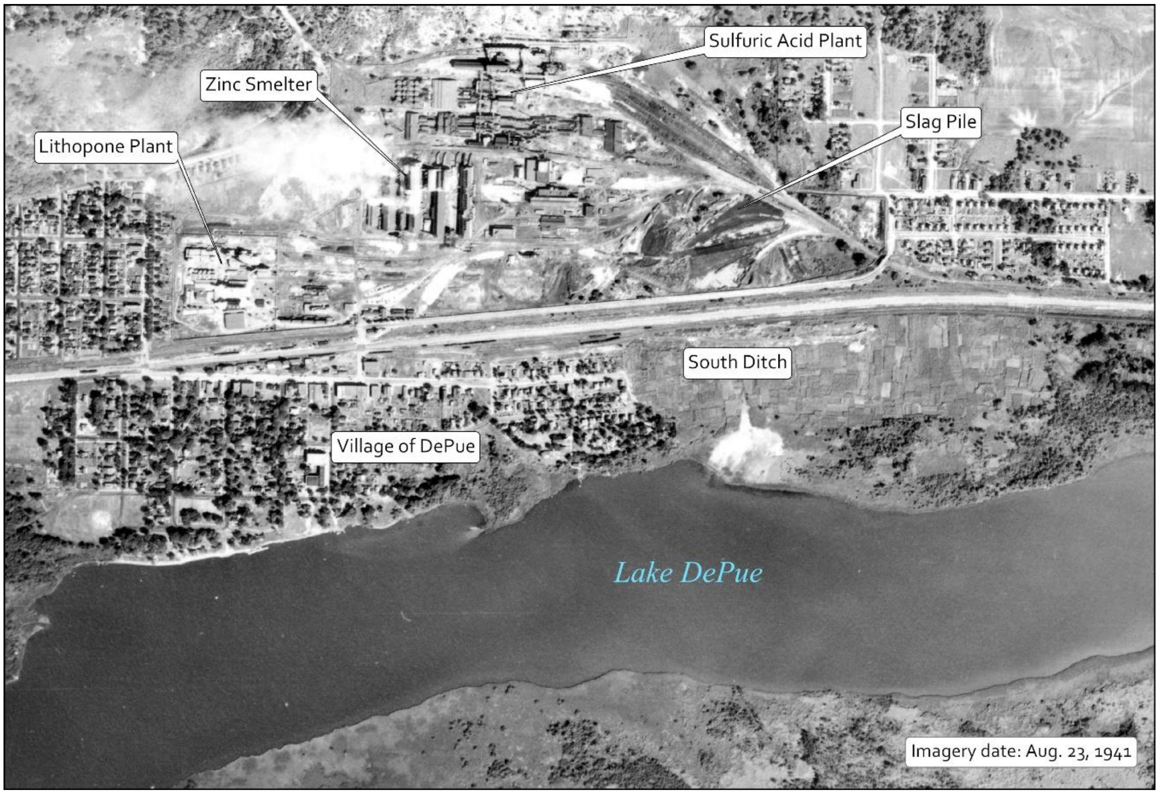
Assessment Plan
for
The Former New Jersey Zinc/Mobil Chemical
National Priorities List Site



1941 Aerial Image of DePue, Illinois

The State of Illinois
The Illinois Department of Natural Resources
The Illinois Environmental Protection Agency
as Trustees of Natural Resources

With assistance from Abt Associates

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14380

*minor revisions incorporated based on public comment

Approval Signatures:

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Acronyms and Abbreviations

ALC	aquatic life criteria
ALCA	Anderson Lake Conservation Area
bgs	below the ground surface
BOLA	Bottom of the Lower Aquifer
BT	benefits transfer
CAA	Clean Air Act
$CaCO_3$	milligrams of calcium carbonate
CAMU	corrective-action management unit
CBS	TCI Pacific Communications, Inc.; CBS/Westinghouse of PA, Inc.; and CBS Operations Inc.
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMC	Criterion Maximum Concentration
CV	contingent valuation
CWA	Clean Water Act
DAP	diammonium phosphate
DePue Group	Entity that Viacom International Inc., Horsehead Industries, Inc., and Mobil Oil Corporation formed
DOI	U.S. Department of the Interior
DSAYs	discounted service acre-years
Eco-SSL	ecological soil screening level
ExxonMobil	ExxonMobil Oil Corporation
FPA	Funding and Participation Agreement
FPSA	Former Plant Site Area
FS	feasibility study
FSP	Field Sampling Plan
GIS	geographic information system
HASP	Health and Safety Plan
HEA	habitat equivalency analysis
Horsehead	Horsehead Industries, Inc.
ICO	Interim Consent Order
ICP	inductively coupled plasma
IDNR	Illinois Department of Natural Resources
Illinois EPA	Illinois Environmental Protection Agency
INHS	Illinois Natural History Survey
IRM	iron-rich material
ISGS	Illinois State Geological Survey

ISWS	Illinois State Water Survey
IWTP	interim water treatment plant
MCL	maximum contaminant level
Mobil	Mobil Oil Corporation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NRDA	Natural Resource Damage Assessment
OU	Operable Unit
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PEC	probable effect concentration
PRP	potentially responsible party
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RCDP	Restoration and Compensation Determination Plan
RCRA	Resource Conservation and Recovery Act
REA	resource equivalency analysis
RI	remedial investigation
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SVOC	semi-volatile organic compound
TACO	Tiered Approach to Corrective Action Objectives
TDS	total dissolved solids
T&E	threatened and endangered
TEC	threshold effect concentration
TOLA	Top of the Lower Aquifer
Trustees	Illinois Department of Natural Resources and Illinois Environmental Protection Agency
TRV	toxicity reference value
UPSEA	upland portion of the southeast area
U.S. EPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UWBZ	Upper Water Bearing Zone
Viacom	Viacom International Inc.
WTP	willingness-to-pay
WWTP	Wastewater Treatment Plant

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1. Introduction

The New Jersey Zinc/Mobil Chemical National Priorities List (NPL) Site (the Site), in the Village of DePue in Bureau County, Illinois, includes a former primary and secondary zinc-smelting facility, a former sulfuric acid plant, a former lithopone paint pigment plant, and a former diammonium phosphate (DAP) fertilizer plant. Operations included zinc smelting, phosphoric and sulfuric acid production, manufacture of zinc dust, and recovery and refinement of other metals. Waste disposal and other activities at the Site released hazardous substances to the environment, including to Lake DePue, and to the Village of DePue, including residential properties. Because of the contamination on the plant property and surrounding areas, the U.S. Environmental Protection Agency (U.S. EPA) listed the Site on the NPL in 1999 (Federal Register, 1999). The Illinois Environmental Protection Agency (Illinois EPA) is the lead agency for cleanup of the Site (ICO, 1995).

The Illinois Department of Natural Resources (IDNR) and Illinois EPA, together the Illinois Natural Resource Trustees (the Trustees), are assessing natural resource damages resulting from the hazardous substance releases from the Site.[1] Releases of hazardous substances and oil into the environment can pose a threat to human health and natural resources such as plants, animals, land, air, water, groundwater, drinking water supplies, and other resources. When releases of hazardous substances or oil injure natural resources that are held in trust for the public, federal and state laws provide mechanisms that authorize trustees to seek compensation from potentially responsible parties (PRPs) for those injuries. These mechanisms include Natural Resource Damage Assessments (NRDAs) and similar processes. Regulations outlining a process for conducting NRDAs after the release of hazardous substances and oil have been promulgated and are set forth in 43 CFR Part 11 for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Clean Water Act (CWA), and in 15 CFR Part 990 for the Oil Pollution Act.

This document presents an Assessment Plan for the NRDA at the Site, which is based on Trustee knowledge and interests. It includes a proposed approach and methods per 43 CFR Part 11 to determine damages resulting from hazardous substances released from the Site.

1.1 Cooperative NRDA

This Assessment Plan was prepared by the Trustees to guide a cooperative NRDA outlined by a Funding and Participation Agreement (FPA) between the Trustees and the PRPs (identified in Section 1.2). Acting through this FPA, the Trustees and PRPs agree to conduct the NRDA consistent with the Type B procedures for injury determination, quantification, and damage determination set forth in 43 CFR Part 11(see Section 1.5 for additional information). The Trustees and PRPs will attempt to work efficiently, cooperatively, and in a cost-effective manner to advance the NRDA and move towards resolution of potential natural resource damage claims related to the release(s), focusing on identifying and evaluating restoration alternatives for any injured resources and/or the services provided by those resources. The Trustees and PRPs will work independently or collaboratively on multiple tasks, including scope of work development,

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1. The U.S. Fish and Wildlife Service (USFWS) is also a Trustee. At this time, the federal government is not participating in this assessment. Therefore, in this document, the term "Trustees" refers to the two State Trustees.

review of data, use of data, interpretation of results, and development of conclusions. The Trustees and PRPs will work cooperatively to resolve differences and develop a cost-effective restoration plan reflective of injured natural resources and the services they provide. Although the Trustees hold final authority as to interpretation of results and development of conclusions, they welcome full participation of the PRPs in this process.

The Trustees intend to complete milestone documents identified in 43 CFR Part 11, including a Preassessment Screen (completed), Assessment Plan, Report of Assessment, and Restoration Plan. The NRDA will be developed in cooperation with the ongoing remedial investigations and feasibility studies (RIs/FSs) to every extent possible.

In the event the cooperative assessment approach fails, the Trustees retain the right to amend this Assessment Plan as deemed necessary.

1.2 PRPs

In 1995, Viacom International Inc. (Viacom), Horsehead Industries, Inc. (Horsehead), and Mobil Oil Corporation (Mobil) formed an entity called "the DePue Group" and signed an Interim Consent Order (ICO) with the Illinois EPA and the Illinois Attorney General's Office for investigating the Site and evaluating possible remedial actions (ICO, 1995). After various corporate mergers and acquisitions, and the bankruptcy of Horsehead, the PRPs for the Site are now TCI Pacific Communications, Inc.; CBS/Westinghouse of PA, Inc. and CBS Operations Inc. (collectively referred to as "CBS"); and ExxonMobil Oil Corporation (ExxonMobil).[2] These entities currently comprise the DePue Group and are the PRPs for the Site.

1.3 NRDA Process

The overall goal of NRDA is to restore damaged natural resources and the services they provide to the conditions that would have existed had the damage not occurred. Key NRDA terms used throughout this document include:

- **"Natural resources"** are land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States . . . [or] any State or local government [43 CFR § 11.14(z)].
- **"Services"** are the physical and biological functions performed by natural resources, including human uses, which are the result of the physical, chemical, or biological quality of the resources [43 CFR § 11.14(nn)]. Example services include physical habitat, nutrient and energy cycling, food web interactions, flood control, groundwater recharge, and recreation [43 CFR § 11.71(e)].
- The term **"hazardous substance"** refers to a hazardous substance as defined in Section 101(14) of CERCLA [43 CFR § 11.14(u)]. This includes hazardous substances designated or listed by Sections 311(b)(2)(A) and 307(a) of the Federal Water Pollution Control Act (a.k.a. the CWA), by Section 102 of CERCLA, by Section 3001 of the Solid

2. See the DePue/New Jersey Zinc Site Natural Resource Damage Assessment Funding and Participation Agreement dated October 5, 2016.

Waste Disposal Act (a.k.a. the Resource Conservation and Recovery Act or RCRA), or listed by Section 112 of the Clean Air Act (CAA).

- **"Release"** refers to a release of a hazardous substance into the environment [43 CFR § 11.14(hh)].
- A **"pathway"** is the "route or medium through which . . . a hazardous substance is or was transported from the source of the discharge or release to the injured resource" [43 CFR § 11.14(dd)].
- **"Injury"** means a measurable adverse change in the chemical or physical quality or the viability of a natural resource resulting directly or indirectly from exposure to a hazardous substance, or exposure to a product of reactions resulting from the discharge of or release of a hazardous substance [43 CFR § 11.14(v)].
- **"Baseline"** is the condition that would have existed had the hazardous substance release(s) not occurred [43 CFR § 11.14(e)]. Baseline is dynamic, describing the condition over time had the resource(s) not been exposed to the release.
- **"Assessment area"** is the area where natural resources have been affected by the release of hazardous substances [43 CFR § 11.14(c)].
- **"Restoration"** is the action taken to return an injured resource to its baseline condition [43 CFR §11.14(ll)].
- **"Damages"** are defined as ". . . the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources as set forth in Section 107(a) or 111(b) of CERCLA" [43 CFR § 11.14(l)]. Damages includes restoration costs, compensable values for interim losses (at the discretion of the Trustees), and reasonable assessment costs [43 CFR § 11.80(b)].

The U.S. Department of the Interior (DOI) regulations for conducting NRDAs [43 CFR Part 11] involve four major components (Figure 1.1). The first is the **Preassessment Screen,** which determines whether a release of hazardous substances warrants an NRDA – the Trustees prepared a Preassessment Screen in 2015 (IDNR and Illinois EPA, 2015). Preparation of an **Assessment Plan**, this document, is the second component. The Assessment Plan is a work plan for the NRDA that ensures that the assessment proceeds in a cost-effective manner. The Trustees developed this Assessment Plan. Prior to public release, the Trustees provided a draft Assessment Plan to the PRPs for review and comment; this final Assessment Plan incorporates feedback from the PRPs. As required in the DOI regulations, the public is now given at least 30 days for review and comment.

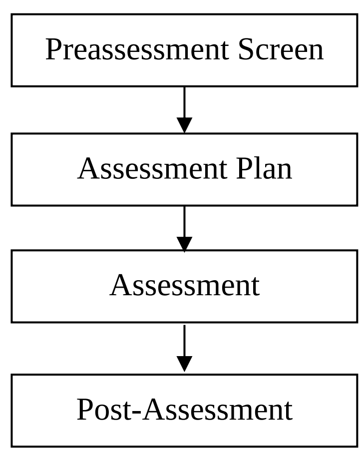

Figure 1.1. Simplified NRDA process.

The third component of NRDA under the DOI regulations is the **Assessment**, which may be conducted using existing data or may include studies to determine the injuries that may have occurred to natural resources, quantifying the injuries and associated reduction of natural resource services, and determining the appropriate damages and restoration actions for the injuries. Assessment studies may be cooperative (involving one or more PRPs and Trustees) or independent (conducted by any party). With extensive ongoing RIs and an associated robust dataset, additional studies may not be necessary. The Trustees and PRPs will assess all potential injuries. The Trustees will review existing data and identify any data gaps that may exist. The Trustees and PRPs will work cooperatively to attempt to resolve uncertainties, address data gaps, and develop a Restoration and Compensation Determination Plan (RCDP) without the need for additional studies.

The fourth component consists of the **Post-Assessment**. The Trustees will publish the results of the cooperative assessment work, presenting the required restoration activities as compensation for losses of natural resources, and provide it to the public. The Trustees, potentially in cooperation with the PRPs, will then develop and implement a restoration plan.

1.4 Preassessment Screen Conclusions

The Trustees published the Preassessment Screen for the Site in September 2015 (IDNR and Illinois EPA, 2015). In the Preassessment Screen, the Trustees determined that the criteria specified in 43 CFR Part 11 have been met and that there is a reasonable probability of making an appropriate claim for damages to natural resources over which the Trustees have trusteeship. Therefore, the Trustees concluded that an assessment of natural resource damages is warranted, and that they would proceed with the preparation of an Assessment Plan.

Specifically, the Preassessment Screen for the Site concluded:

1. *Releases of hazardous substances have occurred* [43 CFR § 11.23(e)(1)]. Releases of hazardous substances to soils, surface water and sediments, and groundwater have been documented.
2. *Natural resources for which the Trustees can assert trusteeship have been, or are likely to be, adversely affected by the release of hazardous substances* [43 CFR § 11.23(e)(2)]. Trust resources, including but not limited to surface water, soils, sediment, and groundwater, have been and continue to be adversely affected by releases of hazardous substances from the Site.
3. *The quantity and concentration of the released substances are sufficient to potentially cause injury to natural resources* [43 CFR § 11.23(e)(3)]. RIs at the Site are ongoing. Based on data used for the scoring of the Site for inclusion on the NPL and collected thus far, there are contaminant sources of sufficient quantity and concentration to potentially cause injury to natural resources.
4. *Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost* [43 CFR § 11.23(e)(4)]. Data with which to pursue an assessment are already available. Under the ICO, the DePue Group is currently performing RIs at the Site, which are generating much of the data. Additional studies and data collection efforts that may be necessary to adequately characterize and quantify injury at the Site can be obtained at a reasonable cost.
5. *Response actions carried out or planned will not sufficiently remedy the injury to natural resources without further action* [43 CFR § 11.23(e)(5)]. Response activities at the Site have not yet mitigated all potentially injured natural resources. Interim losses from past injuries of

natural resources at the Site have not been addressed, and the Trustees are unaware of any plan to mitigate them. Rehabilitation, restoration, or replacement of natural resources is needed to address injuries to and losses of natural resources within the trusteeship of the State of Illinois.

1.5 Assessment Plan

The evaluation of natural resource injuries and damages is conducted during the Assessment Phase. The parts of an assessment include:

1. **Injury determination**: The first part of the injury assessment determines what natural resources have been injured as a result of the release of hazardous substances [43 CFR § 11.13(e)(1)]. It also involves determining the pathway, or route, through which the hazardous substances and/or petroleum products were transported from sources to the injured resource [43 CFR § 11.61(c)(3)].
2. **Injury quantification**: The second part of the assessment quantifies the injuries in terms of the "loss of services that the injured resource would have provided had the discharge or release not occurred" [43 CFR § 11.13(e)(2)]. The extent and degree of injuries, the ability of the resource(s) to recover, and the reduction in services are included in the quantification of injuries [43 CFR § 11.71(c)].
3. **Damage determination**: The third part of the assessment determines the appropriate compensation for the injuries [43 CFR § 11.13(e)(3)]. Damages are the cost of "restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the natural resources and the services those resources provide." Damages may also include the value of the services lost to the public from the time of the release to the reestablishment of the services to baseline conditions [43 CFR § 11.80(b)].

This Assessment Plan provides the methods to be used in the Assessment Phase and was prepared in accordance with DOI NRDA regulations as set forth at 43 CFR Part 11. These regulations are not mandatory. However, assessments performed in compliance with these regulations allow for a rebuttable presumption in any administrative or judicial proceeding under CERCLA [42 USC § 9607(f)(2)(C)]. The DOI guidelines also provide a useful context within which the various aspects of the assessment can be evaluated.

The purpose of the Assessment Plan is to ensure that the assessment is completed in an organized and systematic manner, and that the methodologies utilized for the assessment can be conducted at a reasonable cost [43 CFR § 11.30(b)]. This Assessment Plan includes:

- Descriptions of the geographic area and natural resources involved [43 CFR § 11.31(a)(2)]
- A statement of authority for asserting trusteeship, or co-trusteeship, for natural resources [43 CFR § 11.31(a)(2)]
- Information sufficient to demonstrate coordination with the RI/FS process [43 CFR § 11.31(a)(3)]
- Procedures and schedules for sharing data, splitting samples, and providing analytical results to PRPs and other interested parties [43 CFR § 11.31(a)(4)]
- An explanation of the decision to proceed with a Type B assessment [43 CFR § 11.31(b)]

- Confirmation of exposure of natural resources to hazardous substances [43 CFR § 11.31(c)(1)]
- A Quality Assurance Plan [43 CFR § 11.31 (c)(2)].

An Assessment Plan may also include an RCDP. An RCDP generally lists a reasonable number of possible alternatives for (1) the restoration of injured natural resources to conditions providing the level of services available at baseline, and (2) the replacement of equivalent natural resources capable of providing such services. However, if insufficient information is available to develop the RCDP at the time of Assessment Plan preparation, it may be developed at a later time before the completion of injury determination and quantification [43 CFR § 11.31(c)(4)]. Given the Trustees' vision for the cooperative NRDA, including the assessment, is to follow 43 CFR Part 11 in an effort to assess damages for injuries to natural resources with a focus on habitat restoration, an RCDP may be developed during the assessment phase. In the event the cooperative NRDA fails, the Trustees retain the right to amend this strategy as deemed necessary.

1.6 Public Review and Comment

This Assessment Plan is available to the public for review and comment for a period of at least 30 days. A public comment period provides an opportunity for involvement by other governmental agencies and any other interested members of the public in this important matter. It may also provide new information and ideas that may be incorporated into the assessment.

The public release draft Assessment Plan is available at the Selby Township library in DePue, Illinois, and available online at https://www.dnr.illinois.gov/programs/NRDA/Pages/Lake-DePue---New-Jersey-ZincMobil-Chemical-NPL-site.aspx.

Written comments on the Assessment Plan may be sent to:

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One Natural Resources Way
Springfield, IL 62702
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1.7 Organization of Assessment Plan

This Assessment Plan is organized as follows: Section 2 presents an overview of the assessment area, including a description of Site operations, assessment area natural resources, early Site contamination investigations, sources and releases of hazardous substances, and RI activities. Section 3 describes the authority of the Trustees to proceed with the assessment and describes the Trustees' decision to proceed with a Type B assessment. Section 4 provides confirmation that natural resources have been exposed to hazardous substances in the assessment area and presents methods to be used to estimate the natural recovery period. Section 5 describes the approach and methods to be employed in the injury assessment. Section 6 describes the damage determination process, including both restoration planning and compensable value determination. Section 7 discusses the Quality Assurance Plan, and Section 8 presents a summary and conclusions. Appendix A describes data sources for the assessment. References cited in the text of the document are provided at the end of the main document.

2. Background Information on Assessment Area

The NRDA assessment area includes all locations where hazardous substances released at the Site have come to be located. The geographic extent of the assessment area in DePue has not been delineated, but at a minimum includes the Site Operable Units (OUs) discussed in Section 2.1.3. To ensure that the assessment adequately covers the spatial and temporal extent of all potential injuries and service losses to all natural resources held in trust for the public, the assessment area extends anywhere injury may occur. Over the course of the assessment, the Trustees may conclude that the data do not support an injury claim for certain areas or certain resources, but the Trustees will not make *a priori* determinations of injury or service loss before an assessment is underway.

2.1 Description of the Site and the Assessment Area

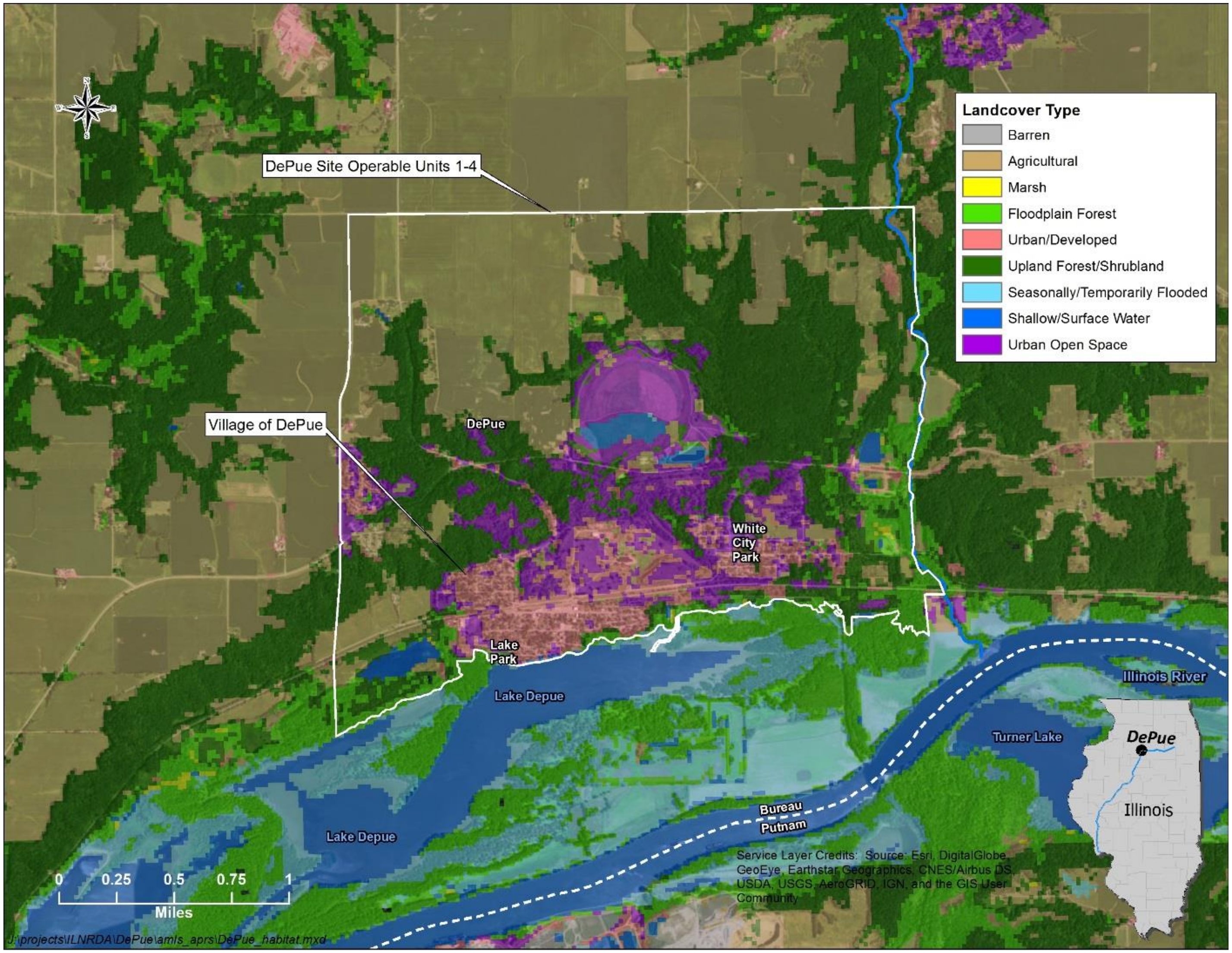
The Site is located in and around the Village of DePue in the Selby Township of Bureau County, Illinois. The Village of DePue hosted several industrial operations from 1903 to 1989. The area was developed because of the abundance of local coal, railroad access, and the market demand for zinc products (Illinois EPA, 1992). The portion of the Site owned by the PRPs is approximately 860 acres (Golder Associates, 1996b). Associated manufacturing facilities are discussed below as part of the Site's operational history.

2.1.1 Natural Environment

The Site is located in the Bloomington Ridged Plain division of the Till Plains Section of the Central Lowland physiographic province (ISGS, 1948). The topography has been shaped by glaciers and has broad sloped glacial moraine ridges typically separated by flatter topography. The Village of DePue and the Site are located in the Illinois River Valley lowland, which cuts through the till plain, and is covered by alluvial floodplain and terrace deposits. The Village of DePue is surrounded by a mixture of upland forest and shrubland, as well as agricultural and other disturbed land (Figure 2.1).

The 524-acre Lake DePue is located south of the Village of DePue, and is part of the 3,015-acre Lake DePue State Fish & Wildlife Area (IDNR, 2017). It is a shallow (less than 3 feet deep in most areas) backwater/bottomland lake connected to the Illinois River at its western end by a narrow, shallow channel (Arcadis, 2012). The lake is depositional, with sediment depths of up to 10 feet. Lake DePue is separated from the Illinois River by a low-elevation peninsula. Negro Creek is east of the Site and Lake DePue, and currently drains into the Illinois River; from approximately 1945 to 1976, Negro Creek was rerouted to enter the eastern end of Lake DePue. USFWS classified areas of the floodplain forest and seasonally flooded areas surrounding Lake DePue as emergent, scrub-shrub, and forested wetlands (Figure 2.1; USFWS, 1987; Arcadis, 2009).

Figure 2.1. Habitat categories of the Site and surrounding area. The boundary of Site OUs 1–4 is shown in the figure for reference; the Site also includes OU5, which is Lake DePue and the floodplain. Note that the habitat data are from 1999 to 2000, and may not represent current conditions (e.g., the area of "Shallow/Surface Water" in the center of the OU area is currently dry, but previously was a holding ponds area).



A wildlife survey conducted as a part of the RI identified 101 species of birds, including songbirds, carnivorous birds, piscivorous birds, waterfowl, and shore birds; 10 reptile and amphibian species; and 10 mammals. Bald eagles, previously a state and federally listed threatened species, nest in areas adjacent to the lake; and pelicans rest on Lake DePue in the spring. A fish community survey of Lake DePue identified 21 species that are found in Lake DePue – the most abundant were gizzard shad, freshwater drum, and several species of sunfish (Arcadis, 2012). IDNR and Illinois Natural History Survey (INHS) records (1974–2001 and 1962–1996, respectively) from Illinois River Mile 211 yield 48 species. River Mile 211 records are assumed to represent Lake DePue, but may also represent species from the Illinois River mainstem. In addition to the records, IDNR Fisheries also acknowledges the occurrence of bighead, and silver and grass carp species in Lake DePue (Ken Clodfelter, IDNR Fisheries, personal communication, September 5, 2014).

2.1.2 Operational History

The Site hosted zinc smelter operations, lithopone paint pigment manufacturing, a DAP fertilizer plant, and other industrial operations from 1903 to 1989 (Table 2.1). This section explains these operations in more detail.

Zinc Ore Processing

The first industrial operations that occurred within the Former Plant Site Area (FPSA) were related to zinc processing. Beginning in 1903, Mineral Point Zinc produced slab zinc for use in the automobile and appliance industries. It also produced zinc dust and sulfuric acid at the primary zinc smelter (Environ, 2006c), using sulfur gas from zinc ore roasting to produce the sulfuric acid. From about 1905 to 1935, zinc smelting operations were continually upgraded, substantially increasing smelting capacities (Golder Associates, 2002). In 1938, New Jersey Zinc Company purchased the primary zinc smelter operations from Mineral Point Zinc. In 1948, New Jersey Zinc Company shut down and demolished the roasters and sulfuric acid plants (Environ, 2014b; Table 2.1). From 1948 to 1968, zinc ore was roasted prior to delivery to DePue (Golder Associates, 2002).

In 1967, New Jersey Zinc (which had been sold to Gulf & Western Industries, Inc.) constructed an integrated zinc smelting plant that included zinc concentrate roasting, sintering, zinc smelting, metal beneficiation, and casting facilities (Environ, 2014b). Between the summer of 1967, when the new roasting and acid facilities began operation, and the summer of 1969, Smith (1969) documented higher than normal emissions of particulate matter (dust) and acid mist. In 1971, New Jersey Zinc closed the integrated zinc smelting plant and roaster. However, zinc dust operations continued for almost two decades before shutting down in 1989. Before shutting down, zinc dust production units were operated by a few companies. In 1981, Horsehead purchased New Jersey Zinc's assets from Gulf & Western Industries, Inc. and operated under the name of New Jersey Zinc Company, Inc. (Golder Associates, 2002). In 1987, Horsehead and New Jersey Zinc Company, Inc. operated zinc dust operations under their unincorporated division name, Zinc Corporation of America. Later, Gulf & Western Industries, Inc. would change its name to Paramount Communications Inc. and then merge with Viacom (Golder Associates, 2002). In 1991, Zinc Corporation of America demolished the zinc plant. By 1992, most of the buildings associated with zinc dust production operations had been demolished (ICO, 1995; Environ, 2006c).

Table 2.1. Timeline for Site operations

Year	Event	Reference
1903	Mineral Point Zinc began producing slab zinc, zinc dust, and sulfuric acid at the primary zinc smelter	Environ, 2006c
1905–1935	Mineral Point Zinc continually upgraded zinc smelting operations, substantially increasing smelting capacities at the Site	Golder Associates, 2002
1923	Mineral Point Zinc began manufacturing lithophone paint pigments	Illinois EPA, 1997
1938	New Jersey Zinc Company purchased the primary zinc smelter operations from Mineral Point Zinc, which subsequently dissolved	Golder Associates, 2002
1948	New Jersey Zinc Company shut down and demolished the roasters and sulfuric acid plants	Environ, 2014b
1956	New Jersey Zinc Company stopped manufacturing lithophone paint pigments	Illinois EPA, 1997
1966	Gulf & Western Industries, Inc. purchased New Jersey Zinc Company; kept the New Jersey Zinc Company name	Environ, 2014b
1967	New Jersey Zinc Company completed construction of an integrated zinc smelting plant that included roasting and acid facilities; documented air pollution issues arose soon thereafter	Smith, 1969; Golder Associates, 2002
1967	New Jersey Zinc Company started manufacturing DAP fertilizer	Golder Associates, 2002
1971	New Jersey Zinc Company closed the integrated zinc smelting plant; zinc dust operations continue	Golder Associates, 2002
1972	Mobil leased DAP fertilizer plant from New Jersey Zinc Company and began operations at the Site soon thereafter	Golder Associates, 2002
1975	Mobil purchased the DAP fertilizer plant from New Jersey Zinc Company	Golder Associates, 2002
1981	Horsehead purchased New Jersey Zinc Company assets from Gulf & Western Industries, Inc. and operated under the name New Jersey Zinc Company, Inc.	Golder Associates, 2002
1987	Mobil closed the DAP fertilizer plant	Golder Associates, 2002
1989	New Jersey Zinc Company, Inc. shut down zinc dust operations, ending zinc processing at the Site	Environ, 2014b
1991	Zinc Corporation of America demolished the zinc dust plant	ICO, 1995; Environ, 2014b
1991–1992	Mobil dismantled the sulfuric acid and fertilizer plants	Golder Associates, 2002
1992	Most buildings associated with zinc dust production were demolished	ICO, 1995; Environ, 2006c

DAP Fertilizer Manufacturing

In 1967, New Jersey Zinc started manufacturing DAP fertilizer. DAP fertilizer manufacturing operations occurred on the north-central portion of the FPSA and included a phosphate ore storage area, a sulfuric acid plant, a phosphoric acid plant, the DAP plant, and product storage buildings (Golder Associates, 2002). The fertilizer manufacturing process combined sulfuric acid with phosphate ore to produce a phosphoric acid and calcium sulfate (phosphogypsum) byproduct. DAP fertilizer pellets were produced by reacting phosphoric acid with anhydrous ammonia. The phosphogypsum waste stream was cooled in settling ponds and deposited on a Phosphogypsum Stack at the north end of the Site (Golder Associates, 2002). The sulfuric acid used to manufacture DAP was originally obtained from sulfur dioxide gas produced by zinc roasting operations until zinc roasting ended in 1971. After 1971, all sulfuric acid was produced from a sulfur burner using purchased elemental sulfur.

Between 1967 and 1972, New Jersey Zinc owned and operated the DAP fertilizer manufacturing plant. In 1972, Mobil leased the DAP fertilizer plant from New Jersey Zinc and began operations at the Site soon thereafter. Mobil purchased the DAP fertilizer plant from New Jersey Zinc in

1975 (Golder Associates, 2002). In 1987, Mobil closed the fertilizer plant and subsequently dismantled the sulfuric acid and fertilizer plants between 1991 and 1992. In 2000, Exxon and Mobil merged to form ExxonMobil.

Other Site Manufacturing Activities

In 1923, Mineral Point Zinc began manufacturing lithophone[3] paint pigments by combining barium sulfide and purified zinc sulfate; and then filtering, washing, and drying the mixture to produce lithopone (Environ, 2014b). Lithophone manufacturing activities were expanded during World War II. After production ended in 1956, the lithophone paint pigment plant was demolished (Illinois EPA, 1997).

Dredging Operations in Lake DePue

In 1982, following the guidelines of a permit and legislative direction, the State of Illinois dredged sediments from Lake DePue to increase the depth of the lake (Illinois Department of Transportation, 1978; Illinois EPA, 1982; Terra, 1995). The spoils from dredging were placed into an impoundment "Dredge Spoil Disposal Area" located between Lake DePue and the Illinois River.

Early Site Assessments

State and federal environmental agencies have been investigating the Site since at least 1980 (Table 2.2). The early investigations led to the listing of the DePue Site on the NPL, making it a Superfund site.

Table 2.2. Timeline for early Site assessment

Year – month	Event	Reference
1980 – December	U.S. EPA performed a Preliminary Assessment	Illinois EPA, 1995
1981 – January	U.S. EPA recommended that "no further action" be conducted at the Site, pending outcome of the Illinois lawsuit against New Jersey Zinc	Illinois EPA, 1995
1981 – October	Illinois and New Jersey Zinc entered into a Consent Agreement that required New Jersey Zinc to conduct a series of site contamination mitigation and monitoring activities; work was completed soon thereafter	Illinois EPA, 1995, 2012
1982 – August	U.S. EPA assigned a Hazard Ranking System score for the Site	Illinois EPA, 1995
1983 – July	U.S. EPA performed a second Preliminary Assessment	Illinois EPA, 1995
1984 – May	U.S. EPA performed a Screening Site Inspection	Illinois EPA, 1995
1987 – June	U.S. EPA performed a second Screening Site Inspection	Illinois EPA, 1995
1991 – September	Illinois EPA began Expanded Site Inspection activities	Illinois EPA, 1995
1992	Mobil began Phosphogypsum Stack closure activities	Terra, 2013
1992 – March	Expanded Site Inspection sampling began	Illinois EPA, 1995
1993 – February	U.S. EPA Remedial Branch investigated the Site	U.S. EPA, 1993
1995 – November	Illinois EPA and DePue Group entered into an ICO to conduct Site investigations and evaluate possible remedial actions	ICO, 1995
1995 – December	DePue Group submitted the Site Assessment Plan to Illinois EPA	Golder Associates, 1996a
1996	DePue Group constructed an interim water treatment plant (IWTP) to treat ground and surface water from the FPSA	Golder Associates, 1996a
1996 – February	DePue Group commenced a Focused RI for the South Ditch (OU1)	Golder Associates, 1997

3. This white pigment consists of zinc sulfide, barium sulfate, and zinc oxide; it was commonly used in paint.

Table 2.2. Timeline for early Site assessment

Year – month	Event	Reference
1996 – August	DePue Group submitted a South Ditch (OU1) Focused RI Report	Golder Associates, 1997
1997 – April	Site proposed for NPL	Illinois EPA, 2010
1997 – June	IWTP fully operational	Golder Associates, 2002
1997 – July	DePue Group submitted a Revised South Ditch (OU1) Focused RI Report	Golder Associates, 1997
1997	Phosphogypsum Stack was partially regraded and vegetated	Terra, 2000
1999 – May	Site listed on the NPL	Federal Register, 1999

While Illinois EPA has documented numerous uncontrolled contamination releases and complaints from the public since the 1960s (Illinois Pollution Control Board, 1972; Illinois EPA, 1992), formal agency Site inspections did not begin until the early 1980s. Early agency inspections were conducted to assess the potential for Site contamination sources to impact human health and the surrounding environment. From 1980 to 1987, U.S. EPA conducted a series of screening-level preliminary assessment and Site inspection activities to determine Hazard Ranking System scores (Table 2.2; Illinois EPA, 1992; U.S. EPA, 1999). Hazard Ranking System scores are used to assess the placement of potentially hazardous sites onto the NPL. During Site inspections, U.S. EPA identified several sources of contamination: "a residue pile, a waste pile, lithopone waste material ridges, a cinder fill area, contaminated soils, lagoons/cooling ponds, and gypsum stack ponds. All of the sources were found to contain elevated levels of zinc, lead, arsenic, cadmium, chromium, and copper" (U.S. EPA, 1999). At the time, U.S. EPA determined that information obtained during these Screening Site Inspections did not meet the criteria for NPL listing for Superfund sites (Illinois EPA, 1995).

Subsequently, the State of Illinois filed a lawsuit against New Jersey Zinc, which resulted in a Consent Agreement. The Consent Agreement required New Jersey Zinc to conduct a series of waste control measures within the FPSA. These requirements included regrading and covering waste piles, neutralizing soil with lime, installing a surface water runoff collection system, and establishing a sampling and monitoring program. As result, New Jersey Zinc and Horsehead implemented waste control measures at the Site. As described earlier, this was also when zinc processing and fertilizer manufacturing operations ceased and associated infrastructure dismantled (see Table 2.1; Illinois EPA, 1995, 2012).

In 1992, after a majority of the Consent Agreement and closure activities were completed, Illinois EPA conducted an Expanded Site Inspection to gather additional contamination and risk information to develop a revised Hazard Ranking System score (Illinois EPA, 1995). The expanded investigations included sampling of residential soils; Lake DePue sediments; and sediment, surface water, waste materials, and soil samples from the Site (Illinois EPA, 1992). Illinois EPA's residential soil samples from an area of over 200 acres contained elevated levels of 11 metals and metalloids compared to background areas, and "higher than expected" cadmium and zinc concentrations (Illinois EPA, 1992). Illinois EPA (1992) also found significantly elevated metal concentrations in Lake DePue sediment samples and other samples collected from the Site. The U.S. EPA (1993) conducted a site assessment, and recommended complete characterization of the extent of contamination, removal of hazardous substances in the soil, and mitigation of the lithopone ridges and highly acidic water in the lagoons near Lake DePue.

In November 1995, Illinois EPA entered an ICO between the State and the DePue Group (ICO, 1995). This ICO required the DePue Group to complete an RI/FS and develop a work plan describing the technical approach, schedules, and personnel requirements. Soon after the ICO was filed, a Site Assessment Plan was developed that outlined the framework for the RI/FS and design study process (Terra, 1995), and then Golder Associates (1996a) developed an addendum to this plan. RIs and interim remedial actions began soon thereafter (Illinois EPA, 2010). These interim actions focused on removing visibly contaminated sediments from the south drainage ditch (Golder Associates, 1997), building the IWTP, vegetating the Site, performing air monitoring, closing a Vanadium Pentoxide Catalyst Disposal Area on the Site, and installing fencing (ICO, 1995).

In April 1997, the Site was re-proposed for listing on the NPL (Illinois EPA, 2010). U.S. EPA noted that the Site had several contaminant sources, including a residue pile, a waste pile, lagoons, cooling ponds, and gypsum stack ponds, which contained elevated levels of metals, including zinc, lead, arsenic, cadmium, chromium, and copper (U.S. EPA, 1999). U.S. EPA also noted that there was contamination in residential soils and adjacent wetlands, and in Lake DePue (U.S. EPA, 1999). On May 10, 1999, U.S. EPA listed the Site on the NPL (Federal Register, 1999).

2.1.3 RI/FS Activities

This section describes activities conducted at the Site since its listing on the NPL in 1999. Illinois EPA is the lead regulatory agency for the RI/FS process at the Site. Although not a signatory to the ICO, U.S. EPA is the support agency for RI/FS work at the Site and reviews certain work products that Illinois EPA provides.

After the Site was listed on the NPL, a Site-wide RI work plan was developed and approved in 1999. In the years following, the Site was divided into five OUs; both OU3 and OU4 have multiple subareas (Figure 2.2).

OU1: South Ditch

The South Ditch (OU1) is a 1,600-foot drainage ditch that discharges into Lake DePue (Figure 2.2). It received groundwater and surface water discharge from the FPSA. Sediments in the South Ditch are contaminated with metals and were assessed as toxic to test species before a subsequent response action occurred (Illinois EPA, 1998, 2003). The entire OU1 is within Lake DePue's 100-year floodplain, and portions of it are in the yearly floodplain (Illinois EPA, 2003). A two-lane road (Marquette Street) and the FPSA are to the north, the lake floodplain is to the east, and a residential area is to the west. The northern 120 to 150 feet of the ditch incises fill consisting of placed soil, slag material, and demolition debris that is considered part of OU3. The remainder of the ditch traverses marshy lowlands adjacent to Lake DePue (Figure 2.3).

In October 2003, Illinois EPA signed an interim action Record of Decision (ROD) requiring the DePue Group to excavate contaminated sediments to a visual standard, dewater and stabilize the sediment, and place it into an interim corrective-action management unit (CAMU) on the FPSA (Apollo, 2006). A more permanent remedy for the South Ditch will be included in the remedy for OU5 (Lake DePue and the Floodplain).

Figure 2.2. OUs at the Site.

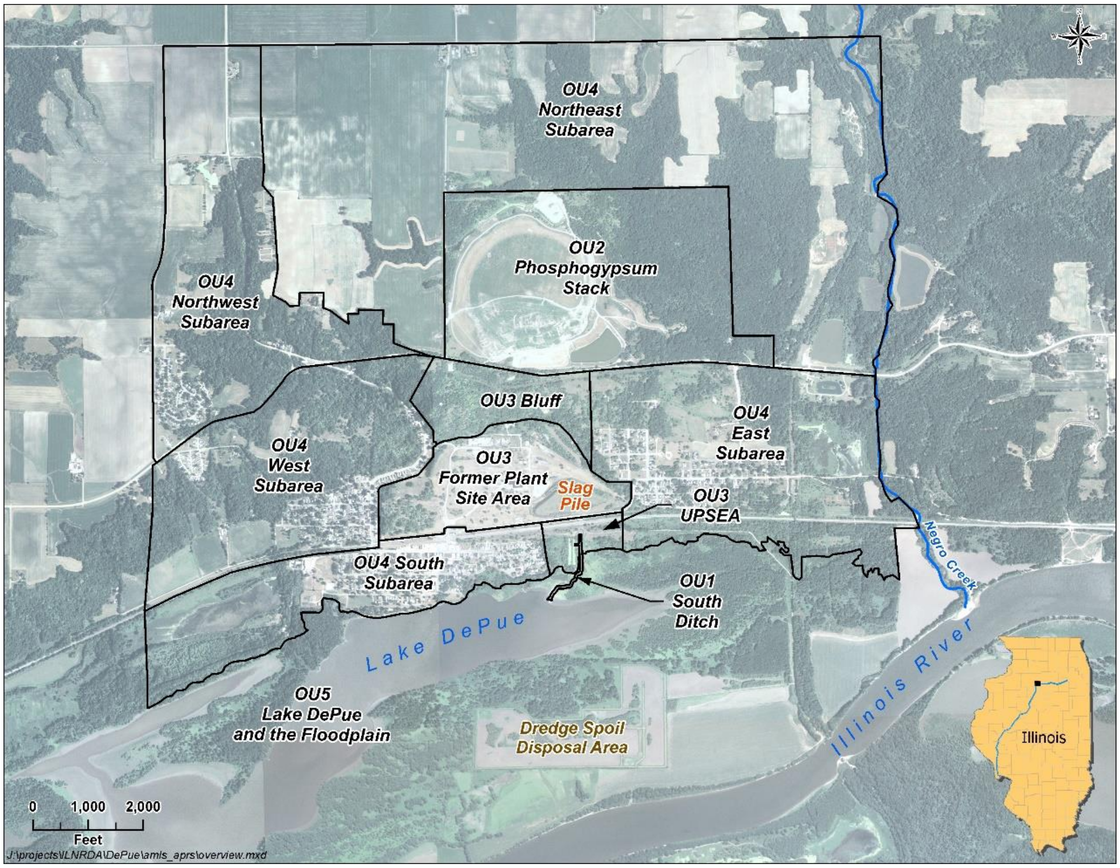


Figure 2.3. OU1 South Ditch.

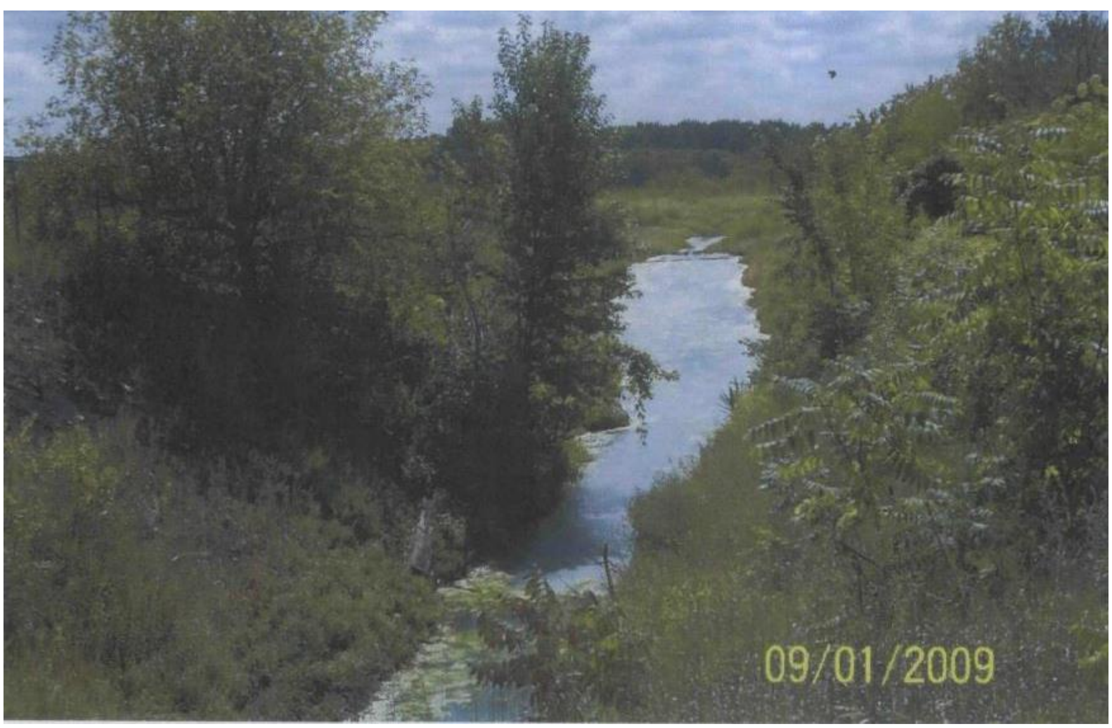


Photo credit: Illinois EPA.

OU2: Phosphogypsum Stack

OU2 encompasses 250 acres on the north side of Route 29 (Illinois EPA, 2017b), approximately 1,300 feet to the north of the FPSA (Figure 2.2). OU2 comprises the Phosphogypsum Stack (125 acres) and associated water-control structures, including drainage swales, a clearwater pond (previously used to hold clarified water for reuse in the plant), a dam, and a constructed treatment wetland. Forested tracts with patches of agricultural fields are immediately to the north and east of the Phosphogypsum Stack. Route 29 is south of OU2, separating this area from the forested bluffs north of the FPSA. Agricultural fields are located to the west of the Phosphogypsum Stack.

The Phosphogypsum Stack is being closed pursuant to the Illinois landfill regulations (35 IAC Part 807). In 1992, Mobil began closure of the area, which included capping, regrading, and seeding portions of the Phosphogypsum Stack as well as the management of runoff and seepage from the stack area (Golder Associates, 1996a; Terra, 2013). In 2003, the DePue Group cleaned the Clearwater Pond and relined it with clay and a high-density polyethylene liner. Between 2005 and 2007, they capped the southern portion with clay soils and native prairie grass and the northern portion with mushroom compost and fescue. They also developed a treatment wetland (> 2 acres) to passively treat seepage from the Phosphogypsum Stack and planted native shrub hedges around it as an alternative to traditional chain-link fencing (Terra, 2013).

In February 2017, Illinois EPA approved the DePue Group's proposed closure plan for OU2. Work in 2017 included upgrading the water management system, continuing treatment of groundwater seepage, and performing long-term monitoring (Enercon and SDI, 2017). In 2018, the DePue Group added a new cover on the northern two-thirds of the stack, regrading and revegetating the soil on the cover on a portion of the south stack (Figure 2.4). Revegetation of the stack with native prairie grasses is scheduled to occur in 2019. In addition, the DePue Group proposed a supplemental wetland water treatment system to increase the capacity to hold and treat seepage water at OU2 (Wood Environment & Infrastructure Solutions, 2018). Illinois EPA approved the supplemental treatment wetland and it became operational in April 2019.

OU3: FPSA, Bluff Area, and Upland Portion of the Southeast Area

OU3 is approximately 251 acres in size and is comprised of the historical manufacturing Site property, which includes the Eastern and Western Areas, the Slag Pile Area, the Lithopone Ridges Area and the Vanadium Pentoxide Catalyst Disposal Area (collectively, 136 acres), adjacent bluffs (~ 90 acres), and the upland portion of the southeast area (UPSEA) of the property (~ 25 acres), including the "municipal dump" (Figure 2.5; Environ, 2006c, 2014b; Illinois EPA, 2016b).

Former operations at the FPSA included a smelter, a sulfuric acid plant, lithopone paint pigment fabrication, and a DAP fertilizer plant. The FPSA is subdivided into five subareas: the Western Area, the Eastern Area, the Slag Pile Area, the Vanadium Pentoxide Catalyst Disposal Area, and the Lithopone Ridges Area (Figure 2.5). Associated waste includes 6 inches to several feet of industrial waste (metal-rich cinders) throughout the FPSA; a zinc slag pile (Figure 2.6; 50-feet tall, covering a 23-acre area, which is equivalent to approximately 702,000 cubic yards or 570,000 tons of waste); ridges of lithopone paint pigment plant waste, estimated at 60,000 tons and covering approximately 10 acres; and 750,000 tons of general fill material (a mix of slag and clean fill) throughout the FPSA (Environ, 2014b; Illinois EPA, 2016a).

Figure 2.4. Regraded Phosphogypsum Stack in October 2018.

Source: Joseph Abel, ExxonMobil.

Figure 2.5. Areas of historical industrial activity in OU3 (Environ, 2014b). The figure also outlines the Bluff Area, which did not have historical activity.

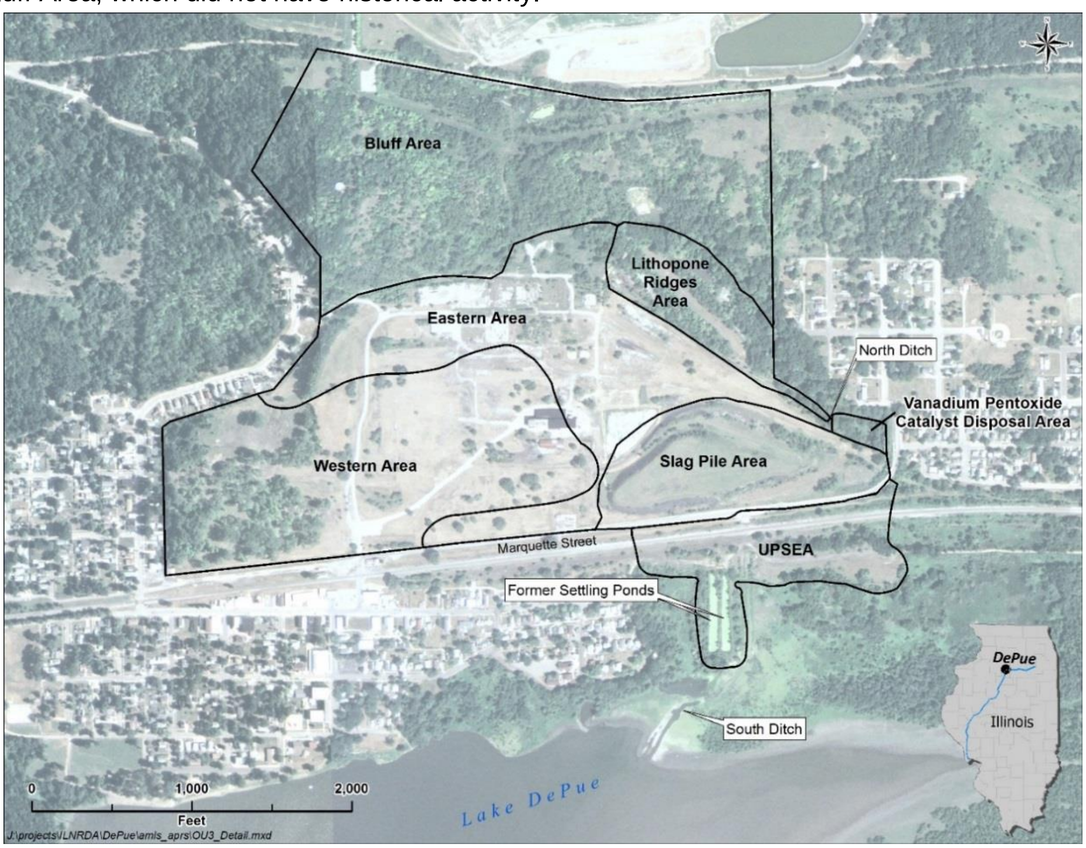


Figure 2.6. Slag Pile and CAMU at the Site in April 2007.

Photo credit: IDNR.

The Bluff Area is a steeply sloped area between the FPSA and Route 29, encompassing approximately 90 acres (Environ, 2014b). It is an undeveloped, wooded property zoned as industrial and owned primarily by ExxonMobil. Because of the steep terrain in this area, land use and industrial zoning are expected to remain unchanged, with little or no future development. The Trustees are only aware of limited historical industrial activity in the Bluff Area. Those activities are related to an operating natural gas pipeline and pipelines previously used to transport process water between the fertilizer plant and the Phosphogypsum Stack area as part of a closed-loop piping system (Terra, 2013; Environ, 2014a). However, past evaluations have documented areas of exposed Site-related materials in a former residential area located in the western part of the Bluff Area near a water tower (Environ, 2014a, 2015a).

The UPSEA is south of Marquette Street and south of the FPSA, and is bounded by the wetlands of OU5 (see Figure 2.2). Features include the northernmost 150 feet of the South Ditch, the plant's two settling ponds, and the municipal dump. The settling ponds, previously used as surface impoundments for cooling and settling of natural suspended solids from cooling water, were dredged in 1994 and the material was disposed of offsite (Environ, 2014b). It is the understanding of the State of Illinois that ExxonMobil is planning to decommission or close the ponds, and has requested that they be removed from the evaluation of ecological risks (Joe Abel, ExxonMobil Environmental Services Company, personal communication, March 19, 2015). The dump contains primarily smelter residue (black sandy gravel and black gravely sand), some general fill and construction debris, other material from operations at the FPSA, and relatively minor amounts of municipal trash (Environ, 2014b). An estimated 203,000 tons of waste, including general fill and slag, are present in this area. The maximum depth of fill in the municipal dump is unknown and extends below the water table.

Prior to 1997, surface water runoff from the eastern portion of the FPSA discharged to the South Ditch (BBL, 2005a). In 1997, the DePue Group constructed an IWTP in one of the FPSA buildings to collect and treat contaminated groundwater and runoff. Between 1997 and June 2000, the IWTP discharged to the South Ditch via the outfall. In June 2000, the IWTP began to discharge to the Illinois River via the River Water Line. The IWTP was brought fully into compliance with state and federal discharge standards in 2000 and substantially reduced discharges of contaminated water to Lake DePue. Annually, this unit removes more than 72,000 pounds of zinc, 5,400 pounds of manganese, and 2,000 pounds of copper for offsite disposal (U.S. EPA, 2017). For example, in August 2009, the DePue Group reported the removal of 11,754 pounds of zinc, 683 pounds of manganese, and 773 pounds of copper by the IWTP; and in August 2017, the DePue Group reported the removal of 6,850 pounds of zinc, 240 pounds of manganese, and 440 pounds of copper (Environ, 2009a; Ramboll Environ, 2017).

A permeable reactive barrier (the iron-rich material or "IRM" walls) and associated interceptor trenches were constructed south of the zinc slag pile to remove zinc, copper, and other metals from the groundwater. Surface water and stormwater from the Bluff Area is routed directly to the River Water Line, and surface water/stormwater from the FPSA is routed to the lift station/IWTP and to the River Water Line after being treated. A 2.5-acre interim CAMU contains contaminated sediments from the South Ditch that were stabilized with power plant combustion ash (Apollo, 2006). This interim CAMU has a clay cap that occasionally retains water on its surface and may attract some organisms, particularly birds (Figure 2.6).

The DePue Group completed Phase I of the RI for OU3 in 2006 and Phase II in 2014, which focused on defining soil and groundwater contamination (Illinois EPA, 2016a). The RI reports document metals contamination in Site soils, sediment, and groundwater. A human health risk assessment was completed in February 2016, and the ecological risk assessment is currently being developed.

OU4: Off-Site Soils

OU4, the OU for soils impacted by Site operations that lie outside of the OU3 plant boundaries, includes approximately 814 residential lots; 1,300 acres of residential soils; and other agricultural properties, woodlands, and surface water bodies (Illinois EPA, 2016b). This OU is divided into the South (221 acres), West (322 acres), Northwest (369 acres), Northeast (1,056 acres), and East (385 acres) subareas in the Village of DePue (Figure 2.2; Environ, 2015b).

Environ (2015b) summarized previous investigations of OU4, showing that metals are elevated in these soils compared to background soils. The DePue Group conducted a Pilot Study that investigated 41 residential properties in December 2013 (Environ, 2014c). Illinois EPA (2017a) issued a ROD in 2017 for the residential portion of OU4, which requires additional sampling, as well as excavation of soils and Site-related material to prevent exposure to soils above designated remedial goals for the protection of human health. The additional sampling commenced in 2018 and is ongoing.

OU5: Lake DePue and the Floodplain

OU5 encompasses Lake DePue, a 524-acre backwater lake, and its associated 1,000-acre floodplain. Illinois EPA (2005) identified a lowland portion of OU5 up to an elevation of 450 feet above mean sea level as the floodplain surrounding Lake DePue. Fluctuating water levels in the lake seasonally inundate these lowland areas. The accumulation of sediment from the Illinois River as well as surface runoff and discharges from the surrounding landscape have degraded the recreational use of the lake (Illinois EPA, 2016a). Lake DePue and its floodplain partially make up the DePue State Fish and Wildlife Area, which IDNR owns and manages.[4]

Specific areas within OU5 include (1) the Lowland Portion of the Southeast Area, (2) the Spring Area west of the Former Settling Ponds, (3) the Division Street Outfall, (4) the DePue Wastewater Treatment Plant (WWTP), and (5) the Southwest Drain and Unnamed Tributary (Arcadis, 2009) (Figure 2.7). Some of the lowland areas to the south of OU5 include agricultural areas and the Dredge Spoil Disposal Area[5] (Figure 2.7). To the north of the lake is the FPSA and associated waste piles, and the residential area of DePue. Surrounding the lake is floodplain forest and marshy lowland habitat. Areas with Site-related fill material have been identified along the northern shoreline of Lake DePue (Arcadis, 2009).

The DePue Group's RI, conducted in 2006 and 2007, concluded that metals are elevated in surface water, seeps, lowland soils, and sediment. The human health risk assessment was finalized in 2014, and the ecological risk assessment is ongoing (Illinois EPA, 2016a).

Future RI/FS Activities

As of the last Site Summary (Illinois EPA, 2016a), identified future remedial activities include:

- Ecological risk assessment and FS for OU3
- Remediation of residential areas of OU4
- Additional sampling/investigation and potential remediation of other areas of OU4 (i.e., agricultural areas, natural areas, other open spaces)
- Ecological risk assessment and FS for Lake DePue (OU5).

As these activities proceed, additional data will be collected and made available for consideration in the NRDA.

4. Also included in the DePue State Fish and Wildlife Area is Spring Lake and the Hormel Landing, both to the southwest of Lake DePue (IDNR, 2017).

5. The Dredge Spoil Disposal Area sits along a peninsula between Lake DePue and the Illinois River in an area informally referred to as the "DePue Wildlife Management Area" (Figure 2.2). In 1982, following the guidelines of a permit and legislative direction, IDNR dredged and pumped sediment from Lake DePue and deposited it on the peninsula. IDNR actively manages this area for waterfowl habitat with diked fields planted with crops that are seasonally flooded.

Figure 2.7. Features of OU5, Lake DePue and the floodplain.

2.2 Description of Hazardous Substances Released

Site operations resulted in hazardous substance releases to the environment throughout the period of operation (1903 to 1989) and some releases continue today. Waste disposal activities and discharges from the former smelter, sulfuric acid plant, lithopone plant, and DAP plant released hazardous substances to the environment. These activities produced the following source areas (Environ, 2006c, 2014b; Arcadis, 2009):

- A primary zinc smelter slag pile, containing in excess of 702,000 cubic yards (or 570,000 tons) of waste material generated during the zinc smelting process
- The lithopone ridges, containing approximately 60,000 tons of paint pigment waste
- Six inches to several feet of contaminated soil and fill throughout much of the 136-acre former plant Site
- A Phosphogypsum Stack, covering more than 125 acres
- Contaminated groundwater beneath the Site
- A municipal dump comprising primarily FPSA-related waste material
- Areas of Site-related fill material along the northern shoreline of Lake DePue and in other portions of the OUs
- The Dredge Spoils Disposal Area between Lake DePue and the Illinois River
- Other impoundments and waste piles (Illinois EPA, 2016a).

When the plant was operating, citizens filed complaints about gas fumes, dust, and fog emanating from the plant (Illinois EPA, 1996). Groundwater containing fluoride, phosphorus, ammonia, high total dissolved solids, and sulfate from the Phosphogypsum Stack seeped into an unnamed tributary of Negro Creek, before the seepage was controlled. Multiple sources have contributed to contamination in Lake DePue. Discharges from the sulfuric acid plant into two lagoons spilled into Lake DePue, resulting in a fish kill in 1974 (Illinois EPA, 1996). Additionally, Site runoff to the lake from the zinc slag pile via the South Ditch contained high levels of zinc (Illinois EPA, 1996).

Multiple studies have found elevated levels of metals in all of the source areas, as well as other areas affected by the releases, including Lake DePue, the Dredge Spoil Disposal Area, and residential areas (Illinois EPA, 1992; Environ, 2006c, 2014b, 2015b; Arcadis, 2009).

Hazardous substances released from the Site vary by OU and media. This section does not list every hazardous substance released at the Site; rather, it focuses on the primary hazardous substances that are highlighted in RI documents. The primary hazardous substances of concern, listed by location below with specific media in parentheses, include:

- OU1: arsenic, cadmium, copper, lead, manganese, and zinc (sediments) (Illinois EPA, 1998)
- OU2: ammonia, arsenic, manganese, and vanadium (groundwater) (Terra, 2013)
- OU3: aluminum, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, nickel, silver, vanadium, and zinc (soil and groundwater) (Environ, 2006c, 2014b, 2015b)

- OU4: arsenic, cadmium, lead, and manganese (soil) (Environ, 2011, 2014c; Illinois EPA, 2017a)
- OU5: ammonia, arsenic, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, nickel, selenium, silver, thallium, vanadium, and zinc (floodplain soil, sediment, and/or surface water) (Arcadis, 2009, 2012).

The assessment will focus on the primary hazardous substances as described above but will also consider other hazardous substance releases. In addition, the injury assessment will consider constituents that may not be listed as hazardous substances under CERCLA [40 CFR § 302.4] but are a product of reactions resulting from the release of hazardous substances at the Site. For example, the fertilizer manufacturing process at the Site combined sulfuric acid with phosphate ore to produce a phosphoric acid and calcium sulfate (phosphogypsum) byproduct. Phosphoric and sulfuric acids are listed as hazardous substances. Sulfuric acid was released from the Site, and sulfate is present in groundwater at the Site as a product of the reaction of phosphorus ore and sulfuric acid. Thus, injuries resulting from the presence of sulfate at the Site may also be considered in the assessment.

The remainder of this section discusses hazardous substances that are typically associated with the types of source materials at the Site, but which have not been detected; as well as other hazardous substances that have been observed at the Site that may or may not be associated with releases from the Site. Slag produced in refining can contain significant concentrations of barium, a potentially toxic element. Likewise, barium is a component of lithopone, which was also produced on the Site. It has been found in OU1, OU3, and in Lake DePue (Illinois EPA, 1998; Environ, 2006c, 2014b; Arcadis, 2009, 2012). Mercury has been found in the lake (Arcadis, 2009). However, Illinois EPA does not consider the Site to be a significant contributor of mercury (Illinois EPA, 2016a).

Researchers also have found polychlorinated biphenyls (PCBs) in Lake DePue fish (Illinois EPA, 2011). However, based on the results of the OU5 RI (Arcadis, 2009), Illinois EPA does not consider the Site to be a significant contributor of PCBs (Illinois EPA, 2011). The Lake DePue fish advisory includes a fish advisory for PCBs, the same fish advisory that exists for the Illinois River. Although the Site cannot be definitively ruled out as a source of concentrations of PCBs, PCBs were not a significant contaminant at the FPSA or in the known source areas.

While metals are the primary contaminants of concern, minor contributors to Site risks include semi-volatile organic compounds (SVOCs) such as polycyclic aromatic hydrocarbons (PAHs) and pesticides. Certain anions and radionuclides associated with the Phosphogypsum Stack and phosphate ore have been included in investigations. Arcadis (2012) measured elevated concentrations of benzo(a)pyrene and other SVOCs in floodplain soil collected near the lake; ammonia and phosphorous concentrations in some lake surface-water samples exceeded Illinois EPA standards. Fluoride occurs in OU3 soils. Uranium and radium naturally occur in phosphate ore, and are therefore byproducts of the Phosphogypsum Stack. Although a load of scrap metal from the phosphoric acid plant in 1992 contained radioactive deposits (Illinois EPA, 1995), other sampling efforts have not detected the presence of uranium and radium at the Site at levels above relevant screening criteria or regulatory standards (Terra, 2013). Volatile organic compounds have generally not been detected at concentrations above relevant screening criteria (Environ, 2006c).

2.3 Natural Resource Damage Coordination with Response Actions

The NRDA is proceeding concurrently with RI/FS work at various stages in the Site OUs. Illinois EPA is both a Trustee in the NRDA and the lead agency in the remedial process. Coordination between the RI/FS process and the NRDA includes the sharing of data, information, and expertise; consideration of planned or likely remedial actions for determining and quantifying future injuries and damages; and planning NRDA restoration actions that supplement remedial actions.

The goals of such coordination between the NRDA and the RI/FS process are to avoid duplication, reduce costs, and achieve common objectives where possible. At a minimum, the Trustees intend to consider the objectives of removal actions, RI/FS activities, and remedial actions during the continued planning and implementation of the NRDA. One key feature of the relationship between the RI/FS remedy and the NRDA is that the NRDA damage amount is related to the timing, type, and amount of remediation selected from the RI/FS process. For example, if a no-action or minimal remedy is selected, then the total amount of lost natural resource services that requires restoration actions may be larger, and the compensable value may be larger. Similarly, if the remedy itself results in a loss of Trust natural resources or services, then additional restoration would be required to compensate the public for these losses. On the other hand, if a selected remedy not only reduces risk to human health and the environment but also restores habitat, future natural resource injuries would be reduced, and the compensable value would be smaller. Whenever possible, the Trustees and PRPs will explicitly coordinate damage assessment activities with other investigations. This exchange of information will help ensure meaningful and useful coordination between the RI/FS process and the NRDA.

3. Authority of Trustees and Decision to Proceed with Type B Assessment

Natural resources subject to state and federal trusteeship, and which have been or are likely to have been adversely affected by the releases of hazardous substances, include surface water, sediments, groundwater, soils, and biological resources, including aquatic biota and wildlife.

Under Section 107(f) of CERCLA, the Trustees, individually and together, are authorized to recover damages for injury to, destruction of, and loss of natural resources resulting from a release of hazardous substances from a facility. The Trustees will coordinate and cooperate in carrying out their Trustee responsibilities as suggested under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP): where there are multiple Trustees, because of coexisting or contiguous natural resources or concurrent jurisdictions, they should coordinate and cooperate in carrying out their Trustee responsibilities [40 CFR § 300.615].

Under the DOI regulations, Assessment Plans must include a statement of the authority for asserting trusteeship or co-trusteeship for those natural resources within the Assessment Plan [43 CFR § 11.31(a)(2)]. A general description of the natural resource authority asserted by the Trustees is given below. These descriptions are not meant to be an exhaustive and all-inclusive listing of their authority over Trustee natural resources. In addition, each Trustee may have co-Trustee authority over natural resources listed within the trusteeship of another Trustee.

3.1 Trusteeship Authority

CERCLA (as amended, 42 USC 9601 et seq.) and the CWA (33 USC 1251–1376) provide authority for natural resource trustees to assess and seek to recover damages to natural resources resulting from a release of a hazardous substance covered under CERCLA or the CWA. The Trustees at the Site include the IDNR and the Illinois EPA. The Directors of the Illinois EPA and IDNR have been designated as the authorized official Trustees for the State of Illinois, pursuant to Section 107(f)(2)(B) of CERCLA.

3.2 Decision to Perform a Type B Assessment

Under the DOI regulations at 43 CFR Part 11, trustees can use Type A or Type B NRDA procedures [43 CFR § 11.33]. Type A procedures apply to releases that are short duration, minor, or resulting from a single event. They are simplified procedures that require minimal field observation [43 CFR § 11.33(a)]. A Type B assessment provides alternative methodologies for conducting NRDAs and consists of three phases: injury determination, injury quantification, and damage determination [43 CFR § 11.60(b)].

Hazardous substances have been released or re-released in the assessment area for many years. Hazardous substances have been transmitted through the food chain, exposing many different trophic levels. Consequently, the releases cannot be considered of a short duration, minor, or resulting from a single event. Further, the spatial and temporal extent and the heterogeneity of exposure conditions and potentially affected resources are not suitable for application of the simplified methods contained in Type A procedures. Therefore, a Type A assessment would be inappropriate for this NRDA.

Thus, the Trustees have determined that (1) the Type A assessment is not appropriate for the long-term, spatially, and temporally complex nature of the releases and exposures to hazardous substances characteristic of the assessment area; (2) substantial Site-specific data already exist to support the assessment; and (3) additional Site-specific data can be collected at reasonable cost. As a result, the Trustees have concluded that the use of Type B procedures is justified. The 2016 FPA, reflecting the cooperation between the Trustees and the PRPs, states that the Trustees and PRPs agree to conduct the NRDA in accordance with the Type B procedures.

4. Confirmation of Exposure and Recovery Period

The DOI NRDA regulations state that the Assessment Plan should confirm that:

- At least one of the natural resources identified as potentially injured in the preassessment screen has in fact been exposed to the . . . hazardous substance [43 CFR § 11.34(a)(1)].
- A natural resource has been exposed to a hazardous substance if “all or part of [it] is, or has been, in physical contact with . . . a hazardous substance, or with media containing the . . . hazardous substance” [43 CFR § 11.14(q)]. The DOI regulations also state that “whenever possible, exposure shall be confirmed using existing data” from previous studies of the assessment area [43 CFR § 11.34(b)(1)].

The following section provides information sufficient to confirm exposure of geologic, surface water/sediment, groundwater, and biological resources to hazardous substances in the assessment area. It is not a complete review of existing information regarding resource exposure to hazardous substances, but it does satisfy the NRDA regulations listed above. For each resource, we provide the resource definition under the DOI regulations, followed by a description of potential injured resources, and data confirming exposure of the resource to hazardous substances released from the Site.

4.1 Geologic Resources

4.1.1 Definition

Geologic resources are defined in the DOI regulations as "those elements of the Earth's crust such as soils, sediments, rocks, and minerals . . . that are not included in the definitions of ground and surface water resources" [43 CFR § 11.14(s)].

4.1.2 Potentially Injured Geologic Resources

The geologic resources of the assessment area include the soils located in the Southeast Area, the Bluff Area, upland forests, agricultural lands, and residential properties. Floodplain soils located along the shores of Lake DePue, Negro Creek and associated tributaries, and the peninsula between Lake DePue and the Illinois River are also considered geologic resources. These resources have been exposed to hazardous substances that originated from the FPSA at concentrations above those measured in similar background/reference areas. Of these geologic resources, soil data were readily available for the Southeast Area, the Bluff Area, residential properties, and the Dredge Spoil Disposal Area. The data described below include examples of hazardous substance concentrations measured in soils, but do not represent a comprehensive evaluation of geologic resource exposure at the Site.

4.1.3 Geologic Resource Exposure

Soils surrounding the FPSA have been exposed to hazardous substances released from the Site, and are contaminated with Site-related metals at the surface and below the ground surface (bgs). Surrounding residential area and Bluff Area soils are also contaminated with metals at concentrations above those observed in reference areas. Some Lake DePue floodplain soils are also heavily contaminated with metals, and the highest concentrations are located in floodplain soils closer to discharge points associated with the FPSA. This section presents data that confirm exposure of geologic resources to hazardous substances in several areas of the Site.

UPSEA

As described above, the UPSEA is a tract of land that is located between the railroad tracks and Lake DePue, outside and immediately southeast of the FPSA (see Figure 2.2; Environ, 2006c). Portions of this tract were once used as a municipal dump, and fill in this area contains slag and construction debris. UPSEA soils are contaminated with Site-related hazardous substances. Soil samples collected by Illinois EPA in 1992 contained arsenic, barium, cadmium, chromium, cobalt, copper, cyanide, lead, mercury, and zinc (Illinois EPA, 1995). Environ (2006c) conducted more extensive soil sampling in 1998 and 1999, demonstrating that soils were contaminated with high concentrations of metals to depths of up to 20 feet bgs (Table 4.1). Between 20 and 50 feet bgs, metals concentrations were significantly lower than those observed in overlying soils. Soil samples collected from test pits dug in the Municipal Dump area of the UPSEA in 2011 also indicate the presence of Site-related materials in fill and native peat material (Table 4.2; Environ, 2014b). Concentrations in an aquitard layer were more similar to background levels.

Table 4.1. Average concentrations (mg/kg) of hazardous substances measured in UPSEA soils during the OU3 Phase I RI (Environ, 2006c)

Depth interval (ft bgs)	Number of samples	Arsenic	Cadmium	Lead	Zinc
0 to 0.5	16	46.2	48.1	1,940	11,000
0.5 to 5.0	12	46.4	52.4	1,260	12,600
5.0 to 10	14	58.5	102	3,200	18,500
10 to 20	20	83.8	80.9	2,400	16,300
20 to 30	2	1.45	1.81	7.65	43.5
30 to 50	5	2.73	1.02	4	53.2
TACO background[a]	na	11.3	0.5	20.9	60.2

a. TACO = Tiered Approach to Corrective Action Objectives, Illinois EPA's method for developing remediation objectives for contaminated soil and groundwater. Background values are presented in Environ, 2006c.

Table 4.2. Concentrations (mg/kg) of hazardous substances measured in Municipal Dump soils during the OU3 Phase II RI (Environ, 2014b)

Type of material	Test pit identification	Arsenic	Cadmium	Lead	Zinc
Fill	TP-120	95.3	286	6,590 J	43,800 J
Fill	TP-128	56.1	155	2,290 J	21,300 J
Fill	TP-128	10.5	23.7	15.5 J	303 J
Native peat	TP-124	16.9	1.6	30.4 J	296 J
Native peat	TP-126	36.9	195	710 J	19,400 J
Native aquitard	TP-125	1.7	0.39 J	9.2 J	180 J
TACO background[a]		11.3	0.5	20.9	60.2

a. TACO, Illinois EPA's method for developing remediation objectives for contaminated soil and groundwater. Background values are presented in Environ, 2006c.

J = estimated concentration.

Residential Soils

Soils located in residential areas surrounding the FPSA have been exposed to hazardous metals. Three soil chemistry sampling studies of residential soils found concentrations of hazardous substances above those occurring at reference areas not affected by FPSA contamination.

Residential soil chemistry sampling was first conducted by Illinois EPA in March 1992 during the Expanded Site Inspection surveys (Illinois EPA, 1995). This sampling event focused on an approximately 200-acre area within the Village of DePue and the residential area of the ground surface at 20 residential sampling locations. Samplers avoided sampling alleys and driveways, which may have been covered with slag or cinders. Most of the 20 sampling locations contained elevated concentrations of cadmium, lead, and zinc in the Expanded Site Inspection surface soil samples (Table 4.3; Illinois EPA, 1995).

Table 4.3. Average (minimum–maximum) surface soil metals concentrations (mg/kg) in residential soils, and soils at residential background sites

Location information	Cadmium	Lead	Zinc
1992 Illinois EPA Expanded Site Inspection residential areas (n = 20)	48.7 (4.32–98.1)	304 (35.9–720)	3,157 (329–6,580)
2013 OU4 off-site surface (0–1 inch) soils in surrounding residential areas (n = 218)	19.8 (1.3–127)	219 (17.9–1,590)	1,679 (183–8,970)
2013 OU4 off-site near-surface (1–6 inch) soils in surrounding residential areas (n = 218)	23.8 (1.1–113)	222 (17.5–1,400)	2,010 (165–8,300)
2007 Arcadis residential/commercial background surface (0–1 inch) soils (n = 10)	0.88 (0.2–1.9)	130 (6.9–705)	153 (31–414)
2007 Arcadis residential/commercial background surface and near-surface (0–6 inch) soils (n = 10)	0.91 (0.14–2.6)	76 (6.8–347)	132 (31–414)

Minimum and maximum concentrations for 2013 samples include duplicates. Note that the Background Soil Sampling Report (Arcadis, 2011) and the Pilot Study (Environ, 2014c) concluded that there were no statistically significant differences between depth interval concentrations for any of the metals.

Sources: Arcadis, 2011; Environ, 2014c, 2015b.

During November and December 2013, Environ (2014c) conducted an OU4 offsite soils pilot study to support RI activities. A total of 218 surface soil (within 1 inch of the ground surface) and 218 near-surface soil samples (1–6 inches bgs) were collected from 41 properties located in 4 residential areas northwest, west, south, and east of the FPSA. Composite samples were collected from different sections of each property and analyzed for total metals. Concentrations of cadmium, lead, and zinc in these residential soils are elevated in comparison to concentrations in reference areas (Table 4.3).

In 2007, Arcadis (2011) characterized metals concentrations in reference area soils, collecting soil samples from six areas located four to eight miles southwest of the FPSA. These six sampling areas were likely to be unaffected by FPSA releases. Samples results were divided into three land use categories that included residential/commercial/recreational, forested/woodland, and cultivated/uncultivated fields. Surface soil cadmium, lead, and zinc sampling results for the residential/commercial/recreational land use category (collected from three of the six areas) are summarized in Table 4.3. The results show that residential soils in OU4 have highly elevated metals concentrations compared to reference sites, confirming exposure of these soils to hazardous substances released from the Site.

Bluff Area

The Bluff Area is the steeply sloped, 75-acre naturally forested area between the FPSA and the Phosphogypsum Stack Area. Although no organized waste disposal or manufacturing activities occurred in this area, some Site-related material has been found in the Bluff Area (Environ, 2014a, 2015a). Further, its close proximity to the FPSA and downwind location make it likely that Bluff Area soils have been exposed to metals.

In September and October 1999, Horsehead and Mobil collected soil samples within the Bluff Area (summarized in Environ, 2014a). Most of the samples were collected at depth, but five samples incorporated surface soils. Cadmium, lead, and zinc concentrations in these Bluff Area surface soils are higher than soils collected in six forested/woodland areas during the 2007 Arcadis background soil study described in the previous section (Table 4.4; Arcadis, 2011).

Table 4.4. Average (minimum–maximum) surface soil metals concentrations (mg/kg) in Bluff Area soils, and in soils at forested/woodland background sites

Location information	Cadmium	Lead	Zinc
1999 Bluff Area near-surface (0–6 inch) soil (n = 5)	14.2 (0.28–36.9)	84.5 (10.5–195)	1,189 (35–2,460)
2007 Arcadis forested/woodland background surface (0–1 inch) soils (n = 10)	0.59 (0.21–0.87)	14.6 (5.3–32.3)	56.6 (21.8–84.2)
2007 Arcadis forested/woodland background surface and near-surface (0–6 inch) soils (n = 10)	0.71 (0.4–1.5)	17.4 (8.6–41.4)	67.5 (29.2–129)

Note that the Background Soil Sampling Report (Arcadis, 2011) concluded that there were no statistically significant differences between depth interval concentrations for any of the metals.

Sources: Arcadis, 2011; Environ, 2014a.

Floodplain Soils

Two studies demonstrate that floodplain soils have been exposed to hazardous substances associated with the Site. Anderson et al. (2002) sampled dredge disposal area soils that were removed from Lake DePue in 1982 and are now in the Dredge Spoil Disposal Area. Samples were collected in September 1998 throughout the dredge disposal area at four depth intervals and analyzed for metals. BBL (2007) conducted an extensive floodplain soils sampling program to support Lake DePue OU5 RI risk assessments. Floodplain sampling was conducted in August and September 2006 in both Lake DePue and nearby Goose Lake, which was identified as a reference area. Samples were collected at 2 depth intervals (0–0.5 feet and 0.5–2 feet bgs) at 83 locations along 21 transects in Lake DePue and from 10 locations in Goose Lake.

Table 4.5 shows that the average concentrations of metals from each depth horizon in the Dredge Spoil Disposal Area and Lake DePue floodplain soils are elevated compared to Goose Lake floodplain soils, confirming exposure to Site hazardous substances. Additionally, concentrations were higher in Lake DePue floodplain soil samples closer to the FPSA than in samples from farther away (BBL, 2007). These data confirm exposure of Lake DePue floodplain soils to Site hazardous substances.

Table 4.5. Average (minimum–maximum) metals concentrations (mg/kg) measured in 1982 Dredge Spoil Disposal Area samples (Anderson et al., 2002), and 2006 Lake DePue and Goose Lake floodplain soils (BBL, 2007)

Area (year)	Depth range in inches, average (minimum–maximum)	Number of samples	Cadmium	Copper	Lead	Zinc
Dredge Spoil Disposal Area (1982)	0–12	67	67.3 (24.9–252)	126 (64.8–769)	325 (124–2,650)	4,239 (1,480–15,200)
Dredge Spoil Disposal Area (1982)	12–24	64	50.4 (6.68–149)	93.1 (9.44–494)	229 (12.0–1,770	3,075 (460–8,780)
Dredge Spoil Disposal Area (1982)	24–35	56	31.7 (3.56–73.8)	79.2 (21.9–137)	150 (33.6–382)	1,905 (267–4,620)
Dredge Spoil Disposal Area (1982)	39–39	44	26.4 (1.24–109)	88.3 (20.4–195)	146 (24.7–444)	1,607 (171–7,300)
Lake DePue (2006)	0–6	73	76.1 (1.5–2,490)	402 (16.8–8,310)	399 (21.3–12,500)	8,095 (187–150,000)
Lake DePue (2006)	6–12	70	82.6 (1.60–1,935)	335 (13.4–6,575)	419 (14.8–7,660)	9,937 (146–178,500)

Table 4.5. Average (minimum–maximum) metals concentrations (mg/kg) measured in 1982 Dredge Spoil Disposal Area samples (Anderson et al., 2002), and 2006 Lake DePue and Goose Lake floodplain soils (BBL, 2007)

Area (year)	Depth range in inches, average (minimum–maximum)	Number of samples	Cadmium	Copper	Lead	Zinc
Goose Lake reference area (2006)	0–6	10	1.66 (0.52–3.10)	30.7 (11.6–45.6)	25.4 (10.2–38.1)	121 (42.0–195)
Goose Lake reference area (2006)	6–24	11	2.83 (0.57–6.30)	34.2 (13.5–65.1)	29.9 (10.2–70.2)	137 (45.6–317)

4.2 Surface Water Resources

4.2.1 Definition

Surface water resources are defined in the DOI regulations as including both surface water and sediments suspended in water or lying on the bank, bed, or shoreline [43 CFR § 11.14(pp)]. Available data on concentrations of metals in surface water and sediment document that these resources have been exposed to hazardous substances originating from the Site.

4.2.2 Potentially Injured Surface Water Resources

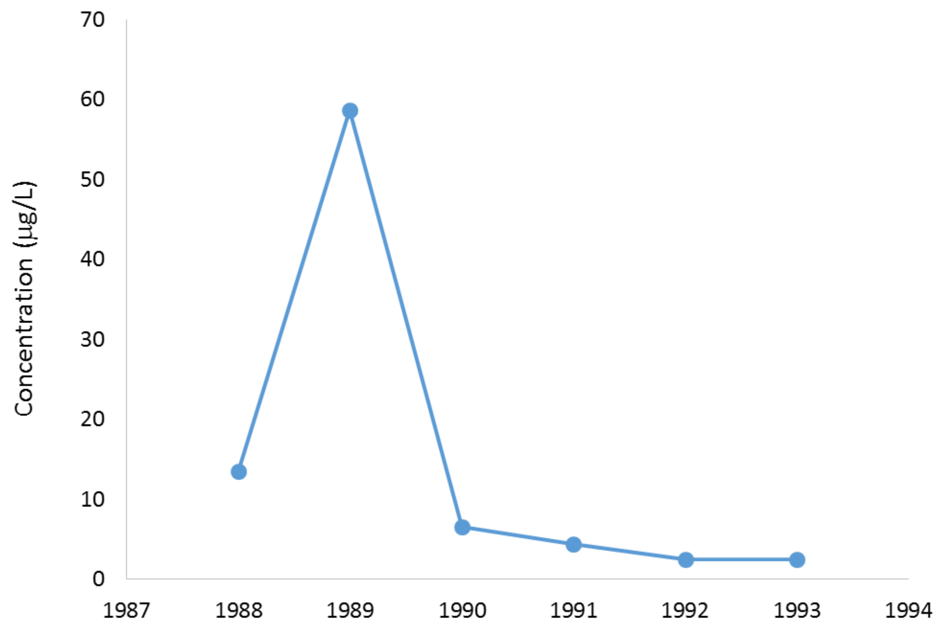
This section focuses exclusively on the confirmation of exposure of surface water resources in Lake DePue, which is the most significant and well-studied surface water body at the Site. The assessment may include an investigation of potential exposure and injury to other surface water resources such as the Illinois River downstream of Lake DePue and the Surge Pond within the Bluff Area of OU3.

4.2.3 Surface Water Exposure

This section presents data that confirm exposure of surface water to hazardous substances in Lake DePue. Surface water quality data are not readily available before the late 1980s, at which point Site manufacturing activities had ceased, and waste control actions were being implemented. However, available data show that concentrations of metals in Lake DePue surface water remain elevated at levels well above reference conditions. Sediment exposure is discussed subsequently in Section 4.2.4.

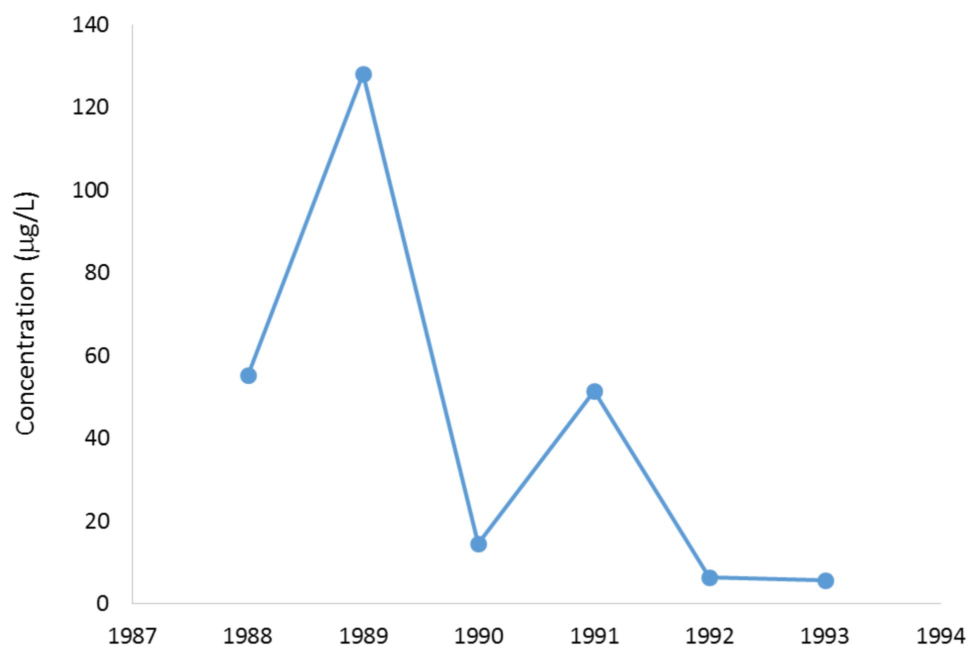
Early Lake DePue surface water chemistry data were available from annual surface water quality surveys conducted from 1988 through 1993 and presented in the Site Assessment Plan (Terra, 1995). These samples were primarily collected near the discharge of the South Ditch and should not be interpreted as indicative of Lake DePue as a whole. However, these results show that surface water resources were exposed to high concentrations of cadmium, copper, and zinc (Figures 4.1 to 4.3, respectively). Concentrations of these metals were highest in the late 1980s and generally declined over time. These declines may be from ending manufacturing operations (1989) and source control actions (1990s), and construction of the IWTP (1997).

Figure 4.1. Average cadmium concentrations measured in surface water in Lake DePue. A value of half the analytical detection limit was used for samples where cadmium was not detected.



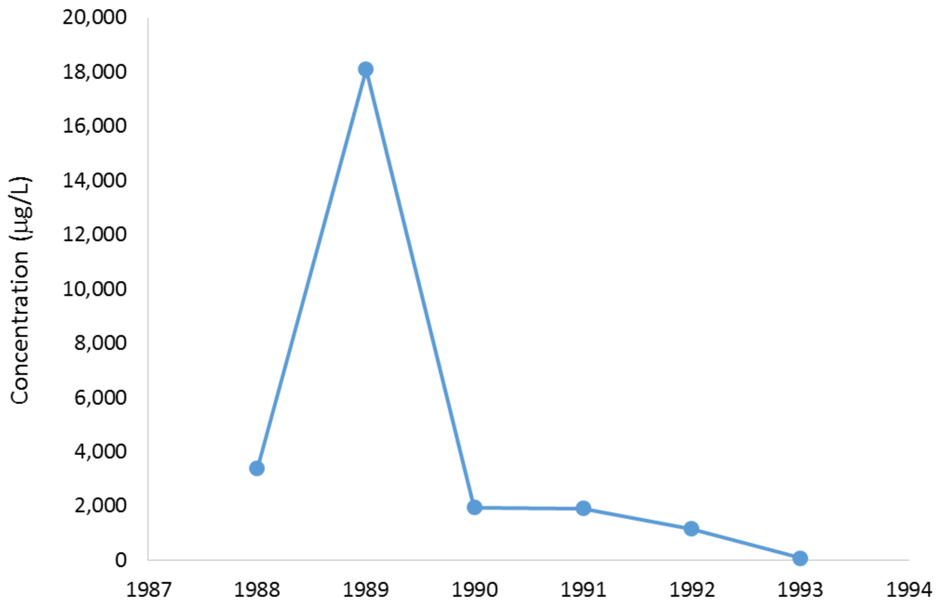
Data source: Terra, 1995.

Figure 4.2. Average copper concentrations measured in surface water in Lake DePue. A value of half the analytical detection limit was used for samples where copper was not detected.



Data source: Terra, 1995.

Figure 4.3. Average zinc concentrations measured in surface water in Lake DePue.



Data source: Terra, 1995.

More recently, Arcadis (2012) collected surface water from Lake DePue in the fall of 2006 and 2007 during different flow regimes to support RI baseline risk assessments, along with surface water from a Goose Lake reference area in fall 2007. Arcadis (2012) also collected samples from underwater groundwater seeps/springs in Lake DePue in fall 2007. Table 4.6 summarizes total cadmium, copper, and zinc concentrations measured by Arcadis (2012) in unfiltered water samples from Lake DePue, which were elevated compared to the Goose Lake reference site. Concentrations of these metals were also elevated in underwater seeps, with concentrations similar to those measured in Lake DePue surface waters.

Table 4.6. Average (minimum–maximum) total metals (unfiltered) concentrations (µg/L) measured in Lake DePue and Goose Lake (reference area) surface waters during fall 2006 and 2007 (Arcadis, 2012)

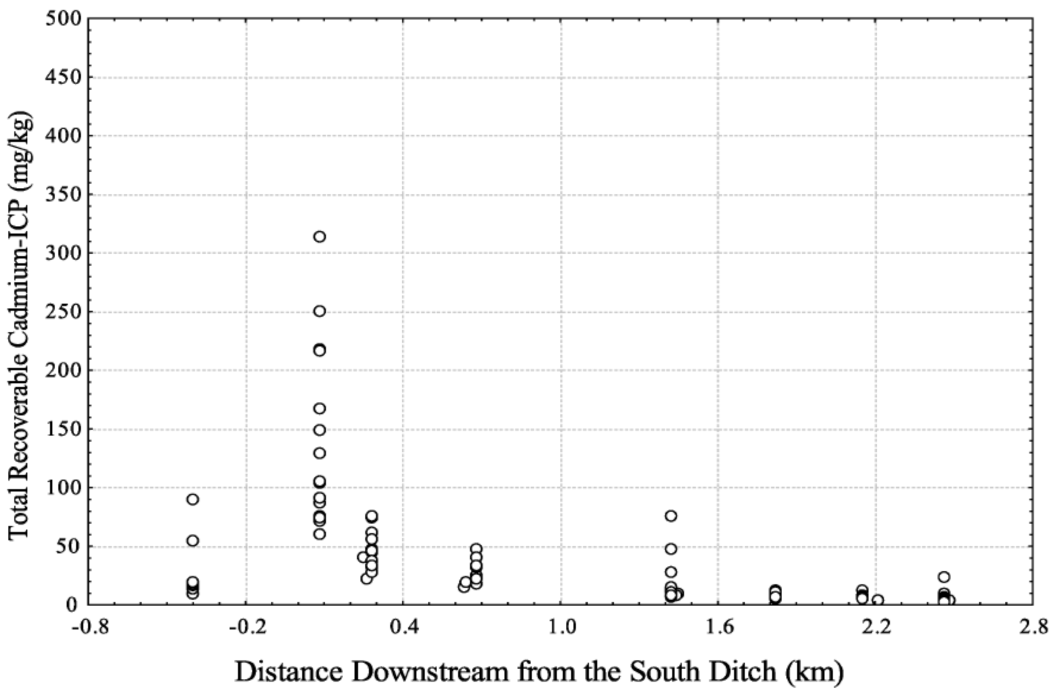
Sample type and location (number of samples)	Cadmium	Copper	Zinc
Lake DePue underwater seeps (n = 7)	2.00 (0.92–3.60)	16.4 (10.0–29.0)	321 (170–600)
Lake DePue surface water (n = 19)	3.22 (0.66–7.20)	14.5 (2.90–57)	332 (32–1,800)
Goose Lake (reference) surface water (n = 4)	< 0.5 µg/L	6.45 (4.10–9.90)	96 (19–250)

4.2.4 Sediment Exposure

Sediments have been exposed to hazardous substances from the Site. Some of the earliest environmental chemistry data were obtained for Lake DePue sediment samples. Results from historical sampling indicated that Lake DePue sediments were contaminated with metals likely before the 1970s (Cahill and Steele, 1986). Later sediment chemistry sampling confirmed that metals contamination still exists in Lake DePue at levels that are more than an order of magnitude greater than in a reference area (Turner Lake; Cahill and Bogner, 2002). More recent sampling by Arcadis (2009) indicates a spatial trend in metals contamination similar to surface water, with the greatest concentrations measured near or downgradient from known Site source areas (e.g., the South Ditch and the Division Street Drain).

Cahill and Steele (1986) found elevated cadmium (up to 116 mg/kg) and zinc (up to 5,000 mg/kg) in lake sediments in core samples collected between 1975 and 1982. Subsequently, Cahill and Bogner (2002) compared concentrations of metals in Lake DePue sediments from transects in 1998 with concentrations in sediments from Turner Lake, another shallow backwater lake located a few miles upstream of Lake DePue. Cadmium and zinc concentrations in Lake DePue sediments ranged from 2 to 309 mg/kg and 300 to 42,300 mg/kg, respectively, compared with 2 to 8.5 mg/kg and 155 to 427 mg/kg in Turner Lake. Total recoverable[6] cadmium and zinc were highest in Lake DePue near the South Ditch (Figures 4.4 and 4.5, respectively). Copper and lead concentrations were also statistically significantly greater in Lake DePue sediments collected near the South Ditch than elsewhere in the lake.

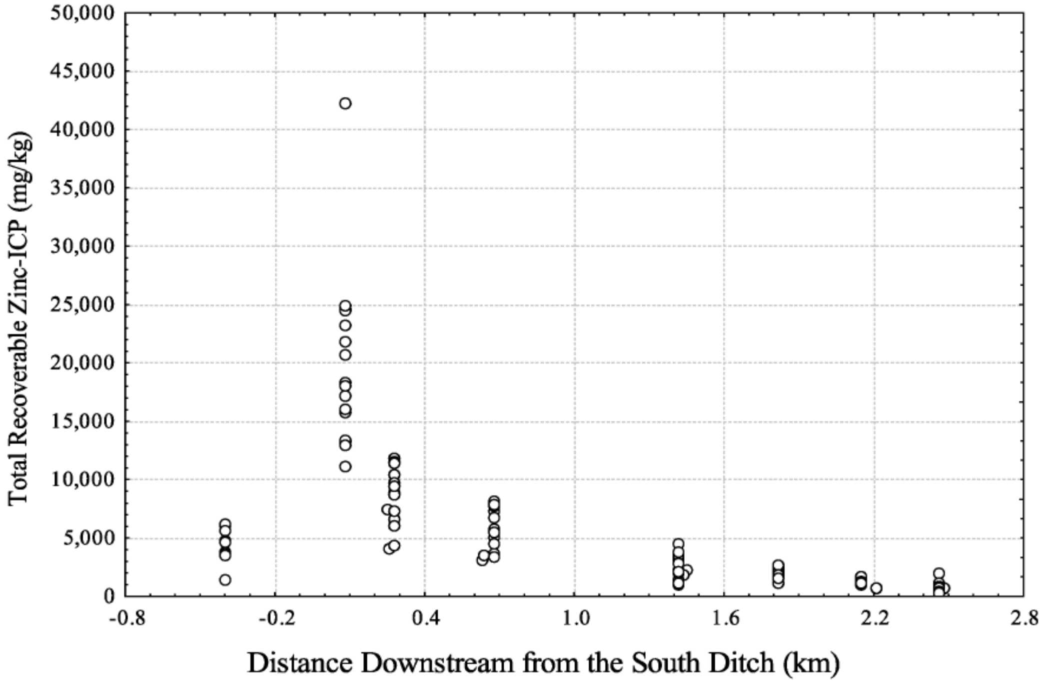
Figure 4.4. Total recoverable cadmium concentrations in Lake DePue sediments relative to distance downstream from the South Ditch.



Source: Cahill and Bogner, 2002, Figure 12.

6. Samples were analyzed using U.S. EPA method SW6010 by inductively coupled plasma (ICP) – Method 6010 is not considered a complete digestion, and thus the concentrations are reported as “total recoverable.” Total concentrations of metals would be expected to be somewhat greater than total recoverable concentrations. For more information, see Cahill and Bogner (2002).

Figure 4.5. Total recoverable zinc concentrations in Lake DePue sediments relative to distance downstream from the South Ditch.



Source: Cahill and Bogner, 2002, Figure 13.

More recently, Arcadis (2009) collected samples in Lake DePue, demonstrating that zinc, cadmium, and lead concentrations are elevated relative to the Goose Lake reference area (Table 4.7).

Table 4.7. Average (minimum–maximum) total metals concentrations (mg/kg) measured in Lake DePue and Goose Lake shallow (0- to 6-inch depth) sediments (Arcadis, 2009)

Sampling area (number of samples)	Zinc	Cadmium	Lead
East Lake DePue (n = 21)	14,948 (2,420–65,100)	122 (7.90–840)	828 (50.7–12,900)
Central Lake DePue (n = 30)	3,017 (306–10,000)	26.2 (4.00–206)	198 (25.0–2,860)
West Lake DePue (n = 26)	980 (178–2,300)	6.62 (1.30–24.4)	48.1 (16.8–77.1)
Goose Lake reference area (n = 12)	197 (160–230)	2.09 (1.40–2.50)	36.2 (30.4–44.3)

4.3 Groundwater Resources

4.3.1 Definition

Groundwater is defined as water in a saturated zone or stratum beneath the surface of land or water, and the rocks or sediments through which groundwater moves. It includes groundwater resources that meet the definition of drinking water supplies [43 CFR § 11.14(t)].

4.3.2 Potentially Injured Groundwater Resources

The glacial deposits at the Site include, from the ground surface, an upper till layer, an Intermediate Sand Aquifer, a lower till layer, and a Lower Aquifer. The sand units form the aquifers at the Site, and the lower-permeability till layers act as aquitards. The vertical zones of the Lower Aquifer are sometimes categorized as a Top of the Lower Aquifer (TOLA) and a Bottom of the Lower Aquifer (BOLA), but there is no hydrologic barrier separating these two zones. In OU3, the Intermediate Sand Aquifer is not present. Perched groundwater is present beneath OU3 in an Upper Water Bearing Zone (UWBZ). Groundwater is also present in the deeper Lower Aquifer, including the TOLA and BOLA layers (Environ, 2006c). In OU2, this UWBZ is not present.

Groundwater flow at the Site is generally southward toward the lake (Cahill and Bogner, 2002; Environ, 2006c, 2014b). Significant discharges of metals to groundwater have occurred (Illinois EPA, 2016a), resulting in groundwater contamination. The quality of water in the groundwater system has been impacted by metals and other chemicals from smelter residues and fertilizer manufacturing materials remaining at the Site (Environ, 2014b). These include hazardous substances and products of the release of hazardous substances at the Site.

4.3.3 Groundwater Potability and Services

As part of the injury assessment, groundwater potability and ecological and human use services absent releases of hazardous substances at the Site (i.e., under baseline conditions) will be evaluated. Several lines of evidence demonstrate that groundwater at the Site would be potable and generally meet water quality criteria absent releases of hazardous substances from the Site. These lines of evidence include (1) the spatial distribution of contaminant concentrations in Site aquifers, (2) the regional water quality in the Intermediate Sand Aquifer and Lower Aquifer, and (3) the historical residential use of groundwater upgradient of the Site. As part of the injury assessment, groundwater services under baseline conditions will also be determined (as described in Sections 5.3.3 and 5.4).

4.3.4 Groundwater Exposure

To confirm exposure of groundwater to hazardous substances, concentrations may be compared to background or baseline concentrations in groundwater, and/or groundwater quality criteria. It does not appear that a comprehensive and statistical evaluation of background water quality in the various aquifers and analytes has been conducted at the Site. Although there are some wells located upgradient of source areas, many of these wells are generally in close proximity to the sources and may have been impacted by Site operations, and thus may not represent background concentrations. Studies to assess background water quality for various source areas are ongoing; the Phase II RI for OU3 (Environ, 2014b) assessed whether the Bluff Area could be used as UWBZ background water quality and determined that it could not. However, the report did propose that some wells installed in the Lower Aquifer [MW-31T, MW-32T, MW-33T, MW-34T, W-02(D), and W-12(D)] could be used for background conditions for the Lower Aquifer in the FPSA. The OU2 groundwater modeling report (SDI and Terra, 2014) provides proposed Lower Aquifer baseline concentrations for four analytes: total dissolved solids (TDS; 400 mg/L), sulfate (100 mg/L), ammonia (10 mg/L), and phosphorus (0.2 mg/L), but the wells and methods used to estimate these concentrations are not described.

Given the absence of agreed-upon background concentrations for all the Site aquifers and analytes, in this Assessment Plan we confirm exposure by comparing concentrations observed in groundwater at the Site with Class I (potable resource) and Class II (general resource) groundwater quality standards (35 IAC 620), or Site-specific criteria that would be expected to be higher than background concentrations. Class I standards protect groundwater intended for human consumption; whereas Class II standards protect groundwater for agricultural, industrial, recreational, or other beneficial uses. We have applied the criteria as they were applied in the source data reports. A comparison of groundwater concentrations to criteria confirms that groundwater in OU2, OU3, and OU4 has been exposed to hazardous substances released from the Site. A comprehensive review of baseline groundwater conditions in the Site aquifers, including determination of appropriate background wells and evaluation of regional water quality data, potability, and use will be conducted as part of the injury assessment (see Section 5.3.3).

In OU2, water infiltrates the Phosphogypsum Stack, where it dissolves ammonia, phosphorus, arsenic, sulfate, and other constituents; and then percolates downward to the Intermediate Sand Aquifer under the stack (Terra, 2013). Some of this water is captured in swales and pumped to a pond for management. However, in the eastern portion of the Phosphogypsum Stack, some contaminants are migrating downward to the Lower Aquifer and are moving downgradient to the south toward the lake. Seeps and springs that are groundwater pathways to surface water have been identified along Lake DePue's north shoreline.

Hazardous substances, including ammonia and metals, are elevated in Intermediate Sand Aquifer groundwater samples from beneath or downgradient of the Phosphogypsum Stack collected between 1999 and 2012, including north of the Phosphogypsum Stack (Table 4.8; Terra, 2013).

Table 4.8. Concentrations of hazardous substances and products of hazardous substances in the Intermediate Sand Aquifer beneath or downgradient of the Phosphogypsum Stack, compared to Class II criteria (Terra, 2013)

Hazardous substance (units)	Maximum concentration	Class II criterion
Ammonia (mg/L)	650	35[a]
Arsenic (μg/L)	322	200
Manganese (μg/L)	13,300	10,000
Sulfate (mg/L)	6,240	400
Vanadium (μg/L)	106	100

a. Site-specific criterion.

Elevated concentrations of metals have been found in the TOLA (Table 4.9) and BOLA (Table 4.10), compared to Class I groundwater standards or site-specific criteria (Terra, 2013).

Table 4.9. Concentrations of hazardous substances and products of hazardous substances in the TOLA beneath or downgradient of the Phosphogypsum Stack, compared to Class I criteria (Terra, 2013)

Hazardous substance (units)	Maximum concentration	Class I criterion
Ammonia (mg/L)	382	35[a]
Arsenic (μg/L)	13	10
Lead (μg/L)	26	7.5
Manganese (μg/L)	1,840	150
Sulfate (mg/L)	3,450	400

a. Site-specific criterion.

Table 4.10. Concentrations of hazardous substances and products of hazardous substances in the BOLA beneath or downgradient of the Phosphogypsum Stack, compared to Class I criteria (Terra, 2013)

Hazardous substance (units)	Maximum concentration	Class I criterion
Ammonia (mg/L)	240	35[a]
Arsenic (μg/L)	53	10
Manganese (μg/L)	3,930	150
Nickel (μg/L)	606	100
Sulfate (mg/L)	3,120	400
Vanadium (μg/L)	65	49

a. Site-specific criterion.

Metal concentrations in groundwater are also elevated in OU3 and OU4, confirming exposure of groundwater resources to hazardous substances released from the Site. The groundwater beneath OU3 generally flows to the south and east. Metals releases have impacted perched groundwater in the UWBZ (Table 4.11) substantially more than the groundwater in the TOLA and BOLA, although groundwater samples from the TOLA and BOLA also contain concentrations of some metals that exceed Class I groundwater criteria (Environ, 2014b).

Table 4.11. Concentrations of hazardous substances and products of hazardous substances in the UWBZ in OU3 and OU4, compared to Class I criteria

Hazardous substance (units)	Maximum concentration[a]	Class I criterion
Ammonia (mg/L)	247	35[b]
Arsenic (μg/L)	202	10
Cadmium (μg/L)	134,000	5
Cobalt (μg/L)	14,300	1,000
Copper (μg/L)	390,000	650
Lead (μg/L)	3,520	7.5
Manganese (μg/L)	979,000	150
Nickel (μg/L)	16,100	100
Sulfate (mg/L)	28,800	400
Zinc (μg/L)	14,100,000	5,000

a. Concentrations from OU3 and OU4 database (Ramboll, 2017).
b. Site-specific criterion (Terra, 2013).

4.4 Biological Resources

4.4.1 Definition

Biological resources are defined in the DOI regulations as "those natural resources referred to in Section 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and state-sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms" [43 CFR § 11.14(s)].

4.4.2 Potentially Injured Biological Resources

The aquatic and terrestrial habitats surrounding the Site support a wide variety of biota that may be or have been exposed to hazardous substance releases from the Site. Potentially injured biological resources include resident and migratory birds, mammals, fish, reptiles, amphibians, clams, benthic invertebrates, and plants (Arcadis, 2012).

Threatened and Endangered Species

Threatened and endangered (T&E) species potentially occur in the assessment area. The Illinois Endangered Species Protection Board reports that 11 threatened and 8 endangered species have potential to occur in Bureau County, Illinois (Table 4.12; IDNR, 2018). In addition to these state T&E listed species, USFWS (2019) also lists the ruby patched bumble bee and the eastern prairie fringed orchid as being threatened in Bureau County.

Table. 4.12. State and federal listed threatened (T) and endangered (E) species for Bureau County, Illinois

Species	State listing status	Federal listing status
Birds		
Cerulean warbler (*Dendroica cerulea*)	T	
Loggerhead shrike (*Lanius ludovicianus*)	E	
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)	E	
Reptiles and amphibians		
Blanding's turtle (*Emydoidea blandingii*)	E	
Plains hog-nosed snake (*Heterodon nasicus*)	T	
Fishes		
American brook lamprey (*Lethenteron appendix*)	T	
American eel (*Anguilla rostrata*)	T	
Banded killifish (*Fundulus diaphanus*)	T	
Blacknose shiner (*Notropis heterolepis*)	E	
Starhead topminnow (*Fundulus dispar*)	T	
Weed shiner (*Notropis texanus*)	E	
Mammals		
Indiana bat (*Myotis sodalis*)	E	E
Northern long-eared myotis (*Myotis septentrionalis*)	T	T
Insects		
Regal fritillary (*Speyeria idalia*)	T	
Ruby patched bumble bee (*Bombus affinis*)		E
Plants		
Broomrape (*Orobanche ludoviciana*)	T	
Decurrent false aster (*Boltonia decurrens*)	T	T
Eastern prairie fringed orchid (*Platanthera leucophaea*)		T

Table. 4.12. State and federal listed threatened (T) and endangered (E) species for Bureau County, Illinois

Species	State listing status	Federal listing status
Jack pine (*Pinus banksiana*)	E	
Queen-of-the-prairie (*Filipendula rubra*)	T	
Tall sunflower (*Helianthus giganteus*)	E	

Sources: IDNR, 2018; USFWS, 2019.

4.4.3 Exposed Biological Resources

Data on numerous biological resources have been collected for the RI process. In this section, we summarize a subset of the available data confirming the exposure of plants, birds, fish, aquatic invertebrates, and small mammals to hazardous substances. The data presented in this section confirm that concentrations of hazardous substances in tissue samples collected from biological resources at the Site are elevated compared to reference areas.

Plants

In 1997, Levengood and Skowron (2000) collected seeds from plant species within the Dredge Spoil Disposal Area and from a reference site, with a similar management regime, the Anderson Lake Conservation Area (ALCA), which is located 146 km from the Dredge Spoil Disposal Area. Concentrations of cadmium and zinc in seeds from the Dredge Spoil Disposal Area were elevated compared to those in the ALCA, and were within lower effects levels for consumption by ducks and other granivorous wildlife in some studies (Table 4.13; Levengood and Skowron, 2000). These concentrations indicate the likely exposure of plants to metals released from the Site, as well as a pathway for wildlife feeding on these plants.

Table 4.13. Concentrations of cadmium and zinc (mg/kg) in seeds in the Dredge Spoil Disposal Area and the ALCA reference area (Levengood and Skowron, 2000)

	Dredge Spoil Disposal Area		ALCA reference area	
Sampling location	Number of samples	Average concentration (minimum–maximum)	Number of samples	Average concentration (minimum–maximum)
Cadmium				
Buckwheat (*Fagopyrum esculentum*)	2	5.51 (4.94–6.07)	1	2.90
Corn (*Zea mays*)	9	1.13 (0.75–1.7)	7	0.81 (0.37–1.19)
Winter hemp (*Amaranthus rudis*)	7	11.8 (7.0–15.7)	6	2.91 (2.22–3.62)
Pennsylvania smartweed (*Polygonum pennsylvanicum*)	5	6.69 (3.19–12.9)	12	4.38 (2.32–6.60)
Zinc				
Buckwheat	2	77.8 (77.8–88.0)	1	30.5
Corn	9	51.5 (39.5–57.2)	7	24.7 (14.3–30.6)
Winter hemp	7	144.3 (93.2–201)	6	43.7 (35.7–51.6)
Pennsylvania smartweed	5	79.1 (29.9–126)	12	33.3 (26.6–45.1)

Birds

Levengood et al. (1999) evaluated metals concentrations in gizzard contents from wild mallards and farm-released ducks utilizing the Dredge Spoil Disposal Area. The Dredge Spoil Disposal Area metals concentrations in gizzard contents were then compared to those in wild wood ducks and mallards in the ALCA reference site. The authors concluded that wild and/or post-release farm-raised mallards from the Dredge Spoil Disposal Area experienced greater exposure to barium, boron, calcium, iron, lead (sentinel), manganese, nickel, phosphorus, strontium, and possibly cobalt than wild mallards from the ALCA reference area or pre-release farm-raised ducks. Extraction of elements from the gizzard contents of ducks indicated increased bioavailability of both cadmium and zinc from ducks within the Dredge Spoil Disposal Area compared to ducks in the reference wetland at ALCA (Table 4.14).

Table 4.14. Average (minimum–maximum) concentrations of metals (mg/L) in duck gizzard contents from the Dredge Spoil Disposal Area and the ALCA reference area (Levengood et al., 1999)

Sampling location (number of samples)	Cadmium	Zinc
Dredge Spoil Disposal Area (n = 6 cadmium, n = 18 zinc) Wild mallard	0.08 (< 0.03–0.17)	2.07 (0.04–6.44)
Dredge Spoil Disposal Area (n = 2) Wild wood duck	< 0.03	0.77 (0.60–0.94)
Dredge Spoil Disposal Area (n = 5) Farm-raised mallard, pre-release	< 0.03	0.28 (0.21–0.41)
Dredge Spoil Disposal Area (n = 10 cadmium, n = 12 zinc) Farm-raised mallard, released 7–21 days	0.16 (< 0.03–0.76)	3.34 (0.60–17.2)
ALCA reference area (n = 4) Wild wood duck	< 0.03	0.62 (0.45–0.84)
ALCA reference area (n = 23) Wild mallard	< 0.03	0.59 (0.02–1.79)

Fish

Gizzard shad occur in both Lake DePue and the Goose Lake reference area, and have a relatively small home range; therefore, data from these fish are good indicators of local exposures. Arcadis (2007a) reported whole fish tissue residuals from gizzard shad to support RI risk assessment activities. Composite samples were collected from three evenly spaced locations between South Ditch and the Illinois River inlet. The gizzard shad whole body cadmium, copper, lead, and zinc concentrations for the eastern and central sampling locations in Lake DePue had higher metal concentrations than the Goose Lake reference site, although samples from the western sampling location were comparable to the reference samples (Table 4.15). Metals concentrations in Lake DePue shad were highest on the east side of the lake near the Site.

Table 4.15. Average (minimum–maximum) metals concentrations (mg/kg) in gizzard shad whole body composite samples in Lake DePue and the Goose Lake reference area (Arcadis, 2007a)

Sampling location (number of samples)	Cadmium	Copper	Lead	Zinc
Lake DePue Area 1 (n = 5) East side of lake	12.7 (3.00–45.5)	49.0 (13.7–142)	41.2 (9.70–151)	1,301 (378–3,820)

Table 4.15. Average (minimum–maximum) metals concentrations (mg/kg) in gizzard shad whole body composite samples in Lake DePue and the Goose Lake reference area (Arcadis, 2007a)

Sampling location (number of samples)	Cadmium	Copper	Lead	Zinc
Lake DePue Area 2 (n = 5) Center of lake	1.65 (0.13–2.60)	12.2 (3.90–16.7)	9.66 (2.30–48.3)	285 (88.6–405)
Lake DePue Area 3 (n = 5) West side of lake	0.75 (0.5–0.98)	8.7 (7.7–9.9)	6.6 (5.0–8.3)	183 (152–226)
Goose Lake (n = 5) Reference area	0.76 (0.23–1.80)	10.3 (6.60–14.5)	6.56 (4.10–8.80)	114 (85.4–140)

Aquatic Macroinvertebrates

Arcadis (2007a) collected aquatic macroinvertebrates from four sampling locations in Lake DePue and the Goose Lake reference area, and analyzed samples for total metals to support RI risk assessment activities. Samples collected in August 2006 consisted of composited individual Notonectidae backswimmers, the most abundant aquatic invertebrate taxon at all sites. Concentrations of zinc in Lake DePue macroinvertebrates from all locations were elevated compared to the concentrations from the reference area. Macroinvertebrates collected from the east side of Lake DePue, particularly those near South Ditch, also contained elevated cadmium, copper, and lead compared to those from the Goose Lake reference area (Table 4.16).

Table 4.16. Average (minimum–maximum) metals concentrations (mg/kg) in aquatic invertebrates (backswimmer) composite samples in Lake DePue and Goose Lake reference area (Arcadis, 2007a)

Sampling location (number of samples)	Cadmium	Copper	Lead	Zinc
Lake DePue Area 1 (n = 2) Far east side of lake	28.3 (7.60–48.9)	116 (73.5–159)	35.8 (13.3–58.2)	3,025 (1,270–4,780)
Lake DePue Area 2 (n = 2) Adjacent to South Ditch	82.3 (50.5–114)	805 (540–1,070)	153 (124–182)	14,150 (12,300–16,000)
Lake DePue Area 3 (n = 2) West-central side of lake near Unnamed Tributary	0.86 (0.86–0.86)	45.7 (44.2–47.1)	4.3 (3.8–4.8)	450 (407–493)
Lake DePue Area 4 (n = 2) South-central side of lake	1.25 (1.2–1.3)	48.2 (46.6–49.8)	6.5 (5.3–7.7)	548 (513–583)
Goose Lake (n = 5) Reference lake	2.93 (1.20–5.20)	71.4 (43.2–130)	15.3 (< 12.8–17.6)	352 (206–492)

Mammals

In September 1998, Levengood et al. (2003) collected tissue samples from small mammals to investigate metals bioaccumulation from exposure to soils located within and near the Dredge Spoil Disposal Area, where contaminated sediments from Lake DePue were placed in 1982. Samples were collected throughout the Dredge Spoil Disposal Area, another area approximately 0.3 miles east of the Dredge Spoil Disposal Area; and at two reference sites, Hormel Landing and the Donnelley State Fish and Wildlife Area, which are located approximately 1.2 miles southwest of the Dredge Spoil Disposal Area. They found that small mammals from the Dredge Spoil Disposal Area had greater exposure to several metals, including cadmium and lead. Table 4.17 summarizes cadmium concentrations measured in white-footed mouse (*Peromyscus leucopus*) and in vole (*Microtus* spp.) and shrew (*Blarina brevicauda*) kidney and liver tissues from each of the four sampling areas. Small mammals collected from the Dredge Spoil Disposal Area had cadmium concentrations that were substantially greater than the reference areas, and concentrations in voles were higher than those observed in mice. Although lower than the Dredge Spoil Disposal Area samples, cadmium concentrations in small mammals collected from the floodplain near the Dredge Spoil Disposal Area were also elevated above reference site samples.

Table 4.17. Concentrations of cadmium (µg/g) in mouse and vole kidney and liver tissues within and near the Dredge Spoil Disposal Area compared to reference areas (Levengood et al., 2003)

Sampling location	Mouse		Vole/shrew	
	Number of samples	Average concentration (minimum–maximum)	Number of samples	Average concentration (minimum–maximum)
Kidney				
Dredge Spoil Disposal Area	20	1.81 (0.45–7.40)	5	8.5 (2.80–20.0)
Floodplain near Dredge Spoil Disposal Area	20	1.02 (0.11–3.30)	4	2.95 (1.10–5.40)
Hormel Landing reference area	20	0.23 (0.04–1.10)	NA	NA
Donnelley State Fish and Wildlife Area reference area	20	0.39 (0.13–0.96)	5	0.41 (0.15–0.54)
Liver				
Dredge Spoil Disposal Area	20	1.08 (0.25–3.10)	5	4.34 (0.68–15.0)
Floodplain near Dredge Spoil Disposal Area	20	0.33 (0.03–0.83)	4	1.54 (0.15–5.20)
Hormel Landing reference area	20	0.06 (0.01–0.31)	NA	NA
Donnelley State Fish and Wildlife Area reference area	20	0.13 (0.06–0.3)	5	0.11 (0.06–0.14)

5. Injury Assessment

As specified in the DOI regulations for NRDAs, the purpose of the injury assessment phase is to:

1. Determine whether injuries to natural resources have occurred [43 CFR § 11.62]
2. Identify the environmental pathways through which injured resources have been exposed to hazardous substances released from the Site [43 CFR § 11.63]
3. Quantify the degree and extent (spatial and temporal) of injury in terms of a reduction of the quantity and quality of services from baseline conditions [43 CFR § 11.70]
4. Establish appropriate compensation for those injuries [43 CFR § 11.80].

As discussed previously, the DOI regulations specify three stages of the assessment: injury determination, injury quantification, and damage determination (see Section 1.5). This assessment will follow the guidance in the regulations.

The Trustees intend to conduct the assessment using a phased approach. Existing data will be utilized to develop preliminary conclusions regarding the types and magnitudes of injury and damages resulting from releases from the Site. Preliminary restoration alternatives will be developed to address those injuries and damages. Results of the initial injury assessment phase will help define any additional focused work necessary to address uncertainties and to help evaluate any potential settlement options. If deemed necessary, the Trustees and the PRPs may conduct focused NRDA studies to address those uncertainties and re-evaluate conclusions of the assessment. This approach is intended to be time- and cost-effective, with the aim of providing restoration benefits to the public in a timely manner.

Consistent with the DOI regulations, injuries will be evaluated on a resource-by-resource basis. However, natural resources and the ecological services they provide are interdependent. For example, surface water and sediments, floodplain soils, and riparian vegetation together provide habitat – and lateral and longitudinal connectivity between habitats – for aquatic biota, semi-aquatic biota, and upland biota dependent on access to Lake DePue or the riparian zone. Hence, injuries to individual natural resources may cause habitat- or ecosystem-level service reductions. While this assessment will be conducted on a resource-by-resource basis, the quantification of injury and damage determination may also incorporate ecosystem processes that encompass the loss of ecosystem services within and across these natural resources.

Section 5.1 first describes the sources of data that may serve as the basis of this assessment, and then the approaches for evaluating pathways are discussed in Section 5.2. This is followed by a discussion of determining injuries (Section 5.3), determining and characterizing baseline conditions (Section 5.4), and quantifying injuries (Section 5.5). A preliminary determination of the recovery period for natural resources is also presented in Section 5.5. The damage determination approach is described in Section 6.

5.1 Data Sources

This section describes the data and information sources that will be used in the injury assessment. The injury assessment will rely primarily on data and information already available, potentially supplemented with additional data collection to address identified data gaps. Many reports and datasets are available for the Site, including state-led studies, and a systematic list of datasets from the RI/FS processes for the various OUs. General data sources that will be evaluated in the injury assessment include:

- Articles published in the peer-reviewed literature
- State and federal government data and reports
- Industry data and reports
- RI/FS data and reports, including technical memoranda
- Long-term monitoring data being collected for the Site
- Ecological risk assessments conducted for OUs, including supporting studies and information
- Other ecological or toxicological studies, such as the ongoing fingernail clam study.

Appendix A contains a list of available Site documents containing relevant data.

The data sources will be screened to verify that supporting documentation is available and sufficient to allow for an evaluation of the reliability and usability of the information. The following types of supporting documentation should be considered in the evaluation of data usability:

- Sampling methodology, including information on sample location, environmental media sampled, and measurement units
- Chemical analysis, including information on detection limits and methodology
- Raw data or data tabulations (e.g., rather than figures only)
- Accompanying quality assurance/quality control (QA/QC) data or separate QA/QC reports.

If necessary, the assessment may rely on historical data that do not have all of this supporting information. This supporting documentation will be evaluated for each potential data source to determine the acceptability of the data for the injury assessment.

5.1.1 Supplemental Data Collection

The assessment will include an evaluation of data needs. With extensive RIs and the associated robust dataset, additional studies may not be necessary. However, if data gaps are identified and the ongoing remedial process does not include a plan to fill the gaps, additional data may be collected through the cooperative assessment process to address substantial data gaps.

The FPA states, "where additional data or studies are deemed necessary by the Parties [Trustees and PRPs], the Parties [Trustees and PRPs] agree to cooperatively develop alternative or additional studies to address data or analysis needs and budgets for conducting the studies or data analysis." The FPA also allows for studies to be conducted independently if all involved cannot agree to the types of study needed. Supplemental data collection may be focused on ecological, chemical, or toxicological research; or on economic data collection. The Trustee review to date of existing data and other activities conducted at the Site, including characterizations and evaluations of habitat, flora and fauna, surface water, sediment, and groundwater including bioavailability assessments, has yielded a preliminary list of potential additional studies:

- Wind patterns and potential impacts to floodplain and forested areas outside of OUs
- Further groundwater and surface water interactions
- Groundwater classification and characterization of the surrounding area (currently, there is a lack of offsite background data)
- Updated sedimentation study
- Monitor/further evaluation of flow/connection between the lake and river (e.g., flow meter)
- Fingernail clams in Lake DePue and related stress factors
- Reptiles and amphibians of Bluff Area
- Avian tissue/health other than waterfowl/ducks.

The Trustees are obligated to assess all potential injuries and related service losses to natural resources held in public trust, and such studies will not be ruled out prior to an assessment.

However, as noted previously, the Trustees' priority is to rely on the extensive data already collected. Additional data collection may be necessary if the Trustees and the PRPs are unable to mutually resolve uncertainties regarding the nature and extent of natural resource injuries and (or) damages.

5.1.2 Procedures for Sharing Data

The DOI NRDA regulations state that an Assessment Plan includes "procedures and schedules for sharing data, split samples, and results of analyses, when requested, with any identified potentially responsible parties and other natural resource Trustees" [43 CFR § 11.31(a)(4)].

Under the 2016 FPA, the Trustees and the PRPs will share all potentially relevant data, reports, and studies. Additionally, any other state or federal agencies will be provided with an opportunity to obtain a copy of all data used in the injury assessment. The Trustees will provide any Trustee-collected data to any other interested parties once the data have been validated and are available.

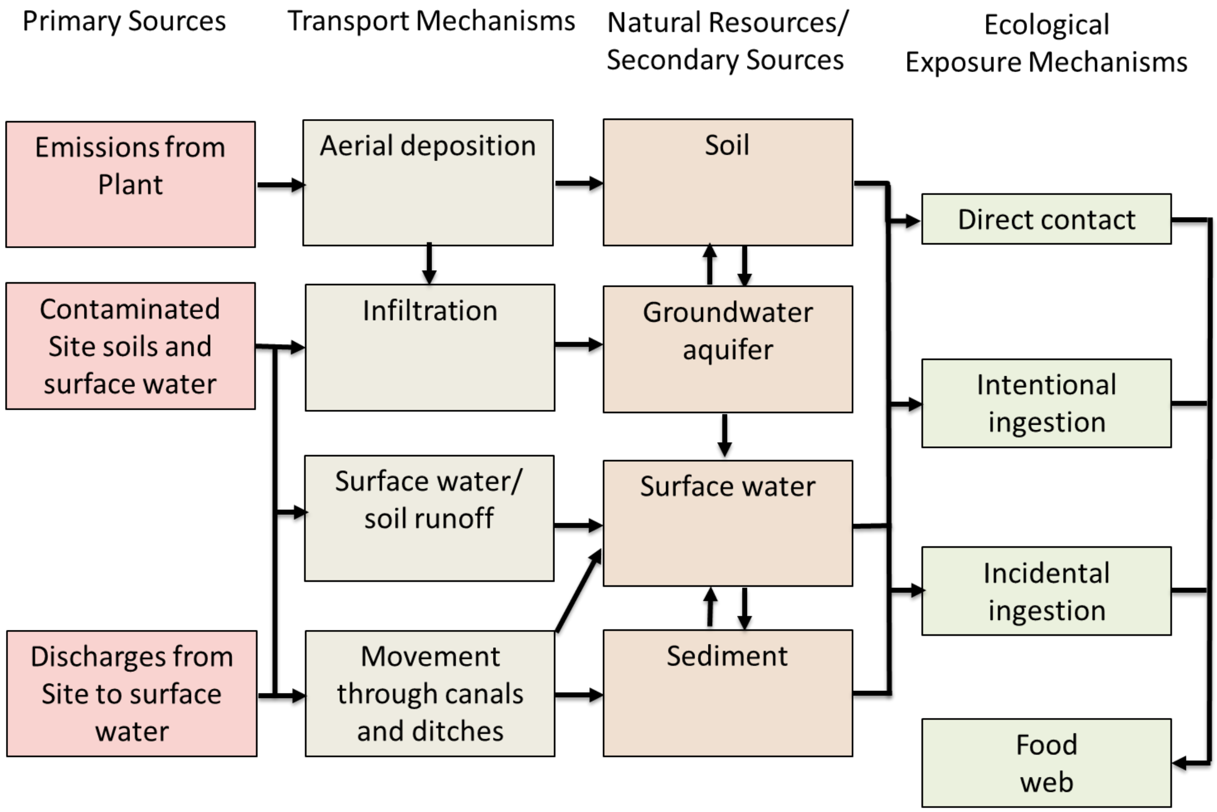
5.2 Pathway Evaluation

The regulations specify pathways through surface water [43 CFR § 11.63(b)], groundwater [43 CFR § 11.63(c)], air [43 CFR § 11.63(d)], geologic resources [43 CFR § 11.63(e)], and biological resources [43 CFR § 11.63(f)]. For example, a hazardous substance might move from a point of release to surface water, through groundwater, into the soil, and into a plant or the food web.

Pathways can be determined using a combination of information about the nature and transport mechanisms of the hazardous substances, potential pathways, and data documenting the presence of the hazardous substance in the pathway resource. Figure 5.1 shows the conceptual relationships between important pathways of exposure from releases at the Site to non-biological natural resources (i.e., soil, groundwater, surface water, and sediments) and subsequent exposure of ecological receptors.

Hazardous substances were released from the Site through air emissions and direct deposition to Site soils and surface water features. Hazardous substances then migrated to natural resources through a range of transport mechanisms, including aerial transport and deposition, infiltration into the ground, runoff of surface water and soil particles, and movement through canals and ditches. Interactions between these natural resources constitute secondary sources over time. For example, hazardous substances in surface water and sediment can interact through deposition, re-suspension, and chemical equilibration processes. Additionally, hazardous substances in groundwater can be transported over time and subsequently released to surface water (e.g., the OU3 RI indicates that the Lower Aquifer appears to be the source of water to shoreline seeps in Lake DePue) (Environ, 2014b). Biological organisms are then exposed to hazardous substances in soils, surface water, and sediments through a variety of pathways, including direct contact, intentional ingestion, and incidental ingestion (e.g., ingestion of soils on plants). Hazardous substances move through the food web as lower trophic-level organisms are consumed by higher trophic-level organisms.

Figure 5.1. Partial ecological conceptual model identifying primary and secondary sources of contamination at the Site with respective exposure routes to ecological receptors.



The pathway evaluation will focus on evaluating the extent to which hazardous substances in the assessment area can be attributed to releases of hazardous substances from Site sources. For example, the evaluation would examine the downstream migration of water and sediments through the South Ditch and deposition within Lake DePue. The pathway evaluation will be based on:

- Available information on releases of hazardous substances at the Site
- Spatial and temporal trends of hazardous substance concentrations in natural resources, including surface water and sediment, groundwater, floodplain soils, and biota.

5.3 Injury Determination

Section 4 confirmed that natural resources, including surface water, sediments, groundwater, soils, and biological resources, have been exposed to hazardous substances released from the Site. The assessment will determine the nature and extent of injuries to these resources, the restoration opportunities that could offset the losses caused by injuries, and the appropriate amount of restoration to make the public whole. The assessment may rely on a combination of metrics that address either the natural resources themselves, the ecological and human services that the natural resources provide, or the human values associated with the natural resources and their services.

This section provides the resource-specific injury definitions contained in the DOI regulations for conducting an NRDA. For each resource, the injury definition is followed by examples of injury determination methods, quantification methods, and relevant thresholds. In general, injuries in the assessment will be quantified in comparison to baseline conditions spatially and temporally, and compensation will be scaled based on the results of the injury assessment.

As noted previously, the Trustees may collect additional data to address data gaps. However, additional studies may not be necessary given the extensive ongoing RI/FS and related investigations, and the associated robust dataset. While the Trustees are obligated to assess all potential injuries and related service losses to natural resources held in public trust, and additional studies will not be ruled out prior to an assessment, such studies would only be necessary if the Trustees and PRPs are unable to resolve uncertainties regarding the extent of natural resource injuries.

5.3.1 Geological Resources

Geologic resources include soils, sediments, rocks, and minerals that are not included in the definitions of ground and surface water resources [43 CFR § 11.14(s)]. Services provided by soils include habitat for biological organisms, a growing media for plants, nutrient cycling, water storage and quality, and carbon storage.

Injury Definition

The relevant injury definitions for geologic resources include the following:

- Concentrations of substances sufficient to cause a toxic response to soil invertebrates [43 CFR § 11.62(e)(9)]
- Concentrations of substances sufficient to cause a phytotoxic response such as retardation of plant growth [43 CFR § 11.62(e)(10)]
- Concentrations of substances sufficient to have caused injury to surface water, groundwater, air, or biological resources, when exposed to geologic resources [43 CFR § 11.62(e)(11)].

Methods for Injury Determination

Potential injury determination methods for geological resources include the comparison of Site soil hazardous substances concentrations to reference concentrations, toxicity reference values (TRVs), or other thresholds for animals and plants (Table 5.1). TRVs are threshold values above which a contaminant is toxic to select biota. Injuries to soils will likely be evaluated using existing TRVs or other thresholds from the RI or the literature that indicate when hazardous substance concentrations in soils are sufficient to cause injury. Examples of TRVs for soil invertebrates and plants (the first two injury definitions above) may include ecological soil screening levels (Eco-SSLs) and other values indicative of toxicological effects in plants, invertebrates, birds, and wildlife. If necessary, the Trustees and/or the PRPs may fill data gaps by conducting additional studies, which could include the collection of soil samples for chemical analysis, field assessments of vegetation, and/or bioassays.

Table 5.1. Components of relevant geologic resource injury definitions and evaluation approaches

Injury definition	Definition components	Potential determination approach(es)
Soil invertebrates injured when exposed to soil [43 CFR § 11.62(e)(9)]	Soil invertebrates are injured when exposed to soil.	Compare concentrations in soils to thresholds for effects in soil invertebrates.
Phytotoxic response when exposed to soil [43 CFR § 11.62(e)(10)]	Plant survival or growth retarded when exposed to soil.	Compare concentrations of hazardous substances in soils to thresholds for effects in terrestrial plants. Compare vegetation community characteristics between assessment area and reference area.
Biological resources injured when exposed to soil [43 CFR § 11.62(e)(11)]	Biological resources are injured when exposed to soil.	Compare concentrations in soils to thresholds for effects in biota.
Surface water and groundwater resources injured when exposed to soil [43 CFR § 11.62(e)(11)]	Surface water and groundwater standards or criteria are exceeded.	Compare concentrations in surface water and groundwater to applicable standards and criteria.

5.3.2 Surface Water Resources

As discussed previously, surface water resources include both surface water and sediments suspended in water or lying on the bank, bed, or shoreline [43 CFR § 11.14(pp)].

Ecosystem services provided by surface water include habitat for migratory birds, fish, benthic macroinvertebrates, and aquatic, semi-aquatic, and amphibious animals; water, nutrients, and sediment transport to riparian vegetation; nutrient cycling; geochemical exchange processes; primary and secondary productivity and transport of energy (food) to downstream and downgradient organisms; growth media for aquatic and wetland plants; and a migration corridor. Human use services include drinking water, swimming, boating, industrial water supply, other water-based recreation, and assimilative capacity (i.e., the ability of a resource to "absorb low levels of [contaminants] without exceeding standards or without effects" [51 Fed. Reg. 27716, August 1, 1986]).

Ecosystem services provided by sediments include habitat for all biological resources that are dependent on associated aquatic habitats. In addition, sediments contribute to services provided by surface water, including suspended sediment transport processes, security cover for fish and their supporting ecosystems, primary and secondary productivity, geochemical exchange processes, and nutrient cycling and transport.

Injury Definition

The relevant definitions of injury to surface water resources include:

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411–1416 of the Safe Drinking Water Act (SDWA), or by other federal or state laws or regulations that establish such standards for drinking water, in surface water that was potable before the release [43 CFR § 11.62(b)(1)(i)].
- Concentrations and duration of hazardous substances in excess of applicable water quality criteria established by Section 304(a)(1) of the CWA, or by other federal or state laws or regulations that establish such criteria, in surface water that before the release met the criteria and is a committed use as habitat for aquatic life, water supply, or recreation [43 CFR § 11.62(b)(1)(iii)].

- Concentrations and duration of hazardous substances sufficient to have caused injury to groundwater, air, geologic, or biological resources, when exposed to surface water [43 CFR § 11.62(b)(1)(v)].

Methods for Injury Determination

Potential approaches to evaluate injury to surface water and sediment resources are provided in Table 5.2. The relevant injury thresholds for surface water in the assessment area may include hazardous substance concentrations in excess of the U.S. EPA aquatic life criteria (ALC; Section 304 of the CWA) and/or the Illinois aquatic life standards for surface water [35 Ill. Adm. Code 302].

Table 5.2. Components of relevant surface water and sediment resource injury definitions and evaluation approaches

Injury definition	Definition components	Potential determination approach
Surface water resources		
Water quality criteria exceedances [43 CFR § 11.62(b)(1)(iii)]	Surface waters are a committed use as aquatic life habitat, water supply, or recreation.	Determine whether assessment area water bodies have or had committed uses. Committed use means either a current public use, or a planned public use of a natural resource for which there is a documented legal, administrative, budgetary, or financial commitment established before the release of a hazardous substance is detected.
	Concentrations and duration of hazardous substances are in excess of applicable water quality criteria.	Compare surface water concentrations to state and federal water quality criteria.
	Criteria were not exceeded before release.	Compare conditions before the release, if data are available, or compare conditions at a carefully selected reference site, to state and federal water quality criteria or standards, to determine whether exceedances of criteria measured since the release are a result of the release.
Biological resources injured when exposed to surface water [43 CFR § 11.62(b)(1)(v)]	Biological resources are injured when exposed to surface water.	Determine whether biological resources have been injured as a result of exposure to surface water. For example, examine individual, population, and community level indicators for health of aquatic biota (e.g., abundance and diversity of fish or benthic invertebrates); consider potential effects on waterbirds and aquatic mammals. Evaluate results of site-specific toxicity testing studies.
Sediment (defined as a surface water resource)		
Biological resources injured when exposed to sediments [43 CFR §§ 11.62(b)(v); 11.62(e)(11)]	Biological resources are injured when exposed to sediments.	Compare sediment concentrations to adverse effect concentrations from peer-reviewed literature to determine whether biological resources exposed to the sediments are likely to be adversely affected.
		Determine whether sediment concentrations have caused an adverse change in benthic invertebrate communities. Compare indices such as benthic invertebrate diversity, abundance, and biomass to evaluate whether contaminants have altered baseline conditions. Evaluate results of site-specific toxicity testing studies.

ALC are expressed as acute and chronic criteria.[7] The acute criterion is an estimate of the highest concentration of a substance in surface water to which an aquatic community can be exposed briefly without an unacceptable effect. The chronic criterion is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without an unacceptable effect (63 FR 68364, December 10, 1998).

The toxicity of metals to aquatic species varies with water hardness and other factors that affect bioavailability. Water hardness is a measure of the concentration of calcium and magnesium present in the water and is expressed as milligrams of calcium carbonate ($CaCO_3$) per liter. Cadmium, copper, and zinc are more toxic to aquatic biota at low hardness than at higher hardness values. Freshwater criteria for cadmium and zinc are calculated using equations that take into account the hardness of the water. For copper, U.S. EPA uses a biotic ligand model that factors in 10 input parameters (temperature, pH, dissolved organic carbon, calcium, magnesium, sodium, potassium, sulfate, chloride, and alkalinity); however, Illinois EPA uses a hardness-based equation.

Ammonia freshwater criteria are pH, temperature, and life-stage dependent; and are expressed as total ammonia nitrogen. At a pH of 7, the acute criterion ranges from 7.3 mg/L at 30°C to 24 mg/L at 0°C, and the chronic criterion ranges from 0.99 mg/L at 30°C to 4.4 mg/L at 0°C [78 FR 52192].

Unlike for surface water, no national sediment quality criteria have been developed to establish contaminant concentrations that protect aquatic life. Various federal, state, and provincial agencies in North America have developed numerical sediment quality guidelines, and several groups have conducted sediment toxicity texts to assess the quality of freshwater and marine sediments. The sediment quality guidelines currently being used in North America have been developed using a variety of approaches. The approaches that have been selected by individual jurisdictions depend on the receptors considered, the degree of protection afforded, the geographic area to which the values are intended to apply, and the intended uses of the values.

MacDonald et al. (2000) assembled and published sediment quality guidelines for 28 chemical substances and classified them into 2 categories according to their original narrative intent: a threshold effect concentration (TEC) and a probable effect concentration (PEC). TECs are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms are not expected to occur. Data used to derive TECs include threshold effect levels, effects range low values, lowest effect levels, and minimal effect thresholds (Table 5.3). The PECs are intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are expected to occur frequently. Data used to derive PECs include probable effect levels, effect range median values, severe effect levels, and toxic effect thresholds (Table 5.4). The TEC (last row in Table 5.3) and the PEC (last row in Table 5.4) are consensus-based sediment quality guidelines based on the compilation of data from the other studies in the table. MacDonald et al. (2000) reported that the consensus-based PEC numbers for arsenic, cadmium, copper, nickel, and zinc correctly predicted sediment toxicity in 76.9%, 93.7%, 91.8%, 90.6%, and 90%, respectively, of 347 samples from freshwater systems in the United States.

7. The acute criteria are also known as Criterion Maximum Concentrations (CMCs) and the chronic criteria are also known as Criterion Continuous Concentrations (CCCs).

Table 5.3. Minimum toxic thresholds for freshwater sediment and the consensus-based TEC from MacDonald et al. (2000). Concentrations are in mg/kg dry weight.

Name	Definition	Basis	Cadmium	Copper	Lead	Zinc	Reference
Lowest effect level	Level that can be tolerated by the majority of benthic organisms	Field data on benthic communities	0.6	16	31	120	Persaud et al., 1991
Threshold effect level	Concentrations that are rarely associated with adverse biological effects	Compiled results of modeling, laboratory, and field studies on aquatic invertebrates and fish	0.596	35.7	35	123	Smith et al., 1996
Minimal effect threshold	Concentration at which minimal effects are observed on benthic organisms	Field data on benthic communities	0.9	28	42	150	Environment Canada, 1992
Effects range low value[a]	Concentration below which adverse effects would be rarely observed	Field data on benthic communities and spiked laboratory toxicity test data	5	70	35	120	Long and Morgan, 1991
Threshold effect level	Concentration below which adverse effects on survival or growth are expected to occur only rarely	Laboratory toxicity tests on the amphipod *Hyalella azteca* using field-collected sediment	0.58	28	37	98	U.S. EPA, 1996
Consensus TEC	Concentration below which adverse effects are expected to occur only rarely	Geometric mean of above published effect concentrations	0.99	31.6	35.8	121	MacDonald et al., 2000

a. Based on data from both freshwater and marine sites.

Table 5.4. Probable toxic thresholds for freshwater sediment and the consensus-based PEC from MacDonald et al. (2000). Concentrations are in mg/kg dry weight.

Name	Definition	Basis	Cadmium	Copper	Lead	Zinc	Reference
Severe effects level	Level at which pronounced disturbance of the sediment-dwelling community can be expected	Field data on benthic communities	10	110	250	820	Persaud et al., 1991
Probable effect level	Concentrations that are frequently associated with adverse effects	Compiled results of modeling, laboratory, and field studies on aquatic invertebrates and fish	3.53	197	91.3	315	Smith et al., 1996
Toxic effect threshold	Critical concentration above which major damage is done to benthic organisms	Field data on benthic communities	3	86	170	540	Environment Canada, 1992
Effects range median[a]	Concentration above which effects were frequently or always observed or predicted among most species	Field data on benthic communities and spiked laboratory toxicity test data	9	390	110	270	Long and Morgan, 1991

Table 5.4. Probable toxic thresholds for freshwater sediment and the consensus-based PEC from MacDonald et al. (2000). Concentrations are in mg/kg dry weight.

Name	Definition	Basis	Cadmium	Copper	Lead	Zinc	Reference
Probable effect level	Concentration above which adverse effects on survival or growth are expected to occur frequently	Laboratory toxicity tests on the amphipod *Hyalella azteca* using field-collected sediment	3.2	100	82	540	U.S. EPA, 1996
Consensus PEC	Concentration above which harmful effects on sediment-dwelling organisms were expected to occur frequently	Geometric mean of above published effect concentrations	4.98	149	128	459	MacDonald et al., 2000

a. Based on data from both freshwater and marine sites.

Comparison of sediment quality data to the consensus-based TECs and PECs will provide an initial means of evaluating injuries to sediment resources. In addition, benthic community composition data will be used to further assess sediment injuries.

5.3.3 Groundwater Resources

As discussed previously, groundwater resources include water beneath the surface of land or water and the rocks or sediment through which it moves, and include any groundwater that meets the definition of drinking water supplies [43 CFR § 11.14(t)]. Drinking water supplies are any raw or finished water sources that may be used by the public or by one or more individuals [43 CFR § 11.14(o)]. Groundwater provides a range of services, including providing a drinking water supply for people, other water uses by people, water storage and retention, recharge to surface water, near-surface water storage for habitats, and dilution and purification of contaminated water (Bergkamp and Cross, 2006). Groundwater also provides biodiversity and genetic resources, particularly in the form of microorganisms (Boulton et al., 2008).

Injury Definition

The relevant injury definitions for groundwater resources include:

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411–1416 of the SDWA, or by other federal or state laws or regulations that establish such standards for drinking water, in groundwater that was potable before the release [43 CFR § 11.62(c)(1)(i)].
- Concentrations and duration of hazardous substances sufficient to have caused injury to surface water, air, geologic, or biological resources, when exposed to groundwater [43 CFR § 11.62(c)(1)(iv)].

Methods for Injury Determination

Table 5.5 provides approaches that may be used to determine and quantify injury to groundwater resources. Methods for assessing injury to groundwater will focus on the review of available groundwater quality data, comparing hazardous substance concentrations to SDWA thresholds, Illinois Class I and II standards (Table 5.6), or other groundwater injury thresholds defined as a part of the assessment. Site groundwater concentrations will also be compared to baseline concentrations (see discussion of baseline conditions in Section 5.4). Groundwater resources exceeding these thresholds will be considered injured.

Table 5.5. Components of groundwater injury definitions and evaluation approaches

Injury definition	Definition components	Potential determination approach
Drinking water standards exceedances [43 CFR § 11.62(c)(1)(i)]	Concentrations and duration of hazardous substances are in excess of applicable drinking water standards.	Compare groundwater concentrations to state and federal standards.
	Water was potable before release.	Compare conditions before the release, upgradient of the release, or conditions in a carefully selected reference site to drinking water standards to determine whether the water met standards before the release.
Other resources injured when exposed to groundwater [43 CFR § 11.62(c)(1)(iv)]	Surface water resources are injured when exposed to groundwater.	Determine whether surface water has been injured as a result of exposure to groundwater. Compare surface water concentrations at seeps and springs to surface water quality criteria.

Table 5.6. Groundwater criteria and standards established for selected hazardous substances and products of hazardous substances

Source	Arsenic (µg/L)	Cadmium (µg/L)	Cobalt (mg/L)	Copper (µg/L)	Lead (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Sulfate (mg/L)	Vanadium (µg/L)	Zinc (mg/L)
SDWA Maximum Contaminant Level [40 CFR Part 141]	10	5	NA	1,300[a]	15[a]	NA	NA	NA	NA	NA
Illinois Class I (potable resource)	10	5	1.0	650	7.5	150	100	400	49	5
Illinois Class II (general resource)	200	50	1.0	NA	100	NA	NA	400	100	NA

a. Lead and copper are regulated by a “treatment technique” rather than a maximum contaminant level (MCL). These values are action levels above which systems must take steps to address the level of the contaminant in drinking water.

The groundwater injury evaluation may include identification of committed uses and potability of groundwater resources, examination of concentrations and duration of hazardous substances in groundwater, and identification of exceedances of state or federal drinking water standards. Depending on the quality and quantity of data available, concentrations of hazardous substances in groundwater will also be evaluated to determine the spatial extent of injuries, delineate vertical and horizontal distribution and movements of contaminant plumes, and determine if groundwater is a significant pathway of exposure to other natural resources.

5.3.4 Biological Resources

Biological resources include fish, wildlife, vegetation, and other biota. More specifically, biological resources relevant to the Site include freshwater aquatic species such as fish, shellfish, and aquatic plants; terrestrial species such as plants, birds, and wildlife; game, nongame, and commercial species; and threatened, endangered, and state-sensitive species [43 CFR § 11.14(f)]. Ecosystem services provided by fish, birds, and wildlife include prey for carnivorous and omnivorous wildlife, and nutrient and energy cycling. Human use services include various types of recreation (fishing, hunting, birdwatching) and food sources.

Injury Definition

The relevant injury definitions for biological resources include the following:

- Concentrations of substances sufficient to cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormality, cancer, genetic mutation, physiological malfunction (including malfunction in reproduction), or physical deformation [43 CFR § 11.62(f)(1)(i)]
- Concentrations of substances sufficient to exceed action or tolerance levels established under Section 402 of the Food, Drug and Cosmetic Act, 21 USC 342, in edible portions of organisms [43 CFR § 11.62(f)(1)(ii)]
- Concentrations of substances sufficient to exceed levels for which an appropriate state health agency has issued directives to limit or ban consumption of such organism [43 CFR § 11.62(f)(1)(iii)].

Methods for Injury Determination

Multiple methods may be used to determine injury in biological resources. Methods that could be employed include comparison of biological receptor tissue concentrations to applicable tissue-based TRVs, modeled dietary exposure to applicable TRVs, RI/FS ecological risk assessment findings, biological community conditions and densities compared to reference conditions, assessment of fish and wildlife consumption advisories, and results of bioassays. Relevant injury definitions and injury determination and quantification methods for biological resources are summarized in Table 5.7.

Table 5.7. Components of biological resource injury definitions and evaluation approaches

Injury definition	Definition components	Potential determination approach
Cause the biological resource or its offspring to have undergone adverse changes in viability [43 CFR § 11.62(f)(1)(i)]	Aquatic and terrestrial biota resources are injured when concentrations of hazardous substances are sufficient to cause changes in viability such as death, disease, behavioral abnormalities, physiological malfunctions, or physical deformation.	Compare surface water concentrations to criteria for the protection of aquatic life. Compare surface sediment concentrations to consensus-based sediment effect concentrations for benthic invertebrates. Evaluate population survey data to determine the degree of impairment of biotic communities using community indices, such as diversity, abundance, biomass, and pollution tolerance indices. Evaluate results of site-specific toxicity tests on biota exposed to assessment area surface water, sediment, soils, and/or diet. Evaluate dietary and tissue concentrations relative to concentrations known to cause death, disease, behavioral abnormalities, physiological malformations, or physical deformities.
	Vegetation resources are injured when concentrations of hazardous substances are sufficient to cause changes in viability such as death, disease, physiological malfunctions, or physical deformation.	Compare concentrations of hazardous substances in floodplain soils to thresholds for phytotoxic effects in terrestrial plants. Evaluate field vegetation survey data and aerial photographs to determine the degree of impairment of riparian vegetation.
Consumption advisories [43 CFR §§ 11.62(f)(1)(ii) and (iii)]	Consumption advisories issued or concentrations that exceed action or tolerance levels.	Evaluate basis of advisories; compare concentrations in organisms with action or tolerance levels.

5.3.5 Indirect Injuries

Trustees may recover damages resulting from natural resource injuries that are reasonably unavoidable as a result of response actions taken or anticipated. Therefore, when hazardous substance releases require response actions or changes in resource management that subsequently cause injuries, natural resource trustees may recover damages for those indirect injuries [43 CFR § 11.15(a)(1)].

The assessment will consider injuries caused by cleanup activities and corrective actions required by the response agencies to protect public welfare and the environment. In many cases, necessary cleanup such as dredging of sediments, soil removal, bank stabilization with hard materials, and capping can cause losses of natural resources and habitats and reduce services provided by the resources. Similarly, restrictions on the use of natural resources, such as limits on groundwater use or limits on dredging affecting Lake DePue use, can reduce the services provided by natural resources. Natural resource restoration will be also used to compensate for these losses of resources and services associated with indirect injuries.

5.4 Determination and Characterization of Baseline Conditions

Baseline refers to the conditions that would have existed had the releases of hazardous substances not occurred [43 CFR § 11.72(b)(1)]. The condition of the injured resources, or the services or values provided by the injured resources, will be compared to baseline conditions to estimate the amount of restoration, service replacement, or the value of offsets required. The regulations suggest using historical data to evaluate baseline conditions, if they are available [43 CFR § 11.72(c)]. Data from control or reference areas may also be used [43 CFR § 11.72(d)].

Baseline services can be affected by other factors that are not related to hazardous substances released from the Site, including but not limited to:

- Upstream Illinois River activities
- Transportation infrastructure
- Agriculture
- Municipal discharges
- Contaminants from nonpoint sources.

Control areas may be evaluated to ensure that they are appropriate in terms of relevant physical, chemical, biological, or socioeconomic conditions. Similarly, contaminant concentrations and consumption advisories will be evaluated to determine whether they are partially or wholly attributable to other causes.

The difference between natural resources, services, or values provided under baseline conditions and those provided under injured conditions can be used to calculate the natural resource damages incurred by the public. The assessment will quantify losses by evaluating how natural resources, services, or values that are normally available under baseline conditions have been or will be disrupted by the release [43 CFR § 11.71(b)].

5.5 Injury Quantification

The quantification of injuries will include an evaluation of the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries throughout the assessment area. To do so, the assessment will include an evaluation of historical and current contaminant data, historical records of the Site's history and releases, studies on toxicological impacts, and human use and enjoyment information. Spatial extent will be evaluated by considering the available information on injuries using geographic information system (GIS)-based spatial analysis tools, and interpolation techniques when appropriate. The quantification of spatial extent may also include three-dimensional estimates of the extent of injuries in groundwater, based on available information on the volume of affected groundwater.

The degree of injuries may be evaluated by considering the degree of exceedances of criteria or other thresholds that are protective of natural resources. Other indicators of injury such as changes in ecological health and viability may also be relied upon in determining the degree of injury.

5.5.1 Estimation of Recovery

A recovery period is defined as either the longest length of time required to return the services of the injured resource to their baseline condition, or a lesser period of time selected by the Trustees and documented in the Assessment Plan [43 CFR § 11.14(gg)]. This section provides a preliminary determination of the recovery period for exposed natural resources of the assessment area, based on existing literature and data. This preliminary determination can serve as a means of evaluating whether the approach proposed for assessing the injuries and damages is likely to be cost-effective [43 CFR § 11.31(a)(2)].

The following factors may be considered in estimating recovery times [43 CFR § 11.73(c)(2)]:

- Ecological succession patterns in the area
- Growth or reproductive patterns, life cycles, and ecological requirements of biological species involved, including their reaction or tolerance to the hazardous substance involved
- Bioaccumulation and extent of hazardous substances in the food chain
- Chemical, physical, and biological removal rates of the hazardous substance from the media involved.

The assessment area natural resources will remain exposed to hazardous substances as long as environmental media such as soils, sediments, groundwater, and surface water remain contaminated and continue to operate as exposure pathways. The RI process is ongoing and the final remedies for the Site have not been determined. However, complete recovery to baseline conditions (i.e., conditions that would be present absent the release of hazardous substances) may take decades. The complete recovery of ecosystem services after site remediation and habitat restoration often requires many years of flora and fauna growth. Also, the selected remedy for some injured habitats could be monitored natural attenuation. If so, complete recovery of those habitats to baseline conditions may also require many decades.

The assessment will evaluate further the likely recovery period of specific injured resources, services, or values to baseline levels. This evaluation will include an estimate of recovery time if no actions beyond the response actions previously implemented are taken; and estimates of recovery time for possible alternatives for restoration, rehabilitation, replacement, and/or acquisition of equivalent resources [43 CFR § 11.73].

6. Damage Determination

This section describes the proposed approach for conducting the damage determination. Section 6.1 provides an overview of the process, Section 6.2 discusses the equivalency analysis methods, and Section 6.3 discusses value-based methods. Section 6.4 describes an approach for restoration planning and Section 6.5 discusses the development of restoration alternatives and cost methods.

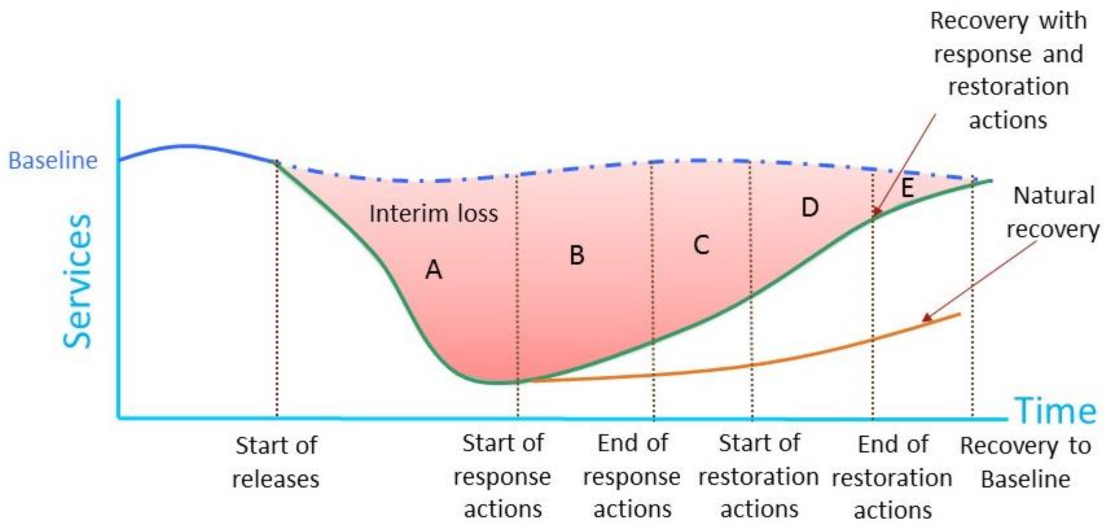
6.1 Overview of Damage Determination Process

Restoration actions can include actions to restore, rehabilitate, replace, or acquire the equivalent of the injured resources and services they provide [43 CFR § 11.80(b)]. Compensable values for interim losses are "the value of lost public use of the services provided by the injured resources" [43 CFR § 11.83(c)(1)] and can include both past losses and losses that will occur in the future until the injured resources and services are returned to baseline conditions. Thus, the total amount of NRDA damages includes both the cost of restoration to baseline conditions and the compensable values for interim losses. All recovered damages will be used for restoration actions and related services.

Compensable values of the injuries to natural resources and services lost to the public accrue from the time of discharge or release (or the enactment of CERCLA in December 1980, whichever is later) until the attainment of the restoration, replacement, and/or acquisition of the equivalent of the resources and their services to baseline conditions. *Interim losses* include all losses from the onset of injury (or December 1980) until resources return to baseline conditions. *Past damages* are those that accrue from the earliest point that injuries from releases can be determined, or authorization of the statute (e.g., December 1980), up to the present. *Future damages* are those that accrue from the present until the resource and its services are restored to baseline conditions. In the damage determination, existing information will be used, potentially supplemented by new Site-specific data collection efforts if deemed necessary, to assess compensable values for interim losses.

Figure 6.1 depicts how injuries (and lost services and values) accumulate over time for a hypothetical scenario. Losses accrue for as long as natural resources and services remain below baseline conditions. Thus, in Figure 6.1, the total losses are quantified as the present value of the sum of Areas A, B, C, D, and E. Area A represents unmitigated natural resource injuries that are worsening over time. Then, response actions are undertaken that may stabilize the site and begin to restore natural resources and the services they provide (Area B). The recovery of natural resources continues after response actions are completed (Area C). Subsequently, restoration activities (onsite or offsite) accelerate the recovery to baseline conditions (Area D). Finally, Area E represents any residual losses that may exist after restoration actions are completed until natural resources and services recover to baseline conditions. In this example, natural recovery, absent any response or restoration activities, would result in minor increases in lost services over time, but baseline service levels would never be achieved.

Figure 6.1. Timeline for natural resource injuries and lost services over time.



A variety of methods can be used to determine the amount of the restoration, the cost of the restoration, or the value of the restoration needed to return resources and services to baseline conditions and compensate the public for interim losses. The damage determination will quantify the link between the injury and pathway determination described previously in this Assessment Plan and necessary restoration.

Determination of damages will include the following:

- **Valuation of natural resources.** Cost estimation or valuation methodologies are used to estimate the value of the resources and/or services lost because of injury [43 CFR § 11.83].
- **Selection of alternatives for restoration**. Alternatives for potential restoration options to restore, rehabilitate, replace, and/or acquire the equivalent of the injured resources are developed and selected [43 CFR § 11.82].
- **Development of the RCDP**. The RCDP lists possible restoration alternatives and the methodologies for determining the costs of different alternatives and the compensable value of the services lost to the public [43 CFR § 11.81]. If existing data are insufficient for developing the RCDP when the Assessment Plan is published, it may be published separately after the injury assessment is completed [43 CFR § 11.81(c)].

The selection of restoration alternatives to compensate for natural resource injuries and service losses requires a means of ensuring that the scale of the restoration projects is commensurate with the amount of past and future injuries resulting from the hazardous substance releases. The Trustees have multiple options for determining damages, including restoration-based options (restoring the equivalent of what was injured) and value-based options (determining damages based on the value of the losses). The Trustees have included multiple alternatives in this Assessment Plan. For this NRDA, the Trustees intend to use a restoration-based approach to damage determination, specifically habitat equivalency analysis (HEA) and/or resource equivalency analysis (REA). The determination of the appropriate amount and type of restoration to compensate for natural resource injuries, as described in Section 6.2, will be conducted in cooperation with the PRPs. If there are additional human use services that are not adequately restored to baseline conditions, one of several economic value-based approaches may be used, as described in Section 6.3.

6.2 Equivalency Analyses

Equivalency analyses, including service-to-service (e.g., HEA) or resource-to-resource (e.g., REA) scaling approaches, entail the selection of restoration alternatives scaled such that services or resources of the same type, quality, and value as those lost to injury are provided by the selected restoration. The injury assessment provides the degree and spatial and temporal extent of resource service losses, and the HEA and REA models provide a method for determining equivalent restoration to offset the injuries.

6.2.1 HEA

Natural resource trustees frequently use HEA to determine the amount of restoration needed to compensate for losses of natural resources resulting from oil spills, hazardous substance releases, or physical injuries such as vessel groundings or construction impacts from remedial activities. Restoration is scaled so that the natural resource service gains provided at restored sites equal the cumulative service losses at the injured site (Allen et al., 2005; Cacela et al., 2005; NOAA, 2006). Thus, HEA is used to determine the amount of restoration that is required to compensate for past, current, and future (i.e., residual to any cleanup) injuries.

A benefit of HEA is that it explicitly creates a connection between services lost because of injury and services gained through restoration. The connection provides a clear demonstration to the public that the Trustees have fulfilled their mandate of compensating the public for the interim losses of natural resources and their services. The implicit assumption of HEA is that the public can be compensated with direct service-to-service scaling, where the services provided by proposed restoration actions are of similar type, quality, and value as the services lost because of the injury (Allen et al., 2005; NOAA, 2006).

HEA is based on the ecological and human use services that habitat provides. Because it is not possible to measure every service that habitats provide, certain quantifiable metrics will be selected to determine service loss from injuries and equivalent service gain from restoration. Metrics are sometimes based on biological data, such as the density of certain plants or animals; or toxicological data, such as the magnitude of exceedance of a toxic threshold. Appropriate metrics for evaluating service losses and gains will be determined with the assistance of IDNR ecologists and other experts.

Injuries and restoration actions typically occur over different timeframes. However, the value to the public of natural resources and services in the past is not equivalent to the value in the future. In HEA, future years are discounted, placing a lower value on benefits that take longer to accrue. Therefore additional restoration must be conducted when restoration is delayed. When scaling in HEA, a discount rate is used to ensure that injuries and restoration that occur at different points in time are compared on an equal basis.

The information required to quantify the habitat service loss (or HEA “debit”) includes (1) time periods of injury, including evaluation of the effect of response activities and scenarios for future losses, if necessary; (2) spatial extent of injury; (3) quantification of lost services (based on specific service metrics) over space and time compared to baseline conditions; and (4) a discount rate (typically 3% per year). Debits are commonly expressed in units that describe space, time, and the discount rate. For each year of injury to a habitat, the injured area is calculated (e.g., in acres), multiplied by the service loss (using the selected metric), and converted to a present value by applying the discount rate. This results in an estimate of habitat injury for each year in discounted service acres. Then the discounted service acres for all years are summed to calculate a single estimate of injury over time in discounted service acre-years (DSAYs).

The Trustees may include a damages claim for interim losses, from the time of the release (or December 1980, whichever is later) until the time that the injured resources recover to baseline conditions. The Trustees will need to estimate past, present, and future losses, based on current information. The scaling calculations will incorporate temporal information, including what level of service loss may have existed in the past, and how quickly the natural resources are expected to recover to baseline conditions in the future under different remediation scenarios. Past losses will be quantified starting when the release began or December 1980, whichever is later (for simplicity, we begin calculations in 1981). Future service losses are often highly uncertain, and thus the assessment may include evaluations of multiple remediation scenarios to estimate the duration of injury and the recovery to baseline conditions.

Quantifying habitat service gain (or HEA "credit") from restoration is similar to quantifying HEA debit, except that service increases from habitat restoration are estimated (using the same metric as used to calculate debit), rather than service losses from injuries. For each year of restored habitat services provided, the acres of restored habitat are multiplied by the service increase and the present value factor is based on a 3% annual discount rate. The discounted service acres of restored habitat per year are summed to provide a total estimate of service gains in units of DSAYs. The number of DSAYs of HEA debit should be offset by an equivalent number of DSAYs of habitat restoration credit.

6.2.2 REA

REA is based on balancing resources lost due to injury (debit) with resources gained due to restoration (credit). In most respects, it is identical to HEA. However, the units are different because the metric for scaling the injury debit and restoration credit is a specific resource (e.g., groundwater volume or birds) rather than a natural resource services metric that allows for scaling between injured and restored habitat. Thus, REA scales restoration on a resource-to-resource basis rather than a service-to-service basis.

The information required to quantify the resource loss or REA debit includes (1) time periods of losses encompassing past and future losses, (2) quantification of lost resources such as the number of organisms or volume of groundwater injured over time compared to baseline conditions, and (3) a discount rate (typically 3%). The calculation is typically the same as the HEA debit calculation, except that the injury is expressed in units that describe the amount of lost resource rather than acres of habitat. For example, if groundwater resources have been injured by releases of hazardous substances, REA debits might be calculated in units of "discounted acre-feet years" or "discounted gallon years."

Quantifying resource gain or REA credit is similar to quantifying HEA credit, where the metric is a resource gain rather than a habitat service gain based on a specific service metric. The credit incorporates the amount of the resource that is restored, the time period required for restoration, the increased resources provided over time, and a discount rate to express future resources in present-value terms. Using the groundwater example above, the number of discounted acre-feet years (or discounted gallon years) of groundwater resource loss is offset by an equivalent number of discounted acre-feet years (or discounted gallon years) of groundwater restoration.

6.3 Value-Based Methods

Value-based methods are often used when lost resources or services are not practically restorable. At this Site, natural resources in the assessment area provide human use services (e.g., recreational activities) that may not be adequately restored to baseline conditions through ecological restoration.

To assess lost human use on Lake DePue, the assessment may use one of several economic valuation approaches to value the full scope of the damages. The potential use of a benefits transfer (BT) approach, identified in the DOI regulations as the "unit value" method [43 CFR § 11.83(c)(2)(vi)], and contingent valuation (CV) approaches are described below.

6.3.1 BT Approach for Human Use Assessment

The dollar value of the lost human use may be assessed using a BT approach. BT is commonly used in economics, and is an accepted methodology under federal regulations [43 CFR § 11.83]. To conduct a BT, one applies dollar values from other sites and adjusts for site-specific factors. In an example of the potential loss of recreational activities, the lost human use may be evaluated in terms of reduced recreational trips to DePue to view or participate in various recreational activities. In this case, two main types of information/inputs would be required: (1) an estimate of the number of recreational trips that will be lost due to the lack of recreational opportunities or reduced quality of such opportunities, and (2) the value that people place on each trip.

The final step in conducting the BT is to combine the inputs described above. For each recreation activity, the number of lost days will be multiplied by the value per person per day, accounting for differences between the original study and the Site where feasible.

6.3.2 CV Approach

CV is a method for estimating the total value (use and nonuse values) of injured natural resources and the services they provide. CV uses carefully crafted surveys to elicit the monetary value of a resource as measured by what individuals would be willing to pay to return the natural resource and services to their uninjured state.

Fundamentally, all CV surveys have three components in common. First, they describe the problem. Then, they describe a solution. And, finally, they ask a valuation question where respondents choose whether or not they are willing to pay for the solution to solve the problem. The results of the survey would be used to estimate the collective willingness-to-pay (WTP) for the resource, which would then be used as a measure of the total value of that resource.

6.4 Restoration Planning

This section describes an approach to restoration planning to identify and select restoration projects that will compensate for injuries to natural resources and the services they provide. The information presented in this section describes the overall approach to restoration planning.

6.4.1 Planning Process

A plan will be developed for restoring injured resources and their services to baseline conditions, and for compensating for the interim losses that have occurred until the time that restoration to baseline conditions occurs. The plan will include a range of potential restoration alternatives to accomplish these goals, including actions to restore, rehabilitate, replace, and/or acquire the equivalent of the injured resources and services [43 CFR § 11.82(b)(1)]. Actions to replace or acquire the equivalent of the injured resources and services could include onsite or offsite habitat restoration or rehabilitation, or the purchase of vulnerable lands or conservation easements for resource protection and management. Additionally, actions may improve the management of a species, or to enhance human use or enjoyment of a resource, provided the actions do not cause collateral harm. Actions may also include primary restoration actions, which directly address injured resources beyond any actions taken by remedial actions, such as enhanced habitat restoration after removal of contaminated soils and sediments.

The restoration planning process will employ the following steps:

1. **Solicit ideas for potential projects**. The Trustees will solicit ideas for potential habitat restoration projects from the PRPs as part of the cooperative NRDA process, as well as from other people and organizations known to have an interest in habitat restoration in Illinois. Example organizations to be solicited may include state agencies such as the INHS and the Illinois Nature Preserves Commission; local organizations such as the Village of DePue; and groups such as The Wetlands Initiative, The Nature Conservancy, Ducks Unlimited, and the Audubon Society. Additionally, the Trustees will solicit ideas from the public.

2. **Develop evaluation factors to assess potential projects**. Factors will be developed to evaluate each restoration alternative. A list of potential evaluation factors to consider is included in Table 6.1. This list may be refined during the assessment.

3. **Evaluate potential restoration project suitability**. Restoration alternatives will be compared to the evaluation factors and ranked accordingly. Based on this ranking, preferred alternative(s) will be selected.

4. **Select an appropriate scale**. The appropriate scale of the selected alternative(s) will be determined as necessary to offset the damages.

6.4.2 Evaluation Factors

The DOI NRDA regulations discuss restoration project selection criteria for consideration when evaluating restoration alternatives [43 CFR § 11.82]:

1. Technical feasibility, meaning that the technology and management skills necessary are well-known and have a reasonable chance of successful completion.

2. The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources.

3. Cost-effectiveness, which incorporates a consideration of both cost and the level of benefits provided.

4. The results of any actual or planned response actions.
5. Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources.
6. The natural recovery period determined in 43 CFR § 11.73(a)(1).
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 state and federal policies.
10. Compliance with applicable state and federal laws.

Based on the above factors, Table 6.1 presents a more detailed list of potential restoration factors that will be considered when evaluating restoration alternatives.

6.5 Development of Restoration Alternatives and Cost Methods

Federal regulations at 43 CFR § 11.81 provide that the Trustees can prepare an RCDP as part of the Assessment Plan or during the assessment phase. The Trustees have discretion to follow 43 CFR Part 11 in an NRDA. For this cooperative assessment, the Trustees intend to focus on habitat restoration as compensation for natural resource injuries. As a result, the Trustees intend to develop the following aspects of an RCDP during the assessment phase:

- A reasonable number of alternatives for restoration, rehabilitation, replacement, or acquisition of equivalent resources; and the related services lost to the public associated with each
- Methods to be used to determine the cost of alternatives and the compensable value of services lost to the public.

In the event the cooperative NRDA fails, the Trustees retain the right to amend this strategy as deemed necessary.

7. Quality Assurance Plan

Any field studies conducted as a part of this NRDA will be conducted in accordance with the Quality Assurance Project Plans (QAPPs) developed for RI studies at the Site, for those sections of the QAPP that are applicable to the NRDA. These documents include the soil and groundwater QAPP (Golder Associates, 1999d), the Field Sampling Plan (FSP; Golder Associates, 1999b), the Health and Safety Plan (HASP; Golder Associates, 1999c), and the Data Management Plan (Golder Associates, 1999a). The work will also be consistent with more recent plan addenda such as those included in the Removal Action Limit Assessment Work Plan (BBL, 2005b) and other RI work plans (Environ, 2006a, 2006b, 2007, 2009b). These addenda include the FSP Addendum, the QAPP Addendum, and the HASP Addendum.

Table 6.1. Factors that may be considered when evaluating restoration alternatives

Factor	Interpretation
Complies with applicable/relevant federal, state, and local laws; regulations; and policies [43 CFR §§ 11.82(d)(9) and (10)]	• Project must be legal.
Protects public health and/or safety [43 CFR § 11.82(d)(8)]	• Project does not jeopardize public health and/or safety.
Is coordinated with planned response actions [43 CFR § 11.82(d)(4)]	• Project does not conflict with planned response actions and will not be undone or harmed by response actions.
Minimizes collateral injury [43 CFR § 11.82(d)(5)]	• Project does not cause additional natural resource injury, service loss, or environmental degradation; collateral injuries that may be caused by the project are minimal compared to the benefits achieved. Projects that avoid collateral injury will be given priority. • Project reduces exposure to hazardous substances and reduces the volume, mobility, and/or toxicity of hazardous substances. Projects may be ranked by degree of expected reductions of one or both of these factors.
Is acceptable to the public	• Project meets a minimum level of public acceptance and project is not a public nuisance. Degree of public acceptance/support can also be used as a criterion following an initial screen of projects.
Is technically feasible [43 CFR § 11.82(d)(1)]	• Project has a high likelihood of success. This factor will be evaluated in more depth for projects that are initially believed to be feasible. Preference will be given to reliable methods/technologies known to have a high probability of success. • Projects incorporating experimental methods, research, or unproven technologies may be deprioritized.
Restores, rehabilitates, and/or replaces habitats of injured resources (including groundwater); and the services that the habitats provide	• Projects may be evaluated based on the degree to which they restore, rehabilitate, and/or replace habitat for injured resources. Habitat protection/restoration may be a preferred means of restoring injured resources. • Projects may also include consideration of onsite resources and habitats.
Addresses in-kind habitat in the same watershed	• Project restores, rehabilitates, and/or replaces in-kind habitat in the same watershed. Acquiring the equivalent may also be a viable option.
Addresses habitat for which the PRP has no current liability and that will be protected from future hazardous substance releases	• Project restores habitat that does not contain hazardous substances for which the PRP is responsible. • Project restores habitat that is likely to provide the restored natural resource services in perpetuity.
Provides benefits not being provided by other restoration projects being or having the potential of being planned/implemented/funded under other programs	• Project will only be implemented with NRDA funding. Preference is given to projects that would not otherwise be implemented without NRDA restoration funds.
Addresses/incorporates restoration of "preferred" trust resources or services	• Project restores preferred specific habitats, species of special concern, living resources, native species, groundwater, etc. A list of priorities will be developed based on the resource types injured and the degree of injury.

Table 6.1. Factors that may be considered when evaluating restoration alternatives

Factor	Interpretation
Generates collateral benefits	• Project generates secondary or cascading benefits to ecological resources and economic benefits, such as enhancing the public's ability to use, enjoy, or benefit from the environment. • Project benefits more than one injured resource or service. Projects that benefit a single group or individual may be ranked lower.
Provides long-term benefits	• Project is persistent rather than short-term.
May be scaled to appropriate level of resource injury or loss	• Project can be scaled to provide restoration of appropriate magnitude. Small projects that provide only minimal benefit relative to lost injuries/services or overly large projects that cannot be appropriately reduced in scope are less favored.
Is consistent with regional planning	• Project does not conflict with regional planning (e.g., project supports species recovery plans); project is administratively feasible.
Is cost-effective [43 CFR §§ 11.82(d)(2) and (3)]	• Project has a high ratio of expected benefits to expected costs. This may be assessed as relative to other projects that benefit the same resource. Also applies to costs of long-term operation, maintenance, and monitoring.
Provides benefits sooner [43 CFR §§ 11.82(d)(6) and (7)]	• Project will achieve expected results sooner than resource would achieve the result through natural recovery (and remediation), and sooner than other projects that benefit the same resource. The sooner restoration is achieved, the better.
Targets a resource or service that is unable to recover to baseline conditions without restoration action, or that will require a long time to recover naturally (e.g., > 25 years) [43 CFR §§ 11.82(d)(6) and (7)]	• Project targets resources/services that will be slow to recover without active restoration. These projects will be favored over projects that target resources/services that will soon recover naturally.

In the event that additional studies are undertaken for which the RI/FS QAPPs and addenda are insufficient, an amended QAPP may be released as part of an amendment to this Assessment Plan, as specified in 43 CFR § 11.32(e). This QAPP will include the following components:

- Description of the team organization and responsibilities for project managers, reviewers, principal investigators, and field sampling team members
- Outline of data quality objectives and data quality indicators to ensure that data are sufficiently complete, comparable, representative, unbiased, and precise so as to be suitable for their intended uses
- Procedures and criteria for maintaining and documenting custody and traceability of environmental samples and data
- A consistent and documented set of QA/QC procedures for the preparation and analysis of samples and data.

8. Summary and Conclusions

This Assessment Plan was developed by the Trustees in accordance with the Type B procedures set forth in 43 CFR Part 11 to determine damages resulting from hazardous substances released from the Site. This Assessment Plan was prepared by the Trustees to guide a cooperative NRDA outlined by an FPA between the Trustees and the PRPs.

As outlined in Exhibit A of the 2016 FPA, the Trustee-prepared Preassessment Screen defined the basic elements of the Assessment Plan.

A review of existing data and other activities conducted at the Site, including characterizations and evaluations of habitat, flora and fauna, surface water, sediment and groundwater, including bioavailability assessments, is ongoing. These data have been and will continue to be used throughout the assessment phase as a basis for determining injury and damages, including identification of additional data needs for the injury assessment, if any.

This Assessment Plan identifies appropriate methods to establish the baseline services for the purpose of quantifying the identified exposure scenarios and injuries. Baseline conditions will be established in accordance with 43 CFR 11.72.

The information provided in this Assessment Plan will be utilized in the assessment to:

- Establish how acceptable biological injury criteria will be used to determine and quantify losses.
- Establish criteria for identifying potential restoration opportunities, linking requirements of the Assessment Plan (injury determination) to potential restoration projects (compensation).

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A. Data Sources

- Pre- and non-RI/FS studies
  - Gibb and Cartwright (1982) studied the impact of the secondary zinc smelter on water quality in 1982. They noted that a 40-foot-high pile of metal-rich cinders covered approximately 12 acres, and a 1- to 5-foot-thick layer of cinder fill covered the remaining 90 acres of the main plant complex.
  - Between 1975 and 1982, Cahill and Steele (1986) collected core samples of sediment in Lake DePue and Turner Lake.
  - Rapps collected nine sediment samples for metals analysis from Lake DePue from locations near the South Ditch in 1982 (BBL, 2005a).
  - Rapps collected 12 surface water samples for metals analysis from 11 Lake DePue sampling locations between 1988 and 1993 (BBL, 2005a).
  - In July 1998, the Illinois State Geological Survey (ISGS) and the Illinois State Water Survey (ISWS) conducted a Lake DePue surface water sampling survey to assess current conditions, as well as the effects of dredging (BBL, 2005a).
  - In 1992, Illinois EPA (1992) conducted an Expanded Site Inspection, which included sampling of groundwater, surface water, soil, sediment, and waste materials.
  - In February 1993, the U.S. EPA (1993) investigated the Site and collected surface water samples.
  - Between 1994 and 1996, the DePue Group conducted a perimeter air monitoring study to evaluate if airborne metals were being released offsite (Terra, 1996).
  - Between 1999 and 2007, several studies were completed on behalf of the Illinois Waste Management and Research Center on metals concentrations, the bioavailability of metals in the Dredge Spoil Disposal Area, and their impact on biological organisms, including:
    - Concentrations of metals in soil cores (Anderson et al., 2002)
    - Concentrations of metals in soil and groundwater (Kelly et al., 2003; Wehrmann et al., 2007)
    - Concentrations of metals in ducks (Levengood et al., 1999; Levengood, 2003; Levengood and Skowron, 2007)
    - Concentrations of metals in seeds (Levengood and Skowron, 2000)
    - Exposure and health of raccoons (Levengood et al., 2002)
    - Demographics, condition, and concentrations of metals in small mammals (Levengood et al., 2003).
  - In 2002, Cahill et al. (2008) collected sediment cores from backwater lakes, including Lake DePue.
  - In 2002, Cahill and Bogner (2002) collected additional sediment samples from Lake DePue and Turner Lake.

- In September 2004, ISGS collected soil probe samples from 10 locations in Lake DePue (Cahill, 2004).

- OU1
  - Between 1995 and 1997, the DePue Group conducted an RI/FS for the South Ditch, which included characterization of metals in “unnatural sediments” in the South Ditch and background locations (OU1; Golder Associates, 1997). See also a fact sheet (Illinois EPA, 1998) and the U.S. EPA ROD Summary (Illinois EPA, 2003).
- OU2
  - Beginning in 2000, the DePue Group conducted hydrogeologic investigations of the Phosphogypsum Stack (OU2; Terra, 2000, 2008, 2013), as well as groundwater flow and solute transport modeling (SDI and Terra, 2014).
  - In 2016 and 2017, the DePue Group collected pre-closure surface water and groundwater data in OU2 (2016 data are reported in Amec Foster Wheeler, 2017; 2017 data are not yet available).
- OU3
  - In 1999, the DePue Group began conducting an RI of the plant area (eventually, OU3). Golder Associates (2002) developed a Phase I RI report focused on soil and groundwater that incorporated earlier data reports from 2000 and 2002, as well as several addenda from 2001. Environ (2006c) developed a Phase I RI report, which included soil, surface water, sediment, air, solid waste, and groundwater chemistry data from multiple historical sampling events. This report was followed by a Phase II RI report in 2014 (Environ, 2014b).
  - In August 2014, the DePue Group conducted soil sampling in bluffs adjacent to the FPSA, called the Bluff Area, to support the human health and ecological risk assessments for the plant area (Environ, 2015a).
- OU4
  - In December 2013, the DePue Group conducted a pilot study to support decision-making for OU4, including sampling of 41 residential yards (Environ, 2014c). Subsequently, the DePue Group conducted an offsite soils investigation (OU4; Environ, 2015a).
- OU5
  - In 2005, the DePue Group began conducting an RI of Lake DePue (OU5), including evaluations of human health and ecological risks [Arcadis, 2009; also see the technical memoranda for sediment and biological organisms (Arcadis, 2007a, 2007b) and floodplain soils (BBL, 2007)].
  - Based on these sampling data, Arcadis (2012) developed a draft baseline ecological risk assessment for Lake DePue; Appendix F of this report included results from the sediment toxicity tests.
  - The DePue Group conducted sonde and grab sample surface water quality monitoring in Lake DePue and Goose Lake in 2014 (Arcadis, 2015).

- The DePue Group collected surface water samples from Lake DePue as part of the OU2 surface water sampling effort in 2016 (Amec Foster Wheeler, 2017).
- The DePue Group has conducted additional research on fingernail clams (Arcadis, 2017, 2018a, 2018b). In July 2017, the DePue Group conducted a survey of fingernail clams in Lake DePue, Goose Lake, and Senachwine Lake; and in August 2017, the DePue Group conducted an in-situ caged pilot study (Arcadis, 2018a). In 2018, the DePue Group conducted a 28-day in-situ caged bioassay study in Lake DePue, a reference lake (Goose Lake), and a control lake (Senachwine Lake). As part of the 2018 study, the DePue Group collected bathymetric survey data of Lake DePue.

- Background
  - In 2007, Arcadis (2011) collected samples of background soils to compare with RI data from OU3 and OU4.