An Assessment of Injury to Human Uses of Fishery Resources in the Grand Calumet River and Indiana Harbor Canal, the Grand Calumet River Lagoons, and Indiana Harbor and the Nearshore Areas of Lake Michigan

Volume I - Technical Report

Prepared for:

U.S. Fish and Wildlife Service
Bloomington Field Office
620 South Walker Street
Bloomington, Indiana 47403

Prepared – February 2003 – by:

MacDonald Environmental Sciences Ltd.
#24-4800 Island Highway North
Nanaimo, British Columbia V9T 1W6

Columbia Environmental Research Center
United States Geological Survey
4200 New Haven Road
Columbia, Missouri 65201

In Association with:

Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, Massachusetts 02140

An Assessment of Injury to Human Uses of Fishery Resources in the Grand Calumet River and Indiana Harbor Canal, the Grand Calumet River Lagoons, and Indiana Harbor and the Nearshore Areas of Lake Michigan

Volume I - Technical Report

Prepared for:

U.S. Fish and Wildlife Service
Bloomington Field Office
620 South Walker Street
Bloomington, Indiana 47403

Prepared – February 2003 – by:

D.D. MacDonald[1], D.E. Smorong[1], R.A. Lindskoog[1], and C.G. Ingersoll[2]

[1] **MacDonald Environmental Sciences Ltd.**
#24-4800 Island Hwy North
Nanaimo, British ColumbiaV9T 1W6

[2]**Columbia Environmental Research Center**
United States Geological Survey
4200 New Haven Road
Columbia, Missouri 65201

In Association with:

Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, Massachusetts 02140

Table of Contents

List of Tables

List of Figures

List of Acronyms

µg/kg	micrograms per kilogram
ABN	Acid-base neutrals
ARCS Program	Assessment and Remediation of Contaminated Sediments in the Great Lakes Program
ASTM	American Society for Testing and Materials
AVS	acid volatile sulfides
BSAF	biota-sediment bioaccumulation factor
BW	body weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601 et seq.)
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
cm	centimeters
COC	contaminant of concern
COPC	chemical of potential concern
CPG	Compliance Policy Guide
CSO	combined sewer overflow
DDTs	*p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDE, *o,p*'-DDE, *p,p*'-DDD, *o,p*'-DDD, and any metabolite or degradation product
DO	dissolved oxygen
DuPont	E.I. du Pont de Nemours
EBGCR	East Branch of the Grand Calumet River
EBGCR-I	East Branch of the Grand Calumet River I
EBGCR-II	East Branch of the Grand Calumet River II
ESRI	Environmental Systems Research Institute, Inc. (ESRI's)
FCA	fish consumption advisory
FIELDS	Fully Integrated Environmental Location Decision Support
ft	feet
GCR/IHC	Grand Calumet River and the Indiana Harbor Canal
GCRL	Grand Calumet River Lagoons
GIS	geographic information system
gm	gram
HCH	hexachlorocyclohexane
HPV	health protection value
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
IEC	Industrial Economics, Inc.
IH	Indiana Harbor
IHC	Indiana Harbor Canal
IH/LM	Indiana Harbor/Lake Michigan
ISBH	Indiana State Board of Health

ISDH	Indiana State Department of Health
K_{ow}	octanol-water partition coefficient
LGB	Lake George Branch
LM	Lake Michigan
MESL	MacDonald Environmental Sciences Ltd.
mg/kg	milligrams per kilogram
NC	not calculated
NG	no guideline
NH_3	unionized ammonia
NIPSCO	Northern Indiana Public Service Company
NPDES	National Pollutant Discharge Elimination System
NR	not reported
NRDA	Natural Resource Damage Assessment
NYSDEC	New York State Department of Environmental Conservation
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDDs	polychlorinated dibenzo-*p*-dioxins
PCDFs	polychlorinated dibenzofurans
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
SEM	simultaneously extracted metal
SOD	sediment oxygen demand
SQC	sediment quality criteria
SQG	sediment quality guidelines
Sum DDD	*p,p*'-DDD + *o,p*'-DDD
Sum DDE	*p,p*'-DDE + *o,p*'-DDE
Sum DDT	*p,p*'-DDT + *o,p*'-DDT
SVOC	semi-volatile organic chemical
TCDD	tetrachlorodibenzo-*p*-dioxin
TDI	tolerable daily intake
TEQ	toxic equivalents
TOC	total organic carbon
Total DDT	*p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDE, *o,p*'-DDE, *p,p*'-DDD, and *o,p*'-DDD
USACE	United States Army Corps of Engineers
USC	United States Canal
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USFDA	United States Food and Drug Administration
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
U.S. Steel	United States Steel (Division of USX Corporation)
VOC	volatile organic compound
WBGCR	West Branch of the Grand Calumet River
WBGCR-I	West Branch of the Grand Calumet River I

WBGCR-II	West Branch of the Grand Calumet River II
WQC	water quality criterion
WSDOH	Washington State Department of Health
WW	wet weight
WWTP	wastewater treatment plant

Glossary of Terms

Action level – The concentration of a substance in the edible portions of fish or shellfish at or above which USFDA will take legal action to remove products from the market.

Air resources – Those naturally occurring constituents of the atmosphere, including those gases essential for human, plant, and animal life.

Aquatic organisms – The species that utilize habitats within aquatic ecosystems (e.g., aquatic plants, invertebrates, fish, amphibians and reptiles).

Aquatic ecosystem – All the living and nonliving material interacting within an aquatic system (e.g., pond, lake, river, ocean).

Aquatic food web – The feeding relationships by which energy and nutrients are transferred from one species to another.

Assessment Area – The areas within which natural resources have been affected directly or indirectly by the discharge of oil or release of a hazardous substance and that serves as the geographic basis for the injury assessment in this report.

Beneficial uses – In the context of the Great Lakes Water Quality Agreement, there are a number of beneficial uses of aquatic resources. Changes in the chemical, physical, and/or biological integrity of the Great Lakes system have resulted in the impairment of 14 beneficial uses in the Indiana Harbor Area of Concern. In this report, restrictions on the consumption of fish and wildlife are of primary interest relative to the assessment of injury to human uses of fishery resources.

Benthic species – The organisms that live in, on, or near bottom sediments, including both epibenthic and infaunal species (see the definition for sediment-dwelling organisms).

Bioaccumulation – The net accumulation of a substance by an organism as a result of uptake from all environmental sources.

Bioaccumulation-based SQGs – Sediment quality guidelines (SQGs) that are established to protect fish and wildlife resources against effects that are associated with the bioaccumulation of contaminants in sediment-dwelling organisms and subsequent food web transfer.

Bioaccumulative substances – The chemicals that tend to accumulate in the tissues of aquatic organisms.

Biological resources – Those natural resources referred to in Section 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition.

Biota-sediment bioaccumulation factor – The ratio of the concentration of a COPC in tissue to the level of the COPC in sediment, which may be determined from field studies or estimated using various modeling approaches.

Chemicals of Potential Concern – The COPCs are the substances that have the potential to cause injury to surface water or biological resources in the Assessment Area, including polychlorinated biphenyls (PCBs), oil and oil-related compounds (including alkanes, alkenes, naphthalenes, and polycyclic aromatic hydrocarbons; PAHs), metals, various pesticides, chlorinated benzenes, chlorophenols, phthalates, and polychlorinated dibenzo-*p*-dioxins / polychlorinated dibenzofurans (PCDDs/PCDFs).

Chemical benchmark – Guidelines for water or sediment quality which define the concentration of contaminants that are associated with high or low probabilities of observing harmful biological effects, depending on the narrative intent.

Contaminants of concern – Those substances that occur in sediments and/or fish tissues at concentrations that are sufficient to cause or substantially contribute to injury to human uses of fishery resources.

Contaminated sediment – Sediment that contains chemical substances at concentrations that could harm sediment-dwelling organisms, wildlife, or human health.

Conventional variables – A number of variables that are commonly measured in water and/or sediment quality assessments, including water hardness, DO, conductivity, total organic carbon (TOC), sediment oxygen demand (SOD), unionized ammonia (NH_3), temperature, dissolved oxygen (DO), pH, and alkalinity.

Discharge – Discharge of oil as defined in Section 311(a)(2) o f the Clean Water Act, and includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying, or dumping of oil.

Ecosystem – All the living (e.g., plants, animals, and humans) and nonliving (rocks, sediments, soil, water, and air) material interacting within a specified location in time and space.

Ecological receptors – A plant or animal that may be exposed to a stressor.

Edible portions of fish – Includes skin-on fillets for scaled fish species and skinless fillets for scaleless fish species (e.g., catfish).

Environmental media – Components of the ecosystem with which ecological receptors and humans interact and, hence, be exposed to COPCs. In this report, the environmental media of greatest interest includes whole sediments and edible fish tissues.

Epibenthic species – The organisms that live on the surface of bottom sediments.

Exposure – Co-occurrence of or contact between a stressor (e.g., chemical substance) and an ecological component (e.g., aquatic organism).

Federal Project Area – Includes United States Canal (USC), Lake George Branch (LGB) from the Forks to Indianapolis Boulevard, and Indiana Harbor Canal (IHC) from the Forks to Columbus Drive.

Fish consumption advisory – A recommendation issued by an appropriate authority that is intended to provide human consumers of fish, other aquatic organisms, and wildlife with information regarding the benefits and risks associated with consumption.

Fishery resources – Those natural resources referred to in Section 101(16) of CERCLA as fish, shellfish, and other aquatic organisms. Fish include marine and freshwater aquatic species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species.

General Population – Adult males and adult females who are not pregnant, breastfeeding, or who plan on having children.

Geologic resources – Those elements of the Earth's crust such as soils, sediments, rocks, and minerals that are not included in the definitions of surface water or ground water resources.

Grab (Dredge) samplers – A device that is used to collect surficial sediments (e.g., petite ponar dredge).

Ground water resources – Water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which ground water moves.

Hazardous substances – A hazardous substance as defined in Section 101(14) of CERCLA.

Infaunal organisms – The organisms that live in bottom sediments.

Injury – A measurable adverse change, either long or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance, or exposure to a product of reactions resulting from the discharge to oil or release of a hazardous substance. As used in this part, injury encompasses the phrases "injury", "destruction", and "loss". Injury definitions applicable to specific resources are provided in § 11.62 of this part.

Injury to human uses of fishery resources – An alteration in the chemical composition of fish or shellfish tissues that adversely affects the beneficial uses of these resources. Conditions sufficient to alter the chemical composition of fish or shellfish tissues were also considered to be indicative of injury to the human uses of fishery resources.

Natural resources – Land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976), and State or local government, or any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe. These natural resources have been categorized into the following five groups: surface water resources, ground water resources, air resources, geologic resources, and biological resources.

Natural resource damage assessment – The process of collection, compiling, and analyzing information, statistics, or data through prescribed methodologies to determine damages for injuries to natural resources.

Oil – Oil as defined in Section 311(a)(1) of the Clean Water Act, of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil.

Piscivorus wildlife species – The wildlife species that consume fish as part or all of their diets (e.g., herons, kingfishers, otter, mink or osprey).

Population – An aggregate of the individuals of a species within a specified location in time and space.

Pore water – The water that occupies the spaces between sediment particles.

Release – A release of a hazardous substance as defined in Section 101(22) of CERCLA.

Sediment quality guideline – A chemical benchmark that is intended to define the concentration of a sediment-associated contaminant that is associated with a high or a low probability of observing harmful biological effects or unacceptable levels of bioaccumulation, depending on its purpose and narrative intent.

Sediment injury – The presence of conditions that have injured or are sufficient to injure sediment-dwelling organisms, fish, or wildlife.

Sediment – Particulate material that usually lies below water.

Sediment chemistry data – Information on the concentrations of chemical substances in bulk sediments or pore water.

Sediment-associated COPCs – COPCs that are present in sediments, including bulk sediments or pore water.

Sediment-dwelling organisms – The organisms that live in, on, or near bottom sediments, including both epibenthic and infaunal species (see the definition for benthic species).

Sensitive Population – Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.

Surface Water Resources – The waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline, and sediments in or transported through coastal and marine areas. This term does not include ground water or water or sediments in ponds, lakes, or reservoirs designed for waste treatment under the Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901-6987 or the Clean Water Act, and applicable regulations.

Threshold concentrations – Limits established by the Indiana State Department of Health (ISDH) to support the development of fish consumption advisories (FCAs).

Tissue-associated COPCs – COPCs that are present in tissues.

Tissue Residue Guideline – Chemical benchmark that is intended to define the concentration of a substance in the tissues of fish or invertebrates that will protect wildlife against effects that are associated with dietary exposure to hazardous substances.

Tolerance level – The concentration of a substance in the edible portions of fish or shellfish at or above which USFDA will take legal action to remove products from the market.

Trustee – Any Federal natural resources management agency designated in the National Contingency Plan and any State agency designated by the Governor of each State, pursuant to Section 107(f)(2)(B) of CERCLA, that may prosecute claims for damages under Section 107(f) or 111(b) of CERCLA; or an Indian tribe, that may commence an action under Section 126(d) of CERCLA.

Whole sediment – Sediment and associated pore water.

Wildlife – The fish, reptiles, amphibians, birds, and mammals that are associated with aquatic ecosystems (i.e., fish and wildlife resources).

Background Information Relevant to the Preparation of this Report

Professional Qualifications

The professional experience and educational qualifications which qualify Dr. Ingersoll and Mr. MacDonald to give the opinions that are included in this report are set out in their curricula vitae, which are included in Appendix 1.

Conflict of Interest

Dr. Ingersoll, Mr. MacDonald, and the other members of the study team do not have any personal interest in this report other than as paid consultants to the United States Fish and Wildlife Service. Our prior involvement with United States government sediment injury has been as paid consultants on specific projects related to hazard and environmental assessments. We have had no prior involvement with the potentially responsible parties in this assessment. The United States Geological Survey and MacDonald Environmental Sciences Ltd. will be paid the same regardless of the outcome of this case.

Documents Used to Prepare Report

In preparing this report, we have reviewed numerous texts, articles, protocols, and publications relating to the fate and effects of sediment-associated and tissue-associated chemicals of potential concern on ecological receptors and human health. A list of the documents that were considered during the preparation of this report is presented in the references cited section. In addition, we have relied on our knowledge of this river system, as acquired through a site reconnaissance (conducted in January, 1998) and previous investigations conducted within this Area of Concern.

Executive Summary

This investigation was conducted to determine if biological resources within the Grand Calumet River and Indiana Harbor Canal, Grand Calumet River Lagoons, Indiana Harbor and the nearshore areas of Lake Michigan (i.e., the Assessment Area) have been injured due to discharges of oil or releases of other hazardous substances, as defined in 43 CFR § 11.62(f)(1)(ii) and (iii) in the United States Department of the Interior (USDOI) regulations for conducting natural resource damage assessments (NRDAs; CFR 2002). In this report, the term injury to human uses of fishery resources has been used to more specifically describe such injuries to biological resources. If the results of this assessment indicated that injury to human uses of fishery resources has occurred within the Assessment Area, then the subsequent objectives of this investigation were to identify contaminants of concern (COCs; i.e., those toxic or bioaccumulative substances that occur in sediments and/or fish tissues at concentrations that are sufficient to cause or substantially contribute to injury to human uses of fishery resources) in the Assessment Area and to evaluate the areal and temporal extent of injury to human uses of fishery resources.

In accordance with the Assessment Plan (Natural Resources Trustees 1997), this assessment of injury to human uses of fishery resources was focused on evaluating the effects on human use and/or consumption of fish that have occurred due to discharges of oil or releases of other hazardous substances. As defined in the assessment plan (Natural Resources Trustees 1997), the primary chemicals of potential concern (COPCs; i.e., the substances that could, potentially, be adversely affecting human uses of fishery resources) in the Assessment Area include polychlorinated biphenyls (PCBs), oil and oil-related compounds (including alkanes, alkenes, naphthalenes, and polycyclic aromatic hydrocarbons; PAHs), and metals (Natural Resources Trustees 1997). The other substances that were considered as COPCs in this investigation include various pesticides, chlorinated benzenes, chlorophenols, phthalates, and polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans (PCDDs/PCDFs). As many of these substances tend to become associated with sediments upon release into aquatic ecosystems, sediment contamination represents a concern with respect to the restoration of beneficial uses in the Assessment Area (IDEM 1991). Subsequent transfer of bioaccumulative substances to sediment-dwelling organisms and, ultimately, to fish and shellfish also has the potential to adversely affect beneficial uses within the Assessment Area, including the utilization of fishery resources by the public.

To facilitate this evaluation, the Assessment Area was initially divided into nine separate reaches, including the Grand Calumet River Lagoons (GCRL), East Branch Grand Calumet

River-I (EBGCR-I), East Branch Grand Calumet River-II (EBGCR-II), West Branch Grand Calumet River-I (WBGCR-I), West Branch Grand Calumet River-II (WBGCR-II), Indiana Harbor Canal (IHC), Lake George Branch (LGB), US Canal (USC) and Indiana Harbor/Lake Michigan (IH/LM; i.e., consistent with the approach used by MacDonald and Ingersoll 2000). In each of these reaches, the available sediment quality, tissue quality, and related information was collected, evaluated, and compiled. Subsequently, the data on seven of the nine reaches was consolidated to support the assessment of injury to human uses of fishery resources within the Grand Calumet River and Indiana Harbor Canal (GCR/IHC). Injury to human uses of fishery resources was also evaluated within the GCRL, and IH/LM. Division of the Assessment Area into these three areas facilitated implementation of a geographically consistent approach to the assessment of injury to human uses of fishery resources using all three of the indicators that were selected [i.e., sediment chemistry, tissue chemistry, and fish consumption advisories (FCAs); i.e., FCAs have been issued for these three geographic areas only].

An overview of the environmental issues and concerns in the Assessment Area, the study objectives, and the study approach are presented in Section 1 of this report. The geographic scope of the Assessment Area, the COPCs, and the natural resources contained within the Assessment Area are described in Section 2. More detailed narratives on the study approach and on the data sets that were used in this assessment are provided in Sections 3 and 4, respectively. Finally, the results of the assessment are presented in Section 5 of this report. A summary of these results is presented below to provide an overview of sediment quality, tissue quality, and related conditions within the Assessment Area, as they relate to injury of human uses of fishery resources.

Injury to Human Uses of Fishery Resources

An assessment of injury to human uses of fishery resources associated with discharges of oil or releases of other hazardous substances was conducted for the Grand Calumet River and Indiana Harbor Canal, Grand Calumet River Lagoons, and Indiana Harbor and the nearshore areas of Lake Michigan. The definitions of injury to biological resources included in the USDOI regulations were generally applied to support this assessment of the effects of chemical contamination on human use and consumption of fish and shellfish [i.e., injury to human uses of fishery resources; 43 CFR § 11.62(f)(1)(ii and iii); CFR 2002]. That is, a total of three indicators were used to assess injury to human uses of fishery resources, including sediment chemistry, tissue chemistry, and FCAs.

In this report, injury to human uses of fishery resources was defined as the presence of conditions that have adversely affected or are sufficient to adversely affect the human use and/or consumption of fish. Accordingly, injury to the human uses of fishery resources is considered to be equivalent to injury to biological resources, as defined in the USDOI regulations for conducting NRDAs [43 CFR § 11.62(f)(1)(ii and iii); CFR 2002]. Injury to human uses of fishery resources was assessed for each of the areas defined above (i.e., the GCR/IHC, GCRL, and IH/LM). Three separate lines of evidence were used to determine if injury to human uses of fishery resources has occurred. More specifically, injury to human uses of fishery resources was considered to have occurred if the concentrations of one or more COPCs in two or more whole-sediment samples (separated by more than 100 feet) from an area exceeded the selected chemical benchmarks for the protection of human health. In addition, human uses of fishery resources were considered to have been injured if the concentrations of one or more COPCs in one or more fish tissue samples from an area exceeded the selected chemical benchmarks for the protection of human health [i.e., the tolerance levels or action levels that have been promulgated by the United States Food and Drug Administration (USFDA) **or** the Group 1 threshold levels that have been established by the Indiana State Department of Health (ISDH) to support the development of FCAs]. Furthermore, issuance of FCAs on one or more species of fish within an area was considered to provide the necessary and sufficient evidence of injury to human uses of fishery resources.

Grand Calumet River/Indiana Harbor Canal - Evaluation of the sediment chemistry data that were compiled in the project database indicate that sediments from the GCR/IHC have concentrations of numerous COPCs sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. There were exceedances of one or more of the selected benchmarks for the protection of human health in all of the samples from this portion of the Assessment Area in which the concentrations of PAHs, PCBs, organochlorine pesticides, and/or other substances were measured (i.e., n=up to 244 for surficial samples and n=up to 127 for sub-surface samples). Therefore, it is concluded that concentrations of PAHs, PCBs, and/or other bioaccumulative substances occur in sediments from the GCR/IHC at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, and certain other chlorophenols, PAHs, and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Comparison of the available data on the levels of COPCs in the edible tissues of goldfish, white sucker, channel catfish, gizzard shad, sunfish, pumpkinseed, and carp from the GCR/IHC to the selected benchmarks for tissue chemistry indicates that mercury and PCBs frequently occurred at concentrations sufficient to injure human uses of fishery resources. Overall, 83% (70 of 87 samples) of the fish tissue samples collected from GCR/IHC had concentrations total PCBs that exceeded the tolerance levels that have been established by the USFDA. In addition, the Group 1 threshold concentrations of mercury and PCBs that were established by the ISDH were commonly exceeded in the edible tissues of fish from this portion of the Assessment Area (i.e., 6 of 86 samples for mercury and 87 of 87 samples for total PCBs). Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs have occurred at concentrations sufficient to injure human uses of fishery resources in the GCR/IHC. Organochlorine pesticides (i.e., chlordane) in the edible tissues of fish only rarely posed a potential risk to human health, based on comparisons to the USFDA action levels. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if certain other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

In 1986, the Indiana State Board of Health (ISBH; which is now referred to as ISDH) advised the public to not eat any fish caught in the GCR/IHC due to the high levels of contamination in fish tissues. Since that time, FCAs have been explicitly issued in 12 additional years, including 1989 to 1994 and 1997 to 2002. As the 1986 and 1994 FCAs were not revoked by ISDH, it is reasonable to assume that these FCAs remained in effect during 1987 to 1988 and 1995 to 1996, respectively. Therefore, it is concluded that human uses of fishery resources in the GCR/IHC were injured during the period 1986 to 2002 as a result of the accumulation of mercury and PCBs in fish tissues.

Three lines of evidence, including information on sediment chemistry, tissue chemistry, and FCAs, were used to determine if injury to human uses of fishery resources has occurred within the GCR/IHC. All three lines of evidence indicate that human uses of fishery resources in the GCR/IHC have been injured, particularly due to the presence of mercury, PCBs, and/or chlordane in environmental media (i.e., whole sediments and edible fish tissues). Therefore, it is concluded that human uses of fishery resources in the GCR/IHC have been injured as a result of discharges of oil or releases of other hazardous substances.

Grand Calumet River Lagoons - Comparison of the measured levels of COPCs in whole sediment samples with the benchmarks for sediment chemistry indicate that a number of COPCs occur in GCRL sediments at concentrations sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. There were exceedances of one or more of the selected benchmarks for the protection of human health in all of the samples from this portion of the Assessment Area in which the concentrations of PAHs, PCBs, and/or organochlorine pesticides were measured (i.e., n=up to 127 for surficial samples and n=up to 2 for sub-surface samples). Therefore, it is concluded that concentrations of PAHs, PCBs, and/or other bioaccumulative substances occur in sediments from the GCRL at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, chlorophenols, tetrachlorodibenzo-*p*-dioxin - toxic equivalents (TCDD-TEQs), and certain other PAHs and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Evaluation of available tissue chemistry data indicate that the levels of certain COPCs occurred in the edible tissues of carp, largemouth bass and/or bluegills at concentrations sufficient to injure human uses of fishery resources. While the USFDA action levels or tolerance levels were never exceeded in fish tissue samples collected from GCRL, the levels of mercury in 14% (i.e., 3 of 21 samples) and total PCBs in 100% (i.e., n=25) of the samples exceeded the Group 1 threshold levels that have been established by the ISDH. Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs have occurred at concentrations sufficient to injure human uses of fishery resources in the GCRL. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

FCAs have been issued for three species of fish from the GCRL. The FCAs on largemouth bass and carp have been effect from 1996 to 2002. In 1999, the ISDH also issued a FCA on bluegills. Therefore, it is concluded that human uses of fishery resources in the GCRL were injured during the period 1996 to 2002 as a result of the accumulation of PCBs in fish tissues.

Three lines of evidence, including information on sediment chemistry, tissue chemistry, and FCAs, were used to determine if injury to human uses of fishery resources has occurred within the GCRL. All three lines of evidence indicate that human uses of fishery resources in the GCRL have been injured, particularly due to the presence of mercury and PCBs in environmental media (i.e., whole sediments and edible fish tissues). Therefore, it is concluded that human uses of fishery resources in the GCRL have been injured as a result of discharges of oil or releases of other hazardous substances.

Indiana Harbor and the Nearshore Areas of Lake Michigan - Although fewer sediment chemistry data are available for IH/LM than are available for the other portions of the Assessment Area, evaluation of these data indicate that sediments from the IH/LM have conditions that are sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. There were exceedances of one or more of the selected benchmarks for the protection of human health in all of the samples from this portion of the Assessment Area in which the concentrations of PAHs, PCBs, organochlorine pesticides and/or other bioaccumulative substances were measured (i.e., n=up to 30 for surficial samples). No data were available on the chemical composition of sub-surface sediments. Therefore, it is concluded that concentrations of PAHs, PCBs, and other bioaccumulative substances occur in IH/LM sediments at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, chlorophenols, and certain other PAHs and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

The available data on COPC concentrations in the edible fish tissues of brown trout, carp, gizzard shad, longnose sucker, sunfish, and yellow perch were compared to the selected benchmarks for tissue chemistry to determine if injury to human uses of fishery resources has occurred within IH/LM. The results of this evaluation indicate that the USFDA tolerance level for PCBs was exceeded in 18% (i.e., 4 of 22 samples) fish tissue samples from IH/LM. In addition, 19% (4 of 21 samples) and 86% (i.e., 19 of 22 samples) of the fish tissue samples from this portion of the Assessment Area had concentrations of mercury and total PCBs, respectively, that exceeded the Group 1 threshold levels that were established by the ISDH. Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs have occurred at concentrations sufficient to injure human uses of fishery resources in IH/LM. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

The first FCA for Lake Michigan was issued by the ISBH in 1977 to address concerns related to the accumulation of COPCs in lake trout. Between 1983 and 1989, the FCA was expanded to include various other fish species that were caught in the Lake Michigan sport fishery, including carp, catfish, brown trout, chinook salmon, coho salmon, and steelhead. The FCA that was issued in 1986 explicitly included all fish species caught in Indiana Harbor. Between 1990 and 2002, FCAs were issued each year to provide the public with guidance on the consumption of sport-caught fish from Lake Michigan and associated tributaries. In total, these FCAs restricted consumption of more than 30 species of fish that occur in Indiana Harbor and/or the nearshore areas of Lake Michigan during 1977, 1983, 1985 to 1987, and 1989 to 2002. As the 1977, 1983, and 1987 FCAs were not revoked by ISDH, it is reasonable to assume that these FCAs were also in effect during 1978 to 1982, 1984, and 1988. Therefore, it is concluded that human uses of fishery resources in Indiana Harbor and the nearshore areas of Lake Michigan were injured during the period 1977 to 2002 as a result of the accumulation of mercury, PCBs, chlordane, dieldrin, and/or DDTs in fish tissues.

Three lines of evidence, including information on sediment chemistry, tissue chemistry, and FCAs, were used to determine if injury to human uses of fishery resources has occurred within IH/LM. All three lines of evidence indicate that human uses of fishery resources in the IH/LM have been injured, particularly due to the presence of mercury, PCBs, chlordane, dieldrin, and DDTs in environmental media (i.e., whole sediments and edible fish tissues). Therefore, it is concluded that human uses of fishery resources in IH/LM have been injured as a result of discharges of oil or releases of other hazardous substances.

Contaminants of Concern

In this investigation, COCs were identified as those substances that occurred in whole sediments and/or edible fish tissues at concentrations that are sufficient to cause or substantially-contribute to injury to human uses of fishery resources. For each area, the sediment-associated COCs were identified as those substances that occurred in two or more whole-sediment samples at concentrations in excess of the corresponding chemical benchmark. Likewise, the tissue-associated COCs for an area included those substances that occurred in one or more fish tissue samples at concentrations in excess of the corresponding chemical benchmark (i.e., the tolerance levels or action levels that have been promulgated by the USFDA **or** the Group 1 threshold levels that have been established by ISDH to support the development of FCAs). Finally, the FCAs that have been issued for the GCR/IHC, for the GCRL, and for IH/LM were reviewed to determine which substance or substances were considered to be responsible for the risk to human health. A substance that was identified as a COPC and that was identified as either a tissue-associated COC or a substance that had driven one or more FCAs was designated as a principal COC. Substances that were identified as sediment-associated COCs, but for which there were no available tissue benchmarks or measured tissue chemistry (i.e., not identified as tissue-associated COCs) were not identified as principal COCs. The principal COCs are those substances that have been demonstrated to be associated with injury.

Grand Calumet River and Indiana Harbor Canal - The sediment-associated COCs in the GCR/IHC include benzene, benz[a]anthracene; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, carbazole, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, total PCBs, chlordane, dieldrin, endrin, heptachlor, heptachlor epoxide, beta-hexachlorocyclohexane, lindane, p,p’-DDD, p,p’-DDE, p,p’-DDT, and TCDD-TEQs.

Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. Comparison of the tissue chemistry data to the selected benchmarks for assessing hazards to human health associated with the consumption of fish tissues indicated that mercury, PCBs, and chlordane are the tissue-associated COCs in the GCR/IHC. Mercury and/or PCBs were identified as the substances responsible for the issuance of FCAs in the GCR/IHC between 1996 and 2002. Therefore, it is concluded that mercury and PCBs are the principal COCs in the GCR/IHC; additional benchmarks for tissue chemistry are needed to confirm that other COPCs (e.g., various PAHs, certain organochlorine pesticides, or TCDD-TEQs) occur in fish tissues at levels sufficient to injure human uses of fishery resources.

Grand Calumet River Lagoons - The sediment-associated COCs in the GCRL include benz[a]anthracene; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, Aroclor 1242, Arclor 1248, Aroclor 1254, Aroclor 1260, total PCBs, chlordane, dieldrin, endrin, p,p'-DDD, p,p'-DDE, and p,p'-DDT. Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. In fish tissues, the substances that exceeded the USFDA action levels, the USFDA tolerance levels, or the ISDH Group 1 threshold levels included mercury and total PCBs. Based on the information provided in the Indiana FCA, PCBs were identified as the substances responsible for the issuance of FCAs in the GCRL between 1996 and 2002. Therefore, it is concluded that mercury and PCBs are the principal COCs in the GCRL; additional benchmarks for tissue chemistry are needed to confirm that other COPCs (e.g., various PAHs, certain organochlorine pesticides, or TCDD-TEQs) occur in fish tissues at levels sufficient to injure human uses of fishery resources.

Indiana Harbor and the Nearshore Areas of Lake Michigan - The sediment-associated COCs in IH/LM include benz[a]anthracene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, Aroclor 1242, total PCBs, and TCDD-TEQs. Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. Both mercury and PCBs were identified as tissue-associated COCs, based on exceedances of the USFDA action levels, USFDA tolerance levels, or ISDH Group 1 threshold levels. Based on the information provided in the Indiana FCA, PCBs, chlordane, dieldrin, and/or DDTs were the substances that were responsible for the issuance of FCAs in IH/LM between 1985 and 1990. In recent years (i.e., 1996 to 2002), PCBs and mercury were identified as the causative substances. Therefore, it is concluded that mercury, PCBs, chlordane, dieldrin, and DDTs are the principal COCs in IH/LM; additional benchmarks for tissue chemistry are needed to confirm that other COPCs (e.g., various PAHs, certain organochlorine pesticides, or TCDD-TEQs) occur in fish tissues at levels sufficient to injure human uses of fishery resources.

Spatial and Temporal Extent of Injury to Human Uses of Fishery Resources

In this investigation, the areal and temporal extent of injury to human uses of fishery resources was evaluated using the information in the Indiana FCAs. More specifically, the entire geographic area covered by a FCA was considered to have conditions sufficient to injure human uses of fishery resources during each year that a FCA was in effect.

Grand Calumet River and Indiana Harbor Canal - The FCAs that have been issued for the GCR/IHC generally apply to the West Branch of the Grand Calumet River (WBGCR), East Branch of the Grand Calumet River (EBGCR) downstream of the GCRL, and the IHC. However, the FCA that was issued in 1986 also included the LGB and Indiana Harbor. Based on the information evaluated, it is apparent that FCAs have been issued each year between 1986 and 2002, with the exception of 1987 and 1988. Although it was not explicitly stated by the ISBH, it is assumed that the FCA that was issued for the GCR/IHC remained in effect through 1987 and 1988. The FCAs for this portion of the Assessment Area recommended against consumption of any fish species taken from these waters. Therefore, it is concluded that the human uses of fishery resources in the GCR and IHC have been injured by discharges of oil or releases of other hazardous substances between 1986 and 2002, a period of 17 years. The human uses of fishery resources present in the LGB were injured during 1986, a period of one year.

Grand Calumet River Lagoons - The FCAs that have been issued for the GCRL apply to the East Lagoon, West Lagoon, Little West Pond, Little East Pond, and the Middle Lagoon. Based on the information provided in the Indiana FCA, it is apparent that FCAs have been issued for the GCRL each year between 1996 and 2002. During the period 1996 to 1998, these FCAs indicated that the consumption of largemouth bass and carp should be restricted or, in some cases avoided. The FCAs issued since 1999 also recommend that the consumption of bluegills from the GCRLs be restricted or avoided. Therefore, it is concluded that the human uses of fishery resources (in particular, the uses of bluegill, largemouth bass, and carp) in the GCRL have been injured by discharges of oil or releases of other hazardous substances between 1996 and 2002, a period of seven years.

Indiana Harbor and the Nearshore Areas of Lake Michigan - In this investigation, the FCAs that have been issued for Lake Michigan (or Lake Michigan and tributaries) were considered to apply to IH/LM. In total, these FCAs restricted consumption of more than 30 species of fish that occur in Indiana Harbor and/or the nearshore areas of Lake Michigan. Fish consumption advisories have been explicitly issued for IH/LM for a total of 19 years, including 1977, 1983, 1985 to 1987, and 1989 to 2002. As the FCAs that were issued in 1977, 1983, and 1987 were not revoked by ISDH, it is concluded that human uses of fishery resources in IH/LM have been injured by discharges of oil or releases of other hazardous substances between 1977 and 2002, a period of 26 years. Although there are numerous sources of COCs within the Lake Michigan basin, it is likely that the oil and other hazardous substances originating from Indiana Harbor (and elsewhere in the Assessment Area) contributed to the loadings of COCs in tissues of fish utilizing habitats within the nearshore areas of Lake Michigan.

Acknowledgments

The authors would like to take this opportunity to gratefully acknowledge the contributions of a number of individuals in the preparation of this report. First, data and other information on the assessment area were provided by Dan Sparks, Tom Simon (USFWS), Jim Stahl, Lee Bridges, Jim Smith, Roger Koelpin, Jeffrey Ewick (IDEM), LaNetta Alexander (ISDH), Scott Cieniawski, Scott Ireland, Sreedevi Yedavalli (USEPA), and many other individuals. Project coordinator and technical oversight were provided by Jeff Loiter. Timely and comprehensive technical reviews of the document were provided by Dan Sparks (USFWS) and Jim Smith (IDEM). Outstanding technical support during data compilation, data analysis, and report preparation was provided by Yvonne Muirhead, Megan Hanacek, Mary Lou Haines, Tadd Berger (MESL), Dwayne Moore (The Cadmus Group), and Ning Wang (USGS). This report was prepared using funding provided by the United States Fish and Wildlife Service.

1.0 Introduction

The Grand Calumet River system is a relatively small drainage basin that flows through northwestern Indiana and northeastern Illinois (Figures 1, 2, and 3). The Grand Calumet River is comprised of two east-west oriented branches that meet at the southern end of the Indiana Harbor Canal (IHC; Natural Resources Trustees 1997). The East Branch of the Grand Calumet River (EBGCR) originates at the Grand Calumet River Lagoons (GCRL), just east of the United States Steel Division of USX Corporation (U.S. Steel) facility in Gary, Indiana. From the headwaters, the EBGCR flows in a westerly direction for about 10 miles to its confluence with the IHC and the West Branch of the Grand Calumet River (WBGCR; Brannon *et al.* 1989). The WBGCR extends some six miles from the IHC to the confluence with the Little Calumet River in northeastern Illinois. The WBGCR is atypical from a hydrological perspective in that the river usually flows in a westerly direction from Columbia Avenue to the confluence with the Little Calumet River (USACE 1995). However, the river can flow in either an easterly or westerly direction between Columbia Avenue and the IHC, depending on the water level in Lake Michigan (USACE 1995).

The Grand Calumet River system is connected to Lake Michigan by the IHC, US Canal (USC), and Indiana Harbor (IH; Figure 2). The IHC extends in a northerly direction from the confluence of the East and West branches of the Grand Calumet River to its junction with Lake George Branch (LGB) and USC (termed the Forks), a distance of approximately two miles. From the Forks, USC extends in a northeasterly direction for about two miles to IH. The LGB of the canal extends to the west from the Forks to the I-90 toll road (Natural Resources Trustees 1997).

Information from a number of sources indicates that the Grand Calumet River drainage basin is one of the most highly industrialized areas in the United States (Bright 1988; Brannon *et al.* 1989; Ryder 1993). Some of the industries that operate, or have operated, in the area include steel mills, foundries, chemical plants, packing plants, a distillery, a concrete/cement fabricator, oil refineries, and milling and machining companies (Ryder 1993). Permitted discharges from industrial operations, municipal wastewater treatment plants (WWTPs), and other sources contribute substantial quantities of wastewater to the river system. Non-point sources of chemicals of potential concern (COPCs) to the system include urban and industrial run-off, combined sewer overflows (CSOs), leachate or overflow from a number of wastefills or ponds, and spills of pollutants in and around industrial operations (Brannon *et al.* 1989). Releases of waste and wastewaters from these sources have resulted in the contamination of surface water, groundwater, sediment, and biota with a variety of toxic and bioaccumulative substances, including heavy metals, phenols, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, cyanide, and several other organic chemicals (Crane 1996; USGS 2000). Concerns associated with the widespread contamination of surface waters and sediments led to the International Joint Commission to designate the Grand Calumet River-Indiana Harbor complex as an Area of Concern under the Great Lakes Water Quality Agreement (IJC 1989).

To address concerns regarding historic discharges of oil or releases of other hazardous substances, the United States Fish and Wildlife Service (USFWS) and the State of Indiana (the trustees) are conducting a natural resource damage assessment (NRDA) of the Grand Calumet River, Indiana Harbor Ship Canal (including USC, IHC, and LGB), IH, and waters of nearshore Lake Michigan (Natural Resources Trustees 1997). As described in the assessment plan for the NRDA (Natural Resources Trustees 1997), the trustees are documenting the cumulative injuries resulting from exposure to multiple COPCs (i.e., due to discharges of oil or releases of other hazardous substances) and to determine the appropriate scope and scale of restoration and compensation (Natural Resources Trustees 1997). The primary COPCs in the Assessment Area (see Chapter 2 for a description of the geographic scope of the Assessment Area) are PCBs, oil and oil-related compounds (including alkanes, alkenes, naphthalenes, and PAHs), and metals (Natural Resources Trustees 1997). Other COPCs in the Assessment Area include various pesticides, chlorinated benzenes, chlorophenols, phthalates, and PCDDs/PCDFs. As many of the COPCs tend to become associated with sediments upon release into aquatic systems, sediment contamination represents a concern with respect to the restoration of beneficial water uses in this system (Ingersoll *et al.* 1997; MacDonald and Ingersoll 2000). As sediment-associated COPCs have the potential to adversely affect biological resources directly and to bioaccumulate in aquatic food webs, the presence of these substances in sediments poses hazards to a variety of ecological receptors and to human health.

1.2 Environmental Issues and Concerns in the Assessment Area

There has been a long history of industrial activities within the Grand Calumet River basin, with the land located north of the river being one of the most heavily industrialized areas in the United States (Natural Resources Trustees 1997). In response to concerns regarding environmental contamination and associated impairment of beneficial uses, the Indiana Department of Environmental Management (IDEM) and its partners developed a Stage One Remedial Action Plan for the IHC, the Grand Calumet River, and nearshore Lake Michigan in 1991 (IDEM 1991). As part of this effort, IDEM (1991) compiled information on potential sources of COPCs within the Area of Concern, which included:

- Four major permitted industrial point source dischargers [i.e., permitted under the National Pollutant Discharge Elimination System (NPDES), including U.S. Steel, E.I. du Pont de Nemours (DuPont), LTV Steel, and Inland Steel];
- 52 properties that were listed in the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) as containing potentially uncontrolled hazardous wastes that require investigation;
- More than 400 facilities that were subject to regulation under the Resource Conservation and Recovery Act (RCRA), which means that they generate, transport, treat, store, or dispose of hazardous wastes; and,
- Three municipal WWTP (i.e., that are operated by the Hammond, Gary, and East Chicago Sanitary Districts).

In total, it was estimated that the Grand Calumet River and the IHC also received more than 11 billion gallons/year of untreated stormwater via 12 CSO outfalls (IDEM 1991). The locations of existing (as of October 2000) and historic outfalls within the Assessment Area are shown in Figure 4.

Discharges of oil or releases of other hazardous substances from both historic and ongoing sources have resulted in the release of a variety of toxic and/or bioaccumulative substances into receiving water systems within the Assessment Area. Some of the substances that have been released include TOC, nutrients, metals, oil and grease, phenolics, PAHs, phthalates, pesticides, and PCBs (Bright 1988; Polls *et al.* 1993; Hoke *et al.* 1993; Dorkin 1994; Ingersoll and MacDonald 1999). However, the trustees conducting this NRDA have agreed to primarily focus the assessment on natural resource injuries and damages which are associated with releases of PCBs, oil and oil-related compounds, and metals (Natural Resources Trustees 1997). Therefore, the primary COPCs in this assessment include PCBs, four classes of petroleum hydrocarbons (including alkanes, naphthalenes, aromatics, and alkenes), and various heavy metals (including aluminum, arsenic, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, strontium, thallium, tin, titanium, and zinc). For the purposes of this assessment, the list of primary COPCs has been expanded to included other bioaccumulative substances for which sediment and tissue benchmarks have been located and for which sediment and tissue residue chemistry exist [i.e., various pesticides, chlorinated benzenes, chlorophenols, phthalates, and tetrachlorodibenzo-*p*-dioxin - toxic equivalents (TCDD-TEQs)]. The subcategory of aromatic hydrocarbons includes a variety of PAHs, 16 of which are classified as priority pollutants by the United States Environmental Protection Agency (USEPA; Natural Resources Trustees 1997).

While some of the COPCs listed above remain in the water column, many others are known to accumulate in sediments (CCME 1999). The results of numerous sediment quality assessments conducted in recent years indicate that many of these substances occur at elevated concentrations in sediments within the Assessment Area (Floyd-Browne 1993; IDEM 1994; USEPA 1996a; 1996b; Tetra Tech EM Inc. 1998; Maxim Technologies 1999; Ingersoll and MacDonald 1999). The presence of elevated concentrations of COPCs in aquatic sediments represents an environmental concern because:

- Bed sediments provide essential and productive habitats for communities of sediment-dwelling organisms, including epibenthic and infaunal organisms. These organisms include such species as scuds (amphipods), mayflies (ephemeropterans), stoneflies (plecopterans), caddisflies (trichopterans), dragonflies and damselflies (odonatans), midges (dipterans), water fleas (cladocerans), worms (oligochaetes), snails (gastropods), and clams (bivalves);

- Sediment-dwelling organisms (including epibenthic and infaunal organisms) are important elements of freshwater ecosystems, representing important sources of food for many fish and other wildlife species;
- The presence of sediment-associated COPCs in freshwater ecosystems can adversely affect sediment-dwelling organisms and other components of the ecosystem;
- Certain sediment-associated COPCs can bioaccumulate in the tissues of aquatic organisms;
- The presence of elevated levels of COPCs in the tissues of fish and/or shellfish poses a potential hazard to piscivorus wildlife species;
- The presence of elevated levels of COPCs in the tissues of fish and/or shellfish poses a potential hazard to human health; and,
- The presence of elevated levels of COPCs in the tissues of fish and/or shellfish can result in the imposition of fish consumption advisories (FCAs) that restrict human uses of fishery resources.

1.3 Study Objectives

This investigation was conducted to determine if biological resources within the Grand Calumet River and Indiana Harbor Canal, Grand Calumet River Lagoons, Indiana Harbor and the nearshore areas of Lake Michigan (i.e., the Assessment Area) have been injured due to discharges of oil or releases of other hazardous substances, as defined in 43 CFR § 11.62(f)(1)(ii and iii) in the United States Department of the Interior (USDOI) regulations for conducting NRDAs (CFR 2002). In this report, the term injury to human uses of fishery resources has been used to more specifically describe such injuries to biological resources. The USDOI regulations define a number of specific injury tests for different natural resources. These specific injury definitions (CFR 2002) include two different injury tests related to the effects of chemical contamination on human use and consumption of fish and shellfish (i.e., injury to human uses of fishery resources). According to these definitions, "injury to a biological resource has resulted from the ... release of a hazardous substance if the concentration of the substance is sufficient to ..."

- Exceed action or tolerance levels established under Section 402 of the Food, Drug, and Cosmetic Act, 21 U.S.C. 342, in edible portions of organisms [43 CFR § 11.62(f)(1)(ii)]; or,
- Exceed levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organisms [43 CFR § 11.62(f)(1)(iii)].

This report, which was prepared collaboratively by MacDonald Environmental Sciences Ltd. (MESL), United States Geological Survey (USGS), and Industrial Economics, Inc. (IEC), is intended to support the NRDA by providing an assessment of injury to biological resources within the Assessment Area. More specifically, this report has been prepared to determine if human uses of fishery resources have been injured or are likely to have been injured due to discharges of oil or releases of other hazardous substances within the Assessment Area. If the results of this assessment indicate that injuries to human uses of fishery resources have occurred within the Assessment Area, then the secondary objectives of this report are to identify the contaminants of concern (COCs; i.e., those substances that are causing or substantially contributing to injury to human uses of fishery resources) and to evaluate the spatial and temporal extent of such injuries. Companion reports, ***An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan*** (MacDonald and Ingersoll 2000) and ***An Assessment of Sediment Injury in the West Branch of the Grand Calumet River*** (Ingersoll and MacDonald 1999) were prepared to assess injuries to surface water resources and other biological resources associated with sediment contamination within the Assessment Area.

1.4 Study Approach

To support completion of the overall project objectives, a number of specific project tasks were identified, including:

- Collect, evaluate, and compile information on the levels of COPCs in whole-sediment samples collected within the Assessment Area;
- Collect, evaluate, and compile information on the levels of COPCs in fish tissue samples collected within the Assessment Area;
- Collect, evaluate, and compile information on fish FCAs that have been issued for the Assessment Area;
- Identify chemical benchmarks for sediments, relevant to human health, for the COPCs that have been identified in the Assessment Area;
- Identify chemical benchmarks for tissues, relevant to human health, for the COPCs that have been identified in the Assessment Area;
- Determine if the levels of the COPCs in whole sediments are sufficient to alter the chemical composition of fish or shellfish tissue to such an extent that the human uses of fishery resources would be adversely affected in the Assessment Area;
- Determine if the levels of the COPCs in fish tissues are sufficient to cause or substantially contribute to injury to human uses of fishery resources in the Assessment Area;
- Identify COCs in sediments and fish tissues (i.e., the substances that occur at concentrations sufficient to cause or substantially contribute to injury to human uses of fishery resources) in the Assessment Area; and,
- Determine the areal and temporal extent of injury to human uses of fishery resources in the Assessment Area.

Definitions of many of the terms that have been used in this document are provided in the Glossary of Terms and the List of Acronyms that appear at the beginning of this report.

2.0 Background

This study was conducted as part of a broader NRDA that is intended to assess injuries to a variety of natural resources that are associated with discharges of oil or releases of other hazardous substances within the Assessment Area (Natural Resources Trustees 1997; Simon *et al.* 2000). To support the development and communication of a plan for assessing natural resource damages, Natural Resources Trustees (1997) compiled relevant background information on the Assessment Area. This background information included a description of the geographic scope of the Assessment Area, the history of industrial activities within that area, the nature of the hazardous substance and oil releases into the environment, and the natural resources subject to injury resulting from these releases. Portions of this Assessment Plan for the NRDA (Natural Resources Trustees 1997) have been reproduced here (with minor edits) to provide the reader with enhanced access to this important background information.

2.1 Geographic Scope of the Assessment Area

This NRDA focuses on the Grand Calumet River, IHC, IH, and associated Lake Michigan environments, and on the riparian and upland habitats closely associated with these waters, including lands within the boundaries of the Indiana Dunes National Lakeshore. The following descriptions establish more specific boundaries for what will be referred to as the "Assessment Area".

2.1.1 Grand Calumet River

The Grand Calumet River comprises two east-west oriented branches that meet at the southern end of the IHC. The EBGCR originates at the GCRL, just east of the U.S. Steel Gary Works facility. The EBGCR flows west from this point for approximately 10 miles to its confluence with the IHC. The WBGCR usually flows both east and west, with a hydraulic divide typically present in the vicinity of Columbia Boulevard. The Assessment

Area includes the GCRL, the reach of the EBGCR from the first railway bridge located upstream of Industrial Highway (ConRail Bridge) to the confluence with the IHC, and the reach of the WBGCR between Indianapolis Boulevard and the IHC, along with the riparian, wetland, and upland habitats closely associated with these stretches of the river. In this report, the additional reaches of the EBGCR and WBGCR (i.e., EBGCR-II and WBGCR-II) were also considered to provide a more comprehensive assessment of injury to human uses of fishery resources (Figure 2).

2.1.2 Indiana Harbor Canal, US Canal, and Indiana Harbor

The IHC flows north for approximately two miles from its confluence with the east and west branches of the Grand Calumet River to the junction with LGB (which is often termed the Forks). The LGB of the canal extends to the west from the point where the main canal turns to the northeast. The USC extends in a northeasterly direction for about two miles from the Forks to IH. This portion of the Assessment Area includes all of the Federal Project Area.

2.1.3 Lake Michigan

The trustees have not defined a specific boundary within which Lake Michigan resources will be subject to assessment. The establishment of such a boundary depends upon a better understanding of injuries to Grand Calumet River and IHC resources and the nature of the relationship between the river and canal and the lake. At a minimum, the trustees committed to review existing information and assess the extent to which the Grand Calumet River and IHC contribute to the degradation or diminishment in value of lake resources and the services these resources provide.

2.1.4 Indiana Dunes National Lakeshore

The Indiana Dunes National Lakeshore is a unit of the National Park system comprising more than 12,000 acres east of and adjacent to the U.S. Steel Gary Works. The trustees included the Indiana Dunes National Lakeshore in the Assessment Area due to the park's proximity to known sources of contamination. The focus of trustee efforts was on the western portion of the park, including portions of the GCRL system. The GCRL are also known as the Marquette Park Lagoons.

2.1.5 Division of Assessment Area into Geographic Areas

To facilitate this evaluation, the Assessment Area was initially divided into nine separate reaches, including the Grand Calumet River Lagoons (GCRL), East Branch Grand Calumet River-I (EBGCR-I), East Branch Grand Calumet River-II (EBGCR-II), West Branch Grand Calumet River-I (WBGCR-I), West Branch Grand Calumet River-II (WBGCR-II), Indiana Harbor Canal (IHC), Lake George Branch (LGB), US Canal (USC) and Indiana Harbor/Lake Michigan (IH/LM; i.e., consistent with the approach used by MacDonald and Ingersoll 2000). In each of these reaches, the available sediment quality, tissue quality, and related information was collected, evaluated, and compiled. Subsequently, the data on seven of the nine reaches was consolidated to support the assessment of injury to human uses of fishery resources within the Grand Calumet River and Indiana Harbor Canal (GCR/IHC). Injury to human uses of fishery resources was also evaluated within the GCRL and IH/LM. Division of the Assessment Area into these three areas (Figure 3) facilitated implementation of a geographically consistent approach to the assessment of injury to human uses of fishery resources using all three of the indicators that were selected [i.e., sediment chemistry, tissue chemistry, and fish consumption advisories (FCAs); i.e., FCAs have been issued for these three geographic areas only].

2.2 Chemicals of Potential Concern in the Assessment Area

The trustees have focused the assessment on natural resource injuries and damages which are associated with the release of PCBs, oil and oil-related compounds, and metals. The purpose of this section is to briefly describe these three categories of chemicals, focusing on general characteristics, sources and environmental effects. Additional COPCs were identified as part of this assessment, but are not described in detail here (see Section 1.0).

2.2.1 Polychlorinated Biphenyls

PCBs are synthetic compounds that were produced commercially in the United States between 1929 and 1977, when their production in this country was subsequently banned. The principal manufacturer of PCBs in the United States was the Monsanto Chemical Co. Monsanto's PCBs were sold under the registered trademark of Aroclor.

PCBs found wide use in commercial and industrial applications due to their favorable properties, including chemical stability, low flammability, and ability to serve as an electrical insulator. Common uses of PCBs ranged from dielectric fluids in capacitors and transformers, to heat transfer fluids, hydraulic fluids, lubricating and cutting oils, to additives in pesticides, paints, copying paper, adhesives, sealants and plastics. Their most common use was in capacitor and transformer dielectric fluids. As a result of their widespread use, the release of PCBs to the environment can occur through a variety of mechanisms, including past uncontrolled use, past disposal practices, illegal disposal, and accidental releases (Erickson 1997).

The chemical stability of PCBs makes them highly persistent in the environment after they have been released. Because they are have relatively high octanol-water partitioning coefficients and low water solubilities, PCBs tend to accumulate in soils and sediments. Having accumulated in these environmental media, PCBs become available to biological organisms, typically moving through the food chain from invertebrates to fish, birds, mammals, and other wildlife. Despite general declines in observed concentrations of PCBs in wildlife since the manufacture of PCBs ceased more than twenty years ago, concentrations still occur at levels that are sufficient to cause adverse effects in exposed organisms. The results of field and laboratory studies indicate that PCBs can be associated with a range of such effects, including impaired reproductive ability in fish, mammals, and birds (Beyer *et al.* 1996; Eisler 1986).

2.2.2 Oil and Oil-Related Compounds

Oil is a term used to classify a variety of complex mixtures of organic compounds and trace elements that are commonly associated with the petrochemical industry. In general, four classes of petroleum hydrocarbons make up the non-animal or plant oils: alkanes, naphthenes, aromatics, and alkenes. Crude or refined oils have the potential to enter the environment wherever they are used, manufactured, stored, or otherwise handled. Releases to the environment can occur as a result of direct discharge to the land surface or to surface water, and can move through the environment via numerous pathways, including the discharge of ground water to surface water, and surface water runoff. Oil can be harmful to the environment as a result of both its physical and chemical properties.

A subcategory of the aromatic hydrocarbons is the group of chemicals known as PAHs. In addition to their occurrence as constituents in petroleum products, PAHs are also formed as a product of incomplete combustion. Sixteen PAHs are classified as priority pollutants by the USEPA. Exposure to PAHs has been associated with a variety of adverse effects in fish, birds, mammals, and other wildlife, including reduced growth, impaired reproduction, and mortality (Beyer *et al.* 1996).

2.2.3 Metals

Metals are naturally-occurring elements that are often found, as a result of industrial and commercial activity, at elevated concentrations in the environment. The group of metals that can be toxic, particularly at high doses, are commonly referred to as the "heavy metals." These metals include aluminum, arsenic, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, strontium, thallium, tin, titanium, and zinc. Cadmium, lead, and mercury are among the more prominent metals which have been associated with adverse effects observed in natural resources. Adverse effects associated with exposure to metals have been observed in invertebrates, fish, birds, and mammals, including reduced growth, impaired reproduction, and mortality (Beyer *et al.* 1996).

2.3 Natural Resources in the Assessment Area

Prior to the period of industrial development, the Assessment Area was characterized by a plain of coastal sediments, the most prominent features of which were the globally-rare dune and swale habitats running parallel to the shoreline. Today only scattered dune and swale remnants are preserved. Nevertheless, the Grand Calumet River and IHC environment continues to comprise a wide range of resources. Importantly, the area has the capacity to support a much richer and much more diverse suite of resources than are currently present.

The USDOI regulations (CFR 2002) define five categories of natural resources for which natural resource damages may be sought: surface water resources, ground water resources, air resources, geological resources, and biological resources. Surface water resources include both the water column and associated bed or bank sediments. The following sections briefly describe each of these categories in the context of the Assessment Area.

2.3.1 Surface Water Resources

The surface water resources in the Assessment Area are particularly important in the context of this damage assessment, as they have been and continue to be the principle receptors of hazardous substances, including oil, released to the environment. The contamination of these resources has both direct and indirect impacts on the health of biological resources. For example, contaminated sediments can cause injury to benthic invertebrate populations, which in turn can result in injuries to resident fish populations for whom the invertebrates are a source of food. Similarly, injury to invertebrates and/or fish resulting from exposure to contaminated sediments and surface water can lead to injury in local insectivorous (i.e., insect-eating) or piscivorus (i.e., fish-eating) bird populations. In addition, contaminated sediments serve as a source of continuing releases of hazardous substances to the water column.

2.3.2 Ground Water Resources

Ground water resources include the water in a saturated sub-surface zone and the rocks or sediments through which this water flows. Ground water resources serve as a potential pathway for contaminants to migrate from their source to surface water resources. Since ground water within the Assessment Area is not used as a public drinking water supply (as a result of contamination), the assessment of these resources focused on establishing if the groundwater resource represents a pathway for contaminants to migrate to surface water resources. The Calumet Aquifer, a shallow ground water aquifer within the Assessment Area, has been documented to be directly connected with the waters of the Grand Calumet River, IHC, and Lake Michigan (IDEM 1991). Injury to ground water resources has been evaluated in a separate report.

2.3.3 Air Resources

Air resources are typically assessed in the context of their ability to serve as a pathway for hazardous substances to reach, and potentially injure, other resource categories. The trustees did not consider an assessment of the air pathway to be a cost-effective use of assessment resources.

2.3.4 Geologic Resources

Geologic resources include soils and sediments that are not otherwise accounted for under the definition of surface water or ground water resources. In this NRDA, geologic resources include the soils and sediments located in upland and wetland areas closely associated with the Grand Calumet River, and the soils of lands within the Indiana Dunes National Lakeshore.

2.3.5 Biological Resources

Along with surface water resources, biological resources comprise a key component of this damage assessment. In this assessment, the trustees focused on evaluating injuries to three categories of biological resources: benthic invertebrates, fish, birds, and mammals. However, it was understood that other ecosystem components, such as amphibians and reptiles, can also be adversely affected by contaminated sediments and should be considered when sufficient information is available to do so.

3.0 Study Approach

A step-wise approach was used in this report to assess injury to human uses of fishery resources in the Assessment Area. The six main steps in this process included:

- Identification of key indicators for assessing injury to human uses of fishery resources;
- Collection, evaluation, and compilation of the existing information on key indicators of injury to human uses of fishery resources in the Assessment Area;
- Selection of chemical benchmarks for assessing injury to human uses of fishery resources in the Assessment Area (including bioaccumulation-based benchmarks for sediment quality and tissue residue benchmarks for the protection of human health);
- Assessment of injury to human uses of fishery resources within the three major areas of the Assessment Area (Figure 3);
- Identification of COCs in the Assessment Area; and,
- Determination of the areal and temporal extent of injury to human uses of fishery resources in the Assessment Area.

Each of these steps is described in the following sections of this report.

3.1 Identification of Key Indicators for Assessing Injury to Human Uses of Fishery Resources

This investigation was conducted to determine if biological resources within the Grand Calumet River and Indiana Harbor Canal, Grand Calumet River Lagoons, Indiana Harbor and the nearshore areas of Lake Michigan (i.e., the Assessment Area) have been injured due to discharges of oil or releases of other hazardous substances, as defined in 43 CFR §

11.62(f)(1)(ii and iii) in the USDOI regulations for conducting NRDAs (CFR 2002). In this report, the term injury to human uses of fishery resources has been used to more specifically describe such injuries to biological resources. This assessment of injury to human uses of fishery resources was conducted to determine if the concentrations of COPCs in whole sediments and/or fish tissues are sufficient to adversely affect human health and/or the human uses of fishery resources. Therefore, it was necessary to identify key indicators for assessing injury to human uses of fishery resources. A total of three types of information were used, as available, to evaluate injury to human uses of fishery resources, including:

- Chemistry of whole sediments;
- Chemistry of fish tissues; and,
- Presence of FCAs.

While any of these indicators could be used alone to determine if injury to human uses of fishery resources has occurred within the Assessment Area, agreement among multiple indicators of injury increases the level of confidence that can be placed on the overall evaluation. The benchmarks that were used to evaluate the information on these three indicators of injury to human uses of fishery resources are described in Section 3.3.

3.2 Collection, Evaluation, and Compilation of Data and Related Information on Key Indicators

Information on the chemical characteristics of sediments and fish tissues in the Assessment Area was collected from a variety of sources to support this assessment of injury to human uses of fishery resources. Importantly, USFWS and IDEM forwarded copies of a number of reports that provided information on sediment and fish tissue quality conditions within the Assessment Area, including the results of several recent investigations that were conducted explicitly to support the current assessment (i.e., Tetra Tech EM Inc. 1998; Maxim Technologies 1999; IDEM 1999; Table 1). In addition, the fish tissue chemistry data that have been assembled by the State of Indiana to support the development of the statewide

FCA were obtained directly from IDEM. Information on the FCAs that have been issued recently (i.e., since 1995) for the Grand Calumet River and Indiana Harbor Canal was obtained by accessing the Indiana FCA reports. Information on the FCAs that were issued prior to 1995 was obtained by contacting representatives of the Indiana State Department of Health (ISDH) and IDEM.

All of the data sets that were retrieved during the course of the study were critically reviewed to determine their applicability to the assessment of injury to human uses of fishery resources in the Assessment Area. The criteria that were used to evaluate each of the candidate data sets are described in Appendix 2 of this report. The data sets that contained information on the Assessment Area and met the selection criteria were incorporated into electronic data files (in MS Excel format). These data were subsequently fully verified against the original data source.

Several types of data were compiled as part of this study. First, the information of the chemical composition of whole sediments (Appendix 3) was compiled for both surficial and sub-surface sediment samples. The data summaries for each geographic area, and the entire Assessment Area, include the number of samples collected (n), 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles, geometric mean and standard deviation, mean, and range for each COPC (See Appendix 4). In addition, information on the levels of COPCs in the tissues of fish were also assembled, as available (Figures 9 to 53; Appendix 5). Other relevant data, such as information on conventional indicators of sediment quality conditions (i.e., NH_3, SOD, TOC, and DO) were also obtained from the studies that were assembled on the Assessment Area.

In a number of studies, additional sediment or fish tissue samples were collected and/or analyzed as part of the quality assurance program. In this report, field replicate samples were treated as unique samples in the data analyses (i.e., by providing information on the small scale spatial variability in sediment quality conditions). By comparison, laboratory split samples were treated as duplicates and averaged to support subsequent data analysis.

Several types of fish tissue samples have been collected within the Assessment Area, including whole body, skin-on fillets, and skin-off fillets. The data on the concentrations of COPCs in skin-on fillets and skin-off fillets were used directly to assess injury to human uses of fishery resources. However, the tissue residue data for whole body samples were first converted to corresponding levels in fish fillets before using them in the assessment of injury to human uses of fishery resources. More specifically, the USEPA-recommended conversion factors (i.e., 0.7 for mercury and 1.35 for pesticides and PCBs) were used to estimate COPC concentrations in fillets from the whole body data (USEPA 2000).

To support subsequent interpretation of the sediment and tissue chemistry data, the total concentrations of several chemical classes were determined for each sediment sample. For PCBs in sediment, the concentrations of total PCBs were determined using various procedures, depending on how the data were reported in the original study. If only the concentrations of total PCBs was reported in the study, then those values were used directly. If the concentrations of various Aroclors (e.g., Aroclor 1242, Aroclor 1248) were reported, then the concentrations of the various Aroclors were summed to determine the concentration of total PCBs. In fish tissue samples, the reported concentration of total PCBs was used preferentially because such results were available for all samples. For DDTs, the concentrations of p,p'-DDD and o,p'-DDD, p,p'-DDE and o,p'-DDE, and p,p'-DDT and o,p'-DDT were summed to calculate the concentrations of sum DDD, sum DDE, and sum DDT, respectively. Total DDTs was calculated by summing the concentrations of sum DDD, sum DDE, and sum DDT. In tissue residue samples, the sum concentrations of aldrin and dieldrin, as well as heptachlor and heptachlor epoxide were determined. Finally, the concentrations of chlordane in sediment were determined by summing the concentrations of alpha- and gamma-chlordane isomers. If only the concentrations of total chlordane were reported in the study, then those values were used directly. In tissue residue samples, the concentration of total chlordane was determined by summing the concentrations of up to five isomers (i.e., alpha- and gamma-chlordane, cis- and trans-nonachlor, and oxychlordane).

Less than detection limit data was treated in several ways, depending on the guidance that has been provided in conjunction with the chemical benchmarks for sediment chemistry and tissue chemistry. In calculating the total concentrations of the various classes of COPCs in sediments, less than detection limit values were assigned a value of one-half of the detection, except when the detection limit was greater than the selected chemical benchmark. In this latter case, the greater than detection limit value was not used in the calculation of the total concentration of the substance or in the assessment of injury to human uses of fishery resources. For tissue samples, less than detection limit data and low level detects were treated as zero in accordance with the guidance provided by the USFDA (2001) to facilitate comparison with the tolerance or action levels. By comparison, less than detection limit data for tissue chemistry were assigned a value of one-half of the detection to facilitate comparison with the thresholds used to develop the Indiana FCAs (Anderson *et al.* 1993). When the detection limit was greater than the selected benchmark for fish tissue chemistry, then the result was not used in the assessment of injury to human uses of fishery resources.

To support the compilation and subsequent analysis of the information on sediment chemistry and tissue chemistry, a relational project database was developed in MS Access format. To the extent possible, the sediment chemistry and tissue chemistry data compiled in the database were georeferenced to facilitate mapping and spatial analysis using geographic information system (GIS)-based applications [i.e., Environmental Systems Research Institute, Inc. (ESRI's) ArcView and Spatial Analyst programs]. In some cases sample locations were estimated using maps or descriptions provided in the report). The database structure made it possible to retrieve data in several ways, including by data type (i.e., sediment chemistry vs. tissue chemistry), by sediment horizon (i.e., surficial vs. sub-surface sediments), by fish species (carp vs. gizzard shad), by geographic area [i.e., GCRL vs. Grand Calumet River and the Indiana Harbor Canal (GCR/IHC)], and by date. As such, the database facilitated a variety of different types of data analyses.

3.3 Selection of Benchmarks for Assessing Injury to Human Uses of Fishery Resources

A total of three indicators were selected for assessing injury to human uses of fishery resources associated with releases of oil or discharges of other hazardous substances in the Assessment Area. As such, assessment of injury to human uses of fishery resources necessitated the identification and application of three types of benchmarks, including:

- Chemical benchmarks for assessing potential effects on human health associated with the bioaccumulation of COPCs from contaminated sediments (Table 2);

- Chemical benchmarks for assessing potential effects on human health associated with the consumption of contaminated fish and shellfish tissues (Tables 3 and 4); and,
- Criteria for assessing the effects on the human uses of fishery resources associated with the issuance of FCAs.

The benchmarks or criteria that were selected to support the current assessment of injury to human uses of fishery resources in the Assessment Area are described in the following sections.

Sediment Chemistry - Many of the COPCs in the Assessment Area have the potential to accumulate in the tissues of sediment-dwelling organisms. Because many benthic and epibenthic species represent important components of the food web, sediment-associated COPCs can be transferred to higher trophic levels in aquatic food webs (e.g., fish and shellfish). In this way, contaminated sediments represent a potential hazard to humans that consume aquatic organisms. While assessments of bioaccumulation can be conducted in several ways, bioaccumulation-based sediment quality guidelines (SQGs) provide practical tools for evaluating sediment quality relative to the potential for adverse effects on human health associated with the accumulation of COPCs in the tissues of aquatic organisms (Cook *et al.* 1992).

Bioaccumulation-based SQGs are important tools for conducting sediment quality assessments for several reasons. First and foremost, bioaccumulation-based SQGs explicitly consider the potential for accumulation of sediment-associated COPCs in fish and shellfish. In addition, the bioaccumulation-based SQGs provide a basis for interpreting sediment chemistry data in terms of the potential for adverse effects on human health. Therefore, sediment chemistry data, relative to bioaccumulation-based SQGs for the protection of human health, were used in this report as indicators for assessing injury to human uses of fishery resources in the Assessment Area.

Bioaccumulation-based SQGs define the concentrations of individual chemicals or classes of chemicals in sediments that will not result in unacceptable levels of COPCs in the tissues of aquatic organisms (Ingersoll *et al.* 1997). The first step in the development of such SQGs involves the derivation or selection of an appropriate tissue residue benchmark for the substance or substances under consideration (e.g., action levels or tolerance levels established under Section 402 of the Food, Drug, and Cosmetic Act). In addition, relationships between concentrations of COPCs in sediments and chemical residues in aquatic biota must be established. In general, the necessary lipid- and carbon-normalized biota-sediment bioaccumulation factors (BSAFs) are determined from field studies or estimated using various modeling approaches. The SQGs are then derived by dividing the tissue residue benchmark by the BSAF (Cook *et al.* 1992).

At least two jurisdictions in the United States have established numerical bioaccumulation-based sediment quality criteria (SQCs) for the protection of human health, including the New York State Department of Environmental Conservation (NYSDEC 1999) and the Washington State Department of Health (WSDOH 1995; 1996). The SQCs that were promulgated by the NYSDEC (1999) were derived for various COPCs using the equilibrium partitioning approach. Using this approach, a numerical SQC was derived for a substance by multiplying the bioaccumulation-based water quality criterion (WQC) by the corresponding octanol-water partition coefficient (K_{ow}). One of the assumptions underlying this approach is that bioaccumulation of sediment-associated COPCs occurs primarily due to exposure to pore water. By comparison, the SQCs that were established by the WSDOH (1995; 1996) were generated using a risk-based procedure that more explicitly considers the various exposure routes that can lead to the accumulation of COPCs in the tissues of aquatic organisms. More specifically, a numerical SQC was derived for a substance by dividing the tolerable concentration of the substance in tissues by the product of the lipid content of the tissue and the BSAF. As the BSAF can be established using field studies or modeling, it typically considers exposure of aquatic organisms to COPCs via multiple routes. In both cases, the resulting SQCs are expressed on an organic carbon-normalized basis.

In this investigation, the SQCs that were established by the WSDOH (1995;1996) were selected for assessing injury to human uses of fishery resources in the Assessment Area. These SQCs were selected because they more directly address the exposure pathways of concern within the Assessment Area. That is, the selected SQCs explicitly consider the bioaccumulation of COPCs due to exposure from all sources (i.e., as evaluated primarily by field-derived BSAFs) rather than from exposure to pore water only. Sediment samples with concentrations of one or more COPCs in two or more samples (separated by 100 feet) in excess of the selected chemical benchmarks were considered to have conditions sufficient to injure human uses of fishery resources. A listing of the SQCs that have been established by the WSDOH (1995;1996) for the protection of human health is presented in Table 2.

Tissue Chemistry - Although many sediment-associated COPCs can adversely affect sediment-dwelling organisms, concerns relative to human health are primarily associated with those substances that accumulate in the tissues of sediment-dwelling organisms. Because many benthic and epibenthic species represent important components of the food web, sediment-associated COPCs can be transferred to higher trophic levels, such as fish and shellfish. In this way, contaminated sediments represent a potential hazard to human health (i.e., dietary exposure).

Data on the concentrations of COPCs in the tissues of aquatic organisms (i.e., fish and shellfish) provides important information for assessing the potential effects of discharges of oil or releases of other hazardous substances on human health. More specifically, tissue chemistry data provide information on the extent to which bioaccumulative substances have accumulated in the tissues of sediment-dwelling organisms and fish and shellfish. Comparison of these data to relevant tissue residue benchmarks provides a basis for determining if COPCs have accumulated in the tissues of aquatic organisms to such an extent that adverse effects on human health could occur if those tissues were consumed by the human population.

In this investigation, the data on the levels of COPCs in fish tissues were compared to two types of tissue residue benchmarks. First, the tissue chemistry data were compared to the action levels or tolerance levels that have been established by the USFDA under Section 402 of the Food, Drug, and Cosmetic Act (21 U.S.C. 342) for the edible portions of fish and shellfish. A summary of the historic and current tolerance levels and action levels that have been established by the United States Food and Drug Administration (USFDA) for selected environmental contaminants and pesticides (i.e., PCBs, methylmercury, chlordane, DDT and metabolites, aldrin and dieldrin, heptachlor and heptachlor epoxide, chlordecone (kepone), and mirex are presented in Table 3. Because most of the mercury in fish tissues occurs as methylmercury, the USFDA action level of methylmercury was applied to the data on the levels of mercury in fish tissues. The USFDA refined the tolerance level for PCBs in 1984 and the action level for methylmercury in 1979 (Table 3); the benchmark that was in effect the year tissue samples were collected was applied to the tissue chemistry data for the purposes of identifying exceedances of the relevant tissue chemistry benchmarks.

Although the USFDA action levels and tolerance levels provide important tools for evaluating fish and shellfish tissue quality (especially for fish and shellfish that are caught and sold commercially), there is general agreement that these benchmarks are not adequately protective of public health (Anderson *et al.* 1993). For this reason, the Great Lakes Sport Fish Consumption Advisory Task Force developed a protocol for establishing uniform sport FCAs in the Great Lakes that would maintain the health benefits associated with fish consumption, minimize the potential for angler exposure to toxic chemicals, use credible and understandable science, and present the information in a manner conducive to maximal voluntary compliance (Anderson *et al.* 1993). The cornerstone of this protocol is the derivation of a health protection value (HPV) for each substance that is associated with tolerable cancer and/or developmental/reproductive risks (i.e., an acceptable daily intake rate or reference dose). The HPV is then used, together with information on the body weight of the target consumer group, the daily consumption rate of fish tissues, and reductions in chemical concentrations during preparation and cooking, to establish thresholds (i.e., concentration ranges) for categorizing fish into one of five advisory groups (i.e., Groups 1 to 5; Stahl and Simon 2000). The recommended spacing (e.g., one meal per week) of Indiana sport-caught fish meals are then specified for each advisory group. Restrictions on the consumption of sport-caught fish are advised when the upper threshold for Group 1 fish is exceeded (note: although there are no restrictions on consumption for fish species with COPC concentrations less than the Group 1 advisory threshold, there are recommendations to limit consumption of undesignated species in named waterways and all waterways not listed in the advisory). Such thresholds are currently available for mercury (0.16 milligrams/kilogram wet weight (mg/kg WW) and total PCBs (50 :g/kg WW for skin-on scaleless fillets) only (Table 4; Stahl and Simon 2000).

For the purposes of identifying exceedances of the tissue chemistry benchmarks, the tissue chemistry data were compared to the relevant threshold level for the two types of sample preparations (i.e., skin on scaleless fillets and skin off fillets). Tissue samples with concentrations of one or more COPCs in one or more samples in excess of the selected chemical benchmarks were considered to have conditions sufficient to injure human uses of fishery resources.

Fish Consumption Advisories - Although data on sediment chemistry and tissue chemistry provide important information for assessing the potential effects of sediment- and tissue-associated COPCs on human health, the actual hazards posed by bioaccumulative substances can be mitigated, at least in part, through the issuance of FCAs. Such FCAs are intended to provide human consumers of fish and shellfish with information regarding the benefits and risks associated with the consumption of sport-caught fish. Because recreational and subsistence fishing are socially-, economically-, and culturally-important activities, the issuance of FCAs represents an injury to human uses of fishery resources. Under the USDOI regulations (CFR 2002), biological resources have been injured if edible fish and/or shellfish tissues contain concentrations of a hazardous substance sufficient to exceed levels for which an appropriate state health agency has issued directives to limit or ban the consumption of such tissues (43 CFR § 11.62). The issuance of a FCA (i.e., restrictions on fish and wildlife consumption) is also considered to be a use impairment under the Great Lakes Water Quality Agreement (IJC 1997).

In Indiana, responsibility for issuing FCAs is vested in ISDH, IDEM, and the Indiana Department of Natural Resources (IDNR). Each year, representatives from these three agencies meet to discuss the recent fish monitoring data and to develop the new statewide FCA (e.g., ISDH, IDEM, and IDNR 2002). Such FCAs are developed using risk-based procedures that consider the segment of the population that may be adversely affected by consuming fish tissues (e.g, adult males, women planning to have children, pregnant or breast-feeding women, and children), the frequency of consumption of tissue-associated COPCs, source of the fish (i.e., water body), and the levels of COPCs in the tissues of fish of various species and sizes from each water body. Accordingly, fish of various species and sizes are classified into one of five categorical groups for each water body, which specify the recommended frequency of consumption of Indiana sport-caught fish, including:

- Group 1: *General Population* - unlimited consumption for adult males and females; *Sensitive Population* - restrict consumption to one meal per week for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15;

- Group 2: *General Population* - restrict consumption to one meal per week for adult males and females; *Sensitive Population* - restrict consumption to one meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15;
- Group 3: *General Population* - restrict consumption to one meal per month for adult males and females; *Sensitive Population* - no consumption for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15;
- Group 4: *General Population* - restrict consumption to one meal every two months for adult males and females; *Sensitive Population* - no consumption for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15; and,
- Group 5: *General and Sensitive Population* - no consumption.

In this investigation, the issuance of Group 2, 3, 4, or 5 FCAs on one or more fish species (and/or size classes) was considered to provide the necessary and sufficient evidence of an injury to human uses of fishery resources within the Assessment Area.

3.4 Assessment of Injury to Human Uses of Fishery Resources

Discharges of oil or releases of other hazardous substances into aquatic ecosystems have the potential to cause injury to surface water resources and/or to biological resources (Natural Resources Trustees 1997), including sediments, sediment-dwelling organisms, wildlife, and/or human health. Assessments of injury to sediments, sediment-dwelling organisms, and wildlife within the Assessment Area were conducted previously (Ingersoll and MacDonald 1999; MacDonald and Ingersoll 2000). This investigation was conducted to determine if biological resources within the Grand Calumet River and Indiana Harbor Canal, Grand Calumet River Lagoons, Indiana Harbor and the nearshore areas of Lake Michigan (i.e., the Assessment Area) have been injured due to discharges of oil or releases of other hazardous substances, as defined in 43 CFR § 11.62(f)(1)(ii and iii) in the USDOI regulations for conducting NRDAs (CFR 2002). In this report, the term injury to human uses of fishery resources has been used to more specifically describe such injuries to biological resources. The definitions of injury to biological resources included in the USDOI regulations were generally applied in this investigation to assess the effects of chemical contamination on human use and consumption of fish and shellfish (i.e., injury to human uses of fishery resources). Injury to human uses of fishery resources was assessed for each of the areas defined above [i.e., the GCR/IHC, GCRL, and Indiana Harbor/ Lake Michigan (IH/LM)]. Three separate lines of evidence were used to determine if injury to human uses of fishery resources had occurred in these geographic areas. More specifically, injury to human uses of fishery resources was considered to have occurred if:

- The concentrations of one or more COPCs in two or more whole-sediment samples from an area (i.e., separated by more than 100 feet) exceeded the selected chemical benchmarks for the protection of human health;
- The concentrations of one or more COPCs in one or more fish tissue samples from an area exceeded the selected chemical benchmarks for the protection of human health (i.e., the tolerance levels or action levels that have been established by the USFDA or the thresholds that have been used by the State of Indiana to establish FCAs); or,
- FCAs have been issued for one or more species of fish within an area.

3.5 Identification of Contaminants of Concern in Sediments and Fish Tissues

In this report, COCs are defined as those substances that occur in sediments and/or fish tissues at concentrations that are sufficient to cause or substantially contribute to injury to human uses of fishery resources. The COCs were identified by comparing the concentrations of each substance that has been measured in whole sediment and fish tissue samples to the corresponding chemical benchmarks. The chemical benchmarks that were used in this evaluation included the published bioaccumulation-based SQCs for the protection of human health (Table 2) and the published tissue residue benchmarks for the protection of human health [including the tolerance levels or action levels that have been established by USFDA (2001) and the thresholds that have been used by the State of Indiana to establish FCAs - Stahl and Simon 2000; Tables 3 and 4]. Those substances that occurred in sediments or fish tissues within a geographic area at concentrations in excess of the selected chemical benchmarks were identified as sediment-associated or tissue-associated COCs (i.e., in two or more sediment samples or one or more tissue samples). In addition, the FCAs that have been issued for the three portions of the Assessment Area (i.e., GCR/IHC, GCRL, and IH/LM) were reviewed to determine which substance or substances were considered to be responsible for the risk to human health. A substance that was identified as a COPC and that was identified as either a tissue-associated COC or a substance that had driven one or more FCAs was designated as a principal COC. Substances that were identified as sediment-associated COCs, but for which there were no available tissue benchmarks or measured tissue chemistry (i.e., not identified as tissue-associated COCs) were not identified as principal COCs. The principal COCs are those substances that have been demonstrated to be associated with injury.

3.6 Evaluation of the Spatial and Temporal Extent of Injury to Human Uses of Fishery Resources

In this evaluation, sediment chemistry, tissue chemistry, and FCAs were used as the primary indicators of injury to human uses of fishery resources. To facilitate an evaluation of the spatial extent of injury to human uses of fishery resources, the available sediment chemistry and tissue chemistry data were tabulated for each of the three geographic areas within the Assessment Area (i.e., GCR/IHC, GCRL, and IH/LM). As such, it was possible to calculate the proportion of sediment or tissue samples within each geographic area that had levels of chemical contamination that were sufficient to cause or substantially contribute to injury to human uses of fishery resources. Human uses of fishery resources within geographic areas with two or more sediment samples (separated by more than 100 feet) with elevated levels of sediment-associated COPCs (as indicated by one or more exceedances of the selected chemical benchmarks) were considered to have been injured by discharges of oil or releases of other hazardous substances. Likewise, geographic areas with one or more fish tissue samples with elevated levels of COPCs (as indicated by one or more exceedances of the selected chemical benchmarks) were considered to have conditions sufficient to injure human uses of fishery resources.

Although sediment chemistry and tissue chemistry data were used to identify the presence of conditions sufficient to injure human uses of fishery resources, the spatial and temporal extent of injury to human uses of fishery resources was evaluated using information on the FCAs than have been issued for the Assessment Area. More specifically, the information on the scope of the geographic area that was covered by a FCA was used to identify the spatial extent of injury to human uses of fishery resources. By comparison, the temporal extent of injury to human uses of fishery resources was evaluated by compiling the information on the FCAs that were issued for each geographic area each year and determining the number of years that such FCAs were in effect.

4.0 Existing Information Relevant to Human Uses of Fishery Resources in the Assessment Area

This report was prepared to determine if discharges of oil or releases of other hazardous substances have caused or substantially contributed to injury to human uses of fishery resources within the Assessment Area. The geographic scope of the Assessment Area is outlined in Figures 1, 2, and 3. To support the assessment of sediment injury, MacDonald and Ingersoll (2000) divided the Assessment Area into nine separate reaches (Figure 2). By comparison, the Assessment Area was divided into three geographic areas in this investigation to facilitate assessment of injury to human uses of fishery resources, including:

- Grand Calumet River/Indiana Harbor Canal [GCR/IHC; which includes the East Branch of the Grand Calumet River (EBGCR-I and EBGCR-II), West Branch of the Grand Calumet River (WBGCR-I and WBGCR-II), Indiana Harbor Canal (IHC), Lake George Branch (LGB), and US Canal (USC)];
- Grand Calumet River Lagoons (GCRL); and,
- Indiana Harbor and the nearshore areas of Lake Michigan (IH/LM; i.e., including the inner harbor, the outer harbor, and nearshore areas of the lake).

This alternate system for dividing up the Assessment Area was adopted because it corresponds with the geographic areas that were used by ISDH, IDEM, and IDNR (2002) to develop the Indiana FCA.

This assessment was conducted using data and information on sediment chemistry, fish tissue chemistry, and FCAs that have been collected over roughly the past 25 years. Over that time, a substantial quantity of data on environmental conditions has been collected in the Assessment Area. In total, more than 120 documents relating to the Assessment Area were identified and retrieved to acquire candidate data sets for possible inclusion in the project database. Each of these studies was then critically reviewed to determine if it contained relevant information for assessing injury to human uses of fishery resources within the Assessment Area (see Appendix 2 for a listing of the criteria that were used to evaluate candidate data sets). A brief description of each study is provided in the following sections, including the reaches that were sampled and the types of data that were reported in the study.

4.1 Data Collected During the Period, 1980 to 1989

In 1980, the United States Army Corps of Engineers (USACE; Waterways Experiment Station) conducted a study to evaluate the physical and chemical characteristics of sediment and water from the USC (USACE 1980). In this study, sediment samples from three sites were collected and analyzed for total metals, oil and grease, total PCBs, phenols, and several conventional variables (including TOC).

The collection of fish tissue samples from the Grand Calumet River system was initiated by IDEM (2000a) in 1980 (n=1), with additional sampling conducted in 1982 (n=2), 1984 (n=2), 1986 (n=13), 1987 (n=5), and 1988 (n=8). This initiative, which has come to be known as the Tissue Contaminant Monitoring Program, resulted in the collection of the edible tissues of five fish species during the 1980's, including carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), pumkinseed (*Lepomis gibbosus*), longnose sucker (*Catostomus catostomus*), and yellow perch (*Perca flavescens*). The tissues (whole body and skin-on fillets) of these fish were then analyzed to determine the concentrations of COPCs, including total metals, pesticides, PCBs, acid extractable compounds, base/neutral extractable compounds, and volatile organic compounds (VOCs).

In September of 1987, the Metropolitan Sanitary District of Greater Chicago initiated a sediment survey to obtain information on the fate of contaminated sediments drifting from IH into Lake Michigan (Polls 1988). This study was designed to support the development of maintenance dredging plans by the USACE. Surficial sediment samples were collected from a total of 30 stations, including one in the LGB, two in the USC, and 27 from IH/LM. Each sediment sample was analyzed for selected metals, PCBs, and TOC.

In 1988, IDEM initiated a monitoring program to evaluate sediment quality conditions at a number of locations within the Assessment Area (IDEM 1994). Surficial sediment samples were collected at up to seven sampling stations every two years between 1988 and 1994, including: Dickey Road on IHC; Cline Avenue and Kennedy Avenue on the EBGCR-I; Bridge Street on the EBGCR-II; Indianapolis Boulevard on the WBGCR-I; Hohman Avenue on the WBGCR-II; and, the confluence of the EBGCR and the WBGCR. The concentrations of conventional variables (including TOC), total metals, PAHs, PCBs, pesticides and acid volatile sulfides (AVS) were determined in each of these sediment samples.

Between October 1988 and May 1990, Hoke *et al.* (1993) collected surficial sediment samples from a total of 13 stations within the Assessment Area, including one station each on the WBGCR-I, USC, and IH, two stations each on the WBGCR-II, EBGCR-II, and IHC, and four stations on the EBGCR-I. These investigators measured the concentrations of conventional variables (including TOC), total metals, PAHs, PCBs, pesticides, and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin in sediment samples and performed additional analyses for other organic chemicals in pore water samples.

In 1988, the Illinois State Geological Survey conducted an investigation to evaluate the potential environmental impacts associated with dredging activities within the Assessment Area (Risatti and Ross 1989). Sediment samples were collected at a total of 13 sampling stations, of which eight were located in IH/LM, three in the USC, and one in the LGB. The sediment samples were collected using a petite ponar grab sampler and analyzed for total metals, total PCBs, total PAHs, and conventional variables (including TOC). The concentrations of total metals and PCBs in the tissues of four fish species (collected from three locations within the study area) were also determined as part of this study.

As part of a five-year project dealing with the Assessment and Remediation of Contaminated Sediments in the Great Lakes (i.e., the ARCS Program), the Biological Resources Division of USGS conducted a sediment quality evaluation in the Assessment Area during 1989 (USEPA 1996a). In this study, samples were collected at a total of seven locations to assess sediment quality conditions within the Assessment Area, including five stations in the USC and two stations in IH. The chemical analyses that were conducted on the whole sediment samples included conventional variables (including TOC), total metals, PAHs, PCBs, pesticides, butyltins, and polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans (PCDDs/PCDFs). The concentrations of simultaneously extracted metals (SEM) and pore water metals were also determined in this study.

4.2 Data Collected During the Period, 1990 to Present

During the period 1990 to present, IDEM's Tissue Contaminant Monitoring Program represented the primary source of data on the levels of COPCs in edible fish tissues from the Assessment Area. Over this period, fish tissue samples were collected in 1990 (n=3), 1992 (n=4), 1994 (n=18), 1996 (n=24), 1997 (n=3), and 2000 (n=16). The species collected within the Assessment Area during these sampling events included carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), white sucker *(Catostomus commersoni*), brown trout (*Salmo trutta*), gizzard shad (*Dorosoma cepedianum*), and channel catfish (*Ictalurus punctatus*; Table 5). The tissues (whole body, skin-on fillets, or skin-off fillets) of these fish were analyzed to determine the concentrations of chemical contaminants, including total metals, pesticides, PCBs, acid extractable compounds, base/neutral extractable compounds, and volatile organic compounds (VOCs).

In 1991, U.S. Steel implemented a major study to characterize sediment quality conditions within a portion of the Assessment Area (Floyd-Browne 1993). In this study, a total of 117 sediment samples were collected from 59 sampling stations, with the majority of the sampling effort (35 of 59 stations; 66 sediment samples) conducted on the EBGCR-II between the GCRL culvert (which is located upstream of U.S. Steel permitted outfall 001) to the Industrial Highway (Highway 12) bridge. Another 29 sediment samples were collected from 14 stations on EBGCR-I and three stations (nine samples) were located in the WBGCR-I. Furthermore, 13 sediment samples were collected from seven stations located in the IHC. Three sediment horizons were sampled in this study, including 0 to 7.9 feet (65 samples), 8 to 12.9 feet (42 samples), and 13+ feet (10 samples). The chemical composition of each sediment sample was characterized by measuring the levels of conventional variables (including TOC), total metals, SEM, PAHs, and PCBs.

In November of the same year (1991), the USEPA implemented a sediment quality investigation to further characterize sediment quality conditions in the IH and USC (USEPA 1991). This investigation involved the collection of a total of eight surficial sediment samples from seven locations in IH and a total of 13 samples from 12 locations in the USC. The chemical analyses conducted on these samples included metals, PAHs, and TOC.

To support the development of a Remedial Action Plan for the IH Area of Concern, the USACE conducted an investigation of sediment quality conditions in the Grand Calumet River in 1993 (USACE 1994). While this study was primarily designed to obtain data on the depth of soft, unconsolidated sediments, it also provided information on the concentrations of sediment-associated COPCs in the river system. In total, 18 sediment samples were obtained from four stations located in the USC between Columbus Drive and the junction of the IHC with the LGB. At each station, sediment cores were obtained and used to prepare sediment samples that represented various sediment depths. The concentrations of conventional variables (including TOC), total metals, PCBs, PAHs, and pesticides were determined in each sediment sample.

In the same year (1993), an evaluation of sediment quality conditions was conducted in the WBGCR (Burton 1994; Dorkin 1994). In this study, a total of 61 samples of surficial and sub-surface sediments were collected from seven locations on the WBGCR-II to evaluate sediment chemistry and sediment toxicity. The samples were situated at Roxana Marsh (two stations), Molsberger Place, Columbia Avenue, Sohl Avenue, State Line Avenue, and Torrence Avenue. Chemical characterization of the 61 sediment samples included measurements of conventional variables (including TOC), total metals, and PAHs.

In 1994, the Lake Michigan Ecological Research Station of USGS initiated an investigation of sediment quality conditions in the GCRL (Gillespie *et al.* 1998). As part of this study, 12 surficial sediment samples were collected in the vicinity of an industrial landfill and storage area that contains slag waste and coke piles. The data from sampling stations located in the East and West Lagoons were reported in Gillespie *et al.* 1998, while the data from the sampling stations located in the Little East and Little West Ponds were acquired from the Fully Integrated Environmental Location Decision Support (FIELDS) database, which is administered by USEPA (USDOI 1994). The concentrations of sediment-associated metals and TOC were measured in all of these sediment samples, while the concentrations of selected PAHs were determined in three of the samples.

In 1996, the USACE conducted an investigation to evaluate sediment quality conditions in the GCRL (USACE 1996). In this study, surficial sediment samples were collected from a total of six sampling stations that were located between the western limit of the Lagoon and a site located roughly 1.5 miles to the east. The sampling depth varied among the samples collected, ranging from 0 to 1 feet (grab samples) to 0 to 4 feet (core samples). The concentrations of total metals, PAHs, PCBs, pesticides, VOCs, semi-volatile organic chemicals (SVOCs), and conventional variables (including TOC) were measured in each of the sediment samples.

In 1997, the USEPA initiated an investigation to evaluate sediment quality conditions in the GCRL (Simon 2000). As part of this study, a total of 214 samples were collected to determine the extent of chemical contamination in surficial sediments. A variety of chemical analytes were measured in these samples, including TOC, nutrients, metals, PCBs, pesticides, and various volatile and semi-volatile organic chemicals.

In 1997, IDEM conducted a study to evaluate the chemical characteristics of the tissues of fish from the Grand Calumet River Lagoons (IDEM 2000b). In this study, carp samples were collected from 18 locations the East Lagoon and West Lagoon. Each fish was separated into skin off fillets, the gastrointestinal tract (i.e., organs in body cavity), and body (i.e., head, gills, skin, fins, skeleton with attached flesh) and used to create a composite sample for each location and tissue type. Subsequently, each sample was analyzed for total metals, total PCBs, PAHs, and conventional variables (percent moisture and percent lipids).

Based on the results of a Phase I Site Investigation, a more detailed river sediment investigation was conducted on a portion of the WBGCR-II that is adjacent to the Northern Indiana Public Service Company (NIPSCO) site in 1998 (ThermoRetec 1999). The objectives of this investigation were to further characterize surface water and sediment quality conditions in the vicinity of the former manufactured gas plant, including the distribution of sediment-associated COPCs. As part of this study, four surface water samples, 12 shallow sediment cores (0 to 5 feet deep), and two whole-sediment surface grab samples were collected during the sampling program. The concentrations of various COPCs (i.e., total metals and PAHs) and TOC were measured in the portions of the sediment cores representing 0 to 2 foot, 2 to 4 foot, or 2 to 5 foot depths (i.e., a total of 21 samples) and in the two grab sediment samples.

The USEPA commissioned a study in 1998 to characterize sediments in the vicinity of Roxana Marsh (WBGCR-II; URS Greiner Woodward Clyde 1999). As part of this study, two water samples and nine sediment samples were collected from a total of three sampling stations in the WBGCR. In addition, four water samples and 10 sediment samples were collected at a total of five locations within Roxana Marsh. Conventional variables, nitrogen-ammonia, and total sulfides were measured in pore water samples. Sediment sampling consisted of the collection of both surficial grab samples and sediment cores, with chemical analyses including conventional variables (including TOC), total metals, PCBs, PAHs, and pesticides.

In the same year (1998), a study was initiated by DuPont to evaluate sediment quality conditions on EBGCR-I (Exponent 1999). Sediment samples were collected from 33 stations on the EBGCR-I and six stations in nearby wetland areas, primarily in the vicinity of DuPont's East Chicago facility (which is adjacent to the EBGCR and IHC confluence). Both surficial grab samples (68 samples) and core samples (25 samples, to a maximum depth of 15 feet) were collected from the EBGCR-I during this investigation. All six of the wetland samples collected were surficial grabs. Chemical characterization of the sediment samples included measuring conventional variables (including TOC), VOCs, total metals, SEM, AVS, PAHs, PCBs, and pesticides.

In early 1999, the IDEM commissioned the USACE to characterize the chemical composition of surficial and sub-surface sediments throughout the Assessment Area (Maxim Technologies 1999). In total, 103 samples from 43 stations were collected and analyzed from transects established on EBGCR-I (60 samples), IHC (10 samples), LGB (18 samples), WBGCR-I (nine samples), and GCRL (five samples). Another 24 samples were collected from 18 wetland stations that were located in the vicinity of EBGCR-I (10 samples), IHC (one sample), and LGB (13 samples). Cores were taken from the right, center, and left bank of the river at each of the 14 transects that were established; a single core was taken at another sampling location. Samples from these cores were taken from the surface layer (0 to 5 feet) and from one to three additional horizons (to a maximum of 15 feet). In addition, surficial sediment grabs were collected from another 16 locations. Each sediment sample was analyzed for total metals, SEM, AVS, PAHs, PCBs, VOCs, pesticides, TOC, and oil/grease.

5.0 Assessment of Injury to Human Uses of Fishery Resources

This investigation was conducted to determine if biological resources within the Grand Calumet River and Indiana Harbor Canal, Grand Calumet River Lagoons, Indiana Harbor and the nearshore areas of Lake Michigan (i.e., the Assessment Area) have been injured due to discharges of oil or releases of other hazardous substances, as defined in 43 CFR § 11.62(f)(1)(ii and iii) in the USDOI regulations for conducting NRDAs (CFR 2002). In this report, the term injury to human uses of fishery resources has been used to more specifically describe such injuries to biological resources. Under the USDOI regulations for conducting NRDAs (CFR 2002), an injury to a biological resource has resulted from the "... release of a hazardous substance if the concentration of the substance is sufficient to ...

- Exceed action or tolerance levels established under Section 402 of the Food, Drug, and Cosmetic Act, 21 U.S.C. 342, in edible portions of organisms [43 CFR § 11.62(f)(1)(ii)]; or,
- Exceed levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organisms [43 CFR § 11.62(f)(1)(iii)]."

In this investigation, the definitions of injury to biological resources included in the USDOI regulations were generally applied to support the assessment of the effects of chemical contamination on human use and consumption of fish and shellfish (i.e., injury to human uses of fishery resources). Injury to human uses of fishery resources was assessed for each of the geographic areas (i.e., the GCR/IHC, GCRL, and IH/LM). Three separate lines of evidence were used to determine if injury to human uses of fishery resources has occurred. More specifically, injury to human uses of fishery resources was considered to have occurred in an area if:

- The concentrations of one or more COPCs in two or more whole sediment samples (separated by more than 100 feet) exceeded the selected chemical benchmarks for the protection of human health;

- The concentrations of one or more COPCs in one or more fish tissue samples exceeded the selected chemical benchmarks for the protection of human health (i.e., the tolerance levels or action levels established by the USFDA or the Group 1 thresholds that have been used by the State of Indiana to establish FCAs); or,

- FCAs have been issued for one or more species of fish.

The following sections of this document present the results of the assessment that was conducted to assess injury to human uses of fishery resources in GCR/IHC, GCRL, and IH/LM.

5.1 Evaluation of Injury to Human Uses of Fishery Resources Based on Exceedances of Benchmarks for Sediment Chemistry

In this report, sediment chemistry data were used in conjunction with selected benchmarks for sediment chemistry to assess injury to human uses of fishery resources in the Assessment Area. More specifically, the concentrations of COPCs in each whole sediment sample were compared to the corresponding sediment chemistry benchmark for the protection of human health (i.e., the organic carbon-normalized SQC that were promulgated by the WSDOH (1995; 1996). These SQCs represent the concentrations of sediment-associated COPCs which do not pose a significant threat to human health (WSDOH 1995). The presence of one or more COPCs in two or more samples (separated by 100 feet) at concentrations in excess of the selected benchmarks for sediment chemistry was considered to provide the necessary and sufficient evidence to demonstrate the presence of conditions sufficient to cause or substantially contribute to injury to human uses of fishery resources in a geographic area.

Grand Calumet River/Indiana Harbor Canal - Information on the concentrations of COPCs (and associated measurements of TOC levels) was compiled for 579 whole sediment samples collected within the GCR/IHC between 1980 and present. Of these, 361 samples provide information on the levels of COPCs in surficial sediment samples (Table 6), while 218 samples provide data on COPC concentrations in sub-surface sediment samples (Table 7). Although additional data on sediment quality conditions were compiled in the project database (see MacDonald and Ingersoll 2000), only those samples for which matching information was available on the concentrations of COPCs and on levels of total organic carbon (TOC) were used to evaluate injury to human uses of fishery resources.

The results of this evaluation indicate that a number of COPCs occur in sediments from the Grand Calumet River and Indiana Harbor Canal at concentrations sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. More specifically, there were exceedances of the selected benchmarks for the protection of human health in all of the samples from this portion of the Assessment Area in which the concentrations of high molecular weight PAHs [i.e., benz[a]anthracene; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno(1,2,3-cd)pyrene] were measured (i.e., n=80 to 244 for surficial samples and n=43 to 127 for sub-surface samples; Tables 6 and 7). In addition, there were exceedances of the selected benchmarks in all of the samples from the GCR/IHC in which the concentrations of total PCBs were measured [i.e., 1.7 :g/kg organic carbon (OC); n=154 for surficial samples and n=52 for sub-surface samples; Tables 6 and 7]. The absence of applicable benchmarks for sediment-associated metals precluded an evaluation of the hazards posed by these substances to human health. The levels of certain pesticides [i.e., chlordane, dieldrin, endrin, heptachlor, heptachlor epoxide, beta-hexachlorocyclohexane (beta- HCH), lindane, and DDTs], TCDD-TEQs, and various other substances (i.e., benzene and carbazole) also exceeded the human health-based benchmarks for sediment chemistry in all or a portion of the whole sediment samples from this portion of the Assessment Area (Tables 6 and 7). Therefore, it is concluded that concentrations of PAHs, PCBs, and other bioaccumulative substances occur in sediments from the GCR/IHC at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, and certain other chlorophenols, PAHs, and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Grand Calumet River Lagoons - Data are available on the concentrations of COPCs and TOC for 222 whole sediment samples collected within the GCRL. All of these samples were collected during the period between 1995 and 1999. Of these, 202 samples provide information on the levels of COPCs in surficial sediment samples (Table 6), while 20 samples provide data on COPC concentrations in sub-surface sediment samples (Table 7). Only the data for those samples for which matching information was available on the concentrations of COPCs and on levels of TOC were used to evaluate injury to human uses of fishery resources.

Comparison of the measured levels of COPCs in whole sediment samples with the benchmarks for sediment chemistry indicate that a number of COPCs occur in GCRL sediments at concentrations sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. More specifically, the concentrations of benz[a]anthracene; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno(1,2,3-cd)pyrene in whole sediment samples from the GCRL always exceeded the levels that have been established to protect human health (n=4 to 127 for surficial sediment samples and n=1 to 2 for sub-surface sediment samples; Tables 6 and 7). Likewise, the levels of total PCBs and various PCB mixtures (e.g., Aroclor 1254) exceeded the benchmarks for sediment chemistry in all of the surficial sediment samples from the GCRL in which these substances were measured (n=4 to 29; Table 6). The concentrations of total PCBs and various PCB mixtures were not measured in any of the sub-surface sediment samples from the GCRL. As applicable benchmarks for sediment-associated metals were not located in the literature, it was not possible to evaluate the hazards to human health posed by these substances. The levels of certain pesticides (i.e., chlordane, dieldrin, endrin, and DDTs) also exceeded the human health-based benchmarks for sediment chemistry in all or a portion of the surficial sediment samples from the GCRL (Tables 6 and 7). Therefore, it is concluded that concentrations of PAHs, PCBs, and other bioaccumulative substances occur in GCRL sediments at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, chlorophenols, TCDD-TEQs, and certain other PAHs and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Indiana Harbor and the Nearshore Areas of Lake Michigan - Fewer data are available on sediment quality conditions in IH/LM than are available for the other two geographic areas of the Assessment Area. In total, data on the concentrations of COPCs in surficial sediments (with associated measurements of TOC levels) were compiled for 53 whole sediment samples collected within IH/LM (Table 6). All of these samples were collected between 1987 and 1991. No data were located on the chemical composition of sub-surface sediment samples. Only those samples for which matching information was available on the concentrations of COPCs and on levels of TOC were considered in the evaluation of injury to human uses of fishery resources.

The results of this evaluation indicate that surficial sediments from IH/LM have concentrations of several COPCs that are sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. More specifically, there were exceedances of the selected benchmarks for the protection of human health in all of the samples from IH/LM in which the concentrations of six high molecular weight PAHs were measured (n=6 to 10; Table 6). In addition, all of the surficial sediment samples from IH/LM for which total PCBs were measured (n=30) had concentrations of total PCBs that exceeded the selected benchmarks for sediment chemistry (i.e., 1.7 : g/kg OC). The benchmarks for various PCB mixtures were consistently exceeded in whole sediment samples from this portion of the Assessment Area (Table 6). The absence of applicable benchmarks for sediment-associated metals precluded an evaluation of the hazards posed by these substances to human health. The levels of certain pesticides (i.e., chlordane, dieldrin, and DDE) and TCDD-TEQs also exceeded the human health-based benchmarks for sediment chemistry in all of the whole sediment samples for which data are available (Table 6). Therefore, it is concluded that concentrations of PAHs, PCBs, and other bioaccumulative substances occur in sediments from IH/LM at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, chlorophenols, and certain other PAHs and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

5.2 Evaluation of Injury to Human Uses of Fishery Resources Based on Exceedances of Benchmarks for Tissue Chemistry

In this report, data on the levels of COPCs in fish tissues were used in conjunction with selected benchmarks for tissue chemistry to assess injury to human uses of fishery resources in the Assessment Area. That is, the concentrations of COPCs in each fish tissue sample were compared to the corresponding benchmarks for the protection of human health. Two sets of benchmarks for tissue chemistry were considered in this assessment, including the action levels or tolerance levels established by the USFDA (2001) and the thresholds that were established by the ISDH for developing the Indiana FCA (Stahl and Simon 2000). The USFDA action levels or tolerance levels represent the concentrations of tissue-associated COPCs that are considered to be safe for human consumption and apply to fish and shellfish caught in commercial fisheries and offered for sale outside the state of origin (i.e., interstate commerce). By comparison, the thresholds that have been established by ISDH identify the concentrations of tissue-associated COPCs that are used for classifying fish species of various sizes into advisory groups based on the maximum recommended frequency of consumption (ISDH, IDEM, and IDNR 2002). The occurrence of one or more COPCs in one or more samples at concentrations in excess of the selected benchmarks for tissue chemistry (i.e., the tolerance levels or action levels that have been promulgated by the

USFDA **or** the Group 1 threshold levels that have been established by the ISDH to support the development of FCAs) was considered to provide the necessary and sufficient evidence to demonstrate the presence of conditions sufficient to cause or substantially contribute to injury to human uses of fishery resources in a geographic area.

Grand Calumet River/Indiana Harbor Canal - Information on the concentrations of COPCs in fish tissues was compiled for 91 samples collected within the GCR/IHC between 1980 and 2000. These samples were analyzed to provide data on the levels of PCBs, pesticides, metals, and conventional variables (e.g., percent lipid, percent moisture) in a total of seven fish species, including carp, pumkinseed, sunfish (species unspecified), goldfish, white sucker, channel catfish, and gizzard shad.

The USFDA has established action levels or tolerance levels for six of the COPCs that occur in the Assessment Area, including methylmercury, PCBs, aldrin/dieldrin, chlordane, DDTs (i.e., DDD, DDE, and DDT), and heptachlor/heptachlor epoxide. These benchmarks for tissue chemistry apply specifically to the edible portions of fish and shellfish. The results of this evaluation indicate that the concentrations of mercury, aldrin, dieldrin, sum DDD, sum DDE, and sum DDT, total DDTs, heptachlor, and heptachlor epoxide never exceeded the USFDA action levels in fish tissue samples from the GCR/IHC (Tables 8 to 20). The action level for chlordane was exceeded in one sample of carp tissue collected in 1982 (Table 19). Therefore, mercury and organochlorine pesticides rarely occurred in fish tissues at concentrations of concern relative to the protection of human health (i.e., levels that would affect the sale of fish or fish products outside Indiana).

In contrast to the other substances considered, the accumulation of PCBs in fish utilizing habitats in the GCR/IHC represents a potential risk to human health. Of the 87 fish tissue samples in which total PCBs was measured, 70 (83%) had concentrations that exceeded the tolerance levels that have been established by the USFDA (Table 20). Among the fish species tested, channel catfish had the highest frequency of exceedance of the USFDA tolerance levels (i.e., 100%; n=1). The frequency of exceedance of the USFDA tolerance levels was also high for carp (86%; n=64) and goldfish (81%; n=16). The frequency of exceedance was lower in white sucker (33%; n=3), gizzard shad (0%;

n=2), and sunfish (0%; n=1; Table 20). Therefore, based on the frequency of exceedances of the USFDA tolerance level for PCBs and the USFDA action level for chlordane, it is concluded that conditions sufficient to injure human uses of fishery resources occur in the GCR/IHC. The available tissue residue data indicate that such conditions have been consistently observed between 1982 and 2000.

Although the USFDA action levels and tolerance levels provide important tools for evaluating fish and shellfish tissue quality (especially for fish and shellfish that are caught and sold commercially), the ISDH Group 1 advisory provide more relevant benchmarks for assessing the quality of sport-caught fish species in Indiana (Anderson *et al.* 1993; i.e., 0.16 mg/kg WW for mercury and 50 µg/kg WW for total PCBs in skin-on scaleless fillets; Stahl and Simon 2000). Comparison of the measured concentrations of mercury and total PCBs to the thresholds used to establish FCAs in Indiana indicates that the accumulation of COPCs in fish tissues poses a human health concern in the GCR/IHC. Data on the concentrations of mercury in edible tissues are available for seven species of fish from the GCR/IHC (n=86 samples). Overall, these results show that most of the fish collected from the GCR/IHC had <0.16 mg/kg WW of mercury in their tissues (i.e., 93%; 80 of 86 samples; Table 21). The Group 1 threshold concentration was never exceeded in the tissues samples obtained from channel catfish, gizzard shad, goldfish, pumpkinseed, sunfish, or white suckers (Table 21). However, 6 of the 62 tissue samples (10%) obtained from carp had concentrations of mercury sufficient to injure human uses of fishery resources. These samples were collected in 1986 and 1996 (Table 21).

A total of 87 fish samples were collected and analyzed between 1980 and 2000 to determine the concentrations of total PCBs in edible fish tissues from the GCR/IHC. Collectively these data indicate that total PCBs were always measured at concentrations that pose unacceptable risks to human health (i.e., >50 µg/kg WW). The majority of these samples (i.e., 83%; 72 of 87) had total PCB concentrations in excess of the Group 5 threshold (i.e., 1900 µg/kg WW for skin-on scaleless fillets; no consumption of such fish is recommended; Table 22). Among the species tested, channel catfish, carp, and goldfish had the highest frequency of exceedance of the Group 5 threshold (100%; n=1 and 88%; 56 of 64 samples and 14 of 16 samples, respectively; Table 22). Therefore, the levels of total PCBs in fish tissues collected from the GCR/IHC were sufficient to injure human uses of fishery resources in all of the species tested between 1980 and 2000.

Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs frequently occurred at concentrations sufficient to injure human uses of fishery resources in the GCR/IHC. Organochlorine pesticides in the edible tissues of fish only rarely posed a potential risk to human health, based on comparisons to the USFDA action levels. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if certain other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Grand Calumet River Lagoons - Information on the concentrations of COPCs in fish tissues was compiled for 25 samples collected within the GCRL during 1986 and 1997. These samples were analyzed to provide data on the levels of PCBs, pesticides, metals, and conventional variables (e.g., percent lipid, percent moisture) in a total of three fish species, including carp, largemouth bass, and bluegill. The concentrations of mercury, PCBs, aldrin/dieldrin, chlordane, DDTs (i.e., DDD, DDE, and DDT), and heptachlor/heptachlor epoxide were compared to the USFDA action levels or tolerance levels to assess injury to human uses of fishery resources. In addition, the ISDH Group 1 thresholds for mercury and total PCBs were used to determine if the concentrations of these substances in fish tissues were sufficient to injure human uses of fishery resources.

Evaluation of the available data on the concentrations of COPCs in fish tissues from the GCRL indicates that the USFDA action levels or tolerance levels were not exceeded in any of the species tested (Tables 23 to 35). Therefore, the concentrations of mercury, PCBs, aldrin/dieldrin, chlordane, DDTs (i.e., DDD, DDE, and DDT), and heptachlor/heptachlor epoxide in the edible tissues of fish (caught in a commercial fishery and offered for sale outside Indiana) from this portion of the Assessment Area are not considered to pose a human health concern (i.e., based on the frequency of exceedance of the USFDA action levels or tolerance levels).

Although the USFDA action levels and tolerance levels provide important tools for evaluating fish and shellfish tissue quality (especially for fish and shellfish that are caught and sold commercially), the ISDH Group 1 advisory provide more relevant benchmarks for assessing the quality of sport-caught fish species in Indiana (Anderson *et al.* 1993; i.e., 0.16 mg/kg WW for mercury and 50 µg/kg WW for total PCBs in skin-on scaleless fillets; Stahl and Simon 2000). Comparison of the measured concentrations of mercury and total PCBs to the thresholds used to establish FCAs in Indiana indicates that the accumulation of COPCs in fish tissues poses a human health concern in the GCRL. For mercury, 18 of 21 fish tissue samples (86%) had concentrations less than 0.16 mg/kg WW; however, three of the 14 carp samples collected in 1997 had mercury concentrations in excess of the Group 1 threshold (Table 36). In addition, all of the fish tissue samples (n=1 for bluegill, n=21 for carp, and n=3 for largemouth bass) collected in 1986 and in 1997 had concentrations of total PCBs in excess of the Group 1 threshold (Table 37). The levels of total PCBs in most of these tissue samples (i.e., 92%; 23 of 25) were sufficient to warrant a recommendation that sensitive components of the human population not consume these fish (i.e., the Group 3 or Group 4 thresholds were exceeded; Table 37).

Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs frequently occurred at concentrations sufficient to injure human uses of fishery resources in the GCRL. Organochlorine pesticides in the edible tissues of fish did not pose a potential risk to human health, based on comparisons to the USFDA action levels. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if certain other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Indiana Harbor and the Nearshore Areas of Lake Michigan - Information on the concentrations of COPCs in fish tissues was compiled for 22 samples collected in IH/LM during 1988 and 1996. These samples were analyzed to provide data on the levels of PCBs, pesticides, metals, and conventional variables (e.g., percent lipid, percent moisture) in a total of six fish species, including brown trout, carp, gizzard shad, longnose sucker, sunfish (species unspecified), and yellow perch. The concentrations of mercury, PCBs, aldrin/dieldrin, chlordane, DDTs (i.e., DDD, DDE, and DDT), and heptachlor/heptachlor epoxide were compared to the USFDA action levels or tolerance levels to assess injury to human uses of fishery resources. In addition, the ISDH Group 1 advisory thresholds for mercury and total PCBs were used to determine if the concentrations of these substances in fish tissues were sufficient to injure human uses of fishery resources.

Evaluation of the available data on the concentrations of COPCs in fish tissues indicates that the USFDA action levels or tolerance levels were only infrequently exceeded in fish collected from IH/LM (Tables 38 to 50). More specifically, the concentrations of mercury, aldrin/dieldrin, chlordane, DDTs (i.e., DDD, DDE, and DDT), and heptachlor/heptachlor epoxide in edible fish tissues from this portion of the Assessment Area did not exceed the USFDA action levels in any of the samples tested during 1988 or 1996. Therefore, these substances are not considered to pose a human health concern in IH/LM (i.e., if these fish were caught in a commercial fishery and offered for sale outside Indiana). However, 11% (i.e., 2 of 18 samples) collected in 1988 and 50% (i.e., 2 of 4 samples) collected in 1996 had levels of total PCBs in excess of the USFDA tolerance level (2000 µg/kg WW; Table 50). The levels of total PCBs in the edible tissues of both carp (3 of 6 samples) and gizzard shad (1 of 8 samples) were sufficient to injure human uses of fishery resources in IH/LM (Table 50).

Although the USFDA action levels and tolerance levels provide important tools for evaluating fish and shellfish tissue quality (especially for fish and shellfish that are caught and sold commercially), the ISDH Group 1 advisory thresholds provide more relevant benchmarks for assessing the quality of sport-caught fish species in Indiana (Anderson *et al.* 1993; i.e., 0.16 mg/kg WW for mercury and 50 µg/kg WW for total PCBs in skin-on scaleless fillets; Stahl and Simon 2000). Comparison of the measured concentrations of mercury and total PCBs in fish tissue samples to the thresholds used to establish FCAs in Indiana indicates that the accumulation of both of these COPCs in fish tissues poses a human health concern in the IH/LM. More specifically, 19% (4 of 21) of the fish tissue samples collected from IH/LM had mercury concentrations in excess of 0.16 mg/kg WW (Table 51). For carp and longnose sucker, 50% of the tissue samples collected from IH/LM (i.e., 3 of 6 for carp and 1 of 2 for longnose sucker) had elevated concentrations of mercury (i.e., relative to the ISDH Group 1 advisory threshold; Table 51). The measured concentrations of mercury in brown trout, gizzard shad, sunfish, and yellow perch were all below the ISDH Group 1 advisory threshold (Table 51).

The levels of total PCBs in the tissues of fish from IH/LM also pose a potential risk to human health. Of the 22 fish tissue samples included in the project database, 86%;19 of 22) had total PCB concentrations in excess of the ISDH Group 1 advisory threshold (Table 52). For brown trout (n=2), carp (n=6), gizzard shad (n=8), and sunfish (n=1), all of the samples collected from this portion of the Assessment Area had levels of total PCBs sufficient to injure human uses of fishery resources (Table 52). The frequency of exceedance of the ISDH Group 1 advisory threshold was lower for longnose sucker (i.e., 50%; n=2) and yellow perch (i.e., 33%; n=3; Table 52). The majority of these samples (i.e., 86%; 19 of 22) had total PCB concentrations in excess of the Group 2 threshold (i.e., 60 μg/kg WW for skin-on scaleless fillets; consumption restrictions are recommended for such fish; Table 52).

Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs frequently occurred at concentrations sufficient to injure human uses of fishery resources in the IH/LM. However, organochlorine pesticides in the edible tissues of fish did not pose a potential risk to human health, based on comparisons to the USFDA action levels. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if certain other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

5.3 Evaluation of Injury to Human Uses of Fishery Resources Based on the Issuance of Fish Consumption Advisories

Under the regulations that have been promulgated by the USDOI, biological resources have been injured if edible fish and/or shellfish tissues contain concentrations of a hazardous substance sufficient to exceed levels for which an appropriate state health agency has issued directives to limit or ban the consumption of such tissues [43 CFR § 11.62 (f)(1)(iii); CFR 2002]. Injuries pursuant to this injury definition were determined by summarizing the FCAs that have been issued by the State of Indiana for the Grand Calumet River and Indiana Harbor Canal in Lake County, the Grand Calumet River Lagoons, and by the four states bordering Lake Michigan (i.e., Illinois, Indiana, Wisconsin, and Michigan) for the lake. This section of this report provides an overview of the FCA program that has been established in Indiana, describes the thresholds that have been used to set FCAs in Indiana, and presents a list of FCAs that have been issued by the State of Indiana since 1972 (ISDH, IDEM, and IDNR 2002).

5.3.1 Overview of Indiana's Fish Consumption Advisory Program

In response to concerns regarding the levels of COPCs in the tissues of fish and other aquatic organisms, the IDNR initiated a program (which is now referred to as the Tissue Contaminant Monitoring Program) in 1972 to sample and analyze fish tissues to assess the levels of bioaccumulative substances. Based on the results of this program and the advice that had been disseminated to the public in the other states bordering Lake Michigan, in 1977 the Indiana State Board of Health (ISBH) recommended that consumption of lake trout from Lake Michigan be restricted due to the presence of elevated levels of COPCs in the tissues of this species (Table 53).

In 1985, a number of important developments occurred that substantially advanced the FCA program in Indiana (Table 53). First, the four states bordering Lake Michigan agreed to share and pool their analytical data on the levels of COPCs in fish tissues. This development provided each state with a more comprehensive understanding of the levels of COPCs in fish from Lake Michigan and, hence, a more defensible basis for issuing FCAs. In addition, the

FCA system was refined to facilitate classification of fish into three advisory groups (i.e., Group 1, 2, and 3), based on the recommended frequency of consumption for various segments of the human population (i.e., general population vs. sensitive population). Fish were classified into these groups according to the proportion of samples that had COPC concentrations in excess of USFDA tolerance levels or action levels (Table 54). More specifically, Group 1 fish included those species and/or size classes for which one or more USFDA tolerance levels or action levels were exceeded in fewer than 10% of the samples tested; consumption of Group 1 fish was considered to pose the lowest risk among the three groups and, hence, consumption was not restricted. If 50 to 90% of the fish tissue samples had concentrations of one or more COPCs in excess of the USFDA tolerance levels or action levels, then those species and/or size classes were classified into Group 2; consumption of Group 2 fish was restricted to one meal per week for the general population (preparation and cooking instructions were also provided to reduce exposure to COPCs), while the sensitive population (i.e., pregnant women, breast-feeding women, women planning to have children, and children under the age of 15) was advised to not eat these fish. Group 3 fish included those species and/or size classes for which one or more of the USFDA tolerance levels or action levels were exceeded in 90% or more of the samples tested; all segments of the human population were advised to not eat these fish. No advisory group was assigned to species and/or age classes for which 10 to 50% of the samples tested had one or more exceedances of the USFDA tolerance levels or action levels.

Although the four states bordering Lake Michigan had worked cooperatively on issues related to FCAs since the early 1980's, a broader plan was initiated in 1986 to provide consistent advice regarding the consumption of Great Lakes fish, as part of the Great Lakes Governor's Toxics Agreement (Table 53). More specifically, the Great Lakes Sport Fish Consumption Advisory Task Force (Task Force) was formally established to facilitate the sharing of information and coordinate FCAs throughout the Great Lakes basin. As part of this effort, the Task Force was charged with the responsibility of developing a uniform sport FCA protocol applicable to all of the Great Lakes. The protocol was intended to maintain the health benefits associated with fish consumption; minimize the potential for angler exposure to toxic substances; utilize credible and understandable science; and, present the information in a manner conducive to maximal voluntary compliance.

To facilitate the development of a defensible protocol for developing FCAs, the Task Force conducted an in-depth review of the procedures that had been used previously to establish FCAs. The results of this review indicated that the USFDA action levels and tolerance levels, that had been promulgated primarily for assessing the levels of COPCs in commercially-caught fish and shellfish, were not adequately protective of human health, particularly for those individuals who consumed sport-caught fish (i.e., anglers and subsistence fishers tended to have higher daily intake rates of fish and shellfish than was assumed in the development of the USFDA action levels). For this reason, the Task Force re-evaluated the available toxicological data for key COPCs (e.g., PCBs and mercury) to establish human HPVs that identified tolerable daily intake rates for certain toxic substances (i.e., initially for PCBs and later for mercury). In turn, the HPVs were used in conjunction with information on daily fish consumption rates, human body weights, and losses of COPCs during preparation and cooking to establish thresholds for grouping fish species and/or size classes into five advisory groups (i.e., Groups 1 to 5). These advisory groupings provide consumers with information on the recommended frequency of consumption of Indiana sport-caught fish, including:

- Group 1 - Unlimited consumption for adult males and females (restrict consumption to one meal per week for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15);
- Group 2 - Restrict consumption to one meal per week for adult males and females (restrict consumption to one meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15);
- Group 3 - Restrict consumption to one meal per month for adult males and females (for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15, do not eat);
- Group 4 - Restrict consumption to one meal every two months for adult males and females (for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15, do not eat); and,
- Group 5 - No consumption (do not eat).

This risk-based approach recognizes that the adverse effects associated with the consumption of contaminated tissues of fish result from the accumulation of COPCs in humans over extended time periods. Accordingly, the resultant FCAs are designed to provide the highest level of protection to those segments of the human population that are most sensitive to the effects of tissue-borne COPCs.

5.3.2 Tissue Residue Benchmarks for Establishing Fish Consumption Advisories

In general, FCAs are developed by evaluating data on the levels of COPCs in the tissues of fish relative to tissue residue benchmarks. Such benchmarks identify tolerable levels of COPCs in the tissues of fish and other aquatic organisms relative to the protection of human health. Benchmarks for tissue chemistry are typically derived by first determining the tolerable daily intake (TDI) rate of a COPC (i.e., in mg/kg body weight (BW)/day), based on an evaluation of the available data on the toxicity of the COPC to mammalian receptors. Subsequently, the TDI is used in conjunction with information or assumptions regarding the body weight of the target receptor group (e.g., general population), the daily intake rate of fish and other aquatic organisms, and reductions in the concentrations of COPCs during food preparation and cooking to establish the tolerable levels of bioaccumulative COPCs in the tissues of fish and other aquatic organisms. The action levels and tolerance levels for methylmercury, PCBs, aldrin/dieldrin, chlordane, DDTs (i.e., DDD, DDE, and DDT), and heptachlor/heptachlor epoxide that have been established by the USFDA are presented in Table 3. The thresholds that have been adopted by the ISDH for mercury and total PCBs to support the development of the Indiana FCA are presented in Table 4.

5.3.3 Fish Consumption Advisories in the Assessment Area

In Indiana, responsibility for issuing FCAs is vested in ISDH, IDEM, and IDNR. Each year, representatives from these three agencies meet to discuss the recent fish monitoring data and to develop the new statewide FCA (e.g., ISDH, IDEM, and IDNR 2002). Such FCAs are developed using risk-based procedures that consider the segment of the population that may be adversely affected by consuming fish tissues (e.g, adult males, women planning to have children, pregnant or breast-feeding women, and children), the duration of exposure to tissue-associated COPCs, source of the fish (i.e., water body), and the levels of COPCs in the tissues of fish of various species and/or sizes. Between 1985 and 1994, fish of various species and sizes were classified into one of three categorical groups based on the frequency of exceedance of the USFDA action levels or tolerance levels (Table 54). Since 1995, fish of various species and sizes have been classified into five categorical groups based on comparisons of the measured concentrations of mercury and PCBs to the thresholds that were adopted by ISDH (Table 54). In this investigation, the issuance of Group 2, 3, 4, or 5 FCAs on one or more fish species (and/or size classes) was considered to provide the necessary and sufficient evidence of an injury to human uses of fishery resources within the Assessment Area.

Grand Calumet River and Indiana Harbor Canal - In 1986, the ISBH (which is now referred to as the ISDH) classified the GCR/IHC (including the WBGCR, EBGCR downstream of the GCRL, IHC, LGB, and IH) as a Group 3 waterway. Accordingly, the public was advised to not eat any fish caught in these waters because of the high levels of contamination in fish tissues (Table 55). The FCA was re-issued in 1989; however, the geographic scope of the waters covered under the advisory was narrowed to included WBGCR, EBGCR, and IHC only (i.e., LGB and IH were excluded from the FCA that applied to GCR/IHC). This revised FCA was re-issued each year between 1990 and 1994 (Table 55). Although ISDH did not issue a FCA for GCR/IHC in either 1995 or 1996, the 1994 FCA was considered to remain in effect during 1995 and 1996 for the purpose of this assessment because it was not revoked and because examination of the underlying tissue residue data revealed no pattern of decreasing concentrations of mercury or PCBs during or immediately prior to this period. Between 1997 and 2002, the GCR/IHC was classified as a Group 5 waterway each year and the associated FCA was issued to the public (Table 55). Therefore, ISDH and its partners have issued FCAs for all species of fish from the GCR/IHC for 13 of the years between 1986 and 2002. Unless the FCA was explicitly revoked, it is reasonable to assume that these FCAs also applied to years when FCA were not issued by ISDH. Therefore, it is concluded that human uses of fishery resources in the GCR/IHC were injured as a result of the accumulation of mercury and PCBs during the period 1986 to 2002 (Tables 56 and 57).

Grand Calumet River Lagoons - In 1996, the ISDH issued a FCA for the GCRL (which are referred to as the Marquette Park Lagoons in the Indiana FCA. This FCA recommended that adult males and females consume no more than one meal per month of largemouth bass greater than 12 inches in length or carp between 15 and 20 inches in length (Table 58). The sensitive population (i.e., women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old) was advised to not eat these fish. At the same time, adult males and females were advised to limit their consumption of carp between 20 and 25 inches in length to no more than one meal every two months. It was further recommended that these fish should not be eaten by women who were planning to have children, pregnant, or breast-feeding or by children under the age of 15 years old (i.e., the sensitive population). The FCA also recommended that carp greater than 25 inches in length from the GCRL not be eaten by anyone. The 1996 FCA for largemouth bass and carp was re-issued in the Indiana FCA each year between 1997 and 2002 (Tables 57 and 58).

In 1999, the ISDH also issued a FCA on bluegills (Table 58). More specifically, it was recommended that adult males and females consume no more than one meal per month of bluegills between four and seven inches in length. The sensitive population was advised to not eat these fish. At the same time, adult males and females were advised to limit their consumption of bluegills greater than seven inches in length to no more than one meal every two months, and the sensitive population was advised that these fish should not be eaten. Therefore, it is concluded that human uses of fishery resources in the GCRL were injured as a result of the accumulation of PCBs during the period 1996 to 2002 (Tables 56 and 57).

Indiana Harbor and the Nearshore Areas of Lake Michigan - While sampling to evaluate the levels of bioaccumulative substance in fish tissues was initiated in 1972, the first FCA for Lake Michigan was not issued until 1977 (L. Bridges. IDEM. Indianapolis, Indiana. Personal communication; Table 53). At that time, the ISBH advised all segments of the human population to not eat lake trout (*Salvelinus namaycush*) from Lake Michigan due to the presence of elevated levels of bioaccumulative substances in their tissues. In 1983, this FCA was expanded to include three other salmonid species, including all size classes of brown trout (*Salmo trutta*), coho salmon (*Oncoryhnchus kisutch*), and steelhead trout (*Oncoryhnchus mykiss*). More specifically, it was recommended that adult males and females consume no more than one meal per week of these three salmonid species. Women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to not eat these fish (Tables 57 and 59).

In 1985, the four states bordering Lake Michigan (i.e., Illinois, Indiana, Michigan, and Wisconsin) agreed to share and pool their data on the levels of COPCs in fish from Lake Michigan. In addition, the FCA classification system was refined to consider the length of the fish species under consideration and to more formally adopt a three tiered system for grouping fish based on the consumption recommendations (Table 53). Based on the information contained in the enhanced database, consumers in Indiana were advised to refrain from consuming any brown trout, carp, and lake trout from Lake Michigan greater that 25 inches in length (ISBH 1985a). This FCA was re-issued in 1986 (ISBH 1986; Tables 57 and 59).

In 1987, the four states bordering Lake Michigan issued the first joint FCA that applied to all of the fish caught in the Lake Michigan recreational fishery (Table 53). More specifically, Illinois, Indiana, Michigan, and Wisconsin indicated that no segment of the human population should eat the following fish from Lake Michigan: carp of any size; catfish of any size; brown trout greater than 23 inches in length; chinook salmon greater than 32 inches in length; or lake trout greater than 23 inches in length (Table 59). These states further recommended that adult males and females consume no more than one meal per week of brown trout up to 23 inches, chinook salmon between 21- 32 inches, coho salmon greater than 26 inches, or lake trout up to between 20- 23 inches from Lake Michigan. Women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to not eat these fish (Tables 57 and 59). The FCA was expanded to include the tributaries to Lake Michigan in 1990 and subsequently remained in effect until 1994. In all cases, these FCAs were established based on exceedances of the action levels or tolerance levels that were established by the USFDA.

In 1995, a number of refinements to the FCA system were implemented to provide the public with more precise advice regarding the consumption of sport-caught fish from

Lake Michigan and associated tributaries (Table 53). Importantly, the protocol for developing a uniform Great Lakes sport FCA (that was completed in 1993; Anderson *et al.* 1993) was adopted by Indiana for assessing the risks to human health associated with the consumption of PCB-contaminated fish (Table 53). Accordingly, the categorical grouping for spacing Indiana sport-caught fish meals was expanded from the three group system that was used between 1985 and 1994 to the five group system that has been used since 1995 (Table 53). This expanded system provided the public with a basis for making more informed choices regarding the consumption of fish from Lake Michigan and its tributaries.

Using the most recent data on the concentrations of COPCs in fish tissues and the new protocol, the ISDH and its partners issued a number of FCAs in 1995 for Lake Michigan and associated tributaries (Table 59). More specifically, it was recommended that consumers not eat carp (*Cyprinus carpio*) of any size, blue suckers (*Cycleptus elongatus*), carpsuckers (*Carpoides velifer*), longnose suckers (*Catostomus catostomus*), spotted suckers (*Minytrema melanops*), or white suckers (*Catostomus commersoni*) of 15 to 23 inches in length, channel catfish (*Ictalurus punctatus*) of 13 or more inches in length, brown trout (*Salmo trutta*) greater than 27 inches in length, or lake trout (*Salvelinus namaycush*) greater than 26 inches in length. It was further recommended that adult males and females limit consumption of the following fish to one meal every two months: blue suckers, carpsuckers, longnose suckers, spotted suckers, or white suckers of 8 to 15 inches in length, walleye (*Stizostedion vitreum*) greater than 26 inches in length, brown trout (*Salmo trutta*) of 18 to 27 inches in length, chinook salmon (*Oncorhynchus tschawytscha*) greater than 26 inches in length, coho salmon (*Oncorhynchus kisutch*) greater than 28 inches in length, lake trout (*Salvelinus namaycush*) of 21 to 26 inches in length, whitefish (*Coregonus clupeaformis*) greater than 23 inches in length, and steelhead (*Oncorhynchus mykiss*) greater than 22 inches in length. The consumption of walleye of 17 to 26 inches in length, brook trout (*Salvelinus fontinalis*) of all sizes, brown trout up to 18 inches in length, chinook salmon up to 26 inches in length, coho salmon of 17 to 28 inches in length, lake trout of up to 21 inches in length, whitefish of up to 23 inches in length, pink salmon (*Oncorhynchus gorbuscha*) of any size, and steelhead of up to 22 inches in length was restricted to one meal per month for adult males and females. Women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to not eat cyprinids, catostomids, percids, ictalurids, or salmonids (Tables 57 and 59). Finally, it was recommended that the consumption of any undesignated species from named waterways or from any waterways not listed in the FCA be limited to one meal per week.

In 1996, the risk-based approach that was used to establish FCAs based on the concentrations of PCBs in fish tissues was also used to evaluate data on the levels of tissue-associated mercury. However, the data on other COPCs were still evaluated using the USFDA action levels and published reference doses. Based on the data available through 1995, the ISDH, IDEM, and IDNR (1996) recommended in 1996 and 1997 that the following fish from Lake Michigan and its tributaries (within Lake, LaPorte, and Porter counties) not be consumed (Table 59): carp (*Cyprinus carpio*) of any size; golden shiner (*Notemigonus crysoleucas*) of three to six in length, goldfish (*Carassius auratus*) of greater than four inches in length; longnose suckers (*Catostomus catostomus)* greater than 23 inches in length; catfish (*Ictalurus* spp.) of any size; brown trout greater than 27 inches in length; or, lake trout greater than 26 inches in length. The consumption of black crappie (*Pomoxis nigromaculatus*) of greater than eight inches in length, largemouth bass greater than seven inches in length, longnose suckers of 15 to 23 inches in length, white suckers greater than 23 inches in length, walleye of greater than 26 inches in length, brown trout of 18 to 27 inches in length, chinook salmon greater than 26 inches in length, coho salmon greater than 28 inches in length, lake trout of 21 to 26 inches in length, whitefish greater than 23 inches in length, rainbow trout *(Oncorhychus mykiss*) of greater than 22 inches in length, and northern pike (*Esox lucius*) greater than 14 inches in length was restricted to one meal every two months for adult males and females. It was further recommended that adult males and females limit consumption of the following fish to one meal per month: black crappie of seven to eight inches in length; largemouth bass of four to seven inches in length; white suckers of 15 to 23 inches in length; walleye of 17 to 26 inches in length; brook trout of all sizes; brown trout up to 18 inches in length; chinook salmon up to 26 inches in length; coho salmon of 17 to 28 inches in length; lake trout of up to 21 inches in length; whitefish of up to 23 inches in length; pink salmon of any size; rainbow trout of up to 22 inches in length; and, northern pike of 10 to 14 inches in length. Women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to not eat any of the aforementioned fish species (Tables 57 and 59).

The FCAs that were issued in 1998 were similar in most respects to the FCAs that were issued in 1997. However, the FCA was extended to include freshwater drum (*Aplodinotus grunniens*) and bloater (*Coregonus hoyi*; Table 59). More specifically, adult males and females were advised to restrict consumption of freshwater drum greater than 22 inches in length to one meal every two months and restrict consumption of bloater greater than 10 inches in length to one meal per month. The consumption of freshwater drum of 17 to 22 inches was restricted to one meal per month. Women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to not eat either of these fish species. The FCA on chinook salmon was also refined to recommend adult males and females not eat fish of greater than 30 inches in length, and limit their consumption of fish up to 26 inches in length and 26 to 30 inches in length to one meal per month and one meal every two months, respectively. For whitefish, it was recommended that adult males and females restrict their consumption to one meal per week for fish of nine to 12 inches, one meal per month for fish of 12 to 20 inches, and one meal every two months for fish of 20 to 24 inches in length. It was further recommended that whitefish greater than 24 inches in length not be eaten. Finally, the FCA provided separate recommendations for rainbow trout (specified above) and steelhead trout (i.e., consumption by adult males and females of steelhead trout of 26 to 32 inches should be restricted to one meal every two months, while larger steelhead should not be eaten).

Although the 1999 FCA was similar in many ways to the FCA that was issued in 1998, it differed in several important respects (Table 59). First, the 1999 FCA did not provide any advice regarding the consumption of golden shiners or goldfish. In addition, several new fish species were included in the 1999 advisory that had not been previously covered under the Indiana FCA, including bluegill (*Lepomis macrochirus*), rock bass (*Ambloplites rupestris*), smallmouth bass (*Micropterus dolomieui*), quillback (*Carpiodes cyprinus*), silver redhorse *(Moxostoma anisurum*), yellow perch (*Perca flavescens*), and round goby (*Neogobius melanostomus*). For adult males and females, the consumption of bluegills of seven to eight inches in length, rock bass of eight to nine inches in length, smallmouth bass of eight to 14 inches in length, yellow perch greater than 10 inches in length, and round goby of three to four inches in length was restricted to one meal per week; women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to restrict their consumption of these fish to one meal per month. The 1999 FCA also recommended that adult males and females restrict their consumption of bluegills greater than eight inches in length, smallmouth bass greater than 14 inches in length, round goby greater than four inches in length, and quillback greater than 20 inches in length to one meal per month. Women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to not eat these three fish species. It was further recommended that silver redhorse greater than 25 inches in length not be eaten by anyone.

Only minor refinements were made to the Indiana FCA in 2000, as compared to the FCA that was issued in 1999. First, the FCAs on smallmouth bass were revised to recommend that adult males and females limit their consumption of fish 11 to 12 inches in length to one meal per month. Women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to not eat these fish. It was further recommended that no one consume smallmouth bass greater than 12 inches in length (Table 59). In addition, the FCA on catfish was revised to apply to channel catfish only (i.e., fish of any size should not be eaten). Furthermore, the FCA on freshwater drum was revised to specify that the consumption of fish 14 to 17 inches in length, 17 to 20 inches in length, and greater than 20 inches in length by adult males and females should be restricted to one meal per month, one meal every two months, and no consumption, respectively. No consumption of freshwater drum 14 inches in length or more was advised for women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old.

With one exception, the FCAs that were issued in 2001 and 2002 were the same as those that were issued in 2000 (Table 59). For both 2001 and 2002, the consumption of yellow perch of seven to 10 inches in length was restricted to one meal per week for adult males and females. Women who were planning to have children, pregnant, or breast-feeding and children under the age of 15 years old were advised to restrict their consumption of these fish to one meal per month. Therefore, it is concluded that human uses of fishery resources in IH/LM were injured as a result of the accumulation of PCBs, chlordane, dieldrin and/or DDT, during the period 1985 to 1990, and as a result of the accumulation of PCBs and mercury during the period 1996 to 2002 (Tables 56 and 57).

5.4 Identification of Contaminants of Concern in Sediments and Fish Tissues

Following the assessment of injury to human uses of fishery resources, it is useful to identify the factors that are causing or substantially contributing to adverse effects on human uses of fishery resources. In this report, the bioaccumulative chemicals that occur in sediments or fish tissues at levels that are sufficient to cause or substantially contribute to injury to human uses of fishery resources are termed COCs. The COCs in whole sediments and fish tissues for each geographic area are identified in this section of the report.

The bioaccumulative COCs in whole sediments and fish tissues were identified from the list of COPCs using a three-step process. First, the measured concentrations of COPCs in whole sediments were compared to the bioaccumulation-based SQC. Those substances that occurred in two or more whole sediment samples (separated by more than 100 feet) at concentrations in excess of the corresponding chemical benchmark were identified as sediment-associated COCs. Next, the measured concentrations of COPCs in fish tissues were compared to the benchmarks for tissue chemistry for the protection of human health. Those substances that occurred in one or more fish tissue samples at concentrations in excess of the corresponding chemical benchmark were identified as tissue-associated COCs. Finally, the FCAs that have been issued for the GCR/IHC, for the GCRL, and for IH/LM were reviewed to determine which substance or substances were considered to be the cause of the risk to human health. A substance that was identified as a COPC and that was identified as either a tissue-associated COC or a substance that had driven one or more FCAs was designated as a principal COC. Substances that were identified as sediment-associated COCs, but for which there were no available tissue benchmarks or measured tissue chemistry (i.e., not identified as tissue-associated COCs) were not identified as principal

COCs. This distinction was made because it was not possible to confirm that certain sediment-associated COCs had actually accumulated in fish tissues to levels that would adversely affect human uses of fishery resources.

Grand Calumet River and Indiana Harbor Canal - A number of substances occurred in GCR/IHC sediments at concentrations sufficient to injure human uses of fishery resources (Tables 6 and 7; Appendix 3). More specifically, the sediment-associated COCs in the GCR/IHC include benzene, benz[a]anthracene; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, carbazole, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, total PCBs, chlordane, dieldrin, endrin, heptachlor, heptachlor epoxide, beta-hexachlorocyclohexane, lindane, p,p'-DDD, p,p'-DDE, p,p'-DDT, and TCDD-TEQs (Table 60). Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. Chemical benchmarks for assessing hazards to human health associated with the consumption of fish and shellfish tissues (i.e., USFDA action levels, USFDA tolerance levels, or ISDH Group 1 threshold levels) were located for mercury, PCBs, aldrin/dieldrin, chlordane, DDTs, and heptachlor/heptachlor epoxide. Of these substances, the USFDA action level for chlordane (1 of 78 samples) and the USFDA tolerance level for PCBs (70 of 87 samples) was exceeded in one or more of the fish tissue samples collected from the GCR/IHC (Tables 19, 20, and 60; Appendix 5). By comparison, the ISDH Group 1 threshold levels for both mercury and total PCBs were commonly exceeded in fish tissues from this portion of the Assessment Area (Tables 21, 22, and 60). Based on the information provided in the Indiana FCA, PCBs and mercury were the substances responsible for issuance of FCAs in the GCR/IHC between 1986 and 2002 (Tables 56 and 60). Therefore, it is concluded that mercury and total PCBs are the principal COCs in the GCR/IHC (Table 60). Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if certain other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Grand Calumet River Lagoons - In GCRL sediments, several substances occurred at concentrations sufficient to injure human uses of fishery resources. More specifically, the sediment-associated COCs in the GCRL include benz[a]anthracene; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, Aroclor 1242, Arclor 1248, Aroclor 1254, Aroclor 1260, total PCBs, chlordane, dieldrin, endrin, p,p'-DDD, p,p'-DDE, and p,p'-DDT (Tables 6, 7, and 61; Appendix 3). Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. In fish tissues, none of the substances measured occurred at concentrations in excess of the USFDA action levels or tolerance levels within the GCRL (Tables 23 to 35, and 61). However, the ISDH Group 1 advisory threshold levels for both mercury and total PCBs were commonly exceeded in fish tissues from this portion of the Assessment Area (Tables 36, 37, and 61; Appendix 5). Based on the information provided in the Indiana FCA, PCBs were identified as the substance responsible for the issuance of FCAs in the GCRL between 1996 and 2002 (Tables 56 and 60). Therefore, it is concluded that mercury and total PCBs are the principal COCs in the GCRL (Table 61). Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if certain other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Indiana Harbor and the Nearshore Areas of Lake Michigan - Sediment-associated COPCs commonly occurred in IH/LM sediment samples at concentrations sufficient to injure human uses of fishery resources. More specifically, the COCs in the IH/LM sediments include benz[a]anthracene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, Aroclor 1242, total PCBs, and TCDD-TEQs (Tables 6, 7, and 62; Appendix 3). Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. By comparison, only PCBs occurred in fish tissues from IH/LM at concentrations in excess of the USFDA action levels or tolerance levels (Tables 38 to 50, and 62). The ISDH Group 1 advisory threshold levels for both mercury and total PCBs were commonly exceeded in fish tissues from this portion of the Assessment Area, however (Tables 51, 52, and 62). Based on the information provided in the Indiana FCA, PCBs, chlordane, dieldrin, and/or DDT were the substances that are responsible for the issuance of FCAs in IH/LM (Table 62) between 1985 and 1990 (Tables 56 and 62). In recent years (i.e., 1996 to 2002), PCBs and mercury were identified as the responsible substances. Therefore, it is concluded that mercury, total PCBs, chlordane, dieldrin, and DDT are the principal COCs in IH/LM (Table 62). Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if certain other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

5.5 Evaluation of the Spatial and Temporal Extent of Injury to Human Uses of Fishery Resources

The areal extent of injury to human uses of fishery resources in the Assessment Area was evaluated using the information available on the FCAs. More specifically, the entire geographic area covered by a FCA was considered to have conditions sufficient to injure human uses of fishery resources during each year that a FCA was in effect. The following provides a summary of the spatial and temporal extent of injury to human uses of fishery resources in the Assessment Area.

Grand Calumet River and Indiana Harbor Canal - The FCAs that have been issued for the GCR/IHC generally apply to the WBGCR, EBGCR downstream of the GCRL, and the IHC. Based on the available information, it is apparent that FCAs have been issued each year between 1986 and 2002, with the exception of 1987 and 1988.

Although it was not explicitly stated by the ISBH, it is assumed that the FCA that was issued for the GCR/IHC remained in effect through 1987 and 1988. The FCAs for this portion of the Assessment Area recommended against consumption of any fish species taken from these waters. Therefore, it is concluded that the human uses of fishery resources in the WBGCR, EBGCR downstream of the GCRL, and the IHC have been injured by discharges of oil or releases of other hazardous substances between 1986 and 2002, a period of 17 years. Although FCAs were not issued for this portion of the Assessment Area prior to 1986, the available tissue residue data suggest that the concentrations of PCBs and mercury in fish tissues collected in 1980, 1982, and 1984 were sufficient to injure human uses of fishery resources (i.e., exceeded the ISDH Group 1 threshold levels). Hence, the temporal extent of injury to human uses of fishery resources was probably greater than 17 years. The available sediment chemistry and tissue chemistry data confirm that conditions sufficient to injure human uses of fishery resources occur throughout the GCR/IHC (Figures 5 to 8).

Grand Calumet River Lagoons - The FCAs that have been issued for the GCRL (i.e., Marquette Park Lagoons) apply to the East Lagoon, West Lagoon, Little West Pond, Little East Pond, and the Middle Lagoon. Based on the information provided in the Indiana FCA, it is apparent that FCAs have been issued for the GCRL each year between 1996 and 2002. During the period 1996 to 1998, these FCAs indicated that the consumption of largemouth bass and carp should be restricted or, in some cases avoided. The FCAs issued since 1999 also recommend that the consumption of bluegills from the GCRLs be restricted or avoided. Therefore, it is concluded that human uses of fishery resources (in particular, the uses of bluegill, largemouth bass, and carp) in the GCRL have been injured by discharges of oil or releases of other hazardous substances between 1996 and 2002, a period of seven years. Although FCAs were not issued for this portion of the Assessment Area prior to 1996, the available tissue residue data suggest that the concentrations of PCBs and mercury in fish tissues collected in 1986 were sufficient to injure human uses of fishery resources (i.e., exceeded the ISDH Group 1 advisory threshold levels). Hence, the temporal extent of injury to human uses of fishery resources was probably greater than seven years. The available sediment chemistry and tissue chemistry data confirm that conditions sufficient to injure human uses of fishery resources occur throughout the GCRLs (Figures 5 to 8).

Indiana Harbor and the Nearshore Areas of Lake Michigan - The first FCA for Lake Michigan was issued by the ISBH in 1977 to address concerns related to the accumulation of COPCs in lake trout. Between 1983 and 1989, the FCA was expanded to include other fish species that are caught in the Lake Michigan sport fishery, including carp, catfish, brown trout, chinook salmon, coho salmon, and steelhead. The FCA that was issued in 1986 explicitly included all fish species caught in Indiana Harbor. Between 1990 and 2002, FCAs were issued each year to provide the public with guidance on the consumption of sport-caught fish from Lake Michigan and associated tributaries. Fish consumption advisories were issued in 1977, 1983, 1985 to 1987, and 1989 to 2002 and restricted consumption of more than 30 species of fish that occur in IH/LM. As the 1977, 1983, and 1987 FCAs were not revoked by ISDH, it is reasonable to assume that these FCAs remained in effect during 1978 to 1982, 1984, and 1988, respectively. Therefore, it is concluded that the human uses of fishery resources present in Indiana Harbor and the nearshore areas of Lake Michigan have been injured by discharges of oil or releases of other hazardous substances during 1977-2002 a period of 25 years. Although there are numerous sources of COCs within the Lake Michigan basin, it is likely that the oil and other hazardous substances originating from Indiana Harbor (and elsewhere in the Assessment Area) contributed to the loadings of COCs in tissues of fish utilizing habitats within Lake Michigan. The available sediment chemistry and tissue chemistry data confirm that conditions sufficient to injure human uses of fishery resources occur in Indiana Harbor and in nearby areas within Lake Michigan (Figures 5 to 8).

6.0 Summary and Conclusions

This investigation was conducted to determine if biological resources within the Grand Calumet River and Indiana Harbor Canal, Grand Calumet River Lagoons, Indiana Harbor and the nearshore areas of Lake Michigan (i.e., the Assessment Area) have been injured due to discharges of oil or releases of other hazardous substances, as defined in 43 CFR § 11.62(f)(1)(ii) and (iii) in the United States Department of the Interior (USDOI) regulations for conducting natural resource damage assessments (NRDAs; CFR 2002). In this report, the term injury to human uses of fishery resources has been used to more specifically describe such injuries to biological resources. If the results of this assessment indicated that injury to human uses of fishery resources has occurred within the Assessment Area, then the subsequent objectives of this investigation were to identify contaminants of concern (COCs; i.e., those toxic or bioaccumulative substances that occur in sediments and/or fish tissues at concentrations that are sufficient to cause or substantially contribute to injury to human uses of fishery resources) in the Assessment Area and to evaluate the areal and temporal extent of injury to human uses of fishery resources.

In accordance with the Assessment Plan (Natural Resources Trustees 1997), this assessment of injury to human uses of fishery resources was focused on evaluating the effects on human use and/or consumption of fish that have occurred due to discharges of oil or releases of other hazardous substances. As defined in the assessment plan (Natural Resources Trustees 1997), the primary chemicals of potential concern (COPCs; i.e., the substances that could, potentially, be adversely affecting human uses of fishery resources) in the Assessment Area include polychlorinated biphenyls (PCBs), oil and oil-related compounds (including alkanes, alkenes, naphthalenes, and polycyclic aromatic hydrocarbons; PAHs), and metals (Natural Resources Trustees 1997). The other substances that were considered as COPCs in this investigation include various pesticides, chlorinated benzenes, chlorophenols, phthalates, and polychlorinated dibenzo-*p*-dioxins/polychlorinated dibenzofurans (PCDDs/PCDFs). As many of these substances tend to become associated with sediments upon release into aquatic ecosystems, sediment contamination represents a concern with respect to the restoration of beneficial uses in the Assessment Area (IDEM 1991). Subsequent transfer of bioaccumulative substances to sediment-dwelling organisms and, ultimately, to fish and shellfish also has the potential to adversely affect beneficial uses within the Assessment Area, including the utilization of fishery resources by the public.

To facilitate this evaluation, the Assessment Area was initially divided into nine separate reaches, including the Grand Calumet River Lagoons (GCRL), East Branch Grand Calumet River-I (EBGCR-I), East Branch Grand Calumet River-II (EBGCR-II), West Branch Grand Calumet River-I (WBGCR-I), West Branch Grand Calumet River-II (WBGCR-II), Indiana Harbor Canal (IHC), Lake George Branch (LGB), US Canal (USC) and Indiana Harbor/Lake Michigan (IH/LM; i.e., consistent with the approach used by MacDonald and Ingersoll 2000). In each of these reaches, the available sediment quality, tissue quality, and related information was collected, evaluated, and compiled. Subsequently, the data on seven of the nine reaches was consolidated to support the assessment of injury to human uses of fishery resources within the Grand Calumet River and Indiana Harbor Canal (GCR/IHC). Injury to human uses of fishery resources was also evaluated within the GCRL, and IH/LM. Division of the Assessment Area into these three areas facilitated implementation of a geographically consistent approach to the assessment of injury to human uses of fishery resources using all three of the indicators that were selected [i.e., sediment chemistry, tissue chemistry, and fish consumption advisories (FCAs); i.e., FCAs have been issued for these three geographic areas only].

An overview of the environmental issues and concerns in the Assessment Area, the study objectives, and the study approach are presented in Section 1 of this report. The geographic scope of the Assessment Area, the COPCs, and the natural resources contained within the Assessment Area are described in Section 2. More detailed narratives on the study approach and on the data sets that were used in this assessment are provided in Sections 3 and 4, respectively. Finally, the results of the assessment are presented in Section 5 of this report. A summary of these results is presented below to provide an overview of sediment quality, tissue quality, and related conditions within the Assessment Area, as they relate to injury of human uses of fishery resources.

Injury to Human Uses of Fishery Resources

An assessment of injury to human uses of fishery resources associated with discharges of oil or releases of other hazardous substances was conducted for the Grand Calumet River and Indiana Harbor Canal, Grand Calumet River Lagoons, and Indiana Harbor and the nearshore areas of Lake Michigan. The definitions of injury to biological resources included in the USDOI regulations were generally applied to support this assessment of the effects of chemical contamination on human use and consumption of fish and shellfish [i.e., injury to human uses of fishery resources; 43 CFR § 11.62(f)(1)(ii and iii); CFR 2002]. That is, a total of three indicators were used to assess injury to human uses of fishery resources, including sediment chemistry, tissue chemistry, and FCAs.

In this report, injury to human uses of fishery resources was defined as the presence of conditions that have adversely affected or are sufficient to adversely affect the human use and/or consumption of fish. Accordingly, injury to the human uses of fishery resources is considered to be equivalent to injury to biological resources, as defined in the USDOI regulations for conducting NRDAs [43 CFR § 11.62(f)(1)(ii and iii); CFR 2002]. Injury to human uses of fishery resources was assessed for each of the areas defined above (i.e., the GCR/IHC, GCRL, and IH/LM). Three separate lines of evidence were used to determine if injury to human uses of fishery resources has occurred. More specifically, injury to human uses of fishery resources was considered to have occurred if the concentrations of one or more COPCs in two or more whole-sediment samples (separated by more than 100 feet) from an area exceeded the selected chemical benchmarks for the protection of human health. In addition, human uses of fishery resources were considered to have been injured if the concentrations of one or more COPCs in one or more fish tissue samples from an area exceeded the selected chemical benchmarks for the protection of human health [i.e., the tolerance levels or action levels that have been promulgated by the United States Food and Drug Administration (USFDA) **or** the Group 1 threshold levels that have been established by the Indiana State Department of Health (ISDH) to support the development of FCAs]. Furthermore, issuance of FCAs on one or more species of fish within an area was considered to provide the necessary and sufficient evidence of injury to human uses of fishery resources.

Grand Calumet River/Indiana Harbor Canal - Evaluation of the sediment chemistry data that were compiled in the project database indicate that sediments from the GCR/IHC have concentrations of numerous COPCs sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. There were exceedances of one or more of the selected benchmarks for the protection of human health in all of the samples from this portion of the Assessment Area in which the concentrations of PAHs, PCBs, organochlorine pesticides, and/or other substances were measured (i.e., n=up to 244 for surficial samples and n=up to 127 for sub-surface samples). Therefore, it is concluded that concentrations of PAHs, PCBs, and/or other bioaccumulative substances occur in sediments from the GCR/IHC at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, and certain other chlorophenols, PAHs, and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Comparison of the available data on the levels of COPCs in the edible tissues of goldfish, white sucker, channel catfish, gizzard shad, sunfish, pumpkinseed, and carp from the GCR/IHC to the selected benchmarks for tissue chemistry indicates that mercury and PCBs frequently occurred at concentrations sufficient to injure human uses of fishery resources. Overall, 83% (70 of 87 samples) of the fish tissue samples collected from GCR/IHC had concentrations total PCBs that exceeded the tolerance levels that have been established by the USFDA. In addition, the Group 1 threshold concentrations of mercury and PCBs that were established by the ISDH were commonly exceeded in the edible tissues of fish from this portion of the Assessment Area (i.e., 6 of 86 samples for mercury and 87 of 87 samples for total PCBs). Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs have occurred at concentrations sufficient to injure human uses of fishery resources in the GCR/IHC. Organochlorine pesticides (i.e., chlordane) in the edible tissues of fish only rarely posed a potential risk to human health, based on comparisons to the USFDA action levels. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if certain other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

In 1986, the Indiana State Board of Health (ISBH; which is now referred to as ISDH) advised the public to not eat any fish caught in the GCR/IHC due to the high levels of contamination in fish tissues. Since that time, FCAs have been explicitly issued in 12 additional years, including 1989 to 1994 and 1997 to 2002. As the 1986 and 1994 FCAs were not revoked by ISDH, it is reasonable to assume that these FCAs remained in effect during 1987 to 1988 and 1995 to 1996, respectively. Therefore, it is concluded that human uses of fishery resources in the GCR/IHC were injured during the period 1986 to 2002 as a result of the accumulation of mercury and PCBs in fish tissues.

Three lines of evidence, including information on sediment chemistry, tissue chemistry, and FCAs, were used to determine if injury to human uses of fishery resources has occurred within the GCR/IHC. All three lines of evidence indicate that human uses of fishery resources in the GCR/IHC have been injured, particularly due to the presence of mercury, PCBs, and/or chlordane in environmental media (i.e., whole sediments and edible fish tissues). Therefore, it is concluded that human uses of fishery resources in the GCR/IHC have been injured as a result of discharges of oil or releases of other hazardous substances.

Grand Calumet River Lagoons - Comparison of the measured levels of COPCs in whole sediment samples with the benchmarks for sediment chemistry indicate that a number of COPCs occur in GCRL sediments at concentrations sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. There were exceedances of one or more of the selected benchmarks for the protection of human health in all of the samples from this portion of the Assessment Area in which the concentrations of PAHs, PCBs, and/or organochlorine pesticides were measured (i.e., n=up to 127 for surficial samples and n=up to 2 for sub-surface samples). Therefore, it is concluded that concentrations of PAHs, PCBs, and/or other bioaccumulative substances occur in sediments from the

GCRL at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, chlorophenols, tetrachlorodibenzo-*p*-dioxin - toxic equivalents (TCDD-TEQs), and certain other PAHs and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

Evaluation of available tissue chemistry data indicate that the levels of certain COPCs occurred in the edible tissues of carp, largemouth bass and/or bluegills at concentrations sufficient to injure human uses of fishery resources. While the USFDA action levels or tolerance levels were never exceeded in fish tissue samples collected from GCRL, the levels of mercury in 14% (i.e., 3 of 21 samples) and total PCBs in 100% (i.e., n=25) of the samples exceeded the Group 1 threshold levels that have been established by the ISDH. Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs have occurred at concentrations sufficient to injure human uses of fishery resources in the GCRL. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

FCAs have been issued for three species of fish from the GCRL. The FCAs on largemouth bass and carp have been effect from 1996 to 2002. In 1999, the ISDH also issued a FCA on bluegills. Therefore, it is concluded that human uses of fishery resources in the GCRL were injured during the period 1996 to 2002 as a result of the accumulation of PCBs in fish tissues.

Three lines of evidence, including information on sediment chemistry, tissue chemistry, and FCAs, were used to determine if injury to human uses of fishery resources has occurred within the GCRL. All three lines of evidence indicate that human uses of fishery resources in the GCRL have been injured, particularly due to the presence of mercury and PCBs in environmental media (i.e., whole sediments and edible fish tissues). Therefore, it is concluded that human uses of fishery resources in the GCRL have been injured as a result of discharges of oil or releases of other hazardous substances.

Indiana Harbor and the Nearshore Areas of Lake Michigan - Although fewer sediment chemistry data are available for IH/LM than are available for the other portions of the Assessment Area, evaluation of these data indicate that sediments from the IH/LM have conditions that are sufficient to alter the chemical composition of fish tissues to such an extent that the human uses of fishery resources would be adversely affected. There were exceedances of one or more of the selected benchmarks for the protection of human health in all of the samples from this portion of the Assessment Area in which the concentrations of PAHs, PCBs, organochlorine pesticides and/or other bioaccumulative substances were measured (i.e., n=up to 30 for surficial samples). No data were available on the chemical composition of sub-surface sediments. Therefore, it is concluded that concentrations of PAHs, PCBs, and other bioaccumulative substances occur in IH/LM sediments at levels that are sufficient to result in the bioaccumulation of these substances in fish tissues to concentrations that pose a human health concern. Insufficient information (e.g., lack of sediment chemistry data or chemical benchmarks for sediments) was available to determine if other sediment-associated COPCs, such as metals, chlorinated benzenes, phthalates, chlorophenols, and certain other PAHs and pesticides, occurred at concentrations in sediments sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

The available data on COPC concentrations in the edible fish tissues of brown trout, carp, gizzard shad, longnose sucker, sunfish, and yellow perch were compared to the selected benchmarks for tissue chemistry to determine if injury to human uses of fishery resources has occurred within IH/LM. The results of this evaluation indicate that the USFDA tolerance level for PCBs was exceeded in 18% (i.e., 4 of 22 samples) fish tissue samples from IH/LM. In addition, 19% (4 of 21 samples) and 86% (i.e., 19 of 22 samples) of the fish tissue samples from this portion of the Assessment Area had concentrations of mercury and total PCBs, respectively, that exceeded the Group 1 threshold levels that were established by the ISDH. Therefore, evaluation of the available data on the levels of COPCs in fish tissues indicates that mercury and PCBs have occurred at concentrations sufficient to injure human uses of fishery resources in IH/LM. Insufficient information (e.g., lack of tissue residue data or chemical benchmarks for fish tissues) was available to determine if other tissue-associated COPCs, such as PAHs, PCDDs/PCDFs, other metals, pesticides, chlorinated benzenes, chlorophenols, or phthalates occurred at concentrations in fish tissues sufficient to injure human uses of fishery resources in this portion of the Assessment Area (i.e., it was not possible to determine if these substances were COCs).

The first FCA for Lake Michigan was issued by the ISBH in 1977 to address concerns related to the accumulation of COPCs in lake trout. Between 1983 and 1989, the FCA was expanded to include various other fish species that were caught in the Lake Michigan sport fishery, including carp, catfish, brown trout, chinook salmon, coho salmon, and steelhead. The FCA that was issued in 1986 explicitly included all fish species caught in Indiana Harbor. Between 1990 and 2002, FCAs were issued each year to provide the public with guidance on the consumption of sport-caught fish from Lake Michigan and associated tributaries. In total, these FCAs restricted consumption of more than 30 species of fish that occur in Indiana Harbor and/or the nearshore areas of Lake Michigan during 1977, 1983, 1985 to 1987, and 1989 to 2002. As the 1977, 1983, and 1987 FCAs were not revoked by ISDH, it is reasonable to assume that these FCAs were also in effect during 1978 to 1982, 1984, and 1988. Therefore, it is concluded that human uses of fishery resources in Indiana Harbor and the nearshore areas of Lake Michigan were injured during the period 1977 to 2002 as a result of the accumulation of mercury, PCBs, chlordane, dieldrin, and/or DDTs in fish tissues.

Three lines of evidence, including information on sediment chemistry, tissue chemistry, and FCAs, were used to determine if injury to human uses of fishery resources has occurred within IH/LM. All three lines of evidence indicate that human uses of fishery resources in the IH/LM have been injured, particularly due to the presence of mercury, PCBs, chlordane, dieldrin, and DDTs in environmental media (i.e., whole sediments and edible fish tissues). Therefore, it is concluded that human uses of fishery resources in IH/LM have been injured as a result of discharges of oil or releases of other hazardous substances.

Contaminants of Concern

In this investigation, COCs were identified as those substances that occurred in whole sediments and/or edible fish tissues at concentrations that are sufficient to cause or substantially-contribute to injury to human uses of fishery resources. For each area, the sediment-associated COCs were identified as those substances that occurred in two or more whole-sediment samples at concentrations in excess of the corresponding chemical benchmark. Likewise, the tissue-associated COCs for an area included those substances that occurred in one or more fish tissue samples at concentrations in excess of the corresponding chemical benchmark (i.e., the tolerance levels or action levels that have been promulgated by the USFDA **or** the Group 1 threshold levels that have been established by ISDH to support the development of FCAs). Finally, the FCAs that have been issued for the GCR/IHC, for the GCRL, and for IH/LM were reviewed to determine which substance or substances were considered to be responsible for the risk to human health. A substance that was identified as a COPC and that was identified as either a tissue-associated COC or a substance that had driven one or more FCAs was designated as a principal COC. Substances that were identified as sediment-associated COCs, but for which there were no available tissue benchmarks or measured tissue chemistry (i.e., not identified as tissue-associated COCs) were not identified as principal COCs. The principal COCs are those substances that have been demonstrated to be associated with injury.

Grand Calumet River and Indiana Harbor Canal - The sediment-associated COCs in the GCR/IHC include benzene, benz[a]anthracene; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, carbazole, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, total PCBs, chlordane, dieldrin, endrin, heptachlor, heptachlor epoxide, beta-hexachlorocyclohexane, lindane, p,p'-DDD, p,p'-DDE, p,p'-DDT, and TCDD-TEQs. Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. Comparison of the tissue chemistry data to the selected benchmarks for assessing hazards to human health associated with the consumption of fish tissues indicated that mercury, PCBs, and chlordane are the tissue-associated COCs in the GCR/IHC. Mercury and/or PCBs were identified as the substances responsible for the issuance of FCAs in the GCR/IHC between 1996 and 2002. Therefore, it is concluded that mercury and PCBs are the principal COCs in the GCR/IHC; additional benchmarks for tissue chemistry are needed to confirm that other COPCs (e.g., various PAHs, certain organochlorine pesticides, or TCDD-TEQs) occur in fish tissues at levels sufficient to injure human uses of fishery resources.

Grand Calumet River Lagoons - The sediment-associated COCs in the GCRL include benz[a]anthracene; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, Aroclor 1242, Arclor 1248, Aroclor 1254, Aroclor 1260, total PCBs, chlordane, dieldrin, endrin, p,p'-DDD, p,p'-DDE, and p,p'-DDT. Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. In fish tissues, the substances that exceeded the USFDA action levels, the USFDA tolerance levels, or the ISDH Group 1 threshold levels included mercury and total PCBs. Based on the information provided in the Indiana FCA, PCBs were identified as the substances responsible for the issuance of FCAs in the GCRL between 1996 and 2002. Therefore, it is concluded that mercury and PCBs are the principal COCs in the GCRL; additional benchmarks for tissue chemistry are needed to confirm that other COPCs (e.g., various PAHs, certain organochlorine pesticides, or TCDD-TEQs) occur in fish tissues at levels sufficient to injure human uses of fishery resources.

Indiana Harbor and the Nearshore Areas of Lake Michigan - The sediment-associated COCs in IH/LM include benz[a]anthracene, benzo(a)pyrene, benzo(k)fluoranthene, chrysene, dibenz[a,h]anthracene, indeno(1,2,3-cd)pyrene, Aroclor 1242, total PCBs, and TCDD-TEQs. Additional benchmarks for sediment chemistry are needed to confirm that other COPCs (e.g., metals and certain PAHs) occur in sediments at levels sufficient to injure human uses of fishery resources. Both mercury and PCBs were identified as tissue-associated COCs, based on exceedances of the USFDA action levels, USFDA tolerance levels, or ISDH Group 1 threshold levels. Based on the information provided in the Indiana FCA, PCBs, chlordane, dieldrin, and/or DDTs were the substances that were responsible for the issuance of FCAs in IH/LM between 1985 and 1990. In recent years (i.e., 1996 to 2002), PCBs and mercury were identified as the causative substances. Therefore, it is concluded that mercury, PCBs, chlordane, dieldrin, and DDTs are the principal COCs in IH/LM; additional benchmarks for tissue chemistry are needed to confirm that other COPCs (e.g., various PAHs, certain organochlorine pesticides, or TCDD-TEQs) occur in fish tissues at levels sufficient to injure human uses of fishery resources.

Spatial and Temporal Extent of Injury to Human Uses of Fishery Resources

In this investigation, the areal and temporal extent of injury to human uses of fishery resources was evaluated using the information in the Indiana FCAs. More specifically, the entire geographic area covered by a FCA was considered to have conditions sufficient to injure human uses of fishery resources during each year that a FCA was in effect.

Grand Calumet River and Indiana Harbor Canal - The FCAs that have been issued for the GCR/IHC generally apply to the West Branch of the Grand Calumet River (WBGCR), East Branch of the Grand Calumet River (EBGCR) downstream of the GCRL, and the IHC. However, the FCA that was issued in 1986 also included the LGB and Indiana Harbor. Based on the information evaluated, it is apparent that FCAs have been issued each year between 1986 and 2002, with the exception of 1987 and 1988. Although it was not explicitly stated by the ISBH, it is assumed that the FCA that was issued for the GCR/IHC remained in effect through 1987 and 1988. The FCAs for this portion of the Assessment Area recommended against consumption of any fish species taken from these waters. Therefore, it is concluded that the human uses of fishery resources in the GCR and IHC have been injured by discharges of oil or releases of other hazardous substances between 1986 and 2002, a period of 17 years. The human uses of fishery resources present in the LGB were injured during 1986, a period of one year.

Grand Calumet River Lagoons - The FCAs that have been issued for the GCRL apply to the East Lagoon, West Lagoon, Little West Pond, Little East Pond, and the Middle Lagoon. Based on the information provided in the Indiana FCA, it is apparent that FCAs have been issued for the GCRL each year between 1996 and 2002. During the period 1996 to 1998, these FCAs indicated that the consumption of largemouth bass and carp should be restricted or, in some cases avoided. The FCAs issued since 1999 also recommend that the consumption of bluegills from the GCRLs be restricted or avoided. Therefore, it is concluded that the human uses of fishery resources (in particular, the uses of bluegill, largemouth bass, and carp) in the GCRL have been injured by discharges of oil or releases of other hazardous substances between 1996 and 2002, a period of seven years.

Indiana Harbor and the Nearshore Areas of Lake Michigan - In this investigation, the FCAs that have been issued for Lake Michigan (or Lake Michigan and tributaries) were considered to apply to IH/LM. In total, these FCAs restricted consumption of more than 30 species of fish that occur in Indiana Harbor and/or the nearshore areas of Lake Michigan. Fish consumption advisories have been explicitly issued for IH/LM for a total of 19 years, including 1977, 1983, 1985 to 1987, and 1989 to 2002. As the FCAs that were issued in 1977, 1983, and 1987 were not revoked by ISDH, it is concluded that human uses of fishery resources in IH/LM have been injured by discharges of oil or releases of other hazardous substances between 1977 and 2002, a period of 26 years. Although there are numerous sources of COCs within the Lake Michigan basin, it is likely that the oil and other hazardous substances originating from Indiana Harbor (and elsewhere in the Assessment Area) contributed to the loadings of COCs in tissues of fish utilizing habitats within the nearshore areas of Lake Michigan.

References Cited

Anderson, H.A., J.F. Amrhein, P. Shubat, J. Hesse. 1993. Protocol for a uniform Great Lakes sport fish consumption advisory. Great Lakes Sport Fish Consumption Advisory Task Force. 81 pp.

Beyer, W.N., G.H. Heinz, and A.W. Redmon-Norwood (Eds.). 1996. Environmental contaminants in wildlife: Interpreting tissue concentrations. SETAC Special Publications Series. CRC Press Inc. Boca Raton, Florida. (As cited in Natural Resources Trustees 1997).

Brannon, J.M., D. Gunnison, D.E. Averett, J.L. Martin, R.L. Chen, and R.F. Athow. 1989. Analysis of impacts of bottom sediments from Grand Calumet River and Indiana Harbor Canal on water quality. Report Number D-89-1. Waterways Experiment Station. U.S. Army Corps of Engineers. Vicksburg, Mississippi.

Bright, G.R. 1988. Recent water quality in the Grand Calumet River as measured by benthic invertebrates. Proceedings of the Indiana Academy of Sciences 98:229-233.

Burton, A. 1994. West Branch Grand Calumet River: 1993 sediment toxicity test data summaries. Prepared for Environmental Sciences Division. United States Environmental Protection Agency. Region V. Chicago, Illinois. 1 pp.

CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. Guidelines and Standards Division. Environment Canada. Winnipeg, Manitoba

CFR (Code of Federal Regulations). 2002. Natural Resource Damage Assessment Regulations. Title 43 CFR 11.62. Section (f) (ii) and (iii). October 1, 2002 Edition.

Cook, P.M., A.R. Carlson, and H. Lee. 1992. Tissue residue approach. *In:* Sediment Classification Methods Compendium. EPA 823-R-92-006. Office of Water. United States Environmental Protection Agency. Washington, District of Columbia.

Crane, J.L. 1996. Carcinogenic human health risks associated with consuming contaminated fish from five Great Lakes Areas of Concern. Journal of Great Lakes Research 22:653-668.

Dorkin, J. 1994. Sediment sampling and analysis plan - West Branch Grand Calumet River: 1993 sediment chemistry data summaries. Environmental Science Division. United States Environmental Protection Agency. Region V. Chicago, Illinois. 30 pp.

Eisler, R. 1986. Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: A synoptic review. Biological Report 85(1.7). Contaminant Hazard Review Report No. 7. United States Fish and Wildlife Service. Laurel, Maryland.

Erickson, M.D. 1997. Analytical chemistry of PCBs. CRC Press Inc. Boca Raton, Florida. (As cited in Natural Resources Trustees 1997).

Exponent. 1999. Sediment characterization study for the DuPont East Chicago facility. Prepared for E.I. du Pont de Nemours and Company. Bellevue, Washington. 160 pp. + apps.

Floyd-Browne (Floyd-Browne Associates, Inc.). 1993. Sediment characterization study, U.S. Steel, Gary, Indiana. Prepared for United States Steel. Gary, Indiana. 26 pp. + apps.

Froese, R. and D. Pauly (Eds). 2002. FishBase. World Wide Web electronic publication. www.fishbase.org, November 13, 2002 - page accessed November 20, 2002.

Gilbert, R.O. 1987. Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold Company Inc. New York, New York. 320 pp.

Gillespie, R.B., J. Speelman, and P.M. Stewart. 1998. An evaluation of the toxic effects of sediments in the Grand Calumet Lagoons near the Indiana Dunes National Lakeshore. Water Resource Division. National Park Service. Fort Collins, Colorado. 45 pp.

Hoke, A.R., J.P. Giesy, M. Zabik, and M. Unger. 1993. Toxicity of sediments and sediment pore waters from the Grand Calumet River - Indiana Harbor, Indiana Area of Concern. Ecotoxicology and Environmental Safety 26:86-112.

IDEM (Indiana Department of Environmental Management). 1991. The remedial action plan for the Indiana Harbor Canal, the Grand Calumet River and the nearshore Lake Michigan, Stage One. Indianapolis, Indiana.

IDEM (Indiana Department of Environmental Management). 1994. Results of sediment and tissue analysis for Indiana Harbor Canal and Grand Calumet River - 1988 to 1994. Office of Water Management. Indianapolis, Indiana.

IDEM (Indiana Department of Environmental Management). 1999. Grand Calumet River sediment sampling results - October 26-27, 1999. Project Number 3961001/6130-10. Office of Land Quality. Indianapolis, Indiana.

IDEM (Indiana Department of Environmental Management). 2000a. Levels of contaminants in fish tissues from Indiana waters - 1980 to 2000 sampling. Unpublished data. Indianapolis, Indiana.

IDEM (Indiana Department of Environmental Management). 2000b. Levels of contaminants in fish tissues from the Grand Calumet River Lagoons - 1997 sampling. Unpublished data. Indianapolis, Indiana.

IDNR (Indiana Department of Natural Resources). 1995. 1995 Indiana Fishing Guide. Indianapolis, Indiana.

IJC (International Joint Commission). 1989. Report on Great Lakes Water Quality. Great Lakes Water Quality Board. Windsor, Ontario. Canada.

IJC (International Joint Commission). 1997. Overcoming obstacles to sediment remediation in the Great Lakes Basin: White Paper by the Sediment Priority Action Committee. Great Lakes Water Quality Board. Ottawa, Ontario. Canada.

Ingersoll, C.G. and D.D. MacDonald. 1999. An assessment of sediment injury in the West Branch of the Grand Calumet River. Volume I. Prepared for Environmental Enforcement Section. Environment and Natural Resources Division. United States Department of Justice. Washington, District of Columbia. 161 pp.

Ingersoll, C.G., T. Dillon, and R.G. Biddinger (Eds.). 1997. Methodological uncertainty in sediment ecological risk assessment. *In*: Ecological Risk Assessments of Contaminated Sediment. SETAC Press. Pensacola, Florida. 389 pp.

ISBH (Indiana State Board of Health). 1985a. Public Health News (March 19, 1985). Indianapolis, Indiana.

ISBH (Indiana State Board of Health). 1985b. Public Health News (January 11, 1985). Indianapolis, Indiana.

ISBH (Indiana State Board of Health). 1986. Public Health News (March 13, 1986). Indianapolis, Indiana.

ISBH (Indiana State Board of Health). 1987. Public Health News (June 18, 1987). Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1989. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1990. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1991. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1992. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1993. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1994. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1995. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1996. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1997. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1998. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 1999. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 2000. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 2001. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

ISBH, IDEM, and IDNR (Indiana State Board of Health, Indiana Department of Environmental Management, and Indiana Department of Natural Resources). 2002. Indiana Fish Consumption Advisory. Indiana State Department of Health. Environmental Epidemiology Section. Indianapolis, Indiana.

MacDonald, D.D. and C.G. Ingersoll. 2000. An assessment of sediment injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the nearshore areas of Lake Michigan B Volume I. Report prepared for the United States Fish and Wildlife Service. Bloomington, Indiana.

Maxim Technologies. 1999. Sediment sampling and characterization for the Grand Calumet River / Indiana Harbor Ship Canal. Prepared for United States Army Corps of Engineers. Chicago District. Chicago, Illinois. 150 pp.

Natural Resources Trustees. 1997. Assessment plan for the natural resource damage assessment of the Grand Calumet River, Indiana Harbor Ship Canal, Indiana Harbor, and associated Lake Michigan environments. Prepared for United States Department of Interior and the State of Indiana. Indianapolis, Indiana.

NYSDEC (New York State Department of Environmental Conservation). 1999. Technical guidance for screening contaminated sediments. Division of Fish and Wildlife. Division of Marine Resources. Albany, New York. 39 pp.

Polls, I. 1988. Sediment survey of the Indiana Harbor Canal, Indiana Harbor, and adjacent Lake Michigan. Prepared for the United States Army Corps of Engineers. Research and Development Department. The Metropolitan Sanitary District of Greater Chicago. Chicago, Illinois. 19 pp. + apps.

Polls, I., S.J. Sedita, D.R. Zenz, and C. Lue-Hing. 1993. A comparison of the water and sediment quality and benthic invertebrates in the Grand Calumet River, the Indiana Harbor Canal, Indiana Harbor, Southwestern Lake Michigan, and the Calumet River during 1982 and 1986. Research and Development Department. Metropolitan Water Reclamation District of Greater Chicago. Chicago, Illinois. 50 pp.

Risatti, J.B. and P.E Ross. 1989. Chemical, biological and toxicological study of sediments from Indiana Harbor Canal and adjacent Lake Michigan. Prepared for United States Army Corps of Engineers. Chicago District. Chicago, Illinois. 83 pp.

Ryder, K. 1993. Preliminary inventory of industries on the Grand Calumet River, Indiana and Illinois. Environmental and Social Analysis Branch. Chicago District. United States Army Corps of Engineers. Chicago, Illinois.

Sheaffer, A.L., J.T. O'Leary, and R.L. Williams. 1999. Consumption of Indiana sport caught fish: mail survey of resident license holders. Purdue University Technical Report 99-D-HDFW-1. Purdue University. Department of Forestry and Natural Resources. W. Lafayette, Indiana. (As cited in Stahl and Simon 2000).

Simon, T.P. 2000. Characterization of Grand Calumet River Lagoons: Unpublished data. Indiana Harbor - chemistry and Grand Calumet River - sediment sampling. Prepared for Water Division. United States Environmental Protection Agency. Region V. Chicago, Illinois.

Simon, T.P., D. Sparks, S. Newhouse, and R. Dufour. 2000. Aquatic community injury assessment for the Grand Calumet River, Indiana Harbor Canal, and the nearshore areas of Lake Michigan. Natural Resource Damage Assessment. United States Fish and Wildlife Service. Bloomington, Indiana.

Stahl, J.R. and T.P. Simon. 2000. A risk-based approach: Understanding underlying assumptions of FCAs. Lake Line 20(4):24-28.

Tetra Tech EM Inc. 1998. Data validation report for sediment split samples collected at E.I. du Pont de Nemours and Company Chemical Manufacturing Plant, East Chicago, Indiana. Prepared for Waste, Pesticides, and Toxics Division. United States Environmental Protection Agency. Chicago, Illinois. 17 pp. + apps.

ThermoRetec (ThermoRetec Consulting Corporation). 1999. River sediment investigation report: Grand Calumet River Hammond, Indiana. Project No. 3-3933-650. Prepared for Northern Indiana Public Service Company. Concord, Massachusetts. 100 pp. + apps.

URS Greiner Woodward Clyde. 1999. Roxana Marsh sediment characterization study. Prepared for Isplat Inland Inc. Indiana Harbor Works. East Chicago, Indiana. Prepared by URS Greiner Woodward Clyde. Chicago, Illinois.

USACE (United States Army Corps of Engineers). 1980. Results of laboratory settling, filtering, leaching, and coagulation tests, Indiana Harbor, Indiana. Waterways Experiment Station. Vicksburg, Mississippi. 166 pp. + apps.

USACE (United States Army Corps of Engineers). 1994. Indiana Harbor and Canal sediment trap investigation: Sediment sampling and probings. Prepared for United States Environmental Protection Agency. Region V. Chicago, Illinois. 45 pp. + apps.

USACE (United States Army Corps of Engineers). 1995. Grand Calumet River flow study. Chicago District. Chicago, Illinois.

USACE (United States Army Corps of Engineers). 1996. Marquette Park Lagoons sediment sampling and analytical results. Prepared by Chicago District. Chicago, Illinois. 19 pp.

USDOI (United States Department of the Interior). 1994. Heavy metal data for whole water and sediments and organic analyses at sites USX4 and USX5. National Biological Survey. Porter, Indiana. Obtained from the FIELDS database. October 27th, 1997 Version (maintained by USEPA Region V, Chicago, Illinois).

USEPA (United States Environmental Protection Agency). 1991. Sediment investigation Indiana Harbor Canal - Sampling dates: November 18, 1991. Environmental Services Division. Central District Office. Region V. Chicago, Illinois. 48 pp. + apps.

USEPA (United States Environmental Protection Agency). 1996a. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. EPA 905-R96-008. Great Lakes National Program Office. Region V. Chicago, Illinois.

USEPA (United States Environmental Protection Agency). 1996b. Assessment and remediation of contaminated sediments (ARCS) program: Assessment of sediment in the Indiana Harbor Area of Concern. EPA 905-R96-009. Prepared by Science Applications International Corporation. Prepared for United States Environmental Protection Agency. Region V. Chicago, Illinois. 82 pp. + apps.

USEPA (United States Environmental Protection Agency). 2000. Proposed changes to the bioaccumulation testing evaluation framework and response to scientific peer reviewers comments on the existing framework for determining the suitability of dredged material to be placed at the historic area remediation site (HARS). Region II. New York, New York.

USFDA (United States Food and Drug Administration). 2001. Fish and fisheries products hazards and controls guidance. Third Edition June 2001. Center for Food Safety and Applied Nutrition. College Park, Maryland.

USGS (United States Geological Survey). 2000. Selected water-quality data and hydrogeology of the Grand Calumet River and the Indiana Harbor Canal watershed, Northwest Indiana. Water Resources Division. Indianapolis, Indiana.

WSDOH (Washington State Department of Health). 1995. Development of sediment quality criteria for the protection of human health. Tier I report. Office of Toxic Substances. Environmental Health Programs. Olympia, Washington.

WSDOH (Washington State Department of Health). 1996. Development of sediment quality criteria for the protection of human health. Tier II report. Office of Toxic Substances. Environmental Health Programs. Olympia, Washington.

Williams, R.L., J.T. O'Leary, A.L. Sheaffer, and D. Mason. 2000. An examination of fish consumption by Indiana recreational anglers: an on-site survey. Purdue University Technical Report 99-D-HDFW-2. Purdue University. Department of Forestry and Natural Resources. W. Lafayette, Indiana. (As cited in Stahl and Simon 2000).

Tables

Table 1. Summary of data sets used to assess sediment quality conditions in the Assessment Area.

Sampling Year	Geographic Area	Reach	Surface Sediment (n)	Sub-surface Sediment (n)	PCBs	PAHs	Metals	Pesticides	PCDDs and PCDFs	Conventional Variables	SEM	ABN	Reference
1980	GCR/IHC	USC	3		✓		✓			✓		✓	USACE (1980)
1987	GCR/IHC	LGB, USC	3		✓		✓			✓			Polls (1988)
1987	IH/LM	IH/LM	27		✓		✓			✓			Polls (1988)
1988	GCR/IHC	LGB, USC	9		✓	✓	✓			✓		✓	Risatti & Ross (1989)
1988	IH/LM	IH/LM	16										Risatti & Ross (1989)
1989	GCR/IHC	USC	5		✓	✓	✓	✓	✓	✓	✓	✓	USEPA (1996a)
1989	IH/LM	IH/LM	2		✓	✓	✓	✓	✓	✓	✓	✓	USEPA (1996a)
1988, 90, 92, 94	GCR/IHC	EBGCR I, EBGCR II, WBGCR II, IHC, USC	19		✓	✓	✓	✓		✓		✓	IDEM (1994)
1990	GCR/IHC	EBGCR I, EBGCR II, WBGCR I, WBGCR II, IHC, USC	10		✓	✓	✓	✓	✓	✓		✓	Hoke *et al.* (1993)
1991	GCR/IHC	EBGCR I, EBGCR II, WBGCR I, IHC	59	58	✓	✓	✓		✓	✓	✓	✓	Floyd-Browne (1993)
1991	GCR/IHC	USC	13			✓	✓					✓	USEPA (1991)
1991	IH/LM	IH/LM	8			✓	✓					✓	USEPA (1991)
1993	GCR/IHC	WBGCR II	32	29		✓	✓			✓		✓	Burton (1994); Dorkin (1994)
1993	GCR/IHC	USC		18	✓	✓	✓	✓		✓		✓	USACE (1994)

Table 1. Summary of data sets used to assess sediment quality conditions in the Assessment Area.

Sampling Year	Geographic Area	Reach	Surface Sediment (n)	Sub-surface Sediment (n)	PCBs	PAHs	Metals	Pesticides	PCDDs and PCDFs	Conventional Variables	SEM	ABN	Reference
1995	GCRL	GCRL		19		✓	✓			✓			Gillespie *et al.* (1998); USDOI (1994)
1996	GCRL	GCRL	5	1	✓	✓	✓	✓		✓		✓	USACE (1996)
1997-98	GCR/IHC	EBGCR II	56		✓	✓	✓	✓					Simon (2000)
1997-98	GCRL	GCRL	192		✓	✓	✓	✓					Simon (2000)
1998	GCR/IHC	EBGCR I	49	51	✓	✓	✓	✓		✓	✓	✓	Exponent (1999)
1998	GCR/IHC	WBGCR II	14	11		✓	✓			✓		✓	Thermoretec (1999)
1998	GCR/IHC	WBGCR II	8	11	✓	✓	✓	✓				✓	URS Greiner Woodward Clyde (1999)
1999	GCR/IHC	EBGCR I, WBGCR I, LGB, IHC	81	40	✓	✓	✓	✓		✓	✓	✓	Maxim Technologies (1999)
1999	GCRL	GCRL	5		✓	✓	✓	✓		✓	✓		Maxim Technologies (1999)
Total for Each Area													
	GCR/IHC		**361**	**218**									
	IH/LM		**53**	**0**									
	GCRL		**202**	**20**									
Total for Assessment Area			***616***	***238***									

SEM = simultaneously extracted metals; ABN = acid-base neutrals; GCR/IHC = Grand Calumet River/Indiana Harbor Canal; GCRL = Grand Calumet River Lagoons; IH/LM = Indiana Harbor and nearshore areas of Lake Michigan; USC = U.S. Canal; LGB = Lake George Branch; EBGCR I & II= East Branch Grand Calumet River I and II; WBGCR I & II = West Branch Grand Calumet River I & II; IHC = Indiana Harbor Canal; PCDDs = polychlorinated dibenzo-*p*- dioxins; PCDFs = polychlorinated dibenzofurans; PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyls.

Table 2. Selected benchmarks for sediment chemistry for assessing injury to human uses of fishery resources (WSDOH 1995; 1996).

Chemicals of Potential Concern	SQC
Metals (mg/kg OC)	
Mercury	NG
Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg OC)	
Acenapthene	NG
Acenaphthylene	NG
Anthracene	NG
Benzene	8000
Carbazole	12000
Fluorene	NG
2-Methylnaphthalene	NG
Naphthalene	NG
Phenanthrene	NG
Benz[a]anthracene	69
Benzo(b)fluoranthene	69
Benzo(k)fluoranthene	69
Benzo(a)pyrene	69
Chrysene	44
Dibenz[a,h]anthracene	69
Fluoranthene	NG
Indeno(1,2,3-cd)pyrene	69
Pyrene	NG
Total PAHs	NG
Polychlorinated Biphenyls (PCBs; µg/kg OC)	
Aroclor 1016	4.9
Aroclor 1242	1.7
Aroclor 1248	1.7
Aroclor 1254	1.7
Aroclor 1260	1.7
Total PCBs	1.7[1]
Chlorinated Benzenes (µg/kg OC)	
Hexachlorobenzene (HCB)	310
Hexachlorobutadiene (HCBD)	8100
Phthalates (µg/kg OC)	
Bis(2-ethylhexyl)phthalate	36000
Chlorophenols (µg/kg OC)	
2,4-Dichlorophenol	450000
2,4,6-Trichlorophenol	8700
Pentachlorophenol	4200

Table 2. Selected benchmarks for sediment chemistry for assessing injury to human uses of fishery resources (WSDOH 1995; 1996).

Chemicals of Potential Concern	SQC
Pesticides (µg/kg OC)	
Aldrin	0.13
Chlordane	1.7
Dieldrin	0.14
p,p'-DDD	9.1
p,p'-DDE	5.5
p,p'-DDT	6.5
Endosulfan	36000
Endrin	550
Heptachlor	1.3
Heptachlor epoxide	0.65
Alpha-hexachlorocyclohexane (HCH)	0.94
Beta-HCH	3.2
Technical-HCH	3.3
Lindane (gamma-HCH)	4.6
PCDDs and PCDFs (µg/kg OC)	
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin	12
1,2,3,4,6,7,8-Heptachlorodibenzofuran	12
1,2,3,4,7,8,9-Heptachlorodibenzofuran	12
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin	0.046
1,2,3,4,7,8-Hexachlorodibenzofuran	0.046
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin	0.046
1,2,3,6,7,8-Hexachlorodibenzofuran	0.046
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin	0.046
1,2,3,7,8,9-Hexachlorodibenzofuran	0.046
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin	0.0092
1,2,3,7,8-Pentachlorodibenzofuran	0.026
2,3,4,6,7,8-Hexachlorodibenzofuran	0.046
2,3,4,7,8-Pentachlorodibenzofuran	0.0031
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	0.00015
2,3,7,8-Tetrachlorodibenzofuran	0.013
Octachlorodibenzodioxin	120
Octachlorodibenzofuran	120
TCDD-TEQ	0.00015[2]

OC = organic carbon; NG = no guideline is available; SQC = sediment quality criteria;
TCDD-TEQ = tetrachlorodibenzo-*p*-dioxin - toxic equivalents; PCDDs = polychlorinated dibenzo-*p*-dioxins;
PCDFs = polychlorinated dibenzofurans.

[1]Adopted guideline for the majority of the Aroclors.
[2]Adopted guideline for 2,3,7,8-tetrachlorodibenzo-*p*- dioxin.

Table 3. Selected tolerance levels and action levels that have been established by U.S. Food and Drug Administration under Section 402 of the Food, Drug, and Cosmetic Act (21 U.S.C. 342) for the edible portions of fish and shellfish (USFDA 2001).

Chemical of Potential Concern (WW units)	Benchmark [1]	Benchmark Type	Regulation	Refinements
Polychlorinated biphenyls (µg/kg)	2000	Tolerance Level	21 CFR 109.30	1984 - refined from 5000 to 2000 µg/kg
Methylmercury (mg/kg)	1.0	Action Level	Sec 540.600 CPG	1979 - refined from 0.5 to 1.0 mg/kg
Chlordane (µg/kg)[2]	300	Action Level	Sec 575.100 CPG	
DDT, TDE (DDD), and DDE (µg/kg)[3]	5000	Action Level	Sec 575.100 CPG	
Aldrin and dieldrin (µg/kg)[4]	300	Action Level	Sec 575.100 CPG	
Heptachlor and heptachlor epoxide (µg/kg)[5]	300	Action Level	Sec 575.100 CPG	
Chlordecone (kepone; µg/kg)	300	Action Level	Sec 575.100 CPG	
Mirex (µg/kg)	100	Action Level	Sec 575.100 CPG	

WW = wet weight; CFR = Code of Federal Regulations; CPG = Compliance Policy Guide; USFDA = United States Food and Drug Administration.

[1]USFDA 2001. Applies to the edible portion of fish (the term "fish" refers to fresh or saltwater fish, crustaceans, all molluscs, and other forms of aquatic animal life other than birds or mammals, as defined in 21 Code of Federal Regulations 123.3 (d).

[2]Action level is for residues of chlordane, including cis and trans chlordane, cis and trans nonachlor, oxychlordane, alpha, beta, and gamma chlordane and chlordane. Levels of individual components must be quantitated at 20 µg/kg or above and confirmed in order to be added into the "chlordane" total value.

[3]The action level applies to residues of the pesticide and its metabolites individually or in combination. In adding amounts of DDT, TDE (DDD), and DDE, any of the three found below 200 µg/kg were not counted.

[4]The action level applies to residues of the pesticide and its metabolite individually or in combination. In adding amounts of aldrin and dieldrin, levels below 100 µg/kg were not counted.

[5]The action level applies to residues of the pesticide and its metabolite individually or in combination. In adding amounts of heptachlor or heptachlor epoxide, levels below 100 µg/kg were not counted.

Table 4. Selected thresholds for tissue chemistry established to support the development of the Indiana Fish Consumption Advisory (Stahl and Simon 2000).

Substance	Tissue Type	Categorical Grouping	Tissue Concentration
Polychlorinated biphenyls (µg/kg WW)[1]	Skin-on scaleless[2]	1	0 - 50
		2	60 to 200
		3	210 to 1000
		4	1100 to 1900
		5	> 1900
Polychlorinated biphenyls (µg/kg WW)[1]	Skin-off fillets[3]	1	0 - 36
		2	37 to 156
		3	157 to 675
		4	676 to 1350
		5	> 1360
Mercury (mg/kg WW)[4]	Edible tissue portions[5]	1	0 - 0.16
		2	0.16 to 0.65
		3	0.66 to 2.80
		4	2.81 to 4.5
		5	> 4.5

WW = wet weight.

[1]Based on a Human Health Protection Value of 0.05 µg/kg/day of PCB consumption, which equates to a daily exposure rate of 3.5 µg/day for total PCBs (Anderson *et al.* 1993).
[2]Based on the assumption that skinning/trimming/cooking reduces residues by 50% from raw, skin-on fillets (Anderson *et al.* 1993).
[3]Based on the assumption that skinning/trimming/cooking reduces residues by 30% from raw skin-off fillets from scaleless species such as catfish (Anderson *et al.* 1993).
[4]Mercury burden thresholds are based on a reference dose (RfD) of 0.3 mg/kg/day and there are no reduction factors for preparation (USEPA recommends a reference dose of 0.1 mg/kg/day - Indiana accounts for this with the "bump-up factor" for sensitive populations; Stahl and Simon 2000).
[5]There is no reduction factor for preparation because mercury tends to concentrate throughout the edible portion (Stahl and Simon 2000).

Table 5. Summary of fish tissue chemistry data sets used to assess injury to human uses of fishery resources in the Assessment Area.

			Fish Species Sampled	Tissue Chemistry				
Geographic Area	Sampling Date	n	Common Name (*Scientific Name*)	Conventionals	Metals	PCBs	Pesticides	Reference
GCR/IHC	1980	1	Carp (*Cyprinus carpio*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1982	2	Carp (*Cyprinus carpio*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1984	2	Carp (*Cyprinus carpio*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1986	9	Carp (*Cyprinus carpio*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1987	5	Carp (*Cyprinus carpio*); Pumpkinseed (*Lepomis gibbosus*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1988	2	Carp (*Cyprinus carpio*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1988	9	Carp (*Cyprinus carpio*); Gizzard shad (*Dorosoma cepedianum*); Sunfish (*Lepomis* [Hybrid])	✓	✓	✓		Risatti & Ross (1989)
GCR/IHC	1990	3	Carp (*Cyprinus carpio*); Goldfish (*Carassius auratus*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1992	4	Carp (*Cyprinus carpio*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1994	18	Carp (*Cyprinus carpio*); Goldfish (*Carassius auratus*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	1996	20	Carp (*Cyprinus carpio*); Goldfish (*Carassius auratus*); White sucker (*Catostomus commersoni*)	✓	✓	✓	✓	IDEM (2000a)
GCR/IHC	2000	16	Carp (*Cyprinus carpio*); Channel catfish (*Ictalurus punctatus*); Goldfish (*Carassius auratus*); White sucker (*Catostomus commersoni*)	✓	✓	✓	✓	IDEM (2000a)
GCRL	1986	4	Carp (*Cyprinus carpio*); Largemouth bass (*Micropterus salmoides*)	✓	✓	✓	✓	IDEM (2000a)
GCRL	1997	3	Bluegill (*Lepomis macrochirus*); Largemouth bass (*Micropterus salmoides*)	✓	✓	✓	✓	IDEM (2000a)
GCRL	1997	18	Carp (*Cyprinus carpio*)	✓	✓	✓	✓	IDEM (2000b)

Table 5. Summary of fish tissue chemistry data sets used to assess injury to human uses of fishery resources in the Assessment Area.

			Fish Species Sampled	Tissue Chemistry				
Geographic Area	**Sampling Date**	**n**	**Common Name (*Scientific Name*)**	**Conventionals**	**Metals**	**PCBs**	**Pesticides**	**Reference**
IH/LM	1988	6	Carp (*Cyprinus carpio*); Longnose sucker (*Catostomus catostomus*); Yellow perch (*Perca flavescens*)	✓	✓	✓	✓	IDEM (2000a)
IH/LM	1988	12	Carp (*Cyprinus carpio*); Gizzard shad (*Dorosoma cepedianum*); Sunfish [*Lepomis* (Hybrid)]; Yellow perch (*Perca flavescens*)	✓	✓	✓		Risatti & Ross (1989)
IH/LM	1996	4	Brown trout (*Salmo trutta*); Carp (*Cyprinus carpio*); Gizzard shad (*Dorosoma cepedianum*)	✓	✓	✓	✓	IDEM (2000a)
Total for Each Area								
GCR/IHC		**91**						
GCRL		**25**						
IH/LM		**22**						
Total for Assessment Area		***138***						

GCR/IHC = Grand Calumet River/Indiana Harbor Canal; GCRL = Grand Calumet River Lagoons; IH/LM = Indiana Harbor and nearshore areas of Lake Michigan; PCBs = polychlorinated biphenyls.

Table 6. Frequency of exceedance of bioaccumulation-based sediment quality criteria for the protection of human health in surficial sediment samples from the Assessment Area.

Chemical of Potential Concern	GCR/IHC	GCRL	IH/LM	Assessment Area
Metals (mg/kg OC)				
Mercury	NG	NG	NG	NG
Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg OC)				
Acenapthene	NG	NG	NG	NG
Acenaphthylene	NG	NG	NG	NG
Anthracene	NG	NG	NG	NG
Benzene	24 of 79 (30%)	NM	NM	24 of 79 (30%)
Carbazole	5 of 5 (100%)	NM	NM	5 of 5 (100%)
Fluorene	NG	NG	NG	NG
2-Methylnaphthalene	NG	NG	NG	NG
Naphthalene	NG	NG	NG	NG
Phenanthrene	NG	NG	NG	NG
Benz[a]anthracene	240 of 240 (100%)	114 of 114 (100%)	10 of 10 (100%)	364 of 364 (100%)
Benzo(a)pyrene	226 of 226 (100%)	125 of 125 (100%)	10 of 10 (100%)	361 of 361 (100%)
Benzo(b)fluoranthene	80 of 80 (100%)	5 of 5 (100%)	NM	85 of 85 (100%)
Benzo(k)fluoranthene	160 of 160 (100%)	6 of 6 (100%)	10 of 10 (100%)	176 of 176 (100%)
Chrysene	244 of 244 (100%)	127 of 127 (100%)	10 of 10 (100%)	381 of 381 (100%)
Dibenz[a,h]anthracene	104 of 104 (100%)	28 of 28 (100%)	6 of 6 (100%)	138 of 138 (100%)
Fluoranthene	NG	NG	NG	NG
Indeno(1,2,3-cd)pyrene	149 of 149 (100%)	4 of 4 (100%)	10 of 10 (100%)	163 of 163 (100%)
Pyrene	NG	NG	NG	NG
Total PAHs	NG	NG	NG	NG
Polychlorinated Biphenyls (PCBs; µg/kg OC)				
Aroclor 1016	NM	NM	NM	NM
Aroclor 1242	8 of 8 (100%)	5 of 5 (100%)	2 of 2 (100%)	15 of 15 (100%)
Aroclor 1248	136 of 136 (100%)	11 of 11 (100%)	NM	147 of 147 (100%)
Aroclor 1254	16 of 16 (100%)	4 of 4 (100%)	1 of 1 (100%)	21 of 21 (100%)
Aroclor 1260	7 of 7 (100%)	13 of 13 (100%)	NM	20 of 20 (100%)
Total PCBs	154 of 154 (100%)	29 of 29 (100%)	30 of 30 (100%)	213 of 213 (100%)
Chlorinated Benzenes (µg/kg OC)				
Hexachlorobenzene (HCB)	NM	NM	NM	NM
Hexachlorobutadiene (HCBD)	NM	NM	NM	NM
Phthalates (µg/kg OC)				
Bis(2-ethylhexyl)phthalate	NM	NM	NM	NM
Chlorophenols (µg/kg OC)				
2,4-Dichlorophenol	0 of 14 (0%)	NM	NM	0 of 14 (0%)
2,4,6-Trichlorophenol	NM	NM	NM	NM
Pentachlorophenol	NM	NM	NM	NM

Table 6. Frequency of exceedance of bioaccumulation-based sediment quality criteria for the protection of human health in surficial sediment samples from the Assessment Area.

Chemical of Potential Concern	GCR/IHC	GCRL	IH/LM	Assessment Area
Pesticides (µg/kg OC)				
Aldrin	NM	NM	NM	NM
Chlordane	27 of 27 (100%)	14 of 14 (100%)	1 of 1 (100%)	42 of 42 (100%)
Dieldrin	21 of 21 (100%)	2 of 2 (100%)	1 of 1 (100%)	24 of 24 (100%)
p,p'-DDD	13 of 13 (100%)	16 of 16 (100%)	NM	29 of 29 (100%)
p,p'-DDE	32 of 32 (100%)	22 of 22 (100%)	1 of 1 (100%)	55 of 55 (100%)
p,p'-DDT	23 of 23 (100%)	22 of 23 (96%)	NM	45 of 46 (98%)
Endosulfan, total	0 of 93 (0%)	0 of 5 (0%)	NM	0 of 98 (0%)
Endrin	2 of 54 (4%)	2 of 22 (9%)	0 of 1 (0%)	4 of 77 (5%)
Heptachlor	17 of 17 (100%)	NM	NM	17 of 17 (100%)
Heptachlor epoxide	12 of 12 (100%)	NM	NM	12 of 12 (100%)
Alpha-hexachlorocyclohexane (	NM	NM	NM	NM
Beta-HCH	6 of 6 (100%)	NM	NM	6 of 6 (100%)
Technical-HCH	NM	NM	NM	NM
Lindane (gamma-HCH)	14 of 14 (100%)	NM	NM	14 of 14 (100%)
PCDDs and PCDFs (µg/kg OC)				
TCDD-TEQ	5 of 15 (33%)	NM	2 of 2 (100%)	7 of 17 (41%)

GCR/IHC = Grand Calumet River/Indiana Harbor Canal; GCRL = Grand Calumet River Lagoons; IH/LM = Indiana Harbor and nearshore areas of Lake Michigan; OC = organic carbon; NG = no guideline is available; NM = not measured (or TOC not measured to calculate OC-normalized concentration, or all values were less than detect and the detection limit was greater than the benchmark); PCDDs = polychlorinated dibenzo-*p* -dioxins; PCDFs = polychlorinated dibenzofurans; TCDD-TEQ = tetrachlorodibenzo-*p* -dioxin - toxic equivalents.

Table 7. Frequency of exceedance of bioaccumulation-based sediment quality criteria for the protection of human health in sub-surface sediment samples from the Assessment Area.

Chemical of Potential Concern	GCR/IHC	GCRL	IH/LM	Assessment Area
Metals (mg/kg OC)				
Mercury	NG	NG	NG	NG
Polycyclic Aromatic Hydrocarbons (PAHs; µg/kg OC)				
Acenapthene	NG	NG	NG	NG
Acenaphthylene	NG	NG	NG	NG
Anthracene	NG	NG	NG	NG
Benzene	22 of 64 (34%)	NM	NM	22 of 64 (34%)
Carbazole	4 of 10 (40%)	NM	NM	4 of 10 (40%)
Fluorene	NG	NG	NG	NG
2-Methylnaphthalene	NG	NG	NG	NG
Naphthalene	NG	NG	NG	NG
Phenanthrene	NG	NG	NG	NG
Benz[a]anthracene	120 of 120 (100%)	1 of 1 (100%)	NM	121 of 121 (100%)
Benzo(a)pyrene	111 of 111 (100%)	1 of 1 (100%)	NM	112 of 112 (100%)
Benzo(b)fluoranthene	43 of 43 (100%)	NM	NM	43 of 43 (100%)
Benzo(k)fluoranthene	92 of 92 (100%)	2 of 2 (100%)	NM	94 of 94 (100%)
Chrysene	127 of 127 (100%)	1 of 1 (100%)	NM	128 of 128 (100%)
Dibenz[a,h]anthracene	52 of 52 (100%)	NM	NM	52 of 52 (100%)
Fluoranthene	NG	NG	NG	NG
Indeno(1,2,3-cd)pyrene	83 of 83 (100%)	1 of 1 (100%)	NM	84 of 84 (100%)
Pyrene	NG	NG	NG	NG
Total PAHs	NG	NG	NG	NG
Polychlorinated Biphenyls (PCBs; µg/kg OC)				
Aroclor 1016	NM	NM	NM	NM
Aroclor 1242	NM	NM	NM	NM
Aroclor 1248	52 of 52 (100%)	NM	NM	52 of 52 (100%)
Aroclor 1254	3 of 3 (100%)	NM	NM	3 of 3 (100%)
Aroclor 1260	2 of 2 (100%)	NM	NM	2 of 2 (100%)
Total PCBs	52 of 52 (100%)	NM	NM	52 of 52 (100%)
Chlorinated Benzenes (µg/kg OC)				
Hexachlorobenzene (HCB)	NM	NM	NM	NM
Hexachlorobutadiene (HCBD)	NM	NM	NM	NM
Phthalates (µg/kg OC)				
Bis(2-ethylhexyl)phthalate	0 of 1 (0%)	NM	NM	0 of 1 (0%)
Chlorophenols (µg/kg OC)				
2,4-Dichlorophenol	0 of 17 (0%)	NM	NM	0 of 17 (0%)
2,4,6-Trichlorophenol	0 of 4 (0%)	NM	NM	0 of 4 (0%)
Pentachlorophenol	0 of 1 (0%)	NM	NM	0 of 1 (0%)

Table 7. Frequency of exceedance of bioaccumulation-based sediment quality criteria for the protection of human health in sub-surface sediment samples from the Assessment Area.

Chemical of Potential Concern	GCR/IHC	GCRL	IH/LM	Assessment Area
Pesticides (µg/kg OC)				
Aldrin	NM	NM	NM	NM
Chlordane	9 of 9 (100%)	NM	NM	9 of 9 (100%)
Dieldrin	17 of 17 (100%)	NM	NM	17 of 17 (100%)
p,p'-DDD	20 of 20 (100%)	NM	NM	20 of 20 (100%)
p,p'-DDE	18 of 18 (100%)	NM	NM	18 of 18 (100%)
p,p'-DDT	2 of 2 (100%)	NM	NM	2 of 2 (100%)
Endosulfan, total	0 of 56 (0%)	NM	NM	0 of 56 (0%)
Endrin	1 of 46 (2%)	0 of 1 (0%)	NM	1 of 47 (2%)
Heptachlor	1 of 1 (100%)	NM	NM	1 of 1 (100%)
Heptachlor epoxide	4 of 4 (100%)	NM	NM	4 of 4 (100%)
Alpha-hexachlorocyclohexane (	NM	NM	NM	NM
Beta-HCH	3 of 3 (100%)	NM	NM	3 of 3 (100%)
Technical-HCH	NM	NM	NM	NM
Lindane (gamma-HCH)	2 of 2 (100%)	NM	NM	2 of 2 (100%)
PCDDs and PCDFs (µg/kg OC)				
TCDD-TEQ	NM	NM	NM	NM

GCR/IHC = Grand Calumet River/Indiana Harbor Canal; GCRL = Grand Calumet River Lagoons; IH/LM = Indiana Harbor and nearshore areas of Lake Michigan; OC = organic carbon; NG = no guideline is available; NM = not measured (or TOC not measured to calculate OC-normalized concentration, or all values were less than detect and the detection limit was greater than the benchmark); PCDDs = polychlorinated dibenzo-*p* -dioxins; PCDFs = polychlorinated dibenzofurans; TCDD-TEQ = tetrachlorodibenzo-*p* -dioxin - toxic equivalents.

Table 8. Frequency of exceedance of the USFDA (2001) action level for mercury (1.0 mg/kg WW) in fish tissues from the Grand Calumet River/ Indiana Harbor Canal.

Species	1980	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 8 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 62 (0%)**
Channel catfish										0 of 1 (0%)	**0 of 1 (0%)**
Gizzard shad					0 of 2 (0%)						**0 of 2 (0%)**
Goldfish						0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
Pumpkinseed				0 of 1 (0%)							**0 of 1 (0%)**
Sunfish					0 of 1 (0%)						**0 of 1 (0%)**
White sucker									0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 5 (0%)**	**0 of 11 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 86 (0%)**

WW = wet weight.

Table 9. Frequency of exceedance of the USFDA (2001) action level for aldrin (300 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 4 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 56 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 5 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 76 (0%)**

WW = wet weight.

Table 10. Frequency of exceedance of the USFDA (2001) action level for dieldrin (300 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 58 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 78 (0%)**

WW = wet weight.

Table 11. Frequency of exceedance of the USFDA (2001) action level for aldrin + dieldrin (300 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 58 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 78 (0%)**

WW = wet weight.

Table 12. Frequency of exceedance of the USFDA (2001) action level for sum DDD (5000 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 58 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 78 (0%)**

Sum DDD = *p,p*'-DDD + *o,p*'-DDD; WW = wet weight.

Table 13. Frequency of exceedance of the USFDA (2001) action level for sum DDE (5000 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 58 (0%)**
Channelcatfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 78 (0%)**

Sum DDE = *p,p*'-DDE + *o,p*'-DDE; WW = wet weight.

Table 14. Frequency of exceedance of the USFDA (2001) action level for sum DDT (5000 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 58 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 78 (0%)**

Sum DDT = *p,p*'-DDT + *o,p*'-DDT; WW = wet weight.

Table 15. Frequency of exceedance of the USFDA (2001) action level for total DDT (5000 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 58 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 78 (0%)**

Total DDT = *p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDE, *o,p*'-DDE, *p,p*'-DDD, and *o,p*'-DDD; WW = wet weight.

Table 16. Frequency of exceedance of the USFDA (2001) action level for heptachlor (300 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 3 (0%)	0 of 3 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 56 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 5 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 76 (0%)**

WW = wet weight.

Table 17. Frequency of exceedance of the USFDA (2001) action level for heptachlor epoxide (300 µg/kg WW) in fish tissues from the Grand Calumet River/ Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 58 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 78 (0%)**

WW = wet weight.

Table 18. Frequency of exceedance of the USFDA (2001) action level for heptachlor + heptachlor epoxide (300 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	0 of 2 (0%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**0 of 58 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**0 of 2 (0%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**0 of 78 (0%)**

WW = wet weight.

Table 19. Frequency of exceedance of the USFDA (2001) action level for chlordane (300 µg/kg WW) in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	1 of 2 (50%)	0 of 1 (0%)	0 of 7 (0%)	0 of 4 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 4 (0%)	0 of 14 (0%)	0 of 14 (0%)	0 of 7 (0%)	**1 of 58 (0%)**
Channel catfish											0 of 1 (0%)	**0 of 1 (0%)**
Goldfish							0 of 1 (0%)		0 of 4 (0%)	0 of 5 (0%)	0 of 6 (0%)	**0 of 16 (0%)**
White sucker										0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 1 (0%)**	**1 of 2 (50%)**	**0 of 1 (0%)**	**0 of 7 (0%)**	**0 of 4 (0%)**	**0 of 2 (0%)**	**0 of 3 (0%)**	**0 of 4 (0%)**	**0 of 18 (0%)**	**0 of 20 (0%)**	**0 of 16 (0%)**	**1 of 78 (1%)**

WW = wet weight.

Table 20. **Frequency of exceedance of the USFDA (2001) tolerance level for total PCBs (2000 µg/kg WW)1 in fish tissues from the Grand Calumet River/Indiana Harbor Canal.**

Species	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	0 of 1 (0%)	1 of 2 (50%)	1 of 1 (100%)	7 of 7 (100%)	4 of 4 (100%)	2 of 8 (25%)	2 of 2 (100%)	4 of 4 (100%)	13 of 14 (93%)	14 of 14 (100%)	7 of 7 (100%)	**55 of 64 (86%)**
Channel catfish											1 of 1 (100%)	**1 of 1 (100%)**
Gizzard shad						0 of 2 (0%)						**0 of 2 (0%)**
Goldfish							1 of 1 (100%)		4 of 4 (100%)	5 of 5 (100%)	3 of 6 (50%)	**13 of 16 (81%)**
Sunfish						0 of 1 (0%)						**0 of 1 (0%)**
White sucker										0 of 1 (0%)	1 of 2 (50%)	**1 of 3 (33%)**
All Species	**0 of 1 (0%)**	**1 of 2 (50%)**	**1 of 1 (100%)**	**7 of 7 (100%)**	**4 of 4 (100%)**	**2 of 11 (18%)**	**3 of 3 (100%)**	**4 of 4 (100%)**	**17 of 18 (94%)**	**19 of 20 (95%)**	**12 of 16 (75%)**	**70 of 87 (83%)**

PCBs = polychlorinated biphenyls; WW = wet weight.

[1]The tolerance level for PCBs was refined in 1984 from 5000 µg/kg to 2000 µg/kg.

Table 21. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for mercury in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	Categorical Grouping[2]	1980	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	Group 1	1 of 1 (100%)	1 of 1 (100%)	2 of 7 (29%)	4 of 4 (100%)	8 of 8 (100%)	2 of 2 (100%)	4 of 4 (100%)	14 of 14 (100%)	13 of 14 (93%)	7 of 7 (100%)	**56 of 62 (90%)**
	Group 2			5 of 7 (71%)						1 of 14 (7%)		**6 of 62 (10%)**
	Group 3											
	Group 4											
	Group 5											
Channel catfish	Group 1										1 of 1 (100%)	**1 of 1 (100%)**
	Group 2											
	Group 3											
	Group 4											
	Group 5											
Gizzard shad	Group 1					2 of 2 (100%)						**2 of 2 (100%)**
	Group 2											
	Group 3											
	Group 4											
	Group 5											
Goldfish	Group 1						1 of 1 (100%)		4 of 4 (100%)	5 of 5 (100%)	6 of 6 (100%)	**16 of 16 (100%)**
	Group 2											
	Group 3											
	Group 4											
	Group 5											

Table 21. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for mercury in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	Categorical Grouping[2]	1980	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Pumpkinseed	Group 1				1 of 1 (100%)							**1 of 1 (100%)**
	Group 2											
	Group 3											
	Group 4											
	Group 5											
Sunfish	Group 1					1 of 1 (100%)						**1 of 1 (100%)**
	Group 2											
	Group 3											
	Group 4											
	Group 5											
White sucker	Group 1									1 of 1 (100%)	2 of 2 (100%)	**3 of 3 (100%)**
	Group 2											
	Group 3											
	Group 4											
	Group 5											
All Species	**Group 1**	**1 of 1 (100%)**	**1 of 1 (100%)**	**2 of 7 (29%)**	**5 of 5 (100%)**	**11 of 11 (100%)**	**3 of 3 (100%)**	**4 of 4 (100%)**	**18 of 18 (100%)**	**19 of 20 (95%)**	**16 of 16 (100%)**	**80 of 86 (93%)**
	Group 2			**5 of 7 (71%)**						**1 of 20 (5%)**		**6 of 86 (7%)**
	Group 3											
	Group 4											
	Group 5											

[1]Source: Stahl and Simon 2000.

[2]See Table 4 for a listing of the selected thresholds for tissue chemistry established to support the development of the Indiana Fish Consumption Advisory; See Table 54 for the recommendation regarding consumption of tissues for each categorical grouping.

Table 22. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for total PCBs in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	Categorical Grouping[2]	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Carp	Group 1												
	Group 2						1 of 8 (13%)						**1 of 64 (2%)**
	Group 3						2 of 8 (25%)			1 of 14 (7%)			**3 of 64 (5%)**
	Group 4	1 of 1 (100%)					3 of 8 (38%)						**4 of 64 (6%)**
	Group 5		2 of 2 (100%)	1 of 1 (100%)	7 of 7 (100%)	4 of 4 (100%)	2 of 8 (25%)	2 of 2 (100%)	4 of 4 (100%)	13 of 14 (93%)	14 of 14 (100%)	7 of 7 (100%)	**56 of 64 (88%)**
Channel catfish	Group 1												
	Group 2												
	Group 3												
	Group 4												
	Group 5											1 of 1 (100%)	**1 of 1 (100%)**
Gizzard shad	Group 1												
	Group 2						1 of 2 (50%)						**1 of 2 (50%)**
	Group 3						1 of 2 (50%)						**1 of 2 (50%)**
	Group 4												
	Group 5												

Table 22. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for total PCBs in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	Categorical Grouping[2]	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
Goldfish	Group 1												
	Group 2												
	Group 3											1 of 6 (17%)	**1 of 16 (6%)**
	Group 4											1 of 6 (17%)	**1 of 16 (6%)**
	Group 5							1 of 1 (100%)		4 of 4 (100%)	5 of 5 (100%)	4 of 6 (67%)	**14 of 16 (88%)**
Sunfish	Group 1												
	Group 2												
	Group 3						1 of 1 (100%)						**1 of 1 (100%)**
	Group 4												
	Group 5												
White sucker	Group 1												
	Group 2												
	Group 3										1 of 1 (100%)	1 of 2 (50%)	**2 of 3 (67%)**
	Group 4												
	Group 5											1 of 2 (50%)	**1 of 3 (33%)**

Table 22. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for total PCBs in fish tissues from the Grand Calumet River/Indiana Harbor Canal.

Species	Categorical Grouping[2]	1980	1982	1984	1986	1987	1988	1990	1992	1994	1996	2000	All Years
All Species	**Group 1**												
	Group 2						**2 of 11 (18%)**						**2 of 87 (2%)**
	Group 3						**4 of 11 (36%)**			**1 of 18 (6%)**	**1 of 20 (5%)**	**2 of 16 (13%)**	**8 of 87 (9%)**
	Group 4	**1 of 1 (100%)**					**3 of 11 (27%)**					**1 of 16 (6%)**	**5 of 87 (6%)**
	Group 5		**2 of 2 (100%)**	**1 of 1 (100%)**	**7 of 7 (100%)**	**4 of 4 (100%**	**2 of 11 (18%)**	**3 of 3 (100%)**	**4 of 4 (100%)**	**17 of 18 (94%)**	**19 of 20 (95%)**	**13 of 16 (69%)**	**72 of 87 (83%)**

PCBs = polychlorinated biphenyls.

[1]Source: Stahl and Simon 2000.

[2]See Table 4 for a listing of the selected thresholds for tissue chemistry established to support the development of the Indiana Fish Consumption Advisory; See Table 54 for the recommendation regarding consumption of tissues for each categorical grouping.

Table 23. Frequency of exceedance of the USFDA (2001) action level for mercury (1.0 mg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	1986	1997	All Years
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)	0 of 14 (0%)	**0 of 17 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 17 (0%)**	**0 of 21 (0%)**

WW = wet weight.

Table 24. Frequency of exceedance of the USFDA (2001) action level for aldrin (300 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	**1986**	**1997**	**All Years**
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)		**0 of 3 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 3 (0%)**	**0 of 7 (0%)**

WW = wet weight.

Table 25. Frequency of exceedance of the USFDA (2001) action level for dieldrin (300 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	1986	1997	All Years
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)		**0 of 3 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 3 (0%)**	**0 of 7 (0%)**

WW = wet weight.

Table 26. Frequency of exceedance of the USFDA (2001) action level for aldrin + dieldrin (300 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	**1986**	**1997**	**All Years**
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)		**0 of 3 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 3 (0%)**	**0 of 7 (0%)**

WW = wet weight.

Table 27. Frequency of exceedance of the USFDA (2001) action level for sum DDD (5000 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	**1986**	**1997**	**All Years**
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)	0 of 7 (0%)	**0 of 10 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 10 (0%)**	**0 of 14 (0%)**

Sum DDD = *p,p'*-DDD + *o,p'*-DDD; WW = wet weight.

Table 28. Frequency of exceedance of the USFDA (2001) action level for sum DDE (5000 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	1986	1997	All Years
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)		**0 of 3 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 3 (0%)**	**0 of 7 (0%)**

Sum DDE = *p,p*'-DDE + *o,p*'-DDE; WW = wet weight.

Table 29. Frequency of exceedance of the USFDA (2001) action level for sum DDT (5000 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	**1986**	**1997**	**All Years**
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)		**0 of 3 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 3 (0%)**	**0 of 7 (0%)**

Sum DDT = *p,p*'-DDT + *o,p*'-DDT; WW = wet weight.

Table 30. Frequency of exceedance of the USFDA (2001) action level for total DDT (5000 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	**1986**	**1997**	**All Years**
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)	0 of 7 (0%)	**0 of 10 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 10 (0%)**	**0 of 14 (0%)**

Total DDT = *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *o,p'*-DDE, *p,p'*-DDD, and *o,p'*-DDD; WW = wet weight.

Table 31. Frequency of exceedance of the USFDA (2001) action level for heptachlor (300 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	**1986**	**1997**	**All Years**
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)		**0 of 3 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 3 (0%)**	**0 of 7 (0%)**

WW = wet weight.

Table 32. Frequency of exceedance of the USFDA (2001) action level for heptachlor epoxide (300 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	**1986**	**1997**	**All Years**
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)		**0 of 3 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 3 (0%)**	**0 of 7 (0%)**

WW = wet weight.

Table 33. Frequency of exceedance of the USFDA (2001) action level for heptachlor + heptachlor epoxide (300 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	1986	1997	All Years
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)		**0 of 3 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 3 (0%)**	**0 of 7 (0%)**

WW = wet weight.

Table 34. Frequency of exceedance of the USFDA (2001) action level for chlordane (300 µg/kg WW) in fish tissues from the Grand Calumet River Lagoons.

Species	1986	1997	All Years
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)	0 of 6 (0%)	**0 of 9 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 9 (0%)**	**0 of 13 (0%)**

WW = wet weight.

Table 35. Frequency of exceedance of the USFDA (2001) tolerance level for total PCBs (2000 µg/kg WW)[1] in fish tissues from the Grand Calumet River Lagoons.

Species	1986	1997	All Years
Bluegill		0 of 1 (0%)	**0 of 1 (0%)**
Carp	0 of 3 (0%)	0 of 18 (0%)	**0 of 21 (0%)**
Largemouth bass	0 of 1 (0%)	0 of 2 (0%)	**0 of 3 (0%)**
All Species	**0 of 4 (0%)**	**0 of 21 (0%)**	**0 of 25 (0%)**

PCBs = polychlorinated biphenyls; WW = wet weight.

[1]The tolerance level for PCBs was refined in 1984 from 5000 µg/kg to 2000 µg/kg.

Table 36. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for mercury in fish tissues from the Grand Calumet River Lagoons.

Species	**Categorical Grouping[2]**	**1986**	**1997**	**All Years**
Bluegill	Group 1		1 of 1 (100%)	**1 of 1 (100%)**
	Group 2			
	Group 3			
	Group 4			
	Group 5			
Carp	Group 1	3 of 3 (100%)	11 of 14 (79%)	**14 of 17 (82%)**
	Group 2		3 of 14 (21%)	**3 of 17 (18%)**
	Group 3			
	Group 4			
	Group 5			
Largemouth bass	Group 1	1 of 1 (100%)	2 of 2 (100%)	**3 of 3 (100%)**
	Group 2			
	Group 3			
	Group 4			
	Group 5			
All Species	**Group 1**	**4 of 4 (100%)**	**14 of 17 (82%)**	**18 of 21 (86%)**
	Group 2		**3 of 17 (18%)**	**3 of 21 (14%)**
	Group 3			
	Group 4			
	Group 5			

[1]Source: Stahl and Simon 2000.

[2]See Table 4 for a listing of the selected thresholds for tissue chemistry established to support the development of the Indiana Fish Consumption Advisory; See Table 54 for the recommendation regarding consumption of tissues for each categorical grouping.

Table 37. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for total PCBs in fish tissues from the Grand Calumet River Lagoons.

Species	Categorical Grouping[2]	1986	1997	All Years
Bluegill	Group 1			
	Group 2			
	Group 3		1 of 1 (100%)	**1 of 1 (100%)**
	Group 4			
	Group 5			
Carp	Group 1			
	Group 2		1 of 18 (6%)	**1 of 21 (5%)**
	Group 3	3 of 3 (100%)	16 of 18 (89%)	**19 of 21 (90%)**
	Group 4		1 of 18 (6%)	**1 of 21 (5%)**
	Group 5			
Largemouth bass	Group 1			
	Group 2		1 of 2 (50%)	**1 of 3 (33%)**
	Group 3	1 of 1 (100%)	1 of 2 (50%)	**2 of 3 (67%)**
	Group 4			
	Group 5			
All Species	**Group 1**			
	Group 2		**2 of 21 (10%)**	**2 of 25 (8%)**
	Group 3	**4 of 4 (100%)**	**18 of 21 (86%)**	**22 of 25 (88%)**
	Group 4		**1 of 21 (5%)**	**1 of 25 (4%)**
	Group 5			

PCBs = polychlorinated biphenyls.

[1]Source: Stahl and Simon 2000.

[2]See Table 4 for a listing of the selected thresholds for tissue chemistry established to support the development of the Indiana Fish Consumption Advisory; See Table 54 for the recommendation regarding consumption of tissues for each categorical grouping.

Table 38. Frequency of exceedance of the USFDA (2001) action level for mercury (1.0 mg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 5 (0%)	0 of 1 (0%)	**0 of 6 (0%)**
Gizzard shad	0 of 6 (0%)	0 of 1 (0%)	**0 of 7 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Sunfish	0 of 1 (0%)		**0 of 1 (0%)**
Yellow perch	0 of 3 (0%)		**0 of 3 (0%)**
All Species	**0 of 17 (0%)**	**0 of 4 (0%)**	**0 of 21 (0%)**

WW = wet weight.

Table 39. Frequency of exceedance of the USFDA (2001) action level for aldrin (300 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

WW = wet weight.

Table 40. Frequency of exceedance of the USFDA (2001) action level for dieldrin (300 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

WW = wet weight.

Table 41. Frequency of exceedance of the USFDA (2001) action level for aldrin + dieldrin (300 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

WW = wet weight.

Table 42. Frequency of exceedance of the USFDA (2001) action level for sum DDD (5000 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	**1988**	**1996**	**All Years**
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

Sum DDD = *p,p*'-DDD + *o,p*'-DDD; WW = wet weight.

Table 43. Frequency of exceedance of the USFDA (2001) action level for sum DDE (5000 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

Sum DDE = *p,p*'-DDE + *o,p*'-DDE; WW = wet weight.

Table 44. Frequency of exceedance of the USFDA (2001) action level for sum DDT (5000 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

Sum DDT = *p,p*'-DDT + *o,p*'-DDT; WW = wet weight.

Table 45. Frequency of exceedance of the USFDA (2001) action level for total DDT (5000 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	**1988**	**1996**	**All Years**
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

Total DDT = *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *o,p'*-DDE, *p,p'*-DDD, and *o,p'*-DDD; WW = wet weight.

Table 46. Frequency of exceedance of the USFDA (2001) action level for heptachlor (300 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	**1988**	**1996**	**All Years**
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

WW = wet weight.

Table 47. Frequency of exceedance of the USFDA (2001) action level for heptachlor epoxide (300 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

WW = wet weight.

Table 48. Frequency of exceedance of the USFDA (2001) action level for heptachlor + heptachlor epoxide (300 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

WW = wet weight.

Table 49. Frequency of exceedance of the USFDA (2001) action level for chlordane (300 µg/kg WW) in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	**1988**	**1996**	**All Years**
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	0 of 2 (0%)	0 of 1 (0%)	**0 of 3 (0%)**
Gizzard shad		0 of 1 (0%)	**0 of 1 (0%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Yellow perch	0 of 2 (0%)		**0 of 2 (0%)**
All Species	**0 of 6 (0%)**	**0 of 4 (0%)**	**0 of 10 (0%)**

WW = wet weight.

Table 50. Frequency of exceedance of the USFDA (2001) tolerance level for total PCBs (2000 µg/kg WW)[1] in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	1988	1996	All Years
Brown trout		0 of 2 (0%)	**0 of 2 (0%)**
Carp	2 of 5 (40%)	1 of 1 (100%)	**3 of 6 (50%)**
Gizzard shad	0 of 7 (0%)	1 of 1 (100%)	**1 of 8 (13%)**
Longnose sucker	0 of 2 (0%)		**0 of 2 (0%)**
Sunfish	0 of 1 (0%)		**0 of 1 (0%)**
Yellow perch	0 of 3 (0%)		**0 of 3 (0%)**
All Species	**2 of 18 (11%)**	**2 of 4 (50%)**	**4 of 22 (18%)**

PCBs = polychlorinated biphenyls; WW = wet weight.

[1]The tolerance level for PCBs was refined in 1984 from 5000 µg/kg to 2000 µg/kg.

Table 51. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for mercury in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	Categorical Grouping[2]	1988	1996	All Years
Brown trout	Group 1		2 of 2 (100%)	**2 of 2 (100%)**
	Group 2			
	Group 3			
	Group 4			
	Group 5			
Carp	Group 1	2 of 5 (40%)	1 of 1 (100%)	**3 of 6 (50%)**
	Group 2	3 of 5 (60%)		**3 of 6 (50%)**
	Group 3			
	Group 4			
	Group 5			
Gizzard shad	Group 1	6 of 6 (100%)	1 of 1 (100%)	**7 of 7 (100%)**
	Group 2			
	Group 3			
	Group 4			
	Group 5			
Longnose sucker	Group 1	1 of 2 (50%)		**1 of 2 (50%)**
	Group 2	1 of 2 (50%)		**1 of 2 (50%)**
	Group 3			
	Group 4			
	Group 5			
Sunfish	Group 1	1 of 1 (100%)		**1 of 1 (100%)**
	Group 2			
	Group 3			
	Group 4			
	Group 5			
Yellow perch	Group 1	3 of 3 (100%)		**3 of 3 (100%)**
	Group 2			
	Group 3			
	Group 4			
	Group 5			
All Species	**Group 1**	**13 of 17 (76%)**	**4 of 4 (100%)**	**17 of 21 (81%)**
	Group 2	**4 of 17 (24%)**		**4 of 21 (19%)**
	Group 3			
	Group 4			
	Group 5			

[1]Source: Stahl and Simon 2000.

[2]See Table 4 for a listing of the selected thresholds for tissue chemistry established to support the development of the Indiana Fish Consumption Advisory; See Table 54 for the recommendation regarding consumption of tissues for each categorical grouping.

Table 52. Frequency of exceedance of the Indiana State Department of Health threshold levels[1] for total PCBs in fish tissues from Indiana Harbor and nearshore areas of Lake Michigan.

Species	Categorical Grouping[2]	1988	1996	All Years
Brown trout	Group 1			
	Group 2			
	Group 3		1 of 2 (50%)	**1 of 2 (50%)**
	Group 4		1 of 2 (50%)	**1 of 2 (50%)**
	Group 5			
Carp	Group 1			
	Group 2			
	Group 3	2 of 5 (40%)		**2 of 6 (33%)**
	Group 4	1 of 5 (20%)		**1 of 6 (17%)**
	Group 5	2 of 5 (40%)	1 of 1 (100%)	**3 of 6 (50%)**
Gizzard shad	Group 1			
	Group 2	4 of 7 (57%)		**4 of 8 (50%)**
	Group 3	2 of 7 (29%)		**2 of 8 (25%)**
	Group 4	1 of 7 (14%)		**1 of 8 (13%)**
	Group 5		1 of 1 (100%)	**1 of 8 (13%)**
Longnose sucker	Group 1	1 of 2 (50%)		**1 of 2 (50%)**
	Group 2			
	Group 3	1 of 2 (50%)		**1 of 2 (50%)**
	Group 4			
	Group 5			
Sunfish	Group 1			
	Group 2			
	Group 3	1 of 1 (100%)		**1 of 1 (100%)**
	Group 4			
	Group 5			
Yellow perch	Group 1	2 of 3 (67%)		**2 of 3 (67%)**
	Group 2			
	Group 3	1 of 3 (33%)		**1 of 3 (33%)**
	Group 4			
	Group 5			
All Species	**Group 1**	**3 of 18 (17%)**		**3 of 22 (14%)**
	Group 2	**4 of 18 (22%)**		**4 of 22 (18%)**
	Group 3	**7 of 18 (39%)**	**1 of 4 (25%)**	**8 of 22 (36%)**
	Group 4	**2 of 18 (11%)**	**1 of 4 (25%)**	**3 of 22 (14%)**
	Group 5	**2 of 18 (11%)**	**2 of 4 (50%)**	**4 of 22 (18%)**

PCBs = polychlorinated biphenyls.

[1]Source: Stahl and Simon 2000

[2]See Table 4 for a listing of the selected thresholds for tissue chemistry established to support the development of the Indiana Fish Consumption Advisory; See Table 54 for the recommendation regarding consumption of tissues for each categorical grouping.

Table 53. A retrospective on the establishment of fish consumption advisories in Indiana.

Year	Action	Reference
1972	Indiana Department of Natural Resources initiated a sampling and analysis program for fish tissue (now referred to as the Tissue Contaminant Monitoring Program) to study the accumulation of chemical contaminants in fish tissues.	Lee Bridges (IDEM. Indianapolis, Indiana. Personal communication, 2001)
1977	Indiana State Board of Health (now the Indiana State Department of Health) recommended that lake trout from Lake Michigan not be consumed due to elevated levels of contaminants in fish tissues.	Lee Bridges (L. Bridges. IDEM. Indianapolis, Indiana. Personal communication 2001)
1983	Indiana State Board of Health (now the Indiana State Department of Health) recommended that consumption of coho salmon, brown trout, and steelhead trout from Lake Michigan be restricted to no more than one meal per week due to elevated levels of contaminants in fish tissues.	Lee Bridges (L. Bridges. IDEM. Indianapolis, Indiana. Personal communication 2001)
1984	U.S. Food & Drug Administration changed the PCB Tolerance Level for fish tissue from 5000 µg/kg to 2000 µg/kg.	ISBH 1985b
1985	Fish Consumption Advisory classification system is refined to consider fish length and classified according to a three advisory group system.	Lee Bridges, personal communication (2001); ISBH 1985b
1985	The four states bordering Lake Michigan (Illinois, Indiana, Michigan and Wisconsin) agree to share and pool analytical laboratory data on fish tissue contaminant concentrations.	ISBH 1985a
1985	Consumers advised to not eat brown trout, carp and lake trout greater than 25 inches in length caught in Lake Michigan.	ISBH 1985a
1986	Consumers advised to not eat fish from the WBGCR, the EBGCR downstream of the Marquette Park Lagoons, the Indiana Harbor Ship Canal (including Lake George branch) and, Indiana Harbor.	ISBH 1986
1987	The four states bordering Lake Michigan (Illinois, Indiana, Michigan and Wisconsin) released the first joint consumption advisory for fish taken from all Great Lakes waters.	ISBH 1987
until 1995	Consumers advised that there are not consumption advisories in effect for undesignated species in named waterways and all waterways not listed in the advisory.	ISBH, IDEM and IDNR 1989
1993	The Great Lakes Fish Consumption Advisory Task Force established a 'Health Protection Value' of 3.5 µg/day for PCBs and developed five consumption categories based on this value.	Anderson *et al.* 1993

Table 53. A retrospective on the establishment of fish consumption advisories in Indiana.

Year	Action	Reference
1995	The Great Lakes Protocol for evaluating PCB contamination in fish tissue was implemented (i.e., used to establish FCAs). Other COPCs are evaluated based on USFDA Action Levels and by evaluating published recommended reference doses.	Stahl and Simon 2000; IDNR 1995
1995	A statewide advisory restricting the consumption of common carp is issued statewide: "no consumption" for common carp greater than 25 inches in length; "no consumption" for sensitive populations for common carp greater than 15 inches in length; consumption restrictions for common carp less than 25 inches in length.	IDNR 1995
1995	Fish Consumption Advisories group classification system is refined from three to five advisory groups.	IDNR 1995
1995	All consumers advised to limit consumption to one meal per week for undesignated species in named waterways and all waterways not listed in the advisory.	IDNR 1995
1996	Fish Consumption Advisories group classification system is refined to include the "bump up" to afford added protection for the sensitive population (women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15).	Stahl and Simon 2000
1996	Implemented a risk-based approach similar to the Great Lakes Protocol, for evaluating mercury contamination in fish tissue. Other COPCs are evaluated using the USFDA action levels and published reference doses.	Stahl and Simon 2000
1998	Indiana Department of Environmental Management's Office of Water commissioned Purdue University to conduct two fish consumption studies of Indiana anglers (Sheaffer et al. 1999, Williams et al. 2000).	Stahl and Simon 2000
2000	A draft document recommending a HPV of 0.15 mg/kg-day for total chlordane is reviewed by state health agencies and USEPA authorities.	Stahl and Simon 2000

WBGCR = West Branch of the Grand Calumet River; EBGCR = East Branch of the Grand Calumet River;
PCBs = polychlorinated biphenyls; USFDA = United States Food and Drug Administration; FCA = fish consumption advisory;
COPC = chemical of potential concern; USEPA = United States Environmental Protection Agency; HPV = health protection value.

Table 54. Criteria for triggering fish consumption advisories in Indiana.

Year	Categorical Grouping	Triggering Criteria	Recommendation Regarding Consumption of Tissues
1985 - 1994	Group 1	90% or more of the fish tested in Group 1 met USFDA action levels.	Eating Group 1 fish poses the lowest risk of exposure to contaminants.
	Group 2	One or more contaminants were found to be above the USFDA action level in 50% or more of the fish tested in Group 2.	Sensitive populations[1] should not eat these fish. Others should limit consumption to 1 meal per week and heed the preparation and cooking recommendations.
	Group 3	One or more contaminants were found to be above the USFDA action levels in 90% or more of the fish tested in Group 3.	Do not consume.
1995 - 2000	Group 1	COPC Levels < Group 1 Thresholds[2]	Unlimited consumption.
	Group 2	COPC Levels > Group 1 Thresholds and < Group 3 Thresholds	Restrict consumption to one meal per week for the general population, and one meal per month for sensitive populations.
	Group 3	COPC Levels > Group 2 Thresholds and < Group 4 Thresholds	Restrict consumption to one meal per month for the general population, and sensitive populations do not eat.
	Group 4	COPC Levels > Group 3 Thresholds and < Group 5 Thresholds	Restrict consumption to one meal every two months for the general population, and sensitive populations do not eat.
	Group 5	COPC Levels > Group 5 Thresholds	No consumption.

USFDA = United States Food and Drug Administration; COPC = chemical of potential concern; FCA = fish consumption advisory; PCBs = polychlorinated biphenyls.

[1]"general population" = adult males and females; "sensitive population" = women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.

[2]See Table 4 for a listing of the thresholds for PCBs and mercury established to support the development of the Indiana Fish Consumption Advisory.

Table 55. Summary of fish consumption advisories for the GCR/IHC (ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; see the bottom of the table for the symbol legend).

Family/ Common name	Size	1986[1,2]	1989[3]	1990[3]	1991[3]	1992[3]	1993-1994[3]	1994[3]	1995	1996	1997	1998	1999	2000	2001	2002
			Unlisted species/waterways: assume Group 1						Unlisted species/waterways: assume Group 2							
ALL SPECIES	All	●	●	●	●	●	●	●	●[4]	●[4]	●	●	●	●	●	●

GCR/IHC = Grand Calumet River and the Indiana Harbor Canal; ISDH = Indiana State Department of Health; FCA = fish consumption advisory.

[1]ISBH 1986

[2]Advisory specified for the following area: west branch of the Grand Calumet River and the east branch downstream from the Marquette Park Lagoons, and in the Indiana Harbor Ship Canal, including the Lake George branch and Indiana Harbor.

[3]Advisory specified for the following area: Grand Calumet River (east and west branches) and the Indiana Harbor Ship Canal.

[4]Advisories for the GCR/IHC are not specifically listed in the 1995 or 1996 ISDH Indiana Fish Consumption Advisory. It was assumed that the FCAs issued for previous years were still in effect, as there was no indication that the FCAs were withdrawn.

Symbol Legend:

1995-2002

○ Group 1 - Unrestricted consumption. One meal per week for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.

⦸ Group 2 - One meal per week (52 meals per year) for adult males and females. One meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.

⊗ Group 3 - One meal per month (12 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.

⊙ Group 4 - One meal every 2 months (6 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.

● Group 5 - No consumption (DO NOT EAT)

1985-1994

○ Group 1 - No consumption advisory is in effect.

□ Group 2 - Adult men and women not of child-bearing age should consume no more than 1 meal per week consisting of up to one-half pound of flesh of designated species from named waterways. Women of child-bearing age and children under the age of 18 should not consume any of the fish listed in Group 2.

● Group 3 - No one should eat designated species from named waterways.

Table 56. Substances responsible for the fish consumption advisories that have been issued for the Assessment Area (ISBH 1985a; 1985b; 1986; 1987; ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002).

Year	GCR/IHC	GCRL	IH/LM
1985	No advisory	No advisory	PCBs, chlordane, dieldrin and DDT
1986	PCBs	No advisory	PCBs, chlordane, dieldrin and DDT
1987	1986 Advisory not modified or withdrawn[1]	No advisory	PCBs
1988	1986 Advisory not modified or withdrawn[1]	No advisory	1987 Advisory not modified or withdrawn[1]
1989	PCBs	No advisory	PCBs, chlordane, dieldrin, and DDT
1990	PCBs	No advisory	PCBs, chlordane, dieldrin, and DDT
1991	Contaminants of concern not specified	No advisory	Contaminants of concern not specified
1992	Contaminants of concern not specified	No advisory	Contaminants of concern not specified
1993	Contaminants of concern not specified	No advisory	Contaminants of concern not specified
1994	Contaminants of concern not specified	No advisory	Contaminants of concern not specified
1995	1994 Advisory not modified or withdrawn[1]	No advisory	Contaminants of concern not specified
1996	1994 Advisory not modified or withdrawn[1]	PCBs	PCBs, mercury
1997	PCBs, mercury	PCBs	PCBs, mercury
1998	PCBs, mercury	PCBs	PCBs, mercury
1999	PCBs, mercury	PCBs	PCBs, mercury
2000	PCBs, mercury	PCBs	PCBs, mercury
2001	PCBs, mercury	PCBs	PCBs, mercury
2002	PCBs, mercury	PCBs	PCBs, mercury

PCBs = polychlorinated biphenyls; GCR/IHC = Grand Calumet River; GCRL = Grand Calumet River Lagoons; IH/LM = Indiana Harbor and nearshore areas of Lake Michigan.

[1]Advisories are not specifically listed in the Indiana Fish Consumption Advisory. It was assumed that the FCAs issued for previous years were still in effect, as there was no indication that the FCAs were withdrawn.

Table 57. Summary of fish consumption advisories that have been issued for the Assessment Area (ISBH 1985a; 1985b; 1986; 1987; ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; each ● indicates that a FCA was issued).

Family/Common Name (*Scientific Name*)[1]	Year/Geographic Area 1977[2]	1983[2]	1985	1986		1987	1989		1990		1991		1992		1993-1994		1994		1995		1996			1997			1998			1999			2000			2001			2002		
	IH/LM	IH/LM	IH/LM	IH/LM	GCR/IHC	IH/LM	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC
All Species					●			●		●		●		●		●		●		●			●			●			●			●			●			●			●
CYPRINIDAE																																									
Carp (*Cyprinus carpio*)			●	●		●	●		●		●		●		●		●		●		●	●		●	●		●	●		●	●		●	●		●	●		●	●	
Golden shiner (*Notemigonus crysoleucas*)																					●			●			●														
Goldfish (*Carassius auratus*)																					●			●			●														
CENTRARCHIDAE																																									
Black crappie (*Pomoxis nigromaculatus*)																					●			●			●			●			●			●			●		
Bluegill (*Lepomis macrochirus*)																														●	●		●	●		●	●		●	●	
Largemouth bass (*Micropterus salmoides*)																					●	●		●	●		●	●		●	●		●	●		●	●		●	●	
Rock bass (*Ambloplites rupestris*)																														●			●			●			●		
Smallmouth bass (*Micropterus dolomieui*)																														●			●			●			●		

Table 57. Summary of fish consumption advisories that have been issued for the Assessment Area (ISBH 1985a; 1985b; 1986; 1987; ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002;each ● indicates that a FCA was issued).

	Year/Geographic Area																																								
	1977[2]	1983[2]	1985	1986		1987	1989		1990		1991		1992		1993-1994		1994		1995		1996			1997			1998			1999			2000			2001			2002		
Family/Common Name (***Scientific Name***)[1]	IH/LM	IH/LM	IH/LM	IH/LM	GCR/IHC	IH/LM	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC
CATOSTOMIDAE																																									
Blue sucker *(Cycleptus elongatus)*																			●																						
Carpsuckers *(Carpiodes velifer)*																			●																						
Longnose sucker *(Catostomus catostomus)*																			●		●			●			●			●			●			●			●		
Quillback *(Carpiodes cyprinus)*																														●			●			●			●		
Silver redhorse *(Moxostoma anisurum)*																														●			●			●			●		
Spotted sucker *(Minytrema melanops)*																			●																						
White sucker *(Catostomus commersoni)*																			●		●			●			●			●			●			●			●		
PERCIDAE																																									
Walleye *(Stizostedion vitreum)*																			●		●			●			●			●			●			●			●		
Yellow Perch *(Perca flavescens)*																														●			●			●			●		

Table 57. Summary of fish consumption advisories that have been issued for the Assessment Area (ISBH 1985a; 1985b; 1986; 1987; ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002;each ● indicates that a FCA was issued).

	Year/Geographic Area																																								
	1977[2]	1983[2]	1985	1986		1987	1989		1990		1991		1992		1993-1994		1994		1995		1996			1997			1998			1999			2000			2001			2002		
Family/Common Name (*Scientific Name*)[1]	IH/LM	IH/LM	IH/LM	IH/LM	GCR/IHC	IH/LM	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC
ICTALURIDAE																																									
Catfish (*Ictalurus* sp.)						●	●		●		●		●		●		●				●			●			●			●											
Channel catfish (*Ictalurus punctatus*)																			●														●			●			●		
SCIAENIDAE																																									
Freshwater drum (*Aplodinotus grunniens*)																											●			●			●			●			●		
GOBIIDAE																																									
Round goby (*Neogobius melanostomus*)																														●			●			●			●		
SALMONIDAE																																									
Bloater (*Coregonus hoyi*)																											●			●			●			●			●		
Brook trout (Salvelinus fontinalis)																			●		●			●			●			●			●			●			●		
Brown trout (Salmo trutta)		●	●	●		●	●		●		●		●		●		●		●		●			●			●			●			●			●			●		
Chinook salmon (*Oncorhynchus tschawytscha*)						●	●		●		●		●		●		●		●		●			●			●			●			●			●			●		

Table 57. Summary of fish consumption advisories that have been issued for the Assessment Area (ISBH 1985a; 1985b; 1986; 1987; ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002;each ● indicates that a FCA was issued).

Family/Common Name (*Scientific Name*)[1]	Year/Geographic Area 1977[2]	1983[2]	1985	1986		1987	1989		1990		1991		1992		1993-1994		1994		1995		1996			1997			1998			1999			2000			2001			2002		
	IH/LM	IH/LM	IH/LM	IH/LM	GCR/IHC	IH/LM	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC	IH/LM	GCRL	GCR/IHC
SALMONIDAE (cont.)																																									
Coho salmon (*Oncorhynchus kisutch*)		●				●	●		●		●		●		●		●		●		●			●			●			●			●			●			●		
Lake trout (*Salvelinus namaycush*)	●		●	●		●	●		●		●		●		●		●		●		●			●			●			●			●			●			●		
Whitefish (*Coregonus clupeaformis*)																			●		●			●			●			●			●			●			●		
Pink salmon (*Oncorhynchus gorbuscha*)																			●		●			●			●			●			●			●			●		
Rainbow trout (*Oncorhynchus mykiss*)																					●			●			●			●			●			●			●		
Steelhead trout (*Oncorhynchus mykiss*)		●																	●								●			●			●			●			●		
ESOCIDAE																																									
Northern pike (*Esox lucius*)																					●			●			●			●			●			●			●		

IH/LM = Indiana Harbor and nearshore areas of Lake Michigan; GCR/IHC = Grand Calumet River and the Indiana Harbor Canal; GCRL = Grand Calumet River Lagoons.

[1]Froese and Pauly 2002

[2]Personal communication with Lee Bridges (IDEM. Indianapolis, Indiana. Personal communication, 2001).

Table 58. Summary of fish consumption advisories for the GCRL[1] (ISDH, IDEM, and IDNR 1996-2002; see the bottom of the table for the symbol legend).

Family/ Common name	Scientific Name[2]	Size	1996	1997	1998	1999	2000	2001	2002
			Unlisted species/waterways: assume Group 2						
CENTRARCHIDAE									
Bluegill	*Lepomis macrochirus*	4-7"				⊗	⊗	⊗	⊗
		7+"				⊙	⊙	⊙	⊙
Largemouth bass	*Micropterus salmoides*	12+"	⊗	⊗	⊗	⊗	⊗	⊗	⊗
CYPRINIDAE									
Carp	*Cyprinus carpio*	15-20"	⊗	⊗	⊗	⊗	⊗	⊗	⊗
		20-25"	⊙	⊙	⊙	⊙	⊙	⊙	⊙
		25+"	●	●	●	●	●	●	●

GCRL = Grand Calumet River Lagoons.

[1]Grand Calumet River Lagoons listed as Marquette Park Lagoons in the Indiana Fish Consumption Advisories.
[2]Froese and Pauly 2002

Symbol Legend:

○	Group 1 - Unrestricted consumption. One meal per week for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.
⦸	Group 2 - One meal per week (52 meals per year) for adult males and females. One meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.
⊗	Group 3 - One meal per month (12 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.
⊙	Group 4 - One meal every 2 months (6 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.
●	Group 5 - No consumption (DO NOT EAT)

Table 59. Summary of fish consumption advisories for the IH/LM (ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; see the bottom of the table for the symbol legend).

			Lake Michigan								Lake Michigan and Tributaries						Lake Michigan and Tributaries (Lake, LaPorte & Porter Counties)[7]						
Family/ Common name	**Scientific name[1]**	**Size**	**1977[2]**	**1978-1982**	**1983[2]**	**1984**	**1985[3]**	**1986[3,4]**	**1987[3]**	**1989[5]**	**1990[5]**	**1991[5]**	**1992[5]**	**1993-1994[5]**	**1994[5]**	**1995[5,6]**	**1996[5]**	**1997[5]**	**1998[5]**	**1999[5]**	**2000[5]**	**2001[5]**	**2002[5]**
			Unlisted species/waterways: no assumption							**Unlisted species/waterways: assume Group 1**						**Unlisted species/waterways: assume Group 2**							
CYPRINIDAE																							
Carp	*Cyprinus carpio*	All							●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
		25+"					●	●															
Golden shiner	*Notemigonus crysoleucas*	3-6"															●[8]	●[8]	●[8]				
Goldfish	*Carassius auratus*	4+"															●[8]	●[8]	●[8]				
CENTRARCHIDAE																							
Black crappie	*Pomoxis nigromaculatus*	7-8"															⊗	⊗	⊗	⊗	⊗	⊗	⊗
		8+"															⊙	⊙	⊙	⊙	⊙	⊙	⊙
Bluegill	*Lepomis macrochirus*	7-8"																		⦸	⦸	⦸	⦸
		8+"																		⊗	⊗	⊗	⊗
Largemouth bass	*Micropterus salmoides*	4-7"															⊗	⊗	⊗	⊗	⊗	⊗	⊗
		7+"															⊙	⊙	⊙	⊙	⊙	⊙	⊙
Rock bass	*Ambloplites rupestris*	8-9"																		⦸	⦸	⦸	⦸
Smallmouth bass	*Micropterus dolomieui*	8-14"																		⦸			
		11-12"																			⊗	⊗	⊗
		12+"																			●	●	●
		14+"																		⊗			

Table 59. Summary of fish consumption advisories for the IH/LM (ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; see the bottom of the table for the symbol legend).

			Lake Michigan								Lake Michigan and Tributaries						Lake Michigan and Tributaries (Lake, LaPorte & Porter Counties)[7]						
Family/ Common name	Scientific name[1]	Size	1977[2]	1978-1982	1983[2]	1984	1985[3]	1986[3,4]	1987[3]	1989[5]	1990[5]	1991[5]	1992[5]	1993-1994[5]	1994[5]	1995[5,6]	1996[5]	1997[5]	1998[5]	1999[5]	2000[5]	2001[5]	2002[5]
			Unlisted species/waterways: no assumption							Unlisted species/waterways: assume Group 1						Unlisted species/waterways: assume Group 2							
CATOSTOMIDAE																							
Blue sucker	*Cycleptus elongatus*	8-15"														⊙							
		15-23"														●							
Carpsuckers	*Carpiodes velifer*	8-15"														⊙							
		15-23"														●							
Longnose sucker	*Catostomus catostomus*	8-15"														⊙							
		15-23"														●	⊙	⊙	⊙	⊙	⊙	⊙	⊙
		23+"															●	●	●	●	●	●	●
Quillback	*Carpiodes cyprinus*	20+"																		⊗	⊗	⊗	⊗
Silver redhorse	*Moxostoma anisurum*	25+"																		●	●	●	●
Spotted sucker	*Minytrema melanops*	8-15"														⊙							
		15-23"														●							
White sucker	*Catostomus commersoni*	8-15"														⊙							
		15-23"														●	⊗	⊗	⊗	⊗	⊗	⊗	⊗
		23+"															⊙	⊙	⊙	⊙	⊙	⊙	⊙

Table 59. Summary of fish consumption advisories for the IH/LM (ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; see the bottom of the table for the symbol legend).

			Lake Michigan								Lake Michigan and Tributaries						Lake Michigan and Tributaries (Lake, LaPorte & Porter Counties)[7]						
Family/ Common name	**Scientific name[1]**	**Size**	**1977[2]**	**1978-1982**	**1983[2]**	**1984**	**1985[3]**	**1986[3,4]**	**1987[3]**	**1989[5]**	**1990[5]**	**1991[5]**	**1992[5]**	**1993-1994[5]**	**1994[5]**	**1995[5,6]**	**1996[5]**	**1997[5]**	**1998[5]**	**1999[5]**	**2000[5]**	**2001[5]**	**2002[5]**
			Unlisted species/waterways: no assumption							Unlisted species/waterways: assume Group 1						Unlisted species/waterways: assume Group 2							
PERCIDAE																							
Walleye	*Stizostedion vitreum*	17-26"														⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
		26+"														⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Yellow perch	*Perca flavescens*	7-10"																				⦸	⦸
		10+"																		⦸	⦸		
ICTALURIDAE																							
Catfish	*Ictalurus sp.*	All							●	●	●	●	●	●	●		●	●	●	●			
Channel catfish	*Ictalurus punctatus*	All																			●	●	●
		13-17"														●							
		17+"														●							
SCIAENIDAE																							
Freshwater drum	*Aplodinotus grunniens*	14-17"																			⊗	⊗	⊗
		17-20"																			⊙	⊙	⊙
		17-22"																	⊗	⊗			
		20+"																			●	●	●
		22+"																	⊙	⊙			
GOBIIDAE																							
Round goby	*Neogobius melanostomus*	3-4"																		⦸	⦸	⦸	⦸
		4+"																		⊗	⊗	⊗	⊗

Table 59. Summary of fish consumption advisories for the IH/LM (ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; see the bottom of the table for the symbol legend).

			Lake Michigan								Lake Michigan and Tributaries						Lake Michigan and Tributaries (Lake, LaPorte & Porter Counties)[7]						
Family/ Common name	Scientific name[1]	Size	1977[2]	1978-1982	1983[2]	1984	1985[3]	1986[3,4]	1987[3]	1989[5]	1990[5]	1991[5]	1992[5]	1993-1994[5]	1994[5]	1995[5,6]	1996[5]	1997[5]	1998[5]	1999[5]	2000[5]	2001[5]	2002[5]
			Unlisted species/waterways: no assumption							Unlisted species/waterways: assume Group 1						Unlisted species/waterways: assume Group 2							
SALMONIDAE																							
Bloater	*Coregonus hoyi*	10+																	⊗	⊗	⊗	⊗	⊗
Brook trout	*Salvelinus fontinalis*	All														⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Brown trout	*Salmo trutta*	All			□	□[9]																	
		Up to 18"														⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
		Up to 23"							□	□	□	□	□	□	□								
		18-27"														⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
		23+"							●	●	●	●	●	●	●								
		25+"					●	●															
		27+"														●	●	●	●	●	●	●	●
Chinook salmon	*Oncorhynchus tschawytscha*	Up to 26"														⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
		21-32"							□	□	□	□	□	□	□								
		26-30"																	⊙	⊙	⊙	⊙	⊙
		26+"														⊙	⊙	⊙					
		30+"																	●	●	●	●	●
		32+"							●	●	●	●	●	●	●								
Coho salmon	*Oncorhynchus kisutch*	All			□	□[9]																	
		17-28"														⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
		26+"							□	□	□	□	□	□	□								
		28+"														⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙

Table 59. Summary of fish consumption advisories for the IH/LM (ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; see the bottom of the table for the symbol legend).

			Lake Michigan								Lake Michigan and Tributaries						Lake Michigan and Tributaries (Lake, LaPorte & Porter Counties)[7]						
Family/ Common name	Scientific name[1]	Size	1977[2]	1978-1982	1983[2]	1984	1985[3]	1986[3,4]	1987[3]	1989[5]	1990[5]	1991[5]	1992[5]	1993-1994[5]	1994[5]	1995[5,6]	1996[5]	1997[5]	1998[5]	1999[5]	2000[5]	2001[5]	2002[5]
			Unlisted species/waterways: no assumption							Unlisted species/waterways: assume Group 1						Unlisted species/waterways: assume Group 2							
Lake trout	*Salvelinus namaycush*	All	●	●[9]																			
		Up to 21"														⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
		20-23"							□	□	□	□	□	□	□								
		21-26"														⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
		23+"							●	●	●	●	●	●	●								
		25+"					●	●															
		26+"														●	●	●	●	●	●	●	●
Whitefish[10]	*Coregonus clupeaformis*	9-12"																	⊘	⊘	⊘	⊘	⊘
		12-20"																	⊗	⊗	⊗	⊗	⊗
		Up to 23"														⊗	⊗	⊗					
		20-24"																	⊙	⊙	⊙	⊙	⊙
		23+"														⊙	⊙	⊙					
		24+"																	●	●	●	●	●
Pink salmon	*Oncorhynchus gorbuscha*	All														⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Rainbow trout	*Oncorhynchus mykiss*	All																					
		Up to 22"															⊗	⊗	⊗	⊗	⊗	⊗	⊗
		22+"															⊙	⊙	⊙	⊙			
		22-32"																			⊙	⊙	⊙

Table 59. Summary of fish consumption advisories for the IH/LM (ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; see the bottom of the table for the symbol legend).

			Lake Michigan								Lake Michigan and Tributaries						Lake Michigan and Tributaries (Lake, LaPorte & Porter Counties)[7]						
Family/ Common name	Scientific name[1]	Size	1977[2]	1978-1982	1983[2]	1984	1985[3]	1986[3,4]	1987[3]	1989[5]	1990[5]	1991[5]	1992[5]	1993-1994[5]	1994[5]	1995[5,6]	1996[5]	1997[5]	1998[5]	1999[5]	2000[5]	2001[5]	2002[5]
			Unlisted species/waterways: no assumption							Unlisted species/waterways: assume Group 1						Unlisted species/waterways: assume Group 2							
Steelhead trout	*Oncorhynchus mykiss*	All			□	□[9]																	
		Up to 22"														⊗							
		22+"														⊙							
		26-32"																	⊙	⊙			
		32+"																	●	●	●	●	●
ESOCIDAE																							
Northern pike	*Esox lucius*	10-14"															⊗	⊗	⊗	⊗	⊗	⊗	⊗
		14+"															⊙	⊙	⊙	⊙	⊙	⊙	⊙

IH/LM = Indiana Harbor and nearshore areas of Lake Michigan; FCA = fish consumption advisory; ISDH = Indiana State Department of Health.

[1]Froese and Pauly 2002
[2]Personal communication with Lee Bridges (IDEM. Indianapolis, Indiana. Personal communication, 2001).
[3]ISBH 1985a; 1985b; 1986; 1987.
[4]The FCA issued in 1986 for the Grand Calumet River and Indiana Harbor Canal also included Indiana Harbor ("all species" classified in Group 5; see Table 55).
[5]ISBH, IDEM, and IDNR 1989; 1990; 1991; ISDH, IDEM, and IDNR 1992; 1993; 1994; 1995; 1996; 1997; 1998; 1999; 2000; 2001; 2002.
[6]Fish Consumption Advisories group classification system is refined from three to five advisory groups.
[7]It was assumed that the FCAs apply directly to nearshore areas of Lake Michigan and tributaries within Lake County.
[8]FCA applies to Lake County only.
[9]Advisories for IH/LM are not specifically listed in the 1978 to 1982 or 1984 ISDH Public Health News bulletin or in the Indiana Fish Consumption Advisory. It was assumed that the FCAs issued for previous years were still in effect, as there was no indication that the FCAs were withdrawn.
[10]Referred to as "Lake Whitefish" in 1998-2002 Fish Consumption Advisories.

Table 59. Summary of fish consumption advisories for the IH/LM (ISBH, IDEM, and IDNR 1989-1991; ISDH, IDEM, and IDNR 1992-2002; see the bottom of the table for the symbol legend).

			Lake Michigan								Lake Michigan and Tributaries						Lake Michigan and Tributaries (Lake, LaPorte & Porter Counties)[7]						
Family/ Common name	Scientific name[1]	Size	1977[2]	1978-1982	1983[2]	1984	1985[3]	1986[3,4]	1987[3]	1989[5]	1990[5]	1991[5]	1992[5]	1993-1994[5]	1994[5]	1995[5,6]	1996[5]	1997[5]	1998[5]	1999[5]	2000[5]	2001[5]	2002[5]
			Unlisted species/waterways: no assumption							Unlisted species/waterways: assume Group 1						Unlisted species/waterways: assume Group 2							

<u>**Symbol Legend:**</u>

<u>1995-2002</u>

○ Group 1 - Unrestricted consumption. One meal per week for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.

⦸ Group 2 - One meal per week (52 meals per year) for adult males and females. One meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.

⊗ Group 3 - One meal per month (12 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.

⊙ Group 4 - One meal every 2 months (6 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat.

● Group 5 - No consumption (DO NOT EAT)

<u>1985-1994</u>

○ Group 1 - No consumption advisory is in effect.

□ Group 2 - Adult men and women not of child-bearing age should consume no more than 1 meal per week consisting of up to one-half pound of flesh of designated species from named waterways. Women of child-bearing age and children under the age of 18 should not consume any of the fish listed in Group 2.

● Group 3 - No one should eat designated species from named waterways.

Table 60. Summary of COPCs, COCs for each line of evidence, and principal COCs for the GCR/IHC.

List of Chemicals	COPCs[1]	Individual Lines of Evidence: Sediment-associated COC[2]	Tissue-associated COC[3]: USFDA	Tissue-associated COC[3]: ISDH	FCA COC[4]	Principal COC[5]
Metals						
Mercury	✓			✓	✓	✓
Polycyclic Aromatic Hydrocarbons						
Benzene	✓	✓				
Carbazole	✓	✓				
Benz[a]anthracene	✓	✓				
Benzo(b)fluoranthene	✓	✓				
Benzo(k)fluoranthene	✓	✓				
Benzo(a)pyrene	✓	✓				
Chrysene	✓	✓				
Dibenz[a,h]anthracene	✓	✓				
Indeno(1,2,3-cd)pyrene	✓	✓				
Polychlorinated Biphenyls						
Aroclor 1016	✓					
Aroclor 1242	✓	✓				
Aroclor 1248	✓	✓				
Aroclor 1254	✓	✓				
Aroclor 1260	✓	✓				
Total PCBs	✓	✓	✓	✓	✓	✓
Chlorinated Benzenes						
Hexachlorobenzene (HCB)	✓					
Hexachlorobutadiene (HCBD)	✓					
Phthalates						
Bis(2-ethylhexyl)phthalate	✓					
Chlorophenols						
2,4-Dichlorophenol	✓					
2,4,6-Trichlorophenol	✓					
Pentachlorophenol	✓					
Pesticides						
Aldrin	✓					
Dieldrin	✓	✓				
Aldrin + dieldrin	✓					
Chlordane	✓	✓	✓			✓

Table 60. Summary of COPCs, COCs for each line of evidence, and principal COCs for the GCR/IHC.

List of Chemicals	COPCs[1]	Individual Lines of Evidence: Sediment-associated COC[2]	Tissue-associated COC[3]: USFDA	Tissue-associated COC[3]: ISDH	FCA COC[4]	Principal COC[5]
Pesticides (cont.)						
p,p'-DDD	✓	✓				
p,p'-DDE	✓	✓				
p,p'-DDT	✓	✓				
Total DDT	✓					
Endosulfan	✓					
Endrin	✓	✓				
Heptachlor	✓	✓				
Heptachlor epoxide	✓	✓				
Heptachlor + heptachlor epoxide	✓					
Alpha-hexachlorocyclohexane (HCH)	✓					
Beta-HCH	✓	✓				
Technical-HCH	✓					
Lindane (gamma-HCH)	✓	✓				
Dioxins and Furans						
TCDD-TEQ	✓	✓				

COC = contaminant of concern; COPC = chemical of potential concern; USFDA = United States Food and Drug Administration; ISDH = Indiana State Department of Health; FCA = fish consumption advisory; PCB = polychlorinated biphenyls; TCDD-TEQ = tetrachlorodibenzo-*p-* dioxin - toxic equivalents; GCR/IHC = Grand Calumet River and the Indian Harbor Canal.

[1]See Section 1.0 for more information on how COPCs were identified.

[2]Substances that occurred in two or more whole-sediment samples at concentrations in excess of the corresponding chemical benchmark.

[3]Substances that occurred in one or more fish tissue samples at concentrations in excess of the corresponding chemical benchmark (i.e., the tolerance levels or action levels that have been promulgated by the USFDA or the Group 1 threshold levels that have been established by ISDH to support the development of FCAs).

[4]Substances responsible for the issuance of FCAs.

[5]The principal COCs included those COPCs that were identified as substances that had driven a FCA or were present in fish tissues at concentrations above one or more of the selected benchmarks. Substances that exceeded the selected benchmarks for sediment chemistry alone were identified as COCs, but were not considered to be the principal COCs.

Table 61. Summary of COPCs, COCs for each line of evidence, and principal COCs for the GCRL.

List of Chemicals	COPCs[1]	Individual Lines of Evidence				Principal COC[5]
		Sediment-associated COC[2]	Tissue-associated COC[3]		FCA COC[4]	
			USFDA	ISDH		
Metals						
Mercury	✓			✓		✓
Polycyclic Aromatic Hydrocarbons						
Benzene	✓					
Carbazole	✓					
Benz[a]anthracene	✓	✓				
Benzo(b)fluoranthene	✓	✓				
Benzo(k)fluoranthene	✓	✓				
Benzo(a)pyrene	✓	✓				
Chrysene	✓	✓				
Dibenz[a,h]anthracene	✓	✓				
Indeno(1,2,3-cd)pyrene	✓	✓				
Polychlorinated Biphenyls						
Aroclor 1016	✓					
Aroclor 1242	✓	✓				
Aroclor 1248	✓	✓				
Aroclor 1254	✓	✓				
Aroclor 1260	✓	✓				
Total PCBs	✓	✓		✓	✓	✓
Chlorinated Benzenes						
Hexachlorobenzene (HCB)	✓					
Hexachlorobutadiene (HCBD)	✓					
Phthalates						
Bis(2-ethylhexyl)phthalate	✓					
Chlorophenols						
2,4-Dichlorophenol	✓					
2,4,6-Trichlorophenol	✓					
Pentachlorophenol	✓					
Pesticides						
Aldrin	✓					
Dieldrin	✓	✓				
Aldrin + dieldrin	✓					
Chlordane	✓	✓				

Table 61. Summary of COPCs, COCs for each line of evidence, and principal COCs for the GCRL.

List of Chemicals	COPCs[1]	Individual Lines of Evidence				Principal COC[5]
		Sediment-associated COC[2]	Tissue-associated COC[3]		FCA COC[4]	
			USFDA	ISDH		
Pesticides (cont.)						
p,p'-DDD	✓	✓				
p,p'-DDE	✓	✓				
p,p'-DDT	✓	✓				
Total DDT	✓					
Endosulfan	✓					
Endrin	✓	✓				
Heptachlor	✓					
Heptachlor epoxide	✓					
Heptachlor + heptachlor epoxide	✓					
Alpha-hexachlorocyclohexane (HCH)	✓					
Beta-HCH	✓					
Technical-HCH	✓					
Lindane (gamma-HCH)	✓					
Dioxins and Furans						
TCDD-TEQ	✓					

COC = contaminant of concern; COPC = chemical of potential concern; USFDA = United States Food and Drug Administration; ISDH = Indiana State Department of Health; FCA = fish consumption advisory; PCB = polychlorinated biphenyls; TCDD-TEQ = tetrachlorodibenzo-*p*-dioxin - toxic equivalents; GCRL = Grand Calumet River Lagoons.

[1]See Section 1.0 for more information on how COPCs were identified.
[2]Substances that occurred in two or more whole-sediment samples at concentrations in excess of the corresponding chemical benchmark.
[3]Substances that occurred in one or more fish tissue samples at concentrations in excess of the corresponding chemical benchmark (i.e., the tolerance levels or action levels that have been promulgated by the USFDA or the Group 1 threshold levels that have been established by ISDH to support the development of FCAs).
[4]Substances responsible for the issuance of FCAs.
[5]The principal COCs included those COPCs that were identified as substances that had driven a FCA or were present in fish tissues at concentrations above one or more of the selected benchmarks. Substances that exceeded the selected benchmarks for sediment chemistry alone were identified as COCs, but were not considered to be the principal COCs.

Table 62. Summary of COPCs, COCs for each line of evidence, and principal COCs for IH/LM.

List of Chemicals	COPCs[1]	Individual Lines of Evidence				Principal COC[5]
		Sediment-associated COC[2]	Tissue-associated COC[3]		FCA COC[4]	
			USFDA	ISDH		
Metals						
Mercury	✓			✓	✓	✓
Polycyclic Aromatic Hydrocarbons						
Benzene	✓					
Carbazole	✓					
Benz[a]anthracene	✓	✓				
Benzo(b)fluoranthene	✓					
Benzo(k)fluoranthene	✓	✓				
Benzo(a)pyrene	✓	✓				
Chrysene	✓	✓				
Dibenz[a,h]anthracene	✓	✓				
Indeno(1,2,3-cd)pyrene	✓	✓				
Polychlorinated Biphenyls						
Aroclor 1016	✓					
Aroclor 1242	✓	✓				
Aroclor 1248	✓					
Aroclor 1254	✓					
Aroclor 1260	✓					
Total PCBs	✓	✓	✓	✓	✓	✓
Chlorinated Benzenes						
Hexachlorobenzene (HCB)	✓					
Hexachlorobutadiene (HCBD)	✓					
Phthalates						
Bis(2-ethylhexyl)phthalate	✓					
Chlorophenols						
2,4-Dichlorophenol	✓					
2,4,6-Trichlorophenol	✓					
Pentachlorophenol	✓					
Pesticides						
Aldrin	✓					
Dieldrin	✓				✓	✓
Aldrin + dieldrin	✓					
Chlordane	✓				✓	✓

Table 62. Summary of COPCs, COCs for each line of evidence, and principal COCs for IH/LM.

List of Chemicals	COPCs[1]	Individual Lines of Evidence				Principal COC[5]
		Sediment-associated COC[2]	Tissue-associated COC[3]		FCA COC[4]	
			USFDA	ISDH		
Pesticides (cont)						
p,p'-DDD	✓					
p,p'-DDE	✓					
p,p'-DDT	✓					
Total DDT	✓				✓	✓
Endosulfan	✓					
Endrin	✓					
Heptachlor	✓					
Heptachlor epoxide	✓					
Heptachlor + heptachlor epoxide	✓					
Alpha-hexachlorocyclohexane (HCH)	✓					
Beta-HCH	✓					
Technical-HCH	✓					
Lindane (gamma-HCH)	✓					
Dioxins and Furans						
TCDD-TEQ	✓	✓				

COC = contaminant of concern; COPC = chemical of potential concern; USFDA = United States Food and Drug Administration; ISDH = Indiana State Department of Health; FCA = fish consumption advisory; PCB = polychlorinated biphenyls; TCDD-TEQ = tetrachlorodibenzo-*p*- dioxin - toxic equivalents; IH/LM = Indiana Harbor and nearshore areas of Lake Michigan.

[1]See Section 1.0 for more information on how COPCs were identified.
[2]Substances that occurred in two or more whole-sediment samples at concentrations in excess of the corresponding chemical benchmark.
[3]Substances that occurred in one or more fish tissue samples at concentrations in excess of the corresponding chemical benchmark (i.e., the tolerance levels or action levels that have been promulgated by the USFDA or the Group 1 threshold levels that have been established by ISDH to support the development of FCAs).
[4]Substances responsible for the issuance of FCAs.
[5]The principal COCs included those COPCs that were identified as substances that had driven a FCA or were present in fish tissues at concentrations above one or more of the selected benchmarks. Substances that exceeded the selected benchmarks for sediment chemistry alone were identified as COCs, but were not considered to be the principal COCs.

An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan

Volume II - Tables

Prepared for:

U.S. Fish and Wildlife Service
Bloomington Field Office
620 South Walker Street
Bloomington, Indiana 47403

Prepared – October 2000 – by:

Donald D. MacDonald
MacDonald Environmental Sciences Ltd.
2376 Yellow Point Road
Nanaimo, British Columbia
V9X 1W5

Christopher G. Ingersoll
Columbia Environmental Research Center
United States Geological Survey
4200 New Haven Road
Columbia, Missouri 65201

In Association with:
Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, Massachusetts
02140

MACDONALD ENVIRONMENTAL SCIENCES LTD.

USGS science for a changing world

Industrial Economics INCORPORATED

An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan

Volume II - Tables

Prepared for:

U.S. Fish and Wildlife Service
Bloomington Field Office
620 South Walker Street
Bloomington, Indiana 47403

Prepared – October 2000 – by:

Donald D. MacDonald
MacDonald Environmental Sciences Ltd.
2376 Yellow Point Road
Nanaimo, British Columbia
V9X 1W5

Christopher G. Ingersoll
Columbia Environmental Research Center
United States Geological Survey
4200 New Haven Road
Columbia, Missouri 65201

In Association with:

Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, Massachusetts 02140

Volume II - Tables (under this cover)

Other Volumes in this Report
Volume I - Text
Volume III - Figures
Volume IV - Appendices

Chapter 6

Chapter 7

Chapter 8

List of Acronyms

%	percent
10-d	10 days
12-d	12 days
14-d	14 days
15-min	15 minutes
20-d	20 days
2,3,7,8-TCDD	tetrachlorodibenzo-*p*-dioxin
28-d	28 days
30-min	30 minutes
48-h	48 hours
7-d	7 days
8-d	8 days
96-h	96 hours
AOC	Area of Concern
ARCS Program	Assessment and Remediation of Contaminated Sediments in the Great Lakes Program
ASTM	American Society for Testing and Materials
AVS	acid volatile sulfides
BSAF	biota-sediment bioaccumulation factor
CCBP	Central Corn Belt Plain
CCME	Canadian Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601 et seq.
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CI	confidence interval
CSO	combined sewer overflow
DDTs	*p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDE, *o,p*'-DDE, *p,p*'-DDD, *o,p*'-DDD, and any metabolite or degradation product
DELT	deformities, fin erosion, lesions, and tumors
DL	detection limit
DO	dissolved oxygen
DQO	data quality objective
DuPont	E.I. du Pont de Nemours
DW	dry weight
EB	east branch
EBGCR	East Branch of the Grand Calumet River
EBGCR-I	East Branch of the Grand Calumet River I
EBGCR-II	East Branch of the Grand Calumet River II

EC	Environment Canada
EC_{50}	median effective concentration
ECBP	Eastern Corn Belt Plain
EPT	Ephemeroptera, Plecoptera, Trichoptera
FIELDS	Fully Integrated Environmental Location Decision Support
gamma-BHC	gamma-hexachlorocyclohexane (lindane)
GCRL	Grand Calumet River Lagoons
GIS	geographic information system
HC	Health Canada
HNTB	Howard, Needles, Tammen and Bergendoff Architects, Engineers, and Planners
IBI	Index of biotic integrity
ID	insufficient data
IDEM	Indiana Department of Environmental Management
IEC	Industrial Economics, Inc.
IH	Indiana Harbor
IHC	Indiana Harbor Canal
IJC	International Joint Commission
IL	Illinois
IN	Indiana
LC_{50}	median lethal concentration
LEP	Little East Pond
LGB	Lake George Branch
LM	Lake Michigan
LTI	Limno-Tech, Inc.
LWP	Little West Pond
mean PEC-Q	mean probable effect concentration quotient
MESL	MacDonald Environmental Sciences Ltd.
mg	milligrams
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mIBI	macroinvertebrate index of biotic integrity
mm	millimeters
MS	Microsoft
n	number of samples
NA	not applicable (i.e., all <DL values were >PEC; therefore total was not calculated)
NA'	not applicable (i.e., toxicity test or chemical analyses not performed).
ND	not determined; compounds were measured as less than the detection limit, but the detection limit is unknown
ND'	not determined; toxicity not determined because mortality was > 40%
ND"	not determined; the lab considered sample to be a hazard to personnel
NE	northeast
NG	no guideline available

NH_3	unionized ammonia
NH_4^+	ionized ammonia
NIPSCO	Northern Indiana Public Service Company
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge and Elimination System
NR	not reported
NRDA	Natural Resource Damage Assessment
NT	not toxic
NW	northwest
NYSDEC	New York State Department of Environmental Conservation
OC	organic carbon
OEPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	probable effect concentration (consensus-based)
PEC-Q	probable effect concentration quotient
QA/QC	quality assurance/quality control
QHEI	qualitative habitat evaluation index
RCRA	Resource Conservation and Recovery Act
RETEC	Remediation Technologies, Inc.
S.U.	standard unit
SAB	Science Advisory Board
SE	southeast
SEC	sediment effect concentration (consensus-based)
SEM	simultaneously extracted metals
SEM-AVS	simultaneously extracted metal minus acid volatile sulfides
SETAC	Society of Environmental Toxicology and Chemistry
SOD	sediment oxygen demand
SQG	sediment quality guideline
STP	sewage treatment plant
sum DDD	*p,p*'-DDD + *o,p*'-DDD
sum DDE	*p,p*'-DDE + *o,p*'-DDE
sum DDT	*p,p*'-DDT + *o,p*'-DDT
SVOC	semi-volatile organic chemical
SW	southwest
T	toxic
TEC	threshold effect concentration (consensus-based)
ThermoRetec	ThermoRetec Consulting Corporation
TOC	total organic carbon
Total DDT	*p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDE, *o,p*'-DDE, *p,p*'-DDD, and *o,p*'-DDD
TRG	tissue residue guideline
U.S. Steel	United States Steel (Division of USX Corporation)
USACE	United States Army Corps of Engineers
USC	United States Canal

USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USS Lead	USS Lead Refinery, Inc.
VOC	volatile organic compound
WB	west branch
WBGCR	West Branch of the Grand Calumet River
WBGCR-I	West Branch of the Grand Calumet River I
WBGCR-II	West Branch of the Grand Calumet River II
WW	wet weight
WWTP	wastewater treatment plant
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µmol/g	micromoles per gram

Tables

Chapter 3 - Study Approach

Table 3.1. Summary of the consensus-based SECs for the chemicals of concern in the Assessment Area (from MacDonald *et al.* 2000a).

Chemicals of Concern	Units	Consensus-Based TEC	Consensus-Based PEC
Metals			
Arsenic	mg/kg (DW)	9.79	33.0
Cadmium	mg/kg (DW)	0.99	4.98
Chromium	mg/kg (DW)	43.4	111
Copper	mg/kg (DW)	31.6	149
Lead	mg/kg (DW)	35.8	128
Mercury	mg/kg (DW)	0.18	1.06
Nickel	mg/kg (DW)	22.7	48.6
Zinc	mg/kg (DW)	121	459
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	µg/kg (DW)	6.71[1]	88.9[2]
Acenaphthylene	µg/kg (DW)	5.87[1]	128[2]
Anthracene	µg/kg (DW)	57.2	845
Fluorene	µg/kg (DW)	77.4	536
2-Methylnaphthalene	µg/kg (DW)	20.2[1]	201[2]
Naphthalene	µg/kg (DW)	176	561
Phenanthrene	µg/kg (DW)	204	1170
Benz(a)anthracene	µg/kg (DW)	108	1050
Dibenz(a,h)anthracene	µg/kg (DW)	33.0	135[2]
Benzo(a)pyrene	µg/kg (DW)	150	1450
Chrysene	µg/kg (DW)	166	1290
Fluoranthene	µg/kg (DW)	423	2230
Pyrene	µg/kg (DW)	195	1520
Total PAHs	µg/kg (DW)	1610	22800
Polychlorinated Biphenyls			
Total PCBs	µg/kg (DW)	59.8	676
Pesticides			
Chlordane	µg/kg (DW)	3.24	17.6
Dieldrin	µg/kg (DW)	1.90	61.8
sum DDD	µg/kg (DW)	4.88	28.0
sum DDE	µg/kg (DW)	3.16	31.3
sum DDT	µg/kg (DW)	4.16	62.9
Total DDT	µg/kg (DW)	5.28	572
Endrin	µg/kg (DW)	2.22	207
Heptachlor epoxide	µg/kg (DW)	2.47	16.0
Lindane (gamma-BHC)	µg/kg (DW)	2.37	4.99

[1]TEL from CCME (1999).

[2]PEL from CCME (1999).

DW = dry weight.

Table 3.2. Toxicity thresholds for chemicals of concern in pore water in the Assessment Area.

Chemicals of Concern	Units	Aquatic Plants		10-d LC_{50} for	Other Aquatic Invertebrates		Fish	
		Acute	Chronic	*Hyalella azteca*	Acute	Chronic	Acute	Chronic
Metals								
Cadmium	µg/L	30 [6]	1 [6]	2.94	3.6 [6]	0.17 [6]	< 0.5 [6]	0.47 [6]
Chromium	µg/L	2500 [7]	NR	NR	15 [2]	2.5 [2]	265 [2]	73 [2]
Copper	µg/L	NR	1 [1]	35 [4]	20 [1]	8 [1]	21 [1]	3.9 [2]
Lead	µg/L	4140 [7]	450 [7]	< 16 [4]	124 [7]	1 [7]	448 [2]	3.5 [7]
Nickel	µg/L	300 [5]	50 [5]	780 [4]	102 [5]	15 [2]	50 [5]	25 [5]
Zinc	µg/L	20 [7]	2 [7]	73 [4]	51 [7]	10 [7]	280 [7]	10 [7]
Phenolics								
o-Chlorophenol	µg/L	NR	NR	NR	5600 [3]	NR	NR	NR
p-Chlorophenol	µg/L	NR	NR	NR	5600 [3]	NR	NR	NR
o-Cresol	µg/L	NR	NR	NR	100 [3]	NR	NR	NR
p-Cresol	µg/L	NR	NR	NR	100 [3]	NR	NR	NR
2,4-Dichlorophenol	µg/L	NR	NR	NR	520 [3]	NR	NR	NR
2,4-Dinitrophenol	µg/L	NR	NR	NR	NR	NR	NR	NR
Phenol	µg/L	NR	NR	NR	45 [3]	NR	NR	NR
Other Substances								
Unionized ammonia	mg/L	NR	NR	NR	0.53 [2]	NR	0.083 [2]	0.002 [2]

[1] Spear and Pierce (1979).
[2] CCREM (1987).
[3] USEPA (1992a).
[4] USEPA (1994).
[5] EC and HC (1994).
[6] Outridge *et al.* (1994).
[7] USGS (1998).
NR = not reported.

Table 3.3. Bioaccumulation-based SQGs for the chemicals of concern in the Assessment Area (from NYSDEC 1994).

Chemicals of Concern	Units	Wildlife-Based SQGs	Human Health-Based SQGs
Polycyclic Aromatic Hydrocarbons			
Benzo(a)pyrene	µg/kg (DW; OC)	NG	1300
Polychlorinated Biphenyls			
Total PCBs	µg/kg (DW; OC)	1400	0.8
Pesticides			
Chlordane	µg/kg (DW; OC)	6	1
Dieldrin	µg/kg (DW; OC)	NG	100
Total DDT	µg/kg (DW; OC)	1000	10
Endrin	µg/kg (DW; OC)	800	800
Heptachlor	µg/kg (DW; OC)	30	0.8
Heptachlor epoxide	µg/kg (DW; OC)	30	0.8
Lindane (gamma-BHC)	µg/kg (DW; OC)	1500	60
Mirex	µg/kg (DW; OC)	3700	70
Toxaphene	µg/kg (DW; OC)	NG	20
Dioxins			
2,3,7,8-TCDD	µg/kg (DW; OC)	0.2	10

NG = no guideline; DW = dry weight; OC = organic carbon.

Table 3.4. Tissue residue guidelines for the protection of piscivorus wildlife (from Newell *et al.* 1987).

Chemical of Concern	Units	Tissue Residue Guidelines (TRGs)			
		Carcinogenic Criteria	*Non-Carcinogenic Criteria*		*TRGs used in this Assessment*
		1 in 100 Cancer Risk Criteria	Birds	Mammals	
PCBs					
Total PCBs	µg/kg (WW)	110	110	130	110
Pesticides					
Chlordane	µg/kg (WW)	370	NG	500	370
Dieldrin + Aldrin	µg/kg (WW)	22	200	120	22
Endrin	µg/kg (WW)	NG	25	430	25
Heptachlor + Heptachlor epoxide	µg/kg (WW)	210	25	200	25
Lindane	µg/kg (WW)	510	100	2000	100
Mirex	µg/kg (WW)	370	2000	330	330
Total DDT	µg/kg (WW)	270	200	500	200
Dioxins					
2,3,7,8-TCDD	µg/kg (WW)	0.0023	NG	0.003	0.0023

NG = no guideline; WW = wet weight.

Table 3.5. Maximum background concentration of metals in Indiana and Illinois stream and lake sediments.

Chemicals of Concern	Units	Illinois [a]	Indiana [b]
Metals			
Cadmium	mg/kg (DW)	1.0	1.0
Chromium	mg/kg (DW)	23.0	50.0
Copper	mg/kg (DW)	60.0	20.0
Nickel	mg/kg (DW)	NR	21.0
Lead	mg/kg (DW)	38.0	150.0
Zinc	mg/kg (DW)	100.0	130.0

[a] Maximum background concentrations of metals in Illinois stream and lake sediments (Adams 1995). Values reported represent the mean plus four standard deviations.
[b] Maximum background concentrations of metals in Indiana stream and lake sediments (IDEM 1992).
NR = not reported; DW = dry weight.

Tables

Chapter 5 - Grand Calumet River Lagoons

Table 5.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in GCRL sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	84 of 178 (47%)	1 of 13 (7.7%)	NG	NG
Cadmium	4 of 201 (2.0%)	0 of 9 (0%)	NG	NG
Chromium	33 of 201 (16%)	0 of 13 (0%)	NG	NG
Copper	4 of 201 (2.0%)	0 of 13 (0%)	NG	NG
Lead	35 of 201 (17%)	0 of 13 (0%)	NG	NG
Mercury	3 of 201 (1.5%)	0 of 13 (0%)	NG	NG
Nickel	2 of 198 (1.0%)	0 of 13 (0%)	NG	NG
Zinc	18 of 196 (9.2%)	0 of 13 (0%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	37 of 37 (100%)	1 of 1 (100%)	NG	NG
Acenaphthylene	18 of 18 (100%)	1 of 1 (100%)	NG	NG
Anthracene	27 of 87 (31%)	1 of 3 (33%)	NG	NG
Benz(a)anthracene	52 of 155 (34%)	1 of 4 (25%)	NG	NG
Benzo(a)pyrene	51 of 167 (31%)	1 of 4 (25%)	NG	NG
Chrysene	55 of 163 (34%)	1 of 4 (25%)	NG	NG
Dibenz(a,h)anthracene	27 of 29 (93%)	0 of 0 (0%)	NG	NG
Fluoranthene	47 of 181 (26%)	1 of 4 (25%)	NG	NG
Fluorene	26 of 40 (65%)	1 of 1 (100%)	NG	NG
2-Methylnaphthalene	22 of 31 (71%)	1 of 1 (100%)	NG	NG
Naphthalene	39 of 80 (49%)	1 of 1 (100%)	NG	NG
Phenanthrene	51 of 163 (31%)	1 of 4 (25%)	NG	NG
Pyrene	59 of 176 (34%)	1 of 4 (25%)	NG	NG
Total PAHs	37 of 194 (19%)	1 of 4 (25%)	NG	NG
PCBs				
Total PCBs	14 of 40 (35%)	0 of 0 (0%)	29 of 29 (100%)	0 of 0 (0%)

Table 5.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in GCRL sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	7 of 18 (39%)	0 of 0 (0%)	14 of 14 (100%)	0 of 0 (0%)
sum DDD	12 of 26 (46%)	0 of 1 (0%)	NG	NG
sum DDE	18 of 32 (56%)	0 of 1 (0%)	NG	NG
sum DDT	10 of 32 (31%)	0 of 1 (0%)	NG	NG
Total DDTs	7 of 33 (21%)	0 of 1 (0%)	20 of 33 (61%)	0 of 1 (0%)
Dieldrin	0 of 33 (0%)	0 of 1 (0%)	NG	NG
Endrin	0 of 33 (0%)	0 of 1 (0%)	1 of 22 (4.5%)	0 of 1 (0%)
Heptachlor	NG	NG	0 of 1 (0%)	0 of 0 (0%)
Heptachlor epoxide	0 of 32 (0%)	0 of 1 (0%)	0 of 1 (0%)	0 of 0 (0%)
Lindane (gamma-BHC)	0 of 17 (0%)	0 of 1 (0%)	0 of 33 (0%)	0 of 1 (0%)
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	NM	NM

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or
the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no guideline (i.e., no PEC or bioaccumulative-based SQG available); NM = substance was not measured.

Table 5.2. Proportion of sediment samples with various chemical characteristics in the GCRL.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Surficial Sediments						
West Lagoon						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	58	4 of 58 (6.9%)	23 of 58 (40%)	15 of 58 (26%)	16 of 58 (28%)	31 of 58 (53%)
Middle Lagoon						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	49	4 of 49 (8.2%)	36 of 49 (73%)	7 of 49 (14%)	2 of 49 (4.1%)	9 of 49 (18%)
East Lagoon						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	47	4 of 47 (8.5%)	29 of 47 (62%)	14 of 47 (30%)	0 of 47 (0%)	14 of 47 (30%)
Little West Pond						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	25	9 of 25 (36%)	14 of 25 (56%)	2 of 25 (8.0%)	0 of 25 (0%)	2 of 25 (8.0%)
Little East Pond						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	23	12 of 23 (52%)	11 of 23 (48%)	0 of 23 (0%)	0 of 23 (0%)	0 of 23 (0%)
Total (all years and locations)	**202**	**33 of 202 (16%)**	**113 of 202 (56%)**	**38 of 202 (19%)**	**18 of 202 (8.9%)**	**56 of 202 (28%)**

NA = not applicable.

Table 5.2. Proportion of sediment samples with various chemical characteristics in the GCRL.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Sub-Surface Sediments						
West Lagoon						
Prior to 1996	5	3 of 5 (60%)	1 of 5 (20%)	0 of 5 (0%)	1 of 5 (20%)	1 of 5 (20%)
1996 and later	1	0 of 1 (0%)	1 of 1 (100%)	0 of 1 (0%)	0 of 1 (0%)	0 of 1 (0%)
Middle Lagoon						
Prior to 1996	3	3 of 3 (100%)	0 of 3 (0%)	0 of 3 (0%)	0 of 3 (0%)	0 of 3 (0%)
1996 and later	0	NA	NA	NA	NA	NA
East Lagoon						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	0	NA	NA	NA	NA	NA
Little West Pond						
Prior to 1996	2	1 of 2 (50%)	1 of 2 (50%)	0 of 2 (0%)	0 of 2 (0%)	0 of 2 (0%)
1996 and later	0	NA	NA	NA	NA	NA
Little East Pond						
Prior to 1996	2	2 of 2 (100%)	0 of 2 (0%)	0 of 2 (0%)	0 of 2 (0%)	0 of 2 (0%)
1996 and later	0	NA	NA	NA	NA	NA
Total (all years and locations)	**13**	**9 of 13 (69%)**	**3 of 13 (23%)**	**0 of 13 (0%)**	**1 of 13 (7.7%)**	**1 of 13 (7.7%)**

NA = not applicable.

Table 5.3. Concentrations of chemicals of concern in pore water from GCRL sediments.

Chemical of Concern	Units	Toxicity Threshold		Sample Site (USGS 1999)				
		10-d LC_{50} for *Hyalella azteca*[1]	Acute Threshold for Aquatic Invertebrates[2]	IH-20	IH-21	IH-22	IH-23	IH-24
Metals								
Cadmium	µg/L	2.9	NG	< 0.11	< 0.11	< 0.11	< 0.11	0.16 (0.06)
Chromium	µg/L	NG	NG	NM	NM	NM	NM	NM
Copper	µg/L	35	NG	5.35 (0.15)	3.29 (0.09)	3.24 (0.09)	15.95 (0.46)	6.03 (0.17)
Lead	µg/L	<16	NG	8.22	4.45	4.62	4.41	15.78
Nickel	µg/L	780	NG	2.78 (0.004)	1.91 (0.002)	1.82 (0.002)	2.35 (0.003)	4.63 (0.01)
Zinc	µg/L	73	NG	23.55 (0.32)	11.59 (0.16)	8.59 (0.12)	13.15 (0.18)	24.17 (0.33)
Sum Toxic Units[3]		NG	NG	0.474	0.252	0.212	0.643	0.57
Phenolics								
o-Chlorophenol	µg/L	NG	5600	NM	NM	NM	NM	NM
p-Chlorophenol	µg/L	NG	5600	NM	NM	NM	NM	NM
2,4-Dichlorophenol	µg/L	NG	520	NM	NM	NM	NM	NM
o-Cresol	µg/L	NG	100	NM	NM	NM	NM	NM
p-Cresol	µg/L	NG	100	NM	NM	NM	NM	NM
2,4-Dinitrophenol	µg/L	NG	NG	NM	NM	NM	NM	NM
Phenol	µg/L	NG	45	NM	NM	NM	NM	NM
Other Substances								
Unionized ammonia	mg/L	NG	0.53	NM	0.01	0.01	<0.01	0.01

[1] The 10-d LC_{50}s for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (1994; 2000b).

[2] Acute toxicity thresholds for unionized ammonia were obtained from CCREM (1987).

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline; NM = not measured.

Table 5.4. Summary of the available information on the toxicity of sediments and elutriates from the GCRL.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
West Lagoon	8	5	63%
Middle Lagoon	3	1	33%
East Lagoon	1	0	0%
Little West Pond	0	NA	NA
Little East Pond	0	NA	NA
Total	**12**	**6**	**50%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of GCRL sediments included amphipod survival and growth in 10-d and 20-d tests with whole sediments; cladoceran survival in 7-d tests with whole sediments and 8-d tests with elutriate; and, fish survival and growth in 10-d tests with whole sediments and 12-d tests with elutriate.
NA = not applicable.

Table 5.5. Levels of TOC in GCRL sediments.

Reach Segment	Number of Samples	TOC (%)	
		Mean	Range
Surficial Sediments			
West Lagoon	57	4.05	0.420 - 38.1
Middle Lagoon	49	1.36	0.320 - 10.4
East Lagoon	47	1.45	0.380 - 13.0
Little West Pond	25	1.32	0.0200 - 9.11
Little East Pond	23	0.941	0.140 - 1.00
All Segments	**201**	**2.09**	**0.0200 - 38.1**
Sub-Surface Sediments			
West Lagoon	6	8.19	0.100 - 34.1
Middle Lagoon	3	0.233	0.100 - 0.400
East Lagoon	0	NA	NA
Little West Pond	0	NA	NA
Little East Pond	0	NA	NA
All Segments	**9**	**5.54**	**0.100 - 34.1**

NA = not applicable.

Table 5.6. Levels of oil and grease in GCRL sediments.

Reach Segment	Number of Samples	Oil and Grease (mg/kg)	
		Mean	Range
Surficial Sediments			
West Lagoon	3	2630	1000 - 3700
Middle Lagoon	1	4000	NA
East Lagoon	1	20000	NA
Little West Pond	NA	NA	NA
Little East Pond	NA	NA	NA
All Segments	**5**	**6380**	**1000 - 20000**
Sub-Surface Sediments			
West Lagoon	NA	NA	NA
Middle Lagoon	NA	NA	NA
East Lagoon	NA	NA	NA
Little West Pond	NA	NA	NA
Little East Pond	NA	NA	NA
All Segments	**NA**	**NA**	**NA**

NA = not applicable.

Table 5.7. Summary of the available information on the toxicity of sediments from the GCRL to fish.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
West Lagoon	5	1	20%
Middle Lagoon	2	0	0%
East Lagoon	0	NA	NA
Little West Pond	0	NA	NA
Little East Pond	0	NA	NA
Total	**7**	**1**	**14%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of GCRL sediments included fish survival and growth in 10-d tests with whole sediments and 12-d tests with elutriate.

NA = not applicable.

Table 5.8. Frequency of exceedance of TRGs in the GCRL.

Chemical of Concern	Fish			Invertebrates	Algae
	Fillets[1]	Whole Body[2]	GI Tract[3]	Composite Sample	Composite Sample
PCBs					
Total PCBs	17 of 18 (94%)	18 of 18 (100%)	18 of 18 (100%)	NM	NM
Pesticides					
Endrin	NM	NM	NM	NM	NM
Chlordane	0 of 6 (0%)	0 of 8 (0%)	0 of 8 (0%)	NM	NM
Dieldrin + Aldrin	NM	0 of 2 (0%)	NM	NM	NM
Heptachlor + Heptachlor epoxide	NM	0 of 1 (0%)	NM	NM	NM
Lindane	NM	NM	NM	NM	NM
Mirex	NM	NM	NM	NM	NM
Total DDTs	0 of 7 (0%)	4 of 10 (40%)	0 of 9 (0%)	NM	NM
Dioxins					
2,3,7,8-TCDD	NM	NM	NM	NM	NM

[1]Fillets = skin-off fillets.

[2]Whole body = head, gills, skin, bones and attached flesh (i.e., without fillets or GI tract).

[3]GI tract = organs in body cavity post gills.

NM = not measured.

Table 5.9. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the GCRL.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediments							
West Lagoon	58	555	0.0556	23800	0.146	26.6	1.04
Middle Lagoon	49	0.941	0.0914	16.1	0.101	2.18	0.290
East Lagoon	47	0.558	0.0768	2.30	0.106	1.28	0.376
Little West Pond	25	0.326	0.0646	2.51	0.0937	0.425	0.178
Little East Pond	23	0.111	0.0639	0.220	0.0668	0.141	0.0995
Overall	**202**	**160**	**0.0556**	**23800**	**0.0925**	**3.19**	**0.289**
Sub-Surface Sediments							
West Lagoon	6	427	0.0185	2560	0.0185	0.317	0.0964
Middle Lagoon	3	0.0336	0.0147	0.06	0.0147	0.026	0.026
East Lagoon	0	NA	NA	NA	NA	NA	NA
Little West Pond	2	0.120	0.0675	0.172	NA	NA	NA
Little East Pond	2	0.0412	0.0334	0.049	NA	NA	NA
Overall	**13**	**197**	**0.0147**	**2560**	**0.0185**	**0.172**	**0.049**

NA = not applicable.

Tables

Chapter 6 - East Branch of the Grand Calumet River - I

Table 6.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in EBGCR-I sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	58 of 130 (45%)	53 of 94 (56%)	NG	NG
Cadmium	57 of 134 (43%)	33 of 94 (35%)	NG	NG
Chromium	92 of 134 (69%)	27 of 94 (29%)	NG	NG
Copper	71 of 128 (55%)	46 of 94 (49%)	NG	NG
Lead	122 of 142 (86%)	64 of 99 (65%)	NG	NG
Mercury	36 of 130 (28%)	38 of 94 (40%)	NG	NG
Nickel	73 of 128 (57%)	27 of 94 (29%)	NG	NG
Zinc	112 of 128 (88%)	57 of 94 (61%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	60 of 60 (100%)	28 of 30 (93%)	NG	NG
Acenaphthylene	48 of 48 (100%)	16 of 23 (70%)	NG	NG
Anthracene	68 of 80 (85%)	24 of 47 (51%)	NG	NG
Benz(a)anthracene	77 of 91 (85%)	29 of 55 (53%)	NG	NG
Benzo(a)pyrene	76 of 87 (87%)	29 of 55 (53%)	NG	NG
Chrysene	76 of 89 (85%)	28 of 55 (51%)	NG	NG
Dibenz(a,h)anthracene	52 of 58 (90%)	15 of 35 (43%)	NG	NG
Fluoranthene	76 of 93 (82%)	34 of 61 (56%)	NG	NG
Fluorene	64 of 74 (86%)	25 of 45 (56%)	NG	NG
2-Methylnaphthalene	21 of 22 (95%)	7 of 14 (50%)	NG	NG
Naphthalene	67 of 74 (91%)	31 of 53 (58%)	NG	NG
Phenanthrene	75 of 94 (80%)	35 of 61 (57%)	NG	NG
Pyrene	83 of 93 (89%)	37 of 61 (61%)	NG	NG
Total PAHs	79 of 98 (81%)	33 of 63 (52%)	NG	NG
PCBs				
Total PCBs	83 of 100 (83%)	22 of 39 (56%)	54 of 54 (100%)	16 of 16 (100%)

Table 6.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in EBGCR-I sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	15 of 25 (60%)	13 of 38 (34%)	12 of 12 (100%)	9 of 9 (100%)
sum DDD	4 of 26 (15%)	1 of 30 (3.3%)	NG	NG
sum DDE	11 of 32 (34%)	9 of 38 (24%)	NG	NG
sum DDT	9 of 65 (14%)	5 of 46 (11%)	NG	NG
Total DDTs	8 of 66 (12%)	8 of 47 (17%)	10 of 30 (33%)	2 of 22 (9.1%)
Dieldrin	8 of 66 (12%)	2 of 41 (4.9%)	NG	NG
Endrin	0 of 77 (0%)	0 of 42 (0%)	2 of 26 (7.7%)	1 of 25 (4.0%)
Heptachlor	NG	NG	5 of 5 (100%)	1 of 1 (100%)
Heptachlor epoxide	4 of 23 (17%)	0 of 31 (0%)	5 of 5 (100%)	0 of 0 (0%)
Lindane (gamma-BHC)	9 of 17 (53%)	6 of 25 (24%)	4 of 58 (6.9%)	1 of 39 (2.6%)
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	NM	0 of 0 (0%)

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or
the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no guideline (i.e., no PEC or bioaccumulative-based SQG available); NM = substance was not measured.

Table 6.2. Proportion of sediment samples with various chemical characteristics in the EBGCR-I.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Surficial Sediments						
EB and WB Confluence to Kennedy Avenue						
Prior to 1996	6	0 of 6 (0%)	1 of 6 (17%)	2 of 6 (33%)	3 of 6 (50%)	5 of 6 (83%)
1996 and later	23	0 of 23 (0%)	6 of 23 (26%)	10 of 23 (43%)	7 of 23 (30%)	17 of 23 (74%)
USS Lead Canal						
Prior to 1996	17	0 of 17 (0%)	0 of 17 (0%)	1 of 17 (5.9%)	16 of 17 (94%)	17 of 17 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Kennedy Avenue to Cline Avenue						
Prior to 1996	6	0 of 6 (0%)	0 of 6 (0%)	0 of 6 (0%)	6 of 6 (100%)	6 of 6 (100%)
1996 and later	45	0 of 45 (0%)	3 of 45 (6.7%)	20 of 45 (44%)	22 of 45 (49%)	42 of 45 (93%)
Cline Avenue to Cline/I-90 Ramps						
Prior to 1996	7	0 of 7 (0%)	0 of 7 (0%)	4 of 7 (57%)	3 of 7 (43%)	7 of 7 (100%)
1996 and later	8	0 of 8 (0%)	1 of 8 (13%)	3 of 8 (38%)	4 of 8 (50%)	7 of 8 (88%)
Cline/I-90 Ramps to Industrial Highway						
Prior to 1996	6	0 of 6 (0%)	0 of 6 (0%)	3 of 6 (50%)	3 of 6 (50%)	6 of 6 (100%)
1996 and later	15	0 of 15 (0%)	0 of 15 (0%)	4 of 15 (27%)	11 of 15 (73%)	15 of 15 (100%)
Industrial Highway to ConRail Bridge						
Prior to 1996	3	0 of 3 (0%)	0 of 3 (0%)	3 of 3 (100%)	0 of 3 (0%)	3 of 3 (100%)
1996 and later	9	0 of 9 (0%)	0 of 9 (0%)	4 of 9 (44%)	5 of 9 (56%)	9 of 9 (100%)
EB Wetland						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	17	1 of 17 (5.9%)	2 of 17 (12%)	6 of 17 (35%)	8 of 17 (47%)	14 of 17 (82%)
Total (all years and locations)	**162**	**1 of 162 (0.6%)**	**13 of 162 (21%)**	**60 of 162 (37%)**	**88 of 162 (54%)**	**148 of 162 (91%)**

Table 6.2. Proportion of sediment samples with various chemical characteristics in the EBGCR-I.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Sub-Surface Sediments						
EB and WB Confluence to Kennedy Avenue						
Prior to 1996	3	0 of 3 (0%)	1 of 3 (33%)	2 of 3 (67%)	0 of 3 (0%)	2 of 3 (67%)
1996 and later	15	1 of 15 (7%)	3 of 15 (20%)	7 of 15 (47%)	4 of 15 (27%)	11 of 15 (73%)
USS Lead Canal						
Prior to 1996	9	0 of 9 (0%)	0 of 9 (0%)	0 of 9 (0%)	9 of 9 (100%)	9 of 9 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Kennedy Avenue to Cline Avenue						
Prior to 1996	7	1 of 7 (14%)	1 of 7 (14%)	1 of 7 (14%)	4 of 7 (57%)	5 of 7 (71%)
1996 and later	47	6 of 47 (13%)	10 of 47 (21%)	12 of 47 (26%)	19 of 47 (40%)	31 of 47 (66%)
Cline Avenue to Cline/I-90 Ramps						
Prior to 1996	4	0 of 4 (0%)	0 of 4 (0%)	3 of 4 (75%)	1 of 4 (25%)	4 of 4 (100%)
1996 and later	3	1 of 3 (33%)	2 of 3 (67%)	0 of 3 (0%)	0 of 3 (0%)	0 of 3 (0%)
Cline/I-90 Ramps to Industrial Highway						
Prior to 1996	5	0 of 5 (0%)	0 of 5 (0%)	2 of 5 (40%)	3 of 5 (60%)	5 of 5 (100%)
1996 and later	7	1 of 7 (14%)	3 of 7 (43%)	3 of 7 (43%)	0 of 7 (0%)	3 of 7 (43%)
Industrial Highway to ConRail Bridge						
Prior to 1996	2	0 of 2 (0%)	1 of 2 (50%)	0 of 2 (0%)	1 of 2 (50%)	1 of 2 (50%)
1996 and later	4	0 of 4 (0%)	0 of 4 (0%)	2 of 4 (50%)	2 of 4 (50%)	4 of 4 (100%)
EB Wetland						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	1	0 of 1 (0%)	1 of 1 (100%)	0 of 1 (0%)	0 of 1 (0%)	0 of 1 (0%)
Total (all years and locations)	**107**	**10 of 107 (9.3%)**	**22 of 107 (21%)**	**32 of 107 (30%)**	**43 of 107 (40%)**	**75 of 107 (70%)**

NA = not applicable.

Table 6.3. Concentrations of chemicals of concern in pore water from EBGCR-I sediments.

Chemical of Concern	Units	Toxicity Threshold: 10-d LC_{50} for *Hyalella azteca* [1]	Toxicity Threshold: Acute Threshold for Aquatic Invertebrates [2]	Sample Site (USGS 1999): IH-02	IH-03	IH-04	IH-05	IH-06	IH-07	IH-08
Metals										
Cadmium	µg/L	2.9	NR	< 0.12	< 0.12	< 0.12	< 0.12	20.42 (7.04)	< 0.12	0.58 (0.20)
Chromium	µg/L	NR	NR	NR	NR	NR	NR	NR	NR	NR
Copper	µg/L	35	NR	6.98 (0.20)	3.19 (0.09)	1.4 (0.04)	1.66 (0.05)	755.5 (21.59)	5 (0.14)	28.68 (0.82)
Lead	µg/L	<16	NR	1.58	8.30	7.37	1.56	2080.00	10.31	107.62
Nickel	µg/L	780	NR	14.47 (0.02)	6.08 (0.01)	5.28 (0.01)	4.24 (0.01)	135.79 (0.17)	14.83 (0.02)	5.97 (0.01)
Zinc	µg/L	73	NR	< 4.4	< 4.4	20.77 (0.28)	< 4.4	2480 (33.97)	< 4.4	81.44 (1.12)
Sum Toxic Units [3]		NR	NR	0.22	0.10	0.33	0.06	62.77	0.16	2.15
Phenolics										
o-Chlorophenol	µg/L	NG	5600	NM	NM	NM	NM	NM	NM	NM
p-Chlorophenol	µg/L	NG	5600	NM	NM	NM	NM	NM	NM	NM
2,4-Dichlorophenol	µg/L	NG	520	NM	NM	NM	NM	NM	NM	NM
o-Cresol	µg/L	NG	100	NM	NM	NM	NM	NM	NM	NM
p-Cresol	µg/L	NG	100	NM	NM	NM	NM	NM	NM	NM
2,4-Dinitrophenol	µg/L	NG	NR	NM	NM	NM	NM	NM	NM	NM
Phenol	µg/L	NG	45	NM	NM	NM	NM	NM	NM	NM
Other Substances										
Unionized ammonia	mg/L	NG	0.53	0.10	0.05	0.06	0.02	6.61	0.04	0.01

Table 6.3. Concentrations of chemicals of concern in pore water from EBGCR-I sediments.

Chemical of Concern	Units	Toxicity Threshold: 10-d LC_{50} for *Hyalella azteca* [1]	Toxicity Threshold: Acute Threshold for Aquatic Invertebrates[2]	Sample Site (USGS 1999): IH-09	IH-10	IH-11	IH-12	IH-15	IH-15D	IH-16
Metals										
Cadmium	µg/L	2.9	NR	0.69 (0.24)	1.29 (0.44)	< 0.12	< 0.12	< 0.12	2.73 (0.94)	< 0.11
Chromium	µg/L	NR	NR	NR	NR	NR	NR	NR	NR	NR
Copper	µg/L	35	NR	21.77 (0.62)	37.73 (1.08)	< 0.65	10.65 (0.30)	2.77 (0.08)	141.63 (4.05)	< 0.51
Lead	µg/L	<16	NR	9.08	257.95	0.28	30.23	5.15	470.95	< 0.4
Nickel	µg/L	780	NR	13.88 (0.02)	29.75 (0.04)	< 0.69	5.24 (0.01)	6.3 (0.01)	75 (0.10)	3.72 (0.005)
Zinc	µg/L	73	NR	31.07 (0.43)	390.87 (5.35)	< 4.4	49.55 (0.68)	< 4.4	1410 (19.32)	< 8.0
Sum Toxic Units[3]		NR	NR	1.31	6.91	ND	0.99	0.09	24.41	0.01
Phenolics										
o-Chlorophenol	µg/L	NG	5600	NM	NM	NM	NM	NM	NM	NM
p-Chlorophenol	µg/L	NG	5600	NM	NM	NM	NM	NM	NM	NM
2,4-Dichlorophenol	µg/L	NG	520	NM	NM	NM	NM	NM	NM	NM
o-Cresol	µg/L	NG	100	NM	NM	NM	NM	NM	NM	NM
p-Cresol	µg/L	NG	100	NM	NM	NM	NM	NM	NM	NM
2,4-Dinitrophenol	µg/L	NG	NR	NM	NM	NM	NM	NM	NM	NM
Phenol	µg/L	NG	45	NM	NM	NM	NM	NM	NM	NM
Other Substances										
Unionized ammonia	mg/L	NG	0.53	<0.01	0.04	NM	0.01	NM	NM	0.01

Table 6.3. Concentrations of chemicals of concern in pore water from EBGCR-I sediments.

Chemical of Concern	Units	Toxicity Threshold: 10-d LC_{50} for *Hyalella azteca* [1]	Toxicity Threshold: Acute Threshold for Aquatic Invertebrates[2]	Sample Site (USGS 1999): IH-17	Sample Site (USGS 1999): IH-18	Sample Site (Hoke *et al.* 1993): UG-3	Sample Site (Hoke *et al.* 1993): UG-4	Sample Site (Hoke *et al.* 1993): UG-5	Sample Site (Hoke *et al.* 1993): UG-6
Metals									
Cadmium	µg/L	2.9	NG	< 0.11	14.43 (4.98)	<10	<5	<10	<10
Chromium	µg/L	NG	NG	NM	NM	<10	<10	<10	<10
Copper	µg/L	35	NG	1.44 (0.04)	143.03 (4.09)	180 (5.14)	61 (1.74)	17 (0.49)	7 (0.20)
Lead	µg/L	<16	NG	0.59	< 0.4	23	<20	<20	<20
Nickel	µg/L	780	NG	8.41 (0.01)	99.54 (0.13)	<100	<100	<100	<100
Zinc	µg/L	73	NG	< 8.0	104.67 (1.43)	28 (0.38)	134 (1.84)	7 (0.10)	490 (6.71)
Sum Toxic Units[3]		NG	NG	0.05	10.63	5.52	3.58	0.59	6.91
Phenolics									
o-Chlorophenol	µg/L	NG	5600	NM	NM	21.6	5.2	63.2	5.8
p-Chlorophenol	µg/L	NG	5600	NM	NM	0.9	0.2	5.9	1.3
2,4-Dichlorophenol	µg/L	NG	520	NM	NM	14.6	15.5	7.4	14.3
o-Cresol	µg/L	NG	100	NM	NM	4.8	3.7	12.6	0.8
p-Cresol	µg/L	NG	100	NM	NM	6.3	6.2	16.2	2.5
2,4-Dinitrophenol	µg/L	NG	NG	NM	NM	26.0	7.3	34.4	15.8
Phenol	µg/L	NG	45	NM	NM	189.9	27.8	256.6	207.1
Other Substances									
Unionized ammonia	mg/L	NG	0.53	0.03	<0.01	1.4	5.3	0.5	0.8

[1] The 10-d LC_{50} concentrations for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (1994; 2000b).

[2] Acute toxicity thresholds for phenols and unionized ammonia were obtained from USEPA (1992a) and in CCREM (1987), respectively.

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline; NM = not measured.

Table 6.4. Summary of the available information on the toxicity of sediments and pore water from the EBGCR-I.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
EB and WB Confluence to Kennedy Avenue	3	3	100%
USS Lead Canal	0	NA	NA
Kennedy Avenue to Cline Avenue	4	3	75%
Cline Avenue to Cline/I-90 Ramps	8	3	38%
Cline/I-90 Ramps to Industrial Highway	16	12	75%
Industrial Highway to ConRail Bridge	6	6	100%
EB Wetland	7	5	71%
Total	**44**	**32**	**73%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of EBGCR-I sediments included amphipod survival and growth in 10-d and 96-h with whole sediments; midge survival and growth in 10-d tests with whole sediments; cladoceran survival in 48-h tests with pore water; 30 min Microtox with pore water; and, fish survival in 96-h tests with whole sediments.

NA = not applicable.

Table 6.5. Status of benthic invertebrate communities in the EBGCR-I.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other Diptera	Gastropoda	Bivalvia			
Artificial Substrate										
Simon *et al.* (2000)	7	26.5	0.0	48.0	0.0	0.6	6.1	0.0	1.40	Altered
IDEM (2000a)	Kennedy Avenue	63.9	0.0	3.8	0.0	17.7	12.3	0.0	2.1	Altered
Simon *et al.* (2000)	5a	59.9	0.0	29.8	0.0	0.0	2.6	0.5	1.13	Altered
IDEM (2000a)	Cline Avenue	47.6	0.0	19.2	0.2	26.5	6.2	0.0	2.4	Altered
Simon *et al.* (2000)	4	57.9	0.0	19.5	0.1	1.6	19.0	0.0	1.67	Altered
Simon *et al.* (2000)	3	59.8	0.0	37.2	0.2	0.1	1.6	0.2	1.13	Altered
Simon *et al.* (2000)	2	32.9	0.0	57.1	0.1	8.1	1.2	0.0	0.87	Altered
Sobiech *et al.* (1994)	Transect 36	0.8	0.5	89.2	0.5	8.7	0.0	0.0	ND	Altered
Simon *et al.* (2000)	1	65.0	0.0	33.2	0.2	0.0	0.8	0.2	0.87	Altered
Simon *et al.* (2000)	8	77.1	0.0	8.6	0.2	5.0	5.1	0.0	0.53	Altered
Grab										
Polls *et al.* (1993)	2-82	98.2	0.2	0.3	0.0	0.1	1.2	0.0	ND	Altered
Polls *et al.* (1993)	2-86	99.2	0.3	0.2	0.0	0.0	0.3	0.0	ND	Altered
Polls *et al.* (1993)	3-86	78.0	1.1	1.5	0.0	14.9	4.2	0.0	ND	Altered
Polls *et al.* (1993)	3-82	97.2	1.3	0.9	0.0	0.4	0.0	0.0	ND	Altered
Percent Altered Samples										**100% (14 of 14)**

[1] Reported values are percent of total abundance of invertebrates.

ND = not determined.

Table 6.6. Levels of TOC in EBGCR-I sediments.

Reach Segment	Number of Samples	TOC (%) Mean	TOC (%) Range
Surficial Sediments			
EB and WB Confluence to Kennedy Avenue	22	4.66	0.320 - 15.9
USS Lead Canal	0	NA	NA
Kennedy Avenue to Cline Avenue	44	2.87	0.340 - 14.3
Cline Avenue to Cline/I-90 Ramps	8	6.17	1.80 - 12.5
Cline/I-90 Ramps to Industrial Highway	15	8.43	3.10 - 13.0
Industrial Highway to ConRail Bridge	8	3.97	0.340 - 9.00
EB Wetland	16	8.44	0.170 - 14.0
All Segments	**113**	**5.06**	**0.170 - 15.9**
Sub-Surface Sediments			
EB and WB Confluence to Kennedy Avenue	16	2.89	0.550 - 8.50
USS Lead Canal	0	NA	NA
Kennedy Avenue to Cline Avenue	51	2.63	0.140 - 14.0
Cline Avenue to Cline/I-90 Ramps	5	3.05	0.230 - 4.85
Cline/I-90 Ramps to Industrial Highway	10	4.38	0.320 - 10.0
Industrial Highway to ConRail Bridge	6	7.88	1.50 - 13.0
EB Wetland	1	5.10	NA
All Segments	**89**	**3.28**	**0.140 - 14.0**

NA = not applicable.

Table 6.7. Levels of oil and grease in EBGCR-I sediments.

Reach Segment	Number of Samples	Oil and Grease (mg/kg)	
		Mean	**Range**
Surficial Sediments			
EB and WB Confluence to Kennedy Avenue	18	25900	500 - 133000
USS Lead Canal	NA	NA	NA
Kennedy Avenue to Cline Avenue	39	31100	1300 - 147000
Cline Avenue to Cline/I-90 Ramps	5	24200	1400 - 66400
Cline/I-90 Ramps to Industrial Highway	10	3190	15500 - 63600
Industrial Highway to ConRail Bridge	5	34700	3000 - 64400
EB Wetland	15	26700	600 - 101000
All Segments	**92**	**29300**	**500 - 147000**
Sub-Surface Sediments			
included fish survival in 96-h tests with whole sedimen	15	19400	300 - 52200
USS Lead Canal	NA	NA	NA
Kennedy Avenue to Cline Avenue	46	20700	<730 - 93600
Cline Avenue to Cline/I-90 Ramps	3	800	200 - 1400
Cline/I-90 Ramps to Industrial Highway	7	11700	300 - 39100
Industrial Highway to ConRail Bridge	4	15200	3100 - 28900
EB Wetland	1	4200	NA
All Segments	**76**	**18400**	**200 - 93600**

NA = not applicable.

Table 6.8. Summary of the available information on the toxicity of sediments and elutriates from the EBGCR-I to fish.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
EB and WB Confluence to Kennedy Avenue	0	NA	NA
USS Lead Canal	0	NA	NA
Kennedy Avenue to Cline Avenue	2	1	50%
Cline Avenue to Cline/I-90 Ramps	6	1	17%
Cline/I-90 Ramps to Industrial Highway	11	7	64%
Industrial Highway to ConRail Bridge	4	4	100%
EB Wetland	0	NA	NA
Total	**23**	**13**	**57%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoint that was used to evaluate the toxicity of EBGCR-I sediments included fish survival in 96-h tests with whole sediments.
NA = not applicable.

Table 6.9. Frequency of exceedance of TRGs in the EBGCR-I.

Chemical of Concern	Fish			Invertebrates	Algae
	Fillets[1]	Whole Body[2]	GI Tract[3]	Composite Sample	Composite Sample
PCBs					
Total PCBs	6 of 6 (100 %)	8 of 10 (80%)	NM	6 of 6 (100 %)	NM
Pesticides					
Chlordane	0 of 6 (0 %)	1 of 10 (10 %)	NM	0 of 6 (0 %)	NM
Dieldrin + Aldrin	1 of 6 (17 %)	3 of 8 (38 %)	NM	0 of 6 (0 %)	NM
Endrin	0 of 6 (0 %)	1 of 7 (14 %)	NM	0 of 6 (0 %)	NM
Heptachlor + Heptachlor epoxide	0 of 6 (0 %)	0 of 8 (0 %)	NM	0 of 6 (0 %)	NM
Lindane	0 of 5 (0%)	0 of 8 (0%)	NM	0 of 6 (0 %)	NM
Mirex	NM	NM	NM	0 of 6 (0 %)	NM
Total DDTs	2 of 6 (33 %)	5 of 10 (50%)	NM	0 of 6 (0 %)	NM
Dioxins					
2,3,7,8-TCDD	NM	NM	NM	NM	NM

[1]Fillets = skin-off fillets.

[2]Whole body = head, gills, skin, bones and attached flesh (i.e., without fillets or GI tract).

[3]GI tract = organs in body cavity post gills.

NM = not measured.

Table 6.10. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the EBGCR-I.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediments							
EB and WB Confluence to Kennedy Avenue	29	8.34	0.112	77.4	0.255	25.9	2.88
USS Lead Canal	17	27.7	3.60	72.6	5.45	65.3	13.0
Kennedy Avenue to Cline Avenue	51	7.20	0.457	58.2	1.20	12.3	4.61
Cline Avenue to Cline/I-90 Ramps	15	4.59	0.104	12.1	1.31	7.29	3.73
Cline/I-90 Ramps to Industrial Highway	21	28.9	0.71	184	2.12	45.4	5.94
Industrial Highway to ConRail Bridge	12	36.8	1.92	357	2.24	18.9	3.58
EB Wetland	17	3.99	0.0655	15.7	0.208	6.88	3.23
Overall	**162**	**14.0**	**0.0655**	**357**	**0.875**	**30.3**	**4.58**
Sub-Surface Sediments							
EB and WB Confluence to Kennedy Avenue	18	3.51	0.0692	13.1	0.193	8.30	2.77
USS Lead Canal	9	24.2	5.64	80.8	5.64	54.4	12.1
Kennedy Avenue to Cline Avenue	54	16.9	0.0286	497	0.0887	16.9	3.06
Cline Avenue to Cline/I-90 Ramps	7	1.47	0.0555	4.20	0.0555	2.63	1.21
Cline/I-90 Ramps to Industrial Highway	12	3.55	0.0847	13.6	0.123	5.50	2.78
Industrial Highway to ConRail Bridge	6	18.6	0.593	99.1	0.593	5.15	2.98
EB Wetland	1	0.627	0.627	0.627	NA	NA	NA
Overall	**107**	**12.7**	**0.0286**	**497**	**0.107**	**16.9**	**2.98**

NA = not applicable.

Tables

Chapter 7 - East Branch of the Grand Calumet River - II

Table 7.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in EBGCR-II sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	20 of 85 (24%)	8 of 29 (28%)	NG	NG
Cadmium	21 of 95 (22%)	9 of 29 (31%)	NG	NG
Chromium	19 of 95 (20%)	5 of 29 (17%)	NG	NG
Copper	11 of 93 (12%)	7 of 29 (24%)	NG	NG
Lead	55 of 95 (58%)	21 of 29 (72%)	NG	NG
Mercury	9 of 93 (9.7%)	10 of 29 (34%)	NG	NG
Nickel	10 of 93 (11%)	2 of 29 (7%)	NG	NG
Zinc	52 of 91 (57%)	20 of 29 (69%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	49 of 49 (100%)	29 of 29 (100%)	NG	NG
Acenaphthylene	40 of 42 (95%)	28 of 28 (100%)	NG	NG
Anthracene	42 of 67 (63%)	29 of 29 (100%)	NG	NG
Benz(a)anthracene	55 of 91 (60%)	33 of 33 (100%)	NG	NG
Benzo(a)pyrene	55 of 93 (59%)	31 of 33 (94%)	NG	NG
Chrysene	54 of 92 (59%)	33 of 33 (100%)	NG	NG
Dibenz(a,h)anthracene	25 of 26 (96%)	9 of 9 (100%)	NG	NG
Fluoranthene	54 of 97 (56%)	31 of 33 (94%)	NG	NG
Fluorene	45 of 49 (92%)	29 of 29 (100%)	NG	NG
2-Methylnaphthalene	11 of 13 (85%)	NM	NG	NG
Naphthalene	54 of 66 (82%)	32 of 33 (97%)	NG	NG
Phenanthrene	57 of 97 (59%)	33 of 33 (100%)	NG	NG
Pyrene	59 of 97 (61%)	33 of 33 (100%)	NG	NG
Total PAHs	49 of 98 (50%)	33 of 33 (100%)	NG	NG
PCBs				
Total PCBs	51 of 53 (96%)	15 of 16 (94%)	46 of 46 (100%)	12 of 12 (100%)

Table 7.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in EBGCR-II sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	4 of 4 (100%)	4 of 4 (100%)	2 of 2 (100%)	0 of 0 (0%)
sum DDD	2 of 12 (17%)	0 of 0 (0%)	NG	NG
sum DDE	6 of 10 (60%)	4 of 4 (100%)	NG	NG
sum DDT	4 of 16 (25%)	3 of 4 (75%)	NG	NG
Total DDTs	4 of 21 (19%)	4 of 4 (100%)	6 of 17 (35%)	0 of 0 (0%)
Dieldrin	4 of 51 (7.8%)	3 of 4 (75%)	NG	NG
Endrin	0 of 57 (0%)	NM	0 of 28 (0%)	NM
Heptachlor	NG	NG	2 of 2 (100%)	0 of 0 (0%)
Heptachlor epoxide	1 of 37 (2.7%)	NM	0 of 0 (0%)	NM
Lindane (gamma-BHC)	4 of 35 (11%)	4 of 4 (100%)	1 of 37 (2.7%)	0 of 0 (0%)
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	NM	0 of 0 (0%)

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or
the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no guideline (i.e., no PEC or bioaccumulative-based SQG available); NM = substance was not measured.

Table 7.2. Proportion of sediment samples with various chemical characteristics in the EBGCR-II.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Surficial Sediments						
ConRail Bridge to Bridge Street						
Prior to 1996	6	0 of 6 (0%)	0 of 6 (0%)	0 of 6 (0%)	6 of 6 (100%)	6 of 6 (100%)
1996 and later	2	0 of 2 (0%)	0 of 2 (0%)	0 of 2 (0%)	2 of 2 (100%)	2 of 2 (100%)
Bridge Street to Grant Street						
Prior to 1996	6	0 of 6 (0%)	0 of 6 (0%)	1 of 6 (17%)	5 of 6 (83%)	6 of 6 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Grant Street to I-90						
Prior to 1996	3	0 of 3 (0%)	0 of 3 (0%)	0 of 3 (0%)	3 of 3 (100%)	3 of 3 (100%)
1996 and later	0	NA	NA	NA	NA	NA
I-90 to Broadway						
Prior to 1996	9	0 of 9 (0%)	0 of 9 (0%)	3 of 9 (33%)	6 of 9 (67%)	9 of 9 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Broadway to Virginia Street						
Prior to 1996	4	0 of 4 (0%)	0 of 4 (0%)	1 of 4 (25%)	3 of 4 (75%)	4 of 4 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Virginia Street to Tennessee Street						
Prior to 1996	4	0 of 4 (0%)	0 of 4 (0%)	0 of 4 (0%)	4 of 4 (100%)	4 of 4 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Tennessee Street to GCRL Culvert						
Prior to 1996	9	0 of 9 (0%)	0 of 9 (0%)	3 of 9 (33%)	6 of 9 (67%)	9 of 9 (100%)
1996 and later	0	NA	NA	NA	NA	NA
EB Wetland						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	55	10 of 55 (18%)	27 of 55 (49%)	16 of 55 (29%)	2 of 55 (3.6%)	18 of 55 (33%)
Total (all years and locations)	**98**	**10 of 98 (10%)**	**27 of 98 (28%)**	**24 of 98 (24%)**	**37 of 98 (38%)**	**61 of 98 (62%)**

Table 7.2. Proportion of sediment samples with various chemical characteristics in the EBGCR-II.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Sub-Surface Sediments						
ConRail Bridge to Bridge Street						
Prior to 1996	9	0 of 9 (0%)	0 of 9 (0%)	3 of 9 (33%)	6 of 9 (67%)	9 of 9 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Bridge Street to Grant Street						
Prior to 1996	4	0 of 4 (0%)	0 of 4 (0%)	1 of 4 (25%)	3 of 4 (75%)	4 of 4 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Grant Street to I-90						
Prior to 1996	4	0 of 4 (0%)	0 of 4 (0%)	2 of 4 (50%)	2 of 4 (50%)	4 of 4 (100%)
1996 and later	0	NA	NA	NA	NA	NA
I-90 to Broadway						
Prior to 1996	6	0 of 6 (0%)	0 of 6 (0%)	1 of 6 (17%)	5 of 6 (83%)	6 of 6 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Broadway to Virginia Street						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	0	NA	NA	NA	NA	NA
Virginia Street to Tennessee Street						
Prior to 1996	3	0 of 3 (0%)	0 of 3 (0%)	0 of 3 (0%)	3 of 3 (100%)	3 of 3 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Tennessee Street to GCRL Culvert						
Prior to 1996	7	0 of 7 (0%)	0 of 7 (0%)	1 of 7 (14%)	6 of 7 (86%)	7 of 7 (100%)
1996 and later	0	NA	NA	NA	NA	NA
EB Wetland						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	0	NA	NA	NA	NA	NA
Total (all years and locations)	**33**	**0 of 33 (0%)**	**0 of 33 (0%)**	**8 of 33 (24%)**	**25 of 33 (76%)**	**33 of 33 (100%)**

NA = not applicable.

Table 7.3. Concentrations of chemicals of concern in pore water from EBGCR-II sediments.

Chemical of Concern	Units	Toxicity Threshold		Sample Site (Hoke *et al.* 1993)	
		10-d LC_{50} for *Hyalella azteca*[1]	Acute Threshold for Aquatic Invertebrates[2]	UG-1	UG-2
Metals					
Cadmium	µg/L	2.9	NG	<5	<5
Chromium	µg/L	NG	NG	<10	<10
Copper	µg/L	35	NG	<5	60 (1.71)
Lead	µg/L	<16	NG	<20	54
Nickel	µg/L	780	NG	<100	<100
Zinc	µg/L	73	NG	19 (0.26)	106 (1.45)
Sum Toxic Units[3]		NG	NG	0.26	3.16
Phenolics					
o-Chlorophenol	µg/L	NG	5600	23.5	13.5
p-Chlorophenol	µg/L	NG	5600	1.4	0.7
2,4-Dichlorophenol	µg/L	NG	520	16.5	5.7
2,4-Dinitrophenol	µg/L	NG	NR	23.1	15.4
o-Cresol	µg/L	NG	100	4.7	4.0
p-Cresol	µg/L	NG	100	8.3	0.3
Phenol	µg/L	NG	45	226.1	50.3
Other Substances					
Unionized ammonia	mg/L	NG	0.53	8.1	0.2

[1] The 10-d LC_{50}s for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (1994; 2000b).

[2] Acute toxicity thresholds for phenols and unionized ammonia were obtained from USEPA (1992a) and in CCREM (1987), respectively.

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline

Table 7.4. Summary of the available information on the toxicity of sediments and pore water from the EBGCR-II.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
ConRail Bridge to Bridge Street	9	8	89%
Bridge Street to Grant Street	3	3	100%
Grant Street to I-90	3	2	67%
I-90 to Broadway	10	8	80%
Broadway to Virginia Street	6	5	83%
Virginia Street to Tennessee Street	3	3	100%
Tennessee Street to GCRL Culvert	18	17	94%
EB Wetland	0	NA	NA
Total	**52**	**46**	**88%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of EBGCR-II sediments included amphipod survival in 10-d and 96-h tests with whole sediments; midge growth in 10-d tests with whole sediments; cladoceran survival in 48-h tests with pore water; 30-min Microtox with pore water; and, fish survival in 96-h tests with whole sediments.

NA = not applicable

Table 7.5. Status of benthic invertebrate communities in the EBGCR-II.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other Diptera	Gastropoda	Bivalvia			
Artificial Substrate										
Sobiech *et al*. (1994)	Transect 32	23.3	20.0	10.0	0.0	46.7	0.0	0.0	ND	Altered
IDEM (2000a)	Bridge Street	80.4	0.0	11.2	0.4	5.6	0.7	0.0	1.3	Altered
Sobiech *et al*. (1994)	Transect 24	13.2	21.0	60.5	0.0	5.3	0.0	0.0	ND	Altered
Sobiech *et al*. (1994)	Transect 16	0.0	0.0	37.3	0.0	61.4	1.2	0.0	ND	Altered
Sobiech *et al*. (1994)	Transect 5	4.2	0.0	70.8	0.0	24.0	0.0	0.0	ND	Altered
Percent Altered Samples										**100% (5 of 5)**

[1] Reported values are percent of total abundance of invertebrates.
ND = not determined.

Table 7.6. Levels of TOC in EBGCR-II sediments.

Reach Segment	Number of Samples	TOC (%)	
		Mean	Range
Surficial Sediments			
ConRail Bridge to Bridge Street	6	4.61	2.23 - 6.40
Bridge Street to Grant Street	4	3.99	1.60 - 6.45
Grant Street to I-90	3	3.73	3.30 - 4.40
I-90 to Broadway	8	4.34	2.10 - 11.0
Broadway to Virginia Street	4	1.97	1.20 - 2.70
Virginia Street to Tennessee Street	4	11.0	2.30 - 16.7
Tennessee Street to GCRL Culvert	8	10.4	2.20 - 28.1
EB Wetland	54	1.02	0.0400 - 1.70
All Segments	**91**	**3.08**	**0.0400 - 28.1**
Sub-Surface Sediments			
ConRail Bridge to Bridge Street	9	3.30	1.55 - 4.80
Bridge Street to Grant Street	4	3.61	1.60 - 4.85
Grant Street to I-90	4	2.38	1.20 - 3.70
I-90 to Broadway	4	2.90	1.60 - 5.10
Broadway to Virginia Street	0	NA	NA
Virginia Street to Tennessee Street	3	2.96	1.30 - 5.79
Tennessee Street to GCRL Culvert	5	5.86	1.20 - 12.0
EB Wetland	0	NA	NA
All Segments	**29**	**3.57**	**1.20 - 12.0**

NA = not applicable.

Table 7.7. Summary of the available information on the toxicity of sediments from the EBGCR-II to fish.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
ConRail Bridge to Bridge Street	6	5	83%
Bridge Street to Grant Street	2	2	100%
Grant Street to I-90	2	1	50%
I-90 to Broadway	7	5	71%
Broadway to Virginia Street	5	4	80%
Virginia Street to Tennessee Street	2	2	100%
Tennessee Street to GCRL Culvert	16	15	94%
EB Wetland	0	NA	NA
Total	**40**	**34**	**85%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of EBGCR-II sediments included fish survival in 96-h tests with whole sediments.

NA = not applicable.

Table 7.8. Frequency of exceedance of TRGs in the EBGCR-II.

Chemical of Concern	Fish			Invertebrates	Algae
	Fillets[1]	Whole Body[2]	GI Tract[3]	Composite Sample	Composite Sample
PCBs					
Total PCBs	2 of 2 (100%)	3 of 3 (100%)	NM	NM	NM
Pesticides					
Chlordane	0 of 2 (0%)	0 of 3 (0%)	NM	NM	NM
Dieldrin + Aldrin	0 of 2 (0%)	1 of 3 (33%)	NM	NM	NM
Endrin	0 of 2 (0%)	1 of 3 (33%)	NM	NM	NM
Heptachlor + Heptachlor epoxide	0 of 2 (0%)	0 of 3 (0%)	NM	NM	NM
Lindane	0 of 2 (0%)	0 of 3 (0%)	NM	NM	NM
Mirex	NM	NM	NM	NM	NM
Total DDTs	0 of 2 (0%)	1 of 3 (33%)	NM	NM	NM
Dioxins					
2,3,7,8-TCDD	NM	NM	NM	NM	NM

[1]Fillets = skin-off fillets.

[2]Whole body = head, gills, skin, bones and attached flesh (i.e., without fillets or GI tract).

[3]GI tract = organs in body cavity post gills.

NM = not measured.

Table 7.9. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the EBGCR-II.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediments							
ConRail Bridge to Bridge Street	8	25.3	13.1	51.9	13.1	38.3	22.5
Bridge Street to Grant Street	6	10.7	2.58	17.6	2.58	13.4	11.1
Grant Street to I-90	3	30.0	4.66	68.8	4.66	16.6	16.6
I-90 to Broadway	9	52.1	1.54	375	1.54	39.5	6.44
Broadway to Virginia Street	4	27.5	2.59	63.4	2.59	29.9	22.1
Virginia Street to Tennessee Street	4	473	87.2	821	87.2	705	492
Tennessee Street to GCRL Culvert	9	286	1.43	987	1.43	589	9.25
EB Wetland	55	1.12	0.000636	16.0	0.0901	2.75	0.230
Overall	**98**	**55.7**	**0.000636**	**987**	**0.0986**	**63.4**	**2.42**
Sub-Surface Sediments							
ConRail Bridge to Bridge Street	9	14.1	2.55	65.3	2.55	19.1	7.21
Bridge Street to Grant Street	4	4.94	2.47	6.58	2.47	5.89	5.36
Grant Street to I-90	4	4.43	2.09	7.19	2.09	6.28	4.21
I-90 to Broadway	6	29.1	2.13	116	2.13	36.2	7.84
Broadway to Virginia Street	0	NA	NA	NA	NA	NA	NA
Virginia Street to Tennessee Street	3	450	118	937	118	296	296
Tennessee Street to GCRL Culvert	7	218	2.80	765	2.80	458	66.3
EB Wetland	0	NA	NA	NA	NA	NA	NA
Overall	**33**	**97.6**	**2.09**	**937**	**2.47**	**188**	**7.21**

NA = not applicable.

Tables

Chapter 8 - West Branch of the Grand Calumet River - I

Table 8.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in WBGCR-I sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	13 of 15 (87%)	5 of 10 (50%)	NG	NG
Cadmium	14 of 16 (88%)	5 of 10 (50%)	NG	NG
Chromium	9 of 16 (56%)	0 of 10 (0%)	NG	NG
Copper	8 of 9 (89%)	5 of 10 (50%)	NG	NG
Lead	16 of 16 (100%)	7 of 10 (70%)	NG	NG
Mercury	12 of 15 (80%)	5 of 10 (50%)	NG	NG
Nickel	5 of 9 (56%)	0 of 10 (0%)	NG	NG
Zinc	9 of 9 (100%)	7 of 10 (70%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	8 of 8 (100%)	1 of 1 (100%)	NG	NG
Acenaphthylene	4 of 4 (100%)	2 of 2 (100%)	NG	NG
Anthracene	14 of 14 (100%)	5 of 6 (83%)	NG	NG
Benz(a)anthracene	16 of 17 (94%)	6 of 7 (86%)	NG	NG
Benzo(a)pyrene	15 of 16 (94%)	4 of 7 (57%)	NG	NG
Chrysene	16 of 16 (100%)	7 of 8 (88%)	NG	NG
Dibenz(a,h)anthracene	7 of 7 (100%)	2 of 3 (67%)	NG	NG
Fluoranthene	13 of 16 (81%)	5 of 8 (63%)	NG	NG
Fluorene	13 of 13 (100%)	4 of 4 (100%)	NG	NG
2-Methylnaphthalene	4 of 4 (100%)	NM	NG	NG
Naphthalene	11 of 11 (100%)	6 of 6 (100%)	NG	NG
Phenanthrene	16 of 16 (100%)	9 of 9 (100%)	NG	NG
Pyrene	14 of 15 (93%)	6 of 9 (67%)	NG	NG
Total PAHs	16 of 17 (94%)	7 of 9 (78%)	NG	NG
PCBs				
Total PCBs	11 of 11 (100%)	2 of 2 (100%)	2 of 2 (100%)	0 of 0 (0%)

Table 8.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in WBGCR-I sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	4 of 4 (100%)	2 of 4 (50%)	1 of 1 (100%)	0 of 0 (0%)
sum DDD	3 of 3 (100%)	0 of 3 (0%)	NG	NG
sum DDE	3 of 3 (100%)	2 of 4 (50%)	NG	NG
sum DDT	4 of 6 (67%)	1 of 5 (20%)	NG	NG
Total DDTs	4 of 7 (57%)	2 of 5 (40%)	1 of 1 (100%)	0 of 1 (0%)
Dieldrin	0 of 5 (0%)	0 of 3 (0%)	NG	NG
Endrin	0 of 10 (0%)	0 of 4 (0%)	0 of 0 (0%)	0 of 1 (0%)
Heptachlor	NG	NG	1 of 1 (100%)	0 of 0 (0%)
Heptachlor epoxide	0 of 0 (0%)	0 of 2 (0%)	0 of 0 (0%)	0 of 0 (0%)
Lindane (gamma-BHC)	2 of 2 (100%)	1 of 3 (33%)	1 of 4 (25%)	0 of 3 (0%)
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	NM	NM

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or
the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no guideline (i.e., no PEC or bioaccumulative-based SQG available); NM = substance was not measured.

Table 8.2. Proportion of sediment samples with various chemical characteristics in the WBGCR-I.

Reach Segment	Number of Samples	Mean PEC-Qs < 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Surficial Sediments						
EB and WB Confluence to Indianapolis Boulevard						
Prior to 1996	5	0 of 5 (0%)	0 of 5 (0%)	0 of 5 (0%)	5 of 5 (100%)	5 of 5 (100%)
1996 and later	14	0 of 14 (0%)	0 of 14 (0%)	2 of 14 (14%)	12 of 14 (86%)	14 of 14 (100%)
Total (all years and locations)	**19**	**0 of 19 (0%)**	**0 of 19 (0%)**	**2 of 19 (11%)**	**17 of 19 (89%)**	**19 of 19 (100%)**
Sub-Surface Sediments						
EB and WB Confluence to Indianapolis Boulevard						
Prior to 1996	8	0 of 8 (0%)	2 of 8 (25%)	2 of 8 (25%)	4 of 8 (50%)	6 of 8 (75%)
1996 and later	4	0 of 4 (0%)	1 of 4 (25%)	2 of 4 (50%)	1 of 4 (25%)	3 of 4 (75%)
Total (all years and locations)	**12**	**0 of 12 (0%)**	**3 of 12 (25%)**	**4 of 12 (33%)**	**5 of 12 (42%)**	**9 of 12 (75%)**

Table 8.3. Concentrations of chemicals of concern in pore water from WBGCR-I sediments.

Chemical of Concern	Units	Toxicity Threshold: 10-d LC_{50} for *Hyalella azteca*[1]	Toxicity Threshold: Acute Threshold for Aquatic Invertebrates[2]	Sample Site (USGS 1999): IH-01	Sample Site (Hoke *et al. 1* 993): UG-8
Metals					
Cadmium	µg/L	2.9	NG	0.43 (0.15)	<16
Chromium	µg/L	NG	NG	NM	<10
Copper	µg/L	35	NG	11.64 (0.33)	8 (0.23)
Lead	µg/L	<16	NG	54.52	37
Nickel	µg/L	780	NG	16.02 (0.02)	<100
Zinc	µg/L	73	NG	66.80 (0.92)	74 (1.01)
Sum Toxic Units[3]		NG	NG	1.42	1.24
Phenolics					
o-Chlorophenol	µg/L	NG	5600	NM	40.5
p-Chlorophenol	µg/L	NG	5600	NM	3.7
2,4-Dichlorophenol	µg/L	NG	520	NM	23.7
o-Cresol	µg/L	NG	100	NM	10.2
p-Cresol	µg/L	NG	100	NM	9.1
2,4-Dinitrophenol	µg/L	NG	NG	NM	54.1
Phenol	µg/L	NG	45	NM	225.3
Other Substances					
Unionized ammonia	mg/L	NG	0.53	0.07	6.4

[1] The 10-d LC_{50}s for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (1994; 2000b).

[2] Acute toxicity thresholds for phenols and unionized ammonia were obtained from USEPA (1992a) and in CCREM (1987), respectively.

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline; NM = not measured

Table 8.4. Summary of the available information on the toxicity of sediments and pore water from the WBGCR-I.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
EB and WB Confluence to Indianapolis Boulevard	2	2	100%
Total	**2**	**2**	**100%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of WBGCR-I sediments included amphipod survival in 10-d tests with whole sediments; midge growth in 10-d tests with whole sediments; cladoceran survival in 48-h tests with pore water; and, 30-min Microtox with pore water.

Table 8.5. Status of benthic invertebrate communities in the WBGCR-I.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other Diptera	Gastropoda	Bivalvia			
Artificial Substrate										
Simon *et al.* (2000)	8	77.1	0.0	8.6	0.2	5.0	5.1	0.0	0.53	Altered
Simon *et al.* (2000)	9	58.4	0.2	35.2	0.2	0.4	0.2	0.2	0.87	Altered
Rainbolt (1993)	ST 1	4.4	0.0	95.6	0.0	0.0	0.0	0.0	ND	Altered
Percent Altered Samples										**100% (3 of 3)**

[1] Reported values are percent of total abundance of invertebrates.

ND = not determined.

Table 8.6. Levels of TOC in WBGCR-I sediments.

Reach Segment	Number of Samples	TOC (%)	
		Mean	Range
Surficial Sediments			
EB and WB Confluence to Indianapolis Boulevard	9	11.0	1.30 - 40.0
Sub-Surface Sediments			
EB and WB Confluence to Indianapolis Boulevard	10	4.24	0.130- 8.60

Table 8.7. Levels of oil and grease in WBGCR-I sediments.

Reach Segment	Number of Samples	Oil and Grease (mg/kg)	
		Mean	Range
Surficial Sediments			
EB and WB Confluence to Indianapolis Boulevard	5	181000	15900 - 404000
Sub-Surface Sediments			
EB and WB Confluence to Indianapolis Boulevard	4	6930	400 - 23300

Table 8.8. Frequency of exceedance of TRGs in the WBGCR-I.

Chemical of Concern	Fish			Invertebrates	Algae
	Fillets[1]	Whole Body[2]	GI Tract[3]	Composite Sample	Composite Sample
PCBs					
Total PCBs	3 of 3 (100%)	4 of 4 (100%)	NM	NM	NM
Pesticides					
Chlordane	0 of 3 (0%)	1 of 4 (25%)	NM	NM	NM
Dieldrin + Aldrin	0 of 3 (0%)	1 of 2 (50%)	NM	NM	NM
Endrin	0 of 3 (0%)	0 of 2 (0%)	NM	NM	NM
Heptachlor + Heptachlor epoxide	0 of 3 (0%)	0 of 2 (0%)	NM	NM	NM
Lindane	0 of 3 (0%)	0 of 2 (0%)	NM	NM	NM
Mirex	NM	NM	NM	NM	NM
Total DDTs	1 of 3 (33%)	3 of 4 (75%)	NM	NM	NM
Dioxins					
2,3,7,8-TCDD	NM	NM	NM	NM	NM

[1]Fillets = skin-off fillets.

[2]Whole body = head, gills, skin, bones and attached flesh (i.e., without fillets or GI tract).

[3]GI tract = organs in body cavity post gills.

NM = not measured.

Table 8.9. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the WBGCR-I.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediment							
EB and WB Confluence to Indianapolis Boulevard	19	29.5	1.13	231	1.35	56.9	11.7
Sub-Surface Sediment							
EB and WB Confluence to Indianapolis Boulevard	12	4.80	0.139	13.7	0.368	8.80	3.77

Tables

Chapter 9 - West Branch of the Grand Calumet River - II

Table 9.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in WBGCR-II sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	19 of 60 (32%)	8 of 65 (12%)	NG	NG
Cadmium	50 of 75 (67%)	20 of 84 (24%)	NG	NG
Chromium	38 of 69 (55%)	8 of 69 (12%)	NG	NG
Copper	44 of 71 (62%)	21 of 70 (30%)	NG	NG
Lead	67 of 76 (88%)	36 of 84 (43%)	NG	NG
Mercury	17 of 29 (59%)	7 of 36 (19%)	NG	NG
Nickel	35 of 71 (49%)	8 of 70 (11%)	NG	NG
Zinc	56 of 71 (79%)	26 of 70 (37%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	39 of 39 (100%)	39 of 39 (100%)	NG	NG
Acenaphthylene	13 of 13 (100%)	5 of 5 (100%)	NG	NG
Anthracene	46 of 53 (87%)	35 of 47 (74%)	NG	NG
Benz(a)anthracene	54 of 66 (82%)	36 of 48 (75%)	NG	NG
Benzo(a)pyrene	61 of 71 (86%)	31 of 44 (70%)	NG	NG
Chrysene	59 of 67 (88%)	38 of 50 (76%)	NG	NG
Dibenz(a,h)anthracene	13 of 13 (100%)	0 of 0 (0%)	NG	NG
Fluoranthene	59 of 76 (78%)	42 of 59 (71%)	NG	NG
Fluorene	46 of 49 (94%)	36 of 47 (77%)	NG	NG
2-Methylnaphthalene	40 of 41 (98%)	38 of 39 (97%)	NG	NG
Naphthalene	50 of 59 (85%)	43 of 55 (78%)	NG	NG
Phenanthrene	66 of 75 (88%)	54 of 64 (84%)	NG	NG
Pyrene	69 of 77 (90%)	49 of 58 (84%)	NG	NG
Total PAHs	67 of 82 (82%)	50 of 67 (75%)	NG	NG
PCBs				
Total PCBs	25 of 30 (83%)	6 of 14 (43%)	3 of 5 (60%)	0 of 0 (0%)

Table 9.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in WBGCR-II sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	20 of 23 (87%)	8 of 13 (62%)	2 of 2 (100%)	0 of 0 (0%)
sum DDD	11 of 21 (52%)	4 of 11 (36%)	NG	NG
sum DDE	17 of 17 (100%)	8 of 13 (62%)	NG	NG
sum DDT	17 of 19 (89%)	8 of 16 (50%)	NG	NG
Total DDTs	18 of 27 (67%)	8 of 16 (50%)	3 of 4 (75%)	0 of 5 (0%)
Dieldrin	17 of 25 (68%)	8 of 16 (50%)	NG	NG
Endrin	0 of 6 (0%)	0 of 9 (0%)	0 of 2 (0%)	0 of 5 (0%)
Heptachlor	NG	NG	2 of 2 (100%)	0 of 0 (0%)
Heptachlor epoxide	0 of 0 (0%)	0 of 5 (0%)	0 of 0 (0%)	0 of 0 (0%)
Lindane (gamma-BHC)	19 of 22 (86%)	8 of 10 (80%)	2 of 8 (25%)	0 of 9 (0%)
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	NM	NM

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or
the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no PEC or bioaccumulative-based SQG available; NM = substance was not measured.

Table 9.2. Proportion of sediment samples with various chemical characteristics in the WBGCR-II.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Surficial Sediments						
Indianapolis Boulevard to I-90						
Prior to 1996	7	0 of 7 (0%)	3 of 7 (43%)	1 of 7 (14%)	3 of 7 (43%)	4 of 7 (57%)
1996 and later	7	0 of 7 (0%)	0 of 7 (0%)	1 of 7 (14%)	6 of 7 (86%)	7 of 7 (100%)
Roxana Marsh						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	5	0 of 5 (0%)	5 of 5 (100%)	0 of 5 (0%)	0 of 5 (0%)	0 of 5 (0%)
I-90 to Columbia Avenue						
Prior to 1996	22	1 of 22 (4.5%)	1 of 22 (4.5%)	5 of 22 (23%)	15 of 22 (68%)	20 of 22 (91%)
1996 and later	0	NA	NA	NA	NA	NA
Columbia Avenue to Calumet Avenue						
Prior to 1996	2	0 of 2 (0%)	1 of 2 (50%)	0 of 2 (0%)	1 of 2 (50%)	1 of 2 (50%)
1996 and later	0	NA	NA	NA	NA	NA
Calumet Avenue to Hohman Avenue						
Prior to 1996	7	0 of 7 (0%)	1 of 7 (14%)	2 of 7 (29%)	4 of 7 (57%)	6 of 7 (86%)
1996 and later	2	0 of 2 (0%)	0 of 2 (0%)	0 of 2 (0%)	2 of 2 (100%)	2 of 2 (100%)
Hohman Avenue to State Line Avenue						
Prior to 1996	8	0 of 8 (0%)	0 of 8 (0%)	1 of 8 (13%)	7 of 8 (88%)	8 of 8 (100%)
1996 and later	13	0 of 13 (0%)	0 of 13 (0%)	3 of 13 (23%)	10 of 13 (77%)	13 of 13 (100%)
Illinois Portion						
Prior to 1996	11	0 of 11 (0%)	0 of 11 (0%)	3 of 11 (27%)	8 of 11 (73%)	11 of 11 (100%)
1996 and later	0	NA	NA	NA	NA	NA
Total (all years and locations)	**84**	**1 of 84 (1.2%)**	**11 of 84 (13%)**	**16 of 84 (19%)**	**56 of 84 (67%)**	**72 of 84 (86%)**

Table 9.2. Proportion of sediment samples with various chemical characteristics in the WBGCR-II.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Sub-Surface Sediments						
Indianapolis Boulevard to I-90						
Prior to 1996	4	0 of 4 (0%)	4 of 4 (100%)	0 of 4 (0%)	0 of 4 (0%)	0 of 4 (0%)
1996 and later	6	1 of 6 (17%)	5 of 6 (83%)	0 of 6 (0%)	0 of 6 (0%)	0 of 6 (0%)
Roxana Marsh						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	5	3 of 5 (60%)	2 of 5 (40%)	0 of 5 (0%)	0 of 5 (0%)	0 of 5 (0%)
I-90 to Columbia Avenue						
Prior to 1996	25	2 of 25 (80%)	5 of 25 (20%)	6 of 25 (24%)	12 of 25 (48%)	18 of 25 (72%)
1996 and later	0	NA	NA	NA	NA	NA
Columbia Avenue to Calumet Avenue						
Prior to 1996	3	0 of 3 (0%)	1 of 3 (33%)	1 of 3 (33%)	1 of 3 (33%)	2 of 3 (67%)
1996 and later	0	NA	NA	NA	NA	NA
Calumet Avenue to Hohman Avenue						
Prior to 1996	9	0 of 9 (0%)	2 of 9 (22%)	2 of 9 (22%)	5 of 9 (56%)	7 of 9 (78%)
1996 and later	4	0 of 4 (0%)	0 of 4 (0%)	4 of 4 (100%)	0 of 4 (0%)	4 of 4 (100%)
Hohman Avenue to State Line Avenue						
Prior to 1996	4	0 of 4 (0%)	0 of 4 (0%)	1 of 4 (25%)	3 of 4 (75%)	4 of 4 (100%)
1996 and later	21	1 of 21 (4.8%)	1 of 21 (4.8%)	0 of 21 (0%)	19 of 21 (90%)	19 of 21 (90%)
Illinois Portion						
Prior to 1996	7	0 of 7 (0%)	2 of 7 (29%)	2 of 7 (29%)	3 of 7 (43%)	5 of 7 (71%)
1996 and later	0	NA	NA	NA	NA	NA
Total (all years and locations)	**88**	**7 of 88 (8.0%)**	**22 of 88 (25%)**	**16 of 88 (18%)**	**43 of 88 (49%)**	**59 of 88 (67%)**

NA = not applicable.

Table 9.3. Concentrations of chemicals of concern in pore water from WBGCR-II sediments.

Chemical of Concern	Units	Toxicity Threshold		Sample Site (Hoke *et al.* 1993)		Sample Site (URS Greiner Woodward Clyde 1999)			
		10-d LC_{50} for *Hyalella azteca* [1]	Acute Threshold for Aquatic Invertebrates[2]	UG-9	UG-10	01RA01SE00	01RA03SE00	01RB01SE00	01RC01SE02
Metals									
Cadmium	µg/L	2.9	NG	<10	<10	NM	NM	NM	NM
Chromium	µg/L	NG	NG	<10	<10	NM	NM	NM	NM
Copper	µg/L	35	NG	25 (0.71)	<5	NM	NM	NM	NM
Lead	µg/L	<16	NG	<20	<20	NM	NM	NM	NM
Nickel	µg/L	780	NG	<100	<100	NM	NM	NM	NM
Zinc	µg/L	73	NG	114 (1.56)	28 (0.38)	NM	NM	NM	NM
Sum Toxic Units[3]		NG	NG	2.27	0.38	NM	NM	NM	NM
Phenolics									
o-Chlorophenol	µg/L	NG	5600	100.4	88.6	NM	NM	NM	NM
p-Chlorophenol	µg/L	NG	5600	15.2	17.5	NM	NM	NM	NM
2,4-Dichlorophenol	µg/L	NG	520	23.5	24.0	NM	NM	NM	NM
o-Cresol	µg/L	NG	100	23.6	20.9	NM	NM	NM	NM
p-Cresol	µg/L	NG	100	10.3	24.2	NM	NM	NM	NM
2,4-Dinitrophenol	µg/L	NG	NG	34.5	30.6	NM	NM	NM	NM
Phenol	µg/L	NG	45	326.2	255.5	NM	NM	NM	NM
Other Substances									
Unionized ammonia	mg/L	NG	0.53	3.4	3.3	4.59	1.83	4.37	2.41

Table 9.3. Concentrations of chemicals of concern in pore water from WBGCR-II sediments.

Chemical of Concern	Units	Toxicity Threshold		Sample Site (URS Greiner Woodward Clyde 1999)	
		10-d LC_{50} for *Hyalella azteca* [1]	Acute Threshold for Aquatic Invertebrates[2]	01RC02SE00	01RC03SE00
Metals					
Cadmium	µg/L	2.9	NG	NM	NM
Chromium	µg/L	NG	NG	NM	NM
Copper	µg/L	35	NG	NM	NM
Lead	µg/L	<16	NG	NM	NM
Nickel	µg/L	780	NG	NM	NM
Zinc	µg/L	73	NG	NM	NM
Sum Toxic Units[3]		NG	NG	NM	NM
Phenolics					
o-Chlorophenol	µg/L	NG	5600	NM	NM
p-Chlorophenol	µg/L	NG	5600	NM	NM
2,4-Dichlorophenol	µg/L	NG	520	NM	NM
o-Cresol	µg/L	NG	100	NM	NM
p-Cresol	µg/L	NG	100	NM	NM
2,4-Dinitrophenol	µg/L	NG	NG	NM	NM
Phenol	µg/L	NG	45	NM	NM
Other Substances					
Unionized ammonia	mg/L	NG	0.53	0.38	8.02

[1] The 10-d LC_{50} concentrations for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (1994; 2000b).

[2] Acute toxicity thresholds for phenols and unionized ammonia were obtained from USEPA (1992a) and in CCREM (1987), respectively.

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline; NM = not measured.

Table 9.4. Summary of the available information on the toxicity of sediments and pore water from the WBGCR-II.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
Indianapolis Boulevard to I-90	2	2	100%
Roxana Marsh	4	1	25%
I-90 to Columbia Avenue	5	5	100%
Columbia Avenue to Calumet Avenue	0	NA	NA
Calumet Avenue to Hohman Avenue	1	1	100%
Hohman Avenue to State Line Avenue	5	5	100%
Illinois Portion	1	1	100%
Total	**18**	**15**	**83%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of WBGCR-II sediments included amphipod survival and growth in 10-d tests with whole sediments; midge survival and growth in 10-d tests with whole sediments; cladoceran survival in 48-h tests with pore water; 30 min Microtox with pore water; and, fish survival in 10-d tests with elutriate.

NA = not applicable.

Table 9.5. Status of benthic invertebrate communities in the WBGCR-II.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other Diptera	Gastropod	Bivalvia			
Artificial Substrate										
IDEM (2000a)	Indianapolis Boulevard	47.3	0.0	29.7	0.3	21.1	0.0	0.0	1.7	Altered
IDEM (2000a)	Sohl Avenue	61.5	0.0	18.4	0.0	0.7	0.0	0.0	1.1	Altered
Rainbolt (1993)	ST 2	77.8	0.0	14.7	7.5	0.0	0.0	0.0	ND	Altered
Rainbolt (1993)	ST 3	73.9	0.0	10.0	11.3	2.3	0.0	0.0	ND	Altered
Rainbolt (1993)	ST 4	87.8	0.0	4.7	2.9	0.0	0.0	0.0	ND	Altered
Rainbolt (1993)	ST 5	14.4	0.0	85.6	0.0	0.0	0.0	0.0	ND	Altered
Grab										
Polls *et al.* (1993)	1-82	97.9	0.0	2.1	0.0	0.0	0.0	0.0	ND	Altered
Polls *et al.* (1993)	1-86	99.8	0.1	0.1	0.0	0.0	0.0	0.0	ND	Altered
ThermoRetec (1999)	SD-98-24	60.0	0.0	20.0	0.0	20.0	0.0	0.0	ND	Unaltered
ThermoRetec (1999)	SD-98-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	Unaltered
ThermoRetec (1999)	SD-98-20	63.0	0.0	31.5	0.0	5.5	0.0	0.0	ND	Unaltered
URS Greiner Woodward Clyde (1999)	C01	62.8	0.0	36.8	0.1	0.0	0.0	0.0	ND	Unaltered
URS Greiner Woodward Clyde (1999)	A03	97.6	0.0	1.9	0.0	0.0	0.0	0.0	ND	Altered
URS Greiner Woodward Clyde (1999)	C02	94.0	0.0	0.9	2.2	0.0	0.0	0.0	ND	Altered
Percent Altered Samples										**71% (10 of 14)**

[1] Reported values are percent of total abundance of invertebrates.
ND = not determined.

Table 9.6. Levels of TOC in WBGCR-II sediments.

Reach Segment	Number of Samples	TOC (%) Mean	TOC (%) Range
Surficial Sediments			
Indianapolis Boulevard to I-90	8	11.6	5.80 - 18.6
Roxana Marsh	5	19.2	12.4 - 27.4
I-90 to Columbia Avenue	17	9.79	1.30 - 19.2
Columbia Avenue to Calumet Avenue	0	NA	NA
Calumet Avenue to Hohman Avenue	5	7.40	1.96 - 11.3
Hohman Avenue to State Line Avenue	13	11.2	4.44 - 15.0
Illinois Portion	2	11.7	11.7 - 11.7
All segments	**50**	**11.2**	**1.30 - 27.4**
Sub-Surface Sediments			
Indianapolis Boulevard to I-90	10	6.05	2.92 - 11.1
Roxana Marsh	5	4.14	2.39 - 5.33
I-90 to Columbia Avenue	21	7.76	0.470 - 15.2
Columbia Avenue to Calumet Avenue	3	17.4	8.47 - 24.9
Calumet Avenue to Hohman Avenue	10	8.12	0.420 - 25.3
Hohman Avenue to State Line Avenue	8	8.95	4.60 - 12.1
Illinois Portion	5	5.13	0.570 - 11.7
All segments	**62**	**7.66**	**0.420 - 25.3**

NA = not applicable.

Table 9.7. Summary of the available information on the toxicity of elutriates from the WBGCR-II to fish.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
Indianapolis Boulevard to I-90	0	NA	NA
Roxana Marsh	0	NA	NA
I-90 to Columbia Avenue	4	4	100%
Columbia Avenue to Calumet Avenue	0	NA	NA
Calumet Avenue to Hohman Avenue	1	1	100%
Hohman Avenue to State Line Avenue	1	1	100%
Illinois Portion	1	1	100%
Total	**7**	**7**	**100%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of WBGCR-II sediments included fish survival in 10-d tests with elutriate.

NA = not applicable.

Table 9.8. Frequency of exceedance of TRGs in the WBGCR-II.

Chemical of Concern	Fish			Invertebrates	Algae
	Fillets[1]	Whole Body[2]	GI Tract[3]	Composite Sample	Composite Sample
PCBs					
Total PCBs	3 of 3 (100%)	2 of 2 (100%)	NM	NM	NM
Pesticides					
Chlordane	0 of 3 (0%)	0 of 2 (0%)	NM	NM	NM
Dieldrin + Aldrin	0 of 3 (0%)	1 of 2 (50%)	NM	NM	NM
Endrin	0 of 3 (0%)	0 of 2 (0%)	NM	NM	NM
Heptachlor + Heptachlor epoxide	0 of 3 (0%)	0 of 2 (0%)	NM	NM	NM
Lindane	0 of 3 (0%)	0 of 2 (0%)	NM	NM	NM
Mirex	NM	NM	NM	NM	NM
Total DDTs	1 of 3 (33%)	1 of 2 (50%)	NM	NM	NM
Dioxins					
2,3,7,8-TCDD	NM	NM	NM	NM	NM

[1]Fillets = skin-off fillets.

[2]Whole sample = head, gills, skin, bones and attached flesh (i.e., without fillets or GI tract).

[3]GI tract = organs in body cavity post gills.

NM = not measured.

Table 9.9. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the WBGCR-II.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediment							
Indianapolis Boulevard to I-90	14	15.5	0.149	75.3	0.243	35.3	6.22
Roxana Marsh	5	0.428	0.123	0.603	0.123	0.595	0.515
I-90 to Columbia Avenue	22	12.3	0.0395	76.0	1.01	16.2	6.53
Columbia Avenue to Calumet Avenue	2	3.71	0.259	7.17	NA	NA	NA
Calumet Avenue to Hohman Avenue	9	37.6	0.311	210	0.311	88.6	6.85
Hohman Avenue to State Line Avenue	21	47.5	0.875	304	2.51	94.9	28.7
Illinois Portion	11	6.00	2.71	10.1	2.97	9.65	4.89
Overall	**84**	**22.6**	**0.0395**	**304**	**0.347**	**67.1**	**6.71**
Sub-Surface Sediment							
Indianapolis Boulevard to I-90	10	0.191	0.0976	0.357	0.0976	0.278	0.205
Roxana Marsh	5	0.0905	0.0652	0.111	0.0652	0.101	0.0919
I-90 to Columbia Avenue	25	8.18	0.0658	30.2	0.128	16.9	3.34
Columbia Avenue to Calumet Avenue	3	3.21	0.215	5.89	0.215	3.53	3.53
Calumet Avenue to Hohman Avenue	13	13.1	0.109	97.3	0.325	17.9	3.78
Hohman Avenue to State Line Avenue	25	51.0	0.0712	193	2.47	129	33.4
Illinois Portion	7	4.69	0.148	13.3	0.148	8.45	3.74
Overall	**88**	**19.3**	**0.0652**	**193**	**0.101**	**51.7**	**3.84**

NA = not applicable.

Tables

Chapter 10 - Indiana Harbor Canal

Table 10.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in IHC sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	13 of 25 (52%)	1 of 4 (25%)	NG	NG
Cadmium	16 of 26 (62%)	3 of 4 (75%)	NG	NG
Chromium	11 of 26 (42%)	1 of 4 (25%)	NG	NG
Copper	6 of 20 (30%)	2 of 4 (50%)	NG	NG
Lead	20 of 26 (77%)	2 of 4 (50%)	NG	NG
Mercury	12 of 25 (48%)	1 of 4 (25%)	NG	NG
Nickel	2 of 20 (10%)	1 of 4 (25%)	NG	NG
Zinc	14 of 20 (70%)	2 of 4 (50%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	17 of 17 (100%)	3 of 3 (100%)	NG	NG
Acenaphthylene	12 of 12 (100%)	2 of 2 (100%)	NG	NG
Anthracene	15 of 19 (79%)	3 of 3 (100%)	NG	NG
Benz(a)anthracene	22 of 27 (81%)	3 of 4 (75%)	NG	NG
Benzo(a)pyrene	17 of 21 (81%)	1 of 3 (33%)	NG	NG
Chrysene	24 of 27 (89%)	5 of 5 (100%)	NG	NG
Dibenz(a,h)anthracene	4 of 7 (57%)	1 of 1 (100%)	NG	NG
Fluoranthene	20 of 26 (77%)	4 of 5 (80%)	NG	NG
Fluorene	14 of 18 (78%)	2 of 2 (100%)	NG	NG
2-Methylnaphthalene	3 of 3 (100%)	NM	NG	NG
Naphthalene	15 of 18 (83%)	5 of 5 (100%)	NG	NG
Phenanthrene	19 of 25 (76%)	6 of 6 (100%)	NG	NG
Pyrene	24 of 27 (89%)	6 of 6 (100%)	NG	NG
Total PAHs	20 of 27 (74%)	5 of 6 (83%)	NG	NG
PCBs				
Total PCBs	21 of 25 (84%)	3 of 3 (100%)	13 of 13 (100%)	1 of 1 (100%)

Table 10.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in IHC sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	3 of 7 (43%)	2 of 2 (100%)	1 of 1 (100%)	0 of 0 (0%)
sum DDD	1 of 9 (11%)	NM	NG	NG
sum DDE	2 of 10 (20%)	2 of 2 (100%)	NG	NG
sum DDT	2 of 16 (13%)	0 of 2 (0%)	NG	NG
Total DDTs	2 of 16 (13%)	2 of 2 (100%)	3 of 6 (50%)	0 of 0 (0%)
Dieldrin	2 of 15 (13%)	2 of 2 (100%)	NG	NG
Endrin	0 of 16 (0%)	NM	0 of 3 (0%)	NM
Heptachlor	NG	NG	1 of 1 (100%)	0 of 0 (0%)
Heptachlor epoxide	1 of 8 (13%)	NM	0 of 0 (0%)	NM
Lindane (gamma-BHC)	2 of 5 (40%)	2 of 2 (100%)	1 of 12 (8%)	0 of 0 (0%)
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	NM	0 of 0 (0%)

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or
the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no PEC or bioaccumulative-based SQG available; NM = substance was not measured.

Table 10.2. Proportion of sediment samples with various chemical characteristics in the IHC.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	≥ 0.1 - < 0.7	≥ 0.7 - < 4.0	≥ 4.0	≥ 0.7
Surficial Sediments						
EB and WB Confluence to 151st Street						
Prior to 1996	5	0 of 5 (0%)	0 of 5 (0%)	2 of 5 (40%)	3 of 5 (60%)	5 of 5 (100%)
1996 and later	2	0 of 2 (0%)	0 of 2 (0%)	0 of 2 (0%)	2 of 2 (100%)	2 of 2 (100%)
151st Street to Chicago Avenue						
Prior to 1996	2	0 of 2 (0%)	0 of 2 (0%)	1 of 2 (50%)	1 of 2 (50%)	2 of 2 (100%)
1996 and later	8	0 of 8 (0%)	3 of 8 (38%)	4 of 8 (50%)	1 of 8 (13%)	5 of 8 (63%)
Chicago Avenue to Columbus Drive						
Prior to 1996	3	0 of 3 (0%)	0 of 3 (0%)	1 of 3 (33%)	2 of 3 (67%)	3 of 3 (100%)
1996 and later	9	0 of 9 (0%)	0 of 9 (0%)	3 of 9 (33%)	6 of 9 (67%)	9 of 9 (100%)
IHC Wetland						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	1	0 of 1 (0%)	0 of 1 (0%)	1 of 1 (100%)	0 of 1 (0%)	1 of 1 (100%)
Total (all years and locations)	**30**	**0 of 30 (0%)**	**3 of 30 (10%)**	**12 of 30 (40%)**	**15 of 30 (50%)**	**27 of 30 (90)%**
Sub-Surface Sediments						
EB and WB Confluence to 151st Street						
Prior to 1996	4	0 of 4 (0%)	1 of 4 (25%)	1 of 4 (25%)	2 of 2 (100%)	3 of 4 (75%)
1996 and later	0	NA	NA	NA	NA	NA
151st Street to Chicago Avenue						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	0	NA	NA	NA	NA	NA
Chicago Avenue to Columbus Drive						
Prior to 1996	2	0 of 2 (0%)	0 of 2 (0%)	1 of 2 (50%)	1 of 2 (50%)	2 of 2 (100%)
1996 and later	0	NA	NA	NA	NA	NA
IHC Wetland						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	0	NA	NA	NA	NA	NA
Total (all years and locations)	**6**	**0 of 6 (0%)**	**1 of 6 (17%)**	**2 of 6 (33%)**	**3 of 6 (50%)**	**5 of 6 (83%)**

NA = not applicable.

Table 10.3. Concentrations of chemicals of concern in pore water from IHC sediments.

Chemical of Concern	Units	Toxicity Threshold: 10-d LC_{50} for *Hyalella azteca* [1]	Toxicity Threshold: Acute Threshold for Aquatic Invertebrates[2]	Sample Site (USGS 1999): IH-13	Sample Site (USGS 1999): IH-14	Sample Site (USGS 1999): IH-19	Sample Site (Hoke *et al.* 1993): UG-7	Sample Site (Hoke *et al.* 1993): UG-11
Metals								
Cadmium	µg/L	2.9	NG	< 0.12	< 0.12	0.15 (0.05)	<10	<5
Chromium	µg/L	NG	NG	NM	NM	NM	<10	<10
Copper	µg/L	35	NG	< 0.65	< 0.65	8.10 (0.23)	73 (2.09)	<5
Lead	µg/L	<16	NG	0.42	3.23	8.95	29	<20
Nickel	µg/L	780	NG	8.24 (0.01)	2.70 (0.004)	6.73 (0.009)	<100	<100
Zinc	µg/L	73	NG	< 4.4	< 4.4	105.37 (1.44)	81 (1.11)	35 (0.48)
Sum Toxic Units[3]		NG	NG	0.01	0.004	1.73	3.20	0.48
Phenolics								
o-Chlorophenol	µg/L	NG	5600	NM	NM	NM	19.2	NM
p-Chlorophenol	µg/L	NG	5600	NM	NM	NM	2.0	NM
2,4-Dichlorophenol	µg/L	NG	520	NM	NM	NM	17.1	NM
o-Cresol	µg/L	NG	100	NM	NM	NM	4.8	NM
p-Cresol	µg/L	NG	100	NM	NM	NM	2.6	NM
2,4-Dinitrophenol	µg/L	NG	NG	NM	NM	NM	14.5	NM
Phenol	µg/L	NG	45	NM	NM	NM	107.6	NM
Other Substances								
Unionized ammonia	mg/L	NG	0.53	NM	0.01	<0.01	1.6	1.0

[1] The 10-d LC_{50}s for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (1994; 2000b).

[2] Acute toxicity thresholds for phenols and unionized ammonia were obtained from USEPA (1992a) and in CCREM (1987), respectively.

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline; NM = not measured.

Table 10.4. Summary of the available information on the toxicity of sediments and pore water from the IHC.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
EB and WB Confluence to 151st Street	1	1	100%
151st Street to Chicago Avenue	1	1	100%
Chicago Avenue to Columbus Drive	2	2	100%
IHC Wetland	1	0	0%
Total	**5**	**4**	**80%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of IHC sediments included amphipod survival and growth in 10-d tests with whole sediments; midge growth in 10-d tests with whole sediments; cladoceran survival in 48-h tests with pore water; and, 30-min Microtox in pore water.

Table 10.5. Status of benthic invertebrate communities in the IHC.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other Diptera	Gastropoda	Bivalvia			
Artificial Substrate										
Simon *et al.* (2000)	12	41.4	0.0	51.4	0.0	0.3	1.8	0.0	1.07	Altered
Simon *et al.* (2000)	11	44.4	0.0	48.6	0.0	0.0	2.0	0.2	1.07	Altered
Simon *et al.* (2000)	8	77.1	0.0	8.6	0.2	5.0	5.1	0.0	0.53	Altered
Simon *et al.* (2000)	10	37.1	0.0	39.9	0.2	2.6	3.8	0.0	1.13	Altered
Grab										
Polls *et al.* (1993)	4-82	99.8	0.1	0.0	0.0	0.1	0.0	0.0	ND	Altered
Polls *et al.* (1993)	4-86	99.9	0.0	0.0	0.0	0.1	0.0	0.0	ND	Altered
Percent Altered Samples										**100% (6 of 6)**

[1] Reported values are percent of total abundance of invertebrates.

ND = not determined.

Table 10.6. Levels of TOC in IHC sediments.

Reach Segment	Number of Samples	TOC (%)	
		Mean	Range
Surficial Sediments			
EB and WB Confluence to 151st Street	3	5.49	0.860 - 14.7
151st Street to Chicago Avenue	7	1.52	0.510 - 3.10
Chicago Avenue to Columbus Drive	8	4.58	1.07 - 13.0
IHC Wetland	1	13.0	NA
All Segments	**19**	**4.04**	**0.510 - 14.7**
Sub-Surface Sediments			
EB and WB Confluence to 151st Street	2	2.10	1.00 - 3.20
151st Street to Chicago Avenue	0	NA	NA
Chicago Avenue to Columbus Drive	2	6.20	0.950 - 11.5
IHC Wetland	0	NA	NA
All Segments	**4**	**4.1**	**0.950 - 11.5**

NA = not applicable.

Table 10.7. Levels of oil and grease in IHC sediments.

Reach Segment	Number of Samples	Oil and Grease (mg/kg)	
		Mean	Range
Surficial Sediments			
EB and WB Confluence to 151st Street	NA	NA	NA
151st Street to Chicago Avenue	5	1940	200 - 7200
Chicago Avenue to Columbus Drive	5	19800	3300 - 54800
IHC Wetland	1	1100	NA
All Segments	**11**	**9980**	**200 - 54800**
Sub-Surface Sediments			
EB and WB Confluence to 151st Street	NA	NA	NA
151st Street to Chicago Avenue	NA	NA	NA
Chicago Avenue to Columbus Drive	NA	NA	NA
IHC Wetland	NA	NA	NA
All Segments	NA	NA	NA

NA = not applicable.

Table 10.8. Frequency of exceedance of TRGs in the IHC.

Chemical of Concern	Fish			Invertebrates	Algae
	Fillets[1]	Whole Body[2]	GI Tract[3]	Composite Sample	Composite Sample
PCBs					
Total PCBs	NM	2 of 2 (100%)	NM	5 of 5 (100%)	NM
Pesticides					
Chlordane	NM	1 of 2 (50%)	NM	0 of 5 (0%)	NM
Dieldrin + Aldrin	NM	NM	NM	0 of 5 (0%)	NM
Endrin	NM	NM	NM	0 of 5 (0%)	NM
Heptachlor + Heptachlor epoxide	NM	NM	NM	0 of 5 (0%)	NM
Lindane	NM	NM	NM	0 of 5 (0%)	NM
Mirex	NM	NM	NM	0 of 5 (0%)	NM
Total DDTs	NM	2 of 2 (100%)	NM	0 of 5 (0%)	NM
Dioxins					
2,3,7,8-TCDD	NM	NM	NM	NM	NM

[1]Fillets = skin-off fillets.

[2]Whole sample = head, gills, skin, bones and attached flesh (i.e., without fillets or GI tract).

[3]GI tract = organs in body cavity post gills.

NM = not measured.

Table 10.9. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the IHC.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediment							
EB and WB Confluence to 151st Street	7	5.44	2.10	10.4	2.10	8.21	4.85
151st Street to Chicago Avenue	10	3.00	0.191	8.84	0.191	7.19	2.29
Chicago Avenue to Columbus Drive	12	7.29	1.09	25.9	1.69	11.5	5.34
IHC Wetland	1	0.718	0.718	0.718	NA	NA	NA
Overall	**30**	**5.21**	**0.191**	**25.9**	**0.491**	**10.4**	**4.08**
Sub-Surface Sediment							
EB and WB Confluence to 151st Street	4	2.90	0.434	4.36	0.434	4.12	3.41
151st Street to Chicago Avenue	0	NA	NA	NA	NA	NA	NA
Chicago Avenue to Columbus Drive	2	5.87	2.09	9.64	NA	NA	NA
IHC Wetland	0	NA	NA	NA	NA	NA	NA
Overall	**6**	**3.89**	**0.434**	**9.64**	**0.434**	**4.36**	**3.41**

NA = not applicable.

Tables

Chapter II - Lake George Branch

Table 11.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in LGB sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	7 of 22 (32%)	4 of 10 (40%)	NG	NG
Cadmium	5 of 22 (23%)	4 of 10 (40%)	NG	NG
Chromium	9 of 23 (39%)	4 of 10 (40%)	NG	NG
Copper	5 of 22 (23%)	3 of 10 (30%)	NG	NG
Lead	21 of 23 (91%)	8 of 10 (80%)	NG	NG
Mercury	4 of 22 (18%)	3 of 10 (30%)	NG	NG
Nickel	8 of 23 (35%)	1 of 10 (10%)	NG	NG
Zinc	15 of 23 (65%)	6 of 10 (60%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	7 of 7 (100%)	5 of 5 (100%)	NG	NG
Acenaphthylene	0 of 0 (0%)	1 of 1 (100%)	NG	NG
Anthracene	6 of 10 (60%)	7 of 9 (78%)	NG	NG
Benz(a)anthracene	13 of 17 (76%)	7 of 9 (78%)	NG	NG
Benzo(a)pyrene	10 of 15 (67%)	7 of 10 (70%)	NG	NG
Chrysene	16 of 19 (84%)	8 of 10 (80%)	NG	NG
Dibenz(a,h)anthracene	4 of 4 (100%)	5 of 5 (100%)	NG	NG
Fluoranthene	9 of 18 (50%)	7 of 9 (78%)	NG	NG
Fluorene	10 of 11 (91%)	7 of 9 (78%)	NG	NG
2-Methylnaphthalene	NM	NM	NG	NG
Naphthalene	1 of 2 (50%)	0 of 3 (0%)	NG	NG
Phenanthrene	12 of 16 (75%)	8 of 10 (80%)	NG	NG
Pyrene	18 of 21 (86%)	8 of 10 (80%)	NG	NG
Total PAHs	9 of 22 (41%)	7 of 10 (70%)	NG	NG
PCBs				
Total PCBs	13 of 16 (81%)	5 of 7 (71%)	15 of 16 (94%)	7 of 7 (100%)

Table 11.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in LGB sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	0 of 3 (0%)	0 of 2 (0%)	0 of 0 (0%)	0 of 0 (0%)
sum DDD	0 of 3 (0%)	0 of 3 (0%)	NG	NG
sum DDE	2 of 7 (29%)	1 of 3 (33%)	NG	NG
sum DDT	0 of 3 (0%)	0 of 2 (0%)	NG	NG
Total DDTs	0 of 7 (0%)	0 of 4 (0%)	1 of 6 (17%)	1 of 4 (25%)
Dieldrin	0 of 3 (0%)	0 of 2 (0%)	NG	NG
Endrin	0 of 12 (0%)	0 of 5 (0%)	0 of 3 (0%)	0 of 2 (0%)
Heptachlor	NG	NG	0 of 0 (0%)	0 of 0 (0%)
Heptachlor epoxide	0 of 3 (0%)	0 of 2 (0%)	0 of 0 (0%)	0 of 0 (0%)
Lindane (gamma-BHC)	0 of 3 (0%)	0 of 2 (0%)	0 of 6 (0%)	0 of 6 (0%)
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	NM	NM

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or
the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no PEC or bioaccumulative-based SQG available; NM = substance was not measured.

Table 11.2. Proportion of sediment samples with various chemical characteristics in the LGB.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Surficial Sediments						
Indianapolis Boulevard to B & O Railroad Bridge						
Prior to 1996	2	0 of 2 (0%)	0 of 2 (0%)	1 of 2 (50%)	1 of 2 (50%)	2 of 2 (100%)
1996 and later	5	0 of 5 (0%)	0 of 5 (0%)	3 of 5 (60%)	2 of 5 (40%)	5 of 5 (100%)
B & O Railroad Bridge to Fill Area						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	4	0 of 4 (0%)	0 of 4 (0%)	1 of 4 (25%)	3 of 4 (75%)	4 of 4 (100%)
Lake George Wetlands						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	12	2 of 12 (17%)	2 of 12 (17%)	8 of 12 (67%)	0 of 12 (0%)	8 of 12 (67%)
Total (all years and locations)	**23**	**2 of 23 (8.7%)**	**2 of 23 (8.7%)**	**13 of 23 (57%)**	**6 of 23 (26%)**	**19 of 23 (83%)**
Sub-Surface Sediments						
Indianapolis Boulevard to B & O Railroad Bridge						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	3	0 of 3 (0%)	0 of 3 (0%)	2 of 3 (67%)	1 of 3 (33%)	3 of 3 (100%)
B & O Railroad Bridge to Fill Area						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	6	0 of 6 (0%)	1 of 6 (17%)	2 of 6 (33%)	3 of 6 (50%)	5 of 6 (83%)
Lake George Wetlands						
Prior to 1996	0	NA	NA	NA	NA	NA
1996 and later	1	1 of 1 (100%)	0 of 1 (0%)	0 of 1 (0%)	0 of 1 (0%)	0 of 1 (0%)
Total (all years and locations)	**10**	**1 of 10 (10%)**	**1 of 10 (10%)**	**4 of 10 (40%)**	**4 of 10 (40%)**	**8 of 10 (80%)**

NA = not applicable.

Table 11.3. Concentrations of chemicals of concern in pore water from LGB sediments.

Chemical of Concern	Units	Toxicity Threshold: 10-d LC_{50} for *Hyalella azteca*[1]	Toxicity Threshold: Acute Threshold for Aquatic Invertebrates[2]	Sample Site (USGS 1999): IH-25	IH-26	IH-27	IH-28	IH-29	IH-30
Metals									
Cadmium	µg/L	2.9	NG	< 0.11	0.24 (0.08)	0.28 (0.10)	0.13 (0.05)	0.39 (0.13)	< 0.11
Chromium	µg/L	NG	NG	NM	NM	NM	NM	NM	NM
Copper	µg/L	35	NG	3.39 (0.10)	7.78 (0.22)	17.91 (0.51)	7.97 (0.23)	26.20 (0.75)	2.58 (0.07)
Lead	µg/L	<16	NG	0.49	17.16	47.88	20.51	48.73	24.77
Nickel	µg/L	780	NG	123.37 (0.16)	4.41 (0.01)	4.08 (0.01)	3.40 (0.00)	7.04 (0.01)	5.89 (0.01)
Zinc	µg/L	73	NG	8.45 (0.12)	11.52 (0.16)	46.43 (0.64)	18.08 (0.25)	98.40 (1.35)	16.63 (0.23)
Sum Toxic Units[3]		NG	NG	0.38	0.47	1.26	0.53	2.24	0.31
Phenolics									
o-Chlorophenol	µg/L	NG	5600	NM	NM	NM	NM	NM	NM
p-Chlorophenol	µg/L	NG	5600	NM	NM	NM	NM	NM	NM
2,4-Dichlorophenol	µg/L	NG	520	NM	NM	NM	NM	NM	NM
o-Cresol	µg/L	NG	100	NM	NM	NM	NM	NM	NM
p-Cresol	µg/L	NG	100	NM	NM	NM	NM	NM	NM
2,4-Dinitrophenol	µg/L	NG	NG	NM	NM	NM	NM	NM	NM
Phenol	µg/L	NG	45	NM	NM	NM	NM	NM	NM
Other Substances									
Unionized ammonia	mg/L	NG	0.53	<0.01	0.01	0.01	0.02	0.03	0.01

[1] The 10-d LC_{50}s for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (1994; 2000b).

[2] Acute toxicity thresholds for phenols and unionized ammonia were obtained from USEPA (1992a) and in CCREM (1987), respectively.

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline; NM = not measured.

Table 11.4. Summary of the available information on the toxicity of sediments and elutriates from the LGB.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
Indianapolis Boulevard to B & O Railroad Bridge	2	2	100%
B & O Railroad Bridge to Fill Area	1	1	100%
Lake George Wetlands	4	1	25%
Total	**7**	**4**	**57%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of LGB sediments included amphipod survival and growth in 10-d tests with whole sediments; and, 15-min Microtox in elutriate.

Table 11.5. Status of benthic invertebrate communities in the LGB.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other	Gastropod	Bivalvia			
Artificial Substrate										
Simon *et al.* (2000)	15a	35.0	0.0	65.6	0.6	0.0	0.2	1.7	0.87	Altered
Simon *et al.* (2000)	15	75.8	0.0	20.7	0.2	0.0	0.0	0.9	0.40	Altered
Simon *et al.* (2000)	14	41.0	0.0	0.1	0.0	2.8	0.0	0.0	0.87	Altered
Grab										
Risatti and Ross (1989)	1	77.6	0.0	0.0	1.0	0.0	21.4	0.0	ND	Altered
Percent Altered Samples										**100% (4 of 4)**

[1] Reported values are percent of total abundance of invertebrates.
ND = not determined.

Table 11.6. Levels of TOC in LGB sediments.

Reach Segment	Number of Samples	TOC (%) Mean	TOC (%) Range
Surficial Sediments			
Indianapolis Boulevard to B & O Railroad Bridge	7	5.21	1.80 - 12.6
B & O Railroad Bridge to Fill Area	4	18.3	14.0 - 22.0
Lake George Wetlands	12	5.30	1.10 - 17.0
All Segments	**23**	**7.52**	**1.10 - 22.0**
Sub-Surface Sediments			
Indianapolis Boulevard to B & O Railroad Bridge	3	6.80	3.50- 12.0
B & O Railroad Bridge to Fill Area	6	9.61	1.70 - 16.0
Lake George Wetlands	1	0.750	NA
All Segments	**10**	**7.88**	**0.750 - 16.0**

NA = not applicable.

Table 11.7. Levels of oil and grease in LGB sediments.

Reach Segment	Number of Samples	Oil and Grease (mg/kg)	
		Mean	Range
Surficial Sediments			
Indianapolis Boulevard to B & O Railroad Bridge	5	23300	7500 - 54200
B & O Railroad Bridge to Fill Area	4	141000	62400 - 227000
Lake George Wetlands	11	17700	1100 - 53700
All Segments	**20**	**43700**	**1100 - 227000**
Sub-Surface Sediments			
Indianapolis Boulevard to B & O Railroad Bridge	3	51300	21300 - 107000
B & O Railroad Bridge to Fill Area	6	59500	1000 - 154000
Lake George Wetlands	1	500	NA
All Segments	**10**	**51200**	**500 - 154000**

NA = not applicable.

Table 11.8. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the LGB.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediments							
Indianapolis Boulevard to B & O Railroad Bridge	7	4.81	1.75	14.5	1.75	6.00	2.91
B & O Railroad Bridge to Fill Area	4	13.9	3.13	31.5	3.13	16.4	10.5
Lake George Wetlands	12	0.870	0.0786	1.67	0.0916	1.60	0.729
Overall	**23**	**4.33**	**0.0786**	**31.5**	**0.484**	**6.00**	**1.67**
Sub-Surface Sediments							
Indianapolis Boulevard to B & O Railroad Bridge	3	5.88	2.66	11.8	2.66	3.19	3.19
B & O Railroad Bridge to Fill Area	6	6.15	0.367	14.2	0.367	9.87	5.40
Lake George Wetlands	1	0.0457	0.0457	0.0457	NA	NA	0.0457
Overall	**10**	**5.46**	**0.0457**	**14.2**	**0.0457**	**11.8**	**3.20**

NA = not applicable.

Tables

Chapter 12 - US Canal

Table 12.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in USC sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	24 of 56 (43%)	29 of 33 (88%)	NG	NG
Cadmium	66 of 90 (73%)	66 of 82 (80%)	NG	NG
Chromium	77 of 92 (84%)	64 of 83 (77%)	NG	NG
Copper	71 of 90 (79%)	63 of 83 (76%)	NG	NG
Lead	84 of 92 (91%)	70 of 83 (84%)	NG	NG
Mercury	16 of 25 (64%)	24 of 33 (73%)	NG	NG
Nickel	70 of 90 (78%)	60 of 83 (72%)	NG	NG
Zinc	86 of 92 (93%)	70 of 83 (84%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	36 of 36 (100%)	18 of 18 (100%)	NG	NG
Acenaphthylene	32 of 32 (100%)	18 of 18 (100%)	NG	NG
Anthracene	50 of 53 (94%)	18 of 18 (100%)	NG	NG
Benz(a)anthracene	54 of 55 (98%)	18 of 18 (100%)	NG	NG
Benzo(a)pyrene	46 of 47 (98%)	18 of 18 (100%)	NG	NG
Chrysene	54 of 56 (96%)	18 of 18 (100%)	NG	NG
Dibenz(a,h)anthracene	19 of 19 (100%)	18 of 18 (100%)	NG	NG
Fluoranthene	56 of 57 (98%)	18 of 18 (100%)	NG	NG
Fluorene	46 of 47 (98%)	18 of 18 (100%)	NG	NG
2-Methylnaphthalene	40 of 41 (98%)	NM	NG	NG
Naphthalene	48 of 49 (98%)	NM	NG	NG
Phenanthrene	54 of 56 (96%)	18 of 18 (100%)	NG	NG
Pyrene	54 of 56 (96%)	18 of 18 (100%)	NG	NG
Total PAHs	54 of 61 (89%)	18 of 18 (100%)	NG	NG
PCBs				
Total PCBs	30 of 38 (79%)	42 of 51 (82%)	15 of 19 (79%)	16 of 16 (100%)

Table 12.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in USC sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	9 of 9 (100%)	0 of 0 (0%)	9 of 9 (100%)	0 of 0 (0%)
sum DDD	6 of 7 (86%)	17 of 18 (94%)	NG	NG
sum DDE	7 of 8 (88%)	12 of 18 (67%)	NG	NG
sum DDT	2 of 7 (29%)	0 of 18 (0%)	NG	NG
Total DDTs	1 of 11 (9.1%)	0 of 18 (0%)	7 of 9 (78%)	11 of 18 (61%)
Dieldrin	4 of 9 (44%)	0 of 18 (0%)	NG	NG
Endrin	0 of 10 (0%)	0 of 18 (0%)	0 of 7 (0%)	0 of 18 (0%)
Heptachlor	NG	NG	6 of 6 (100%)	0 of 11 (0%)
Heptachlor epoxide	8 of 9 (89%)	0 of 18 (0%)	7 of 7 (100%)	4 of 14 (29%)
Lindane (gamma-BHC)	1 of 3 (33%)	1 of 18 (5.6%)	0 of 10 (0%)	0 of 18 (0%)
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	2 of 4 (50%)	NM

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or
the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no PEC or bioaccumulative-based SQG available; NM = substance was not measured.

Table 12.2. Proportion of sediment samples with various chemical characteristics in the USC.

Reach Segment	Number of Samples	Mean PEC-Qs				
		< 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Surficial Sediments (all Prior to 1996)						
Columbus Drive to Forks	12	0 of 12 (0%)	0 of 12 (0%)	4 of 12 (33%)	8 of 12 (67%)	12 of 12 (100%)
Indianapolis Boulevard to Forks	11	0 of 11 (0%)	0 of 11 (0%)	1 of 11 (9.1%)	10 of 11 (91%)	11 of 11 (100%)
Forks to Highway 912	21	0 of 21 (0%)	1 of 21 (4.8%)	6 of 21 (29%)	14 of 21 (67%)	20 of 21 (95%)
Highway 912 to Dickey Road	18	1 of 18 (5.6%)	2 of 18 (11%)	7 of 18 (39%)	8 of 18 (44%)	15 of 18 (83%)
Dickey Road to B & O Railroad Bridge	36	1 of 36 (2.7%)	2 of 36 (5.6%)	12 of 36 (33%)	21 of 36 (58%)	33 of 36 (92%)
B & O Railroad to the Entrance to IH	16	0 of 16 (0%)	2 of 16 (13%)	5 of 16 (31%)	9 of 16 (56%)	14 of 16 (88%)
Total (all years and locations)	**114**	**2 of 114 (1.8%)**	**7 of 114 (6.1%)**	**35 of 114 (31%)**	**70 of 114 (61%)**	**105 of 114 (92%)**
Sub-Surface Sediments (all Prior to 1996)						
Columbus Drive to Forks	33	0 of 33 (0%)	0 of 33 (0%)	0 of 33 (0%)	33 of 33 (100%)	33 of 33 (100%)
Indianapolis Boulevard to Forks	18	0 of 18 (0%)	4 of 18 (22%)	2 of 18 (11%)	12 of 18 (67%)	14 of 18 (78%)
Forks to Highway 912	23	1 of 23 (4.3%)	3 of 23 (13%)	3 of 23 (13%)	16 of 23 (70%)	19 of 23 (83%)
Highway 912 to Dickey Road	6	2 of 6 (33%)	0 of 6 (0%)	2 of 6 (33%)	2 of 6 (33%)	4 of 6 (67%)
Dickey Road to B & O Railroad Bridge	12	0 of 12 (0%)	4 of 12 (33%)	0 of 12 (0%)	8 of 12 (67%)	8 of 12 (67%)
B & O Railroad to the Entrance to IH	9	0 of 9 (0%)	1 of 9 (11%)	5 of 9 (56%)	3 of 9 (33%)	8 of 9 (89%)
Total (all years and locations)	**101**	**3 of 101 (3.0%)**	**12 of 101 (12%)**	**12 of 101 (12%)**	**74 of 101 (73%)**	**86 of 101 (85%)**

Table 12.3. Concentrations of chemicals of concern in pore water from USC sediments.

Chemical of Concern	Units	Toxicity Threshold		Sample Site (Hoke *et al.* 1993)	Sample Site (USEPA 1996a)	
		10-d LC_{50} for *Hyalella azteca* [1]	Acute Threshold for Aquatic Invertebrates[2]	UG-12	IH 01 06	IH 01 07
Metals						
Cadmium	µg/L	2.9	NG	<5	0.19 (0.07)	14.3 (4.93)
Chromium	µg/L	NG	NG	<10	2.46	350.0
Copper	µg/L	35	NG	<5	5.3 (0.15)	126.3 (3.61)
Lead	µg/L	<16	NG	<20	5.3	1284.0
Nickel	µg/L	780	NG	<100	5.9 (0.01)	171.4 (0.22)
Zinc	µg/L	73	NG	36 (0.49)	6.3 (0.09)	1081 (14.8)
Sum Toxic Units[3]		NG	NG	0.49	0.32	23.6
Phenolics						
o-Chlorophenol	µg/L	NG	5600	NM	NM	NM
p-Chlorophenol	µg/L	NG	5600	NM	NM	NM
2,4-Dichlorophenol	µg/L	NG	520	NM	NM	NM
o-Cresol	µg/L	NG	100	NM	NM	NM
p-Cresol	µg/L	NG	100	NM	NM	NM
2,4-Dinitrophenol	µg/L	NG	NG	NM	NM	NM
Phenol	µg/L	NG	45	NM	NM	NM
Other Substances						
Unionized ammonia	mg/L	NG	0.53	6.2	NR	NR

[1] The 10-d LC_{50}s for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (1994; 2000b).

[2] Acute toxicity thresholds for phenols and unionized ammonia were obtained from USEPA (1992a) and in CCREM (1987), respectively.

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline; NM = not measured.

Table 12.4. Summary of the available information on the toxicity of sediments, pore water and elutriates from the USC.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
Columbus Drive to Forks	21	20	95%
Indianapolis Boulevard to Forks	17	15	88%
Forks to Highway 912	20	16	80%
Highway 912 to Dickey Road	12	7	58%
Dickey Road to B & O Railroad Bridge	8	6	75%
B & O Railroad Bridge to the Entrance to IH	12	8	67%
Total	**90**	**72**	**80%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of USC sediments included amphipod survival growth, number of antennal segments, and % mature in 14-d and 28-d tests with whole sediments; midge survival and growth in 10-d and 14-d tests with whole sediments; cladoceran survival in 48-h tests with pore water; cladoceran survival in 48-h tests with elutriate; 30-min Microtox with pore water; and, 15-min Microtox with elutriate.

Table 12.5. Status of benthic invertebrate communities in the USC.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other	Gastropoda	Bivalvia			
Artificial Substrate										
IDEM (2000a)	Dickey Road (1994)	90.7	0.0	0.0	0.0	2.1	0.0	1.0	2.2	Altered
Simon *et al*. (2000)	16	88.5	0.0	8.3	0.0	0.0	1.8	0.2	0.20	Altered
IDEM (2000a)	129th Street (1993)	98.4	0.0	0.0	0.0	0.0	0.0	0.0	2.8	Altered
IDEM (2000a)	Dickey Road (1996)	81.3	0.0	2.7	0.3	0.0	0.0	0.0	1.7	Altered
Simon *et al*. (2000)	13	85.7	0.1	5.8	0.1	0.0	0.0	0.0	0.33	Altered
Grab										
Polls *et al*. (1993)	6-82	97.7	0.3	0.0	0.0	0.0	1.9	0.0	ND	Altered
Polls and Dennison (1984)	C-2	99.0	0.3	0.0	0.0	0.1	0.6	0.0	ND	Altered
Polls *et al*. (1993)	6-86	98.8	0.1	0.0	0.0	0.3	0.3	0.0	ND	Altered
Polls and Dennison (1984)	C-1	95.1	0.9	0.0	0.0	0.0	3.9	0.0	ND	Altered
USEPA (1996a)	IH 01 05	98.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	Altered
Polls and Dennison (1984)	D-3	98.8	0.1	0.0	0.0	0.0	0.1	0.0	ND	Altered
Risatti and Ross (1989)	3	99.9	0.0	0.0	0.0	0.0	0.1	0.0	ND	Altered
Polls *et al*. (1993)	5-86	72.5	0.2	0.1	0.0	0.0	27.30	0.0	ND	Unaltered
USEPA (1996a)	IH 01 06	100.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	Altered
Polls *et al*. (1993)	5-82	98.3	0.0	0.0	0.0	0.0	1.7	0.0	ND	Altered
Polls and Dennison (1984)	D-4	93.7	1.2	0.0	0.0	0.1	0.0	0.0	ND	Altered
Risatti and Ross (1989)	12a	100.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	Altered
Risatti and Ross (1989)	2	99.7	0.3	0.0	0.0	0.0	0.0	0.0	ND	Altered
Polls and Dennison (1984)	F-1	99.9	0.1	0.0	0.0	0.0	0.0	0.0	ND	Altered
Polls and Dennison (1984)	F-2	99.9	0.0	0.0	0.0	0.0	0.0	0.0	ND	Altered
USEPA (1996a)	IH 01 10	100.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	Altered
USEPA (1996a)	IH 01 08	99.9	0.0	0.0	0.0	0.0	0.0	0.0	ND	Altered
Polls and Dennison (1984)	E-2	100.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	Altered
Polls and Dennison (1984)	E-1	99.9	0.0	0.0	0.0	0.0	0.1	0.0	ND	Altered
USEPA (1996a)	IH 01 07	90.6	0.0	0.0	0.0	0.0	1.3	0.0	ND	Altered
Percent Altered Samples										**96% (24 of 25)**

[1] Reported values are percent of total abundance of invertebrates.

ND = not determined.

Table 12.6. Levels of TOC in USC sediments.

Reach Segment	Number of Samples	TOC (%)	
		Mean	Range
Surficial Sediments			
Columbus Drive to Forks	10	14.6	7.1 - 23.7
Indianapolis Boulevard to Forks	8	10.4	5.6 - 14.8
Forks to Highway 912	12	14.6	2.3 - 23.0
Highway 912 to Dickey Road	11	13.2	2.3 - 38.0
Dickey Road to B & O Railroad Bridge	17	13.4	2.1 - 37.0
B & O Railroad Bridge to the Entrance of IH	5	10.4	0.8 - 17.7
All Segments	**63**	**13.2**	**0.8 - 38.0**
Sub-Surface Sediments			
Columbus Drive to Forks	26	12.6	7.27 - 34.9
Indianapolis Boulevard to Forks	13	7.38	0.5 - 12.8
Forks to Highway 912	12	7.33	1.15 - 11.3
Highway 912 to Dickey Road	6	4.34	1.32 - 10.8
Dickey Road to B & O Railroad Bridge	4	9.87	1.07 - 21.0
B & O Railroad Bridge to the Entrance to IH	7	9.14	1.41 - 19.6
All Segments	**68**	**9.41**	**0.5 - 34.9**

Table 12.7. Levels of oil and grease in USC sediments.

Reach Segment	Number of Samples	Oil and Grease (mg/kg)	
		Mean	Range
Surficial Sediments			
Columbus Drive to Forks	1	65400	NA
Indianapolis Boulevard to Forks	2	136000	96600 - 175000
Forks to Highway 912	1	97500	NA
Highway 912 to Dickey Road	NA	NA	NA
Dickey Road to B & O Railroad Bridge	2	54500	43200 - 65700
B & O Railroad Bridge to the Entrance to IH	2	25100	8600 - 41600
All Segments	**8**	**74200**	**8600 - 175000**
Sub-Surface Sediments			
Columbus Drive to Forks	4	54300	44600 - 66600
Indianapolis Boulevard to Forks	5	81500	15800 - 119000
Forks to Highway 912	2	101000	96000 - 106000
Highway 912 to Dickey Road	NA	NA	NA
Dickey Road to B & O Railroad Bridge	2	34100	550 - 67700
B & O Railroad Bridge to the Entrance to IH	2	14300	2200 - 26400
All Segments	**15**	**61600**	**550 - 119000**

NA = not applicable.

Table 12.8. Frequency of exceedance of TRGs in the USC.

Chemical of Concern	Fish			Invertebrates	Algae
	Fillets[1]	Whole Body[2]	GI Tract[3]	Composite Sample	Composite Sample
PCBs					
Total PCBs	3 of 3 (100%)	13 of 13 (100%)	NM	2 of 2 (100%)	1 of 1 (100%)
Pesticides					
Chlordane	0 of 3 (0%)	NM	NM	NM	NM
Dieldrin + Aldrin	2 of 3 (67%)	NM	NM	NM	NM
Endrin	0 of 3 (0%)	NM	NM	NM	NM
Heptachlor + Heptachlor epoxide	0 of 3 (0%)	NM	NM	NM	NM
Lindane	0 of 3 (0%)	NM	NM	NM	NM
Mirex	NM	NM	NM	NM	NM
Total DDTs	1 of 3 (33%)	NM	NM	NM	NM
Dioxins					
2,3,7,8-TCDD	NM	NM	NM	NM	NM

[1]Fillets = skin-off fillets.

[2]Whole body = head, gills, skin, bones and attached flesh (i.e., without fillets or GI tract).

[3]GI tract = organs in body cavity post gills.

NM = not measured.

Table 12.9. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the USC.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediments							
Columbus Drive to Forks	12	5.99	2.25	22.0	2.25	7.98	4.41
Indianapolis Boulevard to Forks	11	13.2	3.51	35.2	4.10	24.9	8.18
Forks to Highway 912	21	10.5	0.610	61.3	3.07	23.7	5.21
Highway 912 to Dickey Road	18	5.72	0.0652	29.3	0.55	12.6	3.14
Dickey Road to B & O Railroad Bridge	36	18.8	0.0395	177	1.17	29.7	9.90
B & O Railroad Bridge to the Entrance to IH	16	7.04	0.233	25.2	0.691	10.8	6.33
Overall	**114**	**11.7**	**0.0395**	**177**	**1.11**	**24.9**	**5.16**
Sub-Surface Sediments							
Columbus Drive to Forks	33	20.9	4.35	57.9	4.90	43.0	13.8
Indianapolis Boulevard to Forks	18	12.8	0.178	37.8	0.207	34.4	6.72
Forks to Highway 912	23	14.9	0.0557	45.3	0.222	36.5	6.71
Highway 912 to Dickey Road	6	2.45	0.0522	5.28	0.0522	5.18	2.08
Dickey Road to B & O Railroad Bridge	12	34.2	0.222	170	0.256	67.9	8.21
B & O Railroad Bridge to the Entrance to IH	9	3.23	0.225	5.04	0.225	4.96	3.47
Overall	**101**	**17.0**	**0.0522**	**170**	**0.245**	**38.8**	**7.25**

Tables

Chapter 13 - Indiana Harbor

Table 13.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in IH and nearshore areas of Lake Michigan sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Metals				
Arsenic	13 of 59 (22%)	4 of 6 (67%)	NG	NG
Cadmium	19 of 44 (43%)	14 of 24 (58%)	NG	NG
Chromium	40 of 75 (53%)	14 of 24 (58%)	NG	NG
Copper	25 of 50 (50%)	14 of 24 (58%)	NG	NG
Lead	36 of 77 (47%)	18 of 24 (75%)	NG	NG
Mercury	0 of 14 (0%)	0 of 7 (0%)	NG	NG
Nickel	28 of 77 (36%)	12 of 24 (50%)	NG	NG
Zinc	43 of 77 (56%)	18 of 24 (75%)	NG	NG
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	19 of 19 (100%)	NM	NG	NG
Acenaphthylene	26 of 26 (100%)	NM	NG	NG
Anthracene	30 of 31 (97%)	NM	NG	NG
Benz(a)anthracene	22 of 32 (69%)	NM	NG	NG
Benzo(a)pyrene	27 of 30 (90%)	NM	NG	NG
Chrysene	33 of 33 (100%)	NM	NG	NG
Dibenz(a,h)anthracene	9 of 9 (100%)	NM	NG	NG
Fluoranthene	35 of 36 (97%)	NM	NG	NG
Fluorene	28 of 30 (93%)	NM	NG	NG
2-Methylnaphthalene	25 of 26 (96%)	NM	NG	NG
Naphthalene	33 of 33 (100%)	NM	NG	NG
Phenanthrene	35 of 35 (100%)	NM	NG	NG
Pyrene	35 of 36 (97%)	NM	NG	NG
Total PAHs	33 of 44 (75%)	NM	NG	NG
PCBs				
Total PCBs	6 of 40 (15%)	2 of 7 (29%)	29 of 33 (88%)	0 of 0 (0%)

Table 13.1. Frequency of exceedances of the PECs and bioaccumulation-based SQGs in IH and nearshore areas of Lake Michigan sediments.

Chemical of Concern	Sediment-Dwelling Organisms		Wildlife	
	Surficial Sediments	Sub-Surface Sediments	Surficial Sediments	Sub-Surface Sediments
Pesticides				
Chlordane	1 of 1 (100%)	NM	1 of 1 (100%)	NM
sum DDD	0 of 0 (0%)	NM	NG	NG
sum DDE	1 of 1 (100%)	NM	NG	NG
sum DDT	0 of 2 (0%)	NM	NG	NG
Total DDTs	0 of 2 (0%)	NM	0 of 2 (0%)	NM
Dieldrin	1 of 2 (50%)	NM	NG	NG
Endrin	0 of 2 (0%)	NM	0 of 2 (0%)	NM
Heptachlor	NG	NG	0 of 0 (0%)	NM
Heptachlor epoxide	0 of 0 (0%)	NM	0 of 0 (0%)	NM
Lindane (gamma-BHC)	0 of 0 (0%)	NM	0 of 2 (0%)	NM
Toxaphene	NG	NG	NG	NG
Dioxins				
2,3,7,8-TCDD	NG	NG	1 of 1 (100%)	NM

Note: The absence of a chemical substance on this list does not necessarily mean that the substance does not pose a hazard to sediment dwelling organisms, wildlife, or fish consumption.
0 of 0 (0%) = the substance was measured but all values were excluded from analyses because they were less than a detection limit that exceeded a PEC or other SQG; or the substance was measured but cannot be compared to the TOC-normalized SQG because TOC was not reported for the station.
NG = no guideline (i.e., no PEC or bioaccumulative-based SQG available); NM = substance was not measured.

Table 13.2. Proportion of sediment samples with various chemical characteristics in the IH and nearshore areas of Lake Michigan.

Reach Segment	Number of Samples	Mean PEC-Qs < 0.1	$ 0.1 - < 0.7	$ 0.7 - < 4.0	$ 4.0	$ 0.7
Surficial Sediments (all Prior to 1996)						
Indiana Harbor	55	1 of 55 (1.8%)	5 of 55 (9.1%)	37 of 55 (67%)	12 of 55 (22%)	49 of 55 (89%)
Nearshore Areas of Lake Michigan	32	7 of 32 (22%)	24 of 32 (75%)	1 of 32 (3.1%)	0 of 32 (0%)	1 of 32 (3.1%)
Total (all years and locations)	**87**	**8 of 87 (9.2%)**	**29 of 87 (33%)**	**38 of 87 (44%)**	**12 of 87 (14%)**	**50 of 87 (57%)**
Sub-Surface Sediments (all Prior to 1996)						
Indiana Harbor	23	3 of 23 (13%)	2 of 23 (8.7%)	14 of 23 (61%)	4 of 23 (17%)	18 of 23 (78%)
Nearshore Areas of Lake Michigan	1	0 of 1 (0%)	1 of 1 (100%)	0 of 1 (0%)	0 of 1 (0%)	0 of 1 (0%)
Total (all years and locations)	**24**	**3 of 24 (13%)**	**3 of 24 (13%)**	**14 of 24 (58)%**	**4 of 24 (17%)**	**18 of 24 (75%)**

Table 13.3. Concentrations of chemicals of concern in pore water from IH sediments.

Chemical of Concern	Units	Toxicity Threshold		Sample Site (Hoke *et al.* 1993)	Sample Site (USEPA 1996a)	
		10-d LC_{50} for *Hyalella azteca* [1]	Acute Threshold for Aquatic Invertebrates[2]	UG-13	IH 01 04	IH 01 03
Metals						
Cadmium	µg/L	2.9	NG	<5	1.0 (0.34)	1.1 (0.38)
Chromium	µg/L	NG	NG	<10	28.6	13.2
Copper	µg/L	35	NG	<5	21.3 (0.61)	21.4 (0.61)
Lead	µg/L	<16	NG	<20	92.8	96.8
Nickel	µg/L	780	NG	<100	7.5 (0.01)	10.4 (0.01)
Zinc	µg/L	73	NG	132 (1.81)	50.3 (0.69)	60.8 (0.83)
Sum Toxic Units[3]		NG	NG	1.81	1.65	1.83
Phenolics						
o-Chlorophenol	µg/L	NG	5600	NM	NM	NM
p-Chlorophenol	µg/L	NG	5600	NM	NM	NM
2,4-Dichlorophenol	µg/L	NG	520	NM	NM	NM
o-Cresol	µg/L	NG	100	NM	NM	NM
p-Cresol	µg/L	NG	100	NM	NM	NM
2,4-Dinitrophenol	µg/L	NG	NG	NM	NM	NM
Phenol	µg/L	NG	45	NM	NM	NM
Other Substances						
Unionized ammonia	mg/L	NG	0.53	0.3	NM	NM

[1] The 10-d LC_{50}s for the amphipod *Hyalella azteca* for water-only exposures were obtained from USEPA (2000b).

[2] Acute toxicity thresholds for unionized ammonia were obtained from CCREM (1987).

[3] Sum toxic units were calculated as the sum of the toxic units that were determined for each substance (i.e., as shown in parenthesis and calculated as the chemical concentration divided by the 10-d LC_{50}).

NG = no guideline; NM = not measured.

Table 13.4. Summary of the available information on the toxicity of sediments, pore water and elutriates from the IH and nearshore areas of Lake Michigan.

Reach Segment	Number of Samples	Number of Toxic Samples	% Toxicity
Overall Toxicity			
Indiana Harbor	32	26	81%
Nearshore Areas of Lake Michigan	6	2	33%
Total	**38**	**28**	**74%**

Overall toxicity was determined when the sample was toxic to one or more species. The species and endpoints that were used to evaluate the toxicity of IH and nearshore areas of Lake Michigan sediments included amphipod survival, growth, # antennal segments and % mature in 14-d and 28-d tests with whole sediments; midge survival and growth in 10-d and 14-d tests with whole sediments; cladoceran survival in 48-h tests with pore water; cladoceran survival in 48-h tests with elutriate; 30-min Microtox with pore water; and, 15-min Microtox with elutriate.

Table 13.5. Status of benthic invertebrate communities in the IH and nearshore areas of Lake Michigan.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other Diptera	Gastropoda	Bivalvia			
Artificial Substrate										
Simon *et al* . (2000)	17	69.4	0.0	1.9	0.0	0.0	9.2	0.2	0.80	Altered
Grab										
Polls *et al* . (1993)	15-86	46.3	0.0	30.5	0.0	3.2	2.7	0.5	ND	Unaltered
Polls *et al* . (1993)	18-86	61.7	1.6	22.9	0.0	1.5	10.4	0.1	ND	Unaltered
Polls *et al* . (1993)	17-86	20.0	0.0	50.0	0.0	2.9	8.6	0.0	ND	Unaltered
Polls *et al* . (1993)	14-86	26.1	1.9	37.9	0.0	5.0	11.5	0.0	ND	Unaltered
Polls *et al* . (1993)	16-86	29.9	0.8	22.4	0.0	7.8	6.9	0.0	ND	Unaltered
LTI (1984)	WS-1	60.8	0.0	26.0	0.0	0.0	4.4	0.0	ND	Unaltered
Polls *et al* . (1993)	13-86	20.0	5.6	25.6	0.0	26.7	20.0	0.0	ND	Unaltered
LTI (1984)	WS-2	76.2	0.0	5.3	0.5	3.7	9.0	0.0	ND	Altered
Polls *et al* . (1993)	17-82	36.2	0.1	57.8	0.3	0.0	0.4	0.0	ND	Unaltered
LTI (1984)	WS-3	74.9	0.0	9.1	2.3	0.0	6.8	0.0	ND	Altered
LTI (1984)	WS-4	84.9	0.0	12.6	0.0	0.0	2.5	0.0	ND	Altered
LTI (1984)	WS-5	78.2	0.0	8.9	1.6	0.8	8.1	0.0	ND	Altered
LTI (1984)	WS-6	51.2	0.0	9.7	4.9	19.5	12.2	0.0	ND	Unaltered
LTI (1984)	WS-7	58.2	0.0	25.0	0.0	0.0	8.4	0.0	ND	Unaltered
LTI (1984)	WS-8	79.5	0.7	4.9	1.4	0.0	9.2	0.0	ND	Altered
Risatti and Ross (1989)	6	66.7	0.0	0.0	0.0	0.0	0.0	0.0	ND	Unaltered
Risatti and Ross (1989)	11	66.7	0.0	7.0	0.0	7.0	7.0	0.0	ND	Unaltered
LTI (1984)	S8-7	96.6	0.0	3.4	0.0	0.0	0.0	0.0	ND	Altered
LTI (1984)	WS-9	75.0	0.0	13.1	2.4	1.2	0.0	0.0	ND	Altered
Polls *et al* . (1993)	10-82	72.7	0.2	16.9	0.0	0.9	4.9	0.3	ND	Unaltered
Polls *et al* . (1993)	12-82	74.5	1.5	19.3	0.0	2.7	0.3	0.2	ND	Altered
Polls *et al* . (1993)	13-82	32.7	0.6	29.4	0.0	10.8	14.4	0.0	ND	Unaltered
Polls *et al* . (1993)	14-82	57.4	1.5	25.7	0.0	2.8	9.5	0.9	ND	Unaltered
Risatti and Ross (1989)	9a	76.7	0.0	10.3	0.0	0.9	3.7	0.0	ND	Altered
Polls *et al* . (1993)	16-82	14.0	1.5	49.9	0.0	6.4	5.1	0.1	ND	Unaltered

Table 13.5. Status of benthic invertebrate communities in the IH and nearshore areas of Lake Michigan.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other Diptera	Gastropoda	Bivalvia			
Grab (cont.)										
Polls *et al*. (1993)	12-86	38.5	4.6	54.5	0.0	0.3	0.0	0.3	ND	Unaltered
Risatti and Ross (1989)	10a	73.1	0.0	0.0	0.0	4.5	0.0	0.0	ND	Unaltered
Polls *et al*. (1993)	18-82	53.1	0.9	36.9	0.3	0.0	0.6	0.0	ND	Unaltered
Risatti and Ross (1989)	8	95.5	1.9	0.6	0.0	0.6	0.0	0.0	ND	Altered
Risatti and Ross (1989)	7	20.7	0.0	0.0	0.0	3.4	13.8	0.0	ND	Unaltered
Polls *et al*. (1993)	10-86	62.5	0.0	14.9	0.0	2.7	19.9	0.0	ND	Unaltered
Polls *et al*. (1993)	11-86	67.0	0.9	18.9	0.0	5.7	7.6	0.0	ND	Unaltered
Polls *et al*. (1993)	15-82	43.4	0.6	36.4	0.0	1.1	11.2	0.0	ND	Unaltered
LTI (1984)	Indiana Hrb.-4	57.3	0.0	28.3	0.0	0.0	0.0	0.0	ND	Unaltered
Polls and Dennison (1984)	H-1	56.8	0.0	7.9	0.0	3.0	4.1	0.0	ND	Unaltered
LTI (1984)	S8-5	94.8	0.0	3.5	0.0	0.0	0.0	0.0	ND	Altered
LTI (1984)	WS-10	40.2	0.0	0.0	0.0	0.0	0.0	0.0	ND	Unaltered
Polls and Dennison (1984)	G-2	94.75	0.47	0.57	0.00	1.53	2.39	0.00	ND	Altered
Polls and Dennison (1984)	G-3	83.7	0.5	3.8	0.0	0.9	5.0	0.0	ND	Altered
Polls and Dennison (1984)	H-2	76.4	0.3	11.1	0.0	2.6	2.8	0.0	ND	Altered
Polls and Dennison (1984)	H-3	15.5	0.0	1.5	0.0	0.2	6.7	0.0	ND	Unaltered
Polls and Dennison (1984)	G-1	92.8	0.4	1.7	0.0	0.2	3.6	0.0	ND	Altered
LTI (1984)	Indiana Hrb.-3	93.8	0.0	0.0	0.0	0.0	6.3	0.0	ND	Altered
LTI (1984)	Indiana Hrb.-2	50.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	Unaltered
LTI (1984)	S8-12	66.7	0.0	0.0	0.0	33.3	0.0	0.0	ND	Unaltered
LTI (1984)	S8-10	88.8	5.6	0.0	0.0	0.0	0.0	0.0	ND	Altered
LTI (1984)	S8-2	74.3	0.0	11.4	5.7	0.0	0.0	0.0	ND	Altered
LTI (1984)	S8-9	85.2	2.9	5.9	3.0	1.5	0.0	0.0	ND	Altered
LTI (1984)	S8-8	76.8	7.7	0.0	0.0	7.7	7.8	0.0	ND	Altered
LTI (1984)	S8-6	95.8	0.0	1.4	2.8	0.0	0.0	0.0	ND	Altered
LTI (1984)	WS-11	74.2	0.0	7.0	3.0	0.0	7.9	0.0	ND	Altered
LTI (1984)	S8-4	100.0	0.0	0.0	0.0	0.0	0.0	0.0	ND	Altered
LTI (1984)	S8-3	54.6	0.0	15.2	6.0	0.0	12.1	0.0	ND	Unaltered

Table 13.5. Status of benthic invertebrate communities in the IH and nearshore areas of Lake Michigan.

Source	Sample Number	Annelida (%)[1]		Diptera (%)[1]		Mollusca (%)[1]		EPT Taxa	mIBI	Altered/ Unaltered
		Oligochaetea	Hirudinea	Chironomidae	Other Diptera	Gastropoda	Bivalvia			
Grab (cont.)										
LTI (1984)	S8-1	97.5	0.0	1.2	1.2	0.0	0.0	0.0	ND	Altered
LTI (1984)	S8-11	60.3	0.0	39.7	0.0	0.0	0.0	0.0	ND	Unaltered
LTI (1984)	WS-12	72.7	0.0	3.7	3.6	3.7	10.9	0.0	ND	Unaltered
Polls *et al*. (1993)	9-82	97.5	0.1	1.0	0.0	0.0	1.2	0.0	ND	Altered
Polls *et al*. (1993)	8-82	96.2	0.2	0.0	0.0	0.2	3.3	0.0	ND	Altered
Polls *et al*. (1993)	7-82	95.4	0.1	0.0	0.0	0.1	4.5	0.0	ND	Altered
Risatti and Ross (1989)	4	60.0	0.0	0.0	0.0	20.0	0.0	0.0	ND	Unaltered
USEPA (1996a)	IH 01 04	98.5	0.0	0.0	0.0	0.0	0.1	0.0	ND	Altered
Risatti and Ross (1989)	5	71.4	0.0	0.0	0.0	0.0	19.1	0.0	ND	Unaltered
LTI (1984)	Indiana Hrb.-1	98.2	0.0	0.3	0.0	0.0	1.5	0.0	ND	Altered
Polls and Dennison (1984)	B-2	90.7	1.0	0.0	0.0	1.0	3.9	0.0	ND	Altered
Polls and Dennison (1984)	B-1	88.6	1.7	0.0	0.0	0.0	5.3	0.0	ND	Altered
USEPA (1996a)	IH 01 03	99.3	0.0	0.0	0.0	0.0	0.2	0.0	ND	Altered
Polls *et al*. (1993)	7-86	96.4	0.2	0.0	0.0	0.5	2.8	0.0	ND	Altered
Polls and Dennison (1984)	A-1	93.2	0.0	1.0	0.0	0.7	1.5	0.0	ND	Altered
Polls *et al*. (1993)	9-86	86.4	0.0	9.7	0.0	0.6	0.6	0.0	ND	Altered
Polls and Dennison (1984)	A-2	60.3	0.0	0.0	0.0	0.0	2.7	0.0	ND	Unaltered
Polls *et al*. (1993)	8-86	81.4	1.6	0.8	0.0	1.9	14.0	0.0	ND	Altered
Percent Altered Samples										**51% (37 of 72)**

[1] Report values are percent of total abundance of invertebrates.
ND = not determined.

Table 13.6. Levels of TOC in IH and nearshore areas of Lake Michigan sediments.

Reach Segment	Number of Samples	TOC (%)	
		Mean	Range
Surficial Sediments			
Indiana Harbor	24	11.8	0.13 - 32.0
Nearshore Areas of Lake Michigan	31	0.511	0.00240 - 7.64
All Segments	**55**	**5.45**	**0.00240 - 32.0**
Sub-Surface Sediments			
Indiana Harbor	17	13.4	0.080 - 60.2
Nearshore Areas of Lake Michigan	0	NA	NA
All Segments	**17**	**13.4**	**0.080 - 60.2**

NA = not applicable.

Table 13.7. Levels of oil and grease in IH and nearshore areas of Lake Michigan sediments.

Reach Segment	Number of Samples	Oil and Grease (mg/kg)	
		Mean	Range
Surficial Sediments			
Indiana Harbor	3	42600	510 - 100000
Nearshore Areas of Lake Michigan	1	310	NA
All Segments	**4**	**32000**	**310 - 100000**
Sub-Surface Sediments			
Indiana Harbor	6	43800	680 - 76000
Nearshore Areas of Lake Michigan	1	520	NA
All Segments	**7**	**37600**	**520 - 76000**

NA = not applicable.

Table 13.8. Frequency of exceedance of TRGs in IH and nearshore areas of Lake Michigan.

Chemical of Concern	Fish			Invertebrates	Algae
	Fillets[1]	Whole Body[2]	GI Tract[3]	Composite Sample	Composite Sample
PCBs					
Total PCBs	NM	15 of 17 (88%)	NM	3 of 4 (75%)	3 of 5 (60%)
Pesticides					
Chlordane	NM	NM	NM	NM	NM
Dieldrin + Aldrin	NM	NM	NM	NM	NM
Endrin	NM	NM	NM	NM	NM
Heptachlor + Heptachlor epoxide	NM	NM	NM	NM	NM
Lindane	NM	NM	NM	NM	NM
Mirex	NM	NM	NM	NM	NM
Total DDTs	NM	NM	NM	NM	NM
Dioxins					
2,3,7,8-TCDD	NM	NM	NM	NM	NM

[1]Fillets = skin-off fillets.

[2]Whole body = head, gills, skin, bones and attached flesh (i.e., without fillets or GI tract).

[3]GI tract = organs in body cavity post gills.

NM = not measured.

Table 13.9. Summary of the distribution of mean PEC-Qs in surficial and sub-surface sediments in the IH and nearshore areas of Lake Michigan.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Surficial Sediments							
Indiana Harbor	55	6.81	0.0699	90.1	0.652	6.84	2.35
Nearshore Areas of Lake Michigan	32	0.215	0.0447	1.31	0.0523	0.379	0.142
Overall	**87**	**4.38**	**0.0447**	**90.1**	**0.104**	**4.92**	**1.27**
Sub-Surface Sediments							
Indiana Harbor	23	2.45	0.0412	7.19	0.0607	5.90	1.81
Nearshore Areas of Lake Michigan	1	0.136	0.136	0.136	NA	NA	NA
Overall	**24**	**2.35**	**0.0412**	**7.19**	**0.0607**	**5.9**	**1.75**

NA = not applicable.

Tables

Chapter 14 - Summary of Sediment Injury for the Assessment Area

Table 14.1. Summary of assessment of sediment injury to sediment-dwelling organisms.

Reach/Segment	Indicator of Injury to Sediment-Dwelling Organisms[1] Sediment Chemistry[2]	Pore Water Chemistry[3]	Sediment Toxicity[4]	Benthic Community[5]	Number of Lines of Evidence for Demonstrating Injury to Sediment-Dwelling Organisms
Grand Calumet River Lagoons	27% (n=215)*	0% (n=5)	50% (n=12)*	ID (n=0)	2
East Branch Grand Calumet River-I	83% (n=269)*	55% (n=20)*	73% (n=44)*	100% (n=14)*	4
East Branch Grand Calumet River-II	72% (n=131)*	100% (n=2)*	88% (n=52)*	100% (n=5)*	4
West Branch Grand Calumet River-I	90% (n=31)*	100% (n=2)*	100% (n=2)*	100% (n=3)*	4
West Branch Grand Calumet River-II	76% (n=172)*	88% (n=8)*	83% (n=18)*	71% (n=14)*	4
Indiana Harbor Canal	89% (n=36)*	60% (n=5)*	80% (n=5)*	100% (n=6)*	4
Lake George Branch	82% (n=33)*	83% (n=6)*	57% (n=7)*	100% (n=4)*	4
US Canal	89% (n=215)*	67% (n=3)*	80% (n=90)*	96% (n=25)*	4
Indiana Harbor / Lake Michigan	61% (n=111)*	100% (n=3)*	74% (n=38)*	51% (n=72)*	4
Overall	**70% (n=1213)***	**65% (n=54)***	**78% (n=268)***	**72% (n=143)***	**4**

[1] For each line of evidence, sediment injury is indicated if two or more samples have conditions sufficient to cause or substantially contribute to sediment injury. Evidence of sediment injury is denoted with an asterisk (*).
[2] Percent of sediment samples with mean PEC-Qs of $\geq$ 0.7.
[3] Percent of pore water samples with chemical concentrations > published toxicity thresholds.
[4] Percent of sediment samples that are toxic to aquatic organisms in laboratory tests.
[5] Percent of samples with altered benthic invertebrate community structure.
ID = insufficient data; n = number of samples.

Table 14.2. Summary of the distribution of mean PEC-Qs in surficial sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Grand Calumet River Lagoons							
West Lagoon	58	555	0.0556	23800	0.146	26.6	1.04
Middle Lagoon	49	0.941	0.0914	16.1	0.101	2.18	0.290
East Lagoon	47	0.558	0.0768	2.30	0.106	1.28	0.376
Little West Pond	25	0.326	0.0646	2.51	0.0937	0.425	0.178
Little East Pond	23	0.111	0.0639	0.220	0.0668	0.141	0.0995
Overall	**202**	**160**	**0.0556**	**23800**	**0.0925**	**3.19**	**0.289**
East Branch Grand Calumet River-I							
EB and WB Confluence to Kennedy Avenue	29	8.34	0.112	77.4	0.255	25.9	2.88
USS Lead Canal	17	27.7	3.60	72.6	5.45	65.3	13.0
Kennedy Avenue to Cline Avenue	51	7.20	0.457	58.2	1.20	12.3	4.61
Cline Avenue to Cline/I-90 Ramps	15	4.59	0.104	12.1	1.31	7.29	3.73
Cline/I-90 Ramps to Industrial Highway	21	28.9	0.71	184	2.12	45.4	5.94
Industrial Highway to ConRail Bridge	12	36.8	1.92	357	2.24	18.9	3.58
EB Wetland	17	3.99	0.0655	15.7	0.208	6.88	3.23
Overall	**162**	**14.0**	**0.0655**	**357**	**0.875**	**30.3**	**4.58**
East Branch Grand Calumet River-II							
EB II Wetland	55	1.12	0.000636	16.0	0.0901	2.75	0.230
ConRail Bridge to Bridge Street	8	25.3	13.1	51.9	13.1	38.3	22.5
Bridge Street to Grant Street	6	10.7	2.58	17.6	2.58	13.4	11.1
Grant Street to I-90	3	30.0	4.66	68.8	4.66	16.6	16.6
I-90 to Broadway	9	52.1	1.54	375	1.54	39.5	6.44
Broadway to Virginia Street	4	27.5	2.59	63.4	2.59	29.9	22.1
Virginia Street to Tennessee Street	4	473	87.2	821	87.2	705	492
Tennessee Street to Lagoon Culvert	9	286	1.43	987	1.43	589	9.25
Overall	**98**	**55.7**	**0.000636**	**987**	**0.0986**	**63.4**	**2.42**
West Branch Grand Calumet River-I							
EB and WB Confluence to Indianapolis Boulevard	**19**	**29.5**	**1.13**	**231**	**1.35**	**56.9**	**11.7**

Table 14.2. Summary of the distribution of mean PEC-Qs in surficial sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
West Branch Grand Calumet River-II							
Indianapolis Boulevard to I-90	14	15.5	0.149	75.3	0.243	35.3	6.22
Roxana Marsh	5	0.428	0.123	0.603	0.123	0.595	0.515
I-90 to Columbia Avenue	22	12.3	0.0395	76.0	1.01	16.2	6.53
Columbia Avenue to Calumet Avenue	2	3.71	0.259	7.17	NA	NA	NA
Calumet Avenue to Hohman Avenue	9	37.6	0.311	210	0.311	88.6	6.85
Hohman Avenue to State Line Avenue	21	47.5	0.875	304	2.51	94.9	28.7
Illinois Portion	11	6.00	2.71	10.1	2.97	9.65	4.89
Overall	**84**	**22.6**	**0.0395**	**304**	**0.347**	**67.1**	**6.71**
Indiana Harbor Canal							
EB and WB Confluence to 151st Street	7	5.44	2.10	10.4	2.10	8.21	4.85
151st Street to Chicago Avenue	10	3.00	0.191	8.84	0.191	7.19	2.29
Chicago Avenue to Columbus Drive	12	7.29	1.09	25.9	1.69	11.5	5.34
IHC Wetland	1	0.718	0.718	0.718	NA	NA	NA
Overall	**30**	**5.21**	**0.191**	**25.9**	**0.491**	**10.4**	**4.08**
Lake George Branch							
Indianapolis Boulevard to B & O Railroad Bridge	7	4.81	1.75	14.5	1.75	6.00	2.91
B & O Railroad Bridge to Fill Area	4	13.9	3.13	31.5	3.13	16.4	10.5
Lake George Wetlands	12	0.870	0.0786	1.67	0.0916	1.60	0.729
Overall	**23**	**4.33**	**0.0786**	**31.5**	**0.484**	**6.00**	**1.67**
US Canal							
Columbus Drive to Forks	12	5.99	2.25	22.0	2.25	7.98	4.41
Indianapolis Boulevard to Forks	11	13.2	3.51	35.2	4.10	24.9	8.18
Forks to Highway 912	21	10.5	0.61	61.3	3.07	23.7	5.21
Highway 912 to Dickey Road	18	5.72	0.0652	29.3	0.55	12.6	3.14
Dickey Road to B & O Railroad Bridge	36	18.8	0.0395	177	1.17	29.7	9.90
B & O Railroad Bridge to IH	16	7.04	0.233	25.2	0.691	10.8	6.33
Overall	**114**	**11.7**	**0.0395**	**177**	**1.11**	**24.9**	**5.16**

Table 14.2. Summary of the distribution of mean PEC-Qs in surficial sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
IH and Nearshore Areas of Lake Michigan							
Indiana Harbor	55	6.81	0.0699	90.1	0.652	6.84	2.35
Nearshore areas of Lake Michigan	32	0.215	0.0447	1.31	0.0523	0.379	0.142
Overall	**87**	**4.4**	**0.0447**	**90.1**	**0.104**	**4.92**	**1.27**

NA = not applicable.

Table 14.3. Summary of the distribution of mean PEC-Qs in sub-surface sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
Grand Calumet River Lagoons							
West Lagoon	6	427	0.0185	2560	0.0185	0.317	0.0964
Middle Lagoon	3	0.0336	0.0147	0.0600	0.0147	0.0260	0.0260
East Lagoon	0	NA	NA	NA	NA	NA	NA
Little West Pond	2	0.120	0.0675	0.172	NA	NA	NA
Little East Pond	2	0.0412	0.0334	0.0490	NA	NA	NA
Overall	**13**	**197**	**0.0147**	**2560**	**0.0185**	**0.172**	**0.0490**
East Branch Grand Calumet River-I							
EB and WB Confluence to Kennedy Avenue	18	3.51	0.0692	13.1	0.193	8.30	2.77
USS Lead Canal	9	24.2	5.64	80.8	5.64	54.4	12.1
Kennedy Avenue to Cline Avenue	54	16.9	0.0286	497	0.0887	16.9	3.06
Cline Avenue to Cline/I-90 Ramps	7	1.47	0.0555	4.20	0.0555	2.63	1.21
Cline/I-90 Ramps to Industrial Highway	12	3.55	0.0847	13.6	0.123	5.50	2.78
Industrial Highway to ConRail Bridge	6	18.6	0.593	99.1	0.593	5.15	2.98
EB Wetland	1	0.627	0.627	0.627	NA	NA	NA
Overall	**107**	**12.7**	**0.0286**	**497**	**0.107**	**16.9**	**2.98**
East Branch Grand Calumet River-II							
EB II Wetland	0	NA	NA	NA	NA	NA	NA
ConRail Bridge to Bridge Street	9	14.1	2.55	65.3	2.55	19.1	7.21
Bridge Street to Grant Street	4	4.94	2.47	6.58	2.47	5.89	5.36
Grant Street to I-90	4	4.43	2.09	7.19	2.09	6.28	4.21
I-90 to Broadway	6	29.1	2.13	116	2.13	36.2	7.84
Broadway to Virginia Street	0	NA	NA	NA	NA	NA	NA
Virginia Street to Tennessee Street	3	450	118	937	118	296	296
Tennessee Street to Lagoon Culvert	7	218	2.80	765	2.80	458	66.3
Overall	**33**	**97.6**	**2.09**	**937**	**2.47**	**188**	**7.21**
West Branch Grand Calumet River-I							
EB and WB Confluence to Indianapolis Boulevard	**12**	**4.80**	**0.139**	**13.7**	**0.368**	**8.80**	**3.77**

Table 14.3. Summary of the distribution of mean PEC-Qs in sub-surface sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
West Branch Grand Calumet River-II							
Indianapolis Boulevard to I-90	10	0.191	0.0976	0.357	0.0976	0.278	0.205
Roxana Marsh	5	0.0905	0.0652	0.111	0.0652	0.101	0.0919
I-90 to Columbia Avenue	25	8.18	0.0658	30.2	0.128	16.9	3.34
Columbia Avenue to Calumet Avenue	3	3.21	0.215	5.89	0.215	3.53	3.53
Calumet Avenue to Hohman Avenue	13	13.1	0.109	97.3	0.325	17.9	3.78
Hohman Avenue to State Line Avenue	25	51.0	0.0712	193	2.47	129	33.4
Illinois Portion	7	4.69	0.148	13.3	0.148	8.45	3.74
Overall	**88**	**19.3**	**0.0652**	**193**	**0.101**	**51.7**	**3.84**
Indiana Harbor Canal							
EB and WB Confluence to 151st Street	4	2.90	0.434	4.36	0.434	4.12	3.41
151st Street to Chicago Avenue	0	NA	NA	NA	NA	NA	NA
Chicago Avenue to Columbus Drive	2	5.87	2.09	9.64	NA	NA	NA
IHC Wetland	0	NA	NA	NA	NA	NA	NA
Overall	**6**	**3.89**	**0.434**	**9.64**	**0.434**	**4.36**	**3.41**
Lake George Branch							
Indianapolis Boulevard to B & O Railroad Bridge	3	5.88	2.66	11.8	2.66	3.19	3.19
B & O Railroad Bridge to Fill Area	6	6.15	0.367	14.2	0.367	9.87	5.40
Lake George Wetlands	1	0.0457	0.0457	0.0457	NA	NA	0.0457
Overall	**10**	**5.46**	**0.0457**	**14.2**	**0.0457**	**11.8**	**3.20**
US Canal							
Columbus Drive to Forks	33	20.9	4.35	57.9	4.90	43.0	13.8
Indianapolis Boulevard to Forks	18	12.8	0.178	37.8	0.207	34.4	6.72
Forks to Highway 912	23	14.9	0.0557	45.3	0.222	36.5	6.71
Highway 912 to Dickey Road	6	2.45	0.0522	5.28	0.0522	5.18	2.08
Dickey Road to B & O Railroad Bridge	12	34.2	0.222	170	0.256	67.9	8.21
B & O Railroad Bridge to IH	9	3.23	0.225	5.04	0.225	4.96	3.47
Overall	**101**	**17.0**	**0.0522**	**170**	**0.245**	**38.8**	**7.25**

Table 14.3. Summary of the distribution of mean PEC-Qs in sub-surface sediments in the Assessment Area.

Reach Segment	Number of Samples	Average of Mean PEC-Q	Minimum Mean PEC-Q	Maximum Mean PEC-Q	10th Percentile	90th Percentile	Median
IH and nearshore areas of Lake Michigan							
Indiana Harbor	23	2.45	0.0412	7.19	0.0607	5.90	1.81
Nearshore areas of Lake Michigan	1	0.136	0.136	0.136	NA	NA	NA
Overall	**24**	**2.35**	**0.0412**	**7.19**	**0.0607**	**5.90**	**1.75**

NA = not applicable.

Table 14.4. Summary of the available information on SEM-AVS in the Assessment Area.

Reach/Segment	n	Number of Samples with SEM > AVS[1]	Percent Samples with SEM > AVS[1]
Grand Calumet River Lagoons	5	0	0%
East Branch Grand Calumet River-I	105	51	49%
East Branch Grand Calumet River-II	0	NA	NA
West Branch Grand Calumet River-I	9	5	56%
West Branch Grand Calumet River-II	0	NA	NA
Indiana Harbor Canal	11	10	91%
Lake George Branch	30	4	13%
US Canal	5	0	0%
Indiana Harbor / Lake Michigan	2	0	0%
Overall	**169**	**70**	**41%**

[1]As determined using the molar concentrations of simultaneously extracted metals (SEM) and acid volatile sulfides (AVS).
n = number of samples.
NA = not applicable.

Table 14.5. Summary of mIBI scores for the various reaches in the Assessment Area, 1993-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
October, 1993	1								2.8	
September, 1994	1								2.2	
October, 1996	1		2.1	1.3		1.1			1.7	
	2		2.4			1.7				
August, 1998	1		1.40		0.87		1.13	0.87	0.33	0.8
	2		1.13		0.53		1.07	0.40	0.20	
	3		1.67				1.07	0.87		
	4		1.13							
	5		0.87							
	6		0.87							
Average mIBI Score		NA	1.4	1.3	0.7	1.4	1.1	0.7	1.4	0.8
Standard Deviation		NA	0.57	NA	0.24	0.42	0.03	0.27	1.15	NA
Number of Samples		0	8	1	2	2	3	3	5	1

Sources: Sobiech *et al.* (1994); Simon and Stewart (1998); Simon *et al.* (2000).
NA = not applicable.

Table 14.6. Summary of QHEI scores for the various reaches in the Assessment Area, 1993-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
September, 1992	1				65.5	57.9				
	2					50.7				
	3					54.7				
	4					51.8				
	5					56.9				
	6					46.0				
June-July 1994	1		48	22						
	2			41						
	3			46						
	4			51						
1998	1		47.4		48.6	49.7	16	16	18	17
	2		41.3		49.7		24	45.2	21	
	3		45.2				24			
	4		42.8							
	5		48.8							
	6		43.0							
	7		39.5							
	8		42.5							
	9		48.6							
Average QHEI Score		NA	44.7	40	54.6	52.5	21.3	30.6	19.5	17
Standard Deviation		NA	3.34	12.68	9.46	4.23	4.62	20.65	2.12	NA
Number of Samples		0	10	4	3	7	3	2	2	1

Sources: Sobiech *et al.* (1994); Simon and Stewart (1988); Simon *et al.* (2000).

NA = not applicable.

Table 14.7. Summary of assessment of effects on fish and wildlife resources.

Reach/Segment	Indicator of Effects on Fish and Wildlife Resources[1] Toxicity to Fish[2]	Fish Health[3]	Fish Community[4]	Whole Sediment Chemistry[5]	Tissue Chemistry[6]	Number of Lines of Evidence for Demonstrating Ecosystem Impacts
Grand Calumet River Lagoons	14% (n=7)	0% (n=12)	38% (n=13)*	84% (n=58)*	100% (n=18)*	3
East Branch Grand Calumet River-I	57% (n=23)*	40% (n=10)*	100% (n=29)*	74% (n=110)*	100% (n=22)*	5
East Branch Grand Calumet River-II	85% (n=40)*	75% (n=4)*	100% (n=22)*	66% (n=90)*	100% (n=5)*	5
West Branch Grand Calumet River-I	ID (n=0)	100% (n=3)*	100% (n=12)*	29% (n=7)*	100% (n=7)*	4
West Branch Grand Calumet River-II	100% (n=7)*	100% (n=1)	100% (n=17)*	18% (n=17)*	100% (n=5)*	4
Indiana Harbor Canal	ID (n=0)	33% (n=3)	100% (n=4)*	93% (n=15)*	100% (n=7)*	3
Lake George Branch	ID (n=0)	50% (n=2)	50% (n=2)	83% (n=29)*	ID (n=0)	1
US Canal	ID (n=0)	50% (n=2)	100% (n=8)*	84% (n=37)*	100% (n=18)*	3
Indiana Harbor / Lake Michigan	ID (n=0)	100% (n=1)	100% (n=1)	88% (n=33)*	86% (n=21)*	2
Overall	**71% (n=77)***	**39% (n=38)***	**92% (n=108)***	**74% (n=396)***	**97% (n=103)***	**5**

[1] For each line of evidence, sediment injury is indicated if two or more samples have conditions sufficient to cause or substantially contribute to sediment injury. Evidence of sediment injury is denoted with an asterisk (*).

[2] Percent of sediment samples that were toxic to fish in laboratory tests.

[3] Percent of fish samples with > 1.3% DELT abnormalities.

[4] Percent of fish samples with IBI scores of $\leq$34 (i.e., poor, very poor, or no fish).

[5] Percent of sediment samples with one or more chemical concentrations in excess of the bioaccumulation SQGs for wildlife.

[6] Percent of fish and invertebrate tissue samples with one or more chemical concentrations in excess of the TRGs for wildlife.

ID = insufficient data; n = number of samples.

Table 14.8. Summary of DELT scores for the various reaches in the Assessment Area, 1993-1998.

Date	Sample	Reach								
		Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
October, 1993	1	0								
	2	0								
	3	0								
	4	0								
	5	0								
	6	0								
	7	0								
	8	0								
	9	0								
	10	0								
	11	0								
	12	0								
June-July, 1994	1		2.7	5.6						
	2			8.0						
	3			17.4						
	4			0						
September, 1992	1				10.8					
1998	1		0		6.15	2.8	6.15	1.68	0	12.8
	2		0.74		2.8		0	0	3.28	
	3		1.57				0.36			
	4		0							
	5		0.65							
	6		0.7							

Table 14.8. Summary of DELT scores for the various reaches in the Assessment Area, 1993-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
1998 (cont.)	7		0.15							
	8		2.4							
	9		6.15							
Average DELT Score		0	1.5	7.8	6.6	2.8	2.2	0.8	1.6	12.8
Standard Deviation		NA	1.89	7.25	4.02	NA	3.45	1.19	2.32	NA
Number of Samples		12	10	4	3	1	3	2	2	1

Sources: Sobiech *et al.* (1994); Simon and Stewart (1998); Simon *et al.* (2000); Simon (1993)

NA = not applicable.

DELT score = % incidence of deformities, fin erosion, lesions, and tumors.

Table 14.9. Summary of IBI scores for the various reaches in the Assessment Area, 1985-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
October, 1985	1		24	24		24				
	2		24			0				
June, 1986	1	32	24	26	22	22			24	
	2		24	24						
October, 1986	1		30	28	20	20			26	
	2		28	28						
April, 1987	1		22	30	24	24	22			
	2		22	32	22	24				
	3		22	24						
April, 1987	1		24	24	22	22			28	
	2		26	26						
November, 1987	1		30	32	0	0			34	
	2		30	30						
May, 1988	1		22	26	0	0				
	2		24	24						
July, 1988	1		32	28	0	0			24	
	2		26	26						
July, 1990	1		20	24	21	21			16	
	2		32	32						

Table 14.9. Summary of IBI scores for the various reaches in the Assessment Area, 1985-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
September, 1992	1				29	24				
	2					24				
	3					12				
	4					12				
	5					19				
June, 1994	1		22	12						
	2			18						
	3			22						
	4			22						
1994	1	42								
	2	42								
	3	42								
	4	34								
	5	32								
	6	31								
	7	38								
	8	32								
	9	43								
	10	43								
	11	42								
	12	42								
1998	1		16		16	22	16	14	12	14
	2		22		22		12	38	18	
	3		16				20			

Table 14.9. Summary of IBI scores for the various reaches in the Assessment Area, 1985-1998.

Date	Sample	Reach: Grand Calumet River Lagoons	East Branch Grand Calumet River-I	East Branch Grand Calumet River-II	West Branch Grand Calumet River-I	West Branch Grand Calumet River-II	Indiana Harbor Canal	Lake George Branch	US Canal	Indiana Harbor/ Lake Michigan
1998 (cont.)	4		18							
	5		20							
	6		24							
	7		24							
	8		26							
	9		18							
Average IBI Score		38.1	23.9	25.5	16.5	15.9	17.5	26.0	22.8	14.0
Standard Deviation		5.0	4.3	4.7	10.4	9.8	4.4	17.0	7.1	NA
Number of Samples		13	29	22	12	17	4	2	8	1
Percent Altered		38%	100%	100%	100%	100%	100%	50%	100%	100%
Classification for Average Score		fair-poor	poor-very poor	poor-very poor	very poor	very poor	very poor	poor-very poor	poor-very poor	very poor

Sources: Sobiech *et al.* (1994); Simon and Stewart (1988); Simon (1993); Stewart *et al* . (1999); Simon *et al.* (2000).

An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan

Volume III - Figures

Prepared for:

U.S. Fish and Wildlife Service
Bloomington Field Office
620 South Walker Street
Bloomington, Indiana 47403

Prepared – October 2000 – by:

Donald D. MacDonald
MacDonald Environmental Sciences Ltd.
2376 Yellow Point Road
Nanaimo, British Columbia
V9X 1W5

Christopher G. Ingersoll
Columbia Environmental Research Center
United States Geological Survey
4200 New Haven Road
Columbia, Missouri 65201

In Association with:
Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, Massachusetts
02140

An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan

Volume III - Figures

Prepared for:

U.S. Fish and Wildlife Service
Bloomington Field Office
620 South Walker Street
Bloomington, Indiana 47403

Prepared – October 2000 – by:

Donald D. MacDonald
MacDonald Environmental Sciences Ltd.
2376 Yellow Point Road
Nanaimo, British Columbia
V9X 1W5

Christopher G. Ingersoll
Columbia Environmental Research Center
United States Geological Survey
4200 New Haven Road
Columbia, Missouri 65201

In Association with:

Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, Massachusetts 02140

Volume III - Figures (under this cover)

Other Volumes in this Report
Volume I - Text
Volume III - Figures
Volume IV - Appendices

Chapter 5

Chapter 6

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Chapter 11

Chapter 12

Chapter 13

Chapter 14

List of Acronyms

%	percent
10-d	10 days
12-d	12 days
14-d	14 days
15-min	15 minutes
20-d	20 days
2,3,7,8-TCDD	tetrachlorodibenzo-*p*-dioxin
28-d	28 days
30-min	30 minutes
48-h	48 hours
7-d	7 days
8-d	8 days
96-h	96 hours
AOC	Area of Concern
ARCS Program	Assessment and Remediation of Contaminated Sediments in the Great Lakes Program
ASTM	American Society for Testing and Materials
AVS	acid volatile sulfides
BSAF	biota-sediment bioaccumulation factor
CCBP	Central Corn Belt Plain
CCME	Canadian Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601 et seq.
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CI	confidence interval
CSO	combined sewer overflow
DDTs	*p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDE, *o,p*'-DDE, *p,p*'-DDD, *o,p*'-DDD, and any metabolite or degradation product
DELT	deformities, fin erosion, lesions, and tumors
DL	detection limit
DO	dissolved oxygen
DQO	data quality objective
DuPont	E.I. du Pont de Nemours
DW	dry weight
EB	east branch
EBGCR	East Branch of the Grand Calumet River
EBGCR-I	East Branch of the Grand Calumet River I

EBGCR-II	East Branch of the Grand Calumet River II
EC	Environment Canada
EC_{50}	median effective concentration
ECBP	Eastern Corn Belt Plain
EPT	Ephemeroptera, Plecoptera, Trichoptera
FIELDS	Fully Integrated Environmental Location Decision Support
gamma-BHC	gamma-hexachlorocyclohexane (lindane)
GCRL	Grand Calumet River Lagoons
GIS	geographic information system
HC	Health Canada
HNTB	Howard, Needles, Tammen and Bergendoff Architects, Engineers, and Planners
IBI	Index of biotic integrity
ID	insufficient data
IDEM	Indiana Department of Environmental Management
IEC	Industrial Economics, Inc.
IH	Indiana Harbor
IHC	Indiana Harbor Canal
IJC	International Joint Commission
IL	Illinois
IN	Indiana
LC_{50}	median lethal concentration
LEP	Little East Pond
LGB	Lake George Branch
LM	Lake Michigan
LTI	Limno-Tech, Inc.
LWP	Little West Pond
mean PEC-Q	mean probable effect concentration quotient
MESL	MacDonald Environmental Sciences Ltd.
mg	milligrams
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mIBI	macroinvertebrate index of biotic integrity
mm	millimeters
MS	Microsoft
n	number of samples
NA	not applicable (i.e., all <DL values were >PEC; therefore total was not calculated)
NA'	not applicable (i.e., toxicity test or chemical analyses not performed).
ND	not determined; compounds were measured as less than the detection limit, but the detection limit is unknown
ND'	not determined; toxicity not determined because mortality was > 40%
ND"	not determined; the lab considered sample to be a hazard to personnel

NE	northeast
NG	no guideline available
NH_3	unionized ammonia
NH_4^+	ionized ammonia
NIPSCO	Northern Indiana Public Service Company
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge and Elimination System
NR	not reported
NRDA	Natural Resource Damage Assessment
NT	not toxic
NW	northwest
NYSDEC	New York State Department of Environmental Conservation
OC	organic carbon
OEPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	probable effect concentration (consensus-based)
PEC-Q	probable effect concentration quotient
QA/QC	quality assurance/quality control
QHEI	qualitative habitat evaluation index
RCRA	Resource Conservation and Recovery Act
RETEC	Remediation Technologies, Inc.
S.U.	standard unit
SAB	Science Advisory Board
SE	southeast
SEC	sediment effect concentration (consensus-based)
SEM	simultaneously extracted metals
SEM-AVS	simultaneously extracted metal minus acid volatile sulfides
SETAC	Society of Environmental Toxicology and Chemistry
SOD	sediment oxygen demand
SQG	sediment quality guideline
STP	sewage treatment plant
sum DDD	*p,p*'-DDD + *o,p*'-DDD
sum DDE	*p,p*'-DDE + *o,p*'-DDE
sum DDT	*p,p*'-DDT + *o,p*'-DDT
SVOC	semi-volatile organic chemical
SW	southwest
T	toxic
TEC	threshold effect concentration (consensus-based)
ThermoRetec	ThermoRetec Consulting Corporation
TOC	total organic carbon
Total DDT	*p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDE, *o,p*'-DDE, *p,p*'-DDD, and *o,p*'-DDD
TRG	tissue residue guideline

U.S. Steel	United States Steel (Division of USX Corporation)
USACE	United States Army Corps of Engineers
USC	United States Canal
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USS Lead	USS Lead Refinery, Inc.
VOC	volatile organic compound
WB	west branch
WBGCR	West Branch of the Grand Calumet River
WBGCR-I	West Branch of the Grand Calumet River I
WBGCR-II	West Branch of the Grand Calumet River II
WW	wet weight
WWTP	wastewater treatment plant
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µmol/g	micromoles per gram

Figure 1.1. Map of study area.