great Lakes Water Quality Board. October 31, 1986.

IJC, 1986c. Summary Report of the Workshop on Great Lakes Atmospheric Deposition. International Joint Commission, Science Advisory Board/Water Quality Board/International Air Quality Advisory Board. 1986.

IJC, 1987a. 1987 Report on Great Lakes Water Quality. International Joint Commission, Great Lakes Water Quality Board. November, 1987.

IJC, 1987b. Guidance on Characterization of Toxic Substance Problems in Areas of Concern in the Great Lakes Basin. Report of the Surveillance Work Group to the Great Lakes Water Quality Board of the International Joint Commission. March, 1987.

IJC, 1988a. Mass Balancing of Toxic Chemicals in the Great Lakes: The Role of Atmospheric Deposition. International Joint Commission, Science Advisory Board/Water Quality Board/International Air Quality Advisory Board. May, 1988.

IJC, 1988b. Options for the Remediation of Contaminated Sediments in the Great Lakes. Report of the Sediment Subcommittee/Remedial Options Work Group to the Great Lakes Water Quality Board of the International Joint Commission. December, 1988.

IJC, 1988c. Procedures for the Assessment of Contaminated Sediment Problems in the Great Lakes. Report of the Sediment Subcommittee/Assessment Work Group to the Great Lakes Water Quality Board of the International Joint Commission. December, 1988.

IJC, 1989. Revised Great Lakes Water Quality Agreement of 1978 as amended by Protocol signed November 18, 1987. Office Consolidation, International Joint Commission, United States and Canada. September, 1989.

IJC, 1990. Register of Great Lakes Dredging Projects 1980-1984. Report of the Sediment Work Group to the Great Lakes Water Quality Board of the International Joint Commission. September, 1990.

IJC, 1991. Listing/Delisting Guidelines for Great Lakes Areas of Concern. International Joint Commission. Published in the March/April 1991 issue of Focus on International Joint Commission Activities, published by the International Joint Commission, Windsor, Ontario/Detroit, Michigan. Volume 16, Issue 1, ISSN 0832-6673.

Jacobson, J., Humphrey, H., Jacobson, S., Schantz, S., Mullin, M., and Welch, R., 1989. Determinants of Polychlorinated Biphenyls (PCBs), Polybrominated Biphenyls (PBBs), and Dichlorodiphenyl Trichloroethane (DDT) Levels in the Sera of Young Children). American Journal of Public Health, October 1989, Vol. 79, No. 10. © American Journal of Public Health.

Jacobson, J., Jacobson, S., and Humphrey, H., 1990a. Effects of Exposure to PCBs and Related Compounds on Growth and Activity in Children. Neurotoxicology and Teratology, Vol. 12, pp. 319-326. © Pergamon Press.

Jacobson, J., Jacobson, S., and Humphrey, H., 1990b. Effects of in utero exposure to polychlorinated biphenyls and related contaminants on cognitive functioning in young children. The Journal of Pediatrics, Jan. 1990, Vol. 116, No. 1, pp. 38-45. © C. V. Mosby Company.

Johnston, E. P., and Baumann, P. C., 1989. Analysis of fish bile with HPLC-fluorescence to determine environmental exposure to benzo(a)pyrene. Hydrobiologia 188/189: 561-566, 1989. ©1989 Kluwer Academic Publishers, Belgium.

Kanetsky, C., 1991. Personal Communication. Laboratory Data sheets from Bioaccumulative Pollutant Study (in progress) (Phase II of National Dioxin Study). Charles A. Kanetsky, Environmental Engineer, Environmental Services Division, U. S. Environmental Protection Agency, Region III.

Kay, G., 1975. Macroinvertebrate Populations with Varying Levels of Acid Mine Pollution in Canoe Creek, Clarion County, Pennsylvania. Master of Science thesis; Division of Graduate Studies, Clarion University of Pennsylvania, Clarion, Pennsylvania.

Kodrich, W. R., 1991. Professor of Biology, Clarion University of Pennsylvania. Personal communications.

Lager, J. A. and Smith, W. G., 1974. Urban Stormwater Management and Technology: An Assessment. USEPA Report No. EPA-670/2-74-040.

Lobins, S., 1990. Erie Bayfront Highway Site #1 Vicinity of Lord Corporation Parking Lot Remedial Investigation Erie County. Memo from S. Craig Lobins, Hydrogeologist, PADER Bureau of Waste Management to A. Patrick Boyle, PADER Regional Monitoring & Compliance Manager, Bureau of Waste Management. April 2, 1990.

Lynch, J. A., Grimm, J. W., and Corbett, E. S., 1989. Atmospheric Deposition: Spatial and Temporal Variations in Pennsylvania--1988. Prepared for the Pennsylvania Department of Environmental Resources by the Penn State Environmental Resources Research Institute. December, 1989.

Lynch, J. A., Grimm, J. W., and E. S. Corbett, 1989. Atmospheric Deposition: Spatial and Temporal Variations in Pennsylvania 1988. Prepared for the Pennsylvania Department of Environmental Resources by the Environmental Resources Research Institute, PennState. December, 1989.

Mac, M. J., 1991. U. S. Fish and Wildlife Service, Great Lakes Fishery Laboratory, Ann Arbor, Michigan. Personal communication.

Masteller, E. C. , 1990. Baseline Analysis of Bioaccumulation of Heavy Metals in Zebra Mussels in Lake Erie and Presque Isle Bay, Erie, Pennsylvania. Report submitted to the Pennsylvania Department of Environmental Resources, Coastal Zone Management Program. October, 1990.

Masteller, E. C., Cunningham, H. N., Jr., Leavers, D. R., and E. Tucker, Jr., 1976. Biological, Chemical and Geological Characteristics During August-September of Lake Erie Tributaries of Erie County, PA. Pennsylvania State University, Behrend College, Division of Natural Sciences and Engineering. Proceedings of the Pennsylvania Academy of Science 50:45-58, 1976.

Meinholtz, T. L., et al., 1979. Verification of the Water Quality Impacts of Combined Sewer Overflows. USEPA publication no. EPA-600/2-79-155 (NTIS No. PB 80-175052), U. S. Environmental Protection Agency, Cincinnati, Ohio.

NFG, 1982. Phase 2 Investigation of the Inactive Waste Disposal Site on the National Fuel Gas Wayne Street Property, Erie, Pennsylvania. Prepared for National Fuel Gas Company by Ecology and Environment. January, 1982.

NUS, 1987. Sampling and Analysis Program, Bayfront-Port Access Road, Erie PA. Report submitted to HDR-Richardson Gordon, Inc. by the NUS Corporation. September 28, 1987.

NUS, 1988. Report on Additional Investigation, Bayfront-Port Access Road (NUS Project No. L513). Report submitted to HDR-Richardson Gordon, Inc. by the NUS Corporation. February 19, 1988.

PADER, 1976. Comprehensive Water Quality Management Plan for the Pennsylvania Portion of the Lake Erie Drainage Basin and the Remaining Portion of Erie County. Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Water Quality Management. September, 1976 (Executive Summary November, 1976, Publication No. 49).

PADER, 1977. Subbasin 15 Report-State Water Plan. Preliminary Draft. Pennsylvania Department of Environmental Resources. 1977.

PADER, 1978. Recreational Guide for Presque Isle State Park. Commonwealth of Pennsylvania, Department of Environmental Resources, Office of Resources Management, Bureau of State Parks. Revision 12-78.

PADER, 1986a. Priority Water Body Survey Report, Water Quality Standards Review, Presque Isle Bay and Outer Erie Harbor. Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management. September, 1986.

PADER, 1986b. Site Inspection of RSR-Jones Chemicals Site; EPA No. PA-1738. Pennsylvania Department of Environmental Resources, Bureau of Waste Management, Division of Emergency & Remedial Response, February 20, 1986. Report prepared for the U. S. Environmental Protection Agency, Hazardous Site Control Division.

PADER, 1988a. 1987 Stationary Source Emission Inventory Report; Pennsylvania Emission Data System. Pennsylvania Department of Environmental Resources, Bureau of Air Quality Control. December, 1988.

PADER, 1988b. Commonwealth of Pennsylvania; 1988 Water Quality Assessment (prepared pursuant to Section 305(b) of P. L. 95-217, as amended). Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management, Division of Water Quality. April, 1988. Volume 2-Text and Volume 3-Appendix.

PADER, 1988c. Waterfowl consumption advisory. Issued jointly by the Pennsylvania DER and the Pennsylvania Game Commission in the DER NEWS, February 14, 1988.

PADER, 1989a. 1989 Air Quality Report. Pennsylvania Department of Environmental Resources, Bureau of Air Quality Control, Division of Technical Services and Monitoring. 1989.

PADER, 1989b. Presque Isle State Park Environmentally Sensitive Area Study. Prepared for the Pennsylvania Department of Environmental Resources, Bureau of State Parks by The RBA Group. June 30, 1989.

PADER, 1991. Trophic State Analysis, Presque Isle Bay, Erie County. Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management, Meadville Regional Office. Draft; March 7, 1991.

PEI, 1989. Emission Test Report, Pilot Wet ESP Test Program. Report to the City of Erie, Bureau of Sewers, by PEI Associates. August, 1989.

Penelec, 1973. A Study of the Effects of the Operation of a Steam Electric Generating Station on the Aquatic Ecology of Presque Isle Bay, Erie, Pennsylvania. Prepared for the Pennsylvania Electric Company by Aquatic Ecology Associates. April, 1973.

PennDOT, 1989a. Alternatives Analysis Report for the Erie Bayfront Highway-Site 1. Results and Recommendations; Final Submittal. Prepared for the Pennsylvania Department of Transportation, District 1-0, by Skelly and Loy. November 11, 1989.

PennDOT, 1989b. Erie Bayfront Highway Section A20 Former Storage Tank Site Emergency Response Report. Prepared for the Pennsylvania Department of Transportation, District 1-0, by Skelly and Loy. November, 1989.

PennDOT, 1989c. Remedial Investigation of the Erie Bayfront Highway-Site 1 Results and Recommendations-Executive Summary. Prepared for the Pennsylvania Department of Transportation, District 1-0, by Skelly and Loy. March 11, 1989.

PennDOT, 1990a. Remedial Investigation of the Erie Bayfront-Port Access Road Site 2 Results and Recommendations. Prepared for the Pennsylvania Department of Transportation, District 1-0, by Skelly and Loy. January, 1990.

PennDOT, 1990b. S. R. 4034 Erie Bayfront-Port Access Road Site 1 Remedial Alternative Justification. Prepared for the Pennsylvania Department of Transportation, District 1-0, by Skelly and Loy. March, 1990.

PennDOT, 1990c. S. R. 4034 Erie Bayfront-Port Access Road Site 1 Test Pit Excavations. Prepared for the Pennsylvania Department of Transportation, District 1-0, by Skelly and Loy. November, 1990.

Pepino, 1991. Personal communications; Rich Pepino, USEPA Region III, Philadelphia, Pennsylvania.

PFC, 1983. Presque Isle Bay (215A) Management Report. Pennsylvania Fish Commission, Division of Fisheries, Fisheries Management Section. January, 1983.

PFC, 1988. Presque Isle Bay Fisheries Assessment. Pennsylvania Fish Commission, Division of Fisheries, Fisheries Management Section. Spring, 1988.

PFC, 1991. Summary of Fishing Regulations and Laws-1991. Pennsylvania Fish Commission. 1991.

Pitt, R., and Bozeman, M., 1982. Sources of Urban Runoff Pollution and Its Effects on an Urban Creek. USEPA publication no. EPA-600/52-82-090 (NTIS No. PB 83-111021), U. S. Environmental Protection Agency, Cincinnati, Ohio.

Plowchalk, D. and Zagorski, S., 1986. Polycyclic Aromatic Hydrocarbon Concentrations from Watersheds With Varying Degrees of Industrialization. Proceedings of the Pennsylvania Academy of Science 60: 174-178. 1986.

Prater, B. L. and M. Anderson, 1977. A 96-hour bioassay of Otter Creek (Ohio). Journal of Water Pollution Control Federation, 49, 10 (October 1977). [As cited in COE, 1982]

Prazer, S., 1970. Effects of Pollution on the Erie Water Supply. Paper presented to the students and faculty at Villa Maria College, Erie, Pennsylvania. April 22, 1970.

Presque Isle Yacht Club, 1988-1989. Public Notice, miscellaneous correspondences, and laboratory analysis data sheets related to a permit application to the U. S. Army Corps of Engineers, Buffalo District for a proposed marina expansion.

Rolfe, G. L., and Reinbold, K. A., 1977. Environmental Contamination by Lead and Other Heavy Metals, Vol. I, Introduction and Summary. Institute for Environmental Studies, University of Illinois, Urbana-Champaign, Il.

SAIC, 1987. Evaluation of PAH Sediment Contamination in USEPA Region V and the Great Lakes. Submitted by Science Applications International Corporation to the U. S. Environmental Protection Agency, Region V. September, 1987.

Shaheen, D. G., 1975. Contributions of Urban Roadway Usage to Water Pollution. USEPA Report No. EPA-600/2-75-004 (NTIS No. PB-245854). 358 pp.

Sonstegard, R. A., 1977. Environmental Carcinogenesis Studies in Fishes of the Great Lakes of North America. In: Aquatic Pollutants and Biologic Effects With Emphasis on Neoplasia. Annals of the New York Academy of Sciences, Volume 298, pp. 261-269.

Turekian, K. K., 1971a. Geochemical Distribution of Elements. Encyclopedia of Science and Technology, Vol. 4. McGraw-Hill, New York, pp. 624-630.

USEPA, 1971. Lake Erie Ohio, Pennsylvania, New York Intake Water Quality Summary 1970. U. S. Environmental Protection Agency, Region V, in cooperation with the Ohio Department of Health, New York State Department of Environmental Conservation, and the Pennsylvania Department of Environmental Resources. August, 1971.

USEPA, 1975. Water Pollution Investigation: Erie, Pennsylvania Area. U. S. Environmental Protection Agency, Region V Enforcement Division, Great Lakes Initiative Contract Program (prepared for the USEPA by Betz Environmental Engineers, Inc.). USEPA publication EPA-905/9-74-015. March, 1975.

USEPA, 1977a. Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments. U. S. Environmental Protection Agency, Region V. April, 1977.

USEPA, 1977b. Zooplankton, Phytoplankton, and Bacteria as Indicators of Water Quality in the Nearshore Zone of Lake Erie: A Prospectus. U. S. Environmental Protection Agency, Region V, Eastern District Office (prepared for the USEPA by the Ohio State University, Center for Lake Erie Area Research, Technical Report No. 86). March, 1977.

USEPA, 1978. Lake Erie Nearshore Surveillance Station Plan for the United States. U. S. Environmental Protection Agency, Region V, Eastern District Office (prepared for the USEPA by the Ohio State University, Center for Lake Erie Area Research, Technical Report No. 77). January, 1978.

USEPA, 1979a. A General Overview of Lake Erie's Nearshore Benthic Macroinvertebrate Fauna. U. S. Environmental Protection Agency, Region V, Eastern District Office (prepared for the USEPA by the Ohio State University, Center for Lake Erie Area Research, Technical Report No. 126). October, 1979.

USEPA, 1979b. Urban Stormwater and Combined Sewer Overflow Impacts on Receiving Water Bodies. Procedings of a national conference in Orlando, Florida, November 26-28, 1979. USEPA Report No. EPA-600/9-80-056 (NTIS No. PB 81-155-6)

USEPA, 1979c. Summary of Lake Erie Nearshore Characteristics and Lake Erie Nearshore Surveillance Design. Final Report. U. S. Environmental Protection Agency, Region V, Eastern District Office (prepared for the USEPA by the Ohio State University, Center for Lake Erie Area Research, Technical Report No. 128). September, 1979.

USEPA, 1979d. Water Quality of the Nearshore Zone of Lake Erie: A Historical Analysis and Delineation of Nearshore Characteristics of the United States. U. S. Environmental Protection Agency, Region V, Eastern District Office (prepared for the USEPA and the International Joint Commission by the Ohio State University, Center for Lake Erie Area Research, Technical Report No. 112). March, 1979.

USEPA, 1983a. Results of the Nationwide Urban Runoff Program. Executive Summary. U. S. Environmental Protection Agency, Office of Water Program Operations, Water Planning Division. NTIS No. PB 84-185545. December, 1983.

USEPA, 1983b. Results of the Nationwide Urban Runoff Program. Volume 1-Final Report. U. S. Environmental Protection Agency, Office of Water Program Operations, Water Planning Division. NTIS No. PB 84-185552. December, 1983.

USEPA, 1984. Lake Erie Intensive Study 1978-1979. Final Report. U. S. Environmental Protection Agency, Great Lakes National Program Office (prepared for the USEPA by the Ohio State University, Center for Lake Erie Area Research). USEPA publication EPA-905/4-84-001. January, 1984.

USEPA, 1985a. Master Plan for Improving Water Quality in the Grand Calumet River/Indiana Harbor Canal. U. S. Environmental Protection Agency, Region V. USEPA Publication EPA-905/9-84-003C. January, 1985.

USEPA, 1985b. Presque Isle National Priorities List Superfund Site. Summary of Investigations and Recommendations for Further Action. U. S. Environmental Protection Agency, Region III. October, 1985.

USEPA, 1987a. An Overview of Sediment Quality in the United States. U. S. Environmental Protection Agency, Office of Water Regulations and Standards. USEPA Publication EPA-905/9-88-002. June, 1987.

USEPA, 1987b. Declaration for the Record of Decision; Presque Isle Superfund Site. U. S. Environmental Protection Agency, Region III. September 30, 1987.

USEPA, 1987c. The National Dioxin Study-Tiers 3, 5, 6, and 7. U. S. Environmental Protection Agency, Office of Water Regulations and Standards, Monitoring and Data Support Division. USEPA Publication EPA 440/4-87-003. February, 1987.

USEPA, 1988. Site Inspection of Kimmel Site. Prepared under TDD No. F3-8706-26, EPA No. PA-1949, Contract No. 68-01-7346 for the Hazardous Site Control Division, U. S. Environmental Protection Agency by the NUS Corporation, Superfund Division. April 13, 1988.

USEPA, 1989. Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish: A Guidance Manual. U. S. Environmental Protection Agency, Office of Marine and Estuarine Protection/Office of Water Regulations and Standards. 1986. USEPA Publication No. EPA-503/8-89-002.

USEPA, 1990a. Bibliography of Storm & Combined Sewer Pollution Control R&D Program Documents. Compiled by Richard Field, Chief, Storm & Combined Sewer Pollution Control Program, Office of Research and Development, Risk Reduction Engineering Laboratory, Edison, NJ. USEPA Publication EPA 600/9-90/032.

USEPA, 1990b. Record of Decision, Lord-Shope Landfill Site, Decision Summary. U. S. Environmental Protection Agency, Region III. June 29, 1990.

USEPA, 1990c. Storm and Combined Sewer Overflow: An Overview of EPA's Research Program. U. S. Environmental Protection Agency, Office of Research and Development, Risk Reduction Engineering Laboratory. USEPA Publication EPA 600/8-89/054. January, 1990.

USEPA, 1991a. ARCS-Assessment and Remediation of Contaminated Sediments-1991 Work Plan. U. S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, Illinois. 1991.

USEPA, 1991b. Storm and Combined Sewer Pollution Control-A Compilation of Significant References. Compiled by Richard Field, Storm & Combined Sewer Pollution Control Program, Office of Research and Development, Risk Reduction Engineering Laboratory, Edison, NJ. Advance Copy; publication date and number not yet determined.

USPHS, 1967. Erieland-2000; A Comprehensive Environmental Health Survey of Erie County, Pennsylvania. U. S. Public Health Service, National Center for Urban and Industrial Health. 1967 (produced in cooperation with various County, City, State and Federal agencies).

Vogel, J., 1991. Director, Erie County Department of Health. Personal communications.

Wellington, R., 1990. Fathead Minnow Toxicity Monitoring [of] Streams Tributary to Presque Isle Bay - Scott Run, Cascade Creek, West Branch of Cascade Creek, Myrtle Street Storm Sewer and Garrison Run; November 1989. File memo; Erie County Department of Health. February 27, 1990.

Wellington, R., 1991a. Preliminary data from 1990 fathead minnow toxicity monitoring of streams tributary to Presque Isle Bay. Unpublished; personal communication. March 25, 1991.

Wellington, R., 1991b. Preliminary data from 1991 survey of brown bullheads in Presque Isle Bay. Unpublished; personal communications. March/April 1991.

Wilbur, W. G., and Hunter, J. V., 1980. The Influence of Urbanization on the Transport of Heavy Metals in New Jersey Streams. Water Resources Institute, Rutgers University, New Brunswick, NJ.

Young, L., 1982. Lake Erie Angler and Boater Use and Angler Harvest Survey. Unpublished Coastal Zone Management Report (as cited in PFC, 1983).

Young, L., 1983. Development of Fishery and Boating Programs for the Lake Erie Coastal Zone. Pennsylvania Fish Commission, Bureau of Fisheries and Engineering. December 31, 1983.

Zagorski, S. and Galus, C., 1971. A Bacteriological Analysis of Presque Isle Bay at Erie, Pennsylvania, 1971. Proc. 15th Conf. Great Lakes Res. 1972: 214-220. Internat. Assoc. Great Lakes Res.

Zagorski, S. J., and A. J. O'Toole, 1970. A Study of Phytoplankton and Zooplankton of the Bay of Lake Erie at Erie, Pennsylvania, Summer 1969. Gannon College, Dept. of Biology. Pennsylvania Academy of Science, Volume 44, 1970.

Zagorski, S. J., and G. Wilcox, 1973. Quantitative and Qualitative Analysis of the Macroinvertebrates of Lake Erie, at Erie, Pennsylvania September-December, 1972. Gannon College, Dept. of Biology. Proc. Pa. Acad. Sci. 47:99-101. 1973.

Zagorski, S. J., and M. Sampson, 1982. The Changing Configuration of Presque Isle Peninsula. The Journal of Lake Erie Studies, Volume 11, Number 1. Published by Mercyhurst College and the Erie County Historical Society. Spring, 1982.

Zar, 1991. Personal communications; Howard Zar, USEPA Region V, Chicago, Illinois.

APPENDIX A

United States Department of State

Washington, D.C. 20520

January 30, 1991

Mr. Gordon K. Durnil
Chairman, United States Section
International Joint Commission
2001 S Street, N.W., Second Floor
Washington, D. C. 20440

Dear Mr. Chairman:

Pursuant to Annex 2 paragraph 3 of the Great Lakes Water Quality Agreement, the United States hereby designates Presque Isle Bay and the waters of Lake Erie in the immediate vicinity of Erie, Pennsylvania, as an Area of Concern under the terms of said Agreement. I am advised that the Government of Canada supports this designation.

The United States as Party to the Agreement thanks the Commission for its advice in this matter as contained in Secretary LaRoche's letter of February 20, 1990. Designation of the Presque Isle area is based upon the terms of the Agreement which focus upon existing environmental conditions and upon information in the area provided by the State and Federal agencies and the Commission. It is noted that the State of Pennsylvania is actively conducting studies in the area which will facilitate preparation of a remedial action plan as called for in the Agreement, and that this designation should not be viewed as an adverse comment on those laudable efforts.

We look forward to continued evaluation and advice from the Commission on matters related to the Areas of Concern.

Sincerely yours,

Robert H. Pines
Deputy Assistant Secretary

APPENDIX B

Pennsylvania Code

Title 25, Chapter 93, §§93.7-93.9

and Title 16, Table 1

TABLE 3

Parameter	*Symbol*	*Criteria*	*Critical Use**
Aluminum	Al	Maximum 0.1 of the 96-hour LC_{50} for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving waters.	1
Alkalinity	Alk_1	Minimum 20 mg/l as $CaCO_3$, except where natural conditions are less. Where discharges are to waters with 20 mg/l or less alkalinity, the discharge should not further reduce the alkalinity of the receiving waters.	1
	Alk_2	Minimum 20 mg/l as $CaCO_3$.	1
	Alk_3	Between 20 and 100 mg/l.	DRBC
	Alk_4	Between 20 and 120 mg/l.	DRBC
Ammonia Nitrogen	Am	The maximum total ammonia nitrogen concentration at all times shall be the numerical value given by: un-ionized ammonia nitrogen (NH_3-N) x ($\log^{-1}[pK_T - pH] + 1$), where: un-ionized ammonia nitrogen = 0.12 x f(T)/f(pH) $f(pH) = 1 + 10^{1.03(7.32-pH)}$ $f(T) = 1,\ T \geq 10°C$ $f(T) = \frac{1 + 10^{(9.73-pH)}}{1 + 10^{(pK_T - pH)}},\ T < 10°C$ and $pK_T = 0.090 + \left[\frac{2730}{(T + 273.2)}\right]$ the dissociation constant for ammonia in water. The average total ammonia nitrogen concentration over any 30 consecutive days shall be less than or equal to the numerical value given by: un-ionized ammonia nitrogen (NH_3-N) x ($\log^{-1}[pK_T - pH] + 1$), where: un-ionized ammonia nitrogen = 0.025 x f(T)/f(pH) $f(pH) = 1,\ pH \geq 7.7$ $f(pH) = 10^{0.74(7.7-pH)},\ pH < 7.7$ $f(T) = 1,\ T \geq 10°C$ $f(T) = \frac{1 + 10^{(9.73-pH)}}{1 + 10^{(pK_T - pH)}},\ T < 10°C$	1

TABLE 3

Parameter	Symbol	Criteria	Critical Use*
		The pH and temperature used to derive the appropriate ammonia criteria shall be determined by one of the following methods: 1) Instream measurements, representative of median pH and temperature—July through September. 2) Estimates of median pH and temperature—July through September—based upon available data or values determined by the Department. For purposes of calculating effluent limitations based on this value the accepted design stream flow shall be the actual or estimated lowest 30-consecutive-day average flow that occurs once in 10 years.	
Bacteria	Bac_1	During the swimming season (May 1 through September 30), the maximum fecal coliform level shall be a geometric mean of 200 per 100 milliliters (ml) based on five consecutive samples each sample collected on different days; for the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2,000 per 100 milliliters (ml) based on five consecutive samples collected on different days.	3
	Bac_2	(Coliforms/100 ml) - Maximum of 5,000/100 ml as a monthly average value, no more than this number in more than 20% of the samples collected during a month, nor more than 20,000/100 ml in more than 5% of the samples.	2
	Bac_3	(Coliforms/100 ml) - Not more than 5,000/100 ml as a monthly geometric mean.	2
	Bac_4	(Fecal Coliforms/100 ml) - Maximum geometric mean of 770/100 ml; samples shall be taken at a frequency and location to permit valid interpretation.	DRBC
	Bac_5	The fecal coliform density in five consecutive samples may not exceed a geometric mean of 200/100 ml.	DRBC
Chloride	Ch_1	Maximum 150 mg/l.	4
	Ch_2	Maximum 250 mg/l.	2
	Ch_3	Not more than 200 mg/l.	DRBC
	Ch_4	Maximum 15-day mean 50 mg/l.	DRBC

TABLE 3

Parameter	*Symbol*	*Criteria*	*Critical Use**
Color	Col_1	Maximum 50 units on the platinum-cobalt scale; no other colors perceptible to the human eye.	3
	Col_2	Maximum 75 units on the platinum-cobalt scale; no other colors perceptible to the human eye.	2
Dissolved Oxygen	DO_1	Minimum daily average 6.0 mg/l; minimum 5.0 mg/l. For lakes, ponds and impoundments only, minimum 5.0 mg/l at any point.	1
	DO_2	Minimum daily average 5.0 mg/l; minimum 4.0 mg/l. For the epilimnion of lakes, ponds and impoundments, minimum daily average of 5.0 mg/l, minimum 4.0 mg/l.	1
	DO_3	Minimum daily average not less than 5.0 mg/l; during periods April 1 - June 15 and September 16 - December 31, not less than 6.5 mg/l as a seasonal average.	DRBC
	DO_4	Minimum daily average not less than 3.5 mg/l; during periods April 1 - June 15 and September 16 - December 31, not less than 6.5 mg/l as a seasonal average.	DRBC
	DO_5	For the period February 15 to July 31 of any year, minimum daily average of 6.0 mg/l, minimum 5.0 mg/l. For the remainder of the year, minimum daily average of 5.0 mg/l, minimum 4.0 mg/l.	1
	DO_6	Minimum 7.0 mg/l.	1
Fluoride	F_1	Daily average 2.0 mg/l.	2
	F_2	Four-day average 0.01 of the 96-hour LC_{50}; one-hour average 0.05 of the 96-hour LC_{50} for representative important species as determined through substantial available literature data or bioassay tests tailored to the ambient quality of the receiving water, or both.	1
Hardness	Hd_1	Maximum monthly mean 150 mg/l.	DRBC
	Hd_2	Maximum monthly mean 95 mg/l.	DRBC
Iron	Fe	Daily average 1.5 mg/l as total iron; maximum 0.3 mg/l as dissolved iron.	1,2
Manganese	Mn	Maximum 1.0 mg/l.	2
Methylene Blue Active Substance	$MBAS_1$	Not more than 0.5 mg/l.	DRBC
	$MBAS_2$	Not more than 1.0 mg/l.	DRBC
Nitrite plus Nitrate	N	Maximum 10 mg/l as nitrogen.	2
Osmotic Pressure	OP	Maximum 50 milliosmoles per kilogram or criteria developed using § 93.5 (d) (relating to the application of water quality criteria to discharge of pollutants).	1

TABLE 3

Parameter	*Symbol*	*Criteria*	*Critical Use**
pH	pH_1	From 6.0 to 9.0 inclusive.	1
	pH_2	Not less than 6.5 and not more than 8.5.	DRBC
	pH_3	From 7.0 to 9.0 inclusive.	1
	pH_4	Not less than 6.0 and not more than 8.5.	DRBC
Phenolics (except Section 307(a)(1)33 U.S.C. §1317(a)(1), Priority Pollutants)	$Phen_1$	Maximum 0.005 mg/l.	2
	$Phen_2$	Maximum 0.02 mg/l.	DRBC
	$Phen_3$	Four-day average 0.02 mg/l; one-hour average 0.1 mg/l.	1
Radioactivity	Rad	Alpha emitters, maximum 3 pc/l; beta emitters, maximum 1,000 pc/1.	DRBC
Sulfate	Sul	Maximum 250 mg/l.	2
Temperature	$Temp_1$	Maximum temperatures in the receiving water body resulting from heated waste sources regulated under Chapter 97 (relating to Industrial Wastes), and any other sources where the Department determines that temperature limits are necessary to protect designated uses, are as follows. Additionally, these wastes may not result in a change by more than 2°F during any 1-hour period. Exceptions to these thermal maxima may be granted on a case-specific basis under § 97.82(a)(2) (relating to allowable discharges).	1

Period	*Temperature °F*
January 1-31	38
February 1-29	38
March 1-31	42
April 1-15	48
April 16-30	52
May 1-15	54
May 16-31	58
June 1-15	60
June 16-30	64
July 1-31	66
August 1-31	66
September 1-15	64
September 16-30	60
October 1-15	54
October 16-31	50
November 1-15	46
November 16-30	42
December 1-31	40

TABLE 3

Parameter	*Symbol*	*Criteria*	*Critical Use**
Temperature	$Temp_1$	Maximum temperatures in the receiving water body resulting from heated waste sources regulated under Chapter 97 and other sources where the Department determines that temperature limits are necessary to protect designated uses, are as follows. Additionally, these wastes may not result in a change by more than 2°F during any 1-hour period. Exceptions to these thermal maxima may be granted on a case-specific basis under § 97.82(a)(2).	1

Period	*Temperature °F*
January 1-31	40
February 1-29	40
March 1-31	46
April 1-15	52
April 16-30	58
May 1-15	64
May 16-31	72
June 1-15	80
June 16-30	84
July 1-31	87
August 1-31	87
September 1-15	84
September 16-30	78
October 1-15	72
October 16-31	66
November 1-15	58
November 16-30	50
December 1-31	42

TABLE 3

Parameter	*Symbol*	*Criteria*	*Critical Use**
Temperature	$Temp_1$	Maximum temperatures in the receiving water body resulting from heated waste sources regulated under Chapter 97, and other sources where the Department determines that temperature limits are necessary to protect designated uses, are as follows. Additionally, these wastes may not result in a change by more than 2°F during any 1-hour period. Exceptions to these thermal maxima may be granted on a case-specific basis under § 97.82(a)(2).	1

Period	*Temperature °F*
January 1-31	40
February 1-29	40
March 1-31	46
April 1-15	52
April 16-30	58
May 1-15	64
May 16-31	68
June 1-15	70
June 16-30	72
July 1-31	74
August 1-15	80
August 16-30	87
September 1-15	84
September 16-30	78
October 1-15	72
October 16-31	66
November 1-15	58
November 16-30	50
December 1-31	42

	$Temp_4$	No rise when ambient temperature is 87°F or above; not more than a 5°F rise above ambient temperature until stream temperature reaches 87°F; not to be changed by more than 2°F during any 1-hour period.	DRBC
	$Temp_5$	Not more than 5°F above the average daily temperature during the 1961-66 period, which is shown below, or a maximum of 86°F, whichever is less.	DRBC

TABLE 3

Parameter	*Symbol*	*Criteria*		*Critical Use**
		Average Daily Temperature 1961 - 1966 (Temperatures may be interpolated)		
	Delaware Estuary, Head of Tide to River Mile 108.4 (about 1 mile below Pennypack Creek)	*Delaware Estuary, River Mile 108.4 (about 1 mile below Pennypack Creek) to Big Timber Creek*	*Delaware Estuary From Big Timber Creek To Pennsylvania - Delaware State Line*	
Date	*°F*	*°F*	*°F*	
January 1	37	41	42	
February 1	35	35	36	
March 1	38	38	40	
April 1	46	46	47	
May 1	58	58	58	
June 1	71	71	72	
July 1	79	79	80	
August 1	81	81	81	
September 1	78	79	78	
September 15	76	77	78	
October 1	70	70	70	
November 1	59	61	60	
December 1	46	50	50	
December 15	40	45	45	
	Temp.₄	Not more than 5°F rise above the ambient temperatures until stream temperatures reach 50°F; nor more than 2°F rise above ambient temperature when temperatures are between 50°F and 58°F; nor may temperatures exceed 58°F, whichever is less, except in designated heat dissipation areas.		DRBC

TABLE 3

Parameter	*Symbol*	*Criteria*	*Critical Use**
Total Dissolved Solids	TDS_1	500 mg/l as a monthly average value; maximum 750 mg/l.	2
	TDS_2	Maximum 1,500 mg/l.	1
	TDS_3	Not to exceed 133% of ambient stream concentration or 500 mg/l, whichever is less.	DRBC
	TDS_4	Not to exceed 133% of ambient stream concentration.	DRBC
Turbidity	Tur_1	Not more than 30 NTU during the period May 30 - September 15, nor more than a monthly mean of 40 NTU or a maximum of 150 NTU during the remainder of the year.	DRBC
	Tur_2	Maximum monthly mean 40 NTU, maximum value not more than 150 NTU.	DRBC
	Tur_3	Not more than 100 NTU.	1
	Tur_4	For the period May 15 - September 15 of any year, not more than 40 NTU; for the period September 16 - May 14 of any year, not more than 100 NTU.	1
	Tur_5	Maximum monthly mean of 10 NTU, maximum 150 NTU.	DRBC
	Tur_6	Maximum monthly mean of 20 NTU, maximum 150 NTU.	DRBC
	Tur_7	Maximum monthly mean of 30 NTU, maximum 150 NTU.	DRBC

*Critical use: The most sensitive designated water use the criteria are intended to protect, identified by the following:

1 = Aquatic Life
2 = Water Supply
3 = Recreation (including esthetics)
4 = Special Protection

DRBC = Criteria adopted by agreement with the Delaware River Basin Commission and that apply only to selected portions of the Delaware River Basin in this Commonwealth.

(d) Unless otherwise specified in subsection (e) §§ 93.5(d) and (e), and 93.9, Statewide specific criteria in the following Table 4 apply to all surface waters of this Commonwealth:

TABLE 4

Symbol	*Specific Water Quality Criteria*
Al	Aluminum
Alk_1	Alkalinity
Am	Ammonia Nitrogen
Bac_1	Bacteria
F_1 & F_2	Fluoride
Fe	Iron
Mn	Manganese
N	Nitrite plus Nitrate
OP	Osmotic Pressure
pH_1	pH
$Phen_1$ & $Phen_2$	Phenolics
TDS_1	Total Dissolved Solids

(e) Table 5 contains groups of specific water quality criteria based upon water uses to be protected. When the symbols listed in Table 5 appear in the *Water Uses Protected* column in § 93.9, they have the meaning listed in the Table 5. Exceptions to these standardized groupings will be indicated on a stream-by-stream or segment-by-segment basis by the words "Add" or "Delete" followed by the appropriate symbols described elsewhere in this chapter.

TABLE 5

Symbol	*Water Uses Included*	*Specific Criteria*
WWF	Statewide list	Statewide list plus DO_2 and $Temp_2$
CWF	Statewide list plus Cold Water Fish	Statewide list plus DO_1 and $Temp_1$
TSF	Statewide list plus Trout Stocking	Statewide list plus DO_3 and $Temp_3$
HQ-WWF	Statewide list plus High Quality Waters	Statewide list plus DO_1 and $Temp_2$
HQ-CWF	Statewide list plus High Quality Waters and Cold Water Fish	Statewide list plus DO_4 and $Temp_1$
HQ-TSF	Statewide list plus High Quality Waters and Trout Stocking	Statewide list plus DO_1 and $Temp_3$
EV	Statewide list plus Exceptional Value Waters	Existing Quality

(f) The list of specific water quality criteria does not include all possible substances that could cause pollution. For substances not listed, the general criterion that these substances shall not be inimical or injurious to the designated water uses applies. The best scientific information available will be used to adjudge the suitability of a given waste discharge where these substances are involved.

§ 93.8. Development of specific water quality criteria for the protection of aquatic life.

(a) When a specific water quality criterion has not been established for a pollutant in § 93.7(c), Table 3, or under (f) (relating to specific water quality criteria) and a discharge of a pollutant into waters of this Commonwealth designated to be protected for aquatic life in § 93.9 (relating to designated water uses and water quality criteria) is proposed, a specific water quality criterion for such pollutant may be determined by the Department through establishment of a safe concentration value.

(b) Establishment of a safe concentration value shall be based upon data obtained from relevant aquatic field studies, standard continuous flow bioassay test data which exists in substantial available literature, or data obtained from specific tests utilizing one or more representative important species of aquatic life designated on a case-by-case basis by the Department and conducted in a water environment which is equal to or closely approximates that of the natural quality of the receiving waters.

(c) In those cases where it has been determined that there are insufficient available data to establish a safe concentration value for a pollutant, the safe concentration value shall be determined by applying the appropriate application factor to the 96-hour (or greater) LC_{50} value. Except where the Department determines, based upon substantial available data, that an experimentally derived application factor exists for a pollutant, the following application factors shall be used in the determination of safe concentration values:

(1) Concentrations of pollutants that are noncumulative shall not exceed 0.05 (1/20) of the 96-hour LC_{50}.

(2) Concentrations of pollutants that are cumulative shall not exceed 0.01 (1/100) of the 96-hour LC_{50}.

(3) Concentrations of pollutants with known synergistic or antagonistic effects with pollutants in the effluent or receiving water will be established on a case-by-case basis using the best available scientific data.

(d) Persons seeking issuance of a permit under the Clean Streams Law and 33 U.S.C. §1342 authorizing the discharge of a pollutant for which a safe concentration value is to be established using specific bioassay tests under subsection (b) shall perform such testing with the approval of the Department and shall submit the following in writing to the Department:

(1) A plan proposing the bioassay testing to be performed.

(2) Such periodic progress reports of the testing as may be required by the Department.

(3) A report of the completed results of such testing including, but not limited to, the following:

(i) All data obtained during the course of testing; and

(ii) All calculations made in the recording, collection, interpretation, and evaluation of such data.

(e) Bioassay testing shall be conducted in accordance with the continuous flow methodologies outlined in EPA Ecological Research Series Publication, EPA-660/3-75-009, *Methods of Acute Toxicity Tests with Fish, Macroinvertebrates, and Amphibians* (April, 1975); *Standard Methods for the Examination of Water and Wastewater* (15th Edition, 1980); *Standard Method of Test for ASTM* D1345-59 (Reapproved 1970) and published in the 1975 *Annual Book of ASTM Standards — Part 31 — Water;* or EPA Environmental Monitoring Series Publication, EPA-600/4-78-012, *Methods for Measuring the Acute Toxicity of Effluents to Aquatic Organisms* (January, 1978). Use of any other methodologies shall be subject to prior written approval by the Department. Test waters shall be reconstituted according to recommendations and methodologies specified in the previously cited references, or methodologies approved in writing by the Department.

§ 93.8a. Toxic substances.

(a) The waters of this Commonwealth may not contain toxic substances attributable to point or nonpoint source waste discharges in concentrations or amounts that are inimical to the water uses to be protected.

(b) Water quality criteria for toxic substances shall be established under Chapter 16 (relating to water quality toxics management strategy—statement of policy) wherein the criteria and analytical procedures will also be listed. Chapter 16 along with changes made to it is hereby specifically incorporated by reference.

(c) Water quality criteria for toxics substances which exhibit threshold effects will be established by application of margins of safety to the results of toxicity testing to prevent the occurrence of a threshold effect.

(d) Nonthreshold carcinogenic effects of toxic substances, will be controlled to a risk management level of one excess case of cancer in a population of one million ($1x10^{-6}$) over a 70-year lifetime. Other nonthreshold effects of toxic substances will be controlled at a risk management level as determined by the Department.

(e) Design conditions for toxics shall be determined under § 93.5(b) (relating to application of water quality criteria to discharge of pollutants), except that for carcinogens, the design stream flow shall be that which results in a lifetime—70 years—average exposure corresponding to the risk management level specified in subsection (d).

(f) The Department will consider both the acute and chronic toxic impacts to aquatic life and human health.

(g) The Department may consider synergistic, antagonistic and additive toxic impacts.

(h) The Department may require effluent toxicity testing as a basis for limiting the addition of toxic substances to waters of this Commonwealth, and may establish water quality based effluent limitations based on the results of effluent toxicity testing.

(i) At intervals not exceeding 1 year, the Department will publish a new or revised water quality criteria for toxic substances, and revised procedures for criteria development in the *Pennsylvania Bulletin*.

(j) A person challenging criteria established by the Department under this section shall have the burden of proof to demonstrate that the criteria does not meet the requirements of this section. In addition, a person who proposes an alternative site-specific criterion shall have the burden of proof to demonstrate that the site specific criterion meets the requirements of this section.

§ 93.9. Designated water uses and water quality criteria.

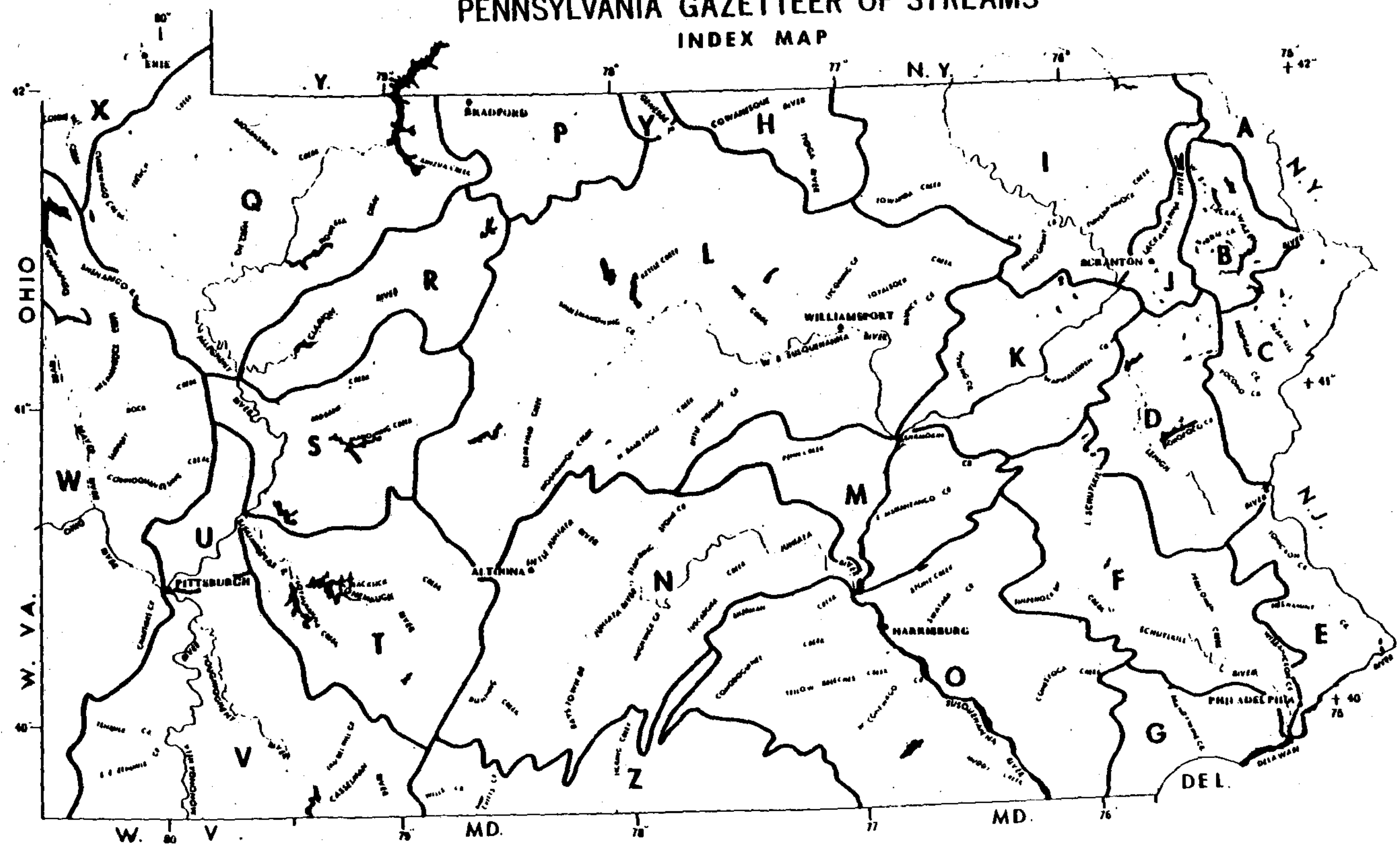
Except as provided in § 93.5(d) and (e) (relating to the application of water quality criteria to discharge of pollutants), the following tables display designated water uses and water quality criteria. The county column in Drainage Lists A through Z indicates the county in which the mouth of the stream is located.

Source

The provisions of section 93.9 amended March 26, 1985, effective immediately, 15 Pa.B. 1624; amended July 21, 1987, effective immediately, 17 Pa.B. 3602; September 10, 1988, effective immediately, 18 Pa. B. 4089; amended November 26, 1988, effective immediately, 18 Pa. B. 5260; amended March 11, 1989, effective immediately, 19 Pa. B. 968; amended May 20, 1989, effective immediately, 19 Pa. B. 2158; amended June 24, 1989, effective immediately, 19 Pa. B. 2645.

PENNSYLVANIA GAZETTEER OF STREAMS

INDEX MAP



DRAINAGE LIST X

Lake Erie

Stream	Zone	County	Water Uses Protected	Exceptions To Specific Criteria
Lake Erie				
Outer Erie Harbor and Presque Isle Bay	Harbor basin and central channel demarcated by U.S. Coast Guard with buoys and channel markers	Erie	WWF; ***Delete*** WC	***Delete*** pH_1 and Bac_1 ***Add*** pH_3 Bac_2 TON and $MBAS_1$.
Outer Erie Harbor and Presque Isle Bay	Entire area except Harbor basin and central channel demarcated by U.S. Coast Guard with buoys and channel markers	Erie	WWF	***Delete*** pH_1 ***Add*** pH_3, TON and $MBAS_1$.
Lake Erie	All portions of the lake in Pennsylvania except Outer Erie Harbor and Presque Isle Bay	Erie	CWF	***Delete*** Fe, pH_1 DO_1 and Bac_1 ***Add*** the "specific criteria for Lake Erie" as listed below.

Specific Criteria for Lake Erie

Determination of compliance with specific criteria shall be based on statistically valid sampling data. For the lake-wide dissolved solids limits, the Great Lakes Regional Office of the IJC will determine compliance.

pH — Values should not be outside range of 6.5 to 9.0

Dissolved Oxygen — In the upper waters of the lakes, the dissolved oxygen level should be not less than 6.0 milligrams per liter at any time; in hypolimnetic waters, it should be not less than necessary for the support of fishlife, particularly cold water species.

Iron (Fe) — Levels should not exceed 0.3 milligrams per liter or natural levels, whichever is greater.

Temperature — $Temp_1$

Dissolved Solids — In addition to TDS, the level of total dissolved should not exceed 200 milligrams per liter as an annual average based on representative lake-wide sampling.

Bacteria — The geometric mean of not less than five samples taken over not more than a thirty-day period should not exceed 1,000/100 milliliters total coliforms, nor 200/100 milliliters fecal coliforms. Waters used for body contact recreation activities should be substantially free from bacteria, fungi, or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections or other human diseases and infections.

Taste and Odor — Phenols and other objectionable taste and odor producing substances should be substantially absent.

Phosphorus (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.

Radioactivity — Radioactivity should be kept at the lowest practicable level and in any event should be controlled to the extent necessary to prevent harmful effects on health.

Aldrin/Dieldrin — Not to exceed 1 nanogram per liter in water; not to exceed 0.3 mg/Kg in the edible portion of fish.

Chlordane — Not to exceed 60 nanograms per liter.

DDT and Metabolites — Not to exceed 3 nanograms per liter in water; not to exceed 1 mg/Kg in the edible portion of fish.

Stream	Zone	County	Water Uses Protected	Exceptions To Specific Criteria
Lake Erie				

Endrin — Not to exced 2 nanograms per liter in water; not to exceed 0.3 mg/Kg in the edible portion of fish.

Heptachlor — Not to exceed 1 nanogram/liter in water; not to exceed 0.3 mg/Kg in the edible portion of fish.

Lindane — Not to exceed 10 nanograms per liter in water; not to exceed 0.3 mg/Kg in the edible portion of fish.

Methoxychlor — Not to exceed 40 nanograms per liter.

Toxaphene — Not to exceed 8 nanograms per liter.

Phthalate Esters: Dibutyl Phthalate — Not to exceed 4 micrograms per liter. Di — (2—ethylhexyl phthalate)— Not to exceed 0.6 micrograms per liter. Other phthalate esters — Not to exceed 0.2 micrograms per liter.

PCB's — Not to exceed 1 nanogram per liter; not to exceed 0.1 mg/Kg in whole fish.

Cadmium — Not to exceed 0.01 of the 96-hour LC50 for representative important species.

Mercury — Not to exceed 0.2 micrograms per liter in an unfiltered water sample.

Selenium — Not to exceed 10 micrograms per liter.

Stream	Zone	County	Water Uses Protected	Exceptions To Specific Criteria
Ashtabula River (OH)				
Unnamed Tributaries to Ashtabula River	Basins	Erie	CWF; MF	None
East Branch Ashtabula River	Basin	Erie	CWF; MF	None
Ashtabula Creek	Main Stem	Erie	WWF	None
Unnamed Tributaries to Ashtabula Creek	Basins	Erie	CWF; MF	None
Conneaut Creek	Main Stem	Erie	WWF; MF	***Delete*** DO_3 and $Temp_2$ ***Add*** DO_1 and $Temp_1$
Unnamed Tributaries to Conneaut Creek	Basins	Erie	CWF; MF	None
Fish Creek	Basin	Erie	CWF; MF	None
Foster Run	Basin	Erie	CWF; MF	None
Crazy Run	Basin	Erie	CWF; MF	None
Stone Run	Basin	Erie	CWF; MF	None
West Branch Conneaut Creek	Basin	Erie	CWF; MF	None
Marsh Run	Basin	Erie	CWF; MF	None
East Branch Conneaut Creek	Basin	Erie	CWF; MF	None
Turkey Creek	Main Stem	Erie	CWF	None
Unnamed Tributaries to Turkey Creek	Basins	Erie	CWF; MF	None
Raccoon Creek	Basin	Erie	CWF; MF	None
Crooked Creek	Basin	Erie	HQ-CWF; MF	None
Elk Creek	Main Stem	Erie	WWF; MF	***Delete*** DO_2 and $Temp_2$ ***Add*** DO_1 and $Temp_1$
Unnamed Tributaries to Elk Creek	Basins	Erie	CWF; MF	None

Stream	Zone	County	Water Uses Protected	Exceptions To Specific Criteria
Lake Erie				
Lamson Run	Basin	Erie	CWF; MF	None
Goodban Run	Basin	Erie	CWF; MF	None
Falk Run	Basin	Erie	CWF; MF	None
Little Elk Creek	Basin	Erie	CWF; MF	None
Brandy Run	Basin	Erie	CWF; MF	None
Halls Run	Basin	Erie	CWF; MF	None
Godfrey Run	Basin	Erie	HQ-CWF; MF	None
Trout Run	Basin	Erie	CWF; MF	None
Walnut Creek	Main Stem	Erie	CWF; MF	None
Unnamed Tributaries to Walnut Creek	Basins	Erie	CWF; MF	None
Bear Run	Basin	Erie	CWF; MF	None
Thomas Run	Basin	Erie	HQ-CWF; MF	None
Cascade Creek	Basin	Erie	WWF; MF	None
Mill Creek	Basin	Erie	WWF; MF	None
Fourmile Creek	Basin	Erie	WWF; MF	***Delete*** DO_2 and $Temp_2$ ***Add*** DO_1 $Temp_1$
Sixmile Creek	Basin	Erie	CWF; MF	None
Sevenmile Creek	Basin	Erie	CWF; MF	None
Eightmile Creek	Basin	Erie	CWF; MF	None
Twelvemile Creek	Basin	Erie	HQ-CWF; MF	None
Sixteenmile Creek	Basin, Source to I-90	Erie	CWF; MF	None
Sixteenmile Creek	Basin, I-90 Mouth	Erie	WWF; MF	***Delete*** DO_2 $Temp_2$ ***Add*** DO_1 and $Temp_1$
Twentymile Creek	Main Stem	Erie	CWF	None
Unnamed Tributaries to Twentymile Creek	Basins	Erie	CWF; MF	None

* * * * *

DRAINAGE LIST X

Lake Erie

Stream	Zone	County	Water Uses Protected	Exceptions to Specific Criteria
Lake Erie (Outer Erie Harbor and Presque Isle Bay)	Harbor area and central channel dredged and maintained by United States Army Corps of Engineers	Erie	WWF; delete WC	*Delete* pH1 and Bac1 *Add* pH3, Bac2, TON and MBAS1.
Lake Erie (Outer Erie Harbor and Presque Isle Bay)	Portion of Lake bordered by Presque Isle on West, Longitude 80°01′50″ on East and Latitude 42°10′18″ on North, except Harbor area and central channel dredged and maintained by United States Army Corps of Engineers	Erie	WWF	*Delete* pH1 *Add* pH3, TON and MBAS1.

* * * * *

Stream	Zone	County	Water Uses Protected	Exceptions to Specific Criteria
Unnamed Tributaries to Lake Erie	Basins, (all sections in PA) PA-OH State Border to Presque Isle	Erie	CWF; MF	None
Ashtabula River (OH)				
* * * * *				
Walnut Creek	Main Stem	Erie	CWF; MF	None
* * * * *				
Thomas Run	Basin	Erie	HQ; CWF; MF	None
Unnamed Tributaries to Lake Erie	Basins, Presque Isle to Unnamed Tributary at RM 23.22	Erie	WWF; MF	None
Unnamed Tributary to Lake Erie at RM 23.22	Basin	Erie	CWF; MF	None
Unnamed Tributaries to Lake Erie	Basins, Unnamed Tributary at RM 23.22 to Longitude 80°01′50″	Erie	WWF; MF	None
* * * * *				
Fourmile Creek	Basin	Erie	WWF; MF	*Delete* DO_2 and $Temp_2$ *Add* DO_1 and $Temp_1$
Unnamed Tributaries to Lake Erie	Basins, Longitude 80°01′50″ to PA-NY State Border	Erie	CWF; MF	None
* * * * *				

[Pa.B. Doc. No. 90-1147. Filed June 22, 1990, 9:00 a.m.]

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
1M	ANTIMONY	07440360	219	1095	145	H
2M	ARSENIC	07440382	190(As3+)	360(As3+)	50	H
3M	BERYLLIUM	07440417	0.01 x 96hr LC50	0.05 x 96hr LC50	0.007	CRL
4M	CADMIUM	07440439	Exp(0.7852[lnH]-3.490) @H= 50 100 200 Crit= 0.66 1.1 2.0	Exp(1.128[lnH]-3.828) @H= 50 100 200 Crit= 1.8 3.9 8.6	10	H
5M	CHROMIUM, TOTAL	07440473	11+Exp(0.8190[lnH]+1.561) @H= 50 100 200 Crit= 131 221 381	16+Exp(0.8190[lnH]+3.688) @H= 50 100 200 Crit= 996 1716 3116	170,050	H
5M	CHROMIUM, VI	07440473	11	16	50	H
6M	COPPER	07440508	Exp(0.8545[lnH]-1.465) @H= 50 100 200 Crit= 6.5 12 21	Exp(0.9422[lnH]-1.464) @H= 50 100 200 Crit= 9.2 18 34	1000	T&O
7M	LEAD	07439921	Exp(1.266[lnH]-4.661 @H= 50 100 200 Crit= 1.3 3.2 7.7	Exp(1.266[lnH]-1.416 @H= 50 100 200 Crit= 34 82 200	50	H
8M	MERCURY	07439976	0.012	2.4	0.144	H
9M	NICKEL	07440020	Exp(0.8460[lnH]+1.1645) @H= 50 100 200 Crit= 88 160 280	Exp(0.8460[lnH]+3.3612) @H= 50 100 200 Crit= 790 1400 2500	632	H
10M	SELENIUM	07782492	5	20	10	H
11M	SILVER	07440224	0.2	Exp(1.72[lnH]-6.52) @H= 50 100 200 Crit= 1.2 4.1 13	50	H

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
12M	THALLIUM	07440280	18	90	13	H
13M	ZINC	07440666	Exp(0.8473[lnH]+0.7614) @H= 50 100 200 Crit= 59 110 190	Exp(0.8473[lnH]+0.8604) @H= 50 100 200 Crit= 65 120 210	5000	T&O
14M	CYANIDE, FREE	00057125	5	22	200	H
15M	PHENOLICS (TOTAL PHENOLS)	---	20	100	5(at water supply intake)	T&O
1A	2-CHLOROPHENOL	00095578	20	100	0.1	T&O
2A	2,4-DICHLOROPHENOL	00120832	337	1685	0.3	T&O
3A	2,4-DIMETHYLPHENOL	00105679	132	660	400	T&O
4A	4,6-DINITRO-o-CRESOL	00534521	16	80	13.4	H
5A	2,4-DINITROPHENOL	00051285	131	655	70	H
6A	2-NITROPHENOL	00088755	20	100	N/A	-
7A	4-NITROPHENOL	00100027	467	2335	N/A	-
8A	p-CHLORO-m-CRESOL	00059507	31	155	3000	T&O
9A	PENTACHLOROPHENOL	00087865	Exp(1.005[pH]-5.290) @pH= 6.5 7.8 9.0 Crit= 3.5 13 43	Exp(1.005[pH]-4.830) @pH= 6.5 7.8 9.0 Crit= 5.5 20 68	30	T&O

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
10A	PHENOL	00108952	20	100	300	T&O
11A	2,4,6-TRICHLOROPHENOL	00088062	91	455	1	CRL
1V	ACROLEIN	00107028	1	5	320	H
2V	ACRYLONITRILE	00107131	129	645	0.06	CRL
3V	BENZENE	00071432	128	640	1	CRL
4V	[DELETED]					-
5V	BROMOFORM	00075252	365	1825	0.2 (b)	CRL
6V	CARBON TETRACHLORIDE	00056235	556	2780	0.3	CRL
7V	CHLOROBENZENE	00108907	236	1180	20	T&O
8V	CHLORODIBROMO-METHANE	00124481	N/A	N/A	0.2 (b)	CRL
9V	CHLOROETHANE	00075003	N/A	N/A	N/A	-
10V	2-CHLOROETHYL VINYL ETHER	00110758	3500	17,500	N/A	-
11V	CHLOROFORM	00067663	389	1945	0.2	CRL
12V	DICHLOROBROMO-METHANE	00075274	N/A	N/A	0.2 (b)	CRL
13V	[DELETED]					

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
14V	1,1-DICHLOROETHANE	00075343	N/A	N/A	N/A	-
15V	1,2-DICHLOROETHANE	00107062	3088	15,440	0.4	CRL
16V	1,1-DICHLOROETHYLENE	00075354	1492	7460	0.06	CRL
17V	1,2-DICHLOROPROPANE	00078875	2165	10,825	N/A	-
18V	1,3-DICHLOROPROPYLENE	00542756	61	305	87	H
19V	ETHYLBENZENE	00100414	580	2900	1400	H
20V	METHYL BROMIDE	00074839	110	550	0.2 (b)	CRL
21V	METHYL CHLORIDE	00074873	5500	27,500	0.2 (b)	CRL
22V	METHYLENE CHLORIDE	00075092	2368	11,840	5	CRL
23V	1,1,2,2-TETRACHLOROETHANE	00079345	208	1040	0.2	CRL
24V	TETRACHLORO-ETHYLENE	00127184	139	695	0.7	CRL
25V	TOLUENE	00108883	330	1650	14,300	H
26V	1,2-trans-DICHLOROETHYLENE	00156605	1350	6750	350	H

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
27V	1,1,1-TRICHLOROETHANE	00071556	605	3025	1000	H
28V	1,1,2-TRICHLOROETHANE	00079005	678	3390	0.6	CRL
29V	TRICHLOROETHYLENE	00079016	450	2250	3	CRL
30V	[DELETED]					-
31V	VINYL CHLORIDE	00075014	N/A	N/A	0.02	CRL
1B	ACENAPHTHENE	00083329	17	85	20	T&O
2B	ACENAPHTHYLENE	00208968	N/A	N/A	0.003	CRL
3B	ANTHRACENE	00120127	N/A	N/A	0.003	CRL
4B	BENZIDINE	00092875	59	295	0.0001	CRL
5B	BENZO(a)ANTHRA-CENE	00056553	0.1	0.8	0.003	CRL
6B	BENZO(a)PYRENE	00050328	N/A	N/A	0.003	CRL
7B	3,4-BENZOFLUORANTHENE	00205992	N/A	N/A	0.003	CRL
8B	BENZO(ghi)PERYL-ENE	00191242	N/A	N/A	0.003	CRL
9B	BENZO(k)FLUOR-ANTHENE	00207089	N/A	N/A	0.003	CRL

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
10B	BIS(2-CHLOROETHOXY) METHANE	00111911	N/A	N/A	N/A	-
11B	BIS(2-CHLOROETHYL) ETHER	00111444	6000	30,000	0.03	CRL
12B	BIS(2-CHLORO-ISOPROPYL)ETHER	00108601	N/A	N/A	34.7	H
13B	BIS(2-ETHYLHEXYL) PHTHALATE	00117817	909	4545	15,000	H
14B	4-BROMOPHENYL PHENYL ETHER	00101553	54	270	N/A	-
15B	BUTYLBENZYL PHTHALATE	00085687	35	140	N/A	-
16B	2-CHLORONAPH-THALENE	00091587	N/A	N/A	N/A	-
17B	4-CHLOROPHENYL PHENYL ETHER	07005723	N/A	N/A	N/A	-
18B	CHRYSENE	00218019	N/A	N/A	0.003	CRL
19B	DIBENZO(a,h) ANTHRACENE	00053703	N/A	N/A	0.003	CRL
20B	1,2-DICHLOROBENZENE	00095501	164	820	400 (c)	H

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
21B	1,3-DICHLOROBENZENE	00541731	69	345	400 (c)	H
22B	1,4-DICHLOROBENZENE	00106467	146	730	400 (c)	H
23B	3,3'-DICHLORO-BENZIDINE	00091941	N/A	N/A	0.01	CRL
24B	DIETHYL PHTHALATE	00084662	800	4000	350,000	H
25B	DIMETHYL PHTHALATE	00131113	495	2475	313,000	H
26B	DI-N-BUTYL PHTHALATE	00084742	21	105	34,000	H
27B	2,4-DINITROTOLUENE	00121142	318	1590	0.1	CRL
28B	2,6-DINITROTOLUENE	00606202	198	990	N/A	-
29B	DI-N-OCTYL PHTHALATE	00117840	N/A	N/A	N/A	-
30B	1,2-DIPHENYLHYDRAZINE	00122667	3	15	0.04	CRL
31B	FLUORANTHENE	00206440	40	200	42	H
32B	FLUORENE	00086737	N/A	N/A	0.003	CRL
33B	HEXACHLOROBENZENE	00118741	N/A	N/A	0.0007	CRL

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
34B	HEXACHLOROBUTA-DIENE	00087683	2	10	0.5	CRL
35B	HEXACHLOROCYCLO-PENTADIENE	00077474	1	5	1	T&O
36B	HEXACHLOROETHANE	00067721	12	60	2	CRL
37B	INDENO(1,2,3-cd)PYRENE	00193395	N/A	N/A	0.003	CRL
38B	ISOPHORONE	00078591	2080	10,400	5200	H
39B	NAPHTHALENE	00091203	43	135	10	T&O
40B	NITROBENZENE	00098953	808	4040	30	T&O
41B	N-NITROSODI-METHYLAMINE	00062759	3420	17,100	0.001	CRL
42B	N-NITROSODI-N-PROPYLAMINE	00621647	N/A	N/A	0.0008	CRL
43B	N-NITROSODI-PHENYLAMINE	00086306	59	295	5	CRL
44B	PHENANTHRENE	00085018	1	8	0.003	CRL
45B	PYRENE	00129000	N/A	N/A	0.003	CRL
46B	1,2,4-TRICHLOROBENZENE	00120821	26	130	700	H
1P	ALDRIN	00309002	0.1	0.5	0.00007	CRL

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)	
2P	alpha-BHC	00319846	N/A	N/A	0.009	CRL
3P	beta-BHC	00310857	N/A	N/A	0.02	CRL
4P	gamma-BHC (LINDANE)	00058899	0.08	2	0.02	CRL
5P	delta-BHC	00319868	N/A	N/A	N/A	-
6P	CHLORDANE	00057749	0.0043	2.4	0.0005	CRL
7P	4,4'-DDT	00050293	0.001	1.1	0.00002	CRL
8P	4,4'-DDE	00072559	0.001	1.1	N/A	-
9P	4,4'-DDD	00072548	0.001	1.1	N/A	-
10P	DIELDRIN	00060571	0.0019	2.5	0.00007	CRL
11P	alpha-ENDOSULFAN	00095988	0.056	0.22	74	H
12P	beta-ENDOSULFAN	33212659	0.056	0.22	74	H
13P	ENDOSULFAN SULFATE	01031078	N/A	N/A	74	-
14P	ENDRIN	00072208	0.0023	0.18	1	H
15P	ENDRIN ALDEHYDE	07421934	N/A	N/A	N/A	-
16P	HEPTACHLOR	00076448	0.0038	0.52	0.0003	CRL
17P	HEPTACHLOR EPOXIDE	01024573	0.1	0.6	N/A	-

TABLE 1

WATER QUALITY CRITERIA FOR TOXIC SUBSTANCES

PP NO	CHEMICAL NAME	CAS NUMBER	FISH and AQUATIC LIFE CRITERIA: CRITERIA CONTINUOUS CONCENTRATIONS (ug/l)	FISH and AQUATIC LIFE CRITERIA: CRITERIA MAXIMUM CONCENTRATIONS (ug/l)	HUMAN HEALTH CRITERIA (ug/l)
18P	PCB-1242	53469219	0.014	2	0.00008(d)CRL
19P	PCB-1254	11097691	0.014	2	0.00008(d)CRL
20P	PCB-1221	11104282	0.014	2	0.00008(d)CRL
21P	PCB-1232	11141165	0.014	2	0.00008(d)CRL
22P	PCB-1248	12672296	0.014	2	0.00008(d)CRL
23P	PCB-1260	11096825	0.014	2	0.00008(d)CRL
24P	PCB-1016	12674112	0.014	2	0.00008(d)CRL
25P	TOXAPHENE	08001352	0.0002	0.73	0.0007 CRL
PP	2,3,7,8-TCDD	01746016	N/A	N/A	1 x 10E-8CRL

APPENDIX C

TABLE 1

GUIDELINES FOR RECOMMENDING THE LISTING AND DELISTING OF GREAT LAKES AREAS OF CONCERN

USE IMPAIRMENT	LISTING GUIDELINE	DELISTING GUIDELINE	RATIONALE	REFERENCE
RESTRICTIONS ON FISH AND WILDLIFE CONSUMPTION	When contaminant levels in fish or wildlife populations exceed current standards, objectives or guidelines, or public health advisories are in effect for human consumption of fish or wildlife. Contaminant levels in fish and wildlife must be due to contaminant input from the watershed.	When contaminant levels in fish and wildlife populations do not exceed current standards, objectives or guidelines, and no public health advisories are in effect for human consumption of fish or wildlife.	Accounts for jurisdictional and federal standards; emphasizes local watershed sources.	Adapted from Mack 1988
TAINTING OF FISH AND WILDLIFE FLAVOR	When ambient water quality standards, objectives, or guidelines, for the anthropogenic substance(s) known to cause tainting, are being exceeded or survey results have identified tainting of fish or wildlife flavor.	When survey results confirm no tainting of fish or wildlife flavor.	Sensitive to ambient water quality standards for tainting substances; emphasizes survey results.	See American Public Health Association (1980) for survey methods
DEGRADED FISH AND WILDLIFE POPULATIONS	When fish and wildlife management programs have identified degraded fish or wildlife populations due to a cause within the watershed. In addition, this use will be considered impaired when relevant, field validated, fish or wildlife bioassays with appropriate quality assurance/quality controls confirm significant toxicity from water column or sediment contaminants.	When environmental conditions support healthy, self sustaining communities of desired fish and wildlife at predetermined levels of abundance that would be expected from the amount and quality of suitable physical, chemical and biological habitat present. An effort must be made to ensure that fish and wildlife objectives for Areas of Concern are consistent with Great Lakes ecosystem objectives and Great Lakes Fishery Commission fish community goals. Further, in the absence of community structure data, this use will be considered restored when fish and wildlife bioassays confirm no significant toxicity from water column or sediment contaminants.	Emphasizes fish and wildlife management program goals; consistent with GLWQA and Great Lakes Fishery Commission goals; accounts for toxicity bioassays.	Adapted from Manny and Pacific, 1988; Wisconsin DNR 1987; United States and Canada, 1987; Great Lakes Fishery Commission 1980
FISH TUMORS OR OTHER DEFORMITIES	When the incidence rates of fish tumors or other deformities exceed rates at unimpacted control sites or when survey data confirm the presence of neoplastic or preneoplastic liver tumors in bull heads or suckers.	When the incidence rates of fish tumors or other deformities do not exceed rates at unimpacted control sites and when survey data confirm the absence of neoplastic or preneoplastic liver tumors in bullheads or suckers.	Consistent with expert opinion on tumors; acknowledges background incidence rates.	Adapted from Mac and Smith, 1988; Black 1983; Baumann et al. 1982
BIRD OR ANIMAL DEFORMITIES OR REPRODUCTIVE PROBLEMS	When wildlife survey data confirm the presence of deformities (e.g. cross-bill syndrome) or other reproductive problems (e.g. egg shell thinning) in sentinel wildlife species.	When the incidence rates of deformities (e.g. cross-bill syndrome) or reproductive problems (e.g. egg-shell thinning) in sentinel wildlife species do not exceed background levels in inland control populations.	Emphasizes confirmation through survey data; makes necessary control comparisons.	Adapted from Kubiak 1988; Miller 1988; Wiemeyer et al. 1984

Table 1 - continued

USE IMPAIRMENT	LISTING GUIDELINE	DELISTING GUIDELINE	RATIONALE	REFERENCE
DEGRADATION OF BENTHOS	When the benthic macroinvertebrate community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when toxicity (as defined by relevant, field validated, bioassays with appropriate quality assurance/quality controls) of sediment associated contaminants at a site is significantly higher than controls.	When the benthic macroinvertebrate community structure does not significantly diverge from unimpacted control sites of comparable physical and chemical characteristics. Further, in the absence of community structure data, this use will be considered restored when toxicity of sediment-associated contaminants is not significantly higher than controls.	Accounts for community structure and composition; recognizes sediment toxicity; uses appropriate control sites.	Adapted from Reynoldson 1988; Henry 1988; IJC 1988
RESTRICTIONS ON DREDGING ACTIVITIES	When contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.	When contaminants in sediments do not exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.	Accounts for jurisdictional and federal standards; emphasizes dredging and disposal activities.	Adapted from IJC 1988
EUTROPHICATION OR UNDESIRABLE ALGAE	When there are persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication.	When there are no persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication.	Consistent with Annex 3 of GLWQA; accounts for persistence of problems.	United States and Canada, 1987
RESTRICTIONS ON DRINKING WATER CONSUMPTION OR TASTE AND ODOR PROBLEMS	When treated drinking water supplies are impacted to the extent that: 1) densities of disease-causing organisms or concentrations of hazardous or toxic chemicals or radioactive substances exceed human health standards, objectives or guidelines; 2) taste and odor problems are present; or 3) treatment needed to make raw water suitable for drinking is beyond the standard treatment used in comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).	For treated drinking water supplies: 1) when densities of disease-causing organisms or concentrations of hazardous or toxic chemicals or radioactive substances do not exceed human health objectives, standards or guidelines; 2) when taste and odor problems are absent; and 3) when treatment needed to make raw water suitable for drinking does not exceed the standard treatment used in comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).	Consistency with GLWQA; accounts for jurisdictional standards; practical; sensitive to increased cost as a measure of impairment.	Adapted from United States and Canada, 1987
BEACH CLOSINGS	When waters, which are commonly used for total-body contact or partial-body contact recreation, exceed standards, objectives, or guidelines for such use.	When waters, which are commonly used for total-body contact or partial-body contact recreation, do not exceed standards, objectives, or guidelines for such use.	Accounts for use of waters; sensitive to jurisdictional standards; addresses water contact recreation; consistent with GLWQA.	Adapted from United States and Canada, 1987; Ontario Ministry of the Environment 1984
DEGRADATION OF AESTHETICS	When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).	When the waters are devoid of any substance which produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).	Emphasizes aesthetics in water; accounts for persistence.	Adapted from the Ontario Ministry of the Environment 1984

Table 1 - continued

USE IMPAIRMENT	LISTING GUIDELINE	DELISTING GUIDELINE	RATIONALE	REFERENCE
ADDED COSTS TO AGRICULTURE OR INDUSTRY	When there are additional costs required to treat the water prior to use for agricultural purposes (i.e. including, but not limited to, livestock watering, irrigation and crop-spraying) or industrial purposes (i.e. intended for commercial or industrial applications and noncontact food processing).	When there are no additional costs required to treat the water prior to use for agricultural purposes (i.e. including, but not limited to, livestock watering, irrigation and crop-spraying) and industrial purposes (i.e. intended for commercial or industrial applications and noncontact food processing).	Sensitive to increased cost and a measure of impairment.	Adapted from Michigan DNR 1977
DEGRADATION OF PHYTOPLANKTON AND ZOOPLANKTON POPULATIONS	When phytoplankton or zooplankton community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when relevant, field-validated, phytoplankton or zooplankton bioassays (e.g. <u>Ceriodaphnia</u>; algal fractionation bioassays) with appropriate quality assurance/quality controls confirm toxicity in ambient waters.	When phytoplankton and zooplankton community structure does not significantly diverge from unimpacted control sites of comparable physical and chemical characteristics. Further, in the absence of community structure data, this use will be considered restored when phytoplankton and zooplankton bioassays confirm no significant toxicity in ambient waters.	Accounts for community structure and composition; recognizes water column toxicity; uses appropriate control sites.	Adapted from IJC 198
LOSS OF FISH AND WILDLIFE HABITAT	When fish and wildlife management goals have not been met as a result of loss of fish and wildlife habitat due to a perturbation in the physical, chemical, or biological integrity of the Boundary Waters, including wetlands.	When the amount and quality of physical, chemical, and biological habitat required to meet fish and wildlife management goals has been achieved and protected.	Emphasizes fish and wildlife management program goals; emphasizes water component of Boundary Waters.	Adapted from Manny and Pacific, 1988

APPENDIX D

Presque Isle Bay Advisory

Committee Members

PRESQUE ISLE BAY ADVISORY COMMITTEE MEMBERS

Mr. Bruce Yount
504 Municipal Building
Erie, PA 16501

Mr. Joseph Vogel
Erie County Health Department
606 West 2nd Street
Erie, PA 16507

Mr. Leroy Gross
Erie County Conservation District
Route 19, R. D. #5
Waterford, PA 16441

Mr. Edward Kissell
S.O.N.S. of Lake Erie
2815 Sigsbee Street
Erie, PA 16508

Dr. Stanley Zagorski
Gannon University
University Square
Erie, PA 16541

Ms. Lisa Danko
Presque Isle Audubon Society
6580 Harborgreen Road
Erie, PA 16510

Mrs. Judith M. Lynch
County Executive
Erie County Court House
Erie, PA 16501-1081

Ms. Sue Weber
Millcreek Township Supervisors
3608 West 26th Street
Erie, PA 16509

Mr. Paul Martin, Chairman
Millcreek Township Supervisors
3608 West 26th Street
Erie, PA 16509

Mr. Richard Kubiak
Mercyhurst College
501 East 38th Street
Erie, PA 16546

Mr. Donald DiPlacido, Executive Director
Greater Erie Chamber of Commerce
1002 State Street
Erie, PA 16501

Sister Pat Lupo, O.S.B.
Erie County Environmental Coalition
6270 East Lake Road
Erie, PA 16511

Ms. Roberta Adams, President
League of Women Voters
1401 Canterbury Lane
Fairview, PA 16415

Dr. Ed Masteller
Penn State-Behrend College
Station Road
Erie, PA 16563

The Honorable Italo Cappabianca
House of Representatives
2nd District
1212 West 26th Street
Erie, PA 16502

Mr. David Skellie
County Planner
Erie County Court House
Erie, PA 16501-1081

Mr. Joseph Giles, Councilman
Erie County Council
Erie County Court House
Erie, PA 16501

Dr. Paul D. Knuth
Edinboro University of PA
Hendricks Hall, Room G-7
Edinboro, PA 16444

Mr. Ralph Pontillo
Manufacturer's Association of
Northwest Pennsylvania
3537 West 12th Street
Erie, PA 16505

The Honorable Karl W. Boyes
House of Representatives
3rd District
5071 Peach Street
Erie, PA 16509

The Honorable Tom Ridge
House of Representatives
108 Federal Court House
Erie, PA 16501

Mr. Jim Karsten
U.S. Army Corps of Engineers
Buffalo District
1776 Niagara Street
Buffalo, NY 14207-3199

Mr. Stan Prazer
3805 Myrtle Street
Erie, PA 16508

David B. Richards, P.E.
U.S. Department of Interior
Moorhead Federal Building
Room 2204
1001 Liberty Street
Pittsburgh, PA 15222

Mr. Ed Donn
Presque Isle Advisory Committee
1140 Wilkins Road
Erie, PA 16505

Mrs. Gayle M. Wright
City Councilwoman
Erie City Council
Room 104, Municipal Building
Erie, PA 16501

The Honorable A. Buzz Andrezeski
Senate of Pennsylvania
200 West 11th Street
Erie, PA 16501

Ms. Catherine Stachera
Greater Erie Board of Realtors
2166 West 8th Street
Erie, PA 16505

Millcreek Sewer Authority
P. O. Box 8195
Erie, PA 16505

The Honorable Harris Wofford
U.S. Senate
130 Federal Building
Perry Square
Erie, PA 16501

U.S. Coast Guard
P. O. Box 8130
Erie, PA 16505

Mr. Frank Parise
Waterways Conservation Officer
Pennsylvania Fish Commission
P. O. Box 225
McKean, PA 16426

Mr. Truman Andrews
4912 Watson Road
Erie, PA 16505

The Honorable Joyce A. Savocchio
Mayor of the City of Erie
Room 502, Municipal Building
Erie, PA 16501

Mr. Charles W. Sapp (3WM10)
Basin Commission Coordinator
U.S. Environmental Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107

Mr. Russell S. Warner
MacDonald, Illig, Jones & Britton
100 State Street
Suite 700
Erie, PA 16507-1498

The Honorable Arlen Specter
U.S. Senate
118 Federal Court House
Erie, PA 16501

Dr. Mike Campbell
Mercyhurst College
501 East 38th Street
Erie, PA 16546

Mr. Ed Sitter
Greater Erie Community
Action Committee
18 West 9th Street
Erie, PA 16501

Mr. Thomas C. Hoffman
Erie Conference on Community Development
420 West 6th Street
Erie, PA 16507

Mr. Harry Leslie, Superintendent
Presque Isle State Park
Peninsula Drive
Erie, PA 16505

Mr. Larry Moroski, Manager
Erie-Western Pennsylvania Port Authority
17 West Dobbins Landing
Erie, PA 16507

Ms. Cindy Rice
U.S. Department of Interior
Fish & Wildlife Service
Suite 322
315 South Allen Street
State College, PA 16801

Mr. John Reilly, Manager
Environmental Licensing
Pennsylvania Electric Company
1001 Broad Street
Johnstown, PA 15907

Mr. Bruce Kershner
Great Lakes United
1300 Elmwood Avenue
Buffalo, NY 14222

Dr. John Lyon
St. Vincent's Professional Building
Suite 501
311 West 24th Street
Erie, PA 16502

Ms. Freda Tarbell
WSEE-TV 35
1220 Peach Street
Erie, PA 16501

Mr. Jerry Allender
Consoer Townsend & Associates, Inc.
155 West 8th Street
Erie, PA 16501

Mrs. Bonney Daubenspeck
4921 Tramaralac Road
Erie, PA 16505

Dr. Richard Brown
412 Wedgewood Drive
Erie, PA 16505

Mr. Maury Mertz, Director
Environmental Services
Hamot Health Systems, Inc.
100 State Street, Suite 500
Erie, PA 16507-1438
(814) 870-2880

Ms. Abby Conley
1124 East Lake Road
Erie, PA 16507

Mr. Timothy M. Yeager
Manager-Environmental Compliance
General Electric Company
2901 East Lake Road
Erie, PA 16531
(814) 875-5804

Mr. Ed Leslie, Manager
Environmental Health & Safety
International Paper
P. O. Box 10050
Erie, PA 16533
(814) 870-6755

Mr. Marty Visnosky
402 Harvey Street
Erie, PA 16511

Mr. Eugene A. Miller
Environmental Services Manager
Lord Corporation
P. O. Box 1003
Erie, PA 16514-0038
(814) 868-0924
(814) 868-3504

Mr. Dave Sterrett
International Paper
1540 East Lake Road
Erie, PA 16533
(814) 870-6761

James N. McKibben, CLU, Partner
Lillis, McKibben & Company
~~245 West 10th Street~~ 100 State Stre
Erie, PA 16501
(814) 452-4085

Mr. Robert Ostryniec
1232 Mission Drive
Erie, PA 16505

Mr. Joseph T. Hosey, Geologist
455 West 2nd Street
P. O. Box 512
Waterford, PA 16441-0512

Mr. Michael Waltz
455 West 2nd Street
P. O. Box 512
Waterford, PA 16441-0512

JDR:GLM:sn:11/17/92

APPENDIX E

City of Erie

Other Sources of Pollution Study

Spring 1992 Analytical Data Summary

TABLE 4-2

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

McDANIEL RUN - CREEK (DP-1)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.88	0.13	0.15
Methylene Chloride (ug/L)				7.59	
Fecal Coliform (#/100 mL)	2,500 (E)	26,000 (E)	4,317 (E)	2,600 (E)	7,508 (E)
Acetone (ug/L)			15.51 (B)	10.65 (B)	10.24
Color					45
Iron (mg/L)			11.5 (E)		
NH_3-N (mg/L)		1.49			
Copper (mg/L)	<0.010	0.011 (+)	0.028 (+)	<0.010	<0.010
Zinc (mg/L)	0.032 (+)	0.033 (+)	0.131 (+)	0.065 (+)	0.064 (+)

NOTES:
(B) Possible blank contamination.
(E) Exceeds Water Quality Criteria.
(+) Present but below Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 4 (RG4).
Evidence of domestic sewerage pollution during wet and dry sampling events.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

CEMETERY RUN - STORM (DP-2)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.88	0.13	0.15
Color			60 (E)		50 (E)
Iron (mg/L)	1.28 (∞)	2.2 (E)	12.4 (E)	1.12 (∞)	1.280 (∞)
Sulfate (mg/L)	230.8 (∞)	228.5 (∞)			123.6 (∞)
Turbidity (NTU)			210 (E)		
Fecal Coliform (#/100 mL)	<350		< 400	760 (E)	4,700 (E)
Toluene (ug/L)		13.25 (∞)			
1,2,4-Trimethyl Benzene (ug/L)		69.54			
Methylene Chloride (ug/L)					1.84 (B)
Acetone (ug/L)			15.15 (B)		
Copper (mg/L)	<0.010	0.017 (+)	0.022 (++)	<0.010	<0.010
Zinc (mg/L)	0.077 (+)	0.077 (+)	0.145 (+)	0.093 (+)	0.058 (+)

NOTES:
- (E) Exceeds Water Quality Criteria.
- (∞) Present but below Water Quality Criteria.
- (B) Possible blank contamination.
- (+) Present but below Water Quality Criteria CCC value @ H=200.
- (++) Exceeds Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 4 (RG4).

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

MOTCH RUN - STORM (DP-3)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.88	0.13	0.15
Tetrachloroethene (ug/L)	41.4 (*)			12.75 (*)	5.53 (*)
Trichloroethene (ug/L)	23.7 (∞)			7.76 (∞)	3.35 (∞)
Color	60 (E)			150 (E)	150 (E)
NO_3-N (mg/L)	12.4	20.0	19.5	15.6	9.83
Sulfate (mg/L)	260 (E)	356.9 (E)	155.6	382.9 (E)	156.3
TSS (mg/L)	67.3		90.7		
Cis-1,2 Dichloroethene (ug/L)	30.21	16.52		19.58	10.4
Iron (mg/L)	9.10 (E)	14.1 (E)	4.94 (E)	11 (E)	12.0 (E)
pH (S.U.)				6.72 (E)	6.70 (E)
Copper (mg/L)	0.040 (++)	0.032 (++)	0.074 (++)	0.016 (+)	0.021 (+)
Zinc (mg/L)	0.114 (+)	0.160 (+)	0.119 (+)	0.172 (+)	0.127 (+)

NOTES:
- (*) Present, but below Water Quality Criteria limit of 139 ug/L.
- (∞) Present, but below Water Quality Criteria limit of 450 ug/L.
- (E) Exceeds Water Quality Criteria.
- (+) Present but below Water Quality Criteria CCC value @ H=200.
- (++) Exceeds Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 4 (RG4).
Industrial pollution evident. Data supports further investigation of the drainage area.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

DUNN BLVD. - STORM (DP-4)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.88	0.13	0.15
1,1,1-Trichloroethane (ug/L)	125.6 (*)		7.67 (*)		
Carbon Disulfide (ug/L)	16.6				
1,2,4-Trimethylbenzene (ug/L)	28.1	208.14	6.08	44.54	1.69
Iron (mg/L)	3.9 (E)	4.11 (E)	3.9 (E)	2.8 (E)	3.11 (E)
Fecal Coliform (#/100 mL)	360,000 (E)	460,000 (E)	73,000 (E)	>374,144 (E)	69,000 (E)
NH_3-N (mg/L)	3.3	2.46		2.15	1.09
NO_3-N (mg/L)	8.76	7.58		3.14	1.88
BOD_5/COD (mg/L)	29.3/80.5	86/177		37/118	12/5,148
TSS (mg/L)	40	100		53.3	34
pH (S.U.)			4.48 (E)		6.50 (E)
Toluene (ug/L)		883 (E)		119.1	
M,P-Xylene (ug/L)		26.7		39.24	
O-Xylene (ug/L)				14.87	
Color					130 (E)
2-Butanone (ug/L)				98.46	
Acetone (ug/L)	69.8 (B)	403.7 (B)	41.4 (B)	161.7	8.36 (B)
Copper (mg/L)	0.027 (++)	0.041 (++)	0.030 (++)	0.036 (++)	0.016 (+)
Zinc (mg/L)	0.079 (+)	0.130 (+)	0.127 (+)	0.121 (+)	0.072 (+)

NOTES:
- (*) Present, but below Water Quality Criteria limit of 605 ug/L.
- (B) Possible blank contamination.
- (E) Exceeds Water Quality Criteria.
- (+) Present but below Water Quality Criteria CCC value @ H=200.
- (++) Exceeds Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 4 (RG4).
Significant industrial and domestic sewerage pollution evident during both dry and wet weather events.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

EAST AVE. - STORM (DP-5)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.88	0.13	0.15
1,1,1-Trichloroethane*	61.7 (*)				
Carbon Disulfide	6.97				
pH (S.U.)		6.48 (E)	4.1 (E)	6.23 (E)	6.31 (E)
Iron (mg/L)		50.0 (E)		53.1 (E)	43.3 (E)
Color (mg/L)				200 (E)	200 (E)
NH_3-N (mg/L)		1.5		2.32	4.49
NO_3-N (mg/L)				0.51	0.44
Sulfate (mg/L)		418.6 (E)		747.7 (E)	
Cyanide, Free (mg/L)		0.147		0.128	
Cyanide, Total (mg/L)		0.226		0.128	0.111
Fecal Coliform (#/100 mL)			490		
Acetone (ug/L)		16.9		11.10 (B)	
Chloroform (ug/L)		13.52 (∞)			
Copper (mg/L)	<0.010	0.033 (++)	0.035 (++)	0.029 (++)	0.017 (+)
Zinc (mg/L)	0.025 (+)	0.213 (++)	0.096 (+)	0.289 (++)	0.207 (++)

NOTES:
(*) Present, but below Water Quality Criteria limit of 605 ug/L.
(E) Exceeds Water Quality Criteria.
(B) Possible blank contamination.
(∞) Present but below Water Quality Criteria.
(+) Present but below Water Quality Criteria CCC value @ H=200.
(++) Exceeds Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 4 (RG4).
Industrial pollution evident. Note low pH values, as well as iron and nitrogen.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

GARRISON RUN - CREEK (DP-6)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.88	0.13	0.15
Color					65 (E)
pH (S.U.)			6.7 (E)		
Fecal Coliform (#/100 mL)	<500	340	69,000 (E)	5,200 (E)	13,545 (E)
Iron (mg/L)			3.98 (E)	1.65 (E)	1.4 (∞)
Acetone (ug/L)			53.14 (B)		
Copper (mg/L)	0.010 (+)	0.024 (++)	0.082 (++)	0.013 (+)	0.011 (+)
Zinc (mg/L)	0.052 (+)	0.118 (+)	0.114 (+)	0.067 (+)	0.103 (+)

NOTES:
- (B) Possible blank contamination.
- (E) Exceeds Water Quality Criteria.
- (∞) Present but below Water Quality Criteria.
- (+) Present but below Water Quality Criteria CCC value @ H=200.
- (++) Exceeds Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 4 (RG4).
No significant dry weather pollution evident. Elevated fecal coliform counts during wet weather indicate sanitary sewer overflows. Low pH was noted during one wet weather sampling event.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

SASSAFRAS ST. - STORM (DP-7)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.86	0.11	0.14
Iron (mg/L)	4.22 (E)	2.86 (E)	2.03 (E)		1.25 (∞)
Chloride (mg/L)	271.9 (E)	274 (E)			97 (∞)
Sulfate (mg/L)	386 (E)	390.9 (E)	99.3 (∞)		99.1 (∞)
TSS (mg/L)	83				
Fecal Coliform (#/100 mL)	<280		<73	2,700 (E)	2,600 (E)
Color					50 (E)
pH (S.U.)		2.3 (@)			
Acetone (ug/L)			10.56 (B)		10.13 (B)
Copper (mg/L)	0.019 (+)	0.015 (+)	0.017 (+)		0.011 (+)
Zinc (mg/L)	0.181 (+)	0.106 (+)	0.184 (+)		0.096 (+)

NOTES:
- (B) Possible blank contamination.
- (@) May be associated with a field testing error.
- (E) Exceeds Water Quality Criteria.
- (∞) Present but below Water Quality Criteria.
- (+) Present but below Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 1 (RG1).

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

MYRTLE ST. - STORM (DP-8)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.86	0.11	0.14
Fecal Coliform (#/100 mL)	1,733	2,100 (E)	ND	68,000 (E)	73,000 (E)
Iron (mg/L)			4.64 (E)		
Chloromethane (ug/L)				8.04 (∞)	
Acetone (ug/L)			13.58 (B)		33.54
Copper (mg/L)	0.011 (+)	0.018 (+)	0.035 (++)	0.018 (+)	0.013 (+)
Zinc (mg/L)	0.036 (+)	0.082 (+)	0.184 (+)	0.165 (+)	0.086 (+)

NOTES:
(E) Exceeds Water Quality Criteria.
(∞) Present but below Water Quality Criteria.
ND No data due to laboratory error.
(+) Present but below Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 1 (RG1).
Tributary area should be checked to identify the source of the dry weather fecal coliform count. Elevated wet weather coliform counts indicate sanitary sewer overflows.
Collected grab samples with Erie County Department of Health for PADER during events O8-W, O9-D, and 11-W. PADER - Pennsylvania Department of Environmental Resources.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

CHERRY ST. - STORM (DP-9)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.86	0.11	0.14
Acetone (ug/L)	29.05	27.7 (B)	17.94 (B)	34.77 (B)	4.52 (B)
Iron (mg/L)	1.93 (E)		2.58 (E)	1.55 (E)	
Fecal Coliform (#/100 mL)	3,600 (E)	>100,937 (E)	260,000 (E)	>654,262 (E)	30,000 (E)
NH_3-N (mg/L)		1.74	2.2	2.06	0.47
NO_3-N (mg/L)	1.86	1.56	1.29	1.17	1.33
Chloromethane (ug/L)				67.71 (∞)	
BOD_5 (mg/L)			37.0	20	
pH (S.U.)					6.94 (E)
Copper (mg/L)	<0.010	0.015 (+)	0.024 (+)	0.018 (+)	<0.010
Zinc (mg/L)	0.102 (+)	0.127 (+)	0.169 (+)	0.165 (+)	0.087 (+)

NOTES:
- (B) Possible blank contamination.
- (E) Exceeds Water Quality Criteria.
- (∞) Present but below Water Quality Criteria limit.
- (+) Present but below Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 1 (RG1).
Significant sanitary sewage contribution evident during both dry and wet weather events, as evidenced by both fecal coliform and nitrogen.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

POPLAR ST. - STORM (DP-10)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.86	0.11	0.14
4-Methyl-2-pentanone (ug/L)	9.3				
Fecal Coliform (#/100 mL)	<2,600	20,000 (E)	38,000 (E)	7,333 (E)	13,562 (E)
Chloromethane (ug/L)				33.94 (∞)	
Acetone (ug/L)	55.06 (B)	38.24 (B)		75.51	10.11 (B)
Iron (mg/L)			3.36 (E)	3.3 (E)	
2-Butanone (ug/L)	10.11				
Copper (mg/L)	<0.010	0.018 (+)	0.081 (+)	0.020 (+)	0.023 (+)
Zinc (mg/L)	0.040 (+)	0.088 (+)	0.197 (++)	0.103 (+)	0.068 (+)

NOTES:
- (B) Possible blank contamination.
- (E) Exceeds Water Quality Criteria.
- (∞) Present but below Water Quality Criteria.
- (+) Present but below Water Quality Criteria CCC value @ H=200.
- (++) Exceeds Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 1 (RG1).
Sanitary sewage overflows likely during wet weather events as evidenced by elevated fecal coliform counts.
Event 9-D also showed high fecal coliform levels. Recommend field investigation of drainage area.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

CASCADE CREEK - CREEK (DP-12)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.86	0.11	0.09
Fecal Coliform (#/100 mL)			ND	3,900 (E)	5,267 (E)
Carbon Disulfide (ug/L)		5.19			
Acetone (ug/L)				10.97 (B)	6.93 (B)
Iron (mg/L)	1.37 (∞)		4.17 (E)		
Copper (mg/L)	<0.021	0.011 (+)	0.023 (++)	0.010 (+)	<0.010
Zinc (mg/L)	0.111 (+)	0.071 (+)	0.114 (+)	0.060 (+)	0.110 (+)

NOTES:
- (E) Exceeds Water Quality Criteria.
- ND No data due to laboratory error.
- (B) Possible Blank Contamination.
- (+) Present but below Water Quality Criteria CCC value @ H=200.
- (++) Exceeds Water Quality Criteria CCC value @ H=200.

REMARKS:

Rainfall information recorded by Rain Gauge No. 1 (RG1) for Event 08W and Rain Gauge No. 6 (RG6) for Events 11-W and 12-W.

No significant dry weather pollution evident. Elevated fecal coliform levels during wet weather sampling events indicates sanitary sewer overflows.

Collected grab samples with Erie County Department of Health for PADER during Events 08-W, 09-D, and 11-W.

TABLE 4-2 (continued)

CITY OF ERIE
OTHER SOURCES OF POLLUTION STUDY
SPRING 1992 ANALYTICAL DATA SUMMARY

COLORADO ST. - STORM (DP-13)

Parameter	Dry Weather Events		Wet Weather Events		
	07-D April 6-7, '92	09-D April 28-29, '92	08-W April 16-17, '92	11-W May 26, '92	12-W June 4-5, '92
Rainfall (in.)			0.86	0.11	0.14
Fecal Coliform (#/100 mL)	460	>4,207 (E)	<4,000	530 (E)	3,100 (E)
1,2,4-Trimethyl Benzene (ug/L)		10.6			
Iron (mg/L)			2.2 (E)		
M,P-Xylene (ug/L)		33.5			
O-Xylene (ug/L)		13.77			
Copper (mg/L)	<0.010	0.034 (++)	0.039 (++)	0.013 (+)	0.010 (+)
Zinc (mg/L)	0.021 (+)	0.052 (+)	0.122 (+)	0.063 (+)	0.050 (+)

NOTES:
(E) Exceeds Water Quality Criteria.
(+) Present but below Water Quality Criteria CCC value @ H=200.
(++) Exceeds Water Quality Criteria CCC value @ H=200.

REMARKS:
Rainfall information recorded by Rain Gauge No. 1 (RG1) for Event O8W and Rain Gauge No. 6 (RG6) for Events 11-W and 12-W.
Sample event 09-D showed evidence of some sanitary/industrial pollution. May have been associated with an uncontrolled overflow. Wet weather sampling events indicate some sanitary sewage overflow.

Errata

In the following changes, deletions are shown as strikeovers and insertions are underlined.

Chapter 1:

Page 2, 2nd Paragraph - Last line should read "Based on the available data and other information, PIB is classified as a Category ~~3~~ 4 AOC, signifying that the causative factors are largely known ~~, but that~~ and a Remedial Action Plan has ~~not~~ been developed ~~and~~, but remedial measures are not fully implemented."

Page 7, 1st Paragraph - Add the line "Therefore, this use is considered unimpaired." to the end of the paragraph.

Chapter 2:

Page 2, 3rd Paragraph - Change the second sentence to read "...was converted to an enclosed, ~~combined~~ storm sewer..."

Chapter 3:

Page 12, 4th Paragraph - Third line begins "Current ~~(1991)~~ (1992) regulations..." Also, a new Table 3.3 has been provided.

Page 24, Last Sentence - "PIB is extensively used as a sport fishery, supporting an estimated average annual total..."

Chapter 4:

Page 33, 4th Paragraph - Second sentence should read "In order to bolster this determination, PADER and USEPA will attempt to conduct additional sediment toxicity testing during the summer of ~~1992~~ 1993.

Page 41, 3rd Paragraph - The last line should read "~~Only one~~ None of the DO values in the six year period of record reviewed fell below the ~~6.0~~ 5.0 mg/l DO standard. The lowest was ~~(~~ 5.7 mg/l on 6/21/89 ~~.~~ , and the second lowest ~~DO~~ was 6.7 mg/l on ~~(~~ 7/12/89 ~~)~~ . All other recorded DO values were >= 7.0 mg/l."

Page 50, 2nd Paragraph - The last sentence should read "The PADER and USEPA ~~will be conducting~~ began a plankton bioassay during the summer of 1992 to resolve this issue. Preliminary results support the no impact conclusion. The study will conclude in the Spring of 1993, at which time a final determination will be made.

Page 50, 6th Paragraph - First sentence should read "The PFC and PGC are ~~is~~ the only identified agenc ~~y~~ ies which is are involved..."

Page 53, 4th Paragraph - First sentence should read "Based on the currently ~~-~~ available information, it is not possible..."

Chapter 5:

Page 1, 3rd Paragraph - Second sentence should read "These pollutants include 10 metals, five conventional/nonconventional pollutants, and ~~(probably)~~ PAHs."

Page 3, 1st Full Paragraph - In the fourth sentence, Appendix C should be changed to Appendix E, which is now included.

Page 7, 3rd Paragraph - First sentence should read "In Erie, a major effort has been made to transmit all collected wastes from the City ~~, Peninsula,~~ and Bay watershed..."

Page 18, 1st Paragraph - Should read "...total organic ~~content~~ carbon (TOC) and ~~%~~ percent sand for most sites. However, sites 1, 2, and 4 have higher TOCs than would be expected, based on their ~~%~~ sand percentage and levels"

Page 20, 3rd Paragraph - The fourth sentence should read "...at an estimated ~~annual~~ rate of ~~approximately~~ 2.5 gallons..." Add the following last line: "This discharge is part of a Consent Adjudication and is scheduled to be tied in to the Erie STP in Spring of 1993"

Page 21, 1st Paragraph - Change last two lines to read "...an average leachate discharge of ~~16,712~~ 3600 gallons/day (~~6.1~~ 1.3 million gallons per year), ..., would be ~~1,223~~ 263 pounds/year."

Chapter 7:

Page 2, 1st Full Paragraph - Add to second sentence "..., and the City has since 1984 implemented a pretreatment program..."

In addition to the above changes, there have also been some minor spelling and cosmetic corrections made, which do not significantly add or detract from the content of the report. These changes will be reflected in subsequent editions of the RAP.