

HANLIN-ALLIED-OLIN NATURAL RESOURCE DAMAGE ASSESSMENT DRAFT ASSESSMENT PLAN

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Prepared by:

United States Department of Interior
Fish and Wildlife Service

West Virginia
Department of Environmental Protection
And
Division of Natural Resources



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LIST OF ACRONYMS

BMI	Benthic Macroinvertebrate
BTAG	Biological Technical Advisory Group
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COCs	Contaminants of Concern
CSDGM	Content Standard for Digital Geospatial Metadata
DOI	United States Department of Interior
FGDC	Federal Geographic Data Committee
FS	Feasibility Study
HaBREM	Habitat-Based Resource Equivalency
HAO	Hanlin-Allied-Olin
HAOAA	Hanlin-Allied-Olin Assessment Area
HEA	Habitat Equivalency Analysis
IBI	Benthic Macroinvertebrate Biological Integrity Index
ISO	International Organization for Standardization
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRDAR	Natural Resource Damage Assessment and Restoration
ORINWR	Ohio River Island National Wildlife Refuge
ORSANCO	Ohio River Valley Water Sanitation Commission
PAS	Preassessment Screen
PCBs	Polychlorinated Biphenyls
PRPs	Potentially Responsible Parties
QA/QC	Quality Assurance/Quality Control
QAP	Quality Assurance Plan
RCRA	Resource Conservation and Recovery Act

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REA	Resource Equivalency Analysis
RI	Remedial Investigation
RM	River Mile
SWMU	Solid Waste Management Unit
USACE	United States Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VOCs	Volatile Organic Compounds
WVDEP	West Virginia Department of Environmental Protection
WVDNR	West Virginia Division of Natural Resources

1. INTRODUCTION AND BACKGROUND INFORMATION

The U.S. Department of the Interior (DOI), acting through the U.S. Fish and Wildlife Service (USFWS), and the State of West Virginia, acting through the Department of Environmental Protection (WVDEP) and the Division of Natural Resources (WVDNR) (collectively, the Trustees) are designated to act on behalf of the public as Trustees for natural resources (40 CFR §§ 300.600-605).

Natural resource trustees are authorized to pursue claims for natural resource damages under Section 107(f) of the Comprehensive Environmental Response, Compensation, and Liability Act as amended (CERCLA), 42 USC § 9607(f), and Section 311 of the Federal Water Pollution Control Act (also known as the Clean Water Act), as amended, 33 USC § 1321. The Trustees undertake this task when natural resources have been, or may have been, injured by releases of hazardous substances. The CERCLA Natural Resource Damage Assessment and Restoration (NRDAR) regulations (43 CFR Part 11) establish an administrative process for conducting a NRDAR to determine and quantify injury; determine the damages; and identify, select, and implement restoration to compensate the public for the injured natural resources and lost services.¹

While following these regulations is optional (43 CFR § 11.10), trustees who conduct an assessment consistent with these regulations are entitled by law to a rebuttable presumption in any subsequent litigation concerning the natural resource damages claim (42 USC § 9607(f)(2)(C); 43 CFR § 11.10). This Assessment Plan is one of the documents identified in the

¹ The term “*services*” is defined in 43 CFR § 11.14(nn) as the “physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource.”

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CERCLA NRDAR regulations. Its purpose is “to ensure that the assessment is performed in a planned and systematic manner and that methodologies selected...can be conducted at a reasonable cost” (43 CFR § 11.30(b)). The Trustees are making this Assessment Plan available for public comment, including comment by the Potentially Responsible Parties (PRPs), for a period of thirty days (43 CFR § 11.32(c)).

A. Description of the Assessment Area

The Hanlin-Allied-Olin (HAO) Superfund site (Figure 1) is located in Moundsville, West Virginia. The HAO Assessment Area (HAOAA) includes three broad geographical regions including: (1) the Hannibal Pool of the Ohio River; (2) the islands and floodplains included in the Ohio River Islands National Wildlife Refuge (ORINWR); and (3) HAO properties. Each of these areas are discussed in more details in the following sections.

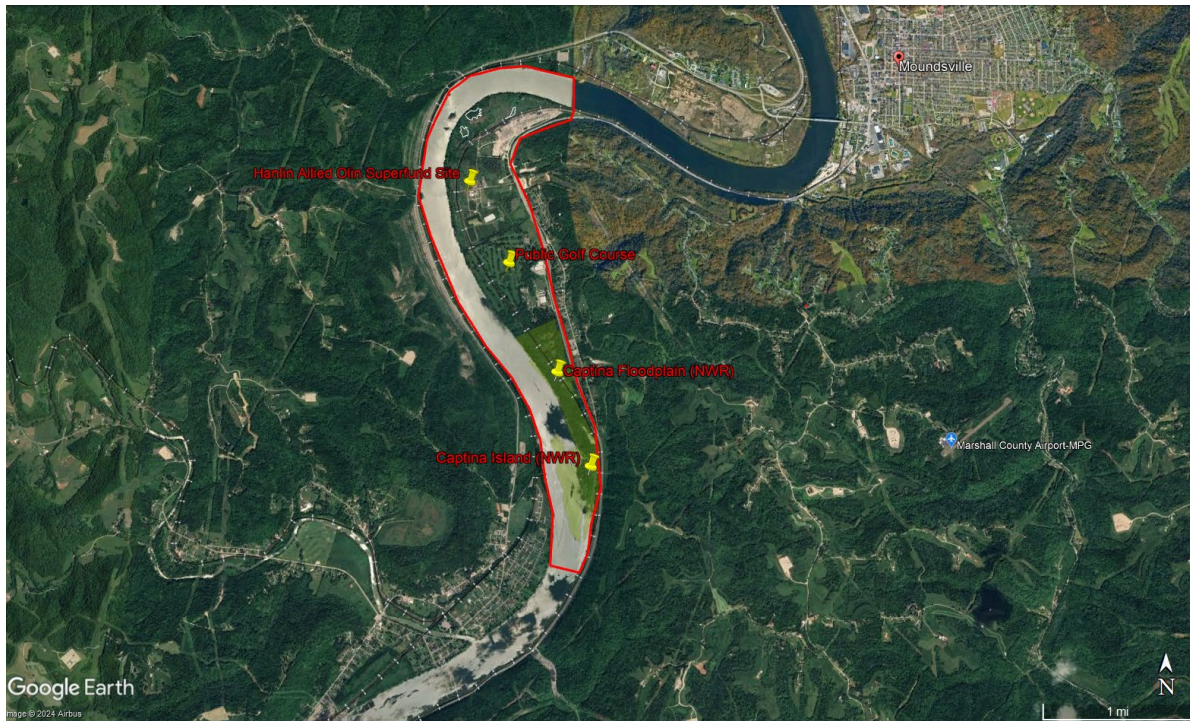


Figure 1 Hanlin-Allied-Olin Assessment Area (HAOAA; red polygon) including the HAO Superfund Site, Moundsville Country Club, two Ohio River Islands National Wildlife Refuge properties, and the adjacent reach of the Ohio River.

i. River System

Geographical location

The Ohio River begins at the confluence of the Allegheny and Monongahela Rivers in Pittsburgh, Pennsylvania, forms the border of West Virginia and Kentucky with Ohio, and ends at mile 981, at Cairo, Illinois. The HAO properties are within a reach of the Ohio River called Hannibal Pool which extends from Pike Island Lock and Dam at river mile (RM) 84.2 to the Hannibal Lock and Dam at RM 126.4. The HAO properties are located between RM 104 and RM 107 south of Moundsville, West Virginia.

Geomorphology

The Ohio River valley occupies a portion of the pre-glacial Teays River Valley, which drained a large portion of the east-central United States. The Teays system ended approximately 1.5 million years ago when the Laurentian ice sheet dammed the northern flow of the Ohio River. Scouring of the landscape by glaciers and damming of the Teays and its tributaries reorganized the drainages in the area and created substantial glacial lakes. Overflow of these glacial lakes carved new drainage basins and led to the formation of the Ohio River system. The Ohio River valley broadened and deepened during interglacial stages and filled with fluvio-glacial deposits throughout the Pleistocene resulting in its present course.

The Ohio River flows down a very gently sloping plateau consisting of almost horizontal sedimentary strata of sandstones, shales, and limestone. Deep alluvial deposits composed mainly of sand and gravel that can be as much as 125 feet thick in some areas cover the bed of the Ohio River. The islands formed from accretion of flood deposits. The base of all but two of the islands are composed of sand and gravel capped with sediments deposited by flooding. Most soils on floodplains and islands are fine sandy or silt loams of various drainage character.

Anthropogenic influences

Many human activities have affected the Ohio River including logging, damming for navigation purposes, and coal mining. Around the time of European settlement, a large majority of Ohio River watershed landscape was dominated by primeval forest. Immense contiguous tracts were only broken up by natural openings and boundaries such as tall grass prairie, wetlands, barrens, bogs etc. Forest types included hemlock-white pine coniferous, oak-hickory, beech-maple, mixed mesophytic, swamp, floodplain/riparian zone etc. Between 1800 and 1970, 65% of the floodplain forest had been lost or converted to agriculture, urbanization, or industrial development (USACE 2006). These activities substantially reduced vegetative cover and affected the hydrology of the watershed. Erosion and sedimentation increased due to increased surface runoff, and base flow decreased.

Anthropogenic changes within the channel converted it from a wide shallow river to a series of deep pools. In 1929, the channelization project finished installation of 51 wooden wicket dams and lock chambers along the length of the river. In the early 1950s, the Army Corps of Engineers began replacing the old structures with 20 modern locks and dams with higher lifts and much longer lock chambers.

Dredging is both navigational and commercial. The U.S. Army Corps of Engineers (USACE) performs periodic maintenance dredging in the channel to accommodate commercial shipping activity (USACE 2006). Commercial sand and gravel operations (instream and land-based) occur throughout the Ohio River. Gas, oil, and salt brine are also recovered from the underlying bedrock.

Hydrology

The average width of the Ohio River varies from 1100 to 1600 feet, while the average depth ranges from 19 to 26 feet. The Hannibal Pool is the sixth of twelve run-of-river impoundments

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managed by the USACE to maintain year-round navigation for commercial towboats and barges. The Hannibal Pool receives water from numerous tributaries, as well as discharges from towns and cities along the river. The primary tributaries are Wheeling Creek, McMahon Creek, and Grave Creek upstream of HAO and Captina Creek, Fish Creek, Sunfish Creek, Opossum Creek, and Proctor Creek downstream of HAO. The upstream cities of Wheeling (WV) and Moundsville (WV) along with the downstream towns of Powhatan Point (OH), Clarington (OH), Proctor (WV) and city of New Martinsville (WV) are located along the Ohio River.

Groundwater reaching the River comes from two major sources. Most of the groundwater immediately adjacent to the Ohio River discharges from the glacial deposits over which the Ohio River flows. The second source is the bedrock beneath the alluvial deposits and soils.

The immediate floodplain and all the islands have flooded numerous times, as evidenced by extensive sediment layers over their sand and gravel cores (USFWS 2002). However, the lock and dam system, as well as numerous tributary and headwater reservoirs have reduced the extent and frequency of flooding on the Ohio River (Figure 2). Islands and riparian lands continue to be affected by altered hydrologic regime. The consequence of a year-round elevated water table is that certain riparian areas do not go through a regular drying cycle reducing their ability to support many riparian tree species (USFWS 2002).

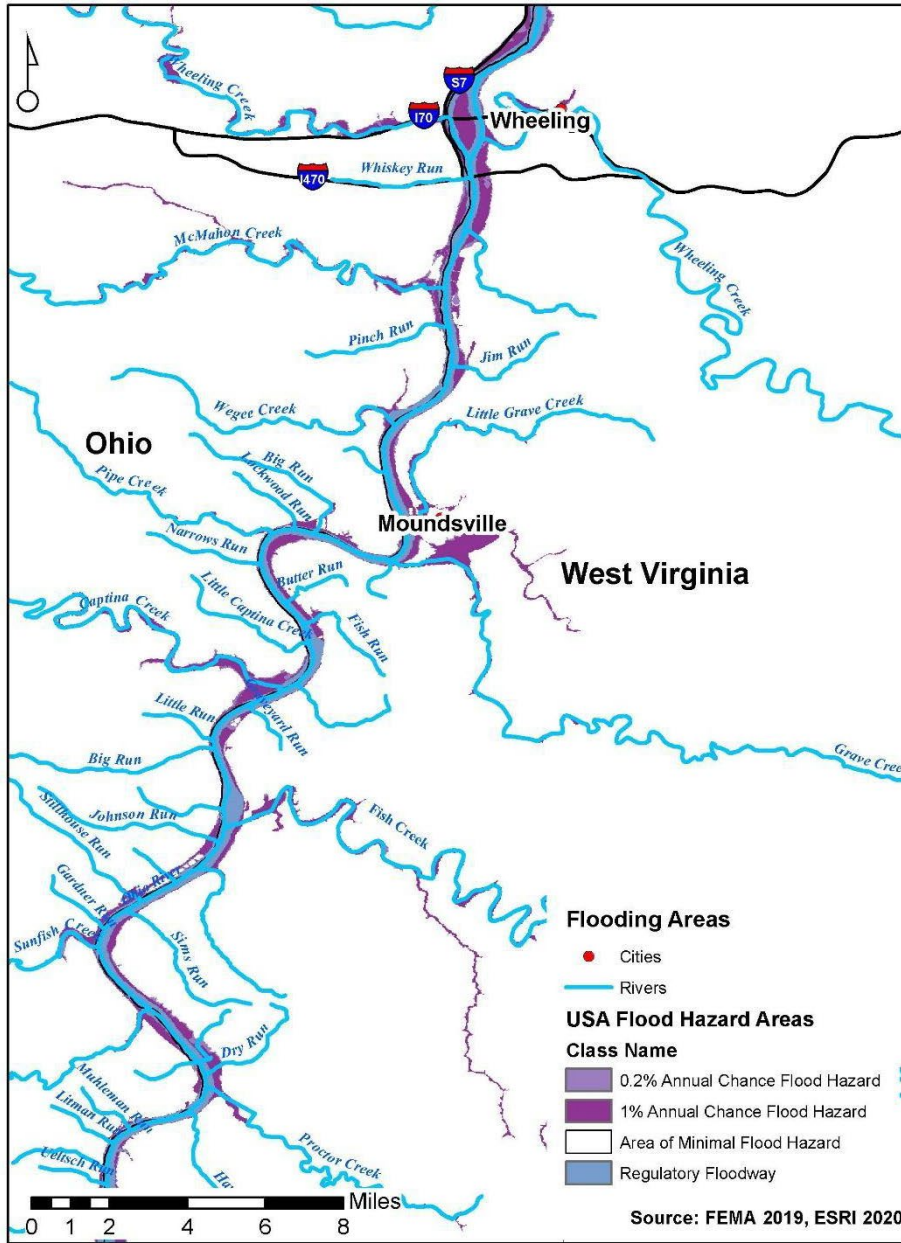


Figure 2 Map of the Hannibal Pool of the Ohio River and its 100-year floodplain.

ii. Ohio River Islands National Wildlife Refuge (ORINWR)

The ORINWR lands and waters begin at RM 35 and extend down to Manchester, OH at RM 397 (Figure 3). The ORINWR lies primarily within the Western Allegheny Plateau ecoregion. Extensive mixed mesophytic forests and mixed oak forests originally grew in the Western Allegheny Plateau. The altered hydrology has significantly affected the quality of both aquatic and terrestrial habitats. Many islands, shallow gravel bars, riffles, and channel wetlands have been lost and have been replaced by deep-water habitats (USFWS 2002). Because there is no longer any glacial transport of sand, gravel, cobble, and boulders which formed the islands, and because of the current navigation system, existing islands are irreplaceable. ORINWR

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boundaries extend down to the original low water mark prior to the construction of the navigation dams in all bordering states except Pennsylvania.



Figure 3 Map of the Ohio River showing the Ohio River Islands National Refuge properties in the Upper Reach.

ORINWR encompasses both terrestrial and aquatic habitats (Table 1). The terrestrial habitats on islands and floodplains include forest, shrub, grassland/old field, palustrine wetlands, riverine, and developed land (Table 2). The forest types are black willow riparian, box elder floodplain, central Appalachian Rich-Cove, Chestnut Oak-Shagbark Hickory-Sugar Maple, Silver Maple-Elm, Sycamore-Silver Maple, and Black Cherry. The shrub land is alder thicket or steplebush-blackberry. The grassland is bluestem, Central Appalachian Riverbank, or Old Field. Most soils on floodplains and islands are classified as fine sandy or silt loams (USFWS 2002).

Aquatic habitats associated with the islands and their back channels comprise less than one percent of the open water acreage of the Ohio River in the study reach. However, these areas provide some of the region's highest quality riverine, wetland, and bottomland habitats (USFWS 2002). Four riverine habitat types were identified within ORINWR, including water-willow rock bar and stone, riverine aquatic bed, riverine unconsolidated shore, and riverine unconsolidated bottom. The heads of the islands more closely resemble a natural riffle/run habitat which was a

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major characteristic of the Ohio River prior to impoundment (USFWS 2002). The backchannel habitats of the islands have a greater degree of protection from natural and human induced disturbances, such as erosive currents, wind, and commercial navigation. The deep and shallow water habitats associated with the islands are major fish and mussel production areas of the Ohio River (USFWS 2002).

The refuge is used by a variety of wildlife species and by humans for recreation. More than 231 species of birds, 41 species of mammals, 20 species of amphibians and reptiles, approximately 100 species of fish, 45 species of mollusk, and more than 100 species of insects have been observed. Popular public recreational activities include fishing, pleasure boating, water-skiing, beach use, wildlife observation, riverbank camping, hiking, swimming (with caution), and hunting (USFWS 2002). In 1993, fishing pressure for the river reach bordering Ohio was estimated at 2.5 million angler hours (Ohio Division of Natural Resources as cited in USFWS 2002).

Table 1 Acreage and location of Ohio River Island National Wildlife Refuge Properties.

Unit	Land Acres	Water Acres	USACE Navigation Pool	River Mile
Upper Twin Island	3.67	67.13	Hannibal	87
Wheeling Island	17.8	0	Hannibal	89.5
Captina Mainland	138	NA	Hannibal	107.5
Captina Island	17	61.4	Hannibal	108.5

Table 2 Captina Mainland and Island acreage by habitat type.

Unit	Riparian Forest & Shrub	Temperate Upland Forest	Oldfields & Grasslands	Open Water	Wetlands & Shorelines	Developed	Total
Captina Island & Mainland	75.33 acres	28.71 acres	19.96 acres	61.4 acres	3.59 acres	2.08 acres	191.06 acres

iii. HAO Properties

HAO is located in Marshall County, West Virginia, approximately three miles south of Moundsville (Figure 4). The approximately 382-acre site contains a former chlor-alkali manufacturing facility that released various contaminants, most notably mercury, into on-site floodplain soils, wetlands, and the adjacent Ohio River. Beginning in 1987, HAO was under investigation under the Resource Conservation and Recovery Act (RCRA). On June 22, 1999, HAO was listed on the National Priorities List (NPL) under the CERCLA. Releases of hazardous substances have impacted surface soils, subsurface soils, surface water, groundwater, and floodplains on HAO.

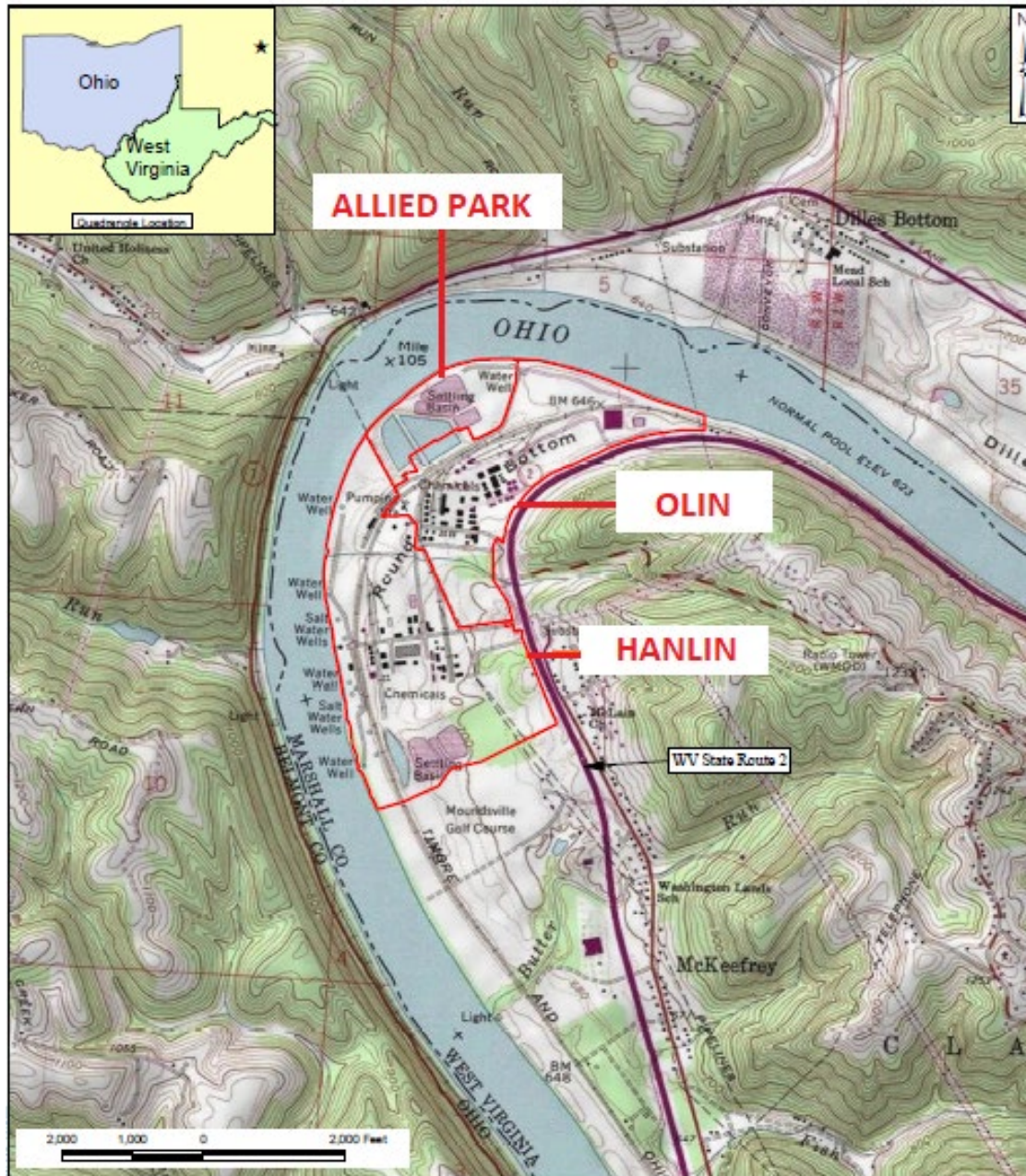


Figure 4 Map showing the HAO historic property boundaries, settling basins, ponds, and process buildings (Environ 2012a).

From 1953 to 1980, Allied Signal, Inc. operated the entire Site to produce various chemicals. In 1980, the southern portion of HAO was sold to LCP Chemicals-West Virginia. LCP Chemicals-West Virginia underwent a name change to become Hanlin Chemicals-West Virginia (Hanlin). In 1981, Allied Signal sold the northeast portion of its facility to Olin Corporation (Olin). Allied Signal retained the northwest portion of the site called Allied Park. In 1991, Hanlin Chemicals filed for Chapter 11 bankruptcy. In 2000, Allied Signal, Inc. also underwent a name change and merged with Honeywell International Inc. (Honeywell) and in 2001, Honeywell reacquired the

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Hanlin Area. Currently, the two viable PRPs identified at HAO are Olin Corporation and Honeywell International Inc.

HAO is divided into areas named after the historic ownership: Olin Corporation, Allied Signal Inc., and Hanlin Chemicals – West Virginia. The 44-acre Allied Park Area in the northwest portion of HAO contained several ponds and solid waste disposal units. No processing was conducted there, and the existing units have been closed under the United States Environmental Protection Agency (USEPA) Superfund Remedial Program.

The Olin Area consists of 137 acres in the northeast. At the Olin Area, the primary activities were the production of aniline, nitrobenzene, methylene dianiline, dinitrotoluene, toluenediamine, and toluene diisocyanate until production was shut down in 1984. Following the shutdown, Olin conducted a phased decommissioning of this area. By 1989, the equipment had been removed and all buildings demolished. The portion of the Olin Area outside of the floodplain has been redeveloped and now houses the Williams Energy Natural Gas Processing Facility. The floodplain portion is relatively flat with open fields, forested areas, and an emergent wetland. The area also contains water storage ponds and an USEPA-approved solid waste disposal unit.

The Hanlin Area consists of the 201-acre southern portion and was the location of the chlor-alkali (mercury cell) process to produce compounds including chlorine, sodium hydroxide, and hydrogen and chloromethane production. Using the chloralkali process, sodium hydroxide (50% caustic) and chlorine were produced via electrolytic mercury decomposition of saturated brine with subsequent purification of product streams. The production area was located within the mercury cell building and was operated from 1953 until 1991. The chloromethane process (CMP) areas comprise approximately six acres of the Hanlin-Allied Area. The process consisted of three main steps: (i) production of chloromethane gas from feedstocks of chlorine and methane, or sometimes methanol; (ii) reaction of the chloromethane with hydrochloric acid to produce a liquid referred to as crude product; and (iii) distillation of the crude product in series to produce dichloromethane (or methylene chloride), chloroform, and carbon tetrachloride. Dichloromethane, chloroform, and carbon tetrachloride were produced in continuous process distillation columns. By-products that formed from impurities in the original chlorine or methane/methanol feedstocks were accumulated in the bottom of the carbon tetrachloride column. By-products accumulated as a viscous liquid consisted of an acidic solution of chloroform, carbon tetrachloride, trichloroethene (TCE), tetrachloroethene (PCE), and other halogenated hydrocarbons. The summation of chloromethane, dichloromethane, chloroform, carbon tetrachloride, TCE and PCE is referred to as the CMP products or CMPs. Prior to the enactment of RCRA regulations, the waste was transferred through an unlined ditch to an unlined neutralization pond (SWMU F). Manufacturing operation in the Hanlin-Allied Area ceased in 1991.

Under a 2001 Administrative Order, Honeywell and Olin were charged with conducting a Remedial Investigation (RI) and Feasibility Study (FS) to address groundwater and soil contaminations. The RI to assess the risk of the remaining contaminated soils including those in the floodplain and wetlands has been completed. The FS for these soils is currently in progress.

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The groundwater and the Ohio River are part of a separate Operable Unit (OU2) which are currently being investigated.

B. Response Actions and Risk Assessments in the HAOAA

This section describes remedial and interim response actions, RI activities, removal actions, and risk assessments that have occurred and/or are underway in the HAOAA. HAO was originally under the jurisdiction of the state. In 1987, USEPA became involved in time-critical removal actions. In 1999, HAO was added to the NPL. Table 3 provides the chronology of agency actions and PRPs' responses.

Table 3 Summary of removal actions, interim response actions (IRAs), and CERCLA remedial actions conducted in the HAOAA.

Date	Actions	Reference
1981	Allied enters into Consent Decree with West Virginia Division of Water Resources requiring Allied to prevent migration of contaminated groundwater to offsite areas and to close some inactive disposal facilities.	Reviewed in USDHH, 1996
1987	Hanlin enters into Administrative Order (AO) by Consent with USEPA requiring Hanlin to perform corrective actions for releases of hazardous wastes in the Hanlin Area.	USEPA, 1987
1989	Hanlin enters into AO by Consent with USEPA requiring Hanlin to clean up of a sulfuric acid spill in the Hanlin Area.	USEPA, 1989
1994	Olin enters into AO by Consent with USEPA requiring Olin to perform an Engineering Evaluation/Cost Analysis in the Olin Area.	USEPA, 1994
1995	USEPA AO Consent Requires Allied to perform an Engineering Evaluation/Cost Analysis in the Hanlin and Allied Areas.	USEPA, 1995
1995	USEPA and Honeywell entered into an AO to evaluate the South Plant and the Allied Park Area.	USEPA, 1995
1997	USEPA entered into an AO with Olin to conduct a removal action (based on the findings of the earlier investigation).	GeoSyntec, 1998
2000	WVDEP issues order to Honeywell to prevent migration of contaminated groundwater and surface water.	WVDEP, 2000
2001	USEPA entered into an AO with Honeywell and Olin to conduct a RI/FS for groundwater and any soils that were not examined under other investigations.	GeoSyntec, 2001a GeoSyntec, 2001b
2002	Honeywell completes groundwater treatment facility required by WVDEP Order	WVDEP, 2000
2003	The South Plant and Allied Park Area investigation was completed.	USEPA, 2025
2003	USEPA entered into an AO with Honeywell to perform several tasks including: <ul style="list-style-type: none"> ○ Design and construct a hazardous waste landfill, consisting of a north and south cell, that complies with the hazardous waste regulations. ○ Excavate and consolidate waste material from several former land disposal units into the landfill. 	USEPA, 2003

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Date	Actions	Reference
	<ul style="list-style-type: none"> ○ Design and construct a soil vapor extraction (SVE) system to remediate contaminated subsurface soils in the former production area. 	
2008	Approximately 100,000 cubic yards of Olin Area contaminated soils were excavated and placed in the north cell of the new landfill.	GeoSyntec, 2010b
2009	Construction of the landfill for site-related wastes was completed.	GeoSyntec, 2010b
2009-2024	A SVE system was installed to treat contaminated subsurface soils in the former chloromethane production area.	GeoSyntec, 2010a
2010	Removal of soil, sediment, and wastes in Olin Area was completed as per EE/CA.	GeoSyntec, 2010b
2011	Removal of soil, sediment, and wastes in Hanlin and Allied Areas was completed as per EE/CA.	GeoSyntec, 2011
2018-2020	RI for groundwater and soils was approved in 2018, and the FS was completed and approved in 2020.	GeoSyntec, 2012a GeoSyntec, 2012b
2020	WVDEP provides USEPA with NPDES permit limits for mercury discharge from the Honeywell groundwater treatment plant.	USEPA, 2020
2021	USEPA issued ROD for OU1 which included an interim action for southern area alluvial groundwater and a final action for shallow soils, mercury cell building area and sewers.	USEPA, 2021

i. OU1 Ecological Risk Assessment

During the period of time-critical and non-time critical removal actions, no consideration was given to ecological risk. Removal action targets were based solely on human health. While not considered, sufficient data are available to determine historic injury. The first screening level ecological assessment (SLERA) was performed in 2011 (GeoSyntec 2012b). Risk from mercury and PCBs in remaining soils in multiple disposal and process areas were identified by USEPA based on the data. Following the SLERA, the PRPs undertook a mercury speciation investigation with the objective of demonstrating that the mercury had lower bioavailability which should be used to adjust the SLERA risk quotients. Based on both total mercury and speciated samples, human health risks drove the remedial goals for both mercury and PCBs with the exception of two areas in the floodplain of the Hanlin Area. These two areas were already encompassed in the OU1 excavation plan which adequately dealt with ecological risk of residual soils and sediments.

ii. OU2 Ecological Risk Assessment

The first investigations in the Ohio River along the site dealt with groundwater to porewater migration and surface sediment sampling. The PRPs modeled mercury flux from HAO to the river, islands and floodplains and relied on this model for their SLERA which was submitted in 2011 (GeoSyntec 2012b). This model was refuted by USEPA mercury scientists who insisted that sampling of floodplain soils, sediment, and biota were warranted to validate any model. PRPs insisted that mercury risks identified in the SLERA were attributable to atmospheric deposition from regional power plants. USEPA contracted with USGS Mercury Lab to perform

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stable isotope analysis of media and biota to establish mercury contribution from HAO. The study indicated that HAO mercury has a different signature from that of atmospheric deposition. Mercury is combined in terrestrial and aquatic biota, but percent attribution can be estimated using stable isotopes.

PRPs submitted a revised SLERA in 2022 which did not account for the USGS findings and concluded that a BERA was not warranted. USEPA developed a BERA Work Plan to sample biota in the river and soil on Captina Island, the refuge island immediately downstream of HAO. PRPs opted to complete only the benthic macroinvertebrate (BMI) survey portion of the BERA. In 2023, USEPA conducted the remainder of the BERA investigations. USEPA Region 3 Biological Technical Advisory Group (BTAG) is currently analyzing those data plus the BMI data and an USEPA BERA report will be prepared. Preliminary review indicates that soils on the refuge island are sufficiently contaminated to impair reproduction in birds based on food chain models. For the river, mussel and periphyton data demonstrate the mercury is migrating from the groundwater plume into porewater in addition to mercury being released from the treatment plant. Methylation proportions are high suggesting that periphyton are methylating the inorganic mercury in the porewater and surface water. USGS is currently analyzing snails that were feeding on periphyton. Food chain modeling in the BERA will be used to determine if injury is likely at upper trophic levels.

C. Purpose of the Assessment Plan

The purpose of this Assessment Plan is to describe the Trustees' approach for conducting a damage assessment in a cost-effective manner. This Assessment Plan outlines the Trustees' proposed approaches for determining and quantifying natural resource injuries and damages associated with those injuries which includes two primary components of a damages claim: 1) the cost to restore, rehabilitate, replace, and/or acquire equivalent resources for the injured resources, and 2) "compensable value," or the monetary value of the natural resource services that were lost pending the restoration of injured resources to their "baseline" condition. Baseline refers to the condition or conditions that would have existed at the assessment area had the discharge of hazardous substances under investigation not occurred (43 CFR § 11.14(e)).

Injury means a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource, resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance (43 CFR § 11.14(v)). Damages is a legal term for the amount of money sought by Trustees as compensation for injury, destruction, or loss of natural resources; damages include the costs of assessing injuries, as well as the costs of restoration (42 U.S.C. §§ 9601(6), 9607(a)(4)(C); 43 CFR § 11.14(l) and §11.15).

By developing an Assessment Plan, the Trustees ensure that the NRDAR will be completed at a reasonable cost relative to the magnitude of damages sought. The Trustees also intend for this Assessment Plan to communicate proposed assessment methodologies to the public, including the PRPs, so that these groups can productively participate in the assessment process.

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The Assessment Plan, as currently written, describes the Trustees' understanding of the studies and identifies other processes (e.g., data review and analysis) that may be needed to confirm exposure to the releases and quantify injury to natural resources and their services. Inclusion of a study within this Assessment Plan does not guarantee that it will be undertaken, and studies not included within the Assessment Plan may be deemed necessary at a later date. The Assessment Plan provides an initial prioritization of efforts the Trustees will take during the Injury Assessment process. Additional plans describing assessment studies, if any, will be tiered off this Assessment Plan, and made available for public comment prior to finalization.

D. Authority to Conduct a NRDAR

The NRDAR is being conducted jointly by the Trustees pursuant to their respective authorities and responsibilities as natural resource trustees. The Trustees have each been designated as a natural resource trustee pursuant to Section 107(f) of CERCLA, 42 USC § 9607(f); Section 311(f)(5) of the Clean Water Act, 33 USC § 1321(f)(5); and Subpart G of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR §§ 300.600 - 300.615.

Under these authorities, the Trustees act on behalf of the public to seek damages for the injury, loss, or destruction of natural resources belonging to, managed by, controlled by, or appertaining to West Virginia or the United States, that resulted from releases of hazardous substances. This authority includes implementing a NRDAR to evaluate the injury, loss, or destruction of natural resources and their services due to releases of hazardous substances.

Pursuant to the NCP at 40 CFR § 300.605, state trustees "shall act on behalf of the public as trustees for natural resources, including their supporting ecosystems, within the boundary of the state or belonging to, managed by, controlled by or appertaining to such state." The HAO plant and surrounding area are within the boundaries of the State of West Virginia, and the Ohio River is waters of the State of West Virginia. The governor of a state may designate state trustee agencies. The Directors of the WVDEP and the WVDNR have been designated as natural resource trustees for the State of West Virginia, pursuant to Section 107(f)(2)(B) of CERCLA.

The President has designated federal resource trustees in the NCP (40 CFR § 300.600) and through Executive Order 12580, dated January 23, 1987, as amended by Executive Order 13016, dated August 28, 1996. Pursuant to the NCP, the Secretary of the DOI acts as a Trustee for natural resources and their supporting ecosystems, managed or controlled by the DOI. In this matter, the USFWS is acting on behalf of the Secretary of the DOI as Trustee for natural resources under its jurisdiction, including but not limited to migratory birds and endangered and threatened species and their habitats, and the ORINWR.

The Trustees decided to proceed with this NRDAR based on the results of a PAS dated December 2018 (Natural Resource Trustees 2018); (43 CFR §§ 11.23-11.25). A copy of the preassessment screen and determination is posted on the WVDEP, WVDNR, and USFWS websites.

In the PAS, the Trustees determined:

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- A discharge of oil and/or a release(s) of a hazardous substance occurred;
- Natural resources the Trustees may assert trusteeship under CERCLA have been or are likely to have been adversely affected by the release;
- The quantity and concentration of the discharged oil or released hazardous substance is sufficient to potentially cause injury to natural resources;
- Data sufficient to pursue an assessment are readily available or likely to be obtained at a reasonable cost; and
- Corrective action carried out or planned do not or will not sufficiently remedy injury to natural resources without further action.

The Trustees therefore concluded that all preassessment screening criteria were met, natural resources over which Trustees may assert trusteeship have been or may have been impacted, and several viable PRPs have been identified.

E. NRDAR Process Overview

It is the intent of the Trustees to conduct the HAO NRDAR consistent with the CERCLA NRDAR regulations at 43 CFR Part 11. These regulations describe the process by which Trustees may conduct a NRDAR. This process includes the following three phases:

- Preassessment,
- Assessment (including the Assessment Plan, injury determination, quantification, and damages determination phases), and
- Post-Assessment (i.e., damages recovery and restoration planning and implementation).

To date, as noted above, the Trustees have completed the Preassessment Phase. The following administrative and preassessment planning documentation is available on the DOI NRDAR Damage Assessment and Restoration Tracking System website for the HAO Superfund Site.

- Notice of Intent. The Trustees sent a notice of intent (Natural Resource Trustees 2019) to initiate a NRDAR to PRPs on June 10, 2019 (43 CFR § 11.32(a)(2)(iii)(A)-(B)).
- Preassessment Screen and Determination. The Trustees finalized a PAS on October 25, 2018, which provided the basis for the Trustees' determination that further investigation was warranted based on review of readily available information of the effects of releases associated with HAO (Natural Resource Trustees 2018).

The Trustees are now in the Assessment Phase, which may include, as necessary:

- Assessment Plan Phase (43 CFR §§ 11.30 - 11.38),
- Injury Determination Phase, including pathway determination (43 CFR §§ 11.61-11.70),
- Quantification Phase, including baseline services determination and resource recoverability analyses (43 CFR §§ 11.70-11.73), and
- Damages Determination Phase (43 CFR §§ 11.80-11.84).

F. Identification of the Potentially Responsible Parties (PRPs)

Honeywell International, Inc. (Honeywell) and Olin Corporation (Olin) have each been identified as a potentially responsible party for HAO.

The Trustees have invited, and will continue to encourage, the active participation of the PRPs in the implementation of this damage assessment. It is the intention of the Trustees to work cooperatively with PRPs at each stage of the assessment and to take advantage of the expertise that PRPs may be able to provide.

G. Coordination with Other Activities

The CERCLA NRDAR regulations support, to the extent possible, the coordination of a damage assessment with other investigations being performed pursuant to the NCP (i.e., cleanup activities). Consistent with 43 CFR § 11.31(a)(3), the Trustees recognize the benefit of coordinating assessment activities associated with sites that may have significant contaminants of potential concern. Integration of Trustee considerations into remedial activities may resolve certain natural resource damages liability or decrease the cost of assessment activities.

The Trustees intend to continue to coordinate with the remedial activities for HAO. Trustee assessment activities discussed in this Assessment Plan make use of existing data generated through the remediation process, and other research and data collection efforts.

Coordination among the Trustees is also an essential component of a cost-effective damage assessment. 43 CFR § 11.34(a)(4). The Trustees signed a Letter of Understanding in 2019 listing the USFWS as the Lead Administrative Trustee.

H. Public Participation

Public participation is an important part of the NRDAR process. To that end, the Trustees will make this Assessment Plan available to the public, including the PRPs, for review and comment for a minimum thirty-day period (43 CFR § 11(c)). The Trustees will review and consider all public comments and input on the Assessment Plan received during the public comment period prior to finalizing the Assessment Plan. The Trustees will prepare a responsiveness summary to the comments that will be included as an Appendix to the final version of this Assessment Plan.. Any comments received by the Trustees, together with responses to those comments, will be included in the report of assessment. Comments on this Assessment Plan may be submitted in writing to:

Carrie Blakeslee, Lead Administrative Trustee
carrie_blakeslee@fws.gov
U.S. Fish and Wildlife Service
110 Radnor Road, Suite 101
State College, PA 16801

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Development of the Assessment Plan, the public comment process, and finalization of the Assessment Plan is performed solely by the Trustees. Based on the public's comments or other information, the Trustees may modify the Assessment Plan at any time. In the event of a significant modification, the Trustees will provide the public with an opportunity to comment on that amendment (43 CFR § 11.32(e)).

I. Timeline

The activities in this plan are expected to take a reasonable amount of time to accomplish. If new information becomes available as this assessment progresses, and additional studies are deemed warranted, updates to this Assessment Plan and the timeline will be made publicly available.

2. ASSESSMENT AREA

Assessment Area is defined as:

The area or areas within which natural resources have been affected directly or indirectly by the discharge of oil or release of a hazardous substance and that serves as the geographic basis for the injury assessment (43 CFR § 11.14(c)).

As mentioned above, the HAOAA includes the location of released hazardous substances and oil included in the Hannibal Pool of the Ohio River, the islands and floodplains included in the ORINWR, and HAO properties. HAO has been occupied by a series of companies using various chemical processes. As a consequence, a wide range of hazardous substances, many in very large quantities, have been released into the environment for more than 60 years. Many of those releases occurred without careful waste minimization or disposal, particularly before the 1980s. Therefore, past releases are critically important to a complete and accurate assessment of natural resource damages, both to address the era when hazardous substance releases and environmental concentrations were greatest, and to address persistent toxins. However, only injuries occurring after December 11, 1980, the enactment of CERCLA may be considered.

Hazardous substances released from the facilities have been the focus of removal and remedial activities within the HAOAA and are the focus of this NRDAR. Some of these substances are distributed in sediments and soils in the assessment area and may accumulate in biota. They may further be re-released and transported as the sediments, soils, and biota move in the environment.

A. Summary of Releases

As described above, Honeywell was responsible for the contamination at the South Plant (Hanlin Area) and northwest portion of North Plant (Allied Area), while Olin's responsibility for remediation was limited the northeast portion of the North Plant (Olin Area).

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i. Allied Areas and Olin Area (North Plant)

Historical industrial activity in the Olin Area occurred predominantly in the Process Area and to a lesser extent in the Northeastern Area. Allied Signal's primary chemical production activities in the Olin Area were the production of aniline and nitrobenzene, starting in 1953, and methylene dianiline (MDA), dinitrotoluene (DNT), diaminotoluene (TDA), and toluene diisocyanate (TDI) starting in 1956. Allied Signal stopped the manufacture and storage of aniline and nitrobenzene in 1973. Other processes included the production of fumaric acid, phosgene, maleic acid, and malic acid (EarthTech 1996). Production occurred in an approximately 3-acre area in the central portion of the Process Area. The fumaric/maleic/malic acid production area included former Tank Park Number 3.

In 1981, Olin purchased a portion of HAO, the 137-acre Olin Area, and operated the MDA/DNT/TDA/TDI area of the facility until the fall of 1984. Production of these chemicals occurred in an approximately 15-acre area located in the northeast end of the Process Area. The MDA/DNT/TDA/TDI area included former Tank Park Numbers 5, 6, 8, and 9 where raw waste and final materials were stored.

The Equalization and Settling Ponds were built by Allied Signal in 1977 in the northwestern portion of the Process Area. These ponds were used for wastewater treatment during North Plant operation. RCRA clean closure of the Equalization Pond was completed in 1986, and closure of the Settling Pond was also completed in 1986 as part of Olin's decommissioning efforts. For both ponds, the EPDM liner and related systems were removed, and the ponds filled with soil from the dike walls and soil from the Grove's Pile as needed (EarthTech 1996).

Process and sanitary sewers were formerly associated with Allied Signal's various production activities over the course of nearly 30 years of production. In 1985, the sewer system terminated at the equalization and settling ponds, which ultimately discharged through National Pollutant Discharge Elimination System (NPDES) permitted Outfall 004 to the Ohio River. In 1986, the equalization pond and the settling basin were clean closed. The sewer system discharge was routed directly to the NPDES outfall 004. In 1987, a temporary waste treatment plant was constructed on site and final effluent discharge to the NPDES outfall 004. At the conclusion of the decontamination effort, all process collection sumps, including floor drains, which were part of the sewer system, were filled with concrete. During the plant closure period, there were no known releases from the sewer system. Pumping of Ranney Well E was discontinued 29 November 2002. (GeoSyntec 2005).

ii. Hanlin Area (South Plant)

From approximately 1953 to 1991, the mercury cell chlor-alkali plant released hazardous substances, including mercury, into the Ohio River and its riparian areas. Metallic liquid mercury was used in the cell building as part of the chloralkali process. Mercury was lost during the process in the following ways: (i) through leaks and minor spills in the mercury cell building; (ii) during the purification of depleted process brines; (iii) as an impurity in the caustic brine solution and hydrogen; (iv) and fugitive emissions of mercury vapors via cell room ventilation. Other

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process related areas that could potentially serve as sources of mercury contamination include the caustic storage area sludge, the stabilization ponds prior to liner placement (Solid Waste Management Unit [SWMU] J), a mercury trap located outside of the cell building, and metering stations associated with the hydrogen line.

During Site operations, wastewater containing mercury was discharged into the Ohio River from an outfall near RM 106. LCP Chemicals-West Virginia, Inc. discharged mercury into the Ohio River above permitted levels of mercury once in 1981, twice in 1982, and once in 1990. Original limits were set at 0.25 lbs. per day which expired in 1990. Until 2000, the companies continued to discharge water contaminated by hazardous substances into the Ohio River in excess of Clean Water Act and State Water Pollution Control Act requirements (WVDEP Order 4330, 2000). In August 2000, Honeywell signed WVDEP Order 4330 which required installation of a wastewater treatment plant to remove a minimum of 90% of organic and inorganic contaminants. The treatment plant functioned under this WVDEP Order without numeric discharge limits, reporting against expired NPDES permit limits, for mercury to protect aquatic resources and prevent risk to upper trophic level consumers of aquatic prey until 2021 when USEPA issued the OUI Record of Decision. In support of providing substantive requirements pursuant to a request from USEPA, WVDEP provided USEPA with discharge limits consistent with NPDES requirements. Discharge Monitoring Reports, which contain analytical data for mercury analysis of plant effluent, indicate that mercury effluent concentrations continue to consistently exceed the discharge limits identified as substantive requirements above.

USEPA and WVDEP investigations conducted at HAO revealed that on-site soils were contaminated with mercury from releases during plant operations. The areas around the former mercury cell building had the highest concentration of contaminated soils. Pursuant to a 1995 Administrative Order of Consent between the USEPA and Allied Signal (now Honeywell), the Hanlin and Allied Park Areas underwent various decommissioning and demolition activities, including contaminated soil consolidation into capped waste management units. HAO was flooded three times during this period; in 1996, 2004, and 2005. Floodwaters likely carried contaminated soils from HAO into the Ohio River.

iii. Waste Management

Historical waste management practices allowed large releases of hazardous substances, both those manufactured as products and those that were produced as waste. Soil was contaminated from processing and waste disposal. Soil to groundwater migration resulted in alluvial and bedrock groundwater contamination. The Ohio River received contaminated groundwater discharged via the Ranney wells, without treatment (ATSDR 1998). The discharge was contaminated with various organic and inorganic chemicals including, but not limited to: carbon tetrachloride, chloroform, manganese, methylene chloride, sulfates, and tetrachloroethylene. Analysis of select river sediment samples showed that sediments immediately downstream of the Ranney well outfalls had elevated levels of mercury when compared with samples taken upstream of the Ranney well outfalls.

Olin

Other than two settling ponds, no waste disposal areas were present on the Olin property. After acquiring the property, Olin continued to use the former Allied disposal areas.

Hanlin-Allied Area

The Hanlin-Allied Area contains 27 SWMUs. The SWMUs consist of tank and drum storage areas, process related surface impoundments, and disposal areas. Both lined and unlined SWMUs are present in the Hanlin-Allied Area. Initial background information related to the individual SWMUs was acquired through interviews with plant employees, review of plant records, and research using historical site-related documents. Background information was supplemented and verified through site characterization work involving soil test borings and laboratory testing. Table 4 summarizes the information including history, waste, and closure status for the SWMUs.

Table 4 Waste Characterization at Solid Waste Management Units (SWMUs) for the Hanlin and Allied Operations.

Area	SWMU	Description	History & Waste Characterization
Hanlin	A1	In-Plant Tank Storage	Two tanks used to stoic spent sulfuric acid. On December 26, 1989, approximately 1,500 to 2,000 gallons of sulfuric acid were released. Remediation included neutralization.
Hanlin	A2	North Tank Storage Area	In June 1989, approximately 250,000 gallons of spent sulfuric acid were released through a leaking tank. Remediation included partial neutralization.
Hanlin	B	Former Drum Storage Area	Warehouse that was used to store drums of CMP dryer residue, CMP sludge, and mercury-containing SWMU material.
Hanlin	C1	Spent Lime Pond	In operation from 1957 to 1965; closed in 1982. Received spent lime and muds from purification of raw brine from the chlor-alkali production area and spent lime and caustic from chloromethanes production area.
Hanlin	C2	Spent Lime Pond	In operation from 1965 to 1978. Received spent lime and muds from purification of raw brine from the chlor-alkali production area and spent lime and caustic from chloromethanes production area.
Hanlin	D	Spent Lime Pond	In use from 1953 to 1957 for disposal of spent lime and muds from purification of raw brine from the chlor-alkali production area. In use in 1962 for disposal of hydrochloric acid.
Hanlin	E1	Former South Trash Dump	Used to dispose of general facility materials and laboratory wastes until 1982 closure.
Hanlin	E2	North Dump	Received general facility trash and ash from 1969 to 1980.
Hanlin	F	Acid Neutralization Pond	Basin where spent sulfuric acid and spent caustics from the chloromethanes production area were neutralized. This area was also used to stabilize the mercury

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			containing sludges from chlor-alkali process. Closed in 1982.
Hanlin	G	Storage Pond	Used as surge pond for storing mercury contaminated wastewater for treatment from 1971 to 1978. Unit was leaking prior to closure.
Hanlin	H	Stabilized Sludge Area	Received approximately 1 million gallons of stabilized mercury containing sludge from SWMU J.
Hanlin	I	Asbestos Burial Area	Two areas used for asbestos disposal.
Hanlin	J	Mercury Settling Basin	Prior to 1977, a single mercury settling pond. After 1977, separating into five pools used to collect mercury-containing wastewater generated in the chlor-alkali production area. Closed in 1986 when leaks were detected.
Hanlin	K	Raw Brine Mud	Received spent lime and muds from purification of raw brine from chlor-alkali production area.
Hanlin	L	Brine Well Pond	Contained brine spills and annular fluid discharge consisting of brine and small quantities of oil.
Hanlin	M	Boiler Ash Disposal Area	Contains fly ash generated by four coal-fired boilers.
Hanlin	N	Sedimentation Basin	Settled solids from stormwater runoff from boiler house area.
Hanlin	O	Clarification Pond	Used to settle solids from treated wastewater prior to discharge through a lined surface ditch to Outfall 001 to Ohio River.
Hanlin	P	Chloromethanes Production Area	Methyl chloride, methylene chloride, chloroform, and carbon tetrachloride were produced.
Hanlin	Q	Wastewater Treatment Tanks	Eight tanks holding 10,000 gallons each of wastewater. In place from 1985 to 2000.
Allied	R	Chemical Dump	Refuse area for paper, pallets, and chemicals.
Allied	S	Aniline Division Pond	In operation from 1965 to 1977, the pond contains sludge from lime treatment of effluent with organics and heavy metals. Approximately 6.5 million gallons annually.
Allied	T	Greater TDI Residue Area	Toluene diisocyanate (TDI) and methylene diamine (MDA) residue disposal area.
Allied	U	Lime Waste Pond	In operation until 1967, pond contains lime waste from acid neutralization in acetylene production.
Allied	V	Waste Pond 2	Pond was used to treat wastewater from toluene diamine (TDA) waste with formaldehyde to cause TDA precipitation.
Allied	W	Waste Pond 3	Former holding pond for TDA waste.
Allied	X	Waste Pond 6	Stormwater diversion pond, but connected to SWMUT.

B. Confirmation of Exposure

The CERCLA NRDAR regulations state that an 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 released substance [43 CFR § 11.37(a)].

A natural resource has been exposed to hazardous substances and/or petroleum products 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 regulations also state that, “whenever possible, exposure shall be confirmed using existing data” from previous studies of the assessment area [43 CFR § 11.37(b)(1)].

Hazardous substances released from the HAO facilities include mercury and a broad range of other organic contaminants and metals. Mercury released from HAO has migrated into the soil and groundwater, along with mercury discharged from the historic wells, the abandoned storm sewer system, and the current treatment plant has contaminated the aquatic, island, and floodplain habitats within the Hannibal Pool of the Ohio River. The following sections provide confirmation of exposure through summaries of readily available information about hazardous substances in the assessment area, including advisory information and data for surface water resources (including sediments), groundwater resources, geological resources (soils), and biological resources such as birds and fish.

3. AFFECTED NATURAL RESOURCES

Natural resources for which natural resource damages may be sought include land, sediment, 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] State...” (43 CFR § 11.14(z)). The CERCLA NRDAR regulations group these natural resources into five categories: surface water resources, ground water resources, air resources, geologic resources, and biological resources. The following paragraphs briefly summarize select features of the natural resources that the Trustees are currently considering assessing for injury.

A. Surface Water Resources

Surface water resources in the Assessment Area include water, suspended sediment, and bed and bank sediments (43 CFR § 11.14(pp)). Surface water may be considered injured if, for example, there is an exceedance of an applicable water quality or drinking water standard as a result of an unpermitted release (43 CFR § 11.62(b)(1)) or if other resources (e.g., fish) are injured as a result of exposure to the concentrations in the surface water (43 CFR § 11.62(v)). Surface water supports other biological resources, so surface water has both direct and indirect impacts on the health of biological resources. For example, contaminated sediments can cause injury to benthic invertebrate populations, which in turn can result in injuries to resident fish populations for

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whom the invertebrates are a source of food. Similarly, injury to invertebrates and/or fish resulting from exposure to contaminated sediments and surface water can lead to injury in local insectivorous (insect eating) or piscivorous (fish eating) bird populations. In addition, contaminated sediments serve as a source of continuing releases of hazardous substances to water.

In the assessment area, exposed surface water and associated sediments include, but are not limited to the:

- Ohio River from the northern groundwater discharge area to the downstream end of the effluent mixing zone (yet to be defined)
- River floodplain
- Refuge Islands within the Ohio River

These resources provide ecological services such as habitat for aquatic biota and a water supply for riparian vegetation habitat. In addition, the surface water is a likely transport pathway for carrying contaminants downstream of the plant.

Sediment, surface water and porewater samples have been analyzed during multiple investigations. Mercury contamination in the sediments and porewater is well documented (Janssen et al. 2020, Environ 2012b). Porewater samples have demonstrated that VOCs from groundwater are entering the river during low flow conditions when groundwater migrates from HAO (Environ 2012a, GeoSyntec 2015; 2023).

B. Groundwater Resources

Groundwater resources include the water in a saturated subsurface zone and the rocks or sediments through which this water flows. Groundwater resources serve as a potential pathway for contaminants to migrate from their source to surface water resources. Groundwater may be determined to be injured if concentrations of substances are in excess of applicable water quality criteria for public water supplies or the contaminated groundwater causes injury to other resources (43 CFR § 11.62(c)).

Groundwater contamination has occurred in both the Olin-Allied Area (northern) and the Hanlin Area (southern). Contaminants in each area are specific to the industrial processes performed in those areas. The northern groundwater contamination is dominated by parent and substituted chlorobenzenes, toluenes, nitrobenzenes, and anilines. The southern plume contamination is comprised of mercury, carbon tetrachloride, methylene chloride, trichloroethylene, tetrachloroethylene, and chloroform.

Groundwater in the southern zone is collected at the treatment plant in the Hanlin Area and is treated for mercury and VOCs. It is sampled and analyzed on a regular basis as part of a discharge agreement between Honeywell, USEPA, and WVDEP. A provisional agreement in concept was made between WVDEP and Honeywell in May 2019 which granted a temporary mixing zone for mercury despite Ohio River guidance stipulating no mixing zones for

bioaccumulative contaminants. This was later agreed to per ARARs in the ROD for OU1 in 2021. Thus, intake and discharge data will be compiled and reviewed by the Trustees as a part of the assessment of injuries to groundwater and within the river mixing zone.

Multiple investigations performed as part of the remedial investigation have demonstrated that contaminated groundwater is not fully captured under all conditions. In the northern zone, groundwater contaminants of concern (COCs) have been identified in porewater samplers. In the southern zone, recent sampling of mussels and periphyton has clearly demonstrated mercury exposure upstream of the treatment plant outfall where the mercury plume abuts the river. Groundwater well sampling and the resulting potentiometric maps (GeoSyntec 2020) indicate that COCs could migrate into the river when the river level is low and the groundwater flows from HAO to the river.

C. Geologic Resources

Geologic resources include soils and sediments that are not otherwise accounted for under the definition of surface water or groundwater resources. Geological resources, including soil and sediment resources in riparian and other wetland areas, provide habitat for natural resources such as migratory birds and also provide other services that regulate ecosystems and water quality, while offering human services and access to recreational fishing. Geologic resources may be injured if, for example, concentrations of substances in the soil are sufficient to cause injury to groundwater or a toxic response to soil invertebrates (43 CFR § 11.62(e)). The ORINWR owns and manages geologic resources within its boundaries.

Geologic resources of the HAOAA include soils exposed to hazardous substances by foot traffic and wind. In addition, soils within the Ohio River floodplains and islands are potentially exposed by flooding. These soils are important in providing a medium for vegetation, invertebrates, microbes, and other biota. Under flooding conditions, contaminated floodplain and island soils can expose aquatic biota and/or surface water resources to hazardous substances.

Soils at the facility were contaminated by the chemical processes and inappropriate handling of waste. These soils were present at the site during the operation of the facility, as well as after the operations ceased. Numerous removal actions and the final remedial action have reduced current contamination to acceptable risk levels.

Sampling of the soils on the ORINWR's Captina Island have demonstrated that mercury contamination has migrated from HAO and deposited on the island (Janssen et al. 2020, CDM 2023). However, the adjacent Captina Mainland property does not appear to be a mercury deposition zone likely due to elevated riverbank and the hydraulic conditions from the discharge of Fish Run.

D. Biological Resources

Biological resources include natural resources, as defined earlier, and other biota, including, terrestrial and aquatic plants, threatened, endangered, or state sensitive species, other legally protected species, and other living organisms not listed (43 CFR § 11.14(f)). Insects, amphibians, reptiles, birds, mussels, fish, and small mammals serve as food sources for higher trophic level animals including raptors and predatory mammals. Biological resources also provide a range of human services including fishing and wildlife viewing. Among other causes, injury to a biological resource could occur if exposure to released hazardous substances and oil cause the biological resource death, disease, or reduction in reproduction or if there is a directive to limit or ban consumption (43 CFR § 11.62(f)). Below characterizes the biota present at the HAOAA.

Macroinvertebrates

Benthic macroinvertebrates live on or near the river bottom and serve several ecological functions, including degrading and digesting plant material and serving as prey for fish, birds, and small mammals. They can also serve as indicators of pollution. Between October 1957 and January 1960, Jackson and Weise (1962) collected invertebrate samples along the length of the Ohio River. They found that invertebrate communities in the main channel of the Ohio River did not include any species which are indicative of unpolluted water. Jackson and Weise also emphasized that only a few specimens of the sensitive Ephemeroptera (mayflies) order were found in the Ohio River during their 1957 to 1960 study period.

The results of intensive Ohio River aquatic macroinvertebrate monitoring from 1963 to 1967 were published by the USEPA (Mason et al. 1971). This survey used rock baskets to eliminate the variable of bottom substrate. They concluded that artificial substrate samples collected more diverse macroinvertebrates than sediment samples. During the five-year period, they observed increases in abundance and diversity in the lower and middle reaches of the Ohio River, but no substantial improvements on the upper reach near Pittsburgh. However, no samples were collected in the Hannibal Pool. In 2002, Wooten et al. (2006) repeated rock basket sampling at one location in each pool to assess temporal variation in the invertebrate community. The results clearly demonstrate that dramatic improvements have occurred along the previous severely impaired upper reach of the Ohio River since 1967. Improvements were observed in the number of taxa and the number of sensitive taxa.

The extensive Ohio River Valley Water Sanitation Commission (ORSANCO) Ohio River aquatic macroinvertebrate data file is a valuable information resource with the potential to yield numerous important insights into the ecology of the Ohio River. For data prior to 2006, critical metrics (i.e., total number of organisms, number of clinging organisms) can be used to evaluate benthic community health. In Figure 5, Panel A depicts these metrics for data from 1997 through 2001. Both the number of invertebrates and the number of clinging-type organisms were reduced downstream of Outfall 001 compared to upstream.

ORSANCO used these historic data to develop a benthic macroinvertebrate index (IBI) for the Ohio River (Applegate et al. 2007; ORSANCO 2020). After validation, ORSANCO began to use

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this IBI to evaluate macroinvertebrate samples collected by kick sampling and Hester-Dendy artificial substrate samplers. From 2006 to present, ORSANCO has applied this technique and generated IBI values (ORMin) on a 5-year rotation for each pool. Figure 5, Panel B shows the 2008 IBI values for the left-descending bank (LDB), while Panel C depicts those from 2013 sampling on the LDB. Scores adjacent to HAO in 2008 and 2013 ranged from good (upstream of Outfall 001) to fair (downstream of Outfall 001). The effect appears to be localized as the 2008 score at Captina Island was excellent, but this may be attributable to the higher quality habitat associated with islands (Thorp 1992). Targeted sampling is necessary to distinguish effects associated with groundwater seeps and Outfall 001 versus habitat quality.

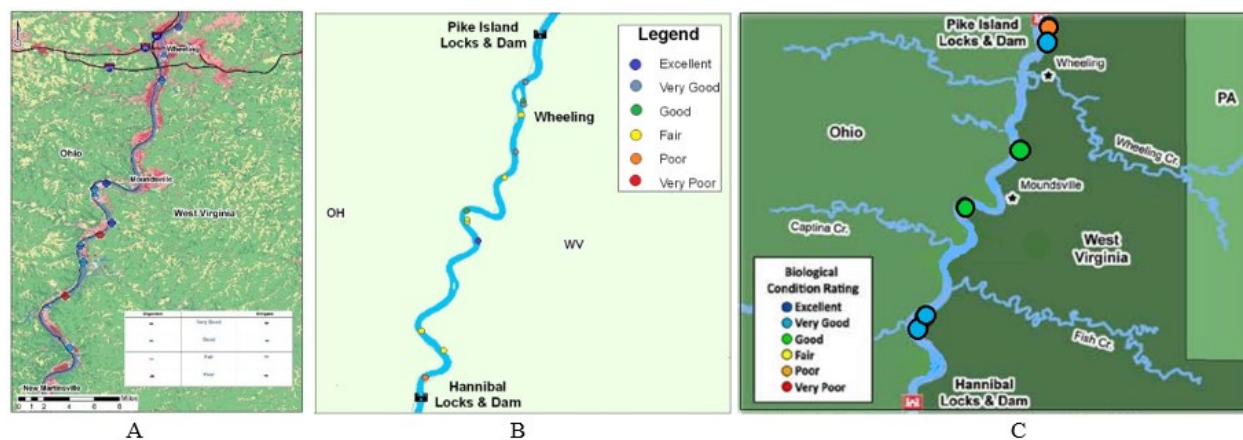


Figure 5 Macroinvertebrate community metrics for Hannibal Pool in pre-2006 (1997-2001: A), 2008 (B), and 2013 (C) sample collections (ORSANCO 2020).

Molluscs

Molluscs in the Ohio River watershed include aquatic snails, terrestrial snails, and freshwater mussels. The aquatic snail diversity is improving in the upper Ohio River, and 5 species inhabit the waters around the islands. Recent studies indicate that 11 species of terrestrial snails are on the ORINWR (USFWS 2017). For uncommon species such as the striped whitelip land snail (*Webbhelix multilineata*), distribution is restricted to forested islands and undisturbed floodplains of the Ohio River.

Mussels are a river's natural filter system, and they play an important role in the breakdown and compartmentalization of organic matter as well as provide habitat for other invertebrates. Water quality degradation starting in the late 1800s stressed or eliminated many mussels and their fish hosts (WVDNR 2015; WVDNR 2006). In the last century the number of mussel species has declined from about 80 to a low of about 25 to 35 species in the 1950s and 1960s. Ecological Specialists (2000) showed 18 or more live species of unionids collected from between the Hannibal and Meldahl pools during various studies between 1969 and 1999. Numerous factors contributed to the decline, including, but not limited to, construction and operation of high-lift locks and dams; water pollution from municipalities, industries, and acid mine drainage; instream extractions of sand and gravel; and disruptions to mussel beds due to barge fleeting areas, queuing, and disposal of dredged materials. The decline in mussel species and densities,

and the areal extent of mussel beds, was more severe in the upper and middle river segments, with the lower river segment concurrently experiencing a lesser, but similar decline.

Studies conducted since 1991 indicate that some species of mussels are recolonizing the upper to middle Ohio River mainstem, reflecting in large part the revitalization the River has undergone in recent years due to more stringent water quality standards (ESI 2009, Cavanaugh and Mitsch 1989). ESI (2009) found that the present fauna of the upper Ohio River appears to be a mix of historical species and new species that have recently colonized the study area from tributaries and downstream pools. Of the 54 documented species, 35 species historically appeared in this portion of the River and 19 new species have recently become established in the upper river. Recent increases in the numbers of species can be attributed to water quality improvements, protection efforts related to mussel beds, and natural reintroductions from tributary and/or downstream populations. Divers found that suitable mussel habitat was found to be widely available at many sites, but largely unoccupied in the Upper Ohio River suggesting that water quality is still a limiting factor (ESI 2009).

In addition to the habitat and water quality problems that mussels have faced, the invasion of the exotic zebra mussel posed another challenge to endemic mussel sustainability. Zebra mussels first entered the ORINWR in 1993, and their density exploded to over 10,000 animals per square meter by 1999 (USFWS 2017). However, zebra mussel populations in the mainstem Ohio River crashed in 2000, and never completely recovered. They persist at generally low levels (< 100 per square meter) and most juveniles do not survive to the next year. The poor recruitment may be influenced by various environmental factors such as high water temperatures, high flow velocities, high suspended sediment loads, and high predation by fish and birds (USFWS 2017). As a result, zebra mussels are not considered a primary stressor on Ohio River mussel populations.

Systematic mussel surveys have not been conducted recently for the Hannibal Pool. Targeted surveys have been performed. The ORINWR islands have been surveyed at least once, and each one has some mussel fauna associated with the underwater habitat surrounding it (USFWS 2017). The upper pools (Emsworth, Montgomery, Dashields and New Cumberland) were surveyed in 2008 (ESI 2009).

Fish

Prior to channelization, over 140 species of fish, many long-distance migratory species, and 72 species of native freshwater mussels occurred in the Ohio River. Many of these aquatic species were extirpated from the Ohio River, and a few big river riffle-dependent species became extinct following channelization, construction of back-channel closure dikes, impoundment, and dredging for year-round navigation.

Over 100 species of warm water fishes inhabit the Ohio River reach of the NWR. The islands provide a variety of habitat types for the diverse fish fauna - shallow gravel and sand bars, aquatic beds, overhanging cover, logs and snags, as well as large rock and cobble. Riverine emergent and submerged wetlands teem with young-of-year fishes. Deep water habitats have

been difficult to sample effectively, but ORINWR divers have noted numerous species of darters, minnows, and madtoms in 20 feet of water.

The ORINWR reach of the Ohio River supports a diverse recreational fishery, highlighted by spotted, smallmouth and largemouth bass, white and hybrid striped bass, channel and flathead catfish, sauger, walleye, black and white crappie, and freshwater drum.

ORSANCO conducted a fish study to determine the effect of outfall discharges on fish communities (Emery et al. 2003). At four unidentified chemical outfall sites, they found that the percent individuals as invertivore species declined in the first 500m downstream, then increased with distance away from the outfall in both the summer and fall samples. The percentage of rock-spawning individuals did not recover until the most downstream zone. They found that most of the other fish metrics indicate a community response within the first 700m. They demonstrated similar chemical effects across habitats, but a greater response at the higher quality substrate sites.

Fish consumption advisories are in place for the Ohio River. According to the CERCLA NRDAR Regulations, an injury to biological resources has resulted from the release of a hazardous substance if the concentration of the substance is sufficient to exceed levels for which an appropriate state health agency has issued directives to limit or ban the consumption of such organism [43 CFR §11.62(f)(1)(iii)]. Regulations also specify that an injury to biological resources can be defined by an exceedance of 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)]. The State of West Virginia began advising that people restrict their consumption of contaminated sport-caught fish in the 1980s. Fish consumption advisories have changed over time to reflect contemporaneous data on fish contaminant levels and contaminant toxicity, and new methodologies for establishing and issuing advisories. Trigger levels have changed over the years, mainly based on refinements in knowledge of the contaminants.

Sport fishing is popular at many locations within the Hannibal Pool. Mercury concentrations in sport fish collected in this Pool exceeded advisory levels when mercury sampling became routine in 1987 (ORSANCO 2018; <http://www.orsanco.org/data/fish-tissue/>). The mercury concentrations and consumption categories for sport fish collected from 1987 to 2015 are presented in Table 5 of the Preassessment Screen (PAS) (Natural Resource Trustees 2018).

West Virginia currently sets mercury consumption advisories on a statewide basis. Current mercury criteria for fish consumption would limit Ohio River anglers to one meal per month for white bass and two meals per month for largemouth bass, smallmouth bass, spotted bass, hybrid striped bass, walleye, sauger, and saugeye.

Reptiles and Amphibians

The wetland habitats on and around the islands and within the embayments and mainland wetlands provide suitable habitat for a variety of amphibians, including American toad, Fowler's toad, green frog, bullfrog, gray tree frog complex, northern spring peeper, pickerel frog, and northern leopard frog. Limited information is available on salamander populations, but surveys

have revealed ravine salamander, smallmouth salamander, mudpuppy, and hellbender on or near ORINWR. Snakes in general are not abundant on the islands due to periodic flooding, however, the occasional garter snake or black rat snake is seen on ORINWR, and northern water snakes swim to and from the islands. Five species of turtles have been recorded on ORINWR so far, including the terrestrial eastern box turtle, and the more aquatic snapping turtle, midland painted turtle, musk turtle, and eastern spiny softshell turtle.

Birds

Waterbirds

Waterbirds heavily use ORINWR floodplain habitats. Herons, egrets, ducks, geese, swans, loons, grebes, gulls, terns, shorebirds, and raptors are common along the islands and in the embayments. Nesting water birds include Great Blue Heron, Green Heron, Wood Duck, Mallard, American Black Duck, Canada Goose, Belted Kingfisher, and Herring Gull. The remaining species of water birds are found on ORINWR during migration, or, in the case of most waterfowl, primarily in the winter. The ORINWR monitors on-Refuge nesting activities of Great Blue Herons.

Shorebirds

Many species of shorebirds migrate through and a few nest on ORINWR, such as Killdeer, Greater and Lesser Yellowlegs, and numerous species of sandpipers including the Spotted Sandpiper.

Raptors

Many ORINWR raptors are year-round residents, such as the Great Horned Owl, Eastern Screech Owl, Barred Owl, Bald Eagle, Red-Tailed Hawk, Cooper's Hawk, Sharp-Shinned Hawk, American Kestrel, and Red-Shouldered Hawk. Other birds of prey visit ORINWR primarily during migration or winter, such as the Osprey, Merlin, Peregrine Falcon, Northern Harrier, and Rough-Legged Hawk. There is an abundance of small mammals and birds that serve as food for the raptor populations. The ORINWR also monitors on-Refuge nesting activities of Osprey and Bald Eagle.

Migratory Landbirds

The Ohio River corridor is poised on the boundary between the Atlantic and Mississippi flyways and is a major migration route for birds. Migratory landbirds (such as warblers, vireos, cuckoos, tanagers, thrushes, orioles, and flycatchers) migrate through the Ohio River Valley. Migratory landbirds are the dominant breeding birds on ORINWR, and the most abundant nesters include Grey Catbird, Wood Thrush, Song Sparrow, Yellow Warbler, Common Yellowthroat, Northern Cardinal, Yellow-Breasted Chat, American Robin, Common Grackle, Acadian Flycatcher, Carolina Wren, White-Eyed Vireo, Red-Eyed Vireo, American Redstart, Carolina Chickadee, Eastern Towhee, and American Goldfinch (ORINWR Breeding Bird surveys, 1995 – 2012).

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Mammals

The most commonly observed mammals include white-tailed deer, fox squirrel, raccoon, muskrat, beaver, opossum, red fox, woodchuck, and eastern cottontail rabbit. The larger mammals are seen frequently swimming back and forth between the islands and the mainland. The small mammal populations include at least 9 species of bats, meadow vole, short-tailed shrew, meadow jumping mouse, white-footed mouse, and deer mouse. Riparian fur bearers, such as mink, muskrat, and beaver, are noticeably more abundant along the back channels (protected from commercial traffic) and wetland habitats of the embayments than along the main channel/navigation sides of the islands. Although most of the mammals are considered residents, some, bats in particular, migrate to their summer range along the Ohio River. The endangered Indiana bat and northern long-eared bat have been documented in riparian forests on ORINWR.

The distribution of mammals on ORINWR is heavily influenced by habitat type (Table 5, Figure 6). As habitats continue to change in favor of the increasingly dominant bottomland hardwood forest, the mammal populations will respond with a shift towards the forest community and away from the old field community.

Table 5 Summary of land cover in the Hannibal Pool watershed taken from Yang et al, 2018.

LAND COVER TYPE	PERCENT
Open Water	1.57
Developed, Open Space (<20% impervious)	5.03
Developed, Low Intensity (20-49% impervious)	1.53
Developed, Medium Intensity (50-79% impervious)	0.99
Developed, High Intensity (80-100% impervious)	0.50
Barren Land (rock/sand/clay)	0.09
Deciduous Forest	67.77
Evergreen Forest	0.07
Mixed Forest (neither deciduous or evergreen >75%)	12.47
Shrub/Scrub	0.43
Herbaceous	0.85
Hay/Pasture (>20% of vegetation)	8.56
Cultivated Crops (>20% of vegetation)	0.11
Woody Wetlands (woody >20%)	0.02
Emergent Herbaceous Wetlands (herbaceous >20%)	0.02



Figure 6 Typical island and floodplain community on the Ohio River islands (ORINWR 2017).

Threatened and Endangered Species

Thirty-two animal species that have been found within counties bordering the Hannibal Pool are listed as species of highest conservation priority by West Virginia (Table 6). Members are not afforded legal protection, but many of these species are of concern because of declining or relict populations in the state (WVDNR 2015). Of those 32, 12 species are federally listed as endangered, threatened, proposed, or candidate under the Endangered Species Act. Although the bald eagle (*Haliaeetus leucocephalus*) is no longer listed as threatened under the federal Endangered Species Act, it is still protected by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act (USFWS, 2008).

Table 6 Threatened species, endangered species, or animal species of special concern documented in Hannibal Pool and its watershed. Bold text indicates federally listed species; plain text indicates status in Ohio and/or West Virginia; *E=endangered, T=threatened, PE=proposed endangered, C=Candidate, Priority 1 = WV Highest conservation priority species of concern. Source: USFWS IPaC 2024, WVDNR 2015.

GROUP	COMMON NAME	SPECIES	STATUS*
Invertebrate	Clubshell	<i>Pleurobema clava</i>	E
Invertebrate	Fanshell mussel	<i>Cyprogenia stegaria</i>	E
Invertebrate	Snuffbox mussel	<i>Epioblasma triquetra</i>	E
Invertebrate	Sheepnose mussel	<i>Plethobasus cyphus</i>	E
Invertebrate	Longsolid	<i>Fusconaia subrotunda</i>	T
Invertebrate	Pink Mucket	<i>Lampsilis abrupta</i>	E
Invertebrate	Round Hickorynut	<i>Obovaria subrotunda</i>	T
Invertebrate	Salamander mussel	<i>Simpsonaias ambigua</i>	PE
Invertebrate	Black Sandshell	<i>Ligumia recta</i>	Priority 1
Invertebrate	Cobblestone Tiger Beetle	<i>Cicindela marginipennis</i>	Priority 1
Invertebrate	Monarch butterfly	<i>Danaus plexippus</i>	C
Fish	Highfin Carpsucker	<i>Carpionodes velifer</i>	Priority 1

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Fish	Tippecanoe Darter	<i>Etheostoma tippecanoe</i>	Priority 1
Fish	Orangespotted Sunfish	<i>Lepomis humilis</i>	Priority 1
Amphibians/Reptiles	Eastern Hellbender	<i>Cryptobranchus alleganiensis</i>	Priority 1
Amphibians/Reptiles	Mudpuppy	<i>Necturus maculosus</i>	Priority 1
Birds	Spotted Sandpiper	<i>Actitis macularius</i>	Priority 1
Birds	Upland Sandpiper	<i>Bartramia longicauda</i>	Priority 1
Birds	Bank Swallow	<i>Riparia riparia</i>	Priority 1
Birds	Canada warbler	<i>Cardellina canadensis</i>	Priority 1
Birds	Black-billed cuckoo	<i>Coccyzus erythrophthalmus</i>	Priority 1
Birds	Cerulean warbler	<i>Setophaga cerulea</i>	Priority 1
Birds	Chimney swift	<i>Chaetura pelagica</i>	Priority 1
Birds	Kentucky warbler	<i>Geothlypis formosa</i>	Priority 1
Birds	Wood Thrush	<i>Hylocichla mustelina</i>	Priority 1
Mammals	Indiana bat	<i>Myotis sodalis</i>	E
Mammals	Northern long-eared bat	<i>Myotis septentrionalis</i>	T
Mammals	Tricolored bat	<i>Perimyotis subflavus</i>	PE
Mammals	Eastern Small-footed Myotis	<i>Myotis leibii</i>	Priority 1
Mammals	Little Brown Myotis	<i>Myotis lucifugus</i>	Priority 1
Mammals	Eastern Red Bat	<i>Lasiurus borealis</i>	Priority 1
Mammals	Hoary Bat	<i>Lasiurus cinereus</i>	Priority 1

Injury to Biological Resources

The Ohio River and floodplain habitats support a wide variety of biota potentially exposed to hazardous substance releases from the plant. Detailed biota lists are provided in the PAS. Potentially injured biological resources may include, but are not limited to:

- Riverine, wetland, and floodplain fish and wildlife habitats
- Mammalian and avian species
- Fish of various species
- Reptiles and amphibians
- Aquatic benthic macroinvertebrates
- Other aquatic flora and fauna
- Vegetation
- Threatened or endangered species.

As noted above, the USGS Stable isotope study clearly established mercury exposure in small fish, benthic and water column molluscs, and riparian spiders (Janssen et al. 2020, unpublished data). More recently, USEPA has demonstrated that periphyton and caged mussels accumulate high concentrations of methylmercury from both groundwater discharge and treated effluent

discharge (CDM 2024). Aquatic snail data from USGS are pending. USFWS has also submitted dragonfly larvae from Captina and Fish Creek Islands of the refuge to the nationwide USGS Dragonfly Mercury Project. Results, which are expected in early 2025, will be used to determine if an aerial insectivore study is warranted.

4. INJURY ASSESSMENT AND PATHWAY DETERMINATION APPROACH

This Assessment Plan sets forth assessment studies or activities the Trustees intend to pursue as part of the HAO NRDAR.

During the injury assessment, the Trustees quantify the effects of the release(s) of hazardous substances and oil on the natural resources to determine whether there is a measurable adverse effect (“injury”) to the resource as a result of the exposure. For purposes of NRDAR, the Trustees measure the extent of the injury, estimate the baseline condition and/or baseline services of the injured natural resources, determine the recoverability of the injured natural resources, and estimate the reduction in services that resulted from the release(s) of hazardous substances (43 CFR § 11.70(c)).

Baseline is defined as the condition or conditions that would have existed in the assessment area had the releases of the hazardous substances under investigation not occurred (43 CFR § 11.14(e)). Baseline conditions may be established based on the review of historical, pre-release data and information, or by control areas that exhibit similar physical, chemical, and biological conditions as the assessment area and lack exposure to the releases (43 CFR § 11.72).

Consistent with the regulations, injury determination, restoration alternatives, and quantification will be evaluated for all relevant categories of natural resources. However, natural resources are interdependent. For example, surface water, sediments, and floodplain soils together provide habitat – and lateral and longitudinal connectivity between habitats – for aquatic biota, semi-aquatic biota, and upland biota. Hence, injuries to individual natural resources may cause ecosystem-level losses and restoration of habitats may allow ecosystem-level gains. The Trustees will consider these interdependent ecosystem-level losses and gains when conducting their assessment.

In addition, the Trustees will evaluate whether any specific natural resources and services are impacted and determine their importance to the public. For instance, the Ohio River and its floodplain have required advisories that may significantly impact the public’s recreational uses and appreciation of natural resources.

A. Temporal

The temporal scope of this NRDAR will be based on determining injuries to natural resources and corresponding reductions in natural resource services from the time of the initial release through the return of the injured resource to baseline conditions. This scope may change as more

information is revealed through the remedial action process or other means discovered during the assessment.

B. Use of Available Data

The Trustees' general approach to the NRDAR is to review the existing data, analyze gaps, and then undertake additional studies or activities including testing and sampling as needed. This approach minimizes the cost of the assessment and maximizes the use of existing information. More details on data management are presented in Section 7.

C. Intent to Perform a Type B Assessment

As part of the assessment planning process, the Trustees decide whether to conduct a simplified assessment (Type A) or a comprehensive assessment (Type B) (43 CFR §§ 11.33-11.36). The Type A procedures, which use minimal field observations and computer models to generate a damage claim, are limited to the assessment of relatively minor, short duration discharges or releases (43 CFR § 11.34). The simplified Type A models have been developed only for Great Lakes environments and coastal and marine environments (43 CFR § 11.33(a)). These models are appropriate for discrete spills of hazardous substances and/or petroleum products up to a few days in duration, with injuries based on acute exposure via the surface water pathway only [see publication incorporated by reference at 43 CFR § 11.18(a)(5)]. Since none of these conditions apply to the HAOAA, a Type A assessment is inappropriate. Furthermore, the nature of the releases and natural resource injuries require more extensive field observations, making a Type B assessment appropriate (43 CFR § 11.33(b)). Therefore, the Trustees are conducting a Type B assessment in this NRDAR.

The Trustees must confirm that at least one of the natural resources identified as potentially injured in the PAS has been exposed to a released hazardous substance before including any Type B methodologies in the Assessment Plan (43 CFR § 11.37). The PAS identified several resources and their services that were potentially exposed as a result of the releases of hazardous substances from the Facility, including:

- Biota
- Surface Water
- Sediment
- Groundwater
- Geologic resources

Multiple natural resource categories are confirmed as exposed to hazardous substances (see Section 2 B Confirmation of Exposure) released from HAO. Information describing the methods that confirm additional resources have been exposed and potentially injured will be described in the sections below under Pathway Determination and Injury Assessment.

D. Pathway Determination

Pathway is defined as the “route or medium through which oil or a hazardous substance is or was transported from the source of the... release to the injured resource” (43 CFR § 11.14(dd)). Determinations involve identifying the sources of hazardous substances and tracing the fate and transport of the substances through the environment to the resources (e.g., through surface water, sediments, to mussels). Pathways may be determined by demonstrating the presence of a hazardous substance in a resource or by using a model that demonstrates that the route served as a pathway (43 CFR §11.63(a)(2)).

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 7 shows the relationships between important pathways of exposure and ecological receptors in an aquatic food web.

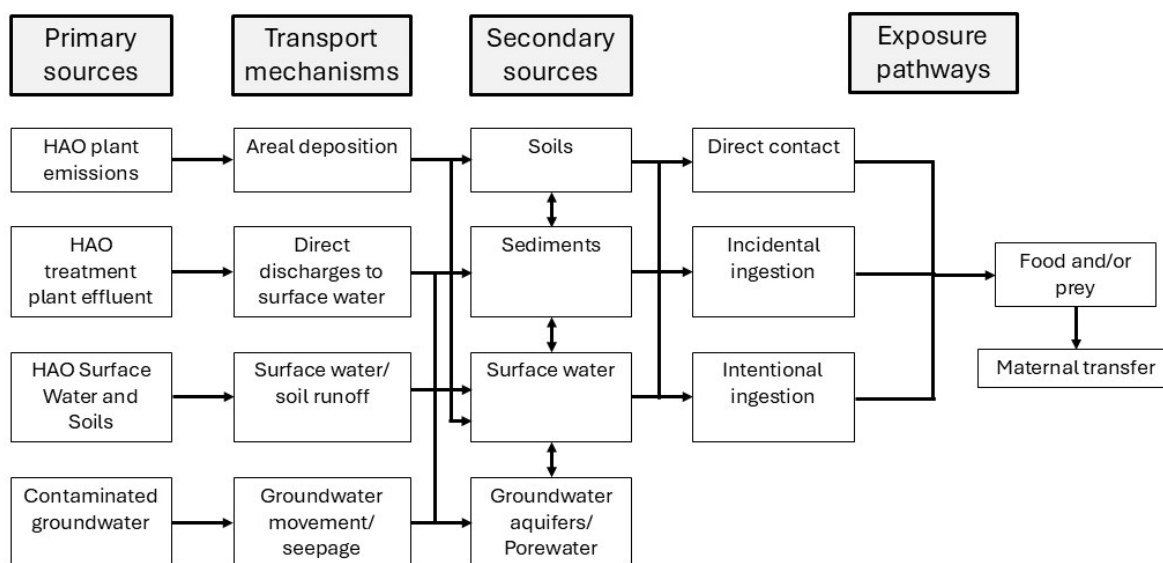


Figure 7 Partial ecological conceptual model identifying primary and secondary sources of contamination in the Ohio River, islands and floodplain with respective exposure routes to ecological receptors.

Bioaccumulation is the process of contaminants being stored in the tissues of biological receptors. This process may lead to biomagnification, where higher levels of contaminants are accumulated with each level of the trophic system. Certain forms of mercury are bioaccumulative and can potentially have impacts on certain resources such as aquatic fish, floodplain mammals, and migratory birds. Mercury is stored in the tissues and proteins of affected organisms. Due to the biomagnifying properties of mercury, predators and organisms higher on a many-tiered food chain are at a greater risk of accumulating high levels. As part of the assessment activities, the Trustees will trace contamination of biota (i.e., fish, mussels, and/or birds) via tissue and chemical analysis for site-related hazardous substances.

5. INJURY ASSESSMENT

The injury assessment, including both injury determination and quantification, is the process that informs the Trustees' ultimate claim for natural resource restoration costs and, if warranted, "compensable values," or compensation for losses incurred prior to the completion of restoration activities (43 CFR 11.83(c)(1)). Loss refers to the measurable adverse reduction of a chemical or physical quality or viability of a natural resource (43 CFR 11.14(x)). The Trustees expect to evaluate injury associated with the natural resources and services using the assessment activities and objectives described below.

The Trustees' defined injury assessment categories combine multiple natural resources that are defined in the CERCLA NRDAR regulations (43 CFR § 11.14(z)) (i.e., surface water resources, ground water resources, geologic resources, and biological resources).

The Trustees intend to evaluate ongoing work to determine its relevance for determining current pathways and current biological injuries, particularly as caused by mercury and other contaminants released from HAO. The Trustees expect that some of the data will be relevant to the assessment of damages within the HAOAA. The Trustees intend to work cooperatively with Olin and Honeywell, as well as USEPA to ensure that ongoing studies maximize their relevance to the assessment. The Trustees also intend to analyze data and results in the context of current pathways and injuries within the HAOAA caused by contaminants from HAO. Finally, the Trustees intend to determine whether additional studies should be conducted to address key questions about current pathways and biological injuries resulting from HAO contamination. The Trustees intend to carefully review the data that have been collected to date on benthic invertebrates, periphyton and mussels to determine if additional studies are warranted to define mercury methylation pathways and resulting injuries from this more toxic and bioaccumulative form.

A. Injury Assessment for Biological Resources

The Trustees anticipate focusing assessment of biological resources on surface water, soil, sediment, and biological tissue data and their pathway(s) of exposure. Biological resources are natural resources referred to in section 101(16) of CERCLA as fish and wildlife and other biota (43 CFR 11.14(f)). The Trustees will review data and information gathered as part of the USEPA remediation process, data collected by the PRPs, other research and data collection efforts associated with HAO, USEPA screening values, published injury thresholds, and other relevant published screening values, standards, and/or benchmarks to determine injury. The Trustees will consider peer-reviewed literature on the harmful effects of mercury and other COCs released at HAO on soil, sediment, surface water, and the biological resources that reside in these habitats. During the NRDAR, the Trustees will continue to evaluate any new or relevant data sources that may inform the injury determination and quantification. Table 7 presents a preliminary list of potential studies investigating impacts to biological receptors of interest to the Trustees.

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Table 7 Summary of potential studies being considered for the HAOAA. "X" indicates selected study is being considered for the given Biological Receptor.

Biological Receptor	Diet Study (Prey Items)	Exposure Study (Measured Tissue)	Reproduction/Population Effects Study
Carolina Wren	X (spiders, beetles, centipedes)	X (eggs)	X
Tree Swallow	X (dragonfly larvae)	X (eggs/feathers/blood -pending diet data)	X
Shrew	X (spiders, beetles, centipedes)		X
Tiger Beetle		X (whole body)	
Centipede		X (whole body)	
Watersnake OR Mudpuppy	X (dragonfly larvae, aquatic snails)		X

Surface water and aquatic-dependent biological resources within HAOAA may have been injured by direct contact with dissolved, floating, or suspended chemicals in the water column, direct contact with contaminated sediments, ingestion of contaminated surface water and sediment during foraging or feeding, inhalation of chemicals, and/or indirect contact through ingestion of contaminated prey species. The Trustees will evaluate the concentrations of mercury and other COCs in surface waters (i.e., water column), sediments, invertebrates, and/or fish to determine and quantify the degree to which these substances may be causing injury.

There are many species of birds that use the HAOAA for all or part of their lifecycle. The Trustees will focus their assessment activities on determining whether, and to what extent birds have been injured as a result of exposure to Releases from HAO.

Specific assessment activities may include:

A. Screening of chemical contaminants in soil, surface waters, sediment, and/or biological tissues

The objectives of this assessment activity include:

- Identify the highest soil, surface water, sediment, and/or biological tissues concentrations for released hazardous substances;
- Identify ecological benchmarks and injury thresholds for COCs;
- Compare the highest concentrations to the lowest and most conservative applicable ecological benchmark (USEPA Region 3 BTAG when available) or injury thresholds; and
- Develop a database of retained COCs for analysis.

B. Assessing trends of contaminant data and performing data analysis

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This assessment activity will identify baseline contaminant concentrations and temporal patterns of chemical contaminant concentrations above baseline and determine if quantifiable injuries to surface water resources and encrusting organisms occurred from exposure to hazardous substances. The Trustees will use data quality objectives approach (USEPA 2000; USEPA 2006a;b;c) to perform a data analysis to:

- Identify the frequency of detection of chemical concentrations in soil, surface water, sediment, and/or biological tissues, by geographic sub-areas and time;
- Analyze and apply appropriate statistics on selected data to compare chemical concentrations in the Assessment Area to baseline concentrations or other appropriate chemical observations;
- Visualize data using charts and graphs; and
- Describe and document analysis results.

C. Performing geospatial analysis

The purpose of this activity is to determine the geographic and temporal extent of injury or contamination. Information from the above activities (i.e., A. Screening of chemical contaminants in surface waters, sediment, invertebrates and/or fish; B. Assessing trends of contaminant data and performing data analysis) will be used during this analysis. Multivariate techniques and/or ArcGIS™ or a similar mapping program will be employed to perform data interpolation and visualization techniques that can quantify the geographical extent of injury or contamination.

The objectives of this task may include the following:

- Identify data that are appropriate for interpolation and visualization;
- Visualize data using charts, graphs, and/or maps; and/or
- Delineate the number of acres of impacted area by magnitude of contamination or magnitude of injury.

B. Injury Assessment for Surface Water and Sediment

Surface water resources are defined as waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline and sediments in or transported through coastal and marine areas (43 CFR 11.14(pp)). Injury occurs to surface water resources when concentrations of contaminants are in excess of drinking water standards or in excess of water quality criteria based on federal or state standards. Injury to sediments occurs when the concentrations of substances cause the sediment to exhibit characteristics identified under or listed pursuant to section 3001 of the Solid Waste Disposal Act or high enough to cause injury to groundwater, geologic, and/or biological resources exposed to the sediments (43 CFR 11.16(b)).

Assessment activities on surface water and sediment will be conducted concurrent with those for biological resources as described above focusing on data historically collected at the site and any new data that becomes available through remedial and/or NRDAR efforts. Changes in

concentrations due to remedial efforts will be considered when determining the extent of injury through time.

C. Injury Assessment for Soil

Soil is included as a geologic resource, which includes elements of the Earth's crust such as soils, sediments, rocks, and minerals (43 CFR 11.14(s)). Injury to soil has occurred when concentrations of contaminants are sufficient for the materials to exhibit characteristics identified under of listed pursuant to section 3001 of the Solid Waste Disposal Act or high enough to cause injury to surface water, groundwater, and/or biological resources exposed to the soils from the site (43 CFR 11.16(e))

Assessment activities on injury to soil will be conducted concurrent with those for biological resources as described above focusing on data historically collected at the site and any new data that becomes available through remedial and/or NRDAR efforts. Changes in concentrations due to remedial efforts will be considered when determining the extent of injury through time.

D. Injury Assessment for Groundwater Resources

The remedial investigation has indicated that COCs associated with the releases have leached through the substrates and entered the groundwater. Groundwater resources are water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which it moves (43 CFR 11.14(t)). The Trustees will focus on assessing injury to groundwater resources and any pathways for the releases to make their way to other natural resources being evaluated as part of the injury assessment.

Similar to surface water resources, injury to groundwater resources has occurred when concentrations of contaminants are in excess of drinking water standards or in excess of water quality criteria based on federal or state standards. Injury can also occur when concentrations have caused injury to surface water, geologic, and/or biological resources exposed to the groundwater (43 CFR 11.16(c)). Changes in concentrations due to remedial efforts will be considered when determining the extent of injury through time.

6. APPROACH TO INJURY QUANTIFICATION AND DAMAGES DETERMINATION

In the damages determination phase, the Trustees determine the monetary value (damages) of the compensation for injuries to natural resources and their services resulting from the releases of hazardous substances (CERCLA §§ 107(a)(4)(C), 107(f)(1); 43 CFR § 11.15). The measure of damages is the cost of (i) restoration, or rehabilitation of the injured natural resources to a condition where they can provide the level of services available at baseline, (ii) the replacement and/or acquisition of equivalent natural resources capable of providing such services, and/or (iii)

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the compensable value² of all or a portion of the services lost to the public for the time period from the release pending restoration to baseline (43 CFR § 11.80(b)).

The CERCLA NRDAR regulations provides a non-exhaustive description of various methodologies the Trustees may use in their damages determination, including Habitat Equivalency Analysis (HEA), Resource Equivalency Analysis (REA), and travel cost (43 CFR § 11.83).

HEA is a service-to-service or resource-to-resource approach that can account for changes in baseline services while estimating interim losses of services. The fundamental concept in HEA is that compensation for lost ecological services can be provided by restoration projects that provide comparable services.

REA is a resource-to-resource approach to injury quantification that assumes that services lost and restored are comparable, an approach similar to HEA (Desvousges et al. 2018). REA generally refers to a stepwise replacement model for killed or injured species.

During the assessment process, the Trustees will determine the most appropriate method to determine damages which may include other models.

Travel cost can be used to determine the value for the use of a specific area. This methodology uses an individual's incremental travel costs to an area to model the economic value of the services of that area. Compensable value is determined by examining the difference between a traveler's value of the area with and without a discharge or release. (43 CFR § 11.83(c)(iii)(3)(iv)).

A. Baseline

In order to quantify injuries, the Trustees must quantify baseline conditions, which include the physical, chemical, and biological conditions and their associated services for natural resources. Baseline is “the condition or conditions that would have existed at the assessment area had the discharge of oil or release of the hazardous substance under investigation not occurred” (43 CFR § 11.14(e)). The baseline conditions for each resource and/or service will be taken into account when determining the level of injury and the amount of restoration required to offset the injury. This evaluation will follow the baseline determination guidelines of 43 CFR § 11.72 for each resource and resource service.

² Compensable value is the amount of money required to compensate the public for the loss in services provided by the injured resources between the time of the release and the time the resources are fully returned to their baseline conditions, or until the resources are replaced and/or equivalent natural resources are acquired (43 CFR §11.83(c)). This is also referred to as “interim loss.”

B. Biological and Groundwater Damages Determination

The Trustees are assessing exposure of natural resources to HAO hazardous substances, oil, and response actions and are determining whether natural resources or their services have been injured or lost. As part of the assessment, the Trustees determine the amount of restoration that is necessary to compensate the public for identified injuries to these resources and their associated services for the period between the onset of injury and the resource's return to baseline ("scaling").

Trustees will likely use models, such as HEA or REA, to scale losses associated with biological and groundwater resources with restoration. The Trustees plan to use a restoration-based approach to determine damages for ecological injuries (43 CFR § 11.83(b)). This means that the damages sought would equal the costs associated with restoring the natural resource and associated services that were injured. For example, this could include costs associated with acquiring, preserving, and restoring habitat that supports the injured resource.

7. RESTORATION PLANNING

After determining the amount of restoration necessary to compensate the public for lost services, the Trustees will prepare a Restoration Plan pursuant to 43 CFR § 11.93. The Restoration Plan will evaluate and describe how the calculated amount will be utilized for restoration. The Trustees may accomplish restoration through rehabilitation, replacement, and/or acquisition of equivalent resources (43 CFR § 11.81 (a)). Efforts often focus on direct restoration of the injured resources. However, in the absence of opportunities for direct restoration, restoration may, if appropriate, include actions that improve the quality of natural resources located away from the Assessment Area. The Trustees will issue additional documents pursuant to the CERCLA NRDAR regulations to obtain input from the public on restoration planning efforts and decisions.

8. DATA MANAGEMENT

Assessments employing Type B methods are required to develop a Quality Assurance Plan (QAP) that adheres to the requirements of the NCP (40 CFR § 300.5) and guidance provided by USEPA (43 CFR § 11.31(c)(2)). The purpose of the QAP is to ensure that data are of sufficient quality to be used for injury assessment and damage determination. For any new Trustee-led data collections, there will be an associated QAP that will be developed and made publicly available. The data management procedures described below are general and will pertain to existing data or data collection activities not led by the Trustees.

The QAPs developed for this damage assessment will be modeled after USEPA requirements for QA Project Plans (USEPA 2001) and USEPA Guidance for QA Project Plans (USEPA 2002a). In general, each QAP should provide sufficient detail to demonstrate that:

- The project's technical and quality objectives (i.e., data quality objectives) are identified;

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- The intended measurements or data acquisition methods are appropriate for achieving project objectives;
- Assessment procedures are sufficient for confirming that data of the type and quality needed and expected are obtained; and
- Any limitations on the use of the data can be identified and documented.

Accordingly, the plans developed for this assessment will address the four general elements identified by USEPA guidance as described below:

- 1) Project Management - documents that the project has a defined goal(s), that the participants understand the goal(s) and the approach to be used, and that the planning outputs are documented;
- 2) Data Generation and Acquisition - ensures that all aspects of project design and implementation including methods for sampling, measurement and analysis, data collection or generation, data handling, and Quality Control (QC) activities are identified and documented;
- 3) Assessment and Oversight - assesses the effectiveness of the implementation of the project and associated QA and QC activities; and
- 4) Data Validation and Usability - addresses the QA activities that occur after the data collection or generation phase of the project is completed.

Data will be managed in compliance with USFWS procedures to ensure that it is accurate and accessible for this NRDAR. The final study plans and other documents for this case are housed on the DOI Damage Assessment and Restoration Tracking System website and are available to the public.

Raw data will be housed within a USFWS digital data repository characterized by a persistent identifier. The repository must allow both public and private access such that confidentiality can be maintained if deemed appropriate.

Various data sources are available to assess baseline conditions and inform understanding of natural resource injuries that occurred as a result of releases from the Facility. Data sources will be screened to verify that supporting documentation is sufficient to allow for an evaluation of the reliability and usability of the information. Individual injury assessment study plans and reports will discuss any relevant uncertainties. Analytical data will be validated by an independent third party using the QAP and USEPA Guidance on Environmental Verification and Validation (USEPA 2002b). Required information will differ with data and information types, but may include:

- Sampling methodology, including information on sample locations, environmental media sampled, and measurement units;
- Chemical analysis, including information on detection limits and methodology accompanying QA/QC data or separate QA/QC report;
- Raw data or data tabulations (e.g., rather than figures only); and

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- Agreement from a governing body such as the USEPA, Trustees, or technical experts, that the data collection methods/analysis were appropriate (e.g., published in a peer reviewed journal; approved for use in the remedial process or by the Trustees).

The Trustees may compile data from multiple sources to assess injury. Quality checks will be made on all data that is keyed into an electronic format. Metadata will meet an acceptable metadata standard such as ISO 17025, 25PA chapter 252, FGDC CSDGM, or ISO 19115. Digital repositories will meet appropriate guidelines with persistent identifiers and machine-readable open formats.

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