RESTORATION AND COMPENSATION DETERMINATION PLAN

GRAND CALUMET RIVER/INDIANA HARBOR CANAL NATURAL RESOURCE DAMAGE ASSESSMENT

Prepared for

U.S. Fish and Wildlife Service and the
Indiana Department of Environmental Management

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List Of Exhibits

INTRODUCTION

Background Information and Contents of this Document

Who are the Grand Calumet River / Indiana Harbor Canal Natural Resource Trustees?

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, more commonly known as the federal "Superfund" law) [42 USC §§ 9601; et seq.], the Federal Water Pollution Control Act (CWA, commonly known as the Clean Water Act) [33 USC §§ 1251, et seq.] and the Oil Pollution Act (OPA) [33 USC §§ 2701, et seq.] authorize States, federally recognized Tribes, and certain federal agencies that have the authority to manage or control natural resources to act as "trustees" on behalf of the public and to bring claims against responsible parties for damages to restore, replace or acquire natural resources equivalent to those harmed by the release of hazardous substances and oil (sometimes collectively referred to as “restoration”.) The State of Indiana (represented by the Indiana Department of Environmental Management [IDEM] and the Indiana Department of Natural Resources [IDNR]), the United States Department of the Interior (represented by the Fish and Wildlife Service [FWS] and the National Park Service [NPS]), and the United States Department of Commerce (represented by the National Oceanic and Atmospheric Administration [NOAA]) (collectively the "trustees") have worked together with the United States Environmental Protection Agency to determine what actions are necessary to address natural resource injuries caused by past releases of hazardous substances and oil to the Grand Calumet River, Indiana Harbor, and Indiana Harbor Canal assessment area (GCR/IHC). CERCLA, the CWA, and OPA require that any natural resource damages received -- either through negotiated settlements or litigation with responsible parties -- must be used to restore, replace, or acquire resources equivalent to injured natural resources.

Releases of hazardous substances and oil to the GCR/IHC occurred over an extended period of time as a result of the actions of various publicly- and privately-held entities. Under CERCLA, OPA, and the CWA, such entities may be held responsible for the costs of conducting a natural resource damage assessment and the costs of implementing restoration actions. These statutes provides for the promulgation of regulations that set up an administrative process for conducting a natural resource damage assessment to determine appropriate damages to restore natural resources injured by hazardous substance releases.[1] These regulations are optional, but trustees who conduct assessments consistent with the regulations are entitled to a rebuttable presumption in any subsequent litigation. The Department of the Interior has been designated as the federal agency responsible for promulgating the CERCLA Natural Resource Damage Assessment (NRDA) Regulations – which are published at 43 CFR Part 11.

What are the Natural Resource Trustees considering for the GCR/IHC ?

[1] The CERCLA NRDA regulations are applicable to releases of hazardous substances covered under both CERCLA and the CWA. Analogous OPA NRDA regulations were promulgated for discharges of oil into navigable waters or the adjoining shoreline at 15 CFR Part 990. At sites such as the GCR/IHC, where natural resource injuries have been caused by a mixture of hazardous substances and oil, the OPA NRDA regulations provide that the CERCLA NRDA regulations are applicable.

Trustees for natural resources in the GCR/IHC assessment area are evaluating projects to restore, replace, or acquire natural resources equivalent to those injured by releases of hazardous substances and oil. The trustees have prepared this Restoration and Compensation Determination Plan (RCDP) in compliance with CERCLA and the CERCLA NRDA regulations, to further inform the public about the natural resource damage assessment and restoration planning efforts that have been conducted. The trustees seek comments on the proposed restoration alternatives presented in this document, and will consider written comments received during the public comment period, and the trustees will respond to these comments in a Report of Assessment..

This RCDP addresses authorities applicable to trustee actions. The CERCLA NRDA regulations provide that trustees should prepare an RCDP as part of the Assessment Plan, to document their evaluation of possible restoration alternatives for the purpose of selecting an appropriate alternative to use in determining cost estimates for restoring, replacing, or acquiring resources equivalent to the injured resources (43 CFR §11.81(a)(2)).[2] The methods for determining such cost estimates are described in Appendix B.

In addition to the requirements of CERCLA and the CERCLA NRDA Regulations, the restoration alternatives evaluated in this RCDP must also conform with other legal authorities. The restoration alternatives considered in this RCDP are subject to the National Environmental Policy Act's (NEPA) requirements for considering the environmental impacts of certain proposed actions before undertaking implementation. Some restoration alternatives may also involve the permit and certification requirements of sections 404 and 401 of the CWA.

This RCDP, however, is not a blueprint for the performance of specific actions. As provided by the CERCLA NRDA regulations, the RCDP is part of a process for determining the appropriate amount of restoration necessary to address natural resource injuries. Before beginning actual implementation of any alternatives identified in the RCDP with recovered damages, the trustees must produce a Restoration Plan, or adopt portions of an existing restoration plan -- as described in section 111(i) of CERCLA -- which must comply with NEPA, and any other applicable legal and permitting requirements. Nevertheless, it is appropriate and practical for the trustees to conduct a preliminary analysis of the requirements of certain authorities in the evaluation of alternatives, as briefly discussed below:

NEPA requires an assessment of any federal action that may significantly impact the human environment. The requirements of NEPA apply to some natural resource restoration actions undertaken by federal trustees. NEPA and the CERCLA natural resource damage provisions share similar goals. NEPA calls for promoting efforts that will "prevent or eliminate damage to the environment", while CERCLA provides for "the protection and restoration of natural resources damaged" by hazardous substance releases. NEPA establishes a national policy calling for the federal government to use all practicable means to "fulfill the responsibilities of each generation as trustee of the environment for succeeding generations."

[2] Trustees also may, at their discretion, calculate the monetary value of natural resource "services" -- including human use and enjoyment -- that the public has lost because of natural resource injuries. As described in more detail below, the trustees have chosen to focus their efforts on addressing service losses through the restoration, replacement, or acquisition of resources equivalent to those injured, and therefore do not describe methods for determining the monetary value of human use and enjoyment losses.

CERCLA similarly authorizes the federal government, along with States and Tribes, to “act on behalf of the public as trustee” for natural resources. Accordingly, the trustees are including a preliminary analysis of the environmental consequences in their comparative evaluation of alternatives for restoring, replacing, or acquiring equivalent natural resources, in consideration of NEPA.

Some of the restoration alternatives considered in this RCDP involve activities that in wetlands and waters of the United States. Section 404 of the CWA requires a permit from the U.S. Army Corps of Engineers for the discharge of any dredge of fill materials into the waters of the United States. Section 401 of the CWA requires States to certify that any federally permitted or licensed activity that might result in a discharge to waters of the United States – including a section 404 permit – will not violate applicable water quality standards established by the State. These types of actions would be subject to review and approval by the appropriate regulatory agencies. Generally, these permits will be subject to their own NEPA analysis.

How is the Trustee’s Evaluation Orgainized?

After the brief summary of findings below, the remainder of the document is structured as follows:

- The first two sections of the report describe the purpose of and need for the proposed action. The first section includes a summary of damage assessment activities to date; the results of these activities are described in the second section.

- The third section describes the alternatives under consideration and summarizes the trustees' evaluation of each.

- The "Affected Environment" section is fourth and summarizes background information on the GCR/IHC from a wide range of sources. It also provides a basis for understanding the effects of hazardous substance releases on the GCR/IHC environment.

- The evaluation presented in the fifth section ("Environmental Consequences") supports the trustees’ identification of on-site restoration as the preferred alternative.

- The appendices provide more detail on the results of assessment activities (Appendix A) and the preliminary screening of restoration alternatives (Appendix B).

Summary of Findings

The findings of the trustees with respect to restoration of the Grand Calumet River/Indiana Harbor Canal (GCR/IHC) are as follows:

- **Natural resource injuries have occurred** - Sediments throughout the project area contain contaminants at levels several times higher than what previous studies have shown to be sufficient to injure and destroy sediment-dwelling organisms. Contaminated sediments impair the aquatic and adjacent upland ecosystems and the fish, migratory birds, and wildlife that inhabit them through direct exposure and uptake of contaminants through the food web. Numerous advisories that severely limit the consumption of fish and waterfowl because of toxic effects are in place in the assessment area. Such advisories are a *de facto* injury under the Natural Resource Damage Regulations at 43 CFR §11.62(f)(1)(iii).

- **Restoration of the GCR/IHC is the preferred alternative of the trustees -** Restoration of the waterway is the most ecologically beneficial and effective means to restore long-term, sustainable use of the unique natural resource services provided by the GCR/IHC ecosystem, and is the fundamental objective of the trustees.

- **Removal of contaminated sediments is the preferred approach to achieve restoration of the GCR/IHC** - Effective restoration of the aquatic and riparian ecosystems is best accomplished by removing a substantial amount of contaminated sediments from the environment of the GCR/IHC. The combination of the range of contaminants found in the GCR/IHC and their distribution in the sediments make treatment or isolation infeasible. Dredging of the contaminated sediments provides the best long-term environmental benefit to the GCR/IHC.

- **Removal of contaminated sediments is economically feasible -** When considered in light of other activities that are ongoing in the area, negotiated settlements with cooperating PRPs and potential damage awards from others could provide a significant portion of the financial resources necessary to accomplish the preferred alternative. Additionally, the trustees (in partnership with EPA, the Army Corps of Engineers, PRPs, and local authorities) could leverage any settlements or awards by coordinating restoration actions with ongoing navigational dredging projects, local sediment management options, and the availability of funds from the Army Corps of Engineers for the enhancement of fish and wildlife under the Water Resources Development Act.

PURPOSE OF THE PROPOSED ALTERNATIVE

Why are the trustees considering the proposed alternative?

Statutory Mandate

As previously discussed, CERCLA, OPA, and the CWA direct natural resource trustees to identify natural resources injured by hazardous substance releases; to evaluate the extent of such injuries; and (when appropriate) to pursue legal claims against responsible parties for the funding and/or implementation of projects that restore, replace, or acquire natural resources equivalent to those injured. To determine the magnitude of natural resource injury and the damages necessary to address it, the trustees are conducting a damage assessment under the authority of Section 107 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, more commonly known as the federal "Superfund" law), 42 U.S.C. § 9607; Section 311 of the Federal Water Pollution Control Act (CWA, commonly known as the Clean Water Act), 33 USC §1321; and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR §300. These laws and their implementing regulations provide procedures by which natural resource trustees can determine compensation for injuries to natural resources that have not been, nor are expected to be, addressed by any response actions.

The CERCLA NRDA Regulations contain guidance on evaluating restoration alternatives in the form of ten factors to consider when evaluating or selecting among possible projects to restore, replace, or acquire the resource equivalent of injured resources (43 CFR 11.82):

1. technical feasibility;
2. the relationship of the cost of the alternative to expected benefits;
3. cost effectiveness;
4. the result of actual or planned response actions;
5. the potential for additional injury resulting from the proposed action;
6. the natural recovery period;
7. ability of the resources to recover with or without alternative actions;
8. potential effects of the action on human health and safety;
9. consistency with relevant federal and state policies; and
10. compliance with relevant federal and state laws.

Accordingly, *the purpose of the proposed GCR/IHC natural resource restoration actions is to use recovered damages in a manner consistent with statutory mandates and regulatory procedures that specify that trustees undertake feasible, safe, cost effective projects to restore, replace or acquire the resource equivalent of injured resources, considering actual and* *anticipated conditions, the likelihood of success, and consistency with applicable laws and policies*.

Typically, NRDA investigations of uncontrolled hazardous waste sites are conducted either contemporaneously with remedial investigations pursued by EPA under CERCLA, or after completion of these investigations. In this case, an EPA action is not pending, nor is one contemplated for the foreseeable future. The trustees have chosen to proceed with an NRDA under the assumption that injuries from past releases of oil and hazardous substances to the GCR/IHC will not be addressed by any other unrelated action. While the trustees intend to minimize or eliminate the impact of *existing* contaminated sediments on the GCR/IHC, control of *future* hazardous substances releases is critical to the process of restoring this resource. Discharge of groundwater and surface runoff to the waterway from the surrounding area may carry significant quantities of contaminants into the system (USGS 2000, 2002). The authority to control the input of these substances to the GCR/IHC rests with other agencies, including EPA and the State of Indiana. The trustees believe that these agencies will successfully limit or eliminate further releases of oil and other hazardous substances to the GCR/IHC, and therefore do not find this category of project a necessary component of the natural resource damage restoration program.

Damage Assessment Activities to Date

The trustees' NRDA at the GCR/IHC site follows the administrative process outlined in the CERCLA NRDA regulations. The objective of this process is to restore resources in the GCR/IHC that have been injured by releases of hazardous substances. The results of this process are contained in a series of planning and decision documents that have been published for public review.[4] These documents include:

- Preassessment Screen and Determination: Grand Calumet River, and Indiana Harbor Canal, Lake County, Indiana. Prepared by USFWS, Indiana Department of Environmental Management, and Indiana Department of Natural Resources. June 1996.

- Assessment Plan for the Natural Resource Damage Assessment of the Grand Calumet River, Indiana Harbor Ship Canal, Indiana Harbor, and Associated Lake Michigan Environments. Industrial Economics, Incorporated. October 1997.

- Initial Restoration and Compensation Determination Plan for the Grand Calumet River, Indiana Harbor Ship Canal, Indiana Harbor, and Associated Lake Michigan Environments: Part I, Restoration Criteria. Prepared by IDEM, IDNR, FWS, NPS, and NOAA. 8 October 1998.

[4] Copies of these documents may be obtained from http://midwest.fws.gov/grandcalumetriver.

- An Assessment of Sediment Injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the Nearshore Areas of Lake Michigan. MacDonald Environmental Services, Ltd. October 2000.

- Surface-Water and Ground-Water Hydrology and Contaminant Detections in Ground Water for a Natural Resource Damage Assessment of the Indiana Harbor Canal and Nearshore Lake Michigan Watersheds, Northwestern Indiana. US Geological Survey. June 2002.

- An Assessment of Injury to 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. MacDonald Environmental Services, Ltd. February 2003.

Description of Project Area

The trustees' damage assessment is focused on the Grand Calumet River, Indiana Harbor Canal and Indiana Harbor, which are an integral part of the Lake Michigan ecosystem, and on the riparian and upland habitats closely associated with these waters, including lands within the boundaries of the Indiana Dunes National Lakeshore. This RCDP only addresses part of the assessment area, as defined by specific river reaches described below. The "project area" covered in this document corresponds to the area covered by the recent settlement with the "Group of Nine" responsible parties.[5] It does not include the most upstream reaches of the East or West Branches, which are covered by other pending and entered settlement agreements, described below.

To distinguish specific areas of the GCR/IHC for their analysis of sediment injury, MacDonald Environmental Services, Ltd (hereafter, MESL) established specific boundaries for ten river "reaches," each denoted by an acronym (MESL, 2000). This RCDP follows those naming conventions (see Exhibit 1). Specifically, the Grand Calumet River comprises two east-west oriented branches that meet at the southern end of the Indiana Harbor Canal (IHC). The east branch of the Grand Calumet River (EBGCR) originates at the Grand Calumet River Lagoons (GCRL), just east of the US Steel Gary Works facility. The EBGCR flows west from this point for approximately ten miles to its confluence with the IHC. We further divide the EBGCR into two segments: EBGCR I runs from the confluence with the IHC east to the ConRail Bridge, with EBGCR II consisting of the remainder from the ConRail Bridge to the GCRL. The west branch of the Grand Calumet River (WBGCR) flows both east and west, with a hydraulic divide typically present in the vicinity of Indianapolis Boulevard. It too is divided into two segments: WBGCR I is that portion east of Indianapolis Boulevard, up to the IHC confluence; WBGCR II runs west from Indianapolis Boulevard to the state line.

[5] The settling responsible parties are Atlantic Richfield Company (and ARCO Environmental Remediation L.L.C.); BP Products North America Inc.; E.I. Du Pont De Nemours and Company; Exxon Mobile Corporation; GATX Corporation; Georgia-Pacific Corporation; ISPAT-Inland Inc., and United States Steel Corporation. Settlement with former LTV Steel is being pursued through Bankruptcy Court.

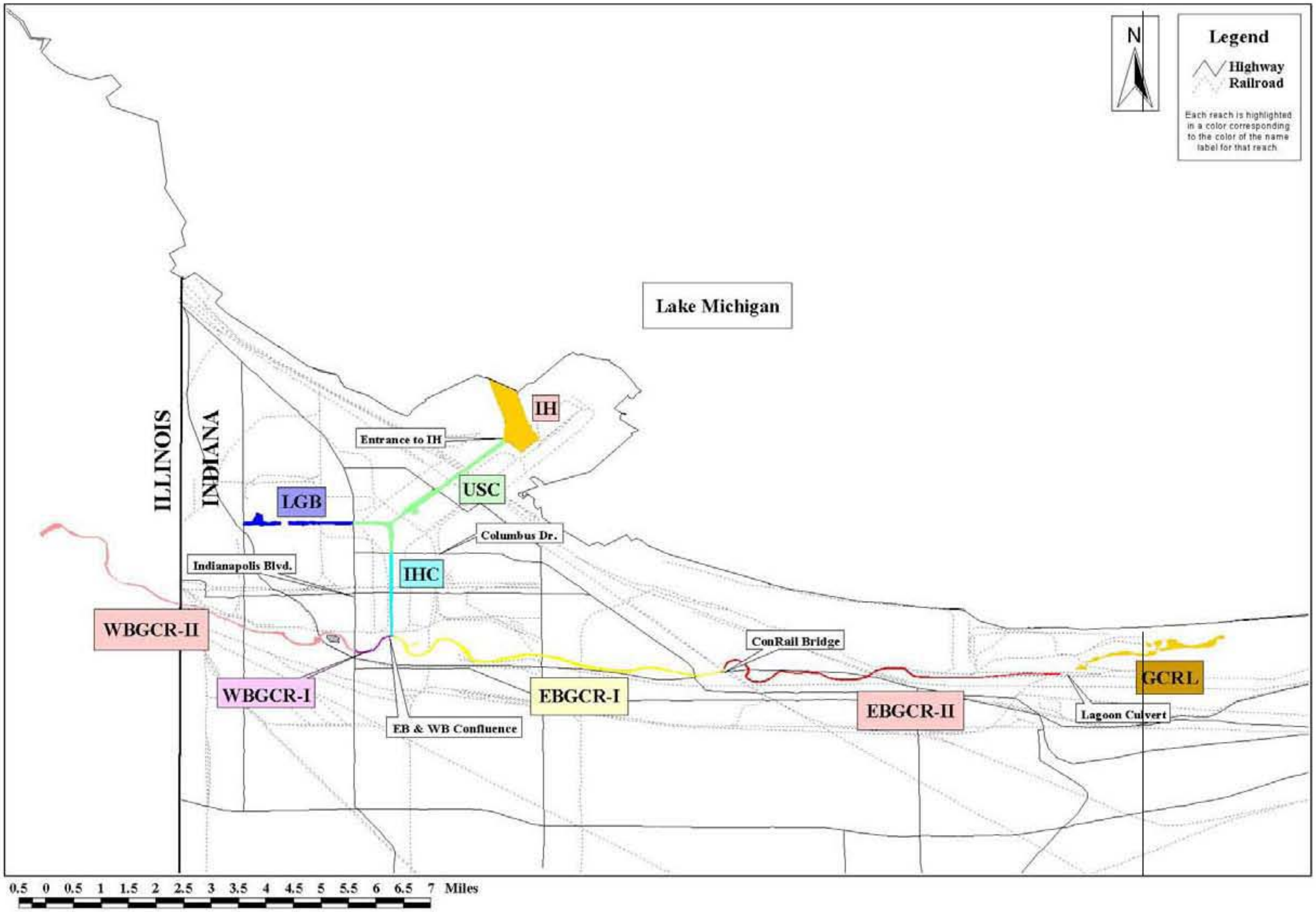
The Indiana Harbor Canal flows north for approximately three miles from its confluence with the east and west branches of the Grand Calumet River before turning to the northeast and flowing for an additional two miles through Indiana Harbor (IH) and into Lake Michigan (LM). MESL use the term Indiana Harbor Canal (IHC) to refer only to the southern portion, extending from the GCR confluence to Columbus Drive. The northern portion consisting of the area north of Columbus Drive up to the entrance to the IH is termed the US Canal (USC). The Lake George Branch (LGB) of the canal extends to the west from the point where the main canal turns to the northeast.

A total of six reaches are included in the project area: WBGCR I, EBGCR I, IHC, LGB, USC, and IH. These are grouped into the "federal project area" (USC and IH) and the "trustee project area" (WBGCR I, IHC, LGB, and EBGCR I). In the federal project area, the Army Corps of Engineers (Corps) is planning to dredge and dispose of contaminated sediment to improve navigation.

Although not included in this RCDP, restoration of other areas of the GCR/IHC is planned. In EBGCR II, two settlements with US Steel Corporation will ensure the eventual recovery of the easternmost five-mile stretch of the GCR adjacent to and downriver from the US Steel Gary Works. The first consent decree will govern sediment remediation through dredging and proper disposal of contaminated sediments as well as implementation of NPDES compliance programs to identify and stop permit violations and unpermitted discharges. The second consent decree will resolve the claims in the NRD action and require US Steel, in addition to implementing the sediment remediation project, to restore the river channel and riparian habitats through removal and control of exotic vegetation; planting of native vegetation and trees; construction and installation of river-channel enhancements such as riffles, snags and structure for fish cover; and river bank contouring and erosion control. US Steel will also provide the trustees with over 100 acres of property to compensate for injuries in the GCRL.

In WBGCR II, previous settlements with industrial users of the Hammond Sanitary District resulted in the establishment of the Grand Calumet River Restoration Fund (GCRRF) in 1997. The Fund is intended to address sediment contamination and restore natural resources in the West Branch of the Grand Calumet River. It is administered by a Council consisting of representatives from IDEM, IDNR, FWS Region 3, and United States Environmental Protection Agency Region 5. To date, the Council has identified data gaps necessary for development of restoration alternatives, has completed sample collection efforts to fill these data gaps, and is analyzing the data collected in order to develop draft remedial alternatives for the West Branch. Once drafted, a public process of evaluating these alternatives will begin.

Exhibit 1. Map of study area showing reach boundaries.



NEED FOR THE PROPOSED ALTERNATIVE

This section describes the problem that the trustees seek to address. It first briefly presents background information on the primary contaminants of concern found in the GCR/IHC. It then summarizes the results of injury assessment activities in the GCR/IHC. It concludes by explaining how the assessment results can be categorized as injuries to natural resources, as described in the Department regulations.

Contaminants of Concern

Years of releases by the various industries that have used the river system for wastewater discharge and drainage have resulted in contamination of the resources of the GCR/IHC with a variety of contaminants of potential concern. The focus of the damage assessment has been on polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and metals.

- Because of their chemical stability, PCBs degrade slowly and may reside in the environment for decades or longer (Erickson 1997). In addition, since PCBs are hydrophobic with low water solubility, they adsorb to materials such as organic matter in sediment. Higher trophic level organisms, such as fish and birds, may accumulate PCBs directly from the water column or sediment, or through the ingestion of contaminated food. PCBs are associated with a range of deleterious effects, including impaired reproductive ability in fish, mammals, and birds (Eisler 2000).

- PAHs are a subcategory of aromatic hydrocarbons and a component of crude and refined oils.[6] PAHs can also form as products of incomplete combustion. PAHs of different molecular weight vary substantially in their behavior and distribution in the environment and in their biological effects. Simple, lower-molecular-weight PAHs have significant acute toxicity to some organisms, while some higher-molecular-weight PAHs are known or suspected carcinogens (Eisler 2000). Sixteen PAHs are classified as priority pollutants by the USEPA (MESL 2000).

- Those metals commonly referred to as "heavy metals" are often associated with anthropogenic sources and are toxic to a wide range of organisms. This group includes metals known to be essential to organisms (*e.g.*, copper, iron, manganese, and zinc) as well as nonessential metals such as cadmium, lead, and mercury (Rainbow 1996). Lead and mercury are two of the most toxic metals found in the GCR/IHC.

[6] Note that releases of oil to the environment are covered under the Oil Pollution Act (OPA) (33 U.S.C. 2701 *et seq.*), but mixtures of oil and hazardous substances such as are found in the GCR/IHC are covered by CERCLA (15 CFR §990.20(c)).

Results of Injury Assessment Activities

Investigations conducted by the trustees and other organizations have found that the contaminants described above are present in the sediments of the GCR/IHC, often at very high levels compared to unaffected sites in southern Lake Michigan. For example, nearly 90 percent of sediment samples collected in the USC, WBGCR I, and IH contained PAHs in excess of 22.8 ppm, the level at which an adverse effect on sediment-dwelling organisms is likely to occur (MacDonald *et al.* 2000a). In EBGCR I, two samples contained over two percent PAHs by weight. For comparison, the maximum measured concentration of PAHs in Lake Michigan is less than 0.1 ppm. Exhibit 2 presents the percentage of sediment samples that exceed adverse-effect levels for each reach of the project area for the four major contaminants of concern in the GCR/IHC.

These high levels of contamination have adversely affected the ecosystem and exceed published guidelines for the protection of aquatic resources, often by several orders of magnitude (MacDonald *et al.* 2000a, 2000b). To demonstrate injury to surface water and sediment, the trustees used four metrics: sediment chemistry, porewater chemistry, sediment toxicity, and benthic community status.[7] In the project area, all four metrics indicated injury (MESL, 2000). Sediment toxicity studies, in particular, have demonstrated the severity of the contamination. ***Even when diluted with clean sediment substrate by a factor of 20, sediments from the EBGCR I were acutely toxic to benthic macroinvertebrates*** (Ingersoll *et al.*, 2004). Researchers conducting toxicity testing on GCR/IHC sediments have noted that "the sediments from the [GCR/IHC] assessment area are among the most contaminated and toxic sites that have ever been reported" (Ingersoll *et al.* 2002). Appendix A provides more detail on the results of sediment injury assessment in the GCR/IHC, including on the levels of contaminants in each reach of the project area.

Exhibit 2

PERCENT OF SEDIMENT SAMPLES IN SEGMENTS OF THE GCR/IHC EXCEEDING PROBABLE EFFECTS CONCENTRATION[1]

Reach	tPAH	Sum PCB	Lead	Mercury
WBGCR I	88%	100%	88%	68%
IHC	76%	86%	73%	45%
LGB	50%	78%	88%	22%
USC	91%	81%	88%	69%
IH	87%	53%	76%	0%
EBGCR I	70%	76%	77%	33%
Lake Michigan	0%	0%	6%	0%

[1] A Probable Effects Concentration (PEC) is the concentration above which an adverse effect on sediment-dwelling organisms is more likely than not to occur. PECs as published in MacDonald *et al*, 2000a: tPAH, 22.8 ppm; Sum PCB, 0.68 ppm; Lead, 128 ppm; Mercury, 1.06 ppm.

[7] Surface water (which includes bed and bank sediments) is defined as injured if it contains concentrations of substances in excess of drinking water standards or water quality criteria, or sufficient to have caused injury to other natural resources (43 CFR §11.62(b)).

Contaminated sediments in the GCR/IHC adversely affect other biological resources. Fish, terrestrial wildlife, and aquatic birds feeding on aquatic insects and benthic organisms are exposed to contaminants accumulated in their prey, and may themselves accumulate deleterious levels of the contaminants through biomagnification.[8] In an assessment of five metrics of injury to wildlife, the trustees found that at least three of these metrics (fish community structure, whole sediment chemistry, and tissue chemistry) suggested injury in four out of six segments of the project area.[9] In all segments with sufficient data, levels of contaminants in sediment and in fish and invertebrate tissue exceed relevant guidelines for protection of aquatic wildlife. Injury to wildlife is also directly observable on the waterway, where oiled waterfowl are commonly seen with reduced buoyancy or having difficulty attaining flight (Hudak 1996a).

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 (MESL 2003). 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.

Due to their chemical characteristics, contaminants found in GCR/IHC sediments are expected to persist for long periods of time. Metals do not degrade and PCBs are highly resistant to transformation in the environment, as are higher molecular weight PAHs. For this reason, the trustees believe that the levels of contaminants found in the GCR/IHC will not substantially decline due to natural processes over the foreseeable future. As a result, the harmful effects of these contaminants are expected to persist indefinitely.

Other organizations have recognized the severity of the contamination in the GCR/IHC. As a Great Lakes Area of Concern (AOC) designated by the International Joint Commission (IJC), the Grand Calumet River is the subject of ongoing evaluation and monitoring outside of the trustees' NRDA process. The IJC prepared a Stage II Remedial Action Plan (RAP) for the GCR in 1997 (IDEM 1997). This document indicates that all 14 of the beneficial uses defined by the IJC are impaired in the GCR/IHC. It is the only one of the 43 AOCs where this is true (Stewart and Butcher, undated). Finally, the Indiana Board of Health has issued advisories not to eat fish caught in the GCR/IHC. Based on the information presented above, the trustees believe that the GCR/IHC is one of the most heavily polluted waterways in the country.

[8] Biomagnification refers to the accumulation of a chemical in an organism at higher levels than found in its food.

[9] Note that the trustees are preparing a separate report evaluating injury to non-aquatic wildlife in the assessment area that will consider other injury metrics, including effects on reproductive success.

Preliminary Assessment of Injured Natural Resources

The DOI regulations define five categories of natural resources for which damages may be sought: surface water (including both the water column and associated bed or bank sediments), ground water, air, geological, and biological.

Surface water resources in the GCR/IHC (which include bed and bank sediments in the waterway itself) have been and continue to be the principal receptors of hazardous substances and oil released to the environment of the assessment area. As summarized above, the river has suffered a significant loss of services due to contamination of bed sediments.[10] In healthy ecosystems, surface water and sediment also support biological resources such as fish and wildlife. In the GCR/IHC, the contaminated sediments do not fully support these biological resources. This has led to an additional loss of ecological and human use functions or "services", as described below under the heading "Biological resources."

Ground water resources in the assessment area are not used as a public drinking water supply. As a result, the trustees have not assessed the loss of services associated with contamination of ground water. Nevertheless, a study by the US Geological Survey confirms that ground water in the GCR/IHC watershed is contaminated with a wide variety of chemical contaminants and that this contaminated ground water commonly discharges to the major surface water bodies (*i.e.*, Grand Calumet River, Indiana Harbor Canal, and Lake Michigan) in the area (USGS, 2002). Thus, ground water in the assessment area serves as a pathway for contaminants to surface water resources.

Geologic resources include soils and sediments that are not included in the definition of surface water or ground water resources. In this case, geologic resources include the soils and sediments located in upland and wetland areas closely associated with the GCR/IHC and the upland areas of the Indiana Dunes National Lakeshore. Areas of wetlands occur in several locations within the GCR/IHC. Wetlands can be found throughout the GCR corridor, including the Grand Calumet River Lagoons (*aka* Marquette Park Lagoons). Wetlands are also found in the Roxanna Marsh located on the West Branch of the Grand Calumet River and in the upper reaches of the Lake George Branch. Wetlands provide many services, including forage and habitat for aquatic, terrestrial, and avian wildlife. The trustees are assessing injury to geologic resources in Roxanna Marsh.

Biological resources are a key component of this damage assessment. Contamination in the GCR/IHC has affected a wide variety of biological resources, including fish, birds, and benthic invertebrates. While these organisms are often thought of in terms of the human-use services they provide (*e.g.*, wildlife viewing, fishing), other elements of the ecosystem also benefit from their presence. Ecosystem services provided by biological resources include soil and sediment bioturbation, seed dispersal, food for other organisms, and predation/population control. As described in more detail in Appendix A, the trustees believe that biological resources in the GCR/IHC have been injured by releases of oil and hazardous substances, and are preparing reports documenting this.

[10] Human use services provided by surface water include contact and non-contact recreation, both of which are severely impaired in the GCR/IHC.

Air resources are typically assessed in the context of their ability to serve as a pathway for hazardous substances to reach other resource categories. Because the air pathway is assumed to play a minor role in causing the potential injuries in the GCR/IHC, the trustees did not consider an assessment of air resources to be a cost-effective use of available resources.

ALTERNATIVES

This section describes the courses of action available to the natural resource trustees. As specified in the DOI regulations, trustees may seek compensation for natural resource injury through the funding and/or implementation of projects to restore, replace, or acquire resources equivalent to those injured (43 CFR §11.13(e)(3)). There are three practical alternatives available to the trustees to accomplish restoration. First, the trustees could wait for the resource to recover naturally, without active intervention (43 CFR §11.82(c)(2)). This corresponds to the "no action" alternative. Second, the trustees could implement restoration and/or rehabilitation actions to directly repair the injured natural resources (43 CFR §11.82(b)(1)(i)). Third, if restoration is infeasible or undesirable for some reason, the trustees could provide a substitute for the injured resource by replacing or acquiring equivalent resources (43 CFR §11.82(b)(1)(ii)). Replacement or acquisition of equivalent resources could involve restoration projects in locations other than the site of the injury. The sections below describe the three alternatives in greater detail.

Alternative A - No Action/Natural Recovery

Under this alternative, no action would be taken to address the injuries to natural resources in the GCR/IHC. Reduction in contaminant levels in the GCR/IHC would depend on a combination of natural processes (*e.g.*, biodegradation, dispersion, sorption, deposition) that may act to improve sediment quality without active intervention by the trustees or PRPs. Trustees must always consider this alternative.

Natural recovery may be an effective remediation strategy if concentrations of hazardous substances are low enough such that natural processes are expected to reduce contaminant concentrations to a level deemed acceptable in a reasonable time frame. As described earlier, concentrations of hazardous substances in the GCR/IHC sediments are several orders of magnitude above relevant guidelines for the protection of natural resources. The contaminants of concern (*i.e.*, PAHs, PCBs, metals) are typically resistant to degradation in the environment, and it is therefore highly unlikely that contaminant concentrations could be reduced to acceptable levels in a reasonable time frame. Other natural processes (*e.g.,* deposition of clean sediment, dispersal and dilution) are also not expected to adequately prevent exposure of natural resources to the contaminated sediments. Therefore, natural recovery will not result in restoration of the GCR/IHC ecosystem.

The costs of this alternative are low, and there would be no additional environmental impacts as a result of selecting the no action/natural recovery alternative.

Alternative B - Restore/Rehabilitate Injured Resources

This alternative (the proposed action) consists of measures to directly restore the GCR/IHC by managing contaminated sediments and rehabilitating the aquatic ecosystem, with the goal of restoring the area to baseline or near-baseline conditions.[11] For purposes of this discussion, this sometimes referred to as "on-site" restoration. As described above, the sediments in the GCR/IHC are heavily contaminated with a variety of hazardous substances. In order to restore the system to baseline, these contaminants must be removed from the system by dredging, isolated from the system by capping or other means, or treated to reduce or eliminate their toxicity to biota. The technologies available to accomplish these objectives are described in detail in Appendix B. Briefly, they would entail one or more of the following.

- **Removal** of the contaminated sediments could be accomplished using established dredging techniques and equipment. Contaminated sediment removed from the river-bottom by dredging would be placed in temporary confined disposal facilities (CDFs) to allow the sediment to dewater.[12] After dewatering the sediment would be disposed of in either a landfill or a permanent CDF.[13]

- **Isolation** of the contaminated sediments from the ecosystem would also serve to reduce or eliminate the harmful impacts to natural resources described elsewhere in this document. In aquatic ecosystems, this is usually accomplished by capping, the placement of a layer of clean sediment over the contaminated sediment. A variety of placement methods are available, depending on the characteristics of the contaminated sediment, the characteristics of the capping material, and the depth of the water.

- **Treatment** of the hazardous substances to make them less harmful to the environment first requires removal by dredging.[14] The particular treatment method chosen is based on the nature of the contaminant, but most methods rely on mechanical, chemical, or thermal processes to either transform the hazardous substance into a less-hazardous substance or to

[11] The trustees acknowledge that achieving baseline may not be possible for all resources or resource services, at least not in the short term.

[12] Confined Disposal Facilities (CDFs) are designed to eliminate contact between contaminated sediment and the adjacent environment. A confinement zone consisting of a clay layer or special plastic sheeting (*i.e.*, geotextile) is placed on the bottom of the containment area, and dikes or structural walls are constructed around the perimeter to retain the dredged sediment. After the CDF is full, it is capped with another layer of clay and/or geotextile.

[13] The trustees note that the Army Corps of Engineers (Corps) is currently constructing a CDF near the GCR/IHC to receive dredge spoils from navigation dredging of Indiana Harbor and the USC. This CDF may have sufficient capacity to contain sediments dredged from the project area for natural resource restoration purposes.

[14] The trustees do not believe that *in-situ* treatment of the submerged contaminated sediments in the GCR/IHC is feasible.

render it unavailable to biota by binding it in an stable matrix that reduces solubility and leachability.

The trustees performed a preliminary evaluation to assess the feasibility of on-site restoration using one or more of the above technologies. After eliminating those deemed infeasible, the trustees developed a number of restoration options which incorporate one or more of the feasible technologies. These options were evaluated and their costs estimated. Appendix B presents the details of this evaluation.

Based on the preliminary evaluation, removal of the contaminated sediments by dredging is likely to be the only feasible method for restoring the GCR/IHC to baseline conditions. Isolating the contaminated sediments would require placement of a thick layer of clean material to adequately prevent migration of the contaminants and exposure of burrowing organisms. This is not feasible in many stretches of the river because the shallow water depth remaining after capping would result in obstruction of river flow.[15] Treatment is not feasible because no one treatment technology is capable of addressing both metals and organic substances, both of which are found in GCR/IHC sediments. Using multiple treatments in series would be prohibitively expensive, and would still require removal of the sediments from the waterway.

The proposed action reflects the trustees' belief that in-stream, on-site restoration is the best way to restore the injured habitats and simultaneously enhance public use and enjoyment of the natural resources in the GCR/IHC area.

Removing the contaminated sediments would allow the ecosystem to begin to recover from the harmful effects of the hazardous substances. This recovery would be assisted by actions taken to rehabilitate the in-stream habitat (*e.g.*, installation of structures to create pools and riffles) after the contaminated sediments are removed. Rehabilitation will also likely be necessary to mitigate the effects of conducting the work, such as impacts to streamside areas from the movement of heavy machinery.

The expected results of these actions would include a more diverse and larger population of macroinvertebrates, fish, and aquatic vegetation; improved forage and refuge opportunities for aquatic waterfowl; and a valuable recreational resource. In addition, on-site restoration would have a positive effect on a number of impaired beneficial uses in the GCR/IHC. The cost of on-site restoration is estimated to be moderate to high compared with other alternatives. Potential adverse environmental effects of this alternative include temporary water quality impacts during dredging; noise and congestion impacts in local areas due to movement of heavy machinery and hauling dredge spoils; and the use of land for temporary dewatering facilities.

Alternative C - Replace/Acquire Equivalent Resources

The third option available to the trustees to restore lost natural resources and resource services in the GCR/IHC is to acquire and make available to the public resources and resource

[15] The evaluation did indicate that capping the sediments remaining after dredging could provide additional environmental benefit, but at additional cost.

services that are equivalent to those lost.[16] There are a wide variety of approaches to this alternative, depending on the resource or resource service being provided. For resources that can be measured in units of area (*e.g.*, acres of wetlands), acquiring an equivalent area of wetlands may be an acceptable restoration.[17] In other cases, trustees may seek to provide a comparable level of human-use services, such as an equivalent number of angling-days in the case of a lost recreational fishery. Most often, the project or projects are carried out in a location other than where the injury and loss occurred. For purposes of this discussion, Alternative C is referred to as "off-site" or "replacement" restoration.

The trustees have not identified specific restoration projects under this alternative, and can therefore only generally describe the resulting environmental consequences. Because natural recovery is not expected to reduce contaminant concentrations in the GCR/IHC to acceptable levels in a reasonable timeframe, current impacts to surface water and biological resources will continue. As described in the following section, the GCR/IHC resource is unique. While replacement restoration projects would provide natural resources similar to those lost, it is unlikely that they could provide truly equivalent resources and services. In addition, this alternative will not have a positive effect on beneficial use impairments as defined by the IJC. The cost of this alternative is not known at this time. Potential adverse effects of this alternative include changes in land use at project locations and risks from the construction and implementation of the projects.

AFFECTED ENVIRONMENT

This chapter presents a brief description of the human environment and water resources of the GCR/IHC, as well as the biological resources affected by the release of hazardous substances to this environment. The affected environment includes the study area as defined above, as well as adjacent lands on the southern shore of Lake Michigan, the Indiana Dunes National Lakeshore (National Park Service lands), and the industrialized portions of northwest Indiana. Because adjacent lands are indirectly affected by contamination in the GCR/IHC and because some of these protected lands represent healthy, though fragmented, components of the original ecosystem, these areas are included in our description of the affected environment.[18]

[16] Trustees must ensure that the resources being provided as restoration truly represents an added resource for the public, either because they were previously not publicly accessible or because they were at some risk of loss (due to development, degradation, contamination, etc.) that will be eliminated or reduced as part of the restoration. For example, a natural area in private ownership that is at risk of development would represent an added resource if transferred to a conservation organization or public ownership. If, however, the natural area is a wetland that is protected from development by existing laws even when privately owned, transfer of ownership would not represent a benefit to the public.

[17] Trustees may incorporate potential differences in the level and nature of services provided by replacement resources by discounting them relative to the injured resources, for example by requiring two acres of replacement wetland for each acre lost.

[18] Although this RCDP only addresses restoration in part of the GCR/IHC system, this discussion incorporates a broader area to provide context for the analysis.

We separate the discussion of affected environment into three sections: human environment (*i.e.*, historic and current land uses), water resources (*i.e.*, the Great Lakes ecosystem, the GCR/IHC and adjacent lagoons and wetlands) and biological resources (*i.e.*, habitat types, flora and fauna, and human use services supported by the these resources).

Human Environment

Northwest Indiana has historically been impacted by human development and represents one of the most heavily industrialized areas of the country. As a result of its location at the southern of Lake Michigan, where water and land transportation routes converge, the Calumet region attracted human habitation dating back to the time of the Native Americans. Original European settlers tended to avoid the dune and swale terrain, considering it an unproductive wasteland. However, in the mid 19th century, when the City of Chicago attracted the majority of industrial development, the Calumet region attracted sportsmen who hunted and fished in its marshes and streams. By the turn of the century recreational sporting gave way to industrial development. The availability of developable land, access to large quantities of fresh water, and proximity to a labor market all contributed to the region's industrial development. Development included construction of steel mills, refineries, and transportation facilities (*i.e.*, railroads and waterways). The steel industry in particular developed rapidly in the twentieth century and by 1920 steel production in the area outpaced the productivity of the Pittsburgh mills.

Today, industrial manufacturing and steel production continue to provide employment opportunities in the local economy. The Indiana Harbor Canal, the transportation hub for the region's industrial output, moves 15 million tons of cargo each year, second only to the port of Chicago in tonnage received on Lake Michigan (AAPA, 2002). A number of large entities benefit from the transportation resources in the harbor, including major steel producers that receive iron ore from major midwestern producing locations. Refiners of petroleum products also depend on the harbor to move asphalt and fuels. Vessels on the Great Lakes have become increasingly large over the past 15 to 20 years, while the absolute number of boats has decreased (USACE, 1995).

Water Resources

Affected water resources include surface water, wetlands, lagoons, river and harbor sediments, and shoreline within, or adjacent to, the Grand Calumet River, Indiana Harbor Canal and Indiana Harbor. Together, these water bodies constitute integral parts of Lake Michigan and the Great Lakes ecosystem.

The Great Lakes Ecosystem represents the largest freshwater system in the world, accounting for 18 percent of the world's freshwater supply. Lake Michigan is the second largest Great Lake, containing 1,180 cubic miles of water. The system provides a number of ecologically important services to the region, including provision of an abundant and consistent water supply and the assimilation of municipal and industrial wastewater discharges. Lake Michigan's cul-de-sac shape, combined with the relatively small outflow into Lake Huron, makes the waterbody particularly sensitive to the effects of a wide range of pollutants. For example, pollutants that enter the lake through tributaries, shoreline discharges, or atmospheric deposition are generally retained within the system for a long time and become more concentrated over time (USEPA and Canada, 1995).

The Grand Calumet is part of the Little Calumet-Galien watershed, which includes portions of the Galien River, Salt Creek, and Deep River. The entire watershed covers approximately 67 square miles and accounts for less than two-tenths of one percent of Lake Michigan's 45,600 square mile drainage (Lawson *et al.* 2000). The original boundaries of the drainage area of the Grand Calumet River are difficult to determine due to extensive historical ditching and filling. Flow in the Grand Calumet river is governed by water levels in Lake Michigan and input flows to the river/canal system. Water levels in Lake Michigan, which regulate the base level of the river/canal system at its mouth, are governed by climatic conditions in the Great Lakes Basin. Lake levels also fluctuate seasonally. High lake levels decrease the water surface slope in the river/canal system and tend to slow the flow in the GCR/IHC. This in turn favors sediment deposition from the water column and diminished erosion. Conversely, lower lake levels increase the surface water slope and promote relatively more erosion and less deposition with enhanced sediment transport. In the 81 years of record, the mean elevation of Lake Michigan is approximately 579 feet (International Great Lakes Datum), with a maximum range of ± 3 feet (Exponent 1999).

The Grand Calumet river currently receives wastewater discharge from five major point sources and three large municipal wastewater treatment plants. Over 90 percent of the dry weather flow in the East Branch of the Grand Calumet River is composed of discharge from the Gary municipal sewage treatment plant and the US Steel facility (Foster Wheeler 2000). As a result of industrial activity, the sediments of the GCR/IHC are contaminated by a wide range of compounds. (Please refer to Appendix A for more detail on the presence of contaminants in GCR/IHC sediments.)

Prior to industrialization, the Grand Calumet River was surrounded by extensive wetlands. Manipulation of the river led to the channelization and straightening of waterways to accommodate industrial development and facilitate navigation. As a result of these changes, the natural drainage of the region has shifted from the St. Lawrence to the Mississippi River system (Simon and Moy 1999/2000). Despite the anthropogenic nature of activities in the area (*e.g.*, artificially maintained river flows), the USFWS notes that wetlands in or near the Canal have historically provided natural resource services and ecological value (Herdendorf *et al.* 1981).

The existing Grand Calumet Lagoons include a series of small pannes and wetlands that border the east side of the City of Gary, Indiana, and lie adjacent to National Lakeshore lands. The lagoons, which are entirely within the western unit of the National Lakeshore, are part of the headwaters of the Grand Calumet River and cover approximately 80 acres. The lagoons can be roughly divided into three similarly sized sections: the Marquette Park Lagoon (City of Gary), the Middle Marquette Lagoon (portions owned by the City of Gary and the National Park Service), and the US Steel Lagoon (owned by NPS and US Steel). The Marquette Park Lagoon is surrounded by significant natural areas, including black oak savannas and scenic walkways that support recreational uses. Lands adjacent to the US Steel and Middle Lagoons include mixed industrial usages and residential development (Stewart and Butcher, undated). Wetlands throughout the study area face colonization by invasive species, particularly during low water levels (Labus, undated).

Sediments found in the Grand Calumet River vary by location and depth. Typically, three distinct layers can be identified. The top one to fifteen feet consists of oily fine to medium sand with a mild to strong petroleum odor. The middle layer ranges from two to five feet thick of non-native silty fine sand to silt. The bottom layer is native fine to medium sand with some shell fragments. The bottom layer may vary from 20 to 50 feet thick and is composed of lacustrine sand (Foster Wheeler 2000).

Biological Resources

The assessment area includes a variety of habitat types, including riparian zones, upland areas associated with the dune and swale ecosystem, and the aquatic environs of the Grand Calumet River, Indiana Harbor, and Canal. These habitats support many different aquatic and terrestrial species. In particular, the western unit of the Indiana Dunes National Lakeshore supports a high concentration of threatened and endangered plants and animals. Overall, the area's biological resources provide many ecological services and support a variety of human uses, including recreational swimming, fishing, boating, and bird watching.

Habitat Types

Despite the filling of a vast wilderness of dunes, lakes, and marshes, the existing physical habitat in Northwest Indiana continues to support a variety of habitat types including sandy dunes, deciduous forests, mixed grass prairies, riparian habitats, and river bottom. (see also "Biological Environment" below). As a result of a unique geologic history of receding glaciers and the convergence of distinct biomes (including dunes, grass prairies, and deciduous forests), the study area supports one of the most biotically diverse regions in the country. In addition to the dune habitat, eastern deciduous forests, fertile lowlands, and mixed-grass prairies provide habitat for more than 1,300 species of flowering plants and ferns. The diverse habitat types allow for the occurrence of a variety of species within a geographically small area. For example, the prickly pear cactus, a southwestern desert plant, can be found alongside the bearberry, an understory species generally found under pine forests or in conjunction with spruce trees in arctic or mountainous environs (National Park Service, 1998). Similarly, prairie species more typical of the Great Plains ecosystems can also be found within only a few short miles of this site.

The nearby Indiana Dunes National Lakeshore is an example of the pre-industrial environment.[19] It contains many of the few remaining examples of the globally-rare dune and swale ecosystem, consisting of upland dune ridges alternating with low-relief depressions. Much of the remaining habitat of this type in northwest Indiana is highly fragmented, with parcels ranging in size from a few acres to nearly 180 acres (Labus, undated). The dunes are characterized by jack pine, black oak, and other assorted savanna woodland communities along dune ridges; low elevation swales more typically support ponds (pannes), marshes, and wetlands. The dune and swale habitat in the vicinity of the Grand Calumet River is the only such habitat

[19] While the National Lakeshore contains 15 miles of Lake Michigan shoreline and a total of 15,000 acres of land (Fredrick 1995), only the western unit, which constitutes approximately one-third of the Park Service lands, is proximate to the GCR/IHC.

remaining in Indiana, and represents approximately 10 percent of the historic distribution of this habitat type (National Park Service, 1998).

Flora and Fauna

Although much of the original acreage of the dune and swale habitat in lands adjacent to the study area has been destroyed, the remaining 1,000 acres provide sanctuary for more than 60 rare plant and animal species. Over 1,400 species of vascular plants are known to occur within the Indiana Dunes National Lakeshore (Stewart and Butcher, undated). In addition, the southern edge of Lake Michigan is an important stop-over point for migrating birds (Brock, 1986). The National Lakeshore in the vicinity of the Lagoons also contains an educational center and nature trails (National Park Service, undated). Although there are contaminated upland parcels adjacent to and within the National Lakeshore, the most heavily contaminated section of the Lagoons lies outside the Park's boundaries.

The historic fish communities found in the Grand Calumet River and Indiana Harbor Canal consisted of a riverine wetland community, with a number of transient species from Lake Michigan. Species included bowfin, yellow perch, northern pike, and freshwater drum, among others. The current assemblage of fish is significantly different from the historic condition and is marked by the absence of many species common to similar habitat in the region (Simon and Moy 2000). Although investigators have noted little change in the fish community since the mid 1980s, there have been recent documented sightings of Chinook salmon in the east and west branches of the Grand Calumet River, as well as the Indiana Harbor Canal (Simon *et al.*, 2000).

Historic freshwater mussel populations included unionid mussels, including wabash pigtoe, spike, and most likely giant floater. Currently, mussel assemblages in the Grand Calumet River are dominated by exotic species (*i.e.*, non-unionid species) including *Corbicula* and *Dressinia* (USFWS *in prep*.). Gill breathing mollusks are present in the Grand Calumet Lagoons, (including *Valvata tricarinata* and *Amnicola limosa*) (Stewart and Butcher, undated). The USFWS conducted a study of macroinvertebrate community structure in the East Branch of the Grand Calumet River in 1994 and found low taxa richness and a disproportionate dominance of a single taxon.

Habitat within the Grand Calumet watershed supports the highest concentrations of State and Federally listed threatened and endangered species in Indiana (DOI, 2001). For example, migratory birds, including the piping plover, use the area as a stopover point during fall migration. The area also supports the range of the Federally endangered Indiana bat, which utilizes caves during the winter and riparian woodlands during the summer. The bat is known to feed on aquatic insects in and around the area. A bald eagle was sighted in the area in 1994 (Stewart and Butcher, undated). The area also supports natural prairie and dune ecosystems that have been identified by the Nature Conservancy as habitat that is critically imperiled globally. Exhibit 3 lists additional Federal and State endangered resources found in the assessment area.

Exhibit 3

SELECTED THREATENED AND ENDANGERED SPECIES IN GRAND CALUMET STUDY AREA

Species/Natural Community	Status
Mead's Milkweed (*Asclepias meadii*)	Federally threatened since 1988
Pitcher's Thistle (*Cirsium pitcheri*)	Federally threatened since 1988
Karner Blue Butterfly (*Lycaeides melissa samuelis*)	Federally endangered since 1992
Piping Plover (*Melodus charadriidae*)	Federally threatened since 1985
Blanding's Turtle (*Emydoidea blandingii*)	State endangered
American Bittern (*Botaurus lentiginosus*)	State endangered
Cooper's Hawk (*Accipter cooperii*)	State rare species of concern
Black-crowned Night Heron (*Nycticorax nycticorax*)	State endangered
Mudpuppy (*Nectaurus maculosus*)	State species of special concern
Jack Pine (*Pinus banksiana*)	State rare species
Fanklin's Ground Squirrel (*Spermophilus franklinii*)	State endangered
Wet-Mesic Sand Prairie (high quality natural community)	State significant area; Nature Conservancy Global Rank 1, indicating habitat that is extremely rare globally

Sources:
Indiana DNR, undated.
National Park Service, 1998.

Human Use Services

Northwest Indiana supports diverse recreational activities including fishing, swimming, boating, and bird watching. Nevertheless, fishing opportunities in the GCR/IHC have been severely degraded due to contamination. . Since 1986, the Indiana State Department of Health has recommended that fish from the GCR/IHC should not be eaten by anyone (MESL 2003). Note that even in the absence of the advisory, recreational fishing in the GCR/IHC would be degraded, based on the limited numbers and diversity of fish (Hudak 1996b). The potential for the GCR/IHC to support recreational fishing in the future is demonstrated by existing fishing use of the nearby Little Calumet River and Salt Creek and the existence of a more diverse and plentiful fishery in Lake Michigan.

Indiana Dunes National Lakeshore is an urban park that provides a recreational experience for over two million visitors per year (Steward and Butcher, undated). The majority of visitors experience the natural areas through hiking nature trails or sunbathing along the many miles of sandy coastline. Boating, swimming, jet-skiing, and water skiing along the lakeshore are also popular summer activities.

Lake Michigan is an important crossroads for migratory birds, and attracts large numbers of birders in the Fall. In particular, Miller Beach, managed by the City of Gary, Indiana, provides a unique lakeside location to view black-crowned night herons, red-throated loons, and jaegers (Indiana Audubon Society, undated). The diversity of bird species found at Miller Beach is the result of the "funnel effect," which tends to channel southward-bound migrants to the southern tip of Lake Michigan.

ENVIRONMENTAL CONSEQUENCES

The purpose of an RCDP is to evaluate restoration alternatives against a variety of criteria, some of which directly relate to the environmental consequences of the action. In this section, the trustees present their evaluation of the restoration alternatives for the GCR/IHC to satisfy the requirements of the DOI NRDA regulations.

Criteria for Evaluation of Restoration Alternatives

The NRDA regulations list ten criteria that trustees must consider when evaluating restoration alternatives (43 CFR §11.82(d)). Exhibit 4 summarizes the criteria and their relevancy to the restoration alternatives being proposed at GCR/IHC. As noted, not all criteria are directly relevant or useful in selecting among the three alternatives being considered. Those that are not relevant have not been evaluated by the trustees. For example, all restoration alternatives are considered technically feasible. Similarly, because each alternative is consistent with relevant statutory requirements, regulatory compliance (criterion #10) is not considered further. Criteria #2 (cost effectiveness) and #4 (response actions) are similarly not relevant, as explained in Exhibit 4.

Evaluation of the Restoration Alternatives

The trustees have evaluated each of the alternatives against the six relevant DOI criteria and with respect to the expected effects on the environment. Exhibit 5 presents a qualitative summary of the trustees' evaluation of the alternatives against the DOI criteria, while the sections that follow provide additional detail on the environmental impacts associated with each restoration alternative. The discussion generally follows the organization of the discussion in the "Affected Environment" section (*e.g.*, water resources, habitat types, flora and fauna, and human use services).

Exhibit 4

APPLICABILITY OF RESTORATION ALTERNATIVE CRITERIA (40 CFR §11.82(d)) TO GCR/IHC NATURAL RESOURCE RESTORATION

Criteria to be Considered	Relevancy to Grand Calumet
1. **Technical feasibility** - Technology and management skills necessary to implement an alternative are well known and each element of the alternative has a reasonable chance of successful completion in an acceptable period of time.	All restoration alternatives being considered are technically feasible.
2. **Cost-effectiveness** - When two or more activities provide the same or a similar level of benefits, the least costly activity providing that level of benefits should be preferred.	The alternatives being considered provide different levels of benefits.
3. **Cost-benefit ratio** - Relationship of the expected costs of the proposed action to restore, rehabilitate, replace, and/or acquire equivalent resources to the expected benefits from this action.	*Relevant* (see below)
4. **Response actions** – Results of any actual or planned response actions.	No response actions are planned for the Grand Calumet site.
5. **Potential for additional injury** - resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources.	*Relevant* (see below)
6. **Natural recovery period** - Consideration of the length of natural recovery as determined by 43 CFR §11.73(a)(1).	*Relevant* (see below)
7. **Recovery of the affected resources** - ability of the resources to recover with or without alternative actions	*Relevant* (see below)
8. **Human health and safety** – Potential effects of the action on human health and safety.	*Relevant* (see below)
9. **Regulatory consistency** - with relevant Federal, State, and tribal policies	*Relevant* (see below)
10. **Regulatory compliance** - with applicable Federal, State, and tribal laws.	All restoration alternatives being considered are compliant with relevant laws.

Exhibit 5
EVALUATION OF GCR/IHC RESTORATION ALTERNATIVES USING APPLICABLE NRDA FACTORS (43 CFR §11.82(d))

Applicable Factors	Alternative A - No Action	Alternative B - On-site Restoration	Alternative C - Replacement Restoration
Costs and benefits	N/A	**<u>Anticipated cost</u>** – \$53 million to \$300+ million. Low end represents maximum dredging depth, no sediment cap, and on-site disposal; high end represents maximum dredging depth, including additional dredging in the federal project area, and transport and disposal in off-site landfill. **<u>Anticipated benefits</u>** – Extent of benefits proportional to selected remediation alternative (see range discussed above). Benefits include: • Reduced uptake of contaminants. • Reduced re-release of contaminants from sediments. • Improved health of benthos, macroinvertebrates, fish, terrestrial wildlife. • Aesthetic and recreational-use improvements. • Rehabilitation-related benefits including stabilization and revegetation of river banks and maintenance of water flow.	**<u>Anticipated cost</u>** Unknown at this time; will vary depending on location and scale of off-site projects. **<u>Anticipated benefits</u>** Projects should be designed so benefits are similar to those under on-site restoration and provide compensation for lost resources and resource services.
Potential for additional injury	No additional impacts. Continued impairment of natural resources for the foreseeable future due to existing contamination of GCR/IHC sediments.	• Elimination of existing aquatic and riparian biota (recovery likely with rehabilitation). • Potential habitat loss resulting from siting of permanent CDF (loss will vary depending on location of CDF). • Potential habitat loss resulting from siting of temporary CDFs for de-watering (recovery likely with rehabilitation). • Temporary decline in water quality during dredging activities. • Temporary risks to birds and terrestrial wildlife resulting from exposed contaminated sediment in de-watering CDFs.	• Opportunity costs associated with land-use changes in parcels used for restoration projects (*e.g.*, creation of mitigation wetlands resulting in loss of upland habitat). • Continued impairment of natural resources for the foreseeable future due to existing contamination of GCR/IHC sediments.
Natural recovery Period	Natural recovery is not expected to reduce contaminant concentrations in the GCR/IHC to acceptable levels in a reasonable timeframe.	N/A	Natural recovery is not expected to reduce contaminant concentrations in the GCR/IHC to acceptable levels in a reasonable timeframe.

Exhibit 5
EVALUATION OF GCR/IHC RESTORATION ALTERNATIVES USING APPLICABLE NRDA FACTORS (43 CFR §11.82(d))

Applicable Factors	Alternative A - No Action	Alternative B - On-site Restoration	Alternative C - Replacement Restoration
Ability of resources to recover	None. Continued injury expected.	• Good to very good. • Rehabilitation of GCR/IHC resources after removal of contaminated sediments necessary to facilitate recovery. • Improved water quality expected to improve habitat for benthic organisms and support a recovered food web. • Migration from adjacent uncontaminated areas (*i.e.*, Lake Michigan) likely to assist recovery.	• Trustees to select restoration projects to provide the public with equivalent or greater resources and resource services; performance criteria required to monitor success of off-site projects. • Continued injury in the GCR/IHC expected.
Human and health and safety concerns	Continued presence of contaminated sediments.	• Occupational risks associated with construction activities. • Truck traffic and congestion on roadways. • Risks associated with transport of contaminated materials.	• Risks dependent on nature and extent of construction and rehabilitation work associated with off-site projects. Risks likely to be less than those associated with on-site alternative. • None, beyond continued existence of contaminated sediments.
Consistency with Federal, state, or other policies	Inconsistent with IJC Restoration Action Plan for the Grand Calumet AOC, which is intended to rehabilitate impaired uses identified in Grand Calumet River AOC.	Positive effect on several impaired uses as defined in the IJC Restoration Action Plan.	Partial mitigation of impairments as defined in the IJC Restoration Action Plan.

Alternative A - No Action/Natural Recovery

Natural recovery may be an effective remediation strategy if concentrations of hazardous substances are low enough such that natural processes reduce the contaminants to a level deemed acceptable in reasonable time frame. However, the concentrations of hazardous substances in the GCR/IHC sediments are several orders of magnitude above relevant guidelines for the protection of natural resources. In addition, the contaminants of concern (*i.e.*, PAHs, PCBs, metals) are typically resistant to degradation in the environment, and it is highly unlikely that degradation would reduce concentrations to acceptable levels in a reasonable time frame. Furthermore, other natural processes (*e.g.*, deposition of clean sediment, dispersal and dilution) are not expected to adequately prevent exposure of biological resources to the contaminated sediments. Although some sediment is mobilized each year and transported to Lake Michigan, the quantities are small compared to the vast reservoir remaining in the GCR/IHC.[20] Supply of "clean" sediment to the waterway is also not sufficient to isolate the contaminated sediments, and itself becomes contaminated through diffusion and mixing of the upper layers of sediment. Therefore, natural recovery will not result in return of surface water resources to baseline conditions.

Because this alternative does not include any active restoration, physical environmental impacts such as direct or indirect changes to riparian, aquatic, or terrestrial habitat are not anticipated. Similarly, the effects of this alternative on the biological environment are anticipated to be minimal. Nevertheless, current impacts to biological resources will continue if this alternative is selected. These include adverse effects on sediment-dwelling organisms, fish, and piscivorous wildlife due to contaminated river sediments, and may also extend to non-aquatic wildlife. (Please refer to Exhibits A-6 and A-7 in Appendix A for a summary of existing biological injuries.) To the extent that these impacts persist, human use of the area's environmental resources (*e.g.*, recreational fishing, boating, swimming, birding, etc) will likely continue to suffer. In particular, the fish consumption advisory that currently exists for the Grand Calumet River is expected to continue under this alternative, thus discouraging fishing and adversely affecting the welfare of those who continue to visit the area. Continued presence of contaminated sediments may reduce visitation to attractions such as Indiana Dunes National Lakeshore. Reduced quality of life and negative public perceptions of the area may also affect future economic activity.

The no action alternative is not consistent with the Great Lakes Water Quality Agreement between the US and Canada. As part of this agreement, the Grand Calumet River was identified as a severely degraded geographic area in the Great Lakes Basin and subsequently designated an Area of Concern (AOC). The Grand Calumet River fails to meet specific environmental objectives which has resulted in the impairment of all 14 identified beneficial uses. As a result, the two nations have agreed to work cooperatively in developing and implementing a Remedial

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[20] The Corps estimated that almost 10,000 tons of sediment enter Lake Michigan each year from the GCR/IHC. Much of this sediment is new material from surface runoff and point-source discharges to the waterway (USACE 1997). Even if the entire sediment load was mobilized from contaminated bed sediments, it would take hundreds of years to rid the GCR/IHC of the millions of tons of these sediments currently in place. In reality, there is no information to suggest that significant quantities of historically-contaminated sediments are being transported to the Lake.

Action Plan (RAP) for the area, which describes specific methods for restoring AOCs through an ecosystem approach. The Grand Calumet River RAP calls for remedial and regulatory measures to enhance the recovery of injured resources in the GCR. As such, this alternative is not consistent with international, federal, and state environmental policy.

Alternative B - Restore/Rehabilitate Injured Resources (On-Site Restoration)

As presented in Appendix B, the trustees' preliminary evaluation of on-site restoration options indicates that dredging and disposal of the contaminated sediment is feasible and expected to result in substantial improvements in the health of the GCR/IHC ecosystem. Preliminary estimates for the trustee project area place the costs between $53 million and $252 million, depending on the depth of dredging, the disposal location of the dredge spoils, and whether or not a clean sediment "cap" is placed in the river after dredging is completed. Assuming maximum dredging and disposal in the Corps CDF results in a cost estimate of $53 million.[21] If disposal in an offsite landfill is necessary, it would represent the single largest component of the project cost, accounting for an additional $200 million in the above scenario.[22] The two scenarios with limited dredging followed by capping have costs between these two estimates.[23] Note that the trustees would also incur additional costs if they wished to pursue additional dredging or capping in the federal project area beyond that contemplated by the Corps for navigation. For example, the cost estimate for additional dredging followed by placement of a cap, with disposal in the Corps CDF, is approximately $15 million.

A number of improvements to the physical environment are anticipated as a result of the implementing this alternative. Removal of contaminated sediments and subsequent rehabilitation will improve water quality, restore aquatic habitats, and enhance the overall health of the watershed. In addition, re-vegetation and removal of invasive species following dredging will improve riparian habitats. As a result, biological improvements are anticipated to occur throughout the food chain, as improved habitat conditions will result in a healthier benthic community that will better support the aquatic foodweb. In particular, reduced uptake of contaminants in fish and piscivorous wildlife will enhance biological recovery. Improved habitat will likely spur migration into the area, thus strengthening biological diversity and improving the resiliency of the ecosystem as a whole. Recovery of a sport fishery will attract additional recreational fishing and improve the welfare of existing anglers, and improved aesthetics may attract additional visitors to use nearby recreational facilities that rely on natural resources (*e.g.*, the lakeshore). The existence of healthy ecosystems will improve the delivery of natural resource services, including the maintenance of water quality.

The trustees note that although some temporary decline in water quality during remediation activities is anticipated, this is not expected to cause lasting impacts to the

[21] Please refer to Appendix B for additional information regarding the dredging scenarios.

[22] The additional cost is composed of both the cost of landfill disposal and the additional costs to haul the material to the landfill vs. to a local disposal facility (i.e., the Corps CDF).

[23] This implies that if local disposal in the Corps CDF is available, maximum dredging is less expensive than limited dredging with capping. If landfill disposal is required, the converse is true.

GCR/IHC. Similarly, short-term displacement of, and risk to, birds and terrestrial wildlife is likely during temporary storage of contaminated dredged materials. Other terrestrial habitat in the assessment area may be impacted, depending on the location of the permanent CDF and other facilities necessary to implement this alternative. Furthermore, the on-site alternative will likely produce some negative impacts on human health and safety. For example, construction activities related to the dredging and transport of contaminated sediment carry a small risk to workers, as do all industrial activities. In addition, increased truck traffic may pose some small additional risk of injury or accident. Nevertheless, these additional risks are anticipated to be minimal and short in duration.

Finally, the provision for active restoration activities is consistent with the Grand Calumet River RAP. The draft RAP (which is currently undergoing review by the IJC) identifies a number of ongoing actions designed to delist beneficial use impairments in the GCR. The on-site alternative also restores and maintains beneficial uses (see Exhibit 5) and is therefore consistent with the RAP. Exhibit 6 presents the trustees' evaluation of the ability of on-site restoration to address the impaired uses listed by the IJC. The numbering convention of the impairments follows that of the RAP.

Exhibit 6

BENEFICIAL USES ON WHICH MANAGEMENT OF CONTAMINATED SEDIMENT WILL HAVE A POSITIVE IMPACT

Degree of impact	**IJC Beneficial Use Impairments**
Substantial positive contribution:	1. Restrictions on fish and wildlife consumption. 3. Degradation of fish and wildlife populations. 4. Fish tumors or other deformities. 5. Bird or animal deformities or reproduction problems. 6. Degradation of benthos. 7. Restrictions on dredging activities. 14. Loss of fish and wildlife habitat.
Moderate positive contribution:	2. Tainting of fish and wildlife flavor. 9. Restrictions on drinking water consumption, or taste and odor problems. 11. Degradation of aesthetics. 13. Degradation of phytoplankton and zooplankton populations.
Minimal or no positive contribution:	8. Eutrophication or undesirable algae. 10. Beach closings. 12. Added costs to agriculture or industry.

Alternative C - Replace/Acquire Equivalent Resources (Replacement Restoration)

To provide compensation for injured natural resources and the services these resources provide, replacement restoration projects would need to provide similar or greater quantities of services as those lost. For example, injury to the surface water resources of the GCR/IHC could be compensated by water quality improvements in a similar waterway. To determine the appropriate scale of the project, the trustees would consider factors such as the habitat types affected, proximity of the project to the injured resources, presence of important resources or species (*e.g.* wetlands, sportfish species), and the extent of improvement in key indicators of water quality (*e.g.*, contaminant levels, dissolved oxygen, etc.). Based on these factors, the scale of the project would be matched to the injury using units such as river-miles, acres of river-bottom habitat, acres of riparian zones, or some combination of these.[24] Given that the GCR/IHC is severely impaired and the fact that available options for restoration and/or protection of similar waterways in the region are few, it is likely that multiple projects would be necessary to fully address the range of injuries and losses at the GCR/IHC. For example, while improving water quality in a nearby waterway would partially address injury to surface water, loss of biological resources may require species-specific projects, such as restocking programs to restore fish populations. To ensure that the projects provide the required level of natural resources and resource services, the trustees would implement performance criteria describing environmental goals to be achieved (*e.g.*, restored fish populations, reduced abundance of exotic species, etc).

Most of the impacts (both positive and negative) of this alternative will occur in locations other than the GCR/IHC.[25] The nature of the impact will depend on the specific projects selected for implementation. Without information about the nature and extent of these projects, the trustees can only generally describe the environmental consequences of this alternative. As with the no action alternative, current impacts to surface water and biological resources will continue as a result of the contaminants present in the GCR/IHC. The trustees would seek to offset these impacts with projects as described above.

As described under the heading "Affected Environment" above, the GCR/IHC ecosystem and surrounding areas are both locally and globally significant and include unique features (*e.g.*, important migratory bird stop-over point, high species diversity, etc.). The trustees believe that replacement restoration projects will not result in restoration and protection of the unique resources to the same extent as will on-site restoration.

The restoration projects may also result in short- or long-term negative impacts. For example, projects may carry opportunity costs associated with the conversion of land into a desired habitat type. That is, conversion of an upland habitat to a wetland results in the loss of upland flora and fauna. If such a project were selected for implementation, the trustees would ensure that the conversion would result in a net gain of environmental services. Replacement projects may also carry some of the same risks associated with the on-site alternative, such as occupational risks to workers, but these are likely to be less than those incurred by implementation of the on-site alternative.

This alternative does not include any direct action to mitigate the harmful effects of contaminated substances currently present in the GCR/IHC. As a result, no positive effect on the beneficial use impairments defined by the IJC is expected. Nevertheless, substitute resources provided under this alternative would provide partial mitigation for impairments to some of the

[24] Trustees must also ensure that the resources being provided as restoration truly represent added resources for the public. For this to be true, the restoration must serve to reduce or eliminate some risk of loss of the resource due to development, degradation, or contamination.

[25] The trustees note that projects could benefit some of the same individual biological resources injured by the release of hazardous substances in the GCR/IHC. For example, migratory birds that are exposed to contaminants at the GCR/IHC might also benefit from a nearby protected natural area provided as compensation under this alternative.

uses, such as restrictions on fish and wildlife consumption and degradation of aesthetics. Individuals who would otherwise use the GCR/IHC resources would benefit from these substitutes, but because the resources would be outside the boundaries of the AOC, the off-site alternative may be considered less consistent with local policy than the on-site alternative.

Conclusion

The trustees have evaluated restoration alternatives for compensating the public for injuries to and losses of natural resources in the GCR/IHC. Based on this evaluation, the trustees select on-site restoration as the preferred alternative. The trustees solicit public comment on this evaluation and the contents of this report, and will prepare a final RCDP addressing all comments received.

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APPENDIX A

RESULTS OF ASSESSMENT ACTIVITIES

CONTAMINANTS IN THE GCR/IHC

Years of releases by the various industries that have used the river system for wastewater discharge and drainage have resulted in contamination of the resources of the GCR/IHC with a variety of contaminants of potential concern. The focus of the damage assessment has been on polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and metals.

Polychlorinated biphenyls (PCBs) are synthetic compounds that were produced commercially in the US between 1929 and 1977, at which time their production was banned. PCBs were widely used in commercial and industrial applications due to their favorable properties, including chemical stability, low flammability, and ability to serve as an electrical insulator. Their presence in the GCR/IHC is due at least in part to cutting and hydraulic oils (Erickson 1997). In addition, since PCBs are hydrophobic with low water solubility, they adsorb to materials such as organic matter in sediment. Higher trophic level organisms, such as fish and birds, may accumulate PCBs directly from the water column or sediment, or through the ingestion of contaminated food. PCBs are associated with a range of deleterious effects, including impaired reproductive ability in fish, mammals, and birds (Eisler 2000).

The term oil refers to a variety of complex mixtures of organic compounds and trace elements commonly associated with the petrochemical industry. Oil can be harmful to the environment as a result of both its physical and chemical properties. Aromatic hydrocarbons are one class of petroleum hydrocarbons, and a subcategory of this is a group known as polycyclic aromatic hydrocarbons, or PAHs. PAHs are a component of crude and refined oils.[1] PAHs can also form as products of incomplete combustion. PAHs of different molecular weight vary substantially in their behavior and distribution in the environment and in their biological effects. Simple, lower-molecular-weight PAHs have significant acute toxicity to some organisms, while some higher-molecular-weight PAHs are known or suspected carcinogens (Eisler 2000). Sixteen PAHs are classified as priority pollutants by the USEPA (MESL 2000).

Those metals commonly referred to as "heavy metals" are often associated with anthropogenic sources and are toxic to a wide range of organisms. This group includes metals known to be essential to organisms (***e.g.***, copper, iron, manganese, and zinc) as well as nonessential metals such as cadmium, lead, and mercury (Rainbow 1996). The presence of these metals in the GCR/IHC is likely related to steel making and metal finishing operations. Lead and mercury are two of the most toxic metals found in the GCR/IHC.

DISTRIBUTION OF CONTAMINATION

Sediment concentrations of PCBs, PAHs, lead and mercury vary greatly within reaches, with most reaches showing concentrations ranging over several orders of magnitude.[2] Due to

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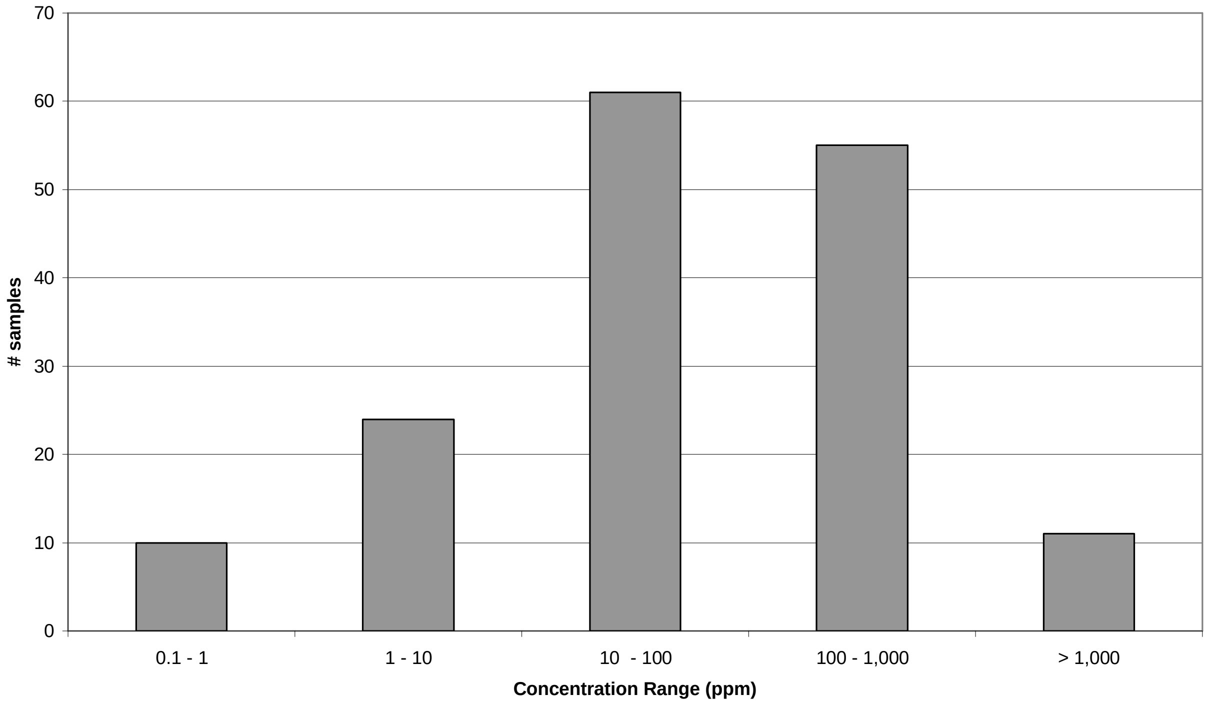
[1] Note that releases of oil to the environment are covered under the Oil Pollution Act (OPA) (33 U.S.C. 2701 *et seq.*), but mixtures of oil and hazardous substances such as are found in the GCR/IHC are covered by CERCLA (15 CFR §990.20(c)).

[2] The trustees note that in the GCR/IHC, areas with relatively 'low' concentrations compared with other areas of the GCR/IHC still contain elevated levels of contaminants in comparison with both uncontaminated areas

this variability, comparing the average sample concentration across reaches does not give an accurate picture of contaminant distribution. Instead, we construct histograms to describe the contaminant data. Due to the wide range in the data, we group the data into logarithmic ranges; each range is ten times as great as the previous one. As an example, Exhibit A-1 shows the histogram for the concentration of total PAHs in sediments in EBGCR I, which varies from less than 1 to over 10,000 ppm.

Exhibit A-1
Total PAHs, EBGCR I Sediment



To compare the data across reaches, we account for differences in the number of samples collected by presenting the *percentage* of samples from the data set in each concentration range, rather than the *number* of samples as in the example above. Exhibit A-2 presents the histogram for total PAH concentrations in each of the six reaches in the project area plus Lake Michigan (LM). Although some areas of LM contain elevated levels of contaminants, particularly near the entrance to Indiana Harbor (IH), it provides a useful comparison between the GCR/IHC and an area not directly receiving discharges and releases of oil and hazardous substances. Also noted on Exhibit A-2 are the Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC) published by MacDonald *et al.* (2000a). The TEC is the concentration below which an adverse effect on sediment-dwelling organisms is unlikely to occur. Conversely, the PEC is the concentration above which it is more likely than not that an adverse effect is likely

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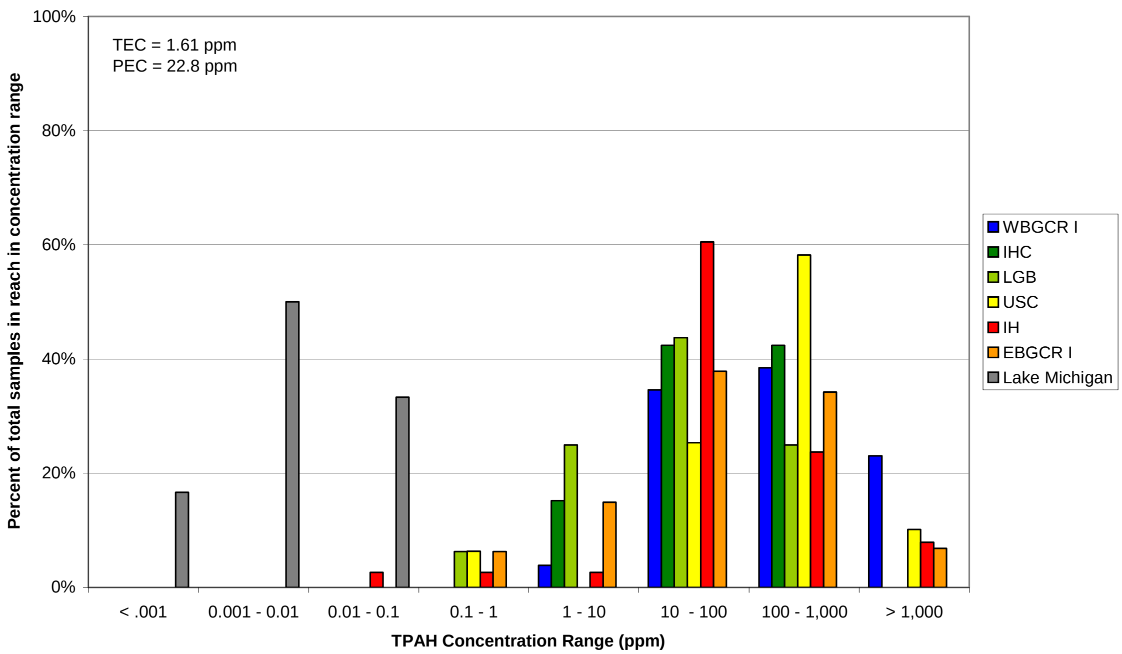
and guidelines or benchmarks for protection of the environment. Please refer to Exhibits A-2 through A-5 and the discussion under "Injury and Lost Services."

to occur. For more information, please refer to MacDonald *et al.* (2000a) and the description of injury assessment using sediment chemistry below.

Exhibits A-3 through A-5 contain the same presentation of the sediment concentration data for PCBs, lead, and mercury.[3] The relevant TECs and PECs are noted on these exhibits as well. Further interpretation of these data in terms of injury to natural resources will be described in the following section under the heading "Sediment Chemistry," but it is clear that concentrations of hazardous substances in the GCR/IHC are several orders of magnitude above levels sufficient to harm natural resources.

Exhibit A-2
Total PAHs Frequency Distribution by Reach



[3] Note that there are no data for lead and mercury in southern Lake Michigan sediments.

Exhibit A-3
Total PCBs Frequency Distribution by Reach

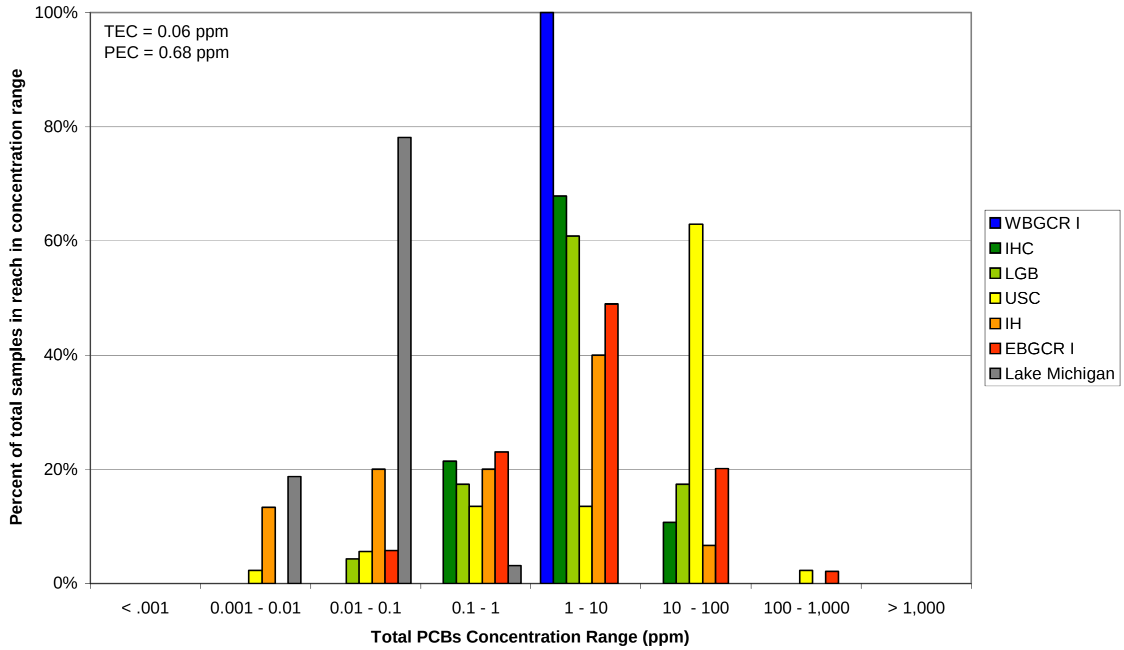


Exhibit A-4
Lead Frequency Distribution by Reach

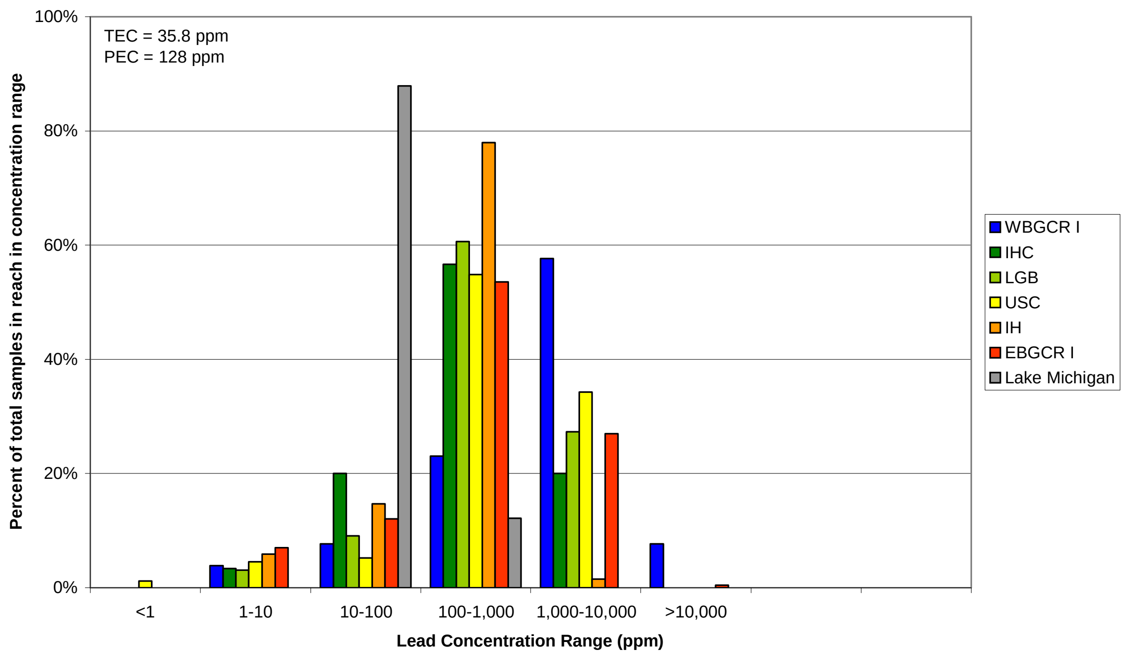
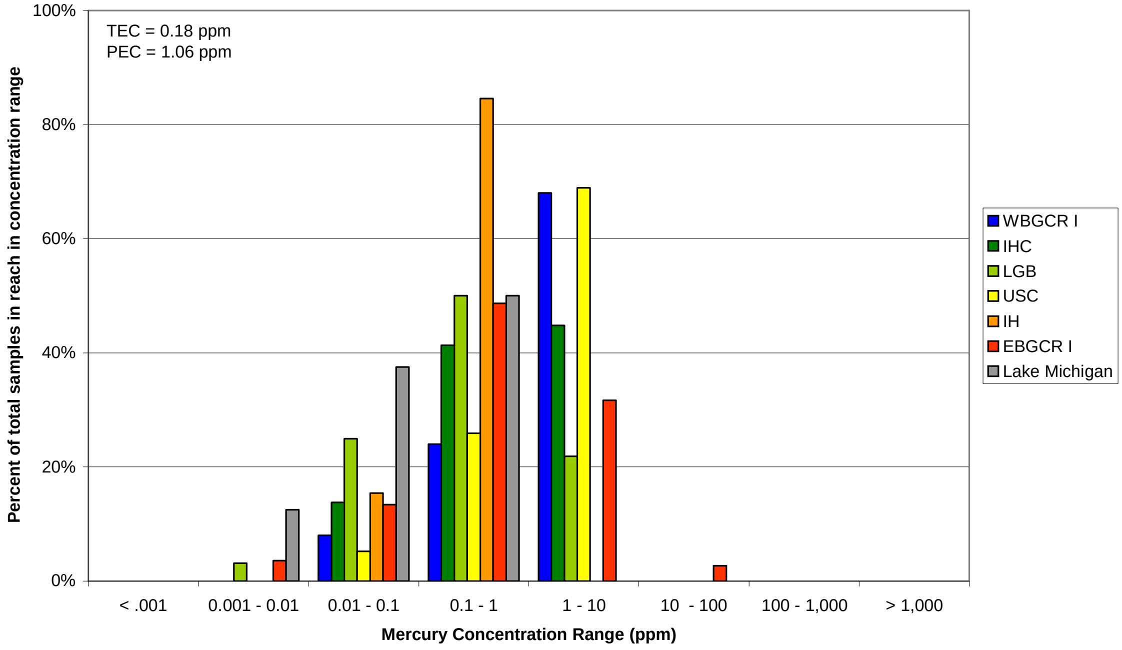


Exhibit A-5
Mercury Frequency Distribution by Reach



INJURY AND LOST SERVICES

The trustees have undertaken several studies to define the nature and extent of injury to natural resources in the GCR/IHC system.[4] Sediment injury determination and quantification is complete and is described in a sediment injury report authored by MESL (2000). The following sections summarize the results of the sediment injury report and some key results from on-going studies of birds and fish.

Sediments

For purposes of NRDA under CERCLA, sediments are considered to be part of surface water resources. Injury to sediments (and therefore surface water resources) can be demonstrated in several ways. One is to demonstrate the presence of concentrations of substances sufficient to cause injury to biological resources. Injury to biological resources can in turn be demonstrated by showing that the resource has undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, mutations, physiological malfunctions, or physical deformations (43 CFR §11.62). Therefore, demonstrating one or more of these effects on sediment-dwelling organisms demonstrates injury to sediments and surface water resources. MESL use four primary indicators to demonstrate or predict these effects:

- Whole sediment chemistry – Assessed by comparing the concentration of contaminants in whole sediment with previously-published benchmarks (described in more detail below.)

- Pore water chemistry – This metric compares the concentration of contaminants in the pore water of sediments with published toxicity thresholds.

- Sediment toxicity – This metric is assessed by conducting laboratory tests to determine the extent to which sediments are toxic (based on a variety of endpoints such as survival and reproduction) to benthic organisms under controlled exposure conditions, including use of control groups.

- Benthic invertebrate community structure – Uses the number of species present and the relative abundance of each to evaluate whether or not the benthic community is statistically different from that which would be expected in a particular ecosystem.

Due to the size of the project area, the trustees determine injury for each reach separately. In all six reaches of the project area, all four indicators show injury to sediment-dwelling organisms, as summarized in Exhibit A-6. The findings based on sediment chemistry and sediment toxicity are described in more detail below. Detailed results of the pore water chemistry and benthic invertebrate community structure assessments are found in MESL (2000).

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[4] Injury is defined as a measurable adverse change in the chemical or physical quality or the viability of a natural resource (43 CFR §11.14(v)).

Exhibit A-6
Summary of assessment of sediment injury to sediment-dwelling organisms

Reach	Indicator of Injury to Sediment-Dwelling Organisms[1]				Number of Lines of Evidence for Demonstrating Injury to Sediment-Dwelling Organisms
	Sediment Chemistry[2]	Pore Water Chemistry[3]	Sediment Toxicity[4]	Benthic Community[5]	
East Branch Grand Calumet River-I	83% (n=269)*	55% (n=20)*	73% (n=44)*	100% (n=14)*	4
West Branch Grand Calumet River-I	90% (n=31)*	100% (n=2)*	100% (n=2)*	100% (n=3)*	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	86% (n=78)*	100% (n=3)*	81% (n=32)*	81% (n=16)*	4
Overall	**86% (n=662)***	**67% (n=39)***	**78% (n=180)***	**94% (n=68)***	**4**
Lake Michigan[6]	3% (n=33)	ID (n=0)	33% (n=6)*	43% (n=56)*	2

[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 concentration > 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.
[6] Provided for comparison purposes only. Lake Michigan is not part of the restoration project area.
ID = insufficient data; n = number of samples.

Sediment Chemistry

Sediment chemistry data were assessed using a sediment quality guideline approach (Swartz 1999, MacDonald *et al.* 2000a, 2000b). This method allows the user to combine chemistry data for a number of contaminants in a sediment sample into a single quantitative measure indicating the probability that the sediment would cause adverse effects to biological resources. The process begins with development of consensus-based probable effect concentrations (PECs) for each contaminant. This is the concentration of the contaminant above which an adverse effect is likely to occur, based on an analysis of many individual studies reported in the literature.[5]

To assess the potential for a given sample to cause injury, the concentration of each contaminant in the sample is divided by the corresponding contaminant-specific PEC. These ratios are termed PEC-quotients, or PEC-Qs. Within each class of contaminant (e.g., PCBs, PAHs, or metals), the PEC-Qs of the individual contaminants are averaged to get an average PEC-Q for that class. For example, the PEC-Qs for arsenic, cadmium, chromium, and other metals in a sample are averaged to derive an average PEC-Q for metals for that sample. The overall mean PEC-Q for the sample is the average of the three average PEC-Qs (i.e., PCBs, PAHs, and metals). Injury is defined as a mean PEC-Q greater than 0.7.

In the six reaches of the project area, approximately 80 percent of samples exceed this criterion (please refer to Exhibit A-6, first column). Over the entire assessment area for which data exists, this figure is 70 percent. Based on sediment chemistry, sediments throughout the GCR/IHC are injured.

Sediment Toxicity

The results of toxicity tests conducted using whole sediments, pore waters, and/or elutriates (i.e., agitated mixtures of sediment and water) represent important indicators for assessing sediment injury and for determining the areal extent of sediment injury. The results of sediment toxicity tests provide quantitative information for discriminating between toxic and non-toxic sediments. They are an empirical demonstration of the effects of the sediment on actual organisms.

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[5] The term *sediment quality guidelines* (SQGs) is used to describe previously published benchmarks for assessing the biological significance of contaminant concentrations in whole sediments (e.g., threshold and probable effect levels - Smith *et al.*1996; no effect concentrations - Ingersoll *et al.* 1996). By comparison, the term ***consensus-based sediment effect concentrations*** (SECs) is used to describe the benchmarks that provide an estimate of the central tendency of the published SQGs (Ingersoll and MacDonald 1999; MacDonald *et al.* 2000a; USEPA 2000). The consensus-based SECs are intended to define the concentrations of sediment-associated contaminants that would be sufficient to cause or substantially contribute to injury to sediment-dwelling organisms, including infaunal (i.e., those species that live in the sediments) and epibenthic (i.e., those species that live on the sediments) organisms. In this report, the term probable effects concentration (PEC) refers to an SEC above which an adverse effect is more likely than not (***i.e.***, 51 percent) to occur. Please refer to MESL (2000) for a more detailed description of this methodology.

The results of sediment toxicity testing in the project area are summarized in MESL (2000). The percentage of samples found to be toxic to sediment-dwelling organisms ranged from 57 percent in LGB to 100 percent in WBGCR I (please refer to Exhibit A-6, third column). Based on sediment toxicity, sediments in all reaches of the project area are injured.

Biological Resources

While it is difficult to measure the overall health of any ecosystem, biologists have developed metrics to assess the health of individual components of an ecosystem. If the health of these components is compromised, the ecosystem itself is likely to be impaired, and there may be a loss of ecosystem services. For example, a reduced food base due to altered benthic community structure would likely reduce fish abundance, which could in turn affect piscivorous wildlife. Therefore, one might infer potential effects on wildlife by assessing the degree and type of alteration to benthic community structure. To date, the trustees have assessed ecosystem impairment in the GCR/IHC by evaluating five indicators or metrics of effects on fish and wildlife resources that are associated with sediment contamination. These are described briefly below.

- Toxicity to fish - This metric is assessed by conducting laboratory tests to determine the extent to which sediments are toxic (based on a variety of endpoints) to fish under controlled exposure conditions, including use of control groups.

- Fish health - This metric measures the incidence of deformities, fin erosion, lesions, and tumors (known collectively as DELT abnormalities) in fish collected from the area of interest.

- Fish community structure - An Index of Biotic Integrity (IBI) is used to assess impairment of fish community structure. The index is based on the number of species present and the relative abundance of these species, compared to an unimpaired reference community.

- Whole sediment chemistry - Measured concentrations of bioaccumulative substances in the sediment are compared to bioaccumulation-based sediment quality guidelines (SQGs) for the protection of wildlife.

- Tissue chemistry - Similar to the above metric, concentrations of contaminants in fish and invertebrates are compared to tissue residue guidelines (TRGs).

In the sections below, we discuss the available data for fish and birds in more detail. While the data presented below is focused on evaluating injury to sediments, the trustees note that reports demonstrating injury to invertebrate and fish communities and to birds are forthcoming.

Metrics to Assess Effects of Sediment on Fish

Contaminated sediments do more than affect organisms that live in the sediment. Fish are exposed to contaminants through direct contact with sediment, contact with water overlying the sediments and carrying contaminants, or ingestion of other contaminated organisms. Toxic effects can be acute or chronic, and result in both mortality and morbidity such as DELT abnormalities, as described above. Due to the lipophilic nature of many of the contaminants of concern in the GCR/IHC system, species that feed on sediment-dwelling organisms will accumulate the contaminants in their own tissues, a process known as bioaccumulation. In this way, predator fish can accumulate significant body-burdens of contaminants without any "direct" exposure to the sediment.

The trustees have assessed the effect of contaminated sediments on the fish of the GCR/IHC using the first three metrics described above (i.e., toxicity to fish, fish health, and fish community structure). These metrics indicate that contaminated sediments contribute to adverse acute or chronic effects to fish in four of the six reaches of the project area (please refer to Exhibit A-7). The trustees are preparing a separate report evaluating injury to fish in the assessment area which will consider these and other metrics such as toxicity to spawned eggs and larvae

The trustees also note that in addition to providing services to other resources (***e.g.***, as prey for wildlife) fish provide human-use services, including the opportunity for recreational fishing. In the case of the GCR/IHC, fish consumption advisories have greatly diminished the recreational fishery since 1986[6] (MESL 2003). These advisories are a *de facto* injury under the Department regulations (43 CFR § 11.62(f)). In the absence of contamination by oil and hazardous substances, the trustees believe that fishing pressure in the GCR would equal that observed at comparable warmwater fisheries in Indiana. This conclusion is supported by inferred existing fishing pressure at the nearby Little Calumet River and Salt Creek and the presence of a large, local population with easy access to the river. The trustees recently completed a report evaluating injury to fishery resources in the assessment (MESL 2003).

Metrics to Assess Effects of Sediment on Non-Aquatic Wildlife

Contaminants in the sediment of the GCR/IHC are available to non-aquatic wildlife (e.g., waterfowl) through both direct exposure and dietary uptake. Direct exposure is typically a problem associated with petroleum-based compounds, although difficult to assess quantitatively. Dietary transfer of contaminants occurs in much the same way as described above for fish. The trustees have assessed the effects of contaminated sediments on non-aquatic wildlife using two metrics, tissue chemistry and whole sediment chemistry.

Tissue residue guidelines (TRGs) reported in the literature specify limits of contaminants in fish that will protect predator species from acquiring a harmful amount of contaminants through bioaccumulation. These TRGs define the concentrations of contaminants in fish tissue

[6] The advisory states that no fish from the GCR/IHC should be consumed, but it is possible that anglers either ignore the advisory or practice catch-and-release fishing for recreation.

which, if not exceeded, are likely to prevent carcinogenic or non-carcinogenic impacts on piscivorous wildlife, including birds and mammals. Similar limits have been developed for sediments (i.e., sediment quality guidelines, SQGs) (MESL 2000).

To assess the potential for adverse effects to non-aquatic wildlife in the GCR/IHC system, sediment chemistry data and fish tissue chemistry data were compared with established SQGs and TRGs, respectively. In five of the six project reaches, both sets of these guidelines are exceeded (see Exhibit A-7). In the LGB, prey species tissue data are insufficient to compare with TRGs, but available whole sediment chemistry data exceed the SQGs in 83 percent of the samples (MESL 2000). This indicates that contaminated sediments in the GCR/IHC have an adverse effect on non-aquatic wildlife.

The trustees are preparing a separate report evaluating injury to non-aquatic wildlife in the assessment area which will consider these and other metrics such as effects on reproductive success.

Exhibit A-7
Metrics indicating adverse effect to fish and wildlife

Reach	Indicator of Effects on Fish and Wildlife Resources[1]					Number of Lines of Evidence for Demonstrating Ecosystem Impacts
	Toxicity to Fish[2]	Fish Health[3]	Fish Community[4]	Whole Sediment Chemistry[5]	Tissue Chemistry[6]	
East Branch Grand Calumet River-I	57% (n=23)*	40% (n=10)*	100% (n=29)*	74% (n=110)*	100% (n=22)*	5
West Branch Grand Calumet River-I	ID (n=0)	100% (n=3)*	100% (n=12)*	29% (n=7)*	100% (n=7)*	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	ID (n=0)	ID (n=1)	ID (n=1)	67% (n=6)*	94% (n=17)*	2
Overall	**57% (n=23)***	**48% (n=21)***	**96% (n=56)***	**77% (n=198)***	**100% (n=54)***	
Lake Michigan[7]	ID (n=0)	ID (n=0)	ID (n=0)	93% (n=27)*	50% (n=4)*	2

1 For each line of evidence, adverse effect is indicated if two or more samples demonstrate conditions sufficient to indicate adverse effects. Evidence of adverse effect 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 ≤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.

7 Provided for comparison purposes only. Lake Michigan is not part of the restoration project area.

ID = insufficient data; n = number of samples.

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APPENDIX B

PRELIMINARY SCREENING OF RESTORATION ALTERNATIVES

ON-SITE RESTORATION ALTERNATIVES

This appendix describes the trustees' process to identify and evaluation options for on-site restoration of the GCR/IHC

To develop restoration alternatives, the trustees first evaluate a range of sediment management technologies. Restoration alternatives are then developed from those technologies judged to be appropriate for this site, as described below. The information this Appendix is a summary of the work presented in the Final Restoration Alternatives Development and Evaluation Report prepared by Foster Wheeler Environmental Corporation, dated December 2000 (Foster Wheeler 2000).

Sediment Management Technologies

The trustees follow a multi-step process to identify a range of sediment remediation alternatives and to evaluate these alternatives against relevant criteria. The first step is the identification of available technologies for management of contaminated sediments. They are:

- Dredging technologies (of various kinds);
- Sediment disposal (in conjunction with dredging);
- Sediment treatment (various kinds, including mechanical, chemical, and thermal treatments); and
- In-place capping (both "thick" and "thin").

These options are "pre-screened" using the criteria of effectiveness, implementability, and order-of-magnitude costs. At this stage, the screen consists simply of "retain" or "eliminate."

Dredging Technologies

Dredging is a remediation technique used to remove material with contaminant concentrations in excess of remediation goals. When dredging, several site-specific characteristics must be considered, including the depth of the water column, volume of material to be removed, width and depth of the dredge cut, firmness of the sediment, and the presence of debris. There are three types of dredging technologies: hydraulic dredging, mechanical dredging, and hybrid or specialty dredging. The key differences lie in the mechanism for removing and transporting the dredged material. In hydraulic dredging, material is removed via suction created by a pump. The resulting slurry can be conveyed via pipeline some distance. In addition, some hydraulic dredging equipment is small enough to be used in confined waterways such as the GCR/IHC. Mechanical dredging involves using a bucket or shovel to excavate material and raise it to the surface for disposal. Hybrid dredging technologies incorporate some features of the two (e.g., a dredge with a mechanical "cutter head" that removes sediment to a controlled depth, and then pumps it to the surface as would a hydraulic dredge). Hydraulic dredging is retained by the trustees for further consideration because of its operational flexibility, which is necessary under the difficult site constraints of the GCR/IHC. Hybrid dredging technologies are also retained. Mechanical dredging does not have this flexibility and thus is eliminated.

Sediment Disposal Options

If dredging is deemed the best alternative for remediation of the contaminated sediment, a site(s) must be chosen for disposal of the dredged material. Consideration must be given to the available geographic alternatives as well as the characteristics of the contaminated sediment when choosing a disposal site. Three options for confined disposal are considered in the following subsections: upland or off-site confined disposal, nearshore confined disposal, and confined aquatic disposal (CAD).

For upland or off-site confined disposal facilities (CDFs), contaminated sediment is transported to an adjoining upland site or a permitted off-site disposal area. The goal of off-site disposal is to eliminate contact between contaminated sediment and the water body. Confinement may be accomplished through construction of dikes or low structural walls, with either a clay or geofabric liner to prevent contaminant migration. Water released from the sediment as it consolidates (supernatant) must usually be treated before discharge. Nearshore CDFs are similar to upland CDFs in most respects, differing mainly in that they are constructed near the dredging location, extending into the water. CAD differs in that disposal occurs below the water line, either directly on the bottom, or in a shallow pit. The material is then capped using a method such as described for capping, above. CDFs, while expensive, are considered viable alternatives, and are retained by the trustees. CADs may result in adverse impacts to aquatic ecosystems, including the risk of future releases of hazardous substances, and are therefore eliminated.

Sediment Treatment

A variety of methods can be used to treat contaminated sediments. The method chosen depends on the characteristics of the sediment, the contaminants that are present, and the concentrations of the contaminants. Potential sediment treatment technologies and process options are the same as those used for upland solid waste such as soil or sludge. The main difference between river sediment and upland soil is that river sediments have a much higher initial water content than upland soil. Before treating the sediment for specific contaminants, dredged material often must be modified by mechanical treatments such as screening, dewatering, and consolidation.

Many treatment technologies were investigated in connection with the disposal of potential dredged materials from Indiana Harbor as part of the Final Feasibility Report and Environmental Impact Statement conducted for the IHC (USACE 1995). Four were selected as having greatest potential for application to the IHC sediments: solidification/stabilization, solvent extraction, incineration, and wet air oxidation. The effectiveness of these technologies, however, is low because none would treat both organic and inorganic contaminants as are found in the GCR/IHC. Only the mechanical technologies (e.g., dewatering) are retained to facilitate disposal.

In-place Capping

In-place capping is generally the most straightforward and least intrusive sediment remediation technique (other than natural recovery). The technique involves placing clean sediments, generally consisting of silty to gravelly sand, over the areas of contaminated sediment. This prevents resuspension of contaminated sediment and reduces the risk of human or biotic contact with contaminated material. The issues generally associated with in-place capping include obtaining appropriate cap thickness over the entire area of contaminated sediment, placing the capping material without displacing the contaminated sediment, and maintaining long-term cap integrity.

There are two approaches to capping: thick and thin. Thick capping isolates areas of contaminated sediment and establishes conditions for the creation of a new benthic habitat. Cap thickness is on the order of three feet to prevent bioturbation into the underlying contaminated sediments. Thin capping (cap thickness approximately one foot) may be used as a way of enhancing natural recovery processes. This allows for mixing of the clean and contaminated sediment, but at a rate such that release of contaminants to the system is slowed. Thick capping is retained by the trustees as an option for the GCR/IHC, but thin capping is unlikely to be effective given the high contamination levels at this site, and is therefore eliminated.

Restoration Alternatives

The trustees next develop several restoration options which incorporate one or more of the technologies retained in the pre-screening step. Multiple technologies may be used in combination to effect a "complete" alternative. The restoration options are:

- Dredging with on-site CDF disposal - Sediment would be removed such that remaining contaminant concentrations resulted in mean PEC-Q values of <0.7. Disposal would be in the Corps CDR.

- Dredging with off-site landfill disposal - Sediment removed as above, with disposal at a commercial landfill.

- Thick Capping - Three feet of clean sediment would be placed over the contaminated sediments to isolate them from the environment.

- Shallow dredging with on-site disposal, followed by thick capping - The top three feet of sediment would be removed, after which a three-foot cap of clean sediment would be placed. Disposal would be in the Corps CDF.

- Shallow dredging with off-site disposal, followed by thick capping - The top three feet of sediment would be removed, after which a three-foot cap of clean sediment would be placed. Disposal would be at a commercial landfill.

The trustees' evaluation of these options is presented in the next section.

EVALUATION OF RESTORATION ALTERNATIVES

The Department regulations describe ten criteria for use in evaluating restoration alternatives (43 CFR § 11.82(d)). To ensure that the evaluation of alternative restoration projects will remain focused on the key considerations for projects that seek to actively address contaminated sediments, the trustees developed criteria specific to this assessment that are intended to include and go beyond those listed in the Department regulations. The Initial RCDP presents two sets of criteria specific to alternatives for management of contaminated sediments, designated as "threshold" and "ranking" criteria (IDEM 1998). Threshold criteria represent the requirements the trustees must satisfy, due to statutory mandates, or choose to satisfy, due to state and federal policies, procedures, or other factors. Ranking criteria represent metrics by which the trustees can compare restoration alternatives than meet the threshold criteria.

Threshold Criteria

The first step in evaluating the restoration alternatives is to assess each against the three threshold criteria. If an alternative fails to meet one or more of the criteria, it is eliminated from further consideration. The threshold criteria for the sediment management restoration alternatives are:

- Does the project clearly address injuries to natural resources or losses of natural resource services?
- Does the project comply with applicable federal and state laws and regulations?
- Is there general public support for the implementation of the project?

The trustees' evaluation of the sediment management restoration alternatives is presented in Exhibit B-1. Thick capping, while potentially able to reduce the effects of contaminated sediment on the environment, would result in unacceptable changes to the hydrology of the GCR/IHC due to changes in bottom profile and elevation of the water surface. It is therefore eliminated from further consideration. Only those alternatives which incorporate removal of contaminated sediment by dredging meet all of the threshold criteria. These four alternatives are retained for further evaluation using the ranking criteria.

Exhibit B-1
Evaluation of sediment management restoration alternatives using threshold criteria

Alternative	Addresses injuries?	Complies with laws?	Public support?	Retain for further evaluation?
Dredging with on-site disposal	Y	Y	Y	Y
Dredging with off-site disposal	Y	Y	Y	Y
Thick capping	N	Y	N	N
Dredging, on-site disposal, & thick capping	Y	Y	Y	Y
Dredging, off-site disposal, & thick capping	Y	Y	Y	Y

Ranking Criteria

The four alternatives that meet the threshold criteria are similar in that they all begin with dredging of contaminated sediments from the GCR/IHC. Therefore, further evaluation is focused on the two components that vary among the alternatives: first, the location of sediment disposal (locally in a CDF or off-site in a commercial landfill); and second, the depth of dredging (and therefore whether or not a thick cap is subsequently placed). Exhibit B-2 presents the trustees' evaluation of these two components using the ranking criteria developed in the Initial RCDP. The criteria are:

- Is the project technically feasible?
- Will the project cause "collateral injuries" or other undesirable short-term impacts?
- Can the project provide the desired habitat improvements within a reasonable timeframe?
- Are the resource-based "benefits" of the project reasonable relative to the project's cost?
- Is the project consistent or compatible with ongoing or planned response activities?
- Will the project simultaneously achieve one or more of the objectives defined under a comparable "restoration" effort (e.g., development and implementation of the Remedial Action Plan for the International Joint Commission's Grand Calumet Area of Concern)?

Exhibit B-2
Evaluation of sediment management restoration alternatives using Ranking Criteria

Criterion	On-site CDF vs. Off-site Landfill	Shallow dredging with cap vs. "Maximum" dredging
Technically feasible?	Equal	Capping adds a potentially difficult technical component to the shallow dredging option.
Collateral injuries?	Additional local impacts if new CDF is sited.	Capping could result in additional short-term impacts to the water column and stream-side areas used for staging, stockpiling, and access. On the other hand, some contamination will remain.
Reasonable timeframe?	Siting and construction of new CDF could delay implementation.	Provision of a clean substrate after shallow dredging may restore baseline conditions in the GCR/IHC sooner and provide additional protection for the ecosystem.
Benefit-cost reasonableness?	Off-site disposal is significantly more expensive with few additional benefits compared to utilizing Corps CDF.	If disposal will be off-site, maximum dredging is substantially more expensive but unlikely to provide substantially larger ecological benefit. If disposal is in Corps CDF, maximum dredging is less expensive.
Consistent with other response activities?	N/A[1]	N/A[1]
Achieve other objectives?	Equal	Because it is likely to bring additional environmental benefits, capping may also achieve other objectives for the restoration of the GCR/IHC environment.

[1] No other response activities are contemplated at this time.

The trustees note the possibility of selecting different dredging depths for different reaches of the GCR/IHC. For example, in areas where contaminated sediments is relatively deep, shallow dredging followed by placement of a cap may result in cost savings compared to removal of all contaminated sediment. Nevertheless, evaluation and selection of the alternatives for implementation on a reach-by-reach basis is not feasible at this time. A more detailed consideration of the river characteristics and restoration specifics at the reach level is left for the Restoration Planning phase, when preliminary engineering design occurs.

COST ASSESSMENT

To fully evaluate the range of restoration alternatives, the trustees must consider the costs of implementing each alternative. This section presents the trustees' cost-estimating methodology and preliminary cost estimates for the four retained alternatives.

Cost Estimating Methodology

First, the trustees conducted a survey of the river to develop accurate measurements of the channel cross section at a large number of sites. Using these cross-sections, the trustees estimated the amount of sediment needing removal under various management alternatives. Volume estimates were made for two dredging scenarios in the "trustee project area" (i.e., WBGCR I, IHC, LGB, EBGCR I) and one dredging scenario in the "federal project area" (i.e., USC, IH).

To estimate costs, dredging and capping alternatives are broken into component actions (e.g., dredging, de-watering, and shipment to disposal site) and cost estimates developed using a unit-cost approach. The cost of each component action of an alternative is estimated based on the predicted amount of work required and the unit cost. For example, dredging sediment and pumping it to a de-watering area is estimated to cost $5 per cubic yard. Therefore, the estimated cost of dredging one million cubic yards is $5 million. The unit costs developed for the various operations are collected from a variety of sources and based on professional experience (Foster Wheeler 2000).

Cost Estimates for Alternatives Carried Forward

Cost estimates for the four restoration alternatives are presented in Exhibit B-3. These estimates are developed using the data provided in the Final Restoration Alternatives Development and Evaluation Report (Foster Wheeler 2000). The cost estimates for the on-site disposal option assume that disposal of contaminated sediments will be in the Corps' CDF at the ECI site. Separate estimates are developed for the trustee project area and the federal project area. Estimates for the trustee project area are further refined by considering two dredging scenarios. The first would entail dredging to a uniform depth of three feet, followed by capping with clean sediment. The second would involve dredging to a variable depth depending on the results of sediment chemistry. That is, dredging would occur until all sediment with a mean PEC-Q > 0.7 is removed. This would represent the maximum dredging effort for the GCR/IHC. The cost estimates for the federal project area assume that additional dredging beyond that required for navigation will be necessary to remove residual contamination. In the event that additional dredging is not necessary, the cost estimates for the federal project area will be limited to the costs of capping, if any. All cost estimates include 20 percent markup to cover design, management, and contingency.

Exhibit B-3
Estimated Restoration Costs

Restoration Alternative	Trustee Project Area	Federal Project Area
Maximum dredging and on-site disposal	$53,000,000	N/A
Maximum dredging and off-site disposal	$252,000,000	N/A
Shallow dredging, on-site disposal, and capping	$69,000,000	$15,000,000
Shallow dredging, off-site disposal, and capping	$173,000,000	$53,000,000

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