Draft Restoration Plan / Environmental Assessment For the Tittabawassee River System Natural Resource Damage Assessment

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November 7, 2019

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

LIST OF ACRONYMS

AOC	Administrative Order on Consent
BIA	Bureau of Indian Affairs
BMP	Best Management Practice
CD	Consent Decree
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
C.F.R.	Code of Federal Regulations
CWA	Clean Water Act or Federal Water Pollution Control Act
DMDF	Dredged Material Disposal Facility
DOI	U.S. Department of the Interior
DNAPL	Dense non-aqueous phase liquid
DSAY	Discounted service acre-year
EA	Environmental Assessment
EGLE	Michigan Department of Environment, Great Lakes, and Energy[1]
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FCA	Fish Consumption Advisory
FONSI	Finding of No Significant Impact
HEA	Habitat Equivalency Analysis
MDAG	Michigan Department of Attorney General
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MOA	Memorandum of Agreement (e.g. between Dow and the Trustees)
MOU	Memorandum of Understanding (e.g. among the Trustees)
NEPA	National Environmental Policy Act
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NREPA	Natural Resources and Environmental Protection Act
NRDA	Natural Resource Damage Assessment
NRDAR	Natural Resource Damage Assessment and Restoration
NWR	National Wildlife Refuge
PCDD	Polychlorinated dibenzo-*p*-dioxins
PCDF	Polychlorinated dibenzofurans
PRP	Potentially Responsible Party
PV	Present value
RCRA	Resource Conservation and Recovery Act
REA	Resource Equivalency Analysis

[1] EGLE was formerly the Michigan Department of Environmental Quality (MDEQ)

RGIS	Revetment groundwater interceptor system
RP/EA	Restoration Plan/Environmental Assessment
TCDD	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
TEQ	Toxic equivalents relative to TCDD
TNC	The Nature Conservancy
TRV	Toxicity reference value
TWG	Technical Work Group
USACE	U.S. Army Corps of Engineers
U.S.C.	U.S. Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

EXECUTIVE SUMMARY

The Dow Chemical Company (Dow) released a wide range of hazardous substances from its Midland, Michigan, plant location starting in the 1890s. One of the major chemical production processes at Dow was electrolysis of brine using carbon electrodes. This process likely produced significant amounts of the polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) that were released to the Tittabawassee River and into the air. PCDDs and PCDFs reached soils through atmospheric deposition in the Midland area and, though various routes, reached water, sediments, and floodplain soils along the Tittabawassee River and then downstream into the Saginaw River and Saginaw Bay of Lake Huron. Natural resources (e.g., sediments, invertebrates, fish, birds, and mammals) have been exposed to and adversely affected by the releases of PCDDs, PCDFs and other hazardous substances. Remedial activities are ongoing under the direction of the U.S. Environmental Protection Agency (USEPA) and the Michigan Department of Environment, Great Lakes, and Energy (EGLE), formerly the Michigan Department of Environmental Quality (MDEQ)[2].

Under federal law, through the Natural Resource Damage Assessment and Restoration (NRDAR) process, natural resource Trustees are authorized to assess and recover damages resulting from injuries to natural resources attributable to hazardous substance releases. Damages recovered from the parties responsible for the releases of hazardous substances may be in the form of restoration projects or money that the Trustees then use to plan and implement actions to restore, replace, rehabilitate, and/or acquire the equivalent of injured natural resources and the services they provide. Trustees in this case, the State of Michigan, acting through EGLE, Michigan Department of Natural Resources (MDNR), and Michigan Department of Attorney General (MDAG); the United States Department of the Interior, acting through U.S. Fish and Wildlife Service (USFWS) and the Bureau of Indian Affairs (BIA); and the Saginaw Chippewa Indian Tribe of Michigan (Tribe), developed this Draft Restoration Plan and Environmental Assessment (Draft RP/EA) in accordance with 43 C.F.R. § 11.93 to inform the public as to the types and amount of restoration that are expected to compensate for injuries to natural resources and the services they provide associated with releases of hazardous substances from the Dow plant in Midland, Michigan.

Under the National Environmental Policy Act (NEPA), federal agencies must identify and evaluate environmental impacts that may result from federal actions. In this Draft RP/EA, the Trustees describe the purpose and need for action, identify potential restoration alternatives, including a No Action alternative, summarize the affected environment, and describe the potential environmental consequences of proposed restoration activities. The Trustees are soliciting comments on this Draft RP/EA, and will address comments in preparing a final RP/EA wherein the Trustees will identify the Selected Restoration Alternative.

[2] The MDEQ became the Michigan Department of Environment, Great Lakes, and Energy (EGLE) effective April 22, 2019. In this document, "EGLE" will be used to refer to this agency except when referring to documents authored or published by the MDEQ.

CHAPTER 1: INTRODUCTION AND SUMMARY

1.1 Purpose and Need for Restoration

This Draft RP/EA has been prepared by the Trustees to address natural resources injured and ecological services lost due to releases of hazardous substances from Dow's plant located in Midland, Michigan. The purpose of this Draft RP/EA is to present the "Preferred Alternative" restoration projects that will accomplish the goal of restoring, rehabilitating, replacing and/or acquiring the equivalent of those natural resources, and the services those natural resources provide, that have been injured from the releases.

For decades, hazardous substances including polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) were released into the Tittabawassee River, and transported downstream into the Saginaw River and Saginaw Bay, and also into associated floodplains and upland habitat. A number of natural resources, including sediments, invertebrates, fish, birds, and mammals have been exposed to and adversely affected by releases from Dow's Midland plant. Ongoing response actions to reduce PCDD and PCDF exposure in the system include removal of sediments and floodplain soils, capping sediments, and stabilizing banks to prevent erosion and re-suspension of contaminated particles in the river. Long-term monitoring and additional risk assessments will be conducted following removal and stabilization in and along the Tittabawassee River downstream of Midland and in the first few miles of the Saginaw River. Results of these efforts will be used to determine if additional remediation will be required in these areas while additional remedial investigations will be conducted farther downstream. This strategy is being implemented in stages and will likely continue for at least five more years. Impacts from the releases are expected to continue into the future, as remedial efforts are not likely to remove all PCDDs and PCDFs from the system.

The Trustees developed this Draft RP/EA in accordance with 43 C.F.R. §11.81 and 43 C.F.R. § 11.93 to inform the public as to the types and scale of restoration to be undertaken towards compensating for injuries to natural resources. In doing so, this document includes a reasonable number of restoration alternatives, identifies a preferred alternative, and explains how the preferred alternative provides restoration of injured natural resources and compensatory value for the natural resources services lost to the public. Additionally, this Draft RP/EA serves as an EA pursuant to NEPA and its implementing regulations at 40 C.F.R. Part 1500 and 43 C.F.R. Part 46 summarizing the current environmental setting, describing the purpose and the need for restoration, identifying potential alternative actions, assessing their applicability and their potential impact on the quality of the physical, biological, and cultural environment, and public participation. Public comments are being sought on this Draft RP/EA and will be considered and incorporated in the final RP/EA as appropriate.

1.2 Trustee Authority and Natural Resource Damage Assessment and Restoration

Under federal law, the Trustees are authorized to act on behalf of the public to assess injuries to natural resources and services resulting from the release of hazardous substances into the environment. The NRDAR process, formalized in the DOI regulations (43 C.F.R. Part 11), allows Trustees to pursue claims against responsible parties for monetary damages based on these injuries in order to compensate the public. The goal of this process is to plan and

implement actions to restore, replace, or rehabilitate the natural resources that were injured or lost as a result of the release of a hazardous substance, or to acquire the equivalent natural resources or the services they provide (Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9601 *et seq*.; 43 C.F.R. Part 11).

The following authorities authorize federal, state and tribal governments to act on behalf of the public as Trustees of natural resources:

- CERCLA, as amended (42 U.S.C. § 9601 *et seq*.)
- Federal Water Pollution Control Act, 33 U.S.C. § 1251, *et seq.* (more commonly known as the Clean Water Act or CWA)
- The Oil Pollution Act of 1990 (OPA)(33 U.S.C. § 2701-2761 *et seq*.)
- Executive Order 12580 (52 Federal Register (FR) 2923 (January 23, 1987)), as amended by Executive Order 12777 (56 FR 54757 (October 19, 1991))
- National Contingency Plan (40 C.F.R. §§ 300.600 *et seq*.)

In addition, the State of Michigan has authorities for response, NRDA and mitigation under Michigan's Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).

The Trustees for this NRDAR are the State of Michigan, acting through EGLE, MDNR, and MDAG; DOI acting through USFWS and BIA; and the Saginaw Chippewa Indian Tribe of Michigan. A Trustee Memorandum of Understanding (MOU) was executed in February 2006, formalizing this collaborative process. The Trustee responsibilities outlined in the MOU include, but are not limited to: assessment of injury to natural resources, restoration planning, developing the cost of restoration, replacement, rehabilitation, and/or acquisition of the equivalent natural resources, and coordination with response actions.

Under CERCLA, the parties responsible for releases of hazardous substances may be invited to participate in a cooperative NRDAR process (43 C.F.R. § 11.32(a)(2)). Although the final authority regarding determinations of injury and restoration rests solely with the Trustees, cooperative assessments can be beneficial to the public by reducing duplication of effort, expediting the assessment, and implementing restoration earlier than might otherwise be the case. Since 2007, Dow has worked cooperatively with the Trustees to conduct assessment studies and develop restoration projects. Dow and the Trustees signed a Memorandum of Agreement (MOA) in September of 2007 that was then amended in 2008, 2012, and 2013. Under the MOA, the parties compiled and reviewed information on the exposure of PCDDs and PCDFs to natural resources including fish, mussels and other invertebrates that live in the rivers, songbirds, and fish-eating birds and mammals and the potential effects resulting from that exposure. The parties also assessed the lost recreational value of natural resources that resulted from fish consumption advisories, wild game consumption advisories, and soil contact advisories, including conducting extensive surveys of anglers and park users. The parties also collected ideas for restoration projects from the public, stakeholders, and partners and developed

additional restoration projects that could compensate for injuries to natural resources and the services provided by natural resources.

The Trustees completed a Damage Assessment Plan in 2008 (Stratus Consulting, Inc. (Stratus), 2008) that summarized existing information on natural resource injuries and described proposed studies to evaluate past, current, and future impacts to natural resources and the services they provide related to the area in which releases from Dow's Midland plant have come to be located. This area is referred to as the Tittabawassee River System Assessment Area (TRSAA) and includes the Tittabawassee River and Saginaw River and their floodplains, Saginaw Bay, and areas affected by aerial deposition from the plant property. In addition, the Damage Assessment Plan outlined how information gathered from the studies would be used to determine the types and scale of restoration needed to address these injuries and how the Trustees would evaluate proposed restoration projects based on specific criteria. During the assessment, certain assessment activities were conducted cooperatively with Dow, as described above, and other activities, including significant data analysis and interpretation, were conducted independently of Dow. The results of the assessment are described in Chapter 3.

The Trustees have reached a proposed settlement of natural resource damage claims with Dow. This Draft RP/EA describes projects that Dow would implement with Trustee oversight and funding that Dow would provide to the Trustees so that they could conduct additional restoration. This Draft RP/EA and a Consent Decree with the terms of the proposed settlement are each subject to public notice and comment, and the Consent Decree is subject to approval by the U.S. District Court. After the close of the public comment periods on the Draft RP/EA and the Consent Decree, the Trustees will respond to public comments and if appropriate, the U.S. Department of Justice will file a motion asking the U.S. District Court for approval of the settlement. Once the U.S. District Court approves the settlement, the Trustees will oversee implementation of restoration projects by Dow, use funding from Dow to implement other restoration projects with partners, oversee long-term stewardship of the restoration projects (including monitoring and maintenance), monitor the recovery of natural resources in the TRSAA, and request proposals from the public for additional projects that are consistent with the Final RP/EA and the Consent Decree.

1.3 Summary of Proposed Settlement

The Trustees, working with the U.S. Department of Justice, intend to lodge a negotiated proposed Consent Decree with Dow in the U.S. District Court for the Eastern District of Michigan to implement various projects to effectuate restoration, replacement, rehabilitation and/or acquisition of the equivalent of the natural resources injured from releases from Dow's Midland plant and/or the services those resources provide.

The proposed Consent Decree will allocate the settlement as follows:

- Dow will complete at its expense eight projects in Midland, Bay, and Saginaw counties;
- Dow will pay $6.75 million into the DOI NRDAR Fund to be expended on an additional five projects specifically described in this RP/EA

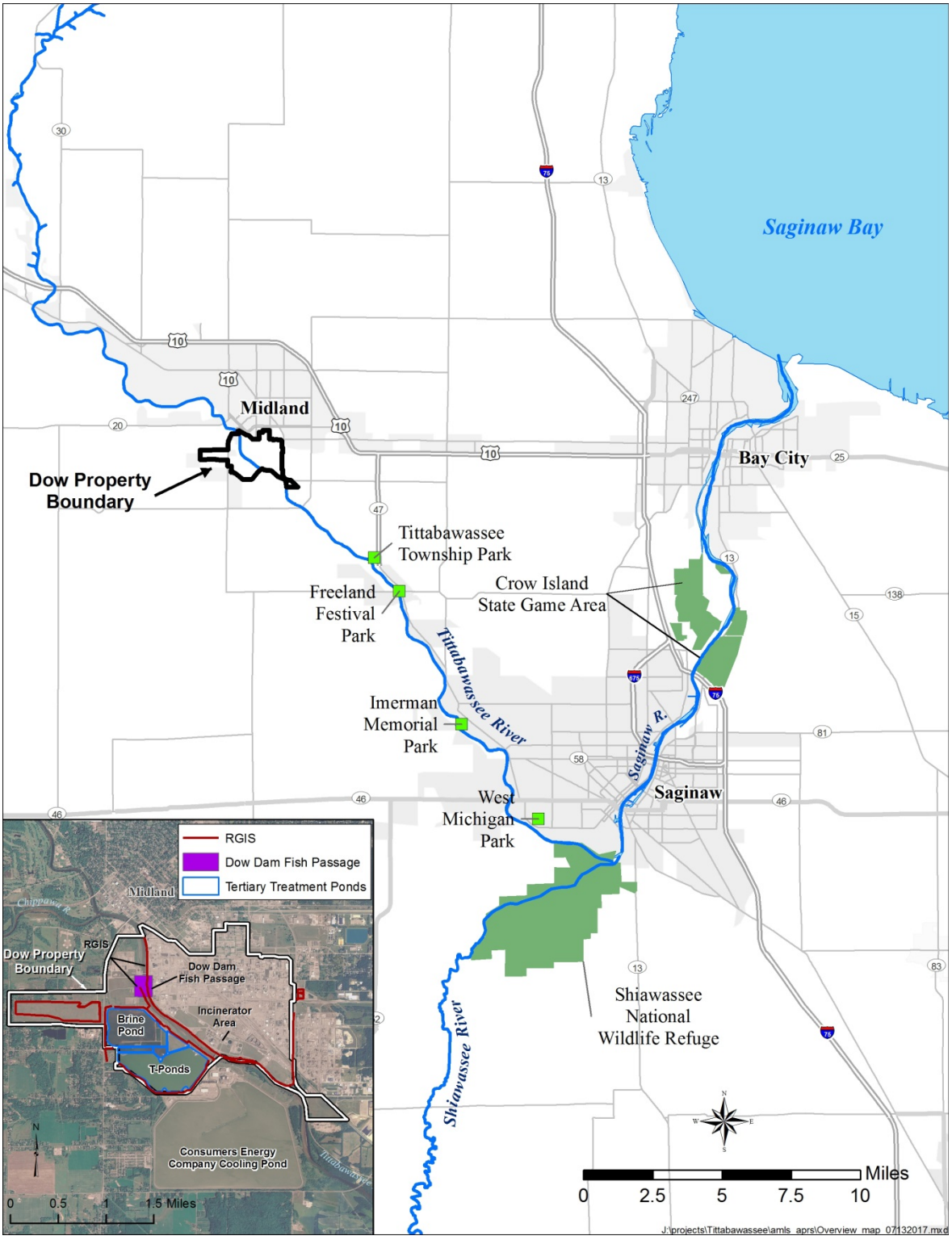
- Dow will pay $15 million into the DOI NRDAR Fund to be expended jointly by the state, federal, and tribal Trustees to assure long-term stewardship of the projects, to conduct monitoring of both the success of the projects and recovery of natural resources in the TRSAA, and to fund additional natural resource restoration projects that are selected from a public proposal process. A minimum of $5 million of this $15 million will be used for the additional restoration projects that will be selected from a public proposal process based on the criteria in the Final RP/EA.

- Dow will reimburse the Trustees for past assessment costs not already provided under the MOA.

1.4 Dow Plant History

The Dow plant located on approximately 1,900 acres along both sides of the Tittabawassee River in Midland, Michigan, (Figure 1) is Dow's headquarters. It has historically been its primary chemical research facility and also a chemical manufacturing facility. The Midland Chemical Company was founded in Midland in 1890 and became the Dow Chemical Company in 1897. The primary product in the 1800s was bleach, which is a chlorine product also known as chloride of lime or calcium hypochlorite. Dow used an electrolytic process that generated chlorine from brine, and bleach was Dow's dominant product until its production stopped in 1914. Dow continued to produce other chlorine-based products, including chlorine gases, caustic soda, liquid chlorine, chlorinated phenols, chlorobenzenes, agricultural products, plastics, synthetic rubber, and Styrofoam™. Production methods changed over time, but electrolytic processes using carbon electrodes (also referred to as graphite rods) were used at the plant into the 1980s. The PCDDs and PCDFs were byproducts of the electrolytic processes that used carbon electrodes. A more detailed history of the chemical production at Dow's Midland plant and tables of chemicals either produced or used throughout the history of the plant are provided in the Trustees' Assessment Plan (Stratus, 2008; See particularly Chapter 3 and Attachment B).

Figure 1. Dow's Midland plant (in black) and the Midland, Saginaw, and Bay City area, including major parks (in green) along the Tittabawassee and Saginaw Rivers



Several dozen of the hazardous substances either used or produced at Dow's Midland plant have been found in the TRSAA, including organic chemicals such as chlorobenzenes, organophosphorus compounds, phthalates, chlorostyrenes, chlorinated phenols, and PCDDs and PCDFs (ATS, 2007, 2008). PCDDs and PCDFs, in particular, have been measured at significantly elevated concentrations in and along the Tittabawassee River, and have been a primary focus of Dow's hazardous waste license, agency-directed cleanup actions, and private party lawsuits.

In addition to contamination found in and along the Tittabawassee River and downstream, hazardous substances have been released through the air from Dow's Midland plant. The incomplete combustion of liquid tars released PCDDs and PCDFs. In the past, incinerator technologies did not have the capability to completely eliminate PCDDs and PCDFs, nor the gas scrubbing technologies to clean emissions to current day standards. This was likely a significant source of atmospheric deposition of PCDDs and PCDFs, which were then distributed through the atmosphere to soils and water (ATS, 2006).

Dow's historical waste management practices allowed releases of hazardous substances, both those manufactured as products and those that were produced as waste at greater levels than current practices allow. Following World War II, Dow significantly and continually upgraded its waste management practices. Dow's waste management history is summarized below from a more detailed account provided in the Trustees' Assessment Plan (Stratus, 2008; see particularly section 3.1.4)

There was no treatment of wastewaters at the Midland Chemical Company and the Dow Chemical Company from 1890 until the early 1920s when settling ponds were put into use. Prior to the 1920's, waste water was discharged directly into the Tittabawassee River. Prior to 1948, solid waste was buried onsite or stockpiled for open air burning (ATS, 2016). In 1948 a kiln upgrade was brought on line. A rotary kiln was placed in service for incinerating rubbish waste and liquids. The Tittabawassee River floods regularly and significantly, and floods often inundated the Midland plant causing stored brine and wastewater to enter the river. In the past, a major source of PCDDs and PCDFs contamination of soils in and around Midland was likely the deposition of ash from the air. Early air emissions, prior to 1948, came from burning stockpiled solid waste in the open air (ATS, 2006).

In the mid-1930's, Dow put additional waste water treatment systems into place, made additional efforts to reduce its discharges, and changed its waste routing practices in order to reduce the volume of waste discharged into the river, all of which was credited with improving the water quality of the Tittabawassee River and Saginaw River and Bay (Michigan Stream Control Commission, 1937). In the 1970s and 1980s, improvements to the on-site waste water treatment plant (WWTP) included construction of tertiary treatment ponds and construction of mixed media sand filters to remove particulate matter after tertiary treatment and before discharge into the Tittabawassee River. In addition, Dow began construction of the revetment groundwater interceptor system (RGIS). The RGIS captures groundwater at the Dow Midland plant before it enters the Tittabawassee River and redirects it back to the WWTP (McDowell and Associates, 1984). The RGIS extends along both sides of the Tittabawassee River and continues to operate.

1.5 Remediation

EGLE and USEPA have overseen numerous investigations and cleanup actions at Dow's Midland plant and outside the plant boundaries to address releases from the plant. Remedial actions, interim response actions, CERCLA removal actions, and remedial investigations conducted in the TRSAA from 1984 through November of 2007 are summarized in sections 3.2.1 and 3.2.2 in the Trustees' Assessment Plan (Stratus, 2008). Since that time, the two major remedial processes have been the Midland Area Soils Corrective Action and the Superfund Alternative Site Remediation.

1.5.1 Midland Area Soils Corrective Action

For the Midland Area Soils Corrective Action, EGLE used its delegated authorities under the Resource Conservation and Recovery Act (RCRA) to address soil contamination in the Midland area that resulted from releases of PCDDs, PCDFs, and other chemicals from Dow's Midland plant. Under EGLE's oversight, Dow remediated soils on residential properties based on the Midland Action Level of 250 parts per trillion (ppt) of total toxic equivalents (TEQs) of PCDDs and PCDFs. Cleanup of residential properties began in 2012 and removals were completed on all properties with willing landowners in 2014. The presumptive remedy for each property undergoing remediation included removal of the upper twelve inches (12") of soil and existing landscaping, followed by replacement with new soil, lawn, and landscaping.

Dow's Revised Corrective Action Report for Midland Area Soils (URS, 2016) summarized the completed cleanups, institutional controls and long-term monitoring. In 2012 through 2014, remedies were completed on 134 properties (or other "decision units" for portions of non-residential parcels) while 1,501 properties and decision units were evaluated that required no further action (URS, 2016).

As part of the Midland Area Soils Corrective Action, an ecological risk assessment was conducted, in addition to the evaluations based on human health. The results of the ecological risk assessment did not result in any additional remediation beyond those being conducted to protect human health. Except for dioxin-like compounds, all chemicals evaluated were either eliminated from additional evaluation for ecological risk or addressed in an uncertainty analysis. The residual ecological risk from dioxin-like compounds was to be considered in the NRDA (URS, 2016).

Long-term monitoring is being conducted by Dow for the Midland Area Soils Corrective Action for the following purposes:

- Obtain access to properties that have not yet granted access;
- Verify that undeveloped woodlands remain consistent with non-residential like use;
- Verify that land use for current non-residential property does not change;
- Verify that agriculturally zoned properties in the City of Midland are monitored for farm animals; and

- Report results and apply adaptive management to the Midland Area Soils Corrective Action.

1.5.2 Superfund Alternative Site Remediation

In late 2009, USEPA and EGLE reached a proposed agreement with Dow for Dow to investigate and remediate contamination in and along the Tittabawassee River, Saginaw River and Saginaw Bay. In January of 2010, following an opportunity for public review and comment, the agencies signed an agreement as an Administrative Order on Consent (AOC) with an accompanying Statement of Work that describes the tasks that Dow must complete (USEPA, 2010a). Under the AOC, Dow has been taking immediate actions to reduce risks at locations along the rivers with high levels of human use (e.g. parks), addressing erosion and movement of highly contaminated riverbanks and sediments, and beginning more comprehensive, systematic cleanup actions for sediments, riverbanks, and floodplain from upstream to downstream of its Midland plant.

The overall Site is defined in the AOC as: 1) the area located in and along the Tittabawassee River and its floodplains beginning at, and including, the Dow Midland plant, extending downstream to, and including, the Saginaw River and its floodplains, 2) Saginaw Bay, and 3) any other areas in or proximate to the Tittabawassee River and its floodplains where the contaminants from the Midland Plant may have come to be located. The Site is further organized into two Operable Units (OUs). OU 1 includes the Tittabawassee River from Midland, and the upper Saginaw River down to and including the Sixth Street Turning Basin. OU 1 is split into eight Segments. OU2 includes the lower Saginaw River and the Saginaw Bay.

As part of the remedial investigations, pilot studies, and remedial design work, approximately 20,000 samples of river sediments, riverbank soils, and floodplain soils have been analyzed for PCDDs and PCDFs. In general, the greatest concentrations in sediments are found associated with sand-sized graphitic particles in both the active bedload of material that is moving through the river system and in sediment deposits along the river. On the riverbanks, the greatest concentrations are found in material that the river has deposited along the banks since the early 1900's, and the areas of greatest concern are those that are eroding or susceptible to erosion. In the floodplains, the greatest concentrations are found within areas that are most frequently flooded. Beyond the eight-year floodplain, concentrations are similar to regional background concentrations.

In OU1, Dow has implemented pilot bank treatments and completed response actions in obviously eroding areas of high contamination known as bank management areas (BMAs), in sediment management areas (SMAs), and on floodplain portions of properties along the Tittabawassee River. From 2007 through 2016, Dow has removed approximately 170,000 cubic yards of contaminated soils and sediments from Tittabawassee River SMAs, BMAs, and floodplains. Other types of remedial actions include the removal of dense non-aqueous phase liquids (DNAPL) from under the river bottom, installation of engineered or natural deposition caps of SMAs, stabilization and removal of BMAs, post-flood response activities, and monitoring. As of the end of 2017, more than 3 miles of banks and 17 SMAs have had response actions. Additional details associated with these response actions are provided in Table 1 below:

Table 1. Response actions completed along the Tittabawassee River, 2007 - 2018

Action Type	Location Addressed	Description of Work in 2007-2017	Current Status (2018)
DNAPL Recovery	Tittabawassee River at Dow	>4,500 gallons of DNAPL pumped from under river	Monitoring and ongoing recovery from shore-based well
Sediment Management[3]	Reach B	Armor stone cap	Construction complete/monitoring
Sediment Management	Reach D	Sediment removal and armor stone and natural deposition cap	Construction complete/monitoring
Sediment Management	SMA 1-2	Geosynthetic clay liner (GCL) and armor stone cap, sheet pile containment	Construction complete/monitoring
Sediment Management	SMA 1-3	GCL and armor stone cap, sheet pile containment	Construction complete/monitoring
Sediment Management	SMA 1-4	Cellular containment system cap	Construction complete/monitoring
Sediment Management	SMA 1-5	Armor stone cap	Construction complete/monitoring
Sediment Management	SMA 1-6	GCL and armor stone cap, sheet pile containment	Construction complete/monitoring
Sediment Management	Reach O	Sediment removal	Construction complete
Sediment Management	SMA 2-1	Cellular containment system cap	Construction complete/monitoring
Sediment Management	SMA 2-2	Cellular containment system cap	Construction complete/monitoring
Sediment Management	SMA 2-3	Sediment removal	Construction complete
Sediment Management	SMA 2-4	Sediment removal, cellular containment system cap and armor stone cap	Construction complete/monitoring
Sediment Management	SMA 2-5	Cellular containment system cap	Construction complete/monitoring
Sediment Management	SMA 3-1	Sediment removal and armor stone cap	Construction complete/monitoring
Sediment Management	SMA 3-2	Cellular containment system cap	Construction complete/monitoring

[3] Sediment management actions each impacted <1/2 acre up to 2 acres

Action Type	Location Addressed	Description of Work in 2007-2017	Current Status (2018)
Sediment Management	Reach MM Island	Soil and sediment removal, armor stone cap	Construction complete/monitoring
Sediment Management	Wickes Park (Segment 8, Upper Saginaw River)	Sediment removal	Construction complete
Bank Management[4]	Reach B river bank; BMA 2-1 through BMA 4-7; Reach N pilot; Reach J/K removal	>18,700 linear feet stabilized with limited excavation /removal, except for complete removal in Reach J/K	Construction complete/monitoring
Bank Management	Segment 4 BMA 4-3 and 4-4	Stabilization with limited removal	2018 work included 2 BMAs totaling 550 linear feet
Bank Management	Segment 5 BMAs	Stabilization with limited removal	2018 work included 9 BMAs totaling 4,562 linear feet
Floodplain Management	Segments 1-3	Remove upper 12", backfill to grade and re-seed for maintained use, some tree removal and planting. Twelve (12) acres remediated through 2016.	Delineation/removal/ monitoring
Floodplain Management	Segment 4	Remove upper 12", backfill to grade and re-seed for maintained use, some tree removal and planting. Non-maintained areas to be replanted with native vegetation. 129 acres require remedial measures.	In progress (2017 and 2018)
Floodplain Management	Segment 5	Land use verifications and delineation	Delineation, removals, grading, re-seeding

[4] Bank management actions each impacted 150 – 2,000 linear feet along shorelines

Action Type	Location Addressed	Description of Work in 2007-2017	Current Status (2018)
Floodplain Management	West Michigan Park	Removing and replacing soil, planting trees and vegetation, and installing new playground equipment on about 8.1 acres.	Construction complete/ post-flood monitoring
Floodplain Management	Riverside Boulevard	Removing and replacing soil, planting trees and vegetation on about 3.4 acres	Construction complete/ post-flood monitoring
Flood Response	Caldwell Boat Launch	Sediment removal, hard surface washing and flushing	Monitoring and recovery
Flood Response	Imerman Park	Sediment removal, hard surface washing and flushing	Monitoring and recovery
Flood Response	Freeland Festival Park	Sediment removal, hard surface washing and flushing	Monitoring and recovery
Flood Response	West Michigan Park	Sediment removal, hard surface washing and flushing	Monitoring and recovery
Flood Response	Center Road	Sediment removal, hard surface washing and flushing	Monitoring and recovery
Flood Response	Riverside Boulevard	Sediment removal, hard surface washing and flushing	Monitoring

Long-term fish monitoring is being used to monitor the success of actions being taken. The fish species being sampled are walleye, channel catfish, and smallmouth bass. Fish were collected and analyzed for all three species in 2014 and 2018 and for only channel catfish in 2016. The fish monitoring plan calls for channel catfish to be sampled every two years and the other two species every four years. Additionally, incremental composite sampling of surface sediment from each quarter mile stretch of Segments 2 – 7 is routinely conducted to see if there are sediment TEQ concentration changes over time.

Under the AOC, Dow is required to submit human health and ecological risk assessments following response actions. These are described as post-response residual risk demonstrations in Task 10 of the AOC. USEPA, in consultation with EGLE, may require Dow to submit a multi-segment, OU-wide, or site-wide residual risk assessment. If a residual risk analysis demonstrates that residual risk does not fall within an acceptable range, Dow will be required to conduct additional analyses, predict how long it may take to achieve acceptable risk, and continue

monitoring. Depending on the results of the analyses and monitoring, Dow may be required to submit new proposals to do additional response work, as appropriate, in the river sediments, banks, and/or floodplain.

1.6 NRDAR Relationship to Remedial Activities

NRDAR is a process that occurs in addition to the remedial process conducted by regulatory agencies like the USEPA. NRDAR and the remedial processes have different goals. Remedial action objectives are risk-based and are developed to protect human health and the environment from further unacceptable harm. The goal of NRDAR is the restoration of natural resources to their baseline condition, or what their condition would be absent the release of a hazardous substance, and to provide compensatory restoration for losses over time. Losses resulting from natural resource exposure to released hazardous substances are estimated over time from the time of release until the natural resource is expected to be restored. These losses can extend beyond the date of remedy completion if contaminants will be left in the environment at levels injurious to natural resources. These losses can also occur in areas beyond the locations where remedial actions are taken. For example, fish consumption advisories may apply to many miles of a river downstream of a release, but remedial actions may only be conducted in depositional areas that contain relatively large masses of contaminants.

There are components of NRDAR and remedial actions that may overlap. Work to remedy a site may partially or completely mitigate injured natural resources, and damage estimates take this into account. Remedial decisions can include consideration of restoration objectives identified by the NRDAR process. Remedial actions may also cause an unavoidable increase in injury to habitat, like cutting down trees during a contaminated soil removal action, and this kind of collateral, remedy-induced injury can be included within the NRDAR process.

For the NRDAR process for the TRSAA, the Trustees have interacted and continue to interact with USEPA and EGLE as they evaluate, select, design, and implement remedies. This coordination provides an understanding of the remedial process and helped the Trustees evaluate how each of the remedial decisions affects estimates of natural resource damages. This also allows the Trustees to have early input on the development of response actions that minimize damage to natural resources.

1.7 Compliance with National Environmental Policy Act and Other Authorities

Restoration alternatives described in this document will be conducted in compliance with all applicable federal, state, and local regulations.

Federal natural resource and environmental laws, orders, and regulations considered during the development of this Draft RP/EA include but are not limited to the: Endangered Species Act (ESA) of 1973; Migratory Bird Treaty Act of 1918; National Historic Preservation Act of 1966; Archeological and Historic Preservation Act of 1974; Fish and Wildlife Coordination Act of 1934; U.S. Fish and Wildlife Mitigation Policy of 1981; Information Quality Act of 2001; Executive Order 11990 on Wetlands of 1977; and Executive Order 11988 on Floodplains of 1977.

The major state environmental statutes and programs considered during the development of this Draft RP/EA include but are not limited to the Michigan's Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA): Part 31, Water Resources Protection; Part 91, Soil Erosion and Sedimentation Control; Part 301, Inland Lakes and Streams; Part 303, Wetlands Protection; and Part 365, Endangered Species Protection.

Actions undertaken by the Trustees to restore natural resources or services under CERCLA and other federal laws are subject to the National Environmental Policy Act (NEPA) (42 U.S.C. § 4321 et seq.) and the regulations guiding its implementation at 40 C.F.R. Parts 1500 through 1517 and the DOI NEPA regulations at 43 C.F.R. Part 46. These authorities outline the responsibilities of federal agencies in their decision making process of proposed actions and consider the relevant NEPA documentation. In general, federal agencies contemplating implementation of a major federal action must produce an environmental impact statement (EIS) if the action is expected to have significant impacts on the quality of the human environment. When it is uncertain whether a contemplated action is likely to have significant impacts, federal agencies prepare an environmental assessment (EA) to evaluate the need for an EIS. If the EA demonstrates that the proposed action will not significantly impact the quality of the human environment, the agency issues a Finding of No Significant Impact (FONSI), which satisfies the requirements of NEPA, and no EIS is required. For a proposed RP, if a FONSI determination is made, the Trustees may then issue a final RP describing the selected restoration action(s).

In accordance with NEPA and its implementing regulations, this Draft RP/EA summarizes the current environmental setting; describes the purpose and need for restoration actions; identifies alternative actions; assesses their applicability and potential impact on the quality of the physical, biological, and cultural environment; and outlines public participation in the decision-making process.

1.8 Public Participation

Public participation and review are an integral part of the restoration planning process and are specifically required in the DOI NRDAR regulations (e.g., 43 C.F.R. §11.81(d)(2)). In addition, NEPA and its implementing regulations require that federal agencies fully consider the environmental impacts of their proposed decisions and that such information is made available to the public. To facilitate public involvement in the ecological and recreational restoration planning process, the Trustees have been meeting with interested stakeholders since 2005 (Appendix A).

To continue the Trustees' dedication to public involvement, this Draft RP/EA is available for public review and comment for at least 30 days in accordance with 43 C.F.R. § 11.81(d)(2). The Trustees will address public comments and will document responses to those comments as part of the final RP/EA.

Comments may be submitted in writing or electronically and are due to the Trustees by 45 days after DOJ publishes a Federal Register Notice advising the public of the opportunity to submit comments on the Draft RP/EA. To submit a comment, request a hard copy of the Draft RP/EA, or for additional information, please contact:

Lisa L. Williams

U.S. Fish and Wildlife Service
2651 Coolidge Road
East Lansing, MI 48823
t.river.nrda@fws.gov (use "TR RP/EA comment" in the subject line for submitting comments).

Copies of this document are available online and the Federal Register Notice with the due date for comments will be posted at:
https://www.fws.gov/midwest/es/ec/nrda/TittabawasseeRiverNRDA

As restoration progresses, the Trustees may amend the RP/EA if significant changes are made to the types, scope, or impact of the projects. In the event of a significant modification to the RP/EA, the Trustees will provide the public with an opportunity to comment on that particular amendment.

1.9 Administrative Record

An administrative record consisting of a catalog of all documents Trustees used to develop and make decisions related to the NRDAR process, including this Draft RP/EA, is maintained by USFWS at the Michigan Ecological Services Field Office in East Lansing, MI.

1.10 Organization of the Draft RP/EA

The remainder of this document is organized as follows:

- Chapter 2 describes the affected environment for the area in which injury was assessed (the TRSAA) as well as the expanded area in which proposed restoration actions could occur.
- Chapter 3 describes the injury assessment strategy, assessments conducted for ecological resources and human uses of those resources, and restoration project scoping.
- Chapter 4 describes restoration alternatives.
- Chapter 5 evaluates the restoration alternatives, including their environmental impacts and their relationship to the Trustees' restoration criteria.
- Chapter 6 describes the reasons for proposing the preferred alternative for restoration of natural resources and human uses of natural resources.
- Chapter 7 lists the preparers of this document and other agencies, tribes, and persons consulted.

CHAPTER 2: AFFECTED ENVIRONMENT – NATURAL RESOURCES / WATERSHEDS

In this Draft RP/EA, the Trustees describe their assessment of natural resource injuries and associated losses in ecological and recreational services resulting from exposure to releases from Dow's Midland plant and their evaluation of restoration options to compensate the public for these losses. As such, the affected environment described in this chapter includes both the area in which injury was assessed (the TRSAA, included in Figure 2) as well as the expanded area in which proposed restoration actions could occur (the Saginaw Bay watershed, shown in Figure 3). Information on the current natural resources of the area will assist the Trustees in planning future restoration activities and ensure that potential restoration projects are designed to both maximize ecological and human use benefits while also minimizing or eliminating project-related adverse environmental consequences.

This chapter presents a description of the physical, biological, and cultural environment for the waterways and ecosystems of the affected environment as required by NEPA (42 U.S.C. § 4321, et seq.).

Figure 2. Tittabawassee River System Assessment Area and vicinity

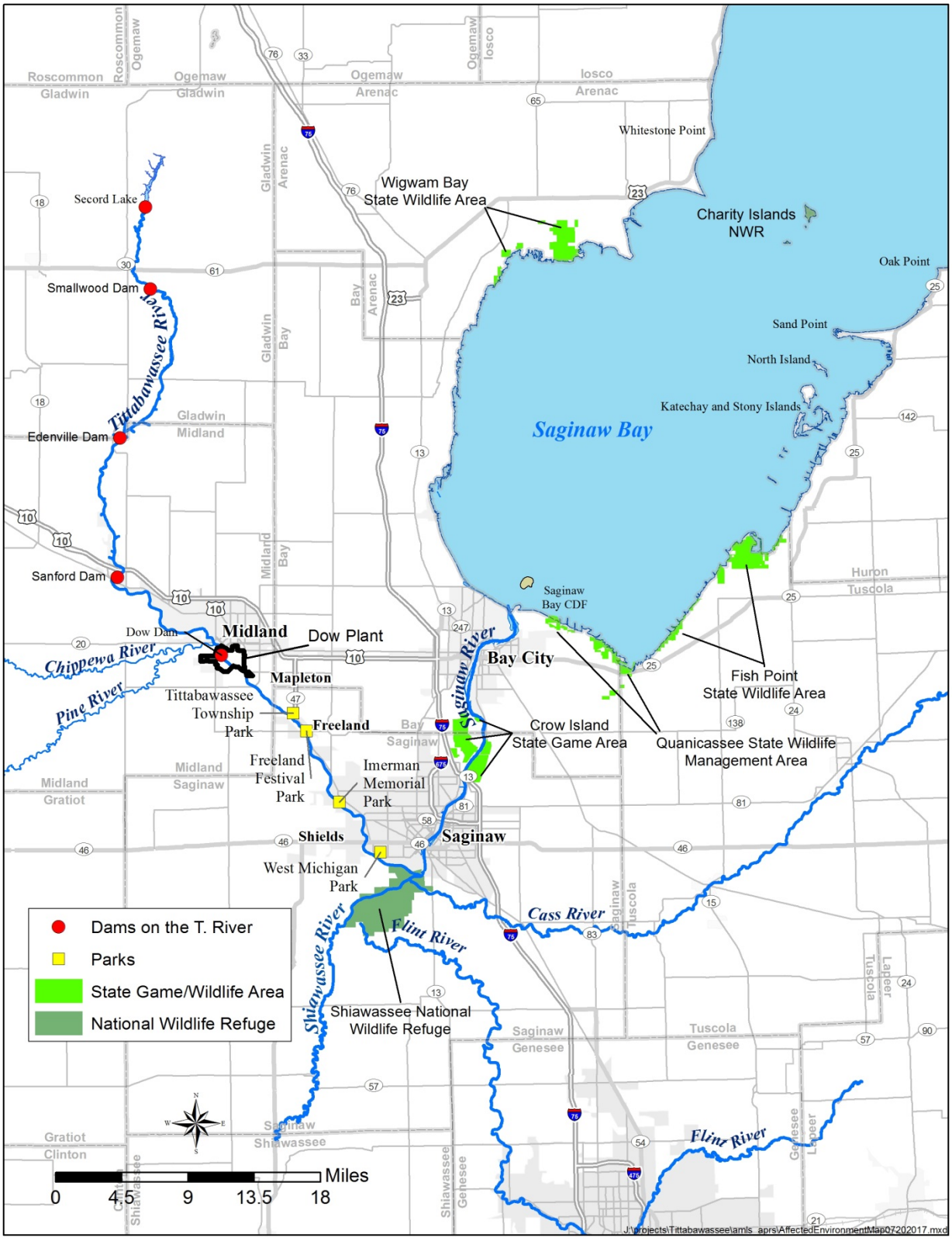


Figure 3. Saginaw Bay watershed in Michigan

2.1 Physical Environment

The Saginaw Bay Watershed encompasses an area of approximately 8,700 squares miles over all or parts of 22 counties in the eastern portion of the lower peninsula of Michigan. Saginaw Bay itself is 1,100 square miles with Saginaw River being its largest tributary. The Saginaw River flows 22 miles from where the Tittabawassee and Shiawassee rivers converge near the City of Saginaw to its mouth at Saginaw Bay. Much of the watershed is in the Saginaw and Tawas Lake Plain Ecoregions with the watersheds of headwater streams extending into the Mio Plateau, Cadillac Hummocky Moraines, Lansing Loamy Plain, and Interlobate Dead Ice Moraines (USEPA, 2010b)

2.1.1 Tittabawassee River location, geomorphology, hydrology, and anthropogenic influences

Location

The Tittabawassee River drains a 2,600 square mile watershed in the east-central Lower Peninsula of Michigan. The Tittabawassee River and its watershed are described in detail in Schrouder et al. (2008) and a summary is provided here. The headwaters of the Tittabawassee River are coldwater streams that begin in the largely forested landscape of Ogemaw and Roscommon counties and transition to coolwater streams before entering the Secord Lake impoundment (Schrouder et al., 2008). From Secord Lake downstream, the Tittabawassee River is a warmwater system. It is influenced by four hydropower dams as it flows 36 miles from the Secord Dam to the Sanford Dam: Secord, Smallwood, Edenville, and Sanford Dams (FERC, 1998). Of the four, the Sanford Dam exerts the greatest influence on river flow, causing daily fluctuations in response to hydroelectric energy demand and production (ATS, 2007). The Pine and Chippewa rivers join the Tittabawassee River upstream of the City of Midland. The Dow Dam is located adjacent to the Midland plant, and below this dam the river is free flowing until it reaches its confluence with the Shiawassee and Saginaw rivers. The Dow Dam is used to maintain hydraulic head for Dow's operations, including a groundwater revetment system that intercepts groundwater for treatment before it reaches the river.

On the stretch of river below Midland, the river flows south and southeast for 22 miles before its confluence with the Shiawassee and Saginaw rivers. Within this reach, there are numerous small agricultural drains that flow into the river. The Towns of Mapleton, Freeland, and Shields are located along the river. The Tittabawassee River joins the Shiawassee River in the Shiawassee National Wildlife Refuge (NWR) to form the Saginaw River south of the City of Saginaw and just downstream of where the Flint and Cass rivers each join the Shiawassee River.

Geomorphology

Between Midland and Saginaw, the Tittabawassee River valley is characterized by relatively flat floodplains extending to a steep scarp rising to upland areas. The river channel varies from relatively straight between the Dow Midland plant and Freeland Park (approximately 4.5 river miles), to a more sinuous system downstream of Freeland Park. The straight nature of the upper part of the river is the result of anthropogenic activities and restrictions, including historical

logging operations, extensive sheet pile along the riverbank, and steep constructed banks along the Midland plant (ATS, 2006, 2007).

Between Freeland Park and the confluence with the Shiawassee River, there are fewer laterally constraining anthropogenic features. Moving downstream, the channel becomes more sinuous and meanders through a broadening floodplain, displaying erosional and depositional features, such as cut banks, point bars, levees, and overbank deposits. Erosion tends to occur on the outsides of the river bends, forming cut banks, and deposition tends to occur on the inside of the bends, forming point bars. Depositional features also occur within the floodplain, including levees and overbank deposits. Overbank deposits are found in low-lying areas of the floodplain where fine materials settle out of suspension following floods. Levees are ridges or embankments of sand and silt that are built by the river on its floodplain along both banks of its channel. Levees accrue particularly during flood events when water overflowing the normal banks slows and deposits larger grained particles. The Tittabawassee River has a distinct double-levee geomorphology, consisting of what are often referred to as "pre-industrial" and "post-industrial" natural levees. The formation of the levees is thought to be associated with changes to the hydrology and hydraulics of the river caused by dam installation, first during the logging era ("pre-industrial" levees), and later for flood control and hydro-electric power generation ("post-industrial" levees; ATS, 2006, 2007). In particular, the construction of the Sanford Dam in 1925 caused a narrowing of the river channel, which formed the younger "post-industrial" levees interior to the older "post-industrial" levees (ATS, 2006).

Flow regime

The upper part of the Tittabawassee River watershed is dominated by porous, well-drained soils that result in relatively stable river flows, whereas the lower part of the watershed generally has heavier, poorly drained soils that are tiled and ditched to promote rapid drainage of agricultural lands. These soil types and drainage alterations result in a flow regime that is "flashy," meaning that it has highly variable flows with a rapid rate of change (ATS, 2007). The average and 100-year flood flow rates for the river, based on data from 1937 and 1984, are approximately 1,700 cubic feet per second (cfs) and 45,000 cfs, respectively (Johnson Co., 2001). The Tittabawassee River has a long history of flooding, with flows greater than 20,000 cfs occurring in 22 of the 95 years of monitoring. The flood stage of the river at Midland is 24 feet (17,300 cfs), but at 20 feet (approximately 9,000 cfs) some bank overflow begins in isolated areas (NOAA, 2007).

Anthropogenic influences

The Tittabawassee River's geomorphology has been affected by many human activities, including extensive logging, construction of dams for flood control and hydroelectric power generation, and riverbank stabilization by riprap or sheet piling. Daily fluctuations in river water levels due to the operation of four dams upstream of Midland, plus also potentially operation of dams on significant tributaries, may play a significant role in bank erosional processes. Forested headwaters of the Tittabawassee River, north of Midland, were once dominated by eastern hemlock (*Tsuga canadensis*), eastern white pine (*Pinus strobus*), and sugar maple (*Acer sacharum*; MNFI, 1998). Beginning in about 1847, this forest was extensively logged (ATS, 2006). Saw logs were rafted down the river to mills in the City of Saginaw. The intensive logging substantially reduced vegetative cover and affected the hydrology of the watershed.

Erosion and sedimentation increased due to increased surface runoff, and base flow decreased. Logjams were common and also affected river flow, erosion, deposition patterns, and aquatic riparian habitat. The Dow Dam, constructed at the Dow Midland plant in Midland in 1945 to provide a reliable water source for Dow plant operations, further altered river geomorphology. Sheet piling and other construction on the riverbank along the Dow plant site also have had substantial impacts on in-stream and riparian habitats (ATS, 2006, 2007). For example, artificial stabilization of riverbanks through the plant site likely increased the incision of the river within its current channel and decreased habitat complexity. Ongoing bank treatments conducted along sections of the shoreline as part of the remedial process are affecting habitat by reducing tree canopy and understory, eliminating large woody debris, adding some artificial materials to stabilize banks and shifting the ground layer of vegetation by promoting native grasses and forbs with extensive root systems and reducing wild grape (*Vitis riparia*), Virginia creeper (*Parthenocissus quinquefolia*) and other plants that provided less extensive root systems along the shoreline.

2.1.2 Saginaw River location, geomorphology, hydrology, and anthropogenic influences

Location

The Saginaw River begins at the confluence of the Tittabawassee and Shiawassee rivers, and runs in a generally northeasterly direction, emptying into Saginaw Bay of Lake Huron approximately 90 miles north of Detroit, Michigan. The Saginaw River is 22 miles long and most of its flow originates from four major tributaries: the Cass, Flint, Shiawassee, and Tittabawassee rivers. The Saginaw River is a relatively low energy river that varies in width from 375 feet to 800 feet.

Geomorphology

The channel of the Saginaw River is relatively straight. In the urban areas of Saginaw and Bay City, the shoreline is dominated by industrial and urban development, but a few parks are also present along the river. The banks here are armored with various types of riprap and sheet pile and flooding over the banks is infrequent (ATS, 2006). Between the two urban areas, the river corridor largely consists of agricultural lands and the Crow Island State Game Area (Figure 1).

Anthropogenic influences

The U.S. Army Corps of Engineers (USACE) has actively dredged the Saginaw River channel since 1963 to accommodate commercial shipping activity (USACE, 2007). Dredged sediments have either been placed in open water out in the Bay, or deposited in one of two disposal facilities: the Saginaw Bay Confined Disposal Facility (CDF) or the Saginaw Upper Dredged Material Disposal Facility (DMDF) (Figure 2). Sediments dredged from parts of the navigation channel in the Saginaw River and Saginaw Bay have elevated levels of polychlorinated biphenyls (PCBs; MDNR, 1994c), and hence require confined disposal (USACE, 2007). Dredging activities have likely redistributed contaminated sediments within the TRSAA. Shipping along the Saginaw River may also contribute significantly to the redistribution of contaminated sediments. Like the Tittabawassee River, the Saginaw River has been affected by

historical activities related to logging. The Saginaw River was the site of numerous sawmills in the 1800s and early 1900s. It also served as a port for Great Lakes vessels. Later, the bicycle and automobile industries replaced lumber mills, bringing their own industrial impacts. General Motors owned and operated four major automobile manufacturing plants along the Saginaw River beginning in the 1910s (CRA, 1992). Municipal wastewater treatment plants are also located along the Saginaw River in the City of Saginaw and Bay City. Urbanization of the watershed, channelization of the river, active dredging, commercial shipping, and industry have altered aquatic habitats.

2.1.3 Saginaw Bay

Saginaw Bay is on the western shore of Lake Huron. The Bay has a drainage basin of 8,700 square miles. Twenty-eight rivers, creeks, and drainages flow directly into Saginaw Bay, but approximately 75% of the tributary hydraulic load comes from the Saginaw River (Beeton et al., 1967). The Bay is 26 miles wide at the mouth and 51 miles long from the midpoint to the mouth of the Saginaw River. Saginaw Bay has a surface area of 1,143 square miles (MDNR, 1994c). A broad shoal between Charity Island and Sand Point divides the Bay into outer and inner zones. The outer zone is considerably deeper (mean depth 48 feet, maximum 133 feet) than the inner zone (mean depth 15 feet, maximum 46 feet). The eastern shore of the outer bay is rocky, and the western shore is sandy. The bay has several islands; the most prominent is Charity Island between Whitestone and Oak points. A group of marshy low-lying islands (North, Stony, and Katechay) lies southwest of Sand Point on the southeast shore of the Bay. These islands are surrounded by marshy shallows that provide important habitat for waterfowl (PSC, 2002).

The typical surface current in the Bay is counterclockwise, due to a strong Lake Huron current that flows down the western edge of the outer bay (Batchelder, 1973). Long-term chloride monitoring by Dow indicates that waters from the Saginaw River flow north along the eastern shore of the Bay toward the open waters of Lake Huron. The Bay freezes in the winter, and ice flows along the deeper water west of the Coreyon Reef.

2.1.4 Climate in the Saginaw Bay region

Michigan has a cold climate with a warm summer and no distinct dry season (Peel et al., 2007). Winters are long and cold, influenced by continental polar air masses from northwest Canada and the Arctic. Summers are cool to warm, dominated by moist tropical air masses from the Gulf of Mexico. The spring and fall seasons are transition periods with frequent fronts moving through the area. Rainfall is typically greatest in the summer and is dominated by short-lived thunderstorms rather than prolonged rain, with 10 to15 sunny days per month. Winter storms are driven by the polar jet stream, which brings frequent storm systems characterized by cloudy skies (less than 5 sunny days per winter month), windy conditions, and precipitation (Hayhoe et al., 2010; Meteoblue, 2017). Current annual average precipitation in Saginaw and Midland is approximately 33 inches of rain and 42 inches of snow; average temperature (across all months) is 48 °F with a high of 83 °F in July and low of 16°F in January (U.S. Climate Data, 2017).

Future climate conditions are expected to change in response to increasing atmospheric carbon dioxide (CO_2) concentrations. Michigan has already experienced some changes in climate, including increased annual temperatures, increased summer extreme heat events, increased

growing season duration, shifts in timing and intensity of precipitation, decreases in duration of snow cover and lake ice formation, and lower lake water levels have been observed in lakes Huron and Michigan (Kling et al., 2003; Hayhoe et al., 2010; NOAA, 2011; USEPA, 2016b; USGCRP, 2017). It is generally projected that Michigan will continue to experience higher temperatures and increased winter and spring precipitation, with hotter and drier summers (Kling et al., 2003; Hayhoe et al., 2010; NOAA, 2011; Gronewold et al., 2013; Pryor et al., 2014).

These projected changes to the regional climate will likely have secondary effects on the environment. For example, reduced summer water levels in lakes, rivers, and streams may result in reductions in wet habitat, such as wetland areas. The distribution of forests and other vegetation may change, affecting the distributions of species that depend on these habitats. Food supplies may be available earlier in the year, but diminished in the hotter months of summer, affecting the ability of migratory species to find food (Kling et al., 2003; NWF, 2007; Glick et al., 2011; NOAA, 2011; Pryor et al., 2014; USEPA, 2016b). The distribution of aquatic biota may also change. For example, warmer temperatures may result in species shifts (warm-water fish species may encroach in historically cool-water areas and the ranges of cold-water fish species may become more limited, and they may have reduced abundance), and could help invasive species to become established. Further, timing of migration and spawning events may shift in response to changes in temperature and water flow, and other stressors, such as pollution, may be exacerbated (Kling et al., 2003; Glick et al., 2011; Collingsworth et al., 2017; Myers et al., 2017).

2.2 Biological Environment

2.2.1 Aquatic Habitat

The Tittabawassee and Saginaw rivers both have sandy bottoms, comprised of fine-grained sediment that is generally 1.5 to 7.5 feet thick, though can reach up to 12 feet thick in some areas. In the Tittabawassee River, sediments are transported downstream during periods of high flow – which are common following large precipitation events – and deposited in the floodplain and other depositional areas within the river. The Saginaw River is a lower-energy river, with a wider channel and lower rates of sediment deposition, and less interaction with the floodplain than the Tittabawassee River. As noted in section 2.1, both rivers have been affected by anthropogenic activities, beginning with logging in the mid to late 1800's, dam and berm construction in the 1900s, other infrastructure construction such as bridges and pipeline crossings throughout the 1900s, and contamination. The bottom substrate in Saginaw Bay varies from year to year but ranges from mostly cobble to silt; the relative sand content throughout the Bay has increased since the 1970s (Nalepa et al., 2003; ATS, 2006; Schrouder et al., 2009; Siersma et al., 2014).

Aquatic macroinvertebrate communities found within the Tittabawassee River, Saginaw River, and Saginaw Bay include worms, flatworms, leaches, oligochaetes, crayfish, isopods, amphipods, mayflies, stoneflies, damselflies, caddisflies, true flies, midges, gastropods, and mussels. Aquatic invertebrates serve an important role within aquatic ecosystems by supporting important ecological functions as prey to biota and digesting and degrading plant material (MDNR, 1994a; MDEQ, 2008).

Numerous fish species dominate the main stem of the Tittabawasse River including carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), quillback (*Carpiodes cyprinus*), freshwater drum (*Aplodinotus grunniens*) white suckers (*Catostomus commersonii*), emerald shiners, (*Notropis atherinoides*) golden redhorse (*Moxostoma erythrurum*), gizzard shad (*Dorosoma cepedianum*), northern hog suckers (*Hypentelium nigricans*), northern pike (*Esox lucius*), rock bass (*Ambloplites rupestris*), shorthead redhorse (*Moxostoma macrolepidotum*), smallmouth bass, walleye (*Sander vitreus*), white bass (*Morone chrysops*), yellow perch (*Perca flavescens*), longnose gar (*Lepisosteus osseus*), and logperch (*Percina caprodes*) (Schrouder et al., 2009).

Many of these species seasonally migrate from Saginaw Bay into the Saginaw River and Tittabawassee River, including walleye, northern pike, white bass, gizzard shad, and sucker species. Since there are no migration barriers in the Tittabawassee River from the Dow Dam to Saginaw Bay/Lake Huron, this reach of the river is particularly important to regional fish stocks. For example, the lower Tittabawassee River hosts large walleye runs – one of the most important migratory species in the region – during their spring migration. However, the Dow Dam does limit migration into the upper reaches of the Tittabawassee River, and addressing this has been identified as one of the highest fisheries management priorities in the state (Schrouder et al., 2009).

There are several species within the area that that rely on fish as a large part of their diet, including piscivorous (fish-eating) mammalian species such as river otter (*Lutra canadensis*), and mink (*Neovison vison*) and piscivorous birds such as herons, egrets, terns, mergansers, cormorants, and eagles (Schrouder et al., 2009; USFWS, 2009).

2.2.2 Floodplain Habitat

The Tittabawassee and Saginaw rivers and floodplains are ecologically similar, though the Saginaw River is more developed, with controlled flow and less hydrologic connection to its floodplain as compared with the Tittabawassee River. Historical forest vegetation consisted of oak-hickory on well-drained soils and beech-sugar maple on clay soils. Wetter soils also supported red maple, American elm, white ash, and American basswood. Intensive agricultural production since the mid-19th century has altered the natural landscape over much of this ecoregion, including within the Tittabawassee River and Saginaw River floodplains (USEPA, 2016a).

Emergent and forested wetlands are two of the major habitat types found in the Tittabawassee and Saginaw River floodplains. These floodplain habitats support diverse wildlife residents, including important bird, mammal, and amphibian species. At least 146 bird species are known to breed within the Tittabawassee River watershed and many of these have unique life histories and habitat requirements that are supported by the local floodplain habitats. For example, cavity-nesting passerines, such as the seasonally resident tree swallow, require abandoned tree cavities or other suitable excavations for nesting habitats. Some of the key mammal species include mink (*Neovison vison*), muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), eastern cottontail (*Sylvilagus floridanus*), short-tailed shrew (*Blarina brevicauda*), and coyote (*Canis latrans*). Amphibians identified within the Tittabawassee River watershed include 11 frog and toad species, 7 salamander species, and 9 turtle species. These species are prey for

many fish and wildlife species, including birds and mammals (Schrouder et al., 2009; Winkler et al., 2011).

There are a number of parks located within the floodplain along the Tittabawassee and Saginaw rivers, including municipal and county parks (see section 2.5 below for a summary of local parks); the Shiawassee NWR, located at the confluence of the Tittabawassee and Saginaw rivers; and the Crow Island State Game Area on either side of the Saginaw River between Saginaw and Bay City. The Shiawassee NWR contains the largest remaining single contiguous forest in the Tittabawassee River watershed, as well as some of the most pristine habitat conditions in the region. The Shiawassee NWR also supports emergent marsh habitat, characterized by interspersed open-water and cattail, which is identified as one of the most valued habitats at the refuge as it provides the most important resting and feeding conditions required by migratory waterfowl (Shiawassee NWR, 2016). Crow Island State Game Area lies within the Saginaw Bay lake plain, formerly characterized by swamp forest, wet-mesic prairie, and emergent marshes. It is presently a complex of emergent wetlands, managed wetland impoundments, and agricultural uplands that provide habitat for a wide variety of migratory birds as well as associated invertebrates, reptiles, amphibians and mammals (MDNR, 2016).

2.2.3 Great Lakes Coastal Wetlands and Other Wetlands

The Tittabawassee River, Saginaw River, and Saginaw Bay watersheds support both coastal and other wetlands, including those associated with the rivers previously described above. The primary coastal wetland types found in Saginaw Bay include open embayments (partially protected areas that support aquatic plants and emergent marsh vegetation) and sand-spit embayments (shallow areas where organic and fine mineral sediment accumulates supporting wetland vegetation) (Albert, 2003). Along the margins of Saginaw Bay, wetlands are found in zones as the elevation rises gradually: the first zone is generally a narrow band of open marsh – wider in protected areas – and then lakeplain prairie wetlands in dune and swale complexes followed by zones dominated by shrubs and then by forested swamps (Albert, 2003). Because the water levels of Lake Huron and Saginaw Bay change significantly over cycles of many years and the slope of the land around the bay is so gradual, the location and widths of these wetland zones can change over time.

Saginaw Bay open embayment wetlands are generally low in diversity, dominated by three-square, a bulrush that can tolerate the storm waves along the shoreline. Sand spit embayments are a more protected environment and support dense beds of submergent and emergent marsh vegetation such as blue-joint grass and tussock sedges. More recently, agricultural runoff has shifted the community to consist of a monoculture of cattails (when water levels are high) and a community of goldenrods, asters, willows, dogwoods, and ash and cottonwood seedlings (when water levels are low). Wetland vegetation in the submergent zone includes coontail (*Ceratophyllum demersum*), pondweeds (*Potamogeton* spp.), common waterweed (*Elodea* spp.), slender naiad (*Najas flexilis*), yellow pond-lily (*Nuphar lutea*), and water-lily (*Nymphaeaceae* spp.) in areas with water depths of 2 to 3 feet and stiff arrowhead (*Sagittaria rigida*), muskgrass (*Chara* spp.), and yellow pond-lily in shallower (6 inches deep) areas (Albert, 2003).

The wetlands surrounding Saginaw Bay have been altered in many locations by dense stands of non-native *Phragmites australis.* Numerous agencies and non-governmental organizations are working to continually improve on ways to control *Phragmites.*

Coastal and riverine wetlands are important spawning habitat for fish such as yellow perch and northern pike. In addition, waterfowl and wading birds (e.g. king rail and American bittern) rely on wetland habitats as forage and nesting habitats (Albert, 2003).

2.2.4 Upland Habitat

The Tittabawassee River, Saginaw River, and Saginaw Bay watersheds are characterized as broad, fertile, nearly flat plain habitat, punctuated by relic sand dunes, beach ridges, and glacial end moraines. Before disturbance by human activities, elm-ash swamp and beech/white pine upland forests dominated the area. Oak savanna was typically found on sandy, well-drained dunes and beach ridges. Today, most of the area has been cleared and artificially drained and contains highly productive farms (USEPA, 2002). The bulk of current land use in the Tittabawassee River, Saginaw River, and Saginaw Bay watersheds is agriculture, followed by forests (Table 2), which are more dominant in the northern part of the Saginaw Bay watershed.

Table 2. Summary of land use in the Tittabawassee River, Saginaw River, and Saginaw Bay watershed

Land Use	Percent Cover
Agriculture	49%
Forest	24%
Open lands	0%
Urban	12%
Wetlands	14%
Water	1%

Source: NLCD database (Homer et al., 2007)

The remaining forested areas within the Tittabawassee and Saginaw River watersheds occur in patches, and are generally in a mid-successional stage. Using the Michigan Natural Features Inventory Community Classification system, these areas are classified as mesic northern forest, which is characterized by varying dominance of conifers and hardwoods and includes a defined shrub-scrub layer and a diverse herb layer (Cohen, 2004). The largest remaining single contiguous forest within the Tittabawassee River watershed is located in the Shiawassee NWR, consisting of approximately 3,500 acres. The Shiawassee NWR is perhaps more similar to the region's presettlement conditions than any other location in the watershed, yet the flooding and flow regimes through it have been highly altered by drains, dikes, and water control structures for both flood protection and habitat manipulation (USFWS, 2001; Cohen, 2004).

2.2.5 Migratory Birds

Saginaw Bay area is a critical migratory stopover for more than 250 bird species, of which more than 200 species remain to nest in the area. The birding checklist for the Shiawassee NWR notes 281 species and their occurrence on the Refuge (USFWS, 2009). Nearly all species of birds

found in the United States are protected by the Migratory Bird Treaty Act (16 U.S.C. 703 et seq.). The exceptions are certain human-introduced, non-native species as described in the Migratory Bird Treaty Reform Act of 2004.

In order to facilitate the conservation of migratory birds beyond just relying on legal protection, the USFWS has identified Birds of Conservation Concern (USFWS, 2008). These are species that without additional conservation action are likely to become candidates for listing under the federal Endangered Species Act (ESA) of 1973. Nearly the entire Saginaw Bay watershed is in Bird Conservation Region 12 – Boreal Harwood Transition. In the U.S. portion of this Bird Conservation Region, the USFWS listed 23 Birds of Conservation Concern in 2008; one of these, the red knot, has since been listed as threatened under the ESA. The 22 species remaining on the list include two species of grebes, nine species of shorebirds, bald eagle, peregrine falcon, black tern, common tern, red-headed woodpecker, olive-sided flycatcher, wood thrush, golden-winged warbler, Canada warbler, Henslow's sparrow, and rusty blackbird.

2.3 Threatened and Endangered Species

Threatened and endangered species listed under both the ESA and the State of Michigan's Endangered Species Act, Part 365 of the Natural Resources and Environmental Protection Act (NREPA), Public Act 451 of 1994, as amended, are found in the Saginaw Bay watershed. Occurrence records are publicly accessible by county, so the following counties were included even though only parts of some of these counties are in the watershed: Iosco, Ogemaw, Roscommon, Arenac, Gladwin, Clare, Bay, Midland, Isabella, Osceola, Mecosta, Montcalm, Gratiot, Saginaw, Tuscola, Sanilac, Huron, Lapeer, Genesee, Shiawassee, Livingston, Oakland. The federally listed species found in these counties include two species of bats, three bird species, two snake species, three mussel species, two butterfly species, and two plant species. These species and the habitats they use are listed in Table 3. The state listed species include all of the federally listed species in Table 3 as well as the additional species listed in Table 4. Threatened and endangered species are legally protected. State species of special concern are not afforded legal protection, but receive attention because of their declining or relict populations in the state (MNFI, 2007). Although the bald eagle (*Haliaeetus leucocephalus*) is no longer listed under the federal ESA, it is still protected by two other federal laws: the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act.

Table 3. Federally listed threatened and endangered species, along with their listing status under state law in Michigan.

Species	Federal Status	State Status	Habitat Associations
Indiana Bat *Myotis sodalis*	Endangered	Endangered	Small to medium rivers with well-developed riparian woods; woodlots within 1-3 miles of rivers and streams; upland forests. Caves and mines as hibernacula.
Northern Long-Eared Bat *Myotis septentrionalis*	Threatened	Special Concern	Hibernates in caves and mines- swarming in surrounding wooded areas in autumn. Roosts and forages in upland areas.
Kirtland's Warbler *Setophaga kirtlandii*	Endangered	Endangered	Nests on the ground in large stands of young jack pines that are 5-20 feet tall.

Species	Federal Status	State Status	Habitat Associations
Piping Plover *Charadrius melodus*	Endangered	Endangered	Uses wide, sandy beaches that are flat and have very little vegetation. Nesting territories include small creeks and wetlands.
Rufa Red Knot *Calidris canutus rufa*	Threatened	NA	Large wetland complexes during the red knot migratory window of May 1-Sep. 30.
Copperbelly Water Snake *Nerodia erythrogaster neglecta*	Threatened	Endangered	Shallow wetlands or floodplain wetlands surrounded by forested uplands. Seasonally flooded wetlands without fish.
Eastern Massasauga Rattlesnake *Sistrurus catenatus*	Threatened	Special Concern	Shallow wetlands or shrub swamps in spring. Crayfish towers or small animal burrows which are adjacent to drier upland open shrub forest sites. During summer, massasauga rattlesnakes move to drier upland areas.
Northern Riffleshell *Epioblasma torulosa rangiana*	Endangered	Endangered	Found in small to large streams. Buries itself in bottoms of firmly packed sand or gravel.
Rayed Bean *Villosa fabalis*	Endangered	Endangered	Small headwater creeks or large rivers and wave-washed areas of glacial lakes. Prefers gravel or sand substrates.
Snuffbox Mussel *Epioblasma triquetra*	Endangered	Endangered	Found in small creeks to large lakes, and inhabiting areas with a swift current. Adults burrow in sand, gravel, or cobble substrates.
Karner Blue Butterfly *Lycaeides melissa samuelis*	Endangered	Threatened	Pine barrens and oak savannas on sandy soils containing wild lupines.
Poweshiek Skipperling *Oarisma poweshiek*	Endangered	Threatened	High quality tallgrass and mixed prairie grass. Found in prairie fens.
Eastern Prairie Fringed Orchid *Platanthera leucophaea*	Threatened	Endangered	Mesic to wet prairies and meadows.
Pitcher's Thistle *Cirsium pitcher*	Threatened	Threatened	Grows on the open sand dunes and low beach ridges of Great Lakes shores. Found in near-shore plant communities or nonforested areas of a dune system.

Table 4. Species listed as endangered, threatened, or of special concern under only State of Michigan law. See preceding table for state listed species that are also federally listed.

Species	State Status	Habitat Associations
Least Shrew *Cryptotis parva*	Threatened	Found in open fields with tall grasses or areas with fallen trees and brush.
Woodland Vole *Microtus pinetorum*	Special Concern	Found in orchards, forested wetlands, bogs, fence rows, and forests. Typically located in dry hardwood forests.
American Bittern *Botaurus lentiginosus*	Special Concern	Emergent wetlands with heavy vegetative cover.
Bald Eagle *Haliaeetus leucocephalus*	Special Concern	Found near large bodies of water. Nests near the tops of trees, nest platforms, or utility poles.
Barn Owl *Tyto alba*	Endangered	Found in grasslands, marshes, and agricultural fields. Nests in natural and man-made cavities.

Species	State Status	Habitat Associations
Black-Crowned Night-Heron *Nyctocorax nyctocorax*	Special Concern	Uses swamps, streams, rivers, margins of pools, ponds, lakes, lagoons, man-made ditches, canals, reservoirs, and wet agricultural fields. Prefers to nest in shrubs and small trees along the shores of Lakes Huron and Erie.
Black Tern *Chlidonias niger*	Special Concern	Prefers open or swampy marsh habitat.
Caspian Tern *Hydroprogne caspia*	Threatened	Prefers open sandy or pebble beaches, usually on islands in large bodies of water.
Cerulean Warbler *Setophaga cerulean*	Threatened	Inhabits mature deciduous forests, preferring mesic to wet stands. Found in areas with an open understory.
Common Gallinule *Gallinula galeata*	Threatened	Inhabits permanently flooded, deep marshes where emergent plants are interspersed with pools and channels that have floating-leaved and submerged plants.
Common Loon *Gavia immer*	Threatened	Found on lakes and reservoirs. Nests placed on lakes with small islands or floating hummocks.
Common Tern *Sterna hirundo*	Threatened	nests on sand, gravel, or cobble substrate with scattered vegetation as coverage. Uses low-lying sand or gravel bars or man-made structures.
Dickcissel *Spiza americana*	Special Concern	Prefers grassland complexes larger than 25 acres consisting of dense cover, moderately tall vegetation, and moderately deep litter. Uses fallow fields, hay fields, old fields, and pastures.
Forster's Tern *Sterna forsteri*	Threatened	Nests on floating vegetation in the interior of marshes and on shallow lakes. Inhabits Great Lakes embayments and connecting channels that support coastal stands of emergent vegetation.
Grasshopper Sparrow *Ammodramus savannarum*	Special Concern	Open grasslands and prairies with patches of bare ground.
Blanding's Turtle *Emydoidea blandingii*	Special Concern	Found in shallow weedy ponds, marshes, river backwaters, and sloughs.
Eastern Box Turtle *Terrapene carolina carolina*	Special Concern	Found in open woodlands and adjacent meadows, thickets, and gardens. Near shallow ponds, swamps, or streams.
Eastern Fox Snake *Pantherophis gloydi*	Threatened	Prefers marshes and adjacent wet meadows.
Gray Ratsnake *Pantherophis spiloides*	Special Concern	Occurs in deciduous forests and adjacent open habitats including shrubby fields, prairies, and marsh and bog edges. Found in barns and other man-made structures.
Six-Lined Racerunner *Aspidoscelis sexlineata*	Threatened	Occurs in sunny, well-drained areas with stretches of loose sandy soil or bare sand between vegetated areas. Occupies prairies, dunes, oak savannas, old fields, vacant lots, and riverbanks.
Spotted Turtle *Clemmys guttata*	Threatened	Inhabits bogs or boggy ponds, fens, sphagnum seepages, and grassy marshes. Prefers shallow, clean water with a mud bottom, clumps of sedge, or marsh grass.
Wood Turtle *Glyptemys insculpta*	Special Concern	Lives in rivers with sandy bottoms. Forages in woods, swamps, and meadows in upland areas adjacent to streams or rivers.
Blanchard's Cricket Frog *Acris blanchardi*	Threatened	Inhabits open, muddy edges of permanent ponds, lakes, bogs, floodplain ponds, and slow-moving streams and rivers.

Species	State Status	Habitat Associations
Smallmouth Salamander *Ambystoma texanum*	Endangered	Prefers moist hardwood forests, fragmented woodlands, fields, and farming areas.
Bigmouth Shiner *Notropis dorsalis*	Special Concern	Uses runs and pools of shallow, open headwaters, creeks, and small to medium rivers with sand bottoms.
Brindled Madtom *Noturus miurus*	Special Concern	Associated with gravel substrates and riffles.
Channel Darter *Percina copelandi*	Endangered	Inhabits rivers and large creeks in areas of moderate current over sand and gravel substrate.
Cisco *Coregonus artedi*	Threatened	Distributed throughout cold waters of the Great Lakes.
Eastern Sand Darter *Ammocryota pellucida*	Threatened	Inhabits clean, sandy areas of small creeks to large rivers. Found in shifting sand substrate free of silt.
Lake Sturgeon *Acipenser fulvescens*	Threatened	Prefers large lakes and rivers and the Great Lakes shorelines.
Pugnose Shiner *Notropis anogenus*	Endangered	Inhabits clear, vegetated lakes and rivers. Intolerant of turbidity.
Redside Dace *Clinostomus elongatus*	Endangered	Relies on clear pools in headwater streams of moderate current with abundant coarse woody material. Establishes spawning territories in gravel riffles.
River Darter *Percina shumardi*	Endangered	Lives in rivers and large streams. Prefers deep, fast-flowing riffles with cobble and boulder bottoms.
River Redhorse *Moxostoma carinatum*	Threatened	Prefers medium and large rivers with moderate to strong currents and gravel or cobble substrates.
Sauger *Sander canadensis*	Threatened	Found in lakes, reservoirs, and large rivers in turbid areas.
Silver Shiner *Notropis photogenis*	Endangered	Abundant in streams of moderate to high current with abundant swift riffles and deep pools. Inhabits gravel, cobble, and boulder substrates.
Southern Redbelly Dace *Chrosomus erythrogaster*	Endangered	Occurs in clear, cool headwaters of river systems. Prefers spring-fed brooks and clear, wooded streams intermixed with small pools.
Angular Spittlebug *Lepyronia angulifera*	Special Concern	Occurs in prairie fens.
Blazing Star Borer *Papaipema beeriana*	Special Concern	Occurs with its larval host plants, the blazing star or snakeroot. Found in lakeplain prairies, prairie fens, and sand prairies or barrens.
Boreal Brachionyncha *Brachionyncha borealis*	Special Concern	Inhabits dry-mesic oak-pine forests.
Cantrall's Bog Beetle *Liodessus cantralli*	Special Concern	Found in bogs, fens, and inland emergent wetlands.
Doll's Merolonche *Merolonche dolli*	Special Concern	Uses bogs.
Dusted Skipper *Atyrtonopsis hianna*	Special Concern	Occurs in remnant dry sand prairies, openings within oak and oak-pine barrens, and dry open fields where native warm season grasses occur. Larval host plants are big bluestem and little bluestem.
Frosted Elfin *Callophrys irus*	Threatened	Uses small openings within woodlots or overgrown savannas. Caterpillars utilize lupine or wild indigo as host plants and adults nectar on blueberry blossoms.
Great Plains Spittlebug *Lepyronia gibbosa*	Special Concern	Occurs in lakeplain oak openings.
Grizzled Skipper *Pyrgus wyandot*	Special Concern	Associated with savannas.

Species	State Status	Habitat Associations
Henry's Elfin *Incisalia henrici*	Threatened	Occurs in deciduous and mesic woodlands or dry, open pine woodlands.
Huron River Leafhopper *Flexamia huroni*	Threatened	Found in association with mat muhly.
Lake Huron Locust *Trimerotropis huroniana*	Threatened	Found in sparsely vegetated coastal sand dunes.
Laura's Snaketail *Stylurus laurae*	Special Concern	Associated with small streams.
Leafhopper *Dorydiella kansana*	Special Concern	Occurs in wet prairies.
Newman's Brocade *Meropleon ambifusca*	Special Concern	Occurs in wet prairies.
Ottoe Skipper *Hesperia ottoe*	Threatened	Occurs in remnant, dry sand prairies and open oak barrens where native warm season grasses occur.
Persius Dusky Wing *Erynnis persius persius*	Threatened	Found in jack pine barrens, pitch pine-scrub oak barrens, and scrubby ridgetops. Also occurs in oak-pine barrens and adjacent prairies.
Phlox Moth *Schinia indiana*	Endangered	Occurs in prairies and oak-pine barrens on sandy soils.
Regal Fern Borer *Papaipema speciosissima*	Special Concern	Associated with wet-mesic prairies.
Regal Fritillary *Speyeria idalia*	Endangered	Occurs in prairies, savannas, and old field grasslands. Larvae feed on violets.
Riverine Snaketail *Stylurus amnicola*	Special Concern	Found in riparian corridors. Associated with clear, medium to large rivers of swift-running current with sand, gravel, or mud substrates.
Secretive Locust *Appalachia arcana*	Special Concern	Found in leatherleaf-dominated sphagnum bog areas surrounded by jack pine and tamarack trees.
Silphium Borer Moth *Papaipema silphii*	Threatened	Occurs in mesic prairies, prairie fens, and lakeplain mesic prairies.
Spike-Lip Crater *Appalachina sayanus*	Special Concern	Found in moist leaf litter or near logs on wooded hillsides. Also found on stone fences.
Swamp Metalmark *Calephelis mutica*	Special Concern	Found in glaciated prairie fens, sedge meadows, and shrub swamps. Associated with open-canopy fens with an herbaceous layer dominated by sedges, rushes, and grasses.
Tamarack Tree Cricket *Oecanthus laricis*	Special Concern	Lives in tamarack trees.
Black Sandshell *Ligumia recta*	Endangered	Occurs in rivers.
Broadshoulder Physa *Physella parkeri*	Threatened	Found in medium to large lakes of clean and cold water and substrates of sand or marl. Found clinging to stones or on rocky, exposed shores.
Campeloma Spire Snail *Cincinnatia cincinnatiensis*	Special Concern	Prefers warmwater streams and shallow wetlands with either a sand/gravel or mud bottom.
Copper Button *Mesomphix cupreus*	Special Concern	Occurs in mesic, rocky woodlands.
Deertoe *Truncilla truncate*	Special Concern	Found in the lower stretches of rivers. Found in mud, sand, and/or gravel substrates.
Eastern Pondmussel *Ligumia nasuta*	Endangered	Occurs in the Great Lakes.
Elktoe *Alasmidonta marginata*	Special Concern	Found in small to large streams and small to medium rivers. Prefers swifter currents over packed sand and gravel substrates.

Species	State Status	Habitat Associations
Ellipse *Venustaconcha ellipsiformis*	Special Concern	Found in small to medium streams with firm and gravel substrates.
Flat Dome *Ventridens suppressus*	Special Concern	Prefers mesic, rocky woodlands.
Giant Northern Pea Clam *Pisidium idahoense*	Special Concern	Occurs in mesotrophic lakes. Found in sandy substrates with vegetation.
Gravel Pyrg *Pyrgulopsis letsoni*	Special Concern	Associated with stones under impoundments.
Greater European Pea Clam *Pisidium amnicum*	Special Concern	Inhabits slow-running, shallow streams and lakes near estuaries with sandy substrates.
Great Lakes Physa *Physella magnalacustris*	Special Concern	
Hickorynut *Obovaria olivaria*	Endangered	Found in large rivers with a good current. Inhabits sand, sand/gravel, and gravel substrates.
Kidney Shell *Ptychobranchus fasciolaris*	Special Concern	Found in small to medium rivers in areas with good flow. Inhabits sand and/or gravel substrates.
Lilliput *Toxoplasma parvum*	Endangered	Found in lakes with sandy mud, mud, or fine gravel substrates.
Paper Pondshell *Utterbackia imbecillus*	Special Concern	Prefers muddy sand in moderate current. Inhabits shallow banks, pools, and drainage canals.
Pink Papershell *Potamilus ohiensis*	Threatened	Found in rivers and large streams. Found in fairly swift currents and silt, mud, or sand substrates.
Purplecap Valvata *Valvata perdepressa*	Special Concern	Occurs in large and medium lakes.
Purple Lilliput *Toxoplasma lividus*	Endangered	Occurs in small to medium streams. Found in well-packed sand or gravel substrates.
Purple Wartyback *Cyclonaias tuberculata*	Threatened	Found in medium to large rivers with gravel or mixed sand and gravel substrates.
Rainbow Mussel *Villosa iris*	Special Concern	Found in small to medium streams with sand and gravel substrates.
River Fingernail Clam *Sphaerium fabale*	Special Concern	
Round Hickorynut *Obovaria subrotunda*	Endangered	Found in medium to large rivers. Found in sand and gravel substrates in areas with moderate flow.
Round Pigtoe *Pleurobema sintoxia*	Special Concern	Found in large rivers. Prefers sand, mud, and gravel bottoms and fast-moving water.
Salamander Mussel *Simpsonaias ambigua*	Endangered	Found in medium to large rivers and lakes. Found in silt or sand under flat stones.
Slippershell *Alasmidonta viridis*	Threatened	Found in lakes, creeks, and headwaters of rivers. Occurs in sand or gravel substrates.
Spindle Lymnaea *Acella haldemani*	Special Concern	Inhabits eutrophic lakes and ponds. Found in reeds at depths of 1-3 feet.
Threehorn Wartyback *Obliquaria reflexa*	Endangered	Found in medium to large rivers. Inhabits gravel, gravel-sand, or gravel-mud substrates with moderate current.
Watercress Snail *Fontigens nickliniana*	Special Concern	Found on watercress.
Wavyrayed Lampmussel *Lampsilis fasciola*	Threatened	Occurs in small to medium shallow streams. Prefers to be in or near riffles with good current.
Widespread Column *Pupilla muscorum*	Special Concern	
Alleghany Plum *Prunus umbellate*	Special Concern	Occurs in grassy openings and open jack pine.

Species	State Status	Habitat Associations
American Chestnut *Castanea dentate*	Endangered	Occurs in southern oak forests.
American Lotus *Nelumbo lutea*	Special Concern	Prefers shallow waters, wetlands, and backwaters.
Bald-Rush *Rhynchospora scirpoides*	Special Concern	Occurs on sandy-mucky shores and sandy-peaty lake beds.
Bastard Pennyroyal *Trichostema dichotomum*	Threatened	Occurs in oak savannas.
Beak Grass *Diarrhena obovate*	Special Concern	Found in floodplain swamps and riverbanks.
Blue-Eyed Grass *Sisyrinchium strictum*	Special Concern	Found in moist meadows, dry or moist sandy soil openings, low prairies, sandy-gravelly dry relict prairies, edges of mixed conifer/hardwood forest, stream banks, and shoreline cliffs.
Blue-Eyed Mary *Collinsia verna*	Special Concern	Found in deciduous forests, especially in ravines and moist areas.
Blunt-Lobed Woodsia *Woodsia obtuse*	Threatened	Occurs in rocky places.
Bog Bluegrass *Poa paludigena*	Threatened	Occurs in undeveloped lowlands. Dependent on wet mossy woods, springs, and tamarack bogs.
Broad-Leaved Puccoon *Lithospermum latifolium*	Special Concern	Found in shaded riverbanks and forested floodplains. Also found on the borders of forests.
Canadian Milk Vetch *Astragalus canadensis*	Threatened	Found in moist prairies, open woodlands, roadsides, thickets, and streambanks.
Climbing Fumitory *Adlumia fungosa*	Special Concern	Found in moist or freshly burned woods, as well as on rocky slopes and slightly acidic soils. Prefers sites protected from wind.
Clinton's Bulrush *Trichophorum clintonii*	Special Concern	Associated with oak barrens and oak openings.
Cooper's Milk Vetch *Astragalus neglectus*	Special Concern	Found in lakeplain oak openings.
Creeping Whitlow Grass *Draba reptans*	Threatened	Found in hillside prairies.
Downy Gentian *Gentiana puberulenta*	Endangered	Occurs in oak savannas, often along coastal plain marshes.
Edible Valerian *Valeriana adulis ciliate*	Threatened	Occurs in wet, open places.
Engelmann's Spike Rush *Eleocharis engelmannii*	Special Concern	Found in moist, open, sandy ground.
English Sundew *Drosera anglica*	Special Concern	Occurs in northern fens. Also occurs in interior areas on floating peat mats and in wet depressions.
Fairy Slipper *Calypso bulbosa*	Threatened	Inhabits moist coniferous forests with cool soils. Found on drier hummocks or at the base of old trees or stumps.
False Boneset *Brickella eupatorioides*	Special Concern	Found in sandy fields and prairies, along with associated bluffs and roadsides.
False Hop Sedge *Carex lupuliformis*	Threatened	Found in forested wetlands. Also inhabits riverine wetlands, marshes, and wet thickets.
False Violet *Dalibarda repens*	Threatened	Found in swamps and moist woodlands.
Fire Pink *Silene virginica*	Endangered	Found in prairies and dry woods.
Forked Aster *Eurybia furcata*	Threatened	Found in moist forests on calcareous soils, especially along rivers.

Species	State Status	Habitat Associations
Fragile Prickly Pear *Opuntia fragilis*	Endangered	Found on steep, south-facing exposed slopes of granite bedrock.
Furrowed Flax *Linum sulcatum*	Special Concern	Prefers lakeplain oak openings.
Gattinger's Gerardia *Agalinis gatteringeri*	Endangered	Occurs in dry, sandy cliffs in prairies or oak barrens/oak savannas.
Ginseng *Panax quinquefolius*	Threatened	Found in hardwoods on slopes or ravines. Grows in heavy soils covered with leaf mold or rotted wood.
Goldenseal *Hydrastis canadensis*	Threatened	Known from beech-maple forests.
Green Violet *Hybanthus concolor*	Special Concern	Occurs in mesic forests, swamps, floodplains, and riverbanks.
Hairy Angelica *Angelica venenosa*	Special Concern	Inhabits upland forests, borders of forests and thickets, sandy ground, and prairie-like areas.
Hairy Mountain Mint *Pycanthemum pilosum*	Threatened	Found in shaded riverbanks and upland roadsides and pastures.
Hay-Scented Fern *Dennstaedtia punctilobula*	Threatened	Prefers sandy, open forests and forest edges with acidic soils.
Heart-Leaved Plantain *Plantago cordata*	Endangered	Occurs in wet sites on forests such as near vernal ponds, wet depressions, streams, and seeps.
Hill's Thistle *Cirsium hillii*	Special Concern	Known from dry, sandy soils in prairies, jack pine barrens, oak savannas, and open woods. Also known from alvar.
Hollow-Stemmed Joe-Pye Weed *Eutrochium fistulosum*	Threatened	Occurs in wet meadows, thickets, and forest edges.
Horsetail Spike Rush *Eleocharis equisetoides*	Special Concern	Found on wet shores on lakes and ponds or in shallow water on sandy, marly, or peaty bottoms.
Jacob's Ladder *Polemonium reptans*	Threatened	Lives in wet prairies.
Lake Cress *Rorippa aquatica*	Special Concern	Inhabits rivers and lakes, especially in cold spring-fed waters.
Large Toothwort *Cardamine maxima*	Threatened	Prefers deciduous forests, often along streams.
Large Water Starwort *Callitriche heterophylla*	Threatened	Inhabits emergent marshes.
Leadplant *Amorpha canescens*	Special Concern	Prefers dry prairies and hills.
Mat Muhly *Muhlenbergia richardsonis*	Threatened	Occurs in prairie fens. Also occurs in a variety of wet to dry alkaline areas and sandy prairies.
Missouri Rock-Cress *Boechera missouriensis*	Special Concern	Uses lakeplain oak openings.
Broad-leaved Mountain Mint *Pycanthemum muticum*	Threatened	Occurs in moist shores and meadows.
Orange- or Yellow-Fringed Orchid *Platanthera ciliaris*	Endangered	Found on open mats of Sphagnum bogs.
Pale Avens *Geum virginianum*	Special Concern	Occurs in dry southern forests.
Pale Beard Tongue *Penstemon pallidus*	Special Concern	Found in dry fields and along roadsides.
Panicled Hawkweed *Hieracium paniculatum*	Threatened	Occurs in lakeplain oak openings.

Species	State Status	Habitat Associations
Pine-Drops *Pterospora andromedea*	Threatened	Known from dry woods containing conifers. Also occurs in dry to dry-mesic forests.
Prairie Birdfoot Violet *Viola pedatifida*	Threatened	Associated with mesic prairies.
Prairie Buttercup *Ranunculus rhomboideus*	Threatened	Occurs in hillside prairies.
Prairie Dropseed *Sporobolus heterolepis*	Special Concern	Occurs in calcareous wetlands. Also occurs in mesic prairies, dry open ground, and open woods.
Prairie False Indigo *Baptisia lacteal*	Special Concern	Prefers mesic prairies.
Prairie Indian-Plantain *Arnoglossum plantagineum*	Special Concern	Found in prairie fens.
Prairie Smoke *Geum triflorum*	Threatened	Prefers woods and prairies.
Pumpkin Ash *Fraximus profunda*	Threatened	Occurs in deciduous swamps.
Purple Milkweed *Asclepias purpurascens*	Threatened	Found in dry soils in prairies and open woodlands, shrub thickets, and on shores.
Ram's Head Lady's-Slipper *Cypripedium arietinum*	Special Concern	Found in dense balsam-white cedar-black spruce swamps and bogs or in conifer uplands characterized by pine or cedar needles over sand. Confined to northern exposures or cold air channels.
Red Mulberry *Morus rubra*	Threatened	Occurs in mesic southern and southern floodplain forests.
Richardson's Sedge *Carex richarsonii*	Special Concern	Known from dry or rocky upland woods. Also found in sandy woodland openings and edges.
Sedge *Carex seorsa*	Threatened	Found in open dunes.
Sedge *Carex squarrosa*	Special Concern	Occurs in moist to wet forests and thickets, wet open depressions, and wet fields and ditches.
Showy Orchis *Galearis spectabilis*	Threatened	Found in deciduous woods. Occurs near temporary spring ponds in sandy clay or loam soils.
Side-Oats Grama Grass *Bouteloua curtipendula*	Endangered	Found in prairies and dry, open areas.
Slough Grass *Beckmannia syzigachne*	Threatened	Found in marshes, sloughs, floodplains, pond shores, lakes, streams, ditches, and other open wetland habitats.
Small-Fruited Panic-Grass *Dichanthelium microcarpon*	Special Concern	Found in moist forests and thickets.
Smooth Carrion-Flower *Smilax herbacea*	Special Concern	Occurs in thickets, moist ground, and forested banks.
Snow Trillium *Trillium nivale*	Threatened	Prefers lowland hardwoods.
Stiff Gentian *Gentianella quinquefolia*	Threatened	Found on riverbanks, marshy meadows, bluffs, and forested hillsides. Found in calcareous soils.
Sullivant's Milkweed *Asclepias sullivantii*	Threatened	Occurs in old fields with secondary prairies and moist, grassy right-of-ways.
Tall Green Milkweed *Asclepias hirtella*	Threatened	Found in lakeplain wet-mesic prairies and mesic sand prairies. Occurs on moist, alkaline clay or fine sandy loam.
Tall Nut Rush *Scleria triglomerata*	Special Concern	Associated with sandy ground such as prairies or open borders of marshes.
Three-Awned Grass *Aristida longespica*	Special Concern	Found in sandy substrates in glacial lakeplain landscapes. Associated with lakeplain wet prairie or lakeplain wet-mesic prairie.

Species	State Status	Habitat Associations
Three-Square Bulrush *Schoenoplectus americanus*	Endangered	Occurs on mineral-rich wetland margins and in marshes.
Toadshade *Trillium sessile*	Threatened	Associated with beech-maple forests.
Torrey's Bulrush *Schoenoplectus torreyi*	Special Concern	Lives in wet, sandy or peaty shores and shallow water.
Twinleaf *Jeffersonia diphylla*	Special Concern	Found in lowland hardwoods.
Umbrella-Grass *Fuirena pumila*	Threatened	Common on sandy-mucky shores where the water level has receded.
Vasey's Pondweed *Potamogeton vaseyi*	Threatened	Occurs in submergent marshes.
Vasey's Rush *Juncus vaseyi*	Threatened	Prefers open wetlands.
Virginia Flax *Linum virginianum*	Threatened	Found in oak savannas and woodland openings.
Virginia Water-Horehound *Lycopus virginicus*	Threatened	Found in floodplain forests. Also known from swamps, bottomland forests, stream banks, margins of wooded ponds and lakes, wet clearings, ditches, and thickets.
Virginia Spiderwort *Tradescantia virginiana*	Special Concern	Found in moist prairies, open woods, meadows, hillsides, stony bluffs, stream banks, and along roadsides.
Wahoo *Euonymus atropurpureus*	Special Concern	Occurs in or near floodplain forests, southern swamp forests, or southern mesic forests. Associated with silt loams in riparian areas.
Water Willow *Justicia americana*	Threatened	Occurs in shallow riffles in large streams and rivers.
White Lady Slipper *Cypripedium candidum*	Threatened	Occurs in prairie fens and marly, alkaline sites with groundwater seepage. Also occurs in wet prairie communities of the clay lakeplain region of Michigan.
Whorled Mountain Mint *Pycanthemum verticillatum*	Special Concern	Occurs within lakeplain wet-mesic prairie and coastal plain marshes. Thrives in the outer zone of shallow wetlands and lakes where it is associated with prairie grasses.
Whorled Pogonia *Isotria verticillata*	Threatened	Occurs in dry-mesic forests, swamp borders, and bogs.
Wild Rice *Zizania aquatic*	Threatened	Found in emergent marshes, lakeshores, and slow-moving streams.
Yellow-Flowered Leafcup *Smallanthus uvedalia*	Threatened	Occurs in swamp margins and moist woods. Also occurs in sedge meadows.

2.4 Cultural and Historic Resources

The Saginaw Bay watershed contains historical and cultural resources from both prehistoric cultures and European settlement since the 1800s. The National Register of Historic Places (NRHP) is the official list of the Nation's historic places worthy of preservation and in Michigan the NRHP list of sites is maintained by the State Historic Preservation Office (SHPO) in Lansing. The SHPO list of sites in the Saginaw Bay watershed contains 96 archeological sites that are either listed on the NRHP or eligible for listing, with over two-thirds of these occurring in Midland, Saginaw, and Bay counties (Table 5). The archeological sites include camps, villages, petroglyphs, mounds, cemeteries, trading posts, missions, and homesteads that date from the prehistoric periods through the Archaic and Woodland periods to the historic period

(Halsey, 1999). Additional NRHP historic sites consisting of structures that still exist above ground include private homes, commercial and government buildings, manufacturing facilities, churches, bridges, navigational structures, and historic districts. The archaeological and above ground sites generally tend to be located in towns and cities that date back to the 1800s and clustered along past routes of transportation, especially along rivers and railroads.

Table 5. Archaeological sites considered eligible for listing or listed on the National Register of Historic Places for the Saginaw Bay watershed (J. Yann, Michigan SHPO, personal communication, July 19, 2017).

County	Total Sites	Brief Descriptions
Midland	20	Prehistoric through 1800's camps, mound, cemetery, village, trading post, homestead
Saginaw	31	Prehistoric through 1800's camps, burial/cemetery, village, cabin
Bay	15	Prehistoric to 1900's camps, dump, hunting club
Arenac	10	Prehistoric to Late Woodland camps and quarry
Gratiot	6	Prehistoric to Late Woodland camps
Genesee	4	Paleo-Indian, Late Archaic, Late Woodland camps and mid-1800's mission
Iosco	4	1900's logging and work camps, barn
Lapeer	2	Prehistoric through 1800's camp, village, cemetery
Ogemaw	1	Late Woodland earthwork
Oakland	1	Prehistoric, undetermined
Sanilac	1	Prehistoric petroglyphs and camp
Tuscola	1	Late Archaic camp

Areas bordering the Tittabawassee and Shiawassee rivers within the Shiawassee NWR are considered to among the most archaeologically rich sites in the State of Michigan (Castle Museum 2015). Shiawassee NWR conducted a comprehensive assessment of cultural resources within the administrative boundary of the Refuge (Robertson et al. 1999). As related within the Refuge's Comprehensive Conservation Plan (USFWS 2001), the Refuge has identified 31 cultural resource sites on the Refuge and an additional 42 sites on additional lands within the expansion area of the Refuge. These include prehistoric archaeological sites, historic archeological sites (Native American and Western), industrial and mining sites, farmsteads, and timbering sites. Evidence for early Paleo-Indian cultures (10,000 to 8000 B.C.) consists only of fluted points in private collections. Other prehistoric cultures are represented in the archeological record: Archaic (8000 to 550 B.C.) and Woodland (600 B.C. to1600 A.D.).

2.5 Human Use of Natural Resources

There are many opportunities for human use of natural resources associated with the Tittabawassee River, Saginaw River, and Saginaw Bay. Based on a survey published in 2006, (Whitehead et al., 2006), approximately 60% of the general public in the Saginaw Bay watershed visit the Saginaw Bay or coastal marsh area multiple times a year for outdoor recreation. Fishing was the primary activity, but people also use the area for boating, beach-going, nature observation, hiking, hunting, or a variety of other activities (Whitehead et al., 2006; Schrouder et al., 2009).

Public lands are prevalent in the Saginaw Bay watershed and include federal, state, and local lands as well as some lands managed by Non-Government Organizations (NGOs). Federal lands include the Shiawassee NWR, Michigan Islands NWR, and Huron-Manistee National Forest. State lands include Tawas Point State Park, Bay City State Recreation Area, Nayanquing Point State Wildlife Area (SWA), Quanicassee SWA, Wigwam Bay SWA, Fish Point SWA, Shiawassee State Game Area, Albert E. Sleeper State Park, Port Crescent State Park, and state forests including the Gladwin Management Unit and the Roscommon Management Unit. County and city parks are found throughout the watershed and include the following along the Tittabawassee River: Imerman Park, Freeland Park, West Michigan Park, and Tittabawassee Township Park (ATS, 2006; MDNR, 2017a; SBLC, 2017). NGOs maintain the Saginaw Basin Land Conservancy Nature Preserves and the Chippewa Nature Center.

Use of public lands along the Tittabawassee River is affected by contamination that has resulted in advisories for consumption of fish and wild game (Appendix B) and for contact with and movement of soil and sediments (Appendix C). In 2003, EGLE issued a soil movement advisory for the 100 year floodplain of the Tittabawassee River for private, public, and commercial projects based on risk of exposure to elevated levels of PCDDs and PCDFs (MDEQ, 2003a). EGLE issued a revised advisory in 2005 that reduced the advisory to those land areas that are flooded by the river every 7 to 10 years (MDEQ, 2005). The state has also issued food farming and gardening guidelines to minimize exposure (MDA, 2002). In addition, interim response actions at local parks have included placement of hand-washing stations for use after recreating (Dow, 2003a; Dow, 2003b; Dow, 2003c).

Recreational fishing is common throughout the Saginaw Bay watershed. The MDNR maintains a Statewide Angler Survey Program, a long-term monitoring program that tracks recreational fisheries and harvest across Michigan's waters (MDNR, 2017b). Creel data collected under this program for the Tittabawassee River, Saginaw River, and Saginaw Bay can be used to estimate the total number of recreational fishing trips taken to the area annually. Over the five years from 2010 to 2014, inclusive, the Trustees calculated that the average annual number of recreational fishing trips taken to the area was 318,285 (see section 3.4.8 below). However, recreational fishing is affected by fish consumption advisories (FCAs), with FCAs in-place for fish contaminated with PCBs, dioxins, and other contaminants in Saginaw Bay, and Tittabawassee and Saginaw rivers (MDHHS, 2016; Appendix B).

In addition to fishing, there are opportunities for hunting throughout the watershed, but these are also affected by contamination. There are wild game advisories in the Tittabawassee River and Saginaw floodplains for deer liver and muscle, turkey, squirrel, and duck skin, based on soil contaminant concentrations (MDCH, 2008; Appendix C).

Tribal uses in the assessment area include the use of wild rice and other plants and animals for nourishment, and for medicinal and cultural purposes. From a holistic perspective, all natural resources provide services to the Tribe, in the sense that uncontaminated natural resources support a healthy ecosystem and tribal use of the resources in traditional lifeways.

Bird watching is popular in the area. The Saginaw Basin Land Conservancy and Michigan Audubon have developed a Saginaw Bay Birding Trail that identifies excellent birding

opportunities over 142 miles, running along the Saginaw Bay shoreline from Port Crescent State Park to Tawas Point State Park (Saginaw Bay Area Birding and Bird Trail, 2017).

2.6 Saginaw River and Bay Area of Concern – Restoration Progress

The Great Lakes Water Quality Agreement (GLWQA) was first signed by the federal governments of the United States and Canada (the Parties) in 1972, to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes. It has been amended and revised several times since then, most recently in 2012. The 1987 amendments directed the Parties to designate Areas of Concern, which are defined as geographic areas that fail to meet water quality objectives of the Agreement, and cause impairment of beneficial uses or of the area's ability to support aquatic life. The International Joint Commission, working with the Parties and coordinating with state and provincial governments, designated 43 Areas of Concern in eight Great Lakes states and two Canadian provinces around that time. Saginaw River and Bay was one of these 43 original Areas of Concern.

The 1987 Amendments to the GLWQA defined Beneficial Use Impairments (BUIs) and directed the Parties to develop and implement Remedial Action Plans (RAPs) for each Area of Concern, in cooperation with the state and provincial governments. The original RAP for the Saginaw River and Bay Area of Concern was finalized in September 1988 and was instrumental in guiding efforts to implement remedial actions related to the BUIs. Updated RAP documents were completed in 1995, 2002, 2008, and 2012. Originally, this Area of Concern exhibited 12 of the 14 BUIs from stressors including excessive nutrient loading, elevated bacteria levels, aquatic habitat loss, and chemical contaminants. While significant progress has been made and three of the BUIs have been officially removed for the Saginaw River and Bay Area of Concern, BUIs still include restrictions on fish or wildlife consumption, bird or animal deformities/reproductive problems, degradation of fish and wildlife populations, and eutrophication (MDEQ, 2017).

With funding from the Great Lakes Restoration Initiative, North American Wetlands Conservation Act grants program, a previous NRDA settlement with General Motors and others for PCB contamination, and many other public and private sources, natural resource agencies and their partners have implemented significant habitat restoration and protection projects for Saginaw Bay coastal wetlands and the Shiawassee Flats area at the confluence of the Tittabawassee, Saginaw, Flint, Cass, and Shiawassee rivers. Based on an analysis completed in 2012, over 63% of the wetlands below the 585' contour line of elevation above sea level had been protected (Selzer et al., 2014), meeting one of the goals for removing the BUI for loss of habitat. Natural resource agencies and their partners have also been working to remove barriers to fish movement in the watershed, prioritizing among the over 300 identified barriers in the Saginaw Bay watershed that prevent spawning of migratory fish species and reduce fish species diversity in the river systems (Selzer et al., 2014). Two of the most significant barriers to fish passage from Saginaw Bay into tributaries have recently been addressed by installing a series of rock steps at the Chesaning Dam on the Shiawassee River (Selzer et al., 2014) and the Frankenmuth Dam on the Cass River (The Nature Conservancy, 2017). Monitoring is being conducted to determine how successful these projects have been in increasing fish passage and populations. The Dow Dam on the Tittabawassee River remains as an impediment to fish passage on the Tittabawassee River system, including the Pine and Chippewa rivers that join the Tittabawassee River upstream from that dam.

CHAPTER 3: INJURY ASSESSMENT

The goal of the injury assessment is to determine the nature and extent of injuries to natural resources in order to quantify the resulting ecological and human use service losses and provide a basis for determining the needed scale and types of restoration actions.

Injury has occurred when a natural resource's viability or function is impaired such that the type and/or magnitude of services provided by that natural resource is reduced as a result of contamination (43 C.F.R. § 11.14 (v)). Determination of injury requires documentation that: (1) there is a viable pathway for the released hazardous substance from the point of release to a point at which natural resources are exposed to the released hazardous substance, and (2) injury of exposed natural resources (e.g., surface water, sediment, soil, groundwater, biota) has occurred as defined in 43 C.F.R. § 11.62.

The natural resources listed in Chapter 2 provide a variety of services. Services are "the physical and biological functions performed by the resource, including the human uses of those functions, [that result from the resource's] physical, chemical, or biological quality" (43 C.F.R. § 11.14 (nn)). For example, ecological services provided by benthic invertebrates and mussels include foraging opportunities for fish and birds, nutrient cycling, and water filtration. Wetland soils provide services by supporting healthy vegetation and diverse plant communities that in turn provide animals with foraging opportunities, nesting or denning areas, and protective cover. Examples of human use services provided by natural resources include opportunities for fishing, boating, and wildlife viewing and appreciation.

3.1 Contaminants of Concern

As described in section 1.4, several dozens of the hazardous substances either used or produced at Dow's Midland plant have been identified in the TRSAA to date. In June 2006, Dow submitted a list to EGLE that contained over 800 chemicals that were either produced or used throughout the history of the plant. ATS and EGLE reviewed the listed chemicals for the likelihood to persist in the environment, and categorized them. This process is described in Appendix G of the Remedial Investigation Work Plan (ATS, 2006b). The category of "primary contaminants of interest" in the Remedial Investigation Work Plan contained certain volatile organics, semi-volatile organics, PCDDs, PCDFs, PCBs, phenols, chlorinated pesticides, chlorinated hydrocarbons, organophosphorus compounds, chlorinated herbicides, and metals. Most of these are also considered "contaminants of concern" (COC) in a NRDAR assessment, which are defined by section 101 (14) of CERCLA as hazardous substances to which natural resources have been exposed as a result of a release

A variety of contaminants released by Dow contributed to ecological losses in past decades, when the Tittabawassee and Saginaw River had severely impacted benthic invertebrate and fish communities. Solvents and other organic compounds have been a particular concern in Segment 1 of the Tittabawassee River, where the river flows through the plant property and DNAPL has been and is being reduced by installing wells into the riverbed and pumping the liquid out. The primary contaminants of concern for the remainder of the TRSAA are the PCDDs and PCDFs.

PCDDs and PCDFs are organic compounds consisting of two benzene rings joined by either two or one oxygen bridges, respectively, and with one to eight chlorine atoms substituted for hydrogen atoms on the rings. Based on the number and arrangement of chlorine atoms, there are 75 different PCDDs and 135 different PCDFs. For most species of organisms tested, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) is the most toxic of these compounds and is used to calculate the relative potency of individual PCDDs, PCDFs and other compounds that have the same mechanism of action. From the relative potency, the concentration of individual compounds can be expressed as the amount of TCDD that has the equivalent toxicity (TEQ). Based on the assumption of additive toxicity for compounds with this mechanism of action, the toxicity of the individual compounds in a mixture can be summed to calculate the total TEQ of the mixture.

PCDDs and PCDFs have very low solubility in water, so in the environment they are generally associated with organic material in sediments and soils and with lipids and membranes in biota. In the TRSAA, one of the major sources of PCDDs and PCDFs was the degradation of graphite rods used in Dow's electrolytic processes, and PCDDs and PCDFs produced as byproducts from that source are found associated with sand-sized particles of graphite in the rivers and floodplains. In biota, PCDDs and PCDFs bioaccumulate and biomagnify in upper trophic level organisms such as fish, birds, and mammals.

PCDDs and PCDFs are toxic at extremely low concentrations. In animals, they can cause weight loss, hepatotoxicity, porphyria, dermal toxicity, gastric lesions, thymus atrophy and immunotoxicity, teratogenicity, reproductive effects, carcinogenicity, and death (IPCS, 1989). Reproductive and teratogenic effects can include embryo death, edema, gastroschisis, deformities of the jaw or beak, cardiac malformations and function, and loss of visual acuity (Gilbertson et al., 1991). In humans, exposure can lead to skin lesions; altered liver function; impairment of the immune system, nervous system, endocrine system, and reproductive functions; and death (WHO, 2007).

3.2 Pathways

Pursuant to 43 C.F.R. § 11.14 (dd), a pathway is defined as:

> The route or medium through which…a hazardous substance is or was transported from the source of the discharge or release to the injured resource.

PCDDs and PCDFs have been detected above background in surface waters, sediment, floodplain soils, soils in the Midland area, groundwater, and biota (Stratus, 2008). Releases of PCDDs and PCDFs were greater in the past, prior to Dow's continual operation of the RGIS system, improvements in their waste water treatment system, and operation of a high-efficiency incinerator. PCDDs and PCDFs released into the environment have reached natural resources by many pathways, including surface runoff, groundwater, movement in surface water and with sediment, and through the biotic food web.

3.3 Injury Assessment Strategy

The injury assessment strategy is to determine the nature and extent of injuries to natural resources and to quantify the resulting natural resource and service losses, providing a basis for

evaluating the need for, type of, and scale of restoration actions. Services means the physical and biological functions performed by natural resources including the human uses of those functions. The Trustees assessed ecological injury to natural resources and associated ecological service losses. They also conducted studies to assess service losses to human use. The relevant NRDA regulatory definitions for the evaluation of injuries to natural resources and related service losses for human use for the TRSAA include the following:

Biota

- Concentrations of a hazardous substance sufficient to cause the biological resource or its offspring to have undergone at least one of the following changes in viability: death, disease, behavioral abnormalities, cancer, physiological malfunctions (including malfunctions in reproduction), or physical deformations [43 CFR § 11.62(f)(1)(i)].

- According to federal 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)]. Federal 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 in edible portions of organisms [43 CFR § 11.62(f)(1)(ii)].

Surface water

- Concentrations and durations of hazardous substances in excess of drinking water standards as established by Sections 1411 - 1416 of the Safe Drinking Water Act (SDWA), or by other federal or state laws or regulations that establish such standards for drinking water, in surface water that was potable before the release [43 CFR § 11.62(b)(1)(i)]

- Concentrations and duration of hazardous substances in excess of applicable water quality criteria established by Section 304(a)(1) of the CWA, or by other federal or state laws or regulations that establish such criteria, in surface water that before the release met the criteria and is committed use as habitat for aquatic life, water supply, or recreation [43 CFR § 11.62(b)(1)(iii)]

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

Sediment

- Concentrations and duration of hazardous substances sufficient to cause injury to biological resources, groundwater, or surface water resources that are exposed to sediments [43 CFR § 11.62(b)(v); 11.62(e)(11)].

Groundwater

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411 - 1416 of the SDWA, or by other federal or state laws or regulations that establish such standards for drinking water, in groundwater that was potable before the release [43 CFR § 11.62(c)(1)(i)]

- Concentrations and duration of hazardous substances sufficient to have caused injury to surface water, when exposed to groundwater [43 CFR § 11.62(c)(1)(iv)].

Geologic resources

- Concentrations of substances sufficient to cause a toxic response to soil invertebrates [43 CFR § 11.62(e)(9)]

- Concentrations of substances sufficient to cause a phytotoxic response such as retardation of plant growth [43 CFR § 11.62(e)(10)]

- Concentrations of substances sufficient to have caused injury to surface water, groundwater, air, or biological resources, when exposed to geologic resources [43 CFR §11.62(e)(11)].

Human use

- Reduction in human use services which include such things as use of water for drinking, the use of fish or wildlife for food, and the use of many components of the environment for recreation. [51 Fed. Reg. 27674, 27886 (Aug. 1, 1986)].

To evaluate potential injury to natural resources, the Trustees reviewed site-specific injury studies as well as other existing information, including remedial investigation data, ecological risk assessments, and scientific literature. Based on information from all these sources and with an understanding of the function of the terrestrial and aquatic ecosystems in the TRSAA, the Trustees evaluated injury to natural resources and determined the expected magnitude and severity of effects of PCDDs and PCDFs on natural resources.

The Trustees considered several factors throughout injury assessment, including, but not limited to the following:

- the specific natural resource and ecological services of concern;

- evidence indicating exposure, pathway and injury;

- mechanisms by which injury occurred;

- type, degree, spatial and temporal extent of injury; and

- types of restoration actions that are appropriate for NRDA and feasible.

The Trustees determined the extent of the effects of the injury, or, in other words, how much of the natural resource has been injured, as provided in 43 C.F.R. § 11.71. To determine the extent of the effects, these reductions can be converted into services. As described in 51 Fed. Reg. 27674, 27886 (Aug. 1, 1986): "a service refers to any function that one natural resource performs for another or for humans. Within the nonhuman part of an ecosystem, plants provide habitat and food for animals, one animal may provide or serve as food for another, or water may be used by fish for support, respiration, and many other functions. This list could be expanded to describe almost any interaction between species or between physical and biological levels. Among these services are the uses that humans make of natural resources."

As further described in Section 3.4, the Trustees addressed the various service losses by quantifying ecological injury and service loss on a habitat basis while service losses for human use were quantified on a monetary basis.

3.3.1 Geographic Scope

The assessment area is based on the geographic scope within which natural resources have been directly or indirectly affected by the releases of hazardous substances (43 C.F.R. §11.14 (c)). For the purposes of this Draft RP/EA, the geographic scope of the assessment area, or TRSAA, includes (1) all segments of the Tittabawassee River directly adjacent to the Midland Facility and all segments of the Tittabawassee River downstream from the Midland Facility to the confluence of the Tittabawassee River and the Shiawassee River, (2) the 100 year floodplain of the Tittabawassee River segments referred to above; (3) the Saginaw River, from the confluence of the Tittabawassee River and the Shiawassee River to the mouth of the Saginaw River at Saginaw Bay; (4) the 100 year floodplain of the Saginaw River, (5) Saginaw Bay extending from the mouth of the Saginaw River to an imaginary line drawn between Au Gres and Sand Point; (6) the Midland Facility and (7) the aerial deposition zone.

The geographic scope of the restoration area being considered by the Trustees is larger than the TRSAA in order to include additional areas where the natural resources and services affected in the TRSAA may also be restored. The Trustees consider this restoration area to include the entire Saginaw Bay watershed (Figure 3).

3.3.2 Temporal Scope

Within the TRSAA, natural resource exposure to hazardous substances has been documented at least since the 1970s and is expected to continue into the future. Damages are calculated beginning in 1981, in accordance with case law related to the enactment of CERCLA in December 1980, and are estimated into perpetuity, unless otherwise specified, with reductions over time as a result of remediation and natural processes. Injury and corresponding damages with regard to recreational fishing, park use, and hunting losses were assumed to persist until 2043.

Natural resource recovery scenarios for settlement negotiations were based on the remedial progress through 2016 and Dow's continuing obligations under the 2010 AOC with USEPA and EGLE. The Trustees assumed that injuries would generally decline over time as the remedies are implemented. The Trustees estimated future injuries as a result of the physical impacts of

cleanup activities based on USEPA's estimated timeline for removal and stabilization actions and a reasonable worst case estimate of the area to be impacted based on characterization of PCDD and PCDF concentrations in soils.

3.4 Injury Evaluation / Resource and Service Losses

Each of the natural resources exposed to and potentially injured by the release of hazardous substances, including surface water, sediment, and the organisms that utilize the riverine and associated wetland and floodplain or upland habitats (e.g., fish, birds, reptiles, amphibians, mammals), is a natural resource. Over the years, these natural resources have been exposed to hazardous substances, including PCDDs and PCDFs, released from Dow's Midland plant and have suffered adverse effects from the contaminants themselves and from cleanup actions taken to address the contaminants. In addition, concentrations of PCDDs and PCDFs have been great enough that the State of Michigan issued advisories for consumption of fish and wild game and for contact with sediments and floodplain soils. Impacted natural resources and services include the following:

- Surface water and sediment
- Soil
- Benthic invertebrates
- Mussels
- Fish
- Reptiles and amphibians
- Migratory birds
- Mammals
- Recreational fishing
- Park use
- Hunting

Injured natural resources within the assessment area sustained some losses in ecological services due to contamination. A reduction in the ability of an injured resource to provide these services (such as food for a higher trophic level, or catch for a recreational angler), as compared to the baseline level of services or that which existed but for the contamination, is considered a service loss. The severity and magnitude of these potential losses are quantified, where possible, to establish a basis for scaling restoration and determining damages. In the sections below, the methodologies and assumptions used to quantify injury for representative natural resources are discussed, and assessment results are summarized.

To address the wide range of injury and service losses at the site, the Trustees developed a multi-pronged approach to damages determination: (1) for the losses of floodplain, aquatic, shoreline, and upland resources, the Trustees' general approach was to first confirm injury to natural resources, and then use habitat equivalency analyses to quantify the ecological losses(described in sections 3.4.1 - 3.4.6); (2) an extensive mail survey and recreational choice models for losses to recreational fishing (section 3.4.8); (3) an intercept survey, counts, and recreational choice models for losses to park use (section 3.4.9); and (4) hunting trip estimates and literature values for estimated losses per trip for losses to hunting (section 3.4.10). In addition, there were other

categories of injury and loss that may have occurred, but that the Trustees did not quantify (see sections 3.4.7 and 3.4.11).

3.4.1 Habitat Equivalency Analysis

Habitat Equivalency Analysis (HEA) is a restoration scaling technique often used by natural resource trustees to quantify the amount of restoration needed to compensate for injuries to natural resources resulting from oil spills, hazardous substance releases, or physical injuries (e.g., vessel groundings). In this technique, trustees identify restoration type(s) that can appropriately offset the injuries and losses that have occurred, and the HEA is used to scale (balance) the gains from the restoration with the injuries, using appropriate scaling metric(s), which are identified by the Trustees (NOAA, 2006). Federal regulations explicitly allow consideration of HEA as an economic tool to estimate damages in NRDAR cases (43 C.F.R. § 11.83).

HEA starts with the question "What, but for the release, would have happened to the injured area?" In this case, how well would the habitat have been functioning and what services would the injured habitats have provided? This is the baseline for determining the degree of loss in services. "Ecological services" in the HEA context might be represented by many different measures of habitat functioning including metrics like primary productivity, reproductive success of specific species, abundance and diversity of benthic invertebrate communities, or native plant species composition.

With HEA, the extent of losses in time and space is quantified in physical units of measure such as acre-years[5], and the extent of losses in severity is quantified as a percent of services relative to baseline. Overall then, the loss in services over time and space can be expressed in service-acre-years. The benefits of selected projects, or project types, can also be expressed in service-acre-years and then scaled so that the quantity of replacement services equals the quantity of lost services in present value terms. Potentially responsible parties (PRPs) implement or provide funds for restoration projects that are sufficient to cover the public's losses.

HEA, then, involves four basic steps:

(1) Assess the present value of lost services over time relative to baseline. This "debit" is measured in discounted[6] service acre-years (DSAYs).

(2) Select appropriate compensatory restoration projects that provide benefits to the same or similar types of natural resources that were injured.

[5] An acre-year refers to natural resource services provided by one acre of habitat for one year. This measure of natural resource services is specific to the location and type of habitat since different habitats in varying locations provide different types of services.

[6] From NOAA (1999): "Discounting is a widely used economic procedure that weights past and future benefits or costs such that they are comparable to present benefits and costs. Discounting is necessary for calculating the present value of interim service losses and restoration gains as well as the present value of emergency restoration, restoration, and assessment costs."

(3) Determine the expected increase in services of a proposed restoration project over time compared to the initial conditions at the project site. This "credit" is also measured in DSAYs.

(4) Identify the size of the project or projects (scaling) that will equate the total discounted quantity of lost services to the total discounted quantity of replacement services to compensate the public's losses. The claim for credit can then be expressed in DSAYs owed, or acres to be restored with an expected amount of service gains over time, or the cost to conduct such a project and maintain the expected level of services over time.

Following the process outlined above, the Trustees determined the loss of floodplain, aquatic, shoreline, and upland resources from the releases of PCDD and PCDF, including losses related to the physical impacts to habitat caused by cleanup actions. The Trustees worked cooperatively with Dow to assemble available data and literature on natural resource injuries, and then the Trustees independently quantified losses. The Trustees also developed restoration criteria and used them to prioritize restoration types. By reaching out to stakeholders and working with Dow, the Trustees identified a suite of specific projects that could be used to estimate the benefits that could be achieved over time by different types of restoration. The Trustees then used this information to determine the amount and types of restoration needed to compensate for the losses.

3.4.2 Tittabawassee River Floodplain

Injury Assessment Results

The Trustees used multiple lines of evidence to determine the extent of injury and ecological losses in the Tittabawassee River floodplain. The Trustees used the eight-year floodplain as the geographical extent of the HEA based on extensive soil sampling showing this as the extent of elevated concentrations of PCDDs and PCDF. Migratory songbirds and mink were selected as representative natural resources to inform the estimate of losses from the toxic effects of PCDDs and PCDFs in the floodplain. Physical habitat loss that occurred as a result of activities to clean up the released PCDDs and PCDFs was evaluated based on the known and expected geographical extent, timing, and nature of floodplain response activities at the time of the assessment.

Birds

The Trustees evaluated evidence of injury to birds and based their assessment of the magnitude of injury on a series of studies conducted along the Tittabawassee and Saginaw rivers by researchers at Michigan State University (MSU) in 2004 – 2009 (Fredricks 2009; Fredricks et al. 2011; Fredricks et al. 2012; Tazelaar et al. 2013; Coefield et al. 2010; Seston 2010; Seston et al. 2009; Seston et al. 2012), combined with published studies related to the toxicity of PCDDs and PCDFs to birds and their own independent analysis of data from the MSU studies. The MSU studies measured multiple endpoints, including productivity, hatching success, and fledgling success for tree swallow, eastern bluebird, house wren, and American robin, as well as measuring PCDD and PCDF concentrations in eggs, nestlings, and dietary items. Some adverse effects were detected in the MSU studies, including reduced hatching success, fledgling success,

and/or productivity in tree swallows, house wren, and American robin were measured near and downstream of Dow's Midland facility (Fredricks et al. 2012; Tazelaar et al. 2013). However, the MSU researchers concluded in several of their publications that only limited effects to birds could be demonstrated by the study results. The Trustees evaluated the bird studies and found limitations in study designs that reduced the ability to draw such conclusions from these studies, as had been found in a peer review of similar studies on effects of PCBs on birds in the floodplain of the Kalamazoo River (Dickson et al. 2008). These limitations included a lack of analysis of sensitive endpoints, limited statistical power, inappropriate selection of the site used as a reference comparison, and lumping of data across study sites both temporally and spatially. The exceptions to this spatial lumping were the regression analysis performed by Fredricks et al. (2011), which showed 20–80% reduced hatching success at nests with elevated concentrations of PCDDs and PCDFs, and the statistically significant spatial trends in concentrations of PCDDs and PCDFs in bird eggs observed by Tazelaar et al. (2013).

In addition, the Trustees undertook an independent reevaluation of the egg concentrations reported by the MSU researchers. The Trustees compared these concentrations to levels that have been shown to cause adverse effects (i.e., embryo mortality) to birds in the literature. This analysis took into consideration more recent literature, which has shown that some of the PCDF compounds are more potent to birds than previously thought (e.g Cohen-Barnhouse et al. 2011). This reanalysis of the data showed that there are likely significant adverse effects to birds in the Tittabawassee River floodplain, with some spatial variation, and consistent with the Fredricks et al. (2011) tree swallow data showing 20–80% reduced hatching success at nests with elevated PCDDs and PCDFs.

Mink

The Trustees evaluated evidence of injury to mink and based their assessment of the magnitude of injury on a series of studies conducted by researchers at MSU in 2004 – 2010 (Blankenship et al. 2008, Bursian et al. 2012, Moore et al. 2009, Moore et al. 2012, Zwiernik et al. 2008, Zwiernik et al. 2009), combined with other published studies related to the toxicity of PCDDs and PCDFs to mink and the Trustees' own independent analysis of data and information from the MSU studies. The MSU mink studies involved a field study, laboratory studies, and development of a literature-derived toxicity reference value (TRV) for mink. Here we provide a brief overview of these studies and the Trustees' interpretation of study results for the injury assessment.

Field studies. In the field studies, MSU trapped mink at locations upstream and downstream of the Dow facility, and measured gross morphology endpoints, including the age, sex, weight, and organ weights of trapped mink. MSU also conducted histological examinations of jaw, kidney, and liver tissues, and evaluated mink abundance. Mink dietary items were also collected and analyzed for PCDDs and PCDFs (Zwiernik et al., 2008). Based on the results of the field work, MSU concluded that the mink population on the Tittabawassee River downstream of the Dow facility was healthy. However, the Trustees' review of the field study revealed several issues. The study had limited statistical power to detect upstream/downstream differences for many of the studied endpoints, so that adverse effects could have been present but went undetected. Despite these statistical limitations, important findings were in fact made in the study, including histological abnormalities in the kidney, liver, and jaw of mink collected downstream of the Dow

facility. Further, the Trustees reviewed the original histology reports, which indicated that the quality of the histology slides was poor, due to sample freeze-thaw issues, particularly in the downstream samples. Despite the poor quality, observations of tooth spacing issues and jaw lesions (a very sensitive endpoint in mink) were nonetheless recorded for mink caught downstream of the Dow facility. However, these observations were not reported in Zwiernik et al. (2008). Further, sensitive endpoints such as reproduction, kit survivability, and kit growth were not studied, and therefore adverse effects could have been occurring but were simply not measured. Finally, even though the field study was designed as an exposure study rather than a population abundance study, MSU did an estimation of mink abundance based on data from their field study, but the Trustees found errors and misinterpretations of the literature in the MSU abundance analysis. These errors appear to have resulted in as much as a 50% over-estimation of the downstream population level of mink, a significant reduction from what would be considered a healthy population.

Laboratory studies. Three separate mink laboratory studies were funded by Dow at MSU: (1) Zwiernik et al. (2009), (2) Moore et al. (2009), and (3) a study led by Bursian that was published in two separate papers – Bursian et al. (2012) and Moore et al. (2012). Furans were fed to adult female and juvenile mink in the three studies, with overlapping concentrations. While the three studies were conducted with overlapping dose ranges, very different results were reported. The Moore et al. (2009) and Zwiernik et al. (2009) studies showed little to no adverse effects in exposed mink, while the Bursian study (Bursian et al., 2012; Moore et al., 2012) found jaw lesions and reduced reproduction. Importantly, the observed lesions and reduced reproduction reported in the Bursian study (Bursian et al., 2012; Moore et al., 2012) occurred within the range of dietary exposure that was measured by Zwiernik et al. (2008) in the Tittabawassee River mink field study. The Bursian study (Bursian et al., 2012; Moore et al., 2012) confirmed exposure and dose response via analysis of diet and mink tissue samples, unlike Moore et al. (2009) and Zwiernik et al. (2009), who did not. This leaves open the question of whether the mink in the latter two studies were exposed to the full estimated doses (i.e., if the mink consumed everything they were given to eat). In addition, Zwiernik et al. (2009) used a pastel colored mink, while Bursian et al. (2012) used a wild-type natural brown mink, and there is some indication in the literature that there may be variable responses to contaminant exposure across mink strains. For example, Ellick et al. (2013) observed a different response to polychlorinated biphenyls (PCBs) in blue iris versus natural dark mink strains. The blue iris mink exhibited lesions indicative of osteomyelitis and lymphoplasmacytic gingivitis, whereas the natural brown mink developed the typical squamous cell proliferation of maxilla and mandible observed in wild mink exposed to PCDDs, PCDFs, and PCBs. It is possible that there are also other strain-related differences that have not yet been tested, and that the differences in jaw lesion frequency observed between the Zwiernik et al. (2008) study and the Bursian et al. (2012) study are the result of these differences. Therefore, the Trustees put more weight on the result of the Bursian study conducted with the wild-type brown mink. The Bursian study predicts that the concentrations of PCDDs and PCDFs in mink dietary items downstream of the Dow facility were sufficiently elevated to result in both reduced reproduction and jaw lesions.

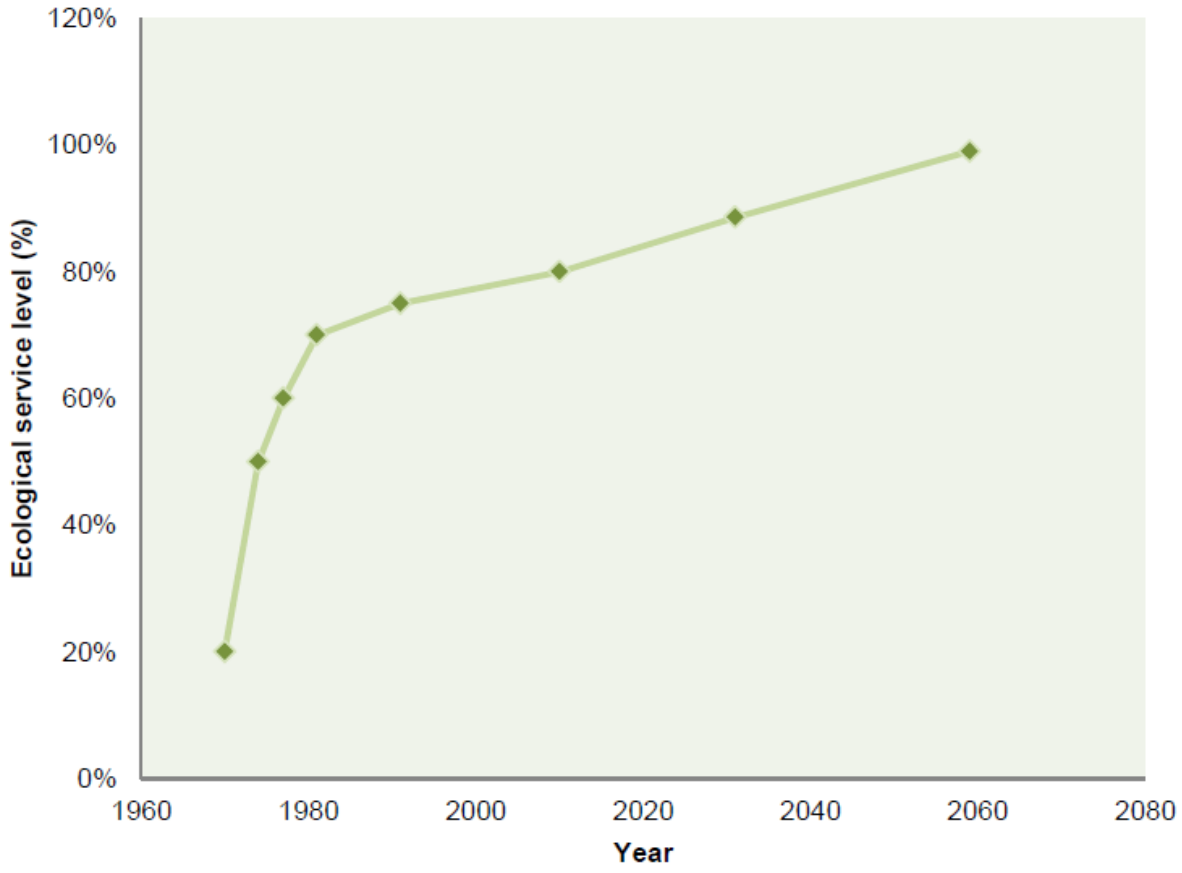
TRV derivation. Blankenship et al. (2008) conducted a literature review to develop a TRV for TEQs for Tittabawassee River mink. They reviewed over 30 published mink feeding studies conducted with PCDDs, PCDFs, and PCBs. However, the authors rejected the majority of the studies based on narrow criteria (e.g., approximately 15 were rejected because the TRV was not

reported as a TEQ – which was in fact easily calculable with information provided in the publications). Blankenship et al. (2008) recommended a site-specific dietary TRV for mink that was based on their own field study – Zwiernik et al. (2008) – that was not designed to measure reproductive success or other sensitive endpoints. TRVs that are based on a single study can be problematic for a number of reasons. The analysis of a larger number of studies reduces dependence on the specifics of any single study and makes it more likely that an accurate TRV can be determined. Given these limitations of using a TRV based on a single study, the Trustees undertook an independent analysis of the literature-reported values. Effects levels from 20 mink feeding toxicity testing studies for kit reproduction and growth endpoints were compiled. For each study and endpoint, the average of the reported no observed adverse effect level (NOAEL) and low observed adverse effect level (LOAEL) was calculated, and then normalized to the study's response control to derive a percent response. The percent response values for all studies were then plotted as dose-response curves. When plotted on the dose-response curves, mink dietary exposures reported by Zwiernik et al. (2008) fell within the range of ~ 75–50% decreased reproduction. Even when two of the dominant furans from the Tittabawassee River exposures were removed from the analysis (the potency of these two furans in mink has been questioned based minks' ability to metabolize them), the adjusted dietary TEQ concentrations still fell within the range of ~ 25–50% decreased reproduction.

Severity of injuries over time

The Trustees made reasonable assumptions to extrapolate floodplain conditions in the past and future. The Trustees looked for data on exposure and injury in the past, but found little useful information. A limited number of floodplain soil cores collected by ATS (2007) were analyzed at regular depth intervals for PCDDs and PCDFs and for age dating. However, the required sample volume resulted in low depth/age resolution, so the results were difficult to interpret (ATS, 2007). By contrast, historical data exist for in-river species, including benthic invertebrates and fish. In particular, numerous biological surveys of these resources were conducted between the 1970s and the present, and records of fish kills were kept. Because there is interaction between the river and the floodplain (i.e., it is a naturally functioning system and the floodplain is regularly inundated by the river as well as drains into it), the Trustees extrapolated trends in past exposure and injury levels in the floodplain based on the trends in exposure and injury available for in-river biological resources. The benthic invertebrate and fish studies reviewed all indicate that ecological conditions were worse in the past and have improved over time. Based on the date that CERCLA was enacted, the Trustees only included injuries from 1981 in their assessment of injury, though data from before 1981 was used in developing the injury recovery curve shown in Figure 4 . The Trustees based their estimates of future recovery of natural resources on the planned remedial activities for the site. It was assumed that through the implementation of effective site remedies, ecological conditions will gradually improve within the floodplain until fully recovering to baseline in 2059.

Figure 4. Injury recovery curve for the Tittabawassee River floodplain; illustrating the change in ecological service level over time, relative to baseline conditions (those that would exist but for the contamination by PCDDs and PCDFs).



Physical injury due to cleanup

The geographical extent and timing of floodplain response activities was based on information available at the time of assessment. By 2015, USEPA and EGLE had established a floodplain cleanup level of 250 ng/kg dry weight (parts per trillion or ppt) TEQs in soil for maintained residential areas and of 2,000 ppt for unmaintained areas. The Trustees focused on the unmaintained portions of the eight-year floodplain to estimate the expected geographical extent of the cleanup activities. In order to estimate areas within that boundary that exceeded 2,000 ppt and would thus be subject to cleanup activities to natural habitat, the Trustees used established geomorphic features with the floodplain to create polygons and then estimated TEQs within the polygons based on an extensive database of concentrations measured as part of the response actions.

Not all of the geomorphic polygons contained TEQ sampling locations, so the Trustees extrapolated from polygons of the same geomorphic type (e.g. low terrace, splay) according to the following steps for each of the seven river segments:

1) All polygons in the segment with data were sorted with respect to geomorphic feature and river bank orientation

2) For each type, the percent of polygons with a sample average plus one standard deviation greater than 2,000 ppt TEQ was calculated.

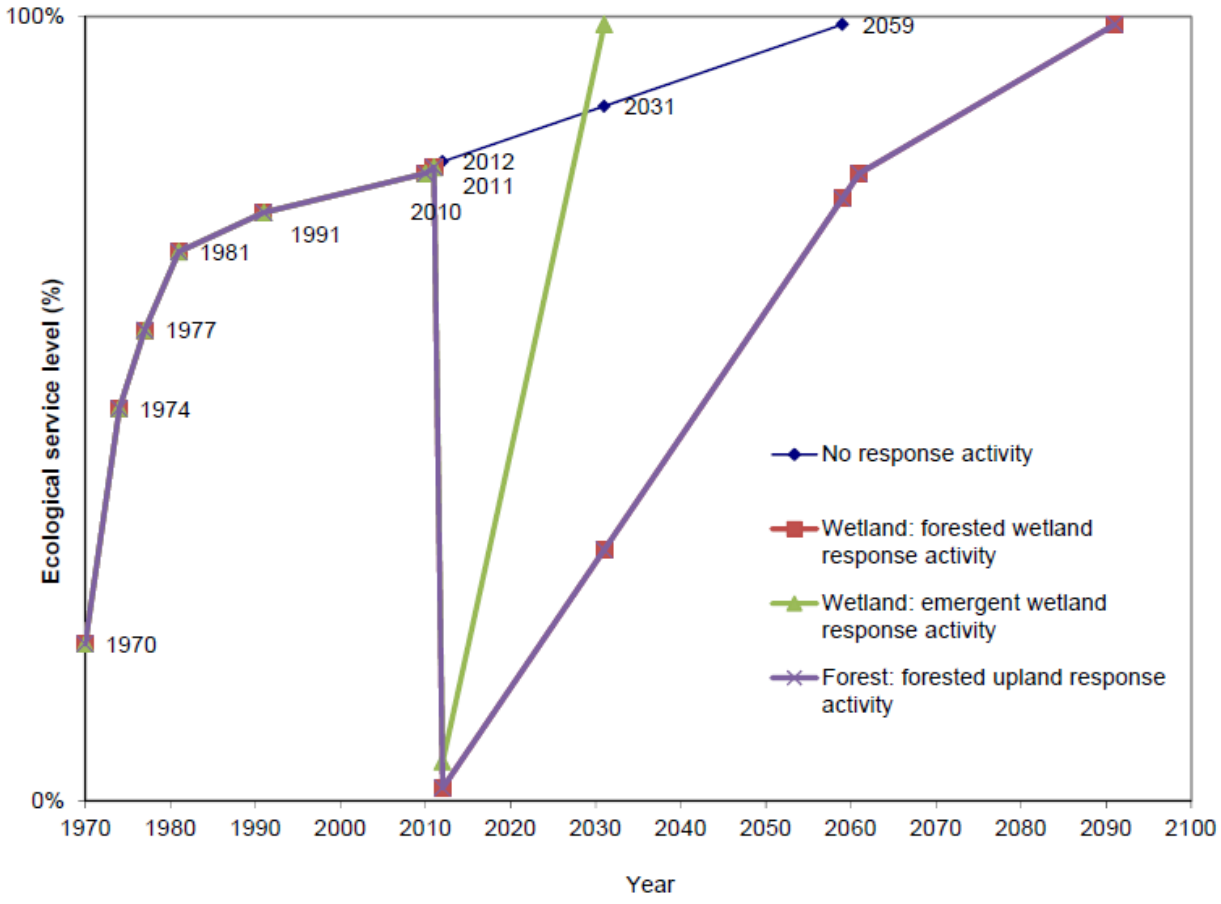
3) This percentage was applied to polygons of the same type that did not have TEQ data to calculate the area of the polygons without data that would be expected to be greater than 2,000 ppt TEQ.

4) For a few geomorphic types with very little data in a segment or segment, the overall percent exceedance across polygons with data, regardless of geomorphic type, was used to calculate the percent exceedance within that type. The high surface geomorphic type is an exception to this. No exceedances were extrapolated to this type because of the low likelihood of contamination at these higher elevations, even within the eight-year floodplain.

The total acreage exceeding 2,000 ppt TEQ in the Tittabawassee River floodplain across all geomorphic types was determined to be 322 acres of the 4,761 acres included in the Trustees' evaluation of the eight-year floodplain. The floodplain, including the areas expected to be impacted by cleanup activities, were classified by major land cover type (wetland, upland forest, and agricultural/developed). Note that the extrapolation analysis described above only added an average of approximately 2% of the total acreage with exceedances for each habitat type within each segment.

The cleanup activities for unmaintained properties exceeding the 2,000 ppt TEQ value that are described in Dow's Floodplain Response Proposal (Dow, 2014) consist of either capping or excavation and backfilling, both of which require tree removal in forested areas and severe loss of ecological function with a prolonged period for recovery. Capped areas would require perpetual maintenance and a permanent loss of trees. For purposes of estimating losses over time, the Trustees assumed different recovery rates and times for forested and non-forested (e.g. emergent wetlands) habitat types. For forested habitats, the Trustees assumed excavation actions rather than capping and used a two-staged recovery with services increasing from 0% to 80% as trees grew and formed a complete canopy over the first 50 years and then from 80% to 99% over the next 30 years as the ecological complexity returned toward full functioning. For emergent wetlands, the Trustees assumed 99% recovery over 20 years (Figure 5). The Trustees assumed that response activities would have only a negligible effect on the ecological functioning of agricultural and developed habitat types. For purposes of the assessment, the cleanup activities in the floodplain were assumed to begin in Segment 1 in 2012 and then progress downstream, segment by segment, with removals reaching each segment in two year intervals.

Figure 5. Injury recovery curve illustrating how remedial actions reset and change the recovery trajectory for Segment 1, where soil excavation began in 2012. For other segments, the curves reflect remedial activities beginning in subsequent years.



HEA results

Based on the body of information on injuries to mink and birds as representative of biological resources that utilize the Tittabawassee River floodplain, the Trustees conservatively concluded that there was a 20% ecological service loss at the time of the assessment, and extrapolated service levels in the past and future, based on the injury levels shown in Figure 4.

The Trustees used these service losses over time, as represented by birds and mink, for all acreages not expected to receive cleanup actions. For those areas receiving cleanup actions, the same service losses over time were used until the year in which cleanups were expected to occur in a given area. From that point forward, the recovery curve for the physical habitat impacts was used for that area. Overall, the Trustees calculated a loss of 33,700 DSAYs of Tittabawassee River floodplain habitat. To put this number of DSAYs in perspective, a high quality restoration project might produce approximately 18 DSAYs of benefits per acre, so a single project of this quality would need to be 1,872 acres in size to fully address this loss (restoration projects are discussed further in Chapter 4).

3.4.3 Saginaw River Floodplain

Injury Assessment Results

The Trustees used the same general approach for the Saginaw River floodplain as they did for the Tittabawassee River floodplain. Because the Saginaw River floodplain is not as well-characterized as the Tittabawassee River floodplain, the Trustees used a structured approach to identify portions of the Saginaw River floodplain that would be expected to be similarly impacted by PCDDs and PCDFs as the Tittabawassee River floodplain.

To determine the impacted area of the Saginaw River floodplain, the Trustees first used available datasets for PCDDs and PCDFs in that floodplain to identify locations with elevated concentrations (MDEQ, 2003, 2014; ENVIRON,2008; Weston, 2008). The Trustees then used LIDAR imagery to delineate areas with similar elevations along the floodplain to those with TEQ > 90 ppt TEQs and added in areas of historical dredge materials that had been side cast into the floodplain. In areas without LIDAR imagery, aerial photographs and land cover information were used to delineate floodplain locations with similar geomorphology as those locations where elevated soil TEQ values were measured. Developed areas were not included. Acreages of the Ploudry and Davis Units of the Crow Island State Game Area were included because they are regularly flooded from the Saginaw River during high flow events. Other units were not included because under most conditions they receive flood water from their own watersheds rather than from the river. The total number of acres of the Saginaw River floodplain identified as being impacted by PCDDs and PCDFs similarly to the Tittabawassee River floodplain was 2,177 acres with 1,192 acres of that directly along the Saginaw River and 985 acres in two units of the of Crow Island State Game Area.

HEA Results

The Trustees applied the same service levels and recover timeframes for the Saginaw River as were used for the Tittabawassee River floodplain HEA, with the exception of the Ploudry and Davis Units of the Crow Island State Game Area. Because of the limited contaminants data from these two units, the Trustees assigned a lesser service loss for these units (e.g. 5% instead of 20% for current service loss elsewhere in the Saginaw River floodplain). For purposes of the assessment, the Trustees assumed that physical losses to habitat from cleanup actions in the Saginaw River floodplain would be negligible. The Trustees calculated a loss of 11,700 DSAYs of Saginaw River floodplain habitat based on estimated direct impacts of PCDDs and PCDFs.

3.4.4 Aquatic

Injury Assessment Results

The Trustees used multiple approaches to examine the extent of injury and ecological losses in the aquatic portion of the Tittabawassee River including benthic invertebrate and fish community diversity and abundance metrics, sediment toxicity testing, sediment and tissue concentrations relative to benchmarks for effects on benthic invertebrates, and fish tissue concentrations PCDDs and PCDFs relative to toxicity thresholds from the literature.

At the time of the assessment, benthic invertebrate and fish surveys were available from 1971 to 2006. In order to establish losses over time, the Trustees compared data collected upstream and downstream of the Dow Dam from the different studies, with the upstream data representing baseline conditions (those that existed but for the release of contamination from Dow's Midland facility). The benthic invertebrate and fish studies indicate that ecological conditions were worse in the past and have improved over time:

- Environmental conditions below the Dow plant were poor in the early 1970s, as indicated by low diversity of species, limited to pollution-tolerant taxa such as midges and sludgeworms (*Tubifex tubifex*; MWRC, 1972; Zillich, 1972). In contrast, upstream Tittabawassee River and tributary reference locations at the same time period had diverse benthic invertebrate communities, which are indicative of clean water conditions (MWRC, 1972; Zillich, 1972).

- Similarly, fish populations downstream of the Dow Dam in the early 1970s were very poor: no game fish were found in the entire stretch of the river between the Dow Dam and the confluence of the Tittabawassee River with the Saginaw River (22 miles downstream of Dow; MWRC, 1972; Zillich, 1972). Two fish kills were observed in 1971, both related to discharges from the Dow Midland plant into the Tittabawassee River (Zillich, 1972).

- From the 1970s onward, both benthic invertebrate and fish population metrics improved. This is consistent with the water treatment measures Dow implemented over time, in response to state and federal regulations and to meet their Resource Conservation and Recovery Act (RCRA) operating license requirements.

The Trustees' interpretation of these studies in terms of injury and service levels from the past to the present are presented in Table 6, although the nature of these survey-type studies does not allow for distinctions between releases from Dow and other possible sources in Midland. In addition, the Trustees later became aware of benthic community survey work conducted by Dow in 2010 (Dow Chemical, 2011). Dow's conclusion from its 2010 survey was that the benthic invertebrate communities in the specific areas surveyed were not impaired.

Table 6. Summary of past benthic invertebrate and fish community information on the Tittabawassee River downstream of Midland with assigned service levels for these indicators

Year	Service Level	Description
1971	20%	Invertebrate community degraded, poor diversity, limited to pollution-tolerant taxa. No game fish. Carp only in low numbers. Fish-kills common. [MWRC 1972, Zillich 1972]
1974	50%	Invertebrates less diverse than reference, but some sensitive taxa found. Forage fish and game fish found. [Sylvester 1974]
1978	50%	Pollution-tolerant invertebrate taxa dominate, but some more-sensitive taxa also found; diversity improved since 1972. Fish abundance and diversity "further improved." [Lenon et al. 1979]
1979-1982		Increase in "infaunal abundance" from 1979 to 1982, but no changes in invertebrate diversity or abundance. Sites downstream of Dow plant only. [LMSE 1983a, LMSE 1983b]
1985	70%	Pollution-tolerant invertebrate taxa dominate, but more-sensitive taxa also found, including stonefly. [Gersich et al. 1985]
1991-1992	80%	Pollution-tolerant invertebrate taxa dominate, but some more sensitive taxa also found. Comparison to reference showed community impoverished compared to reference sites. Fish community "good/moderately impaired." [MDNR 1994]
2004		Sensitive invertebrate taxa found in sufficient mass for contaminants analysis. [Zwiernik 2006b]
2009	80%	No information on invertebrate abundance and diversity. Abundant variety of fish. Uncertainty on sturgeon reproduction. Sediment toxicity observed in some locations. [K. Schrouder, MDNR, personal communication, July 2009; A. Taylor, MDEQ, personal communication, July 2009]

Sediment and tissue concentrations relative to benchmarks for effects on benthic invertebrates vary widely for TCDD and TEQs. For example, a lowest observe effects level (LOAEL) for TEQs in oyster tissue in one study was 2 ng/kg (Wintermyer and Cooper 2003). The sensitivity of native freshwater mussels found in the Tittabawassee River relative to the sensitivity of marine oysters is unknown. In controlled laboratory studies with test organisms, a LOAEL for TCDD in the freshwater crayfish, *Pacifastacus leniusculus,* was found at a dose of 3,000 ng/kg body weight while no effects were found at 300 ng/kg body weight (Ashley et al. 1996), and in tests with *Chironomus tentans* and *Lumbriculus variegatus*, no effects were found at the greatest tissue concentrations tested (120,000 – 140,000 ng/kg) (West et al. 1997). No effects were observed for the amphipod *Ampelisca abdita* in spiked sediments with up 25,000 ng/kg dry weight in sediments (Barber et al. 1998). Although concentrations in tissues were not measured in that study for direct comparisons to tissue concentrations, this sediment concentration is high relative to the general range of concentrations measured in sediments in the Tittabawassee River. MSU researchers measured PCDDs and PCDFs in benthic invertebrates in the Tittabawassee River in 10 taxa: concentrations of TEQs in composite samples of benthic invertebrates calculated using TEFs for fish ranged from 0.20 to 88 ng/kg (Zwiernik 2006). The measured concentrations confirmed that benthic invertebrates in the Tittabawassee River are exposed to PCDDs and PCDFs. However, given the variability in effects levels and exposure, the Trustees did not attempt to relate sediment and tissue PCDD and PCDF concentrations directly to levels of injury for benthic invertebrates.

The Trustees compared fish tissue TEQ concentrations in the Tittabawassee River to a tissue residue benchmark for toxicity developed from a species-sensitivity distribution by Steevens et al. (2005). The benchmark used was 0.32 ng TEQ/g lipid based on protecting 95% of fish species. In 2008-2009, the Trustees and Dow collected recent fish concentration data from EGLE, MSU, and Entrix (contracted by Dow) that included data from 442 individual fish across 13 species. Of those samples, 31% of the individual fish and 46% of the mean concentrations within species exceeded this benchmark.

Using their best professional judgment, the Trustees assume that the implementation of effective site remedies will result in gradual recovery from toxicological effects. In addition, physical impacts from response activities to aquatic habitat appear to be transient in this system and likely offset by at least temporary increases in aquatic habitat diversity from rooted macrophytes and rocks associated with some of the capping structures in a riverbed that is normally dominated by sand.

3.4.5 Banks

Injury Assessment Results

The Trustees analyzed the impacts that Dow's response actions for the banks of the Tittabawassee River have had on habitat functions and values along the first several segments of the river corridor and estimated the extent of expected future response actions for the banks of the river. The response actions in bank management areas (BMAs) are mainly focused on stabilizing the banks (minimizing erosion) to keep the contamination in place and buried at depth, as described in section 1.5.2. These actions, while reducing the potential for additional releases of PCDDs and PCDFs to the river, also alter bank-edge fluvial processes and habitats by removing some trees, trimming others back so they do not hang over the river and shade vegetation on the bank, smoothing the shape of the bank, and removing large woody debris along the shoreline and into the water. Further, the affected habitats and ecological functions they provide (such as bank edge complexity, over-story shade and inputs of nutrients, perches for insect- and fish-eating birds, and microhabitat features including eddies) are distinct from the floodplain habitat and functions analyzed separately.

Based on information available in 2015, the Trustees estimated that work at BMAs was impacting approximately 12% of the shoreline, or 5.4 miles in total. The timeframe for injuries was based on the expected start and end dates for response actions in each segment. For example, Segment 2 response actions began in 2014, while Segment 7 response actions are expected to begin in 2020.

HEA Results

While the response actions reduce some habitat functions, the Trustees decided it is likely to be a relatively minor effect, as the banks are being re-sloped with natural materials rather than being armored with concrete or steel and being planted with native vegetation. As such, the Trustees estimated the net service loss at 10% of baseline prior to response actions. Because Dow is required to monitor and maintain the BMAs, the Trustees assumed the lost functions would be permanent, so they were kept constant throughout the HEA calculations to 2065. The Trustees

calculated injuries based on a "discounted-river-mile-year" (DRMY). Based on the inputs described above, the total debit was 13.22 DRMYs.

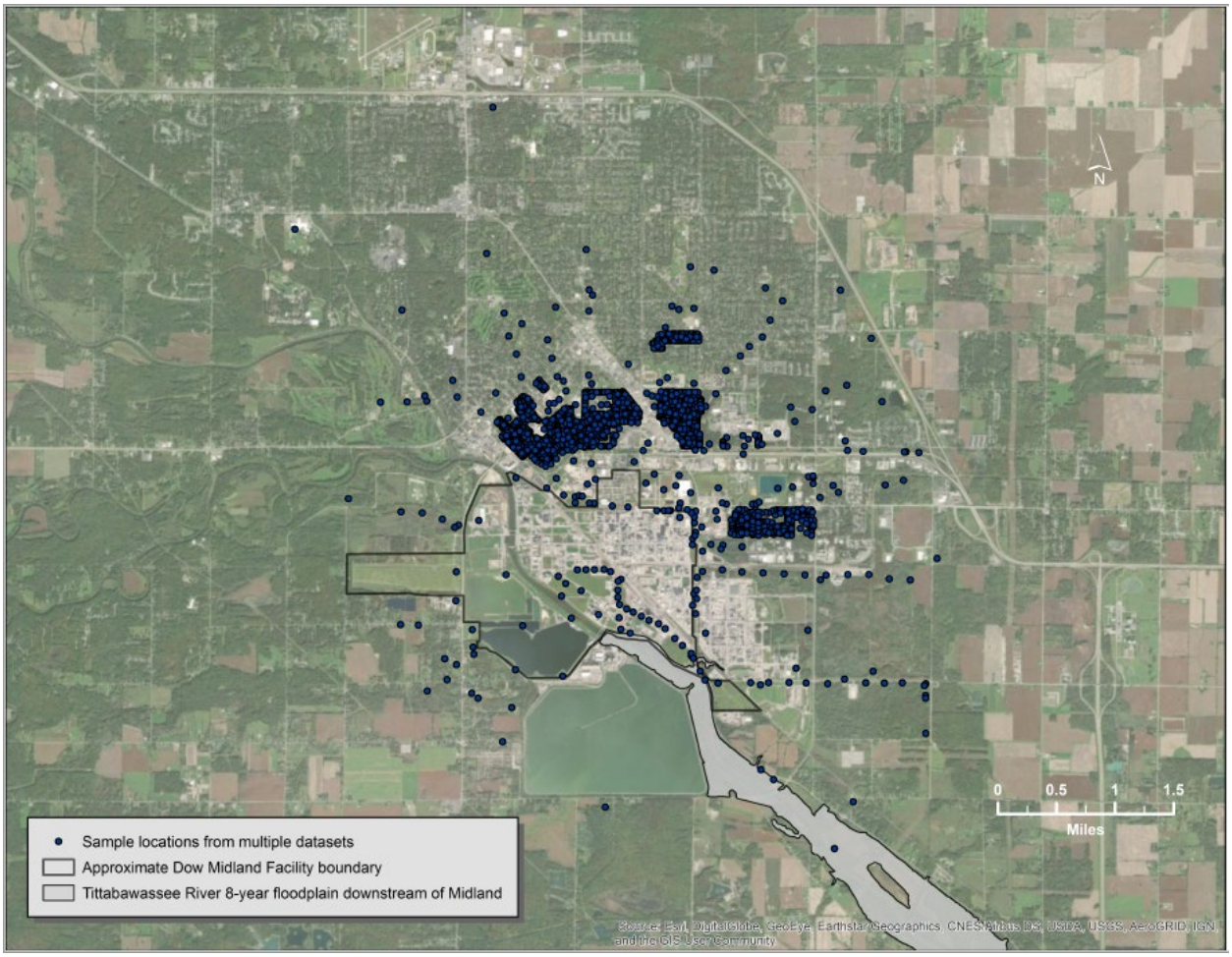
3.4.6 Upland

Injury Assessment Results

The Trustees assessed the extent of injury and ecological losses associated with releases of hazardous substances from Dow's Midland facility to the aerial deposition zone by evaluating soils in the surrounding area. Based on extensive sampling of Midland area soils and the ecological risk assessment conducted under RCRA (URS, 2016), the Trustees focused on PCDDs and PCDFs as the hazardous substances of greatest concern and selected the American robin as the representative natural resource to inform the quantification of losses. The Trustees used a TEQ dietary toxicity reference value based on reduced egg production and hatchability as an injury threshold. The lowest observable adverse effect level (LOAEL) for these endpoints measured in ring-necked pheasants by Nosek et al. (1992) was converted to an equivalent dietary dose for the American robin based on relative food intake rates and body weights following the modeling of Sample et al. (1996). The resulting injury threshold for the American robin was determined to by 116 ng TEQ / kg food.

To determine the area over which this dietary injury threshold would be exceeded, the Trustees assumed that the American robin diet was composed of 100% earthworms and that the bioaccumulation of PCDDs and PCDFs from soil into earthworms could be estimated from the data in Fagervold et al. 2010 for the Tittabawassee River floodplain. Bioaccumulation factors were calculated from lipid-normalized concentrations of each PCDD and PCDF congener in earthworms and organic carbon-normalized concentrations of the same congener in co-located soils. For three congeners for which Fagervold et al. (2010) did not have data, the Trustees estimated the bioaccumulation factors for those congeners using the standard approach of developing a regression of bioaccumulation factors versus the logarithm of the octanol-water partitioning coefficients. The Trustees then used concentrations of PCDDs and PCDFs in Midland area soils from the Midland Soils Resolution 2012 – 2014 dataset (URS, 2016) and the congener-specific bioaccumulation factors to calculate dietary concentrations of TEQs predicted by each soil concentrations. Additional soil concentration datasets from EGLE, Dow, and EPA were used by converted mammalian TEQs to avian TEQs using a relationship developed from the Midland Soils Resolution dataset. Collectively, these datasets, depicted in Figure 6, were used to evaluate the extent of the aerial deposition zone. The Trustees then determined the geographic extent of injury exceedance within the aerial deposition zone by using spatial interpolation to calculate an area of injury exceedance. Areas within Dow's Midland plant boundary and the eight year floodplain of the Tittabawassee River were excluded, as well as residential areas that were remediated.

Figure 6. Area in and around Midland showing where soil samples were analyzed in order to investigate the extent of aerial deposition and injury exceedences



HEA Results

Based on their interpretation of the toxicological literature and the range and distribution of concentrations observed, the Trustees set the service loss at 30% for soils exceeding the 116 ng/kg adverse effect level of reduced egg production and hatchability. The Trustees assumed a constant service loss over time from 1981 until 2015 and then a slight and gradual decrease in losses through 2065. Losses prior to enactment of CERCLA in 1981 were not included. Overall, the Trustees calculated a loss of approximately 2,200 DSAYs of upland habitat.

3.4.7 Other Potential Ecological Losses

Addition ecological losses may have occurred as a result of the releases of hazardous substances from Dow's Midland plant, but the Trustees did not specifically quantify these injuries. One example of potential additional losses is the contribution of PCDDs and PCDFs from Dow to historical and on-going poor reproductive success, low site fidelity, and impaired immune functioning in colonial waterbirds like Caspian terns and herring gulls that nest on islands in Saginaw Bay (Mora et al. 1993, Ludwig et al. 1993, Grasman et al. 1996, Grasman et al. 2017).

In eggs of those birds, a large fraction of the TEQs is contributed by PCBs rather than PCDDs and PCDFs, so, for settlement purposes, the Trustees did not attempt to quantify injuries to colonial waterbirds in Saginaw Bay.

3.4.8 Recreational Fishing

In addition to the ecological services, natural resources within the assessment area provide recreational services. In particular, the aquatic habitat and fishery resources of the assessment area provide anglers with extensive opportunities for recreational fishing. The Tittabawassee River, Saginaw River, and Saginaw Bay support a regionally significant recreational fishery, with the most sought-after game fish being walleye and yellow perch with smallmouth bass, catfish, and northern pike being other popular species. This section describes the Trustees' approach to quantifying the losses in recreational fishing resulting from contaminant-related Fish Consumption Advisories (FCAs).

The State of Michigan began advising that people restrict their consumption of contaminated sport-caught fish in the 1970s. FCAs have changed over time to reflect contemporaneous data on fish contaminant levels and contaminant toxicity as well as new methodologies for establishing and issuing advisories. Until 1980, Michigan issued FCAs based on the U.S. Food and Drug Administration's guidelines. In 1981, Michigan began to apply risk assessment methodologies to determine FCA trigger levels for certain contaminants. Trigger levels have changed over the years, mainly based on refinements in knowledge of the contaminants. For example, in 1986 the Michigan Department of Community Health (MDCH) reevaluated the dioxin trigger level of 25 ppt and adopted a lower trigger value of 10 ppt. The details of the advisories for the TRSAA through 2016 are provided in Appendix B. Over time, various FCAs have been issued in the TRSAA for different sections of waterbodies and different species and sizes of fish because of TCDD, "dioxin," PBBs, PCBs, chlordane, DDT and mercury.

The Trustees worked with Dow to (1) compile the relevant literature on impacts of FCAs and determine its applicability to the TRSAA; (2) investigate the impacts of FCAs qualitatively, including through the use of focus groups; and (3) develop and implement a survey of licensed anglers from a 40-county area in central Michigan. The Trustees then independently developed recreational choice models from the survey data to estimate recreational fishing losses both in the year of the survey and also at different advisory levels to allow for calculation of losses in other years.

The Trustees' analysis of the survey data indicated that 75,622 recreational fishing trips were lost in 2012 because of the fish consumption advisories, with a resulting loss in value of $2,108,956. Over the years that the fish consumption advisories have been in place, the severity of the advisories has changed and the numbers of fishing trips taken per year in the Tittabawassee River, the Saginaw River, and Saginaw Bay have also changed. To calculate losses for each year, the Trustees made adjustments to the losses calculated in 2012 to account for each of these factors.

- Based on the survey respondents' stated preferences for different hypothetical fishing locations with varying levels of advisories, the Trustees' calculated an adjustment factor for the losses associated with 13 different advisory levels that could be applied to the

specific advisory levels in each year. Adjustments for the severity of the advisories were applied to each year prior to 2012 based on the FCAs in place in that year. Advisories were assumed to remain the same as 2012 for subsequent years through 2018 and then decrease linearly to zero in 2043.

- Based on annual onsite survey data from the MDNR's Michigan Statewide Angler Survey Program, the Trustees estimated the total number of fishing trips in each year relative to those taken in 2012. MDNR's onsite survey data do not include all months in all years for the three waterbodies, so the Trustees used patterns of activity revealed in the existing data to make estimates where data were lacking. Adjustments using the onsite fishing data were made for each year from 1981 to 2014. From 2015 through 2043, the annual number of fishing trips was assumed to be the same as the average from 2010 through 2014. This average total number of fishing trips per year was 318,285.

All adjusted annual losses were converted to a 2012 present value using a 3-percent discount rate. Summing over the full period, the Trustees estimated the total losses for recreational fishing as a result of fish consumption advisories to be approximately $168 million. Because of the variety of contaminants that have contributed to FCAs in the TRSAA, not all of these losses can be attributed to releases from Dow.

3.4.9 Park Use

The floodplain of the Tittabawassee River, including four public parks, has been subjected to soil contamination advisories since 2004 (Appendix C). The parks are Imerman Memorial Park, West Michigan Park, Freeland Festival Park, and the Shiawassee National Wildlife Refuge. The advisories recommend that park users avoid contact with soil in the parks and rinse off any dirt or mud they come into contact with before leaving the park. The advisories specify "dioxin" as the contaminant of concern.

The Trustees worked with Dow to investigate perceptions of contamination and the impacts of contamination on park use. These cooperative investigations included the use of focus groups to explore qualitatively how local residents responded to advisories and contamination. They also included quantitative data collection using onsite counts and intercept surveys of park users at four parks with advisories and seven parks in the area that did not have advisories. The counts and survey were conducted in 2012. The Trustees then independently developed an economic model to analyze the data and estimate lost recreational value at parks from contamination.

The Trustees' analysis of the 2012 survey data indicated that 14,365 trips to the affected parks were lost annually because of the advisory, with a resulting loss in value of $108,452. Estimated losses were then extended to all past years since 2004 and to future years through 2043 and then converted to a 2012 present value using a 3-percent discount rate. Summing over the full period, the Trustees estimated the total losses for park use to be approximately $2.5 million.

3.4.10 Hunting

Advisories about the consumption of wild game have been in place in the assessment area since 2004 (Appendix B). The 2004 advisories suggest limiting the consumption of deer, turkey, and

small game taken in or near the floodplain of the Tittabawassee River downstream of Midland and the floodplain of the Saginaw River, including no consumption at all of turkey meat, skin, or internal organs or deer liver harvested downstream of Midland along the Tittabawassee River. In 2007, the Michigan Department of Community Health extended these advisories to include a recommendation to not eat the skin of Canada geese or wood ducks harvested in or near the floodplain of the Tittabawassee River downstream of Midland and the floodplain of the Saginaw River. In 2015, the wild game advisories were updated to recommend no consumption of any organ meats for any species harvested in the Tittabawassee and Saginaw River floodplains and limited consumption of deer, rabbit, squirrel, turkey, ducks, and geese. Hunting in the floodplain occurs in the Crow Island State Game Area, the Shiawassee National Wildlife Refuge, and on private lands.

Assessment activities for hunting included a preliminary investigation of potential impacts in focus groups and development of an estimate of the number of hunting trips taken annually in the area affected by the wild game advisories. The Trustees used an estimate of $6.50 in reduced value per trip as a result of the advisories and estimates of the number of hunting trips per year to Shiawassee National Wildlife Refuge (NWR; 2,300), Crow Island State Game Area (1,000) and other lands along the floodplains (1,000). Multiplying the reduction in value per trip by the annual number of trips, extending annual losses to the period 2004 through 2043, and discounting losses to a 2012 present value, the Trustees estimated the total value of losses to hunting to be approximately $671,000.

3.4.11 Other Potential Human Service Losses

Tribal Use

Tribal uses in the assessment area include the use of wild rice and other plants and animals for nourishment, and for medicinal and cultural purposes. From a holistic perspective, all natural resources provide services to the Tribe, in the sense that uncontaminated natural resources support a healthy ecosystem and tribal use of the resources in traditional lifeways. As a part of the assessment, the Trustees and their contractors conducted small-group interviews with tribal members to learn more about the Tribe's use of natural resources, how tribal members have been affected by the hazardous substances released from the Dow facility, and what restoration actions could best compensate for those losses. Based on the results of the small-group interviews, it was determined that tribal lost uses would be best compensated for by restoring the injured habitat and associated native species, thereby restoring both ecological and tribal services.

Passive Use

Passive use services (also called non-use services) are those services provided by natural resources that are not based on direct use or consumption of the resources. For example, the public may benefit from knowing that Saginaw Bay wetland habitats exist now and into the future, even if they never visit them. Passive use services include providing existence value (the value of knowing the resources persists, even if not providing direct uses), option value (the option to use the resource in the future), and bequest value (the option to pass along uncontaminated natural resources to future generations). Non-use values are compensable under the NRDA DOI regulations (see § 11.83(c)(1)). The Trustees did not directly measure passive

use losses or gains as a part of the assessment, but rather focused on determining the amount of restoration needed based on ecological services, as described above. However, through the implementation of the Trustees' restoration criterion (see sections 3.5 and 5.1.1) "Projects that benefit natural resources on site (within or adjacent to the Tittabawassee River system) are preferred", the Trustees are prioritizing projects that will provide the most similar flow of services as possible compared to those that were lost, including both use and non-use services.

3.5 Restoration Criteria and Scoping

Early in their assessment, the Trustees developed criteria for selecting and ranking restoration projects that could best address the injuries they were investigating. Throughout the assessment, the Trustees actively searched out potential restoration projects in the TRSAA and the Saginaw Bay watershed as a whole.

The Trustees developed criteria for evaluating potential restoration ideas and projects for the NRDA restoration planning process for the TRSAA and published them in their Assessment Plan (Stratus, 2008). These criteria were based on those identified in federal regulations at 43 CFR § 11.82, 15 CFR §§ 990.54 and 990.55, as well as relevant criteria developed as part of NRDAs conducted at other sites such as Bunker Hill, Idaho; Pecos Mine, New Mexico; New Bedford Harbor, Massachusetts; Green Bay, Wisconsin and Michigan; and Kalamazoo River, Michigan. The criteria are listed and described in section 5.1.

The Trustees solicited restoration project ideas from the public, natural resource agencies, local units of government, non-profit organizations, and other stakeholders starting in November of 2005 with a presentation made at a public meeting on the cleanup actions being taken and planned in response to releases from the Dow Midland plant. In addition, the Trustees hosted public meetings specifically on the NRDA process, including restoration criteria and scoping, in 2007 and 2008 and also directly contacted numerous stakeholders for project ideas. Project ideas along with the stakeholders who provided them are summarized in Appendix D. In 2009, the Trustees hosted a workshop with stakeholders to accomplish the following objectives (Stratus Consulting, 2009):

- Identify the major environmental issues of the TRSAA as a whole and ranked their relative importance;
- Create a comprehensive list of restoration project ideas and categories that could address environmental impacts, along with some specific high-priority restoration projects;
- Identify the restoration ideas that best address the highest-ranked impacts; and
- Identify ecological benefits provided by the top-ranked restoration project ideas.

Following the 2009 workshop, the Trustees presented a prioritized list of projects that met NRDA objectives and ranked highly based on the Trustees' restoration project selection criteria to Dow. Dow contributed additional restoration project ideas, and ultimately the Trustees and Dow developed the list of proposed projects described in Chapter 4 and evaluated in Chapter 5.

CHAPTER 4: PROPOSED RESTORATION ALTERNATIVES

To compensate the public for injuries (e.g., service losses) to natural resources resulting from releases of hazardous substances from Dow's Midland plant into the TRSAA, the Trustees are required to develop alternatives for the "restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the natural resources and the services those resources provide" (42 C.F.R. §11.82 (a)). The Trustees' proposed settlement with Dow for natural resource damages includes a set of restoration projects that Dow would implement with Trustee oversight; a set of specific projects for which Dow would provide funding for the Trustees to implement with partners; and a cash payment of $15 million to be used by the Trustees to provide long-term stewardship of the restoration projects beyond Dow's obligations, conduct monitoring of natural resource recovery, and work with the public and local communities to identify and implement additional projects that benefit natural resources and their services consistent with the restoration criteria described in section 5.1.1.

This chapter describes the Trustees' restoration objectives and proposed restoration alternatives to compensate for the ecological and recreational injuries. Several restoration projects were proposed to the Trustees that are: 1) not expected to provide natural resource services similar to injured/lost services, or to provide services in a cost-effective way; 2) already required or funded in non-NRDAR contexts; 3) lacking in sufficient detail to permit analysis; and/or 4) not feasible. These projects are discussed further in section 4.5 and summarized in Appendix D.

The Trustees' proposed alternatives are Alternative A, a "no action" alternative; Alternative B, an alternative with restoration projects with some flexibility in how the cash payment would be used; and Alternative C, an alternative with restoration projects and set amounts for how the cash payment would be used. A "no action" alternative is included to serve as basis for comparison for the other alternatives. Both Alternatives B and C include multiple projects to be implemented by Dow or funded by Dow as described in this chapter and in the Consent Decree but differ in how the Trustees would manage additional funding from Dow over time (Table 7).

Table 7. Outline of Trustees' proposed restoration alternatives

Alternative	Description
A	No Action, no projects implemented
B	Projects and Flexible Funding for Stewardship and Proposals (Preferred) • Tittabawassee River Floodplain Restoration and Bike Trail Project • Thomas Township Nature Preserve - $1M funding • Tittabawassee River Green Corridor • Shiawassee National Wildlife Restoration - $3.25M funding • Shiawassee National Wildlife Expansion • Saginaw Riverfront Park - $1M funding • Bay City Ecological Restoration Project • Saginaw River Mouth Boating Access Site Expansion • Greater Midland Nature Preserve • Eagle Ridge Nature Area • Saginaw Chippewa Tribe Restoration - $0.5M funding • Midland Fish Passage • Saginaw Bay Spawning Reefs - $1M funding • Stewardship, monitoring, and future projects - $15M funding o Long-term stewardship of implemented projects o Monitoring recovery of natural resources o Trustee oversight costs o Future projects – at least $5M of the $15M
C	Projects and Fixed Funding for Stewardship and Proposals All components of Alternative B, except that the funding for stewardship, monitoring, and future projects would be structured as follows: o Stewardship of implemented projects - $6M o Monitoring recovery of natural resources - $2M o Trustee oversight costs - $2M o Future projects - $5M

Trustees evaluated the alternatives to determine if they provided sufficient type, quality, and quantity of ecological services to compensate for those lost due to contamination in the context of both site-specific and regulatory evaluation criteria (43 C.F.R. §11.82 (d)) and compliance with potentially applicable laws. The Trustees may implement restoration projects that are not specifically identified in this Draft RP/EA, but are similar to those projects identified and consistent with restoration objectives. Any project not reviewed within the Draft RP/EA will be evaluated against the site specific and regulatory criteria, and if a project uses alternative techniques other than described below, a project-specific NEPA determination will be made and public notice will be given to provide details on the new project proposal.

4.1 Restoration Objectives

The Trustees' overall ecological restoration objective is to compensate the public for past and expected future ecological losses due to releases of hazardous substances from Dow's Midland plant into the TRSAA. The releases have impacted the ability of natural resources to provide

their baseline level of ecological services. Therefore, the Trustees focused on restoration projects that will compensate the public by providing additional ecological services in or near the TRSAA, within the Saginaw Bay watershed.

The Trustees' overall human use restoration objective is to compensate the public for interim and expected future losses to recreational fishing, park use, and hunting as a result of public health advisories issued because of releases from Dow's Midland plant. Therefore, the Trustees focused on restoration projects that will compensate recreational anglers, park users, and hunters by improving habitat for fish and game species, and by creating new or improving existing habitat areas that also provide for public access to natural resources in or near the TRSAA, within the Saginaw Bay watershed.

4.2 Alternative A: No Action Alternative (Natural Recovery)

As required under NEPA, the Trustees considered a restoration alternative of no action. Under this alternative, the Trustees would rely on natural recovery and would take no direct action to restore injured natural resources or compensate for interim lost natural resource services. The remedial process would still continue, separate from NRDA, and this alternative would include the continuance of ongoing monitoring programs, such as those conducted by the State of Michigan for determining fish consumption advisories and those required as part of the remedial process. No additional activities aimed at enhancing ecosystem biota or processes would be provided nor would any compensation be provided to compensate the public for losses of natural resources and the services they provide over time.

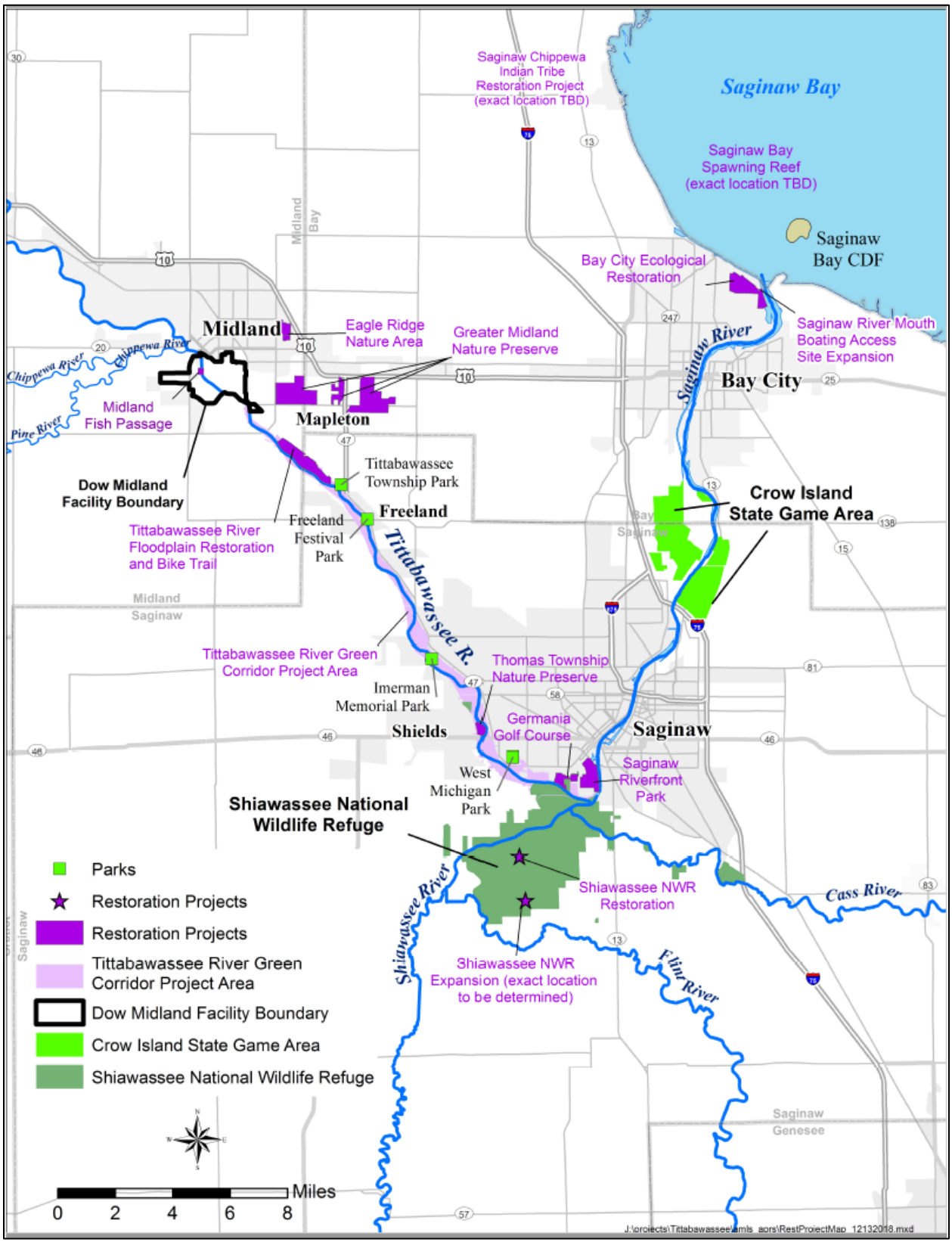
Under the no-action alternative, no habitats would be preserved, restored, or enhanced beyond what agencies and organizations are already doing in the area with limited existing resources. Local citizens would not benefit from improved recreational opportunities and increased education and stewardship.

4.3 Alternative B: Projects and Flexible Funding for Stewardship and Proposals (Preferred)

The Trustees considered a broad set of restoration projects and project types that could potentially improve ecological services and recreational fishing services relevant to the assessment area. The restoration projects and project types included in Alternative B are expected to provide natural resource services similar to the services that the injured habitat would have provided but for the releases of contaminants. In addition to those proposed by Trustee agencies, projects and project types were solicited from the public and stakeholders through meetings and discussions with local governments, conservation organizations, and academic researchers and from Dow through cooperative discussions (see Appendix D).

The broad categories of proposed restoration project types are described below along with specific projects that have been identified in the proposed settlement. The locations of these specific projects are shown on Figure 7. Collectively, these specific projects and the broad categories of restoration projects that the Trustees could fund in the future are expected to increase habitat quality and quantity, promote habitat connectivity, create new public use opportunities, and benefit natural resources within the Saginaw Bay watershed.

Figure 7. Locations of proposed restoration projects to be implemented or funded by Dow



For the specific projects that Dow would be required to implement, the Trustees would oversee Dow's implementation according to Statements of Work that include pre-project environmental characterization of the sites, preliminary design plans, final design and implementation plans, monitoring and maintenance plans with performance standards to be met, construction completion reports, monitoring and maintenance reports, and project completion reports. Dow would be held responsible for five years of monitoring and maintenance or until performance standards are met, whichever is later.

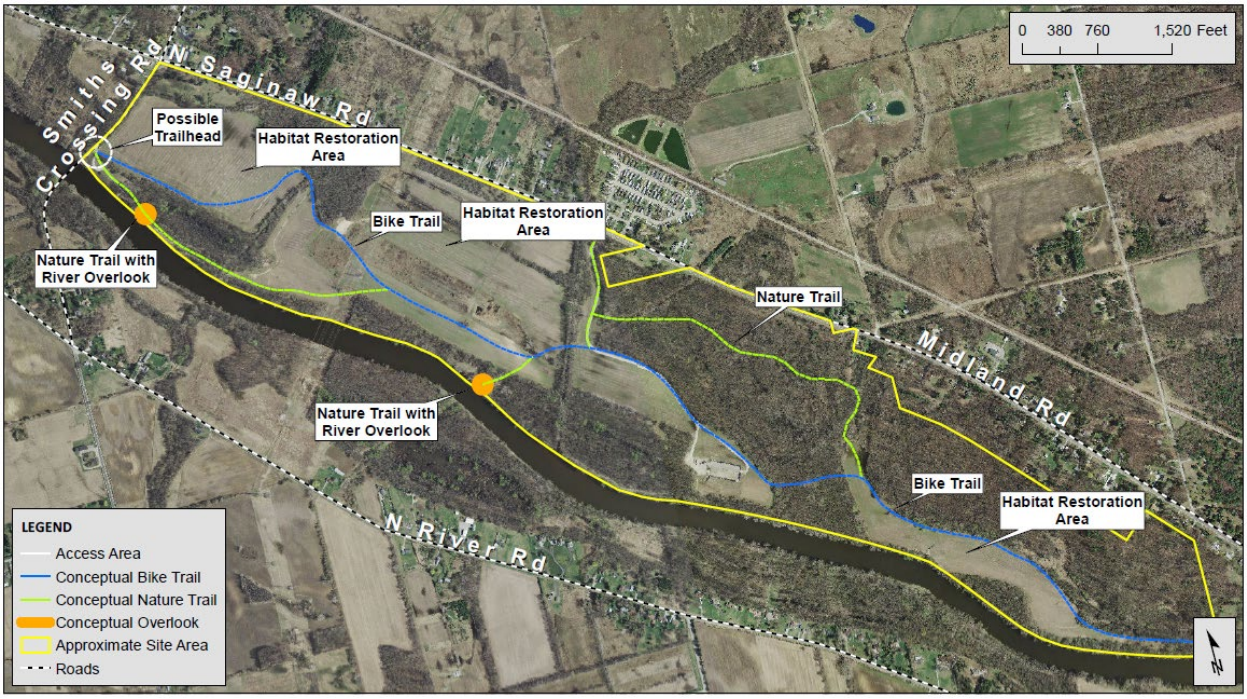
For the specific projects for which Dow would provide funding to the Trustees, the Trustees would work with project proponents to finalize project designs, implementation, and monitoring and maintenance plans. The Trustees would use project-specific funding to support long-term stewardship of these projects to the extent possible.

As described below, the Trustees would use additional funding from Dow to fund additional projects through a public proposal process, continue long-term stewardship of restoration projects, and cover the costs of managing this restoration program, including overseeing Dow's work on the projects they would be required to implement.

4.3.1 Tittabawassee River Floodplain Restoration and Bike Trail Project

As part of the proposed settlement, Dow would complete this project under Trustee oversight. The Tittabawassee River Floodplain Restoration and Bike Trail Project would be located within the Tittabawassee River Floodplain on a 490 acre parcel that is currently owned by Dow. This parcel is adjacent to the Tittabawassee River and located in Midland and Saginaw Counties in Michigan (Figure 8).

Figure 8. Location and conceptual plan for the Tittabawassee River Floodplain Restoration and Bike Trail Project[7]



In addition to protecting this parcel from development in perpetuity, Dow would implement habitat restoration efforts to convert approximately 175 acres currently in agricultural production or idle land to floodplain wetlands or other natural habitat. This project would also include the installation of biking and multi-use trails on the 490 acre parcel. Specifically, as described below, the proposed project would:

- Protect in perpetuity 490 acres through a conservation easement that is enforceable by all Trustees.

- Convert approximately 175 acres of existing agricultural property to restored habitat (e.g., wetland and natural habitat) by planting and maintaining vegetation, controlling invasive vegetation, and restoring hydrologic connectivity where feasible. Where supported by existing hydrology, soils and climate, wetland creation will be prioritized.

- Create natural resource-related recreational amenities that allow public access to the Tittabawassee Floodplain Preserve, through construction of approximately 2.4 miles of biking trails and an additional approximately 1.5 to 3.0 miles of multi-use trails, and public access parking and informational signage (i.e., maps and educational information).

Dow would be responsible for at least five years of monitoring and maintenance to ensure that the restoration work is successful. After that time, it is anticipated that Dow would transfer management of the preserve to a local non-profit organization with a conservation mission.

[7] Figure provided by Dow.

4.3.2 Thomas Township Nature Preserve

As part of the proposed settlement with Dow, Dow would provide $1 million that will go toward the creation of the Thomas Township Nature Preserve on a 60 acre parcel currently owned by the township along the Tittabawassee River, north of Gratiot Road and east of River Road (Figure 9). The parcel is currently being used for row crop agriculture. This funding would be used to restore the current farm land on this property to natural habitat to functioning floodplain habitat, including a small pond on the north end. Multi-use trails, signage, observation decks, walkways, and pavilions are planned to allow the public to use and enjoy the natural area. Project plans also include a kayak and canoe launch as additional public access points to the river, which will provide opportunities for fishing, kayaking and canoeing. The funding proposed as a part of this NRDA settlement is expected to accomplish the following:

- Perform an evaluation to determine the most appropriate habitat restoration activities within the 60 acres of current farm land based on topography, soil types, and potential hydrology.

- If not already done, decommission farm tiles and pumping system to improve hydraulic connectivity.

- Restore habitat by converting the approximately 60 acres currently in agricultural production to wetland and other natural habitat types based on the topography, hydrology, soils, and climate through seeding, planting, and using the natural seed bed where possible.

- Provide for a portion of the costs associated with installation of trails, boardwalks, viewing platforms and other recreational amenities.

- Manage invasive species in the habitat restoration areas.

The Trustees would provide funding to Thomas Township and work with it to implement this project, and then Thomas Township would manage this preserve as part of its park system.

Figure 9. Location and conceptual plan for Thomas Township Nature Preserve[8]

4.3.3 Tittabawassee River Green Corridor

Dow has been implementing a Tittabawassee River Conservation Program (http://www.triverconservation.com/en) by securing conservation covenants from private landowners on the undeveloped portions of their properties within the eight-year floodplain of the Tittabawassee River (Figure 7). These covenants will commit the property use as a non-maintained area within the floodplain. Specifically, the covenants (a) provide access to the property for floodplain soil investigations, (b) provide access to Dow to conduct cleanup activities on the property if needed, (c) put in place restrictions to ensure the cleanup remains protective of human health and the environment, and (d) promote conservation in a buffer zone along the Tittabawassee River to enhance the river's natural and scenic beauty, improve the river's natural environment, and reduce erosion and runoff. The restrictions put in place include the following:

- The owner shall not remove soil from the floodplain
- The owner shall not allow poultry or livestock to feed or graze in the floodplain
- The owner shall not allow any portion of the conservation areas of the property to be converted to an area that is maintained for residential use (e.g. converted to lawns, play areas or gardens)
- The owners are still allowed to:

[8] Figure provided by Dow.

- access the conservation areas, including for hunting or recreation,
- maintain a pathway to the river,
- trim or harvest trees and downed wood, and
- plant trees, grasses, shrubs, or other plants in order to supplement or restore a natural landscape.

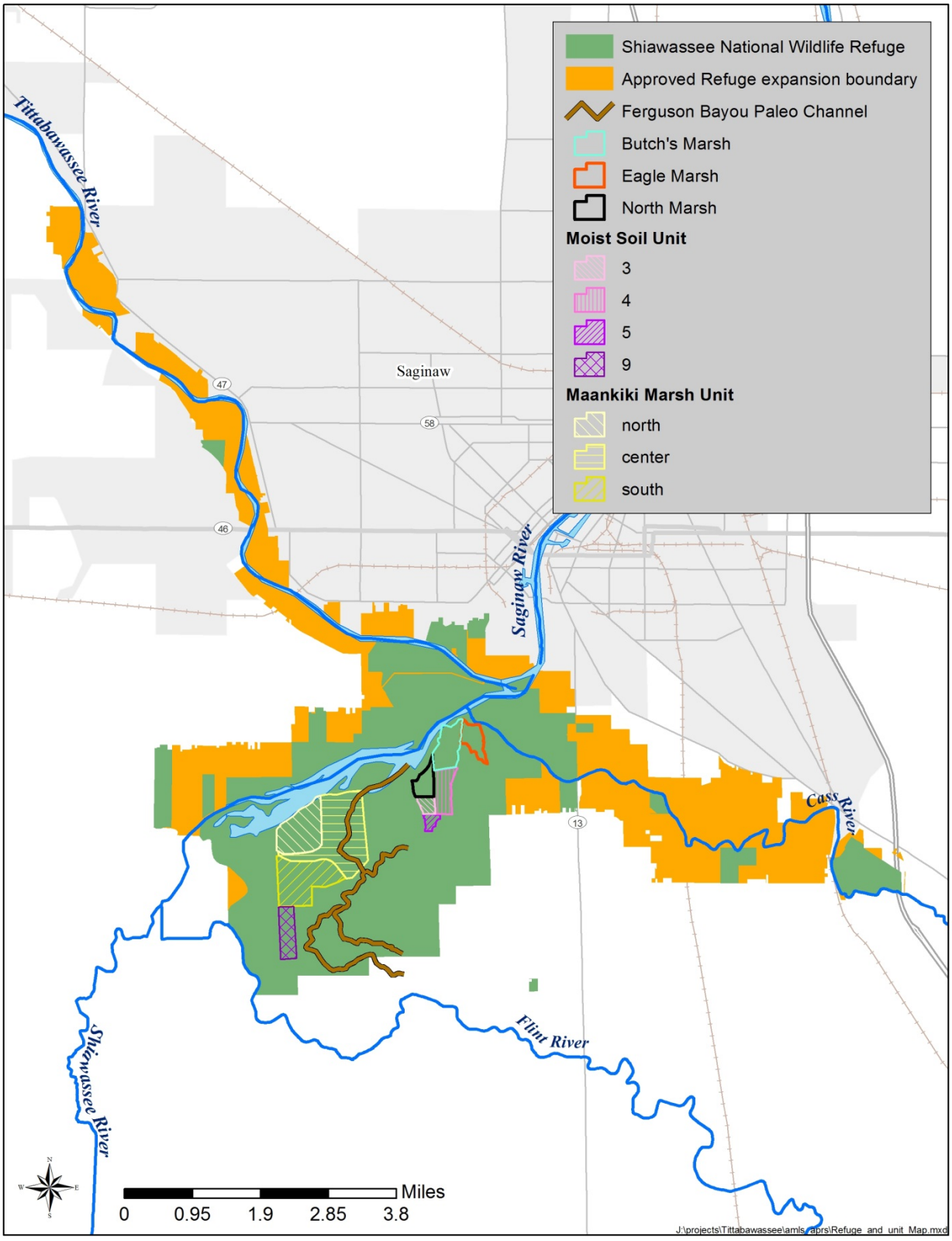
These covenants are registered with the deed and will apply to future owners of the land.

In recognition of the long-term benefits of protecting the eight-year floodplain in perpetuity, as a part of this alternative the Trustees would include a relatively small amount of credit per acre with Dow committing to secure covenants on at least 2,000 acres of floodplain habitat of the approximately 2,500 acres that are considered eligible for the program. For purposes of the NRDA, the conservation of floodplain habitat through this program is being referred to as the Tittabawassee River Green Corridor Project. As of July 12, 2018, Dow had enrolled 1,697 acres of conservation areas in floodplain habitat on private property along with 98 acres of maintained residential areas for a total of 1,795 acres included in the covenants (Scott Madill, Dow, personnel communication).

4.3.4 Shiawassee National Wildlife Refuge Restoration

As part of the proposed settlement with Dow, Dow would pay $3.25 million to DOI for the USFWS to restore habitat in the Shiawassee NWR. The USFWS would use this funding to restore and enhance multiple units of the Shiawassee NWR, including maintaining and monitoring the restoration as this funding allows. The USFWS would also be able to seek additional funding from the Trustees for long-term stewardship of this project once this $3.25 million in funding is committed. Preliminary plans for the restoration work were used to estimate costs for the work needed to improve hydrologic re-connection and water flow through the NWR units to restore and enhance habitat based on on-going planning and design work that the USFWS, Greenbrier Wetland Services, The Nature Conservancy, and Ducks Unlimited have been conducting over several years using funding from other sources. The preliminary plans include installing water control structures at key locations, reconfiguring dikes between NWR units, and installing additional water gauges to improve understanding of the relationship between river stage/discharge and water levels in the NWR units. In addition to this work, the proposed project would include establishing and maintaining native vegetation, monitoring the success of the project, and performing additional management as indicated by the monitoring results. The NWR units that would be expected to be restored or enhanced with this funding are shown in Figure 10. Major elements of the restoration project are described in the following paragraphs, although details, including the structures to be built, are subject to change during the planning and design in order to best meet the objectives of the project given the constraints of the complicated flow patterns and existing elevations and the possibility of combining this funding with funding from other sources.

Figure 10. Shiawassee National Wildlife Refuge with selected units shown



Cass River Connectivity. Hydrologic re-connection would be enhanced to allow increased flow and fish passage between Cass River and Eagle Marsh (76 acres). In addition, water management would be improved in Butch's Marsh (126 acres) and Moist Soil Units 3, 4, and 5 (158 acres) by repairing existing infrastructure, and fish passage would be provided to both Butch's Marsh and North Marsh (46 acres). Hydrologic re-connection that allows fish and other aquatic species to pass from the Cass River to these three marshes and back again is expected to provide extensive spawning and nursery areas for species originating in the Saginaw River and Bay system and improve water quality in the marshes. This would result in a shift in the fish communities in the marshes from ones dominated by pond and lake species tolerant of lower water quality to ones with mixtures of both riverine and pond/lake species. Being able to manage water levels would also allow the NWR to control invasive vegetation and increase desirable native vegetation with less labor, equipment, and herbicides than would be necessary without a water control structure. The proposed work would enhance hydrologic connectivity, improve fish passage, enhance wetland quality, and increase floodplain connectivity.

Ferguson Bayou Restoration. Installation of multiple water control structures combined with removal of a section of existing dike would hydrologically reconnect Ferguson Bayou to the Maankiki Marsh Unit. The Ferguson Bayou is a paleo channel of the Flint River that previously conveyed water through the middle of the Shiawassee NWR. The proposed changes would increase flows through Ferguson Bayou (868 acres) and Maankiki Marsh (940 acres) and thereby improve diversity in aquatic and floodplain vegetation, benthic invertebrates, and fish. These changes would also benefit amphibians, reptiles, birds, and mammals that depend on the aquatic food webs of the Bayou and Marsh. Routing more of the Flint River flow through these areas would also improve nutrient retention and use and thereby improve water quality downstream of the NWR. The proposed water control structures may increase floodplain storage capacity from the Flint River although this is not the primary purpose.

Moist Soil Unit 9. A 100 acre unit that is a former farm field now planted in warm season grasses would be converted to a moist soil unit that would be managed to benefit shorebirds, wading birds, waterfowl, and other species that depend on a mosaic of wetland types throughout the migration and breeding seasons. Converting this area to a moist soil unit would require changing the current hydrology to allow for independent manipulation of water levels among this and adjacent moist soil units as well as with the existing Eastwood Drain. Any alterations of the Eastwood Drain would need to be approved by the Saginaw County Drain Commissioner, and the drainage needs of the landowners along the Eastwood Drain would need to be addressed. Preliminary designs include adding multiple water control structures in Eastwood Drain and performing maintenance in the Eastwood Drain. Additional design work, along with coordination with the Saginaw County Drain Commissioner and others, may provide for a more cost effective approach that could include abandonment of the portion of the Eastwood Drain that is within the Refuge to allow for the restoration and long-term management of the restored areas while still meeting the drainage needs of the adjacent landowners. The initial establishment of Moist Soil Unit 9 would also include constructing a dike at an adjacent moist soil unit to allow independent manipulation of water levels among the moist soil units along with establishing and maintaining appropriate vegetation for at least five years.

Monitoring. The funding provided would also be expected to be able to fund sampling and surveys of fish, macroinvertebrates, mussels, and nutrients that build on existing baseline data

that the USFWS has collected already in anticipation of these improvements. In addition, the USFWS would continue ongoing surveys of bird use, vegetation quality, and invasive species in these units. Collectively, these data would be used to evaluate the progress of the restoration toward meeting the objectives.

Access. The Trustees anticipate that public access to the restored area would remain similar to what it is currently. Ferguson Bayou can be accessed by foot on a trail system and parts of it are also visible from the Wildlife Drive, a 6.5 mile auto tour route, during the times of year that it is open, for wildlife viewing and nature photography. The Ferguson Bayou Trail is open year-round, except when restricted during deer hunting season, and the Wildlife Drive is open to the public from June 1 through September 30. Maankiki Marsh, Moist Soil Unit 9, and portions of the Ferguson Bayou are visible from Wildlife Drive. Eagle Marsh, Butch's Marsh, and North Marsh are in a more remote part of the Refuge that is not currently accessible to the public and is expected to remain so, consistent with the purposes of the Shiawassee NWR as set forth in two Acts and the Comprehensive Conservation Plan for the NWR. Specifically, the Shiawassee NWR was established in 1953 under the Migratory Bird Conservation Act "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." Additional purposes designated under the Refuge Recreation Act for all National Wildlife Refuges are "…incidental fish and wildlife-oriented recreational development, the protection of natural resources, and the conservation of endangered and threatened species." A Comprehensive Conservation Plan for the Shiawassee NWR was finalized in 2001 to determine and define which portions of the Refuge would provide for wildlife-dependent activities and which portions would have limited disturbance by humans for use as a sanctuary for wildlife.

4.3.5 Shiawassee National Wildlife Refuge Expansion

Dow would purchase land from willing sellers that would be transferred to the United States and managed by the Shiawassee NWR. This land acquisition would compensate for the loss of hunting opportunities as a result of the wild game advisories. The USFWS would evaluate proposed acquisitions and seek to ensure that the selected properties meet the following criteria:

- suitable for hunting and likely to remain so into the future,
- within or adjacent to the currently approved acquisition boundary of the Refuge, and
- contiguous with other Refuge property where hunting is allowed.

Under this preferred alternative, Dow or a third party would complete purchase of the selected parcels using an interest-bearing trust account funded at $1.2 million by Dow. After purchase, the parcels would be transferred to the United States. Based on current information, the Trustees anticipate that this funding would be sufficient to purchase at least 200 acres of suitable land. If Dow is not able to find willing sellers of suitable property in 5 years, despite its best efforts, then the remaining funds would be transferred to the Trustees. The Trustees would then spend these funds consistent with the Consent Decree, other funding from the settlement as described in this RP/EA, and, to the extent possible, prioritizing projects or activities that provide benefits to hunting.

Dow also recently provided funding to TNC to purchase three parcels of land in the immediate vicinity of the Green Point Environmental Learning Center in Saginaw, Michigan, and TNC then transferred ownership to the United States. These parcels are the following:

- former Germania Golf Course property, a 135 acre parcel consisting of most of the former golf course,
- former Bourdow Trucking property at 2039 and 2041 Maple Street, a 6.7 acre parcel, and
- former Kohl property at 2401 Maple Street, a 6.3 acre parcel.

Collectively, these three parcels increase the number of contiguous acres that the USFWS manages in the Green Point Area from 140 acres to 288 acres. The USFWS is working to restore and enhance habitat in this area while providing for wildlife compatible, natural resource based recreation and environmental education using funds from a previous NRDA settlement with General Motors, as described in a restoration plan developed with public input in 2016 (USFWS, 2016).

4.3.6 Saginaw Riverfront Park

As part of the proposed settlement, Dow would provide $1 million for sustainable redevelopment of the future Saginaw Riverfront Park on 332 acres that the State of Michigan recently acquired from RACER Trust at the site of the former General Motors Saginaw Malleable Iron Plant and Greenpoint Landfill along the Saginaw River in the City of Saginaw (Figure 11). For this project, MDNR would partner with Saginaw County to operate the Saginaw Riverfront Park in order to provide passive recreation opportunities to the City of Saginaw. Potential recreation opportunities include hiking trails, biking trails, wildlife viewing, and catch and release fishing. The funding proposed as a part of this NRDA settlement is expected to accomplish the following:

- Provide for a portion of costs associated with installation of trails, boardwalks, bridges, and wildlife viewing and fishing platforms;
- Provide for additional, appropriate habitat restoration work at the facility. This may include prairie, wetland or forest stand improvement or enhancement; and,
- Provide up to $750,000 to endow the property with a portion of the funding for long-term operations and maintenance costs for use by the owner or operator of the park, for the purpose of maintaining public recreational opportunities at a site with legacy contamination.

The Trustees, including MDNR would work with Saginaw County to implement the funded portions of this project and then Saginaw County would manage this park as part of its park system.

Figure 11. Location of Saginaw Riverfront Park[9]

4.3.7 Bay City Ecological Restoration Project

As part of the proposed settlement, Dow would complete this project under Trustee oversight. The Bay City Restoration Project would be located near the mouth of the Saginaw River at Saginaw Bay on a 415 acre parcel that is currently owned by Dow (Figure 12). In addition to protecting this parcel from development in perpetuity, Dow would implement habitat restoration efforts to convert approximately 245 acres currently in agricultural production to a mixture of wetland, lake plain prairie, uplands, or other natural habitat. To improve natural resource-based recreation, this project would also include the installation of 3 to 5 miles of trails, informational signage, 2 or 3 fishing platforms on the Saginaw River, and public access parking.

Dow would be responsible for at least five years of monitoring and maintenance to ensure that the restoration work is successful. After that time, it is anticipated that Dow would transfer management of the preserve to a local non-profit organization with a conservation mission.

[9] Figure provided by Dow.

Figure 12. Location and conceptual plan for Bay City Ecological Restoration Project[10]

4.3.8 *Saginaw River Mouth Boating Access Site Expansion*

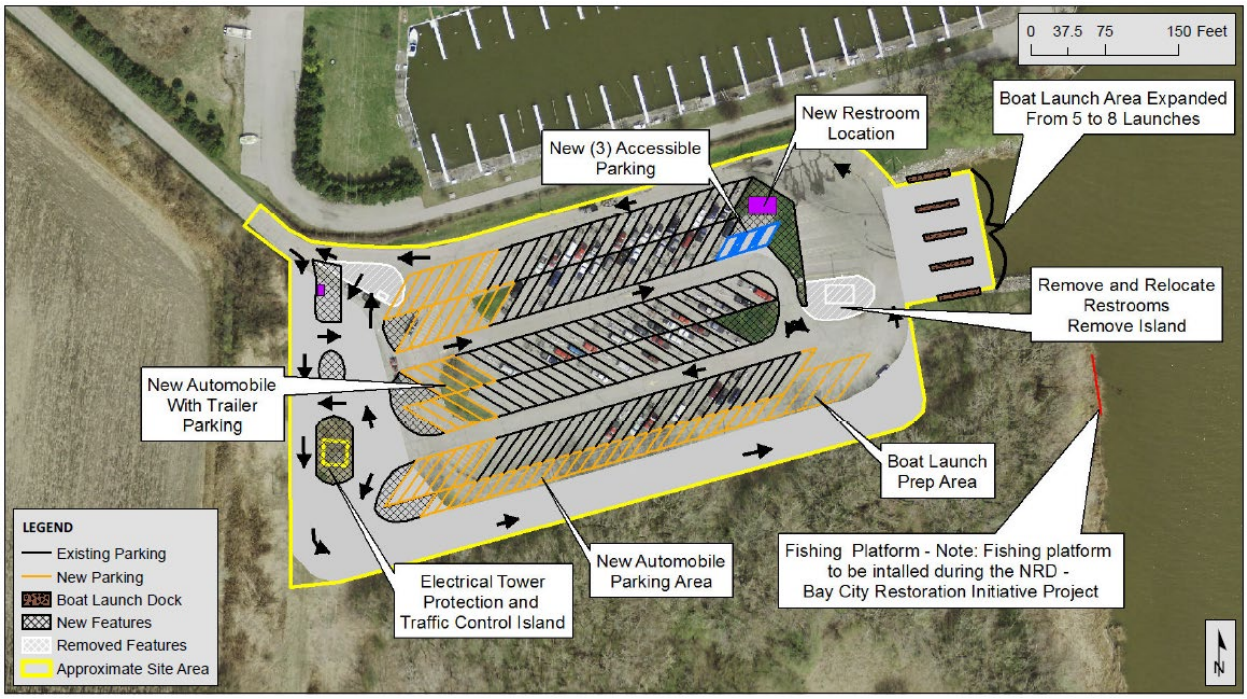
As part of the proposed settlement, Dow would complete this project under Trustee oversight. The Saginaw River Mouth Boating Access Site Expansion would be located north of Bay City, Michigan, in Bangor Township, near the mouth of the Saginaw River at the existing Saginaw River Mouth Boating Access Site at the end of Shady Shore Road (Figure 13). Under the proposed settlement, Dow would expand the number of boat ramps, including accompanying docks, at the launch from 5 to 8 and add 50 or more parking spaces where at least 25 of those parking spaces will accommodate vehicles with trailers (Figure 14). To make this possible, Dow would also transfer land that it owns adjacent to the current boat launch parking area to the State of Michigan to accommodate some of the additional parking spaces. Expansion of the number of boat ramps will require soil excavation and some dredging of Saginaw River sediments.

Dow would be responsible for monitoring the adequacy of the construction for two years following its completion. MDNR would continue to own and operate the boat launch area for public access to Saginaw River and Bay.

[10] Figure provided by Dow. BaySail and Lighthouse projects are described in section 4.5

Figure 13. Existing Saginaw River Boating Access Site with outline of proposed conceptual project area[11]

Figure 14. Conceptual plan for expansion of existing Saginaw River Boating Access Site

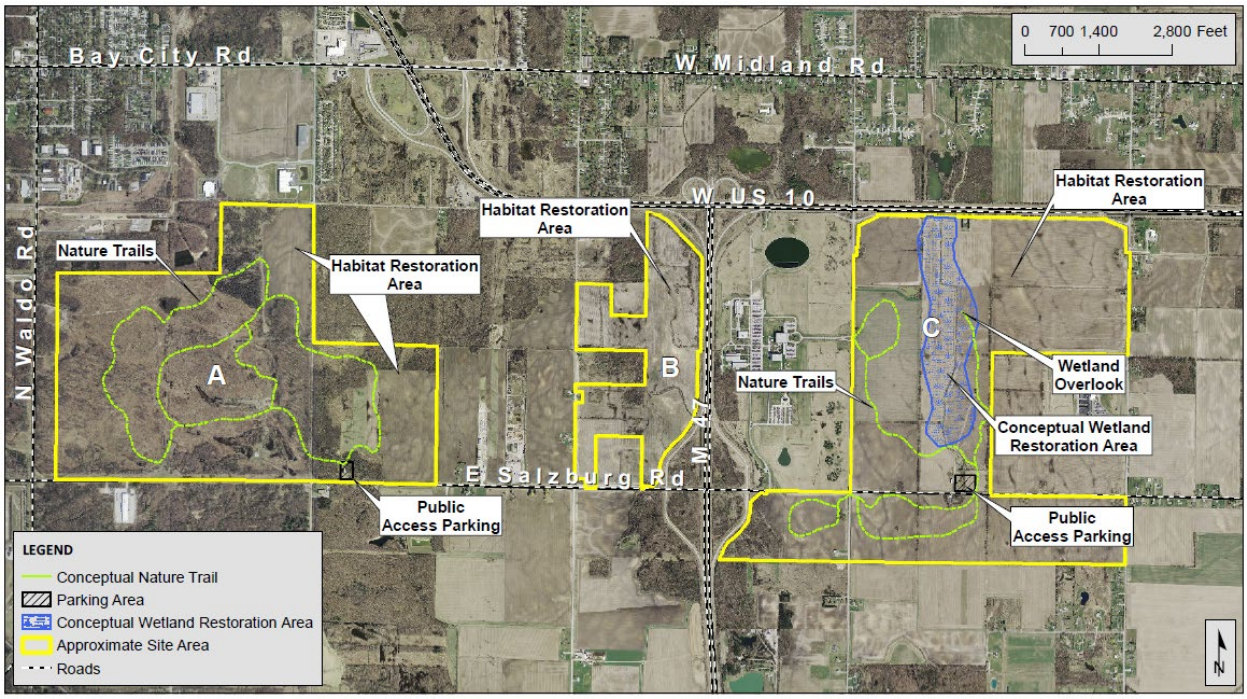


[11] Figures of Saginaw River Boating Access Site provided by Dow.

4.3.9 *Greater Midland Nature Preserve*

As part of the proposed settlement, Dow would complete this project under Trustee oversight. The Greater Midland Nature Preserve would be located on three tracts of land in Midland and Bay Counties in Michigan, approximately 3 miles north of the Tittabawassee River. The three tracts are designated as Tracts A, B, and C (Figure 15) and are currently owned by Dow Corning. Tract A is approximately 620 acres and is predominantly forested, but also includes over 100 acres of farmland and early successional shrub-scrub. Tract B is approximately 165 acres and is predominantly farmland. Tract C is approximately 675 acres and is also predominantly farmland, though narrow forested buffer strips are interspersed throughout.

Figure 15. Location and conceptual plan for Greater Midland Nature Preserve Restoration Project[12]



In addition to protecting these 1,460 acres from development in perpetuity, Dow would implement habitat restoration efforts to convert the approximately 940 acres that currently in agricultural production to create or restore approximately 200 acres of wetlands and 740 acres of other natural habitat. Within the 740 acres, additional wetlands may be restored where feasible. Habitat creation and restoration from agricultural fields would involve re-grading and possibly removal of soil as well as rendering any existing agricultural drain tiles inoperable in order to provide suitable hydrology for wetlands, amending or adding soil as necessary to establish native vegetation, planting and maintaining native vegetation, and controlling invasive vegetation.

[12] Figure provided by Dow.

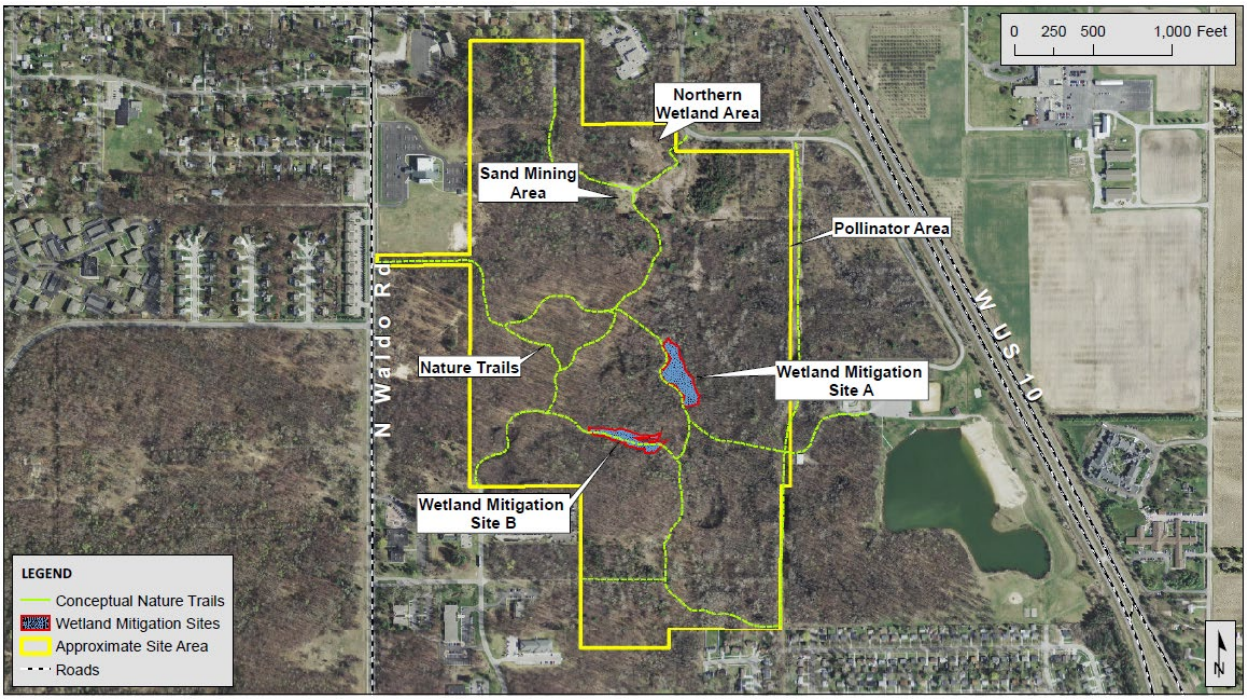
This project would also include natural resource-related recreational amenities that allow public access to the Greater Midland Nature Preserve at Tracts A and C. This would include construction of approximately 4 to 6 miles of trails, public access parking, and informational signage (i.e., maps and educational information).

Dow would be responsible for at least five years of monitoring and maintenance to ensure that the restoration work is successful.

4.3.10 Eagle Ridge Nature Area

As part of the proposed settlement, Dow would complete this project under Trustee oversight. The Eagle Ridge Nature Area would be located on an approximate 140 acre property currently owned by Dow, adjacent to the City of Midland's Stratford Park east of Waldo Road (Figure 16). This property is also adjacent to both commercial development and residential neighborhoods. This project would open the parcel to the public and would include the preservation of all 140 acres from development in perpetuity, restoration of upland and wetland habitat, and improvements to enhance natural resource-related recreation. The parcel includes topography and vegetation unique to this region, such as remnant Lake Saginaw dunes from the Pleistocene Era and glacial moraines. As a result, elevations across the parcel vary between approximately 654 and 690 feet above sea level. These topographic features of the property are important natural features within the urban environment of the City of Midland. A trails system would highlight these natural features of the property while being designed to minimize maintenance costs and damage to sensitive areas.

Figure 16. Location and conceptual plan for Eagle Ridge Project[13]



Specifically, the project would consist of the following:

- Protection in perpetuity of 140 acres through a conservation easement that is enforceable by the Trustees;
- Removal of a portion of an abandoned road and associated fill that bisects an existing wetland in the northeast part of the property to reconnect the two sides of the wetland to each other;
- Installation of 10 to 15 habitat boxes consisting of bird nest boxes, wood duck boxes, and/or bat roost boxes;
- Seeding and planting of pollinator species in full sun areas on 1 to 2 acres;
- Removal/control and treatment of invasive species in three areas:
    - Within the wetland area in the northeast part of the property;
    - Within the sand mining area west of the same wetland area; and
    - Within two wetland mitigation sites that are under a EGLE Conservation Easement on the property, subject to EGLE authorization;

[13] Figure provided by Dow.

- Development and construction of the following recreational amenities for public access and outreach:
    - Construction or enhancement of 1.5 to 2.5 miles of managed trails;
    - A boardwalk/viewing area that provides access and viewing of existing wetlands on the northern end of the property (replacing the gravel road that bisects the two wetlands);
    - Five to ten benches along the managed trails; and
    - Signage to support interpretive education including the unique topographic features of the property.

At Dow's discretion, additional project elements may be added to this project:

- Improved hydrologic connectivity in addition to removal of a portion of the road that bisects the wetland area in the northeast part of the property
- Increased accessibility to the boardwalk and viewing area of existing wetlands in the northeast part of the property by adding a small parking area and access point nearby that meet accessibility requirements under the Americans with Disabilities Act.

Dow would be responsible for at least five years of monitoring and maintenance to ensure that the restoration work is successful.

4.3.11 Saginaw Chippewa Tribe Restoration

Dow would provide $500,000 that will be allocated by the Trustees for the Saginaw Chippewa Indian Tribe of Michigan (Tribe) to identify and convert agricultural land to restored wetlands. At present, the Tribe has not specifically identified land to convert, but expects to be able to convert up to 80 acres with this amount of funding. The Tribe uses wetland areas for hunting, fishing, and gathering practices important to sustaining cultural activities.

For this project, the Tribe would identify potential wetland restoration locations that are expected to have a high probability of successful restoration based on soil type, hydrology, and position in the watershed. In selecting a project location or locations, the Tribe would also prioritize locations that reduce fragmentation of natural spaces. Indigenous plants, shrubs, and trees would be used to provide multiple benefits, including cultural uses and uptake of excess nutrients from surrounding areas. In addition, the restoration would be engineered to assist in reducing sheet flow, erosion, and other issues frequently observed in the watershed.

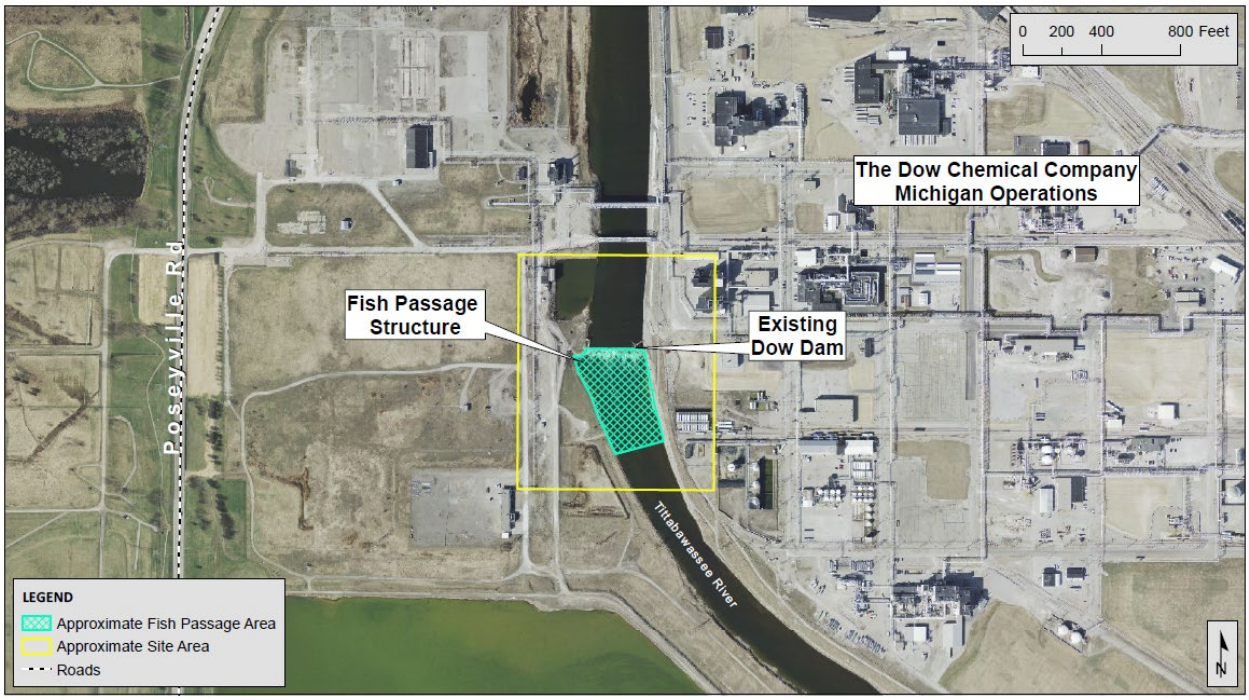
4.3.12 Midland Fish Passage

As part of the proposed settlement, Dow would complete this project under Trustee oversight. The Midland Fish Passage Project would be constructed at the Dow Dam on the Tittabawassee River in Midland (Figure 17. The Dow Dam currently impedes fish passage during most flow conditions and yet also provides opportunities for spawning by species like walleye. This project

is intended to provide improved fish passage upstream and downstream in perpetuity while providing rock substrates similar to the current conditions to benefit fish spawning.

This project will involve construction of a nature-like fish passage structure (e.g., rock ramp, step pool rapids) to allow fish to pass over the existing Dow Dam. The Trustees considered complete removal of this dam, but that option is not feasible for several reasons. Complete removal of the dam would be expected to maximize opportunities for year-round fish passage in perpetuity as well as provide for unimpeded movement of sediment, nutrients, and large woody debris. However, maintaining the existing water elevations behind the dam is essential to proper functioning of Dow's RGIS that protects the river from contaminated groundwater, keeping stable river conditions for caps over remaining deposits of contaminated sediments upstream of the dam, providing sufficient water volume for Dow's fire suppression requirements, supporting restored wetlands upstream of the dam, and ensuring sufficient water depths for recreation at parks in the City of Midland.

Figure 17. Location and approximate extent of Midland Fish Passage Project[14]



Dow and the Trustees would work together on the design of a nature-like fish passage structure that would be designed based on the requirements of the major species in the river system that migrate upstream to spawn: walleye, white sucker, and white bass. Stone of various types and sizes would be used in order to provide habitat within the structure for a variety of species and, if feasible, would include stone sizes suitable for lake sturgeon spawning in order to support the recovery of this species within the Saginaw Bay watershed.

[14] Figure provided by Dow.

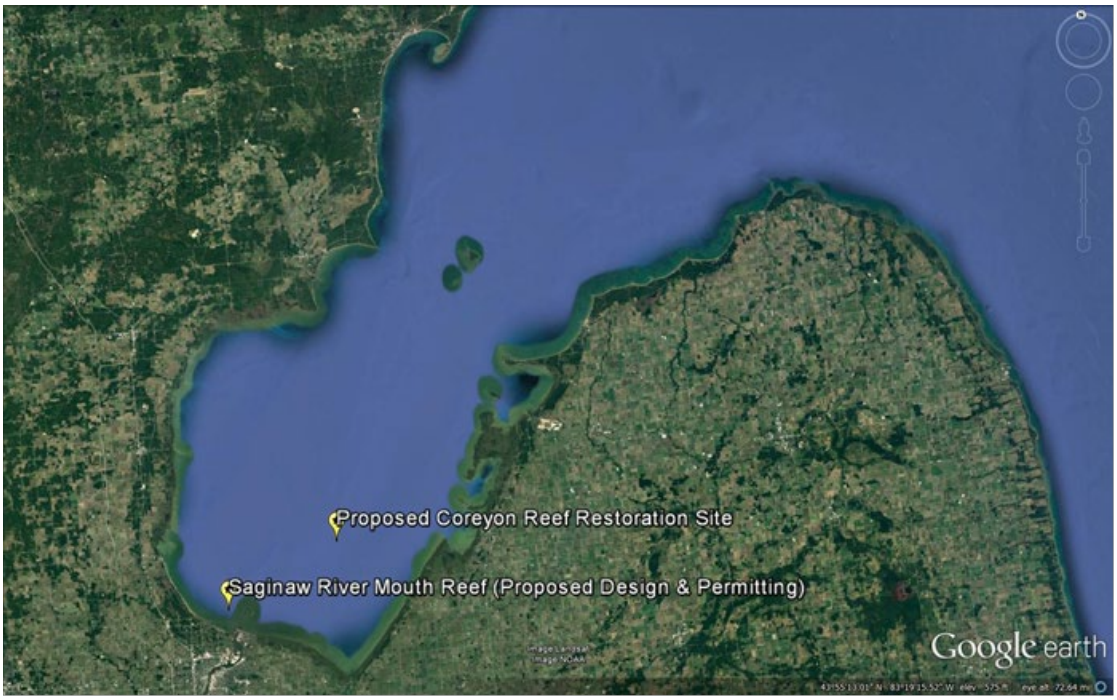
Dow would be responsible for construction of the fish passage project and monitoring its stability and physical functioning for at least five years, including at least one year with a flow equal to or exceeding a 5 year return interval of approximately 23,000 cubic feet per second at USGS Gage 4156000 Tittabawassee River at Midland to test the stability of the structure. In addition, Dow would conduct additional monitoring of fish use upstream of the Dow Dam before and after construction.

4.3.13 Saginaw Bay Spawning Reefs

As part of the proposed settlement, Dow would provide $1 million for creation or enhancement of spawning reefs in the inner portion of Saginaw Bay based on assessment and design work being conducted by the MDNR and its partners. In the past, sedimentation in the inner bay limited the feasibility of restoring or creating productive fish spawning reefs there. With sedimentation rates now within acceptable ranges, the MDNR has determined that restoring and creating new spawning reef habitat in the bay would diversify spawning habitat, improve populations of local fish strains, and buffer temporal recruitment variation of walleye and other species including lake trout and lake whitefish. Reef restoration would also complement efforts to reintroduce and reestablish cisco, a fish species listed as threatened by the State of Michigan. Given the productivity of inner Saginaw Bay, reef restoration there would facilitate and support resilient and diverse fish populations throughout Saginaw Bay and much of Lake Huron. Furthermore, restoration of rock reef in Saginaw Bay is included as a recommended action in the recent Lake Huron Lakewide Action Management Plan.

With funding from the USFWS provided by the Great Lakes Fish and Wildlife Restoration Act, MDNR and its partners completed a pre-construction assessment of potential reef restoration sites within inner Saginaw Bay. The results of this pre-construction assessment identified the Coreyon Reef and Saginaw River Mouth Reef as priority restoration sites (Figure 18). The current status of these restoration sites, as indicated by the pre-construction project, are: 1) environmental conditions are suitable and that local sedimentation is within acceptable rates (i.e. sedimentation rates are similar to reference sites where remnant reefs persist); 2) reproductively ripe lake whitefish and walleye are present at the sites and are depositing some eggs; and 3) various egg predators are present and consuming eggs but does not appear prohibitive. The presence of spawning fishes that are using these degraded sites suggests that reproductive utilization would increase dramatically if the sites were restored. Second, current egg predation points to the need for reef restoration, as such an effort would provide substrate conditions with sufficient interstitial space to allow eggs to incubate while being protected from predators.

Figure 18. Location of proposed inner Saginaw Bay reef restoration sites



In 2018, EGLE and partners received $980,000 from U.S. EPA to complete design, permitting and bid documents for the two reefs and begin construction of both reefs at a pilot size of approximately 1 acre each. With the additional $1 million in funding from Dow, EGLE and its partners would be able to monitor fish spawning success and reef conditions and then use the monitoring results to continue to improve fish reproduction in Saginaw Bay by making adjustments to these projects, expanding them, or potentially constructing new spawning reefs in the bay.

4.3.14 Flexible Funding for Project Stewardship and Future Project Proposals

Within the proposed settlement, Dow would provide $15 million to the Trustees for additional restoration projects in the future, Trustee costs to oversee Dow's restoration work, stewardship of restoration projects following completion of Dow's obligations, and management of all projects and funding. As a requirement of the Consent Decree, the Trustees are obligated to spend at least $5 million of the funding on future restoration projects by soliciting proposals from the public and making selections consistent with this RP/EA. In Alternative B, the Trustees would issue one or more requests for project proposals to the public for up to $5 million following the receipt of funding from Dow. Selection of future projects would be based on the restoration criteria and thus projects in the following categories would be expected to be prioritized in requests for project proposals:

- Floodplain restoration and preservation
- Wetland restoration

- Upland habitat restoration
- Aquatic habitat enhancements, including barrier removal
- When combined with habitat restoration, improved access to natural resources for recreational fishing, hunting, and park use

Following one or more requests for proposals, the Trustees would select projects based on the criteria in section 5.1 and make awards totaling at least $5 million. As described below, the Trustees may make additional funding available for additional restoration projects in the future based on their periodic review of other funding needs.

During the five years following the entry of the Consent Decree, the Trustees would be overseeing Dow's work and beginning implementation of the other projects identified in the Alternative. They would also be conducting monitoring of both restoration actions and recovery of natural resources as a result of cleanup and other processes. Once Dow completed construction of the required projects, the Trustees would then be overseeing Dow's maintenance of those projects and progress toward meeting the project-specific performance standards for each project for at least an additional five years.

The Trustees would be able to fund ongoing stewardship activities at any of the projects to ensure that the expected benefits from the projects are realized over a 30-year time period. For projects that Dow would implement, this would begin once Dow completed its obligations to maintain the projects and meet performance standards. The Trustees would work closely with the managers of the projects to determine stewardship objectives and needs for the projects and how to most efficiently meet the objectives, and then would provide funding and/or other assistance on an annual or multi-year basis.

Every five years, the Trustees would re-evaluate remaining funds and projected costs (e.g. stewardship, monitoring, oversight) to determine if and when additional funds can be used to issue an additional request or requests for proposals from the public. Priority would be given to ensuring that funding would be available to meet stewardship objectives for 30 years.

4.3.15 Funding for Trustee Oversight and Management of Projects and Funds

The Trustees would use funding from the settlement to support staff time and expenses to oversee Dow's work, implement and/or oversee the specific projects funded but not implemented by Dow that are described in this alternative, develop requests for proposals for additional projects, select projects, develop and manage funding agreements to implement additional projects, monitor both restoration actions and recovery of natural resources in the TRSAA in general, work with local land managers on the stewardship of the projects in this alternative, manage the remaining funds, and otherwise implement this RP/EA.

Trustee staff expenses are expected to be greatest during the first five years following the settlement while restoration projects are being implemented and a request or requests for proposals are being issued. In the following five years, the Trustees will still have significant work to do while overseeing Dow's monitoring and maintenance as it achieves performance

standards for the projects it is implementing and while working with local land managers to meet stewardship objectives and plan for long-term maintenance. After that, the Trustees would be expected to have fewer expenses as they continued to monitor the success of projects, manage any remaining funds, and solicit proposals for new restoration projects if funding allows.

4.4 Alternative C: Projects and Fixed Funding for Stewardship and Proposals

4.4.1 Fixed Funding for Project Stewardship and Future Project Proposals

Alternative C would include all components of Alternative B, except that the funding for stewardship, monitoring, and future projects would be structured more rigidly, as follows:

- Stewardship of implemented projects - $5.9 million - $6 million
- Monitoring recovery of natural resources - $2 million
- Trustee oversight costs - $2 million
- Future projects - $5.0 - $5.1 million

Future projects and stewardship funding amounts are given as a range because the amounts of funding required by the highest ranking project proposals are not likely to total exactly $5 million. Other than the future projects category, the amounts in the other categories of funding would be allowed to vary by up to 15% as determined by the Trustees.

4.5 Non-Preferred Projects Discussion

Starting in 2005, the Trustees sought ideas for restoration projects from the public and conservation groups, but not all project ideas received met the eligibility requirements for NRDA restoration projects or they ranked significantly lower than projects included in Alternatives B and C based on the criteria described in section 5.1.1. Many of the project ideas received over the years are listed in Appendix D. An example of a project that did not meet the eligibility requirements was discussed above in section 4.3.12: complete removal of the Dow Dam in Midland was proposed several times, but was not deemed to be feasible because of the many requirements to keep water elevations maintained at the current level, including ensuring the functioning of some of the response actions to address contamination (e.g. the RGIS). Instead, the Trustees worked with Dow to develop a fish passage project that could produce many of the same benefits to natural resources that dam removal would have while maintaining water elevations upstream of the Dow Dam.

Projects that would not restore, replace, or enhance natural resources or the services they provide were also found to not be eligible. These included historical renovation and preservation projects; creation of dog parks, playgrounds, and farmer's markets; expanding municipal infrastructure; and providing medical testing for people living near dredging operations. The renovation of the historic Rear Range Lighthouse near the Saginaw River outlet to Saginaw Bay was one of these projects that was not considered eligible as an NRDA restoration project, but under the Consent Decree that would settle NRDA claims, Dow would also settle certain past cost claims with the State of Michigan by conducting two projects, one of which would involve

the Rear Range Lighthouse. Under the settlement with the State and as described in Appendix O of the Consent Decree, Dow would contribute up to $1 million for renovation of the Rear Range Lighthouse, dedicate the approximately 3 acres of land with the lighthouse to public use associated with the lighthouse, and provide public access to the lighthouse by improving an existing road or, if necessary, constructing a new gravel road at the same time that it implements the adjacent Bay City Ecological Restoration Project described above in section 4.3.7.

The second project that Dow would conduct under the settlement with the State is a project to provide land, funding for connections to public utilities, and public access for an environmental education center near the Rear Range Lighthouse and the Bay City Ecological Restoration Project, as described in Appendix P of the Consent Decree. The environmental education center and the associated mooring area on the Saginaw River would be available for the BaySail Environmental Education Program, a community-based education program located in Bay City, Michigan, that provides a hands-on learning experience in environmental science on the Saginaw River and Saginaw Bay.

Projects that ranked significantly lower than projects included in Alternatives B and C included, but were not limited to, projects that only benefitted a single natural resource or natural resource service, projects for which the technical feasibility was uncertain or the cost to benefit ratios were considered to be high, and projects for which the benefits to injured natural resources were uncertain or unclear.

CHAPTER 5: EVALUATION OF ALTERNATIVES

The Trustees' primary goal in this chapter is to identify a preferred restoration alternative that compensates the public for natural resource injuries and associated losses resulting from Dow's Midland plant. The Trustees use NRDA restoration project selection criteria to evaluate the proposed projects within Alternatives B and C. In addition, the Trustees assess the environmental consequences of Alternatives A, B, and C to determine whether implementation of any of these alternatives may significantly affect the quality of the human environment, particularly with respect to physical, biological, socio-economic, or cultural environments as required by NEPA.

The following definitions will be used to characterize the nature of the various impacts evaluated in this Draft RP/EA:

- *Short-term or long-term impacts*. In general, short-term impacts are those that would occur only with respect to a particular activity or for a finite period. Long-term impacts are those that are more likely to be persistent and chronic.

- *Direct or indirect impacts*. A direct impact is caused by a proposed action and occurs contemporaneously at or near the location of the action. An indirect impact is caused by a proposed action and might occur later in time or be farther removed in distance but still be a reasonably foreseeable outcome of the action.

- *Minor, moderate, or major impacts*. These relative terms are used to characterize the magnitude of an impact. Minor impacts are generally those that might be perceptible but, in their context, are not amenable to measurement because of their relatively inconsequential effect. Moderate impacts are those that are more perceptible and, typically, more amenable to quantification or measurement. Major impacts are those that, in their context and due to their intensity (severity), have the potential to meet the thresholds for significance set forth under NEPA (40 C.F.R. § 1508.27) and, thus, warrant heightened attention and examination for potential means for mitigation to fulfill the requirements of NEPA.

- *Adverse or beneficial impacts*. An adverse impact is one having unfavorable or undesirable outcomes on the man-made or natural environment. A beneficial impact is one having positive outcomes on the man-made or natural environment. A single act might result in adverse impacts on one environmental resource and beneficial impacts on another resource.

- *Cumulative impacts*. Cumulative impacts are defined as the "impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions" (40 C.F.R. § 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time within a geographic area.

This chapter first describes the evaluation criteria for NRDA project selection and for environmental consequences under NEPA, then evaluates the proposed projects for each, and finally compares the consequences among the alternatives.

5.1 Evaluation Criteria

5.1.1 NRDAR Restoration Project Selection Criteria

The Trustees have developed criteria for evaluating potential restoration ideas and projects for the NRDA restoration planning process for the TRSAA and previously published them in their Assessment Plan (Stratus, 2008). These criteria were based on those identified in federal regulations at 43 CFR § 11.82, 15 CFR §§ 990.54 and 990.55, as well as relevant criteria developed as part of NRDAs conducted at other sites such as Bunker Hill, Idaho; Pecos Mine, New Mexico; New Bedford Harbor, Massachusetts; Green Bay, Wisconsin and Michigan; and Kalamazoo River, Michigan.

The criteria have been grouped into four evaluation categories: eligibility, focus, implementability, and benefits. These categories are intended to provide a framework to use when evaluating potential projects. Initially, the eligibility criteria will be used to screen out projects that do not meet the minimum standards described in federal regulations. Following the initial screening, the remaining projects will be evaluated in more detail using the focus, implementability, and benefits criteria. A brief description of each criteria category follows:

Eligibility: Criteria that relate to whether a proposed project meets minimum standards of relevance to injured natural resources and/or services, achieves a beneficial outcome, and complies with applicable and relevant laws including the ability to obtain any necessary regulatory permits. A project must meet each of these criteria to be considered further.

Focus: Criteria that relate to achieving the documented goals and objectives of the Trustees for the restoration of the TRSAA.

Implementability: Criteria that relate to project implementability, feasibility, and cost effectiveness.

Benefits: Criteria that relate to the types, timing, and permanence of benefits provided by a project.

The specific criteria in each of these categories are described in the tables below:

Table 8. Eligibility criteria for restoration planning

Priority	Criteria	Interpretation
Pass/fail	E1: Complies with applicable/relevant federal, state, local, and tribal laws and regulations.	Project must be legal, able to be permitted, and must not jeopardize public health and safety.

Priority	Criteria	Interpretation
Pass/fail	E2: Benefits natural resources injured by hazardous substances released to the Tittabawassee River system, or natural resource services[15] lost because of injuries.	Projects will be evaluated as to whether they restore, rehabilitate, replace, or acquire the equivalent of injured natural resources and services.
Pass/fail	E3: Is technically feasible.	Projects must have a high likelihood of success.

Table 9. Focus criteria for restoration planning

Priority	Criteria	Interpretation
Higher	F1: Restores, rehabilitates, replaces, or acquires the equivalent of injured natural resources.	Restoration/rehabilitation is preferred. Projects that benefit natural resources on site (within or adjacent to the Tittabawassee River system) are preferred. Acquisition of the equivalent is least preferred.
Medium	F2: Addresses/incorporates restoration of targeted natural resources and services as documented by Trustee mandates and priorities.	Priorities will be based on the resource types injured and degree of injury. Targeted natural resources include fish and wildlife and their habitats with emphasis on dynamic floodplain/riverine habitats, habitat continuity, water quality, soil and sediment quality, public game/wildlife/recreation areas, threatened and endangered species, native species, important food-web species, recreationally significant species, and culturally significant resources.
Lower	F3: Targets natural resources or services that are unable to recover to baseline[16] without restoration action, or that will require a long time to recover naturally (e.g., > 25 years).	Projects that target resources/services that will be slow to recover will be favored over projects that target resources/services that will recover quickly naturally.

[15] The term "services" includes ecological and active and passive public use services.
[16] Baseline is the state of natural resources and services that would exist if hazardous substances being addressed in this assessment had never been released.

Table 10. Implementation criteria for restoration planning

Priority	Criteria	Interpretation
High	I1: Is cost-effective, including planning, implementation, and long-term operation, maintenance, and monitoring activities.	Projects are preferred that have a high ratio of expected benefits to expected cost. Projects will be evaluated relative to other projects that benefit the same resource. Cost-sharing, e.g., for monitoring or maintenance, will be considered in evaluating expected costs.
High	I2: Benefits can be measured for success by evaluation/comparison to baseline, and can be scaled to the appropriate level of resource injury or loss.	Projects will be evaluated in terms of whether the benefits can be quantified and the success of the project determined. Projects can be scaled to provide restoration of appropriate magnitude. Small projects that provide only minimal benefit relative to lost injury/service or larger projects that cannot be appropriately reduced in scope are less favored.
Medium	I3: Uses established, reliable methods/technologies known to have a high probability of success.	Projects will be evaluated for their likelihood of success given the proposed methods. Factors that will be considered include whether the proposed technique is appropriate to the project, whether it has been used before, and whether it has been successful. Projects incorporating experimental methods, research, or unproven technologies will be given lower priority.
Medium	I4: Takes into account completed, planned, or anticipated response actions.	Projects that restore or enhance habitat impacted by response actions will be preferred over those not associated with response actions. Projects proposed in areas likely to be impacted by response actions must be coordinated with response actions to provide cost savings and to take advantage of the availability of mobilized equipment on site during response actions, if possible, and to avoid damage to the restoration project by any subsequent response actions.

Priority	Criteria	Interpretation
Medium	I5: If the project involves source control, it reduces exposure of natural resources to hazardous substances, including reduction of the volume, mobility, and/or toxicity.	Projects that address source control will be evaluated in terms of the extent to which they reduce exposure to hazardous substances, including by reducing volume, mobility, and/or toxicity.
Lower	I6: Is consistent with regional planning.	Project will be evaluated for consistency with regional planning, especially planning that has been publicly reviewed and/or formally adopted. Examples of relevant regional plans include species recovery plans and fish and wildlife management plans.

Table 11. Benefit criteria for restoration planning

Priority	Criteria	Interpretation
Higher	B1: Provides the greatest scope of ecological, cultural, and economic benefits to the largest area or population.	Projects that benefit more than one injured resource or service will be given priority. Projects that avoid or minimize additional natural resource injury, service loss, or environmental degradation will be given priority.
Higher	B2: Provides benefits not being provided by other restoration projects being implemented/funded under other programs.	Preference is given to projects that are not already being implemented or have no planned funding under other programs. Although the Trustees will use restoration-planning efforts by other programs, preference is given to projects that would not otherwise be implemented without NRDA restoration funds.
Medium	B3: Aims to achieve environmental equity and environmental justice.	A restoration program should benefit low-income and ethnic populations (including Native Americans) in proportion to the impacts to these populations. A restoration program should not have disproportionate high costs or low benefits to low-income or ethnic populations. Further, where there are specific service injuries to these populations, such as impacts on subsistence fishing, restoration programs should target benefits to these populations.

Priority	Criteria	Interpretation
Lower	B4: Maximizes the time over which benefits accrue.	Projects that provide benefits sooner are preferred. Projects that provide longer-term benefits are preferred.

5.1.2 NEPA Criteria

As described in section 1.7, actions undertaken by the Trustees to restore natural resources or services under CERCLA and other federal laws are subject to the National Environmental Policy Act (NEPA) (42 U.S.C. § 4321 et seq.) and the regulations guiding its implementation at 40 C.F.R. Parts 1500 through 1517 and 43 C.F.R. Part 46. In undertaking their NEPA analysis, the Trustees evaluated the potential significance of proposed actions, considering both context and intensity. For the actions considered in this Draft DARP/EA, the appropriate context for considering potential significance of the action is at the local or regional level, as opposed to national, or worldwide.

NEPA regulations (40 C.F.R. §1508.27) require consideration of ten factors in determining significance of a proposed action:

1. Likely impacts of the proposed project.
2. Likely effects of the project on public health and safety.
3. Unique characteristics of the geographic area in which the project is to be implemented.
4. Controversial aspects of the project or its likely effects on the human environment.
5. Degree to which possible effects of implementing the project are highly uncertain or involve unknown risks.
6. Effect of the project on future actions that may significantly affect the human environment.
7. Possible significance of cumulative impacts from implementing this and other similar projects.
8. Effects of the project on National Historic Places, or likely impacts to significant cultural, scientific, or historic resources.
9. Degree to which the project may adversely affect endangered or threatened species or their critical habitat.
10. Likely violations of environmental protection laws.

For the actions considered in this Draft DARP/EA, the Trustees looked to previous analysis for NEPA compliance that related to these types of actions. NOAA recently analyzed potential impacts of numerous types of habitat restoration in a Programmatic Environmental Impact Statement (NOAA, 2015) and the USFWS has adopted that document (USFWS, 2016). In addition, for projects that have a minimal impact on the human environment, they may be addressed by Categorical Exclusions under the NEPA (40 C.F.R. §1508 and 43 C.F.R. §46.205). As such, by regulation, they would be excluded from the need to conduct additional analyses such as an Environmental Assessment or Environmental Impact Statement. The following U.S. Fish and Wildlife Service Categorical Exclusions (Part 516 DM Chapter 8, Appendix 7) may apply to at least some of the proposed restoration projects:

a) Research, inventory, and information collection activities directly related to the conservation of fish and wildlife resources which involve negligible animal mortality or habitat destruction, no introduction of contaminants, or no introduction of organisms not indigenous to the affected ecosystem. 516 DM Chapter 8.5 B.(1)

b) The operation, maintenance, and management of existing facilities and routine recurring management activities and improvements, including renovations and replacements which would result in no or only minor changes in the use, and would have no or negligible environmental effects on site or in the vicinity of the site. 516 DM Chapter 8.5 B.(2)

c) The construction of new, or the addition of, small structures or improvements, including structures and improvements for the restoration of wetland, riparian, in stream, or native habitats, which would result in no or only minor changes in the use of the affected local area. 516 DM Chapter 8.5 B. (3).

d) The reintroduction of native, formerly native, or established species into suitable habitat within their historic or established range, where no or negligible environmental disturbances would be anticipated. 516 DM Chapter 8.5 B. (6)

e) Natural resource damage assessment restoration plans, prepared under sections 107, 111, and 122(j) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); section 311(f)(4) of the Clean Water Act; and the Oil Pollution Act; when only minor or negligible change in the use of the affected areas is planned. 516 DM Chapter 8.5 B. (11).

5.2 Evaluation of Alternative A: No Action

The No Action Alternative would not initiate any restoration action outside of the remedial cleanup process already underway. Without active environmental restoration, impacts from contaminants and from cleanup actions themselves would decrease gradually over time while human land use patterns would be expected to remain fairly stable, although with a trend toward increasing development. The Trustees considered the changes in ecological services from natural recovery and found that the No Action Alternative:

- *Does not restore injured natural resources to baseline*. Remediation is expected to span many years and include years of monitoring after the bank and sediment stabilization

actions are completed. Actions like bank stabilization and removal of trees for cleanup alter habitat for decades. Lack of restoration beyond remedial actions will reduce the potential for natural resources to fully recover to baseline conditions.

- *Does not compensate the public for interim losses*. Because remedial activity will not improve the site above baseline conditions, interim losses have and will continue to accrue from continued ecological and human use injury due to PCDDs and PCDFs.

While the No Action Alternative does not create additional adverse impacts to the environment, and is technically feasible and cost-effective, it does not provide the ecological, recreational, and socio-economic benefits described under Alternatives B and C. Given the long time frame until cleanup, recovery from cleanup actions, and natural attenuation of residual PCDDs and PCDFs in the system is achieved, under the No Action Alternative adverse environmental consequences from PCDDs and PCDFs (e.g., ecological and human use injuries) are expected to continue into the future and would not be mitigated through restoration actions. Therefore, the No Action Alternative is not a favorable restoration alternative when evaluated against the NRDAR factors. This Alternative serves as a point of comparison to determine the context, duration, and magnitude of environmental consequences resulting from the implementation of Alternative B or C.

5.3 Evaluation of Alternative B: Projects and Flexible Funding for Stewardship and Proposals (Preferred)

Alternative B includes a suite of restoration projects that compensate for interim ecological losses and provide recreational and socio-economic benefits plus additional funding for project stewardship (e.g. monitoring and maintenance) and additional restoration projects to be determined in the future with additional public input. The proposed projects satisfy the NRDAR project selection criteria listed above (section 5.1.1) as set forth in Table 12.

Table 12. Evaluation of proposed projects relative to NRDA restoration criteria listed in section 5.1.1, where "+" to "+++" indicates increasing relative rank; all proposed projects scored positively on criteria, so relative ranks of "0" for neutral and a range of "-" to "---" for increasing adverse impacts do not appear on this table

Project	Location	Description	Eligibility	Focus	Implementability	Benefits
Tittabawassee River (TR) Floodplain Restoration and Bike Trail	TR floodplain, downstream of Midland	Floodplain habitat restoration; bike trail; nature trails with river access	Pass	+++ On-site, direct benefits to injured natural resources	++ Established methods, but with some drainage questions Trails will require maintenance	+++ Long-term, wide-scope, including local public access to river
Thomas Township Nature Preserve	TR floodplain, downstream of Midland in Thomas Township	Floodplain habitat restoration; nature trails with river access	Pass	+++ On-site, direct benefits to injured natural resources	++ Established methods, but with some drainage questions Trails will require maintenance	+++ Long-term, wide-scope, including local public access to river
Tittabawassee River Green Corridor	TR floodplain, downstream of Midland	Floodplain habitat preservation	Pass	+++ On-site, direct benefits to injured natural resources	++ Requires willing landowners and long-term enforcement	+ Long-term but no increase in habitat or service Not open to public
Shiawassee National Wildlife Refuge Restoration	Floodplain of TR and other rivers near Saginaw	Floodplain habitat restoration; increased water quality and connectivity for riverine fish	Pass	+++ On-site, direct benefits to injured natural resources	+++ Established methods Improved water control will decrease costs for long-term habitat management by federal Refuge	+++ Long-term, very wide scope within large area Partially open to public
Shiawassee National Wildlife Refuge Expansion	Floodplain of TR and other rivers near Saginaw	Floodplain habitat preservation and likely succession from agricultural land to natural habitat on some parcels; hunting opportunities	Pass	+++ On-site, direct benefits to injured natural resources	++ Established methods but will require landowners willing to sell	++ Long-term, wide scope adding on to wide area of habitat Human use mainly limited to hunters
Saginaw Riverfront Park	Saginaw River (SR) floodplain and adjacent uplands in Saginaw	Development and long-term maintenance of public park for passive recreation	Pass	++ On-site, some benefits to injured natural resources	+++ Established methods with long-term operation by county and state	++ Long-term, medium scope. Environmental justice benefits with non-motorized urban access

Project	Location	Description	Eligibility	Focus	Implementability	Benefits
Bay City Ecological Restoration	SR floodplain and Saginaw Bay coastal wetlands near Bay City	Floodplain and coastal wetland restoration from agricultural land	Pass	+++ On-site, direct benefits to injured natural resources	++ Established methods, but some uncertainty as to who will eventually own and operate the area and lead long-term stewardship	+++ Long-term, wide scope with good public access and shoreline fishing opportunities
Saginaw River Mouth Boating Access Site Expansion	On SR near Saginaw Bay in Bangor Township	Expansion of boating access to Saginaw River and Bay in popular fishing location	Pass	+ On-site, but expands only services and not natural resources themselves	+++ Established methods with long-term stewardship by MDNR	+ Benefits primarily recreational fishing by boats
Greater Midland Nature Preserve	Fields and woodlands east of Midland	Preservation of existing habitat plus restoration of wetlands and uplands from agricultural fields	Pass	++ Off-site, but benefits many natural resources	++ Established methods, but some uncertainty as to who will eventually own and operate the area and lead long-term stewardship	+++ Long-term, wide-scope, including public access primarily by car
Eagle Ridge Nature Area	Woodland northeast of Midland	Primarily preservation of existing habitat plus limited restoration and opening to public	Pass	+ On site relative to Midland soils; benefits to natural resources and public somewhat offset by increased disturbance	++ Established methods, but some uncertainty as to who will eventually own and operate the area and lead long-term stewardship	+ Long-term, benefits primarily to Midland residents
Saginaw Chippewa Tribe Restoration	To be determined	Acquisition and restoration of habitat and cultural resources from agricultural fields	Pass	++ Off-site, but benefits many natural resources and tribal cultural uses	+++ Established methods with long-term stewardship by Saginaw Chippewa Tribe	+++ Long-term, wide scope, open to public with enhancements specific to tribal values
Midland Fish Passage	On TR in Midland	Construction of nature-like fish passage structure	Pass	+++ On-site, benefits to many aquatic natural resources	+ These structures can require initial adjustments from design. Dow owns the dam but some uncertainty as to who will eventually own and lead long-term stewardship of the new structure	+++ Long-term, with benefits to fish, mussels, and shoreline recreational fishing upstream of Midland

Project	Location	Description	Eligibility	Focus	Implementability	Benefits
Saginaw Bay Spawning Reefs	In Saginaw Bay	Construction of rock reefs for fish spawning	Pass	++ On-site, benefits to some aquatic invertebrates and certain fish species including game fish	++ Established methods of construction with demonstrated success elsewhere; planned locations expected to have acceptable levels of sedimentation	++ Long-term benefits to fish stocks and recreational fishing
Stewardship	All projects listed above	Monitoring and maintenance of projects above, beyond Dow's obligations	Pass	+++ Mostly on-site, benefits to wide variety of natural resources and services	+++ Established methods building on initial project monitoring and maintenance to achieve performance standards	+++ Expected to extend high level of project benefits for an additional 20 years or more
Monitoring	Along the rivers, floodplains, and Saginaw Bay plus reference areas	Monitoring of continuing recovery of the health of natural resources	Pass	++ On-site, wide variety of natural resources	+++ Established methods with existing data to build on	+ Allows for adjustments in stewardship if benefits are not as expected
Floodplain restoration and preservation	To be determined	Floodplain restoration and preservation selected using criteria	Pass	Preference given to on-site projects benefitting a wide variety of natural resources and services	Preference given to projects that use established methods and with high benefits to cost ratio	Preference given to projects that benefit many resources and services and might not be accomplished by other programs
Wetland restoration	To be determined	Wetland creation or enhancement in watershed, selected using criteria	Pass	Preference given to on-site projects benefitting a wide variety of natural resources and services	Preference given to projects that use established methods and with high benefits to cost ratio	Preference given to projects that benefit many resources and services and might not be accomplished by other programs
Upland habitat restoration	To be determined	Upland creation or enhancement in watershed, selected using criteria	Pass	Preference given to on-site projects benefitting a wide variety of natural resources and services	Preference given to projects that use established methods and with high benefits to cost ratio	Preference given to projects that benefit many resources and services and might not be accomplished by other programs

Project	Location	Description	Eligibility	Focus	Implementability	Benefits
Aquatic habitat enhancements, including barrier removal	To be determined	Aquatic habitat enhancements, including barrier removal, in the watershed; selected using criteria	Pass	Preference given to on-site projects benefitting a wide variety of aquatic natural resources and services	Preference given to projects that use established methods and with high benefits to cost ratio	Preference given to projects that benefit many resources and services and might not be accomplished by other programs
Improved access to natural resources for passive recreation like wildlife viewing	To be determined	May include trails and interpretative signage	Pass	Preference given to projects that combine benefits to natural resources with the increased access and the disturbance that brings	Preference given to projects that use established methods and with high benefits to cost ratio	Preference given to projects that increase accessibility for members of the public with few options for experiencing natural resources
Improved access to natural resources for consumptive use like fishing, hunting, and gathering	To be determined	May include boating and shoreline access points for fishing, management of programs for hunting and gathering	Pass	Preference given to projects that combine benefits to natural resources with the increased consumption and disturbance	Preference given to projects that use established methods and with high benefits to cost ratio	Preference given to projects that increase accessibility for members of the public with few options for experiencing natural resources

In addition, the Trustees believe that the proposed projects and types of projects in Alternative B meet NEPA requirements. The proposed projects and types of projects would not cause significant negative impacts to the environment, or to natural resources or the services they provide. None of the proposed projects is controversial, has highly uncertain impacts or risks, or is likely to violate any environmental protection laws. Further, the Trustees do not believe the proposed projects would adversely affect the quality of the human environment or pose any significant adverse environmental impacts. Instead, habitat restoration projects would benefit species and some may also improve water quality and flood risk by restoring natural habitat functions. Likewise, the proposed restoration actions would provide positive benefits for human recreational use and non-recreational use by tribal members and the general public. The evaluation of each of the projects and project types relative to NEPA criteria listed in 5.1.2 is summarized in Table 13. Based on this evaluation, unless new information is made available during the public review process of the Draft RP/EA, the Trustees expect to be able to make a Finding of No Significant Impact for the preferred alternative consisting of suite of proposed projects and future restoration categories. For specific projects proposed in the future, the Trustees will re-evaluate the NEPA factors and document whether any impacts require additional consideration beyond what is covered in this RP/EA.

Table 13. Evaluation of proposed projects relative to NEPA criteria listed in section 5.1.2

Project	Location	Environmental Impacts: Positive	Environmental Impacts: Negative	Social Impacts: Positive	Social Impacts: Negative
Tittabawassee River (TR) Floodplain Preserve	TR floodplain, downstream of Midland	Increase in floodplain habitat from row agriculture Potential water quality and flood flow improvements from re-routing drain	Short term disturbance during construction Paths result in minor habitat loss and some human disturbance of wildlife	Increased recreational opportunities Increased nature interpretation Economic benefits of minor construction project	Minor short-term construction traffic
Thomas Township Nature Preserve	TR floodplain, downstream of Midland in Thomas Township	Increase in floodplain habitat from row agriculture Water quality and flood flow improvements by reducing agricultural drainage	Short term disturbance during construction	Increased recreational opportunities, including walking access from neighborhood Increased nature interpretation Economic benefits of minor construction project	Minor short-term construction traffic
Tittabawassee River Green Corridor	TR floodplain, downstream of Midland	Protection of existing floodplain habitat from development into maintained lawns	None	None	None
Shiawassee National Wildlife Refuge Restoration	Floodplain of TR and other rivers near Saginaw	Increased quality of floodplain habitat Increased connectivity between rivers and marshes to benefit water quality and fish	Short term disturbance during construction	Increased quality of wildlife viewing and of fish communities that support recreational fishing Economic benefits of minor construction project	Minor short-term construction traffic
Shiawassee National Wildlife Refuge Expansion	Floodplain of TR and other rivers near Saginaw	Depending on properties acquired, may protect existing habitat from future development and may also increase habitat quality through natural succession	None	Increase in public hunting opportunities	None

Project	Location	Environmental Impacts: Positive	Environmental Impacts: Negative	Social Impacts: Positive	Social Impacts: Negative
Saginaw Riverfront Park	Saginaw River (SR) floodplain and adjacent uplands in Saginaw	Some increase in habitat quality	Short term disturbance during management activities. Improved public access will result in some wildlife disturbance	Increased recreational opportunities, including walking access from neighborhoods Increased nature interpretation Economic benefits of minor construction project	Minor short-term construction traffic
Bay City Ecological Restoration	SR floodplain and Saginaw Bay coastal wetlands near Bay City	Increase in floodplain habitat from row agriculture Water quality and flood flow improvements by reducing agricultural drainage	Short term disturbance during construction	Increased recreational opportunities Increased nature interpretation Economic benefits of minor construction project	Minor short-term construction traffic
Saginaw River Mouth Boating Access Site Expansion	SR near Saginaw Bay in Bangor Township	None	Loss of narrow strip of wooded habitat along one edge	Increased recreational fishing opportunities during times of peak use Economic benefits of minor construction project	Minor short-term construction traffic Temporary closure of site during construction
Greater Midland Nature Preserve	Fields and woodlands east of Midland	Increase in wetland and upland habitats from row agriculture Protection of existing habitat from development Water quality and flood flow improvements by reducing agricultural drainage	Short term disturbance during construction	Increased recreational opportunities Increased nature interpretation Economic benefits of minor construction project	Minor short-term construction traffic
Eagle Ridge Nature Preserve	Woodland northeast of Midland	Some increase in habitat quality through control of invasives and planting of native species	Short term disturbance during management activities. Improved public access will result in some wildlife disturbance	Increased recreational opportunities, including walking access from neighborhoods Increased nature interpretation Economic benefits of minor construction project	Minor short-term construction traffic

Project	Location	Environmental Impacts: Positive	Environmental Impacts: Negative	Social Impacts: Positive	Social Impacts: Negative
Saginaw Chippewa Tribe Restoration	To be determined	Increase in wetland and upland habitats from row agriculture Protection of existing habitat from development Water quality and flood flow improvements by reducing agricultural drainage	Short term disturbance during construction	Increased recreational and tribal cultural opportunities Increased nature interpretation Economic benefits of minor construction project	Minor short-term construction traffic
Midland Fish Passage	On TR in Midland	Increased passage of fish upstream and downstream Increased passage of invertebrates, sediment, and wood debris downstream Increased gravel and cobble habitat for fish spawning and aquatic invertebrates	Short term disturbance during construction	Increased recreational fishing opportunities, especially upstream of the Dow Dam and for anglers without boats Economic benefits of construction project	Minor short-term construction traffic Potential decrease in fish density for boating anglers downstream of Dow Dam during spring runs
Saginaw Bay Spawning Reefs	In Saginaw Bay	Expect increased spawning success for several species of fish, resulting in improved fish populations, along with an increase in gravel and cobble substrate for aquatic invertebrates	Short term disturbance during construction	Increased recreational fishing opportunities Economic benefits of minor construction project	Minor short-term construction traffic
Stewardship	All projects listed above	Maintenance of habitat quality achieved through restorations	Short term disturbance during maintenance activities, including targeted use of herbicides	Positive benefits for projects will continue over time Economic benefits of minor seasonal maintenance work	None
Monitoring	Along the rivers, floodplains, and Saginaw Bay plus reference areas	Information to benefit efficient maintenance of habitat quality achieved through restorations	None	None	None
Floodplain restoration and preservation	To be determined	See similar specific projects above	See similar specific projects above	See similar specific projects above	See similar specific projects above
Wetland restoration	To be determined	See similar specific projects above	See similar specific projects above	See similar specific projects above	See similar specific projects above

Project	Location	Environmental Impacts: Positive	Environmental Impacts: Negative	Social Impacts: Positive	Social Impacts: Negative
Upland habitat restoration	To be determined	See similar specific projects above	See similar specific projects above	See similar specific projects above	See similar specific projects above
Aquatic habitat enhancements, including barrier removal	To be determined	See similar specific projects above	See similar specific projects above	See similar specific projects above	See similar specific projects above
Improved access to natural resources for passive recreation like wildlife viewing	To be determined	Public appreciation of natural resources may indirectly aid in future protection and restoration efforts	Some minor habitat loss and some human disturbance of wildlife	Increased recreational opportunities Economic benefits of minor construction project	Minor short-term construction traffic
Improved access to natural resources for consumptive use like fishing, hunting, and gathering	To be determined	Public appreciation of natural resources may indirectly aid in future protection and restoration efforts	Some minor habitat loss and some human disturbance of wildlife	Increased recreational opportunities Economic benefits of minor construction project	Minor short-term construction traffic

In addition to the tables above, specific benefits of the projects and projects types as they relate to addressing injuries and any special concerns are described in the following subsections of section 5.3.

5.3.1 Tittabawassee River Floodplain Restoration and Bike Trail Project

This approximately 490 acre project would provide direct, long-term benefits to multiple natural resources along the Tittabawassee River by preserving and restoring floodplain habitat and reducing agricultural run off to the river from the approximately 175 acres of agricultural land that will be restored to floodplain habitat. Additional benefits to water quality may also be realized if it is determined during the planning and design phase that it is feasible to disperse additional run off from an agricultural drain across a portion of this project, thereby further restoring floodplain functioning by slowing and dispersing flood waters. This project would also provide opportunities for the public to access natural resources along the Tittabawassee River using both nature trails and a bike path that is expected to become a segment in the Great Lakes Bay Regional Trail system. As such, the public would be able to experience natural resources in mature floodplain habitat, in habitat that is being restored from an agricultural field to floodplain habitat, and along the Tittabawassee River. Along with the Tittabawassee River Green Corridor Project (section 4.3.3), the Thomas Township Nature Preserve (section 4.3.2), and the addition of land to the Refuge at and adjacent to the former Germania Golf Course (section 4.3.5) this project would contribute to cumulative benefits of preserving habitat in much of the riparian corridor from Midland to Saginaw. Overall, this project compensates for losses in the Tittabawassee River floodplain and to aquatic natural resources, recreational fishing, and park use.

The restoration is anticipated to use established techniques with only short-term disturbances during construction of trails and parking access. Beak grass, a state-listed species, is known to occur along the Tittabawassee River in areas similar to this, so plant surveys would be conducted when planning the project so that impacts to this species could be avoided or, with the approval of the MDNR, minimized by transplanting or other measures. The trails and parking access would slightly reduce habitat and increase human disturbance to wildlife along the paths, but this would be more than offset by the many acres of improved habitat quality, floodplain functioning, and permanent preservation of the project area.

The local economy would be expected to benefit from jobs, purchases, and associated economic outputs during construction (Thomas et al. 2016); from tourism associated with the trail system, especially when connected with the Great Lakes Bay Regional Trail system; and from increased property values on adjacent parcels associated with being near conservation areas (Reeves et al. 2018). While Dow would continue to pay property taxes while it continues to own the property throughout the restoration project, conversion of 175 acres from agricultural use to natural habitat may result in a decrease in assessed value of the 490 total acres and therefore in local property taxes.

5.3.2 Thomas Township Nature Preserve

This approximately 60 acre project would provide direct, long-term benefits to multiple natural resources along the Tittabawassee River by preserving and restoring floodplain habitat and

reducing agricultural run off to the river from the approximately 60 acres of agricultural land that will be restored to floodplain habitat. Additional habitat diversity may also be realized if it is determined during the planning and design phase that it is feasible to create a wetland pond with a mix of open water and emergent vegetation on the property. This project would also provide opportunities for the public to access natural resources in and along the Tittabawassee River using nature trails, observation decks, and a canoe and kayak launch. As such, the public would be able to experience natural resources in habitat that is being restored from an agricultural field to floodplain habitat as well as in and along the Tittabawassee River, where they may also be able to fish from kayaks and canoes. With this nature preserve being accessible by sidewalks, members of the public without access to personal vehicles would also be able to use and enjoy the area. Along with the Tittabawassee River Floodplain and Bike Trail Project (section 4.3.1), the Tittabawassee River Green Corridor Project (section 4.3.3), and the addition of land to the Refuge at and adjacent to the former Germania Golf Course (section 4.3.5) this project would contribute to cumulative benefits of preserving habitat in much of the riparian corridor from Midland to Saginaw. Overall, this project compensates for losses in the Tittabawassee River floodplain and to aquatic natural resources, recreational fishing, and park use.

The restoration is anticipated to use established techniques with only short-term disturbances during construction of trails and other features. The trails, observation decks, and other features would slightly reduce habitat and increase human disturbance to wildlife along the paths, but this would be more than offset by the many acres of improved habitat quality and permanent preservation of the project area.

The local economy would be expected to benefit from jobs, purchases, and associated economic outputs during construction. A recent study indicates the every $1 million invested in ecosystem restoration generates approximately 12 to 32 job-years and approximately $2.2 to $3.4 million in total economic output (Thomas et al. 2016). In addition, Thomas Township would be expected to benefit from tourism associated with the trail system and canoe and kayak access to the river and potentially from increased property values associated with being near conservation areas (Reeves et al. 2018).

5.3.3 Tittabawassee River Green Corridor

This project would preserve existing floodplain habitat rather than restoring any habitat, so the Trustees would recognize only a relatively small amount of benefits per acre for this project. Nonetheless, the location along many miles of the Tittabawassee River where natural resources have been impacted and the 2,000 acre size of this project made it unique among the proposed projects. This project would provide the critical continuity need to realize the cumulative benefits of preserving habitat in much of the riparian corridor from Midland to Saginaw when combined with the Tittabawassee River Floodplain and Bike Trail Project (section 4.3.1), the Thomas Township Nature Preserve (section 4.3.2), and the addition of land to the Refuge at and adjacent to the former Germania Golf Course (section 4.3.5). This project occurs on private land, so the public would not be able to access any additional natural areas as a result of this project but will be able to continue to enjoy boating, nature observation, and fishing along long stretches of river banks and floodplain that are protected from future development. Overall, this project compensates for losses in the Tittabawassee River floodplain and protects additional banks from development.

5.3.4 Shiawassee National Wildlife Refuge Restoration

This project would provide direct, long-term benefits to multiple natural resources over a large area south of the confluences of the Tittabawassee River, Shiawassee River, Flint River and Cass River by restoring floodplain, marsh, and wooded wetland habitats and restoring hydrologic connections among habitat management units of the Refuge and the rivers that flow through it. Natural resources benefitted would include waterfowl, bald eagles, and other birds; mammals like muskrat and mink; reptiles and amphibians including eastern fox snake and Blanding's turtles; and fish species that would be able to move from the rivers into the restored marshes for spawning. In addition, being able to control flows and route additional river water through the Refuge would improve nutrient retention and use and thereby improve water quality downstream while also potentially increasing floodplain storage capacity under some flow conditions. Improvements to natural resources on the Refuge and fish populations in the rivers would be able to be enjoyed by the public, although public access to the Refuge is not expected to be directly affected by this project, as discussed in section 4.3.4, other than potential short-term reductions in access during restoration construction that temporarily closes sections of roads or trails for safety. Overall, this project compensates for losses in the Tittabawassee River floodplain and to aquatic natural resources, recreational fishing, and park use.

The restoration is anticipated to use established techniques with only short-term disturbances during construction of water control structures and re-configuration of dikes and/or berms. Long-term management of vegetation to promote native species and control invasive species may require the use of herbicides as part of a vegetation management program, but herbicide use is expected to be reduced from what would be required to manage vegetation without the water control structures that would be installed, as they would allow the Refuge to manipulate water levels to reduce certain invasive species.

The local economy would be expected to benefit from jobs, purchases, and associated economic outputs during construction. A recent study indicates the every $1 million invested in ecosystem restoration generates approximately 12 to 32 job-years and approximately $2.2 to $3.4 million in total economic output (Thomas et al. 2016).

5.3.5 Shiawassee National Wildlife Refuge Expansion

This expansion would increase hunting opportunities in the Refuge, increase general public use and opportunities for outdoor education in the area around the Green Point Environmental Learning Center, and preserve additional land both along the Tittabawassee River corridor and in the larger area around the Refuge. Along with the Tittabawassee River Floodplain and Bike Trail Project (section 4.3.1), the Tittabawassee River Green Corridor Project (section 4.3.3), and the Thomas Township Nature Preserve (section 4.3.2), this project would contribute to cumulative benefits of preserving habitat in much of the riparian corridor from Midland to Saginaw. Except for the parcels near the Green Point Environmental Learning Center that have already been purchased, completing the proposed expansion will require finding landowners that are willing to sell suitable land at appropriate prices. The USFWS, for example, is limited to paying fair market value to purchase property. Should such suitable properties with willing landowners not be found within 5 years, the Trustees would seek to provide equivalent benefits elsewhere in the watershed or through enhancements on existing public land. Overall, this

project compensates for losses in the Tittabawassee River floodplain and to hunting and park use.

Though federal acquisition of private lands may result in removal of these lands from local tax rolls, the Refuge Revenue Sharing Act of 1978 (16 U.S.C. 715s), as amended, ensures that local communities receive funding that equals or exceeds those property taxes lost as a result of land acquisition. In addition, most communities recognize the economic contribution of National Wildlife Refuges to local tourism economies (Carver and Caudill 2007; The Conservation Fund 2014) and, as stated above, this expansion would specifically increase opportunities for hunting and outdoor recreation at Refuge.

5.3.6 Saginaw Riverfront Park

This project would provide funding for direct, long-term benefits to multiple natural resources along the Saginaw River by providing funding for a limited amount of habitat restoration on the 332 acre parcel and funding for significant long-term operation and maintenance of the entire parcel for the benefit of the public. The location of this project, just downstream of where the Tittabawassee and Shiawassee rivers join to form the Saginaw River in the Shiawassee NWR, means that habitat benefits here are enhanced by being connected to the natural habitats protected in the Shiawassee NWR and along the Tittabawassee River through the set of projects described above. This project would also provide important opportunities for the public to access natural resources along the Saginaw River using trails, boardwalks, bridges, and wildlife viewing and fishing platforms. With this park being accessible by sidewalks and immediately adjacent to residential neighborhoods, members of the public without access to personal vehicles would also be able to use and enjoy the area. This location also makes it likely that this park would be further connected to the residents of Saginaw through an expanding trail network. It is just over a bridge, across the Saginaw River, from the MDNR's Iron Belle Trail[17] that could provide access to additional people in the region via biking and hiking. Overall, this project compensates for losses in the Saginaw River floodplain and to recreational fishing and park use.

The restoration work included in this project is anticipated to use established techniques with only short-term disturbances during construction of trails and other features. The trails, observation decks, and other features would slightly reduce habitat and increase human disturbance to wildlife along the paths, but this is balanced by providing easy access for a wide variety of people to natural resources in an urban area and by increasing the overall availability and long-term maintenance of a natural area that extends a protected river corridor up into the City of Saginaw.

The local economy would be expected to benefit from jobs, purchases, and associated economic outputs during construction. A recent study indicates the every $1 million invested in ecosystem restoration generates approximately 12 to 32 job-years and approximately $2.2 to $3.4 million in total economic output (Thomas et al. 2016). In addition, the local area would be expected to benefit from tourism and increased property values on adjacent parcels associated with converting this former industrial site that has been vacant and fenced off to a public green space.

[17] https://www.michigan.gov/dnr/0,4570,7-350-79133_79206_83634---,00.html

Additional benefits from tourism would also be realized as this park is connected to the Saginaw Valley Rail Trail and from it to the Iron Belle trail that crosses through 48 Michigan counties.

5.3.7 Bay City Ecological Restoration

This approximately 415 acre project would provide direct, long-term benefits to multiple natural resources along the Saginaw River and Bay by preserving and restoring upland, floodplain, and lake plain coastal habitat and by reducing agricultural run off to the river from the approximately 245 acres of agricultural land that will be restored to natural habitat. This project would also provide opportunities for the public to access natural resources along the Saginaw River using nature trails and fishing platforms – providing an opportunity for fishing from the Saginaw River shoreline for people without access to a boat. Overall, this project compensates for losses in the Saginaw River floodplain and to recreational fishing and park use.

The restoration is anticipated to use established techniques with only short-term disturbances during construction of trails, fishing platforms, and parking access. The trails, fishing platforms, and parking access would slightly reduce habitat and increase human disturbance to wildlife along the paths relative to other areas of the project, but this would be more than offset by the many acres of improved habitat quality and permanent preservation of the project area.

The local economy would be expected to benefit from jobs, purchases, and associated economic outputs during construction (Thomas et al. 2016); from tourism associated with the trail system, fishing platforms, and the immediate proximity to the renovated Saginaw Rear Range Lighthouse (see section 4.5); and from increased property values on adjacent parcels associated with being near conservation areas (Reeves et al. 2018). While Dow would continue to pay property taxes while it continues to own the property throughout the restoration, conversion of 245 acres from agricultural use to natural habitat may result in a decrease in assessed value of the 415 total acres and therefore in local property taxes.

5.3.8 Saginaw River Mouth Boating Access Site Expansion

This project would benefit primarily recreational fishing in Saginaw River and Saginaw Bay for anglers using boats. Loss of recreational fishing as a result of fish consumption advisories, including in Saginaw Bay, was a significant component of the Trustees' claim for natural resource damages, so this project was included in the suite of projects in the settlement to address this loss despite this specific project alone not providing benefits directly to injured natural resources themselves. This project is immediately adjacent to the Bay City Ecological Restoration Project (section 4.3.7) where restoration of natural resources would be achieved as a part of this Alternative B.

This project would result in minor short-term construction traffic and temporary closure of the site during construction. The Trustees would work with Dow to schedule this work during a time of year when this boating access facility is in relatively low demand to minimize pressure on other boating access sites and the need for boaters to spend extra time boating from those other sites out to Saginaw Bay. The expansion of the boating access site will eliminate a limited amount of habitat (expected to be less than 2 acres) along the west and/or south sides of the

existing site. These losses would be minimized to the extent practicable and mitigated as necessary, likely as part of the immediately adjacent Bay City Ecological Restoration Project.

5.3.9 Greater Midland Nature Preserve

This approximately 1,460 acre project would provide direct, long-term benefits to multiple natural resources in the Midland area by preserving and restoring upland and wetland habitats and by reducing agricultural runoff in the watershed from the approximately 940 acres of agricultural land that would be restored to natural habitat. This project would also provide opportunities for the public to access natural resources using 4 to 6 miles of new nature trails. Overall, this project compensates for losses to upland and wetland habitats and to park use.

The restoration is anticipated to use established techniques with only short-term disturbances during construction of trails and parking access. The trails and parking access would slightly reduce habitat and increase human disturbance to wildlife along the paths relative to other areas of the project, but this would be more than offset by the many acres of improved habitat quality and permanent preservation of the project area.

The local economy would be expected to benefit from jobs, purchases, and associated economic outputs during construction (Thomas et al. 2016); from tourism associated with the trail system; and from increased property values on adjacent parcels associated with being near conservation areas (Reeves et al. 2018). While Dow would continue to pay property taxes while it continues to own the property throughout the restoration, conversion of 940 acres from agricultural use to natural habitat may result in a decrease in assessed value of the 1,460 total acres and therefore in local property taxes.

5.3.10 Eagle Ridge Nature Preserve

This approximately 140 acre project would provide direct, long-term benefits to multiple natural resources in the Midland area by preserving upland and wetland habitats and enhancing habitat in several areas within the property. This project would also provide opportunities for the public to access natural resources using nature trails. With this nature preserve being immediately adjacent to a residential area of Midland, members of the public without access to personal vehicles would also be able to use and enjoy the area. Overall, this project compensates for losses to upland and wetland habitats and to park use.

The restoration is anticipated to use established techniques with only short-term, minor disturbances during construction of trails. The trails would very slightly reduce habitat (an informal trail network is already present) and opening the property to the public would increase disturbance to wildlife along the paths, but this would be offset by permanent preservation of the project area along with some habitat restoration.

The local economy would be expected to benefit from jobs, purchases, and associated economic outputs during construction (Thomas et al. 2016), but other impacts are expected to be minor given that this project is on property that is currently not developed in any way and the trail system would provide an expansion to multiple recreational opportunities already available at the existing adjacent park.

5.3.11 Saginaw Chippewa Tribe Restoration

This project would provide direct, long-term benefits to multiple natural resources near Saginaw Bay and provide specific benefits to members of the Saginaw Chippewa Indian Tribe by preserving and restoring wetland habitats while incorporating plant species with cultural values and uses. This project may also reduce runoff to Saginaw Bay if the parcel that is chosen for the restoration contains row agriculture that could then be converted to natural habitat types, including wetlands. Overall, this project compensates for losses to wetland habitats and to cultural uses of injured natural resources.

The restoration is anticipated to use established techniques with only short-term, minor disturbances during construction. Any trails or boardwalks that might be incorporated into the project would slightly reduce habitat and increase disturbance to wildlife along the paths relative to areas of the project without trails, but this would be offset by permanent preservation and habitat restoration.

The local economy would be expected to benefit from jobs, purchases, and associated economic outputs during construction (Thomas et al. 2016); increasing tourism from this project's contribution to the emerging complex of nature preserve properties owned by the Tribe and the Saginaw Basin Land Conservancy as part of the Huron Coastal Wildlife Initiative; and from increased property values on adjacent parcels associated with being near conservation areas (Reeves et al. 2018). Conversion of approximately 80 acres of agricultural land to conservation land may decreased the assessed value and thus local property tax revenues.

5.3.12 Midland Fish Passage

This project would provide direct, permanent benefits to aquatic natural resources in the Tittabawassee River and to migratory fish from Saginaw Bay that migrate up through the Saginaw River, the Tittabawassee River, and its tributaries. Improved fish passage would provide more opportunities for spawning in hundreds of miles upstream in the Tittabawassee River and its tributaries and would be expected to improve populations of migratory fish species as a result. Freshwater mussels would likely benefit because of increase mobility of fish which act as hosts for an early life stage of freshwater mussels. The increased ability of migratory fish species like walleye to move upstream of the Dow Dam in the spring would make recreational fishing opportunities available to more people over a broader area than at present. Currently, anglers need access to a boat to approach the Dow Dam area where fish congregate. Overall, this project compensates for losses to aquatic habitat and recreational fishing.

While engineers and fisheries managers are gaining experience with the creation of fish passage structures like rock ramps and step pool rapids in locations like this with significant constraints on complete dam removal, achieving unimpeded passage of target species has uncertainty and techniques to quantitatively measure fish passage are still improving. This project would have a collaborative planning and design phase in order to involve multiple experts. Monitoring would be conducted after construction to determine if the design is resulting in the expected flow rates and water elevation changes. Adjustments to the structure would be made if necessary as the structure stabilizes over the first few years after construction.

Best management practices would be used to minimize disturbance during construction, including working in the river during low flow conditions, but the project would still disturb sediments and could cause increases in turbidity during construction. Turbidity is expected to be minor and transitory given that this area immediately downstream of the dam is subject to frequent scouring because of the effects of the dam. To the extent that the area downstream of the dam can be safely accessed, the project would include performing surveys for freshwater mussels in the project area and, if mussels are present, relocating them so that they are not crushed or buried by the construction.

While the Dow Dam does currently impair fish passage, it does not block it altogether and thus does not currently serve as a reliable barrier to upstream movement of aquatic nuisance species like sea lamprey. The USFWS's Sea Lamprey Control Program already monitors and manages for sea lamprey upstream of the Dow Dam. Increasing fish passage at the Dow Dam would not be expected to change the amount of fish included in fish consumption advisories. The migratory species in this river return downstream after spawning, unlike salmon species that die after spawning and become a potential source of contaminants in upstream reaches.

5.3.13 Saginaw Bay Spawning Reefs

This project would provide direct, permanent benefits to aquatic natural resources in Saginaw Bay by adding areas of rock substrate that would benefit aquatic invertebrates and fish. This increase in suitable spawning substrate for fish species that rely on rock substrates, with their interstitial spaces, is expected to increase the amount of spawning and spawning success in Saginaw Bay and ultimately diversify and increase populations of those species. Improved populations of fish would improve recreational fishing by increasing catch rates and supporting a larger sustainable harvest. Overall, this project compensates for losses to aquatic habitat and recreational fishing.

As described in section 4.3.13, recent research has indicated that sedimentation rates in Saginaw Bay are now low enough in certain locations to make this type of project feasible. A portion of the funding for this project would also be able to be used for monitoring to validate that pilot reefs are providing productive spawning habitat. The project could be phased so that monitoring could occur on expanded or newly constructed reefs, and, if problems are detected, fisheries managers and make adjustments to reef placement and design over the course of the project.

5.3.14 Flexible Funding for Project Stewardship and Future Project Proposals

As described in section 4.3.14, the benefits of the $15 million in flexible funding with a minimum of $5 million spent on new restoration projects would include ensuring the continuing success and benefits from the original projects over time as well as providing additional benefits from new projects similar to the benefits from the original projects, given that the new projects would also be highly ranked with the restoration criteria. Stewardship needs, methods, and costs may change over time, so the flexibility provided by this Alternative B would allow the Trustees to adapt and maximize benefits to injured natural resources and their services. Depending on monitoring results, potentially changing stewardship cost projections, and the availability of high

ranking projects, the Trustees could choose to solicit and fund additional new projects beyond the initial $5 million or to keep funding available to ensure project benefits on existing projects continue to be realized.

As listed in Table 13, the negative impacts of stewardship activities and monitoring are expected to be low to none. The positive and negative impacts of new projects that are selected using the restoration criteria are expected to be similar to the original projects. If a high ranking restoration project has substantially different, non-negligible impacts than specific projects already evaluated in this RP/EA, then the federal Trustee (USFWS), would conduct a project-specific NEPA analysis as part of the selection process for that project.

5.4 Evaluation of Alternative C: Projects and Fixed Funding for Stewardship and Proposals

5.4.1 Projects

The specific projects and types of projects that would be implemented in Alternative C are the same as for Alternative B, so the evaluation provided in section 5.3 applies to Alternative C as well.

5.4.2 Fixed Funding for Project Stewardship and Future Project Proposals

As described in section 4.4.14.3.14, the benefits of the $15 million in fixed funding would consist of the benefits from the approximately $5 million spent on new restoration projects, the approximately $6 million spent on stewardship to enhance the continuing success and benefits from the restoration projects over time, and the $2 million spent on monitoring the recovery of natural resources from impacts of contaminants as well as the results of the restoration efforts. Benefits from new projects would be similar to the benefits from the original projects, given that the new projects would also be highly ranked with the restoration criteria. Stewardship needs, methods, and costs may change over time, but under this Alternative C, the Trustees would not be able to make trade-offs among stewardship, new projects, monitoring, and Trustee costs.

As listed in Table 13, the negative impacts of stewardship activities and monitoring are expected to be low to none. The positive and negative impacts of new projects that are selected using the restoration criteria are expected to be similar to the original projects. If a high ranking restoration project has substantially different, non-negligible impacts, then the federal Trustee (USFWS), would conduct a project-specific NEPA analysis as part of the selection process for that project.

5.5 Compliance with NEPA and Other Potentially Applicable Laws and Policies

Upon completion of the public comment period, and if warranted, an Environmental Action Statement and a FONSI will be circulated for signature by the DOI Authorized Official upon publication of the notice of availability of the final RP/EA. These documents will remain within the administrative record for this matter.

Coordination and evaluation of required compliance with specific federal acts, executive orders, and other policies for the preferred restoration plan is achieved, in part, through the coordination of this document with appropriate agencies and the public. All restoration projects will be in compliance with all applicable federal statutes, executive orders, and policies, including, but not limited to: NEPA, 42 U.S.C. § 4321 et seq.; ESA, 16 U.S.C. § 1531, et seq.; the National Historic Preservation Act of 1966, 16 U.S.C. § 470 et seq.; the Fish and Wildlife Coordination Act, 16 U.S.C. § 661 et seq.; the Rivers and Harbors Act of 1899, 33 U.S.C. § 403 et seq.; the Federal Water Pollution Control Act, 33 U.S.C. § 1251 et seq.; Executive Order 11990, Protection of Wetlands; and Executive Order 11988, Flood Plain Management. Compliance with the laws cited above, and any necessary permitting, will be undertaken during specific restoration project planning stages, and will completed early in the project planning process.

State permits may be required to implement certain activities within the proposed restoration alternatives, depending upon the exact nature of proposed work. Proposed restoration activities in wetland and floodplain habitats would need to meet the requirements of the U.S. Army Corps of Engineers (USACE) Nationwide and/or General Permits as well as requirements under the State of Michigan's Natural Resource and Environmental Protection Act.

Federal Trustees are also required under Executive Order Number 12898, 59 C.F.R. § 7629, to identify and address any policy or planning impacts that disproportionately affect the health and environment in low income and minority populations. Since the restoration alternatives will result in changes that benefit natural resources throughout the TRSAA and Saginaw Bay watershed, including in and near Midland, Saginaw, and Bay City, the federal Trustee has concluded that there would be no adverse impacts on low-income or minority communities due to implementation of the restoration alternatives. Furthermore, several proposed projects would specifically provide benefits to low-income or minority communities by increasing access to nature preserves and parks.

After considering NEPA requirements, the Trustees believe that the proposed projects described in this Draft DARP/EA would not cause significant negative impacts to the environment, or to natural resources or the services they provide. None of the proposed projects is controversial, has highly uncertain impacts or risks, or is likely to violate any environmental protection laws. Further, the Trustees do not believe the proposed projects would adversely affect the quality of the human environment or pose any significant adverse environmental impacts. Instead, habitat restoration projects would benefit species and some may also improve water quality and flood risk by restoring natural habitat functions. Likewise, the proposed restoration actions would provide positive benefits for human recreational use and non-recreational use by tribal members and the general public. Thus, unless new information is made available during the public review process, the Trustees expect to be able to make a Finding of No Significant Impact for the preferred alternative consisting of suite of proposed projects and future restoration categories. For specific projects proposed in the future, the Trustees will re-evaluate the NEPA factors and document whether any impacts require additional consideration beyond what is covered in this RP/EA.

CHAPTER 6: PROPOSED PREFERRED ALTERNATIVE

The Trustees evaluated three restoration alternatives. Of these, Alternative B best addresses natural resource injuries and service reductions resulting from the release of hazardous substances within the assessment area and includes the majority of the project categories originally suggested by stakeholders. Based on the Trustees' evaluation of the environmental consequences of Alternatives A, B, and C, the NRDAR factors described in 43 C.F.R. § 11.82(d), and the potential for greater restoration project opportunities, the Trustees propose Alternative B as their Preferred Alternative.

Alternative A provides no restoration options, and is therefore insufficient to compensate for natural resource injuries.

Alternative C provides all of the restoration projects contained in Alternative B, but provides the Trustees with less flexibility to respond to new restoration opportunities that might arise while still ensuring that the continuing success and stewardship of the original restoration projects. Stewardship costs may change over time.

The Trustees believe that the Preferred Alternative, Alternative B, represents cost-effective and beneficial means by which to restore or replace the injured natural resources and the services they provided. If this Alternative is selected in the Final RP/EA, assurance of compliance with the relevant laws, regulations, and policies as well as completion of any necessary permitting would be undertaken during the planning stages of specific restoration projects.

Future proposed projects would be evaluated against the same restoration priorities and factors described above, and, if needed, a further review of environmental consequences would be conducted. Any selected projects that are expected to have non-negligible impacts would be subject to a project-specific NEPA analysis prior to implementation. In addition, Section 7 consultation (under the ESA) would be completed for restoration projects that may affect threatened or endangered species or their designated critical habitat, and Section 106 of the National Historic Preservation Act would be followed for each restoration project that would be implemented.

CHAPTER 7: PREPARERS, AGENCIES, AND PERSONS CONSULTED

7.1 Preparers

Lisa L. Williams, U.S. Fish and Wildlife Service, East Lansing, MI
Kaylene Ritter, Abt Consulting, Boulder, CO, under contract to USFWS

7.2 Agencies and Persons Consulted

Federal Agencies

U.S. Fish and Wildlife Service, East Lansing, MI
Bureau of Indian Affairs, Washington, D.C.
U.S. Environmental Protection Agency, Chicago, IL

State Agencies

Michigan Department of Environment, Great Lakes, and Energy
Michigan Department of Natural Resources
Michigan Department of Attorney General

Tribes

Saginaw Chippewa Indian Tribe of Michigan

Local Agencies, Non-Governmental Organizations, and Others

See Appendices C and D
The Dow Chemical Company

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Appendices for Draft Restoration Plan / Environmental Assessment For the Tittabawassee River System Natural Resource Damage Assessment

Prepared by:
U.S. Fish and Wildlife Service
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November 7, 2019

Appendices

Appendix A. Trustee Outreach and Stakeholder Involvement

Appendix B. Summary of Fish and Wild Game Consumption Advisories in the Tittabawassee River, Saginaw River, and Saginaw Bay Area

Appendix C. Summary of Soil and Sediment Advisories in the Tittabawassee River, Saginaw River, and Saginaw Bay Area

Appendix D. Projects Proposed to the Trustees but Not Carried Forward in Alternatives

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Appendix A

Trustee Outreach and Stakeholder Involvement

Contents

This appendix provides a summary of outreach, public meetings, and surveys of the public in support list of projects proposed to the Trustees since 2005. This appendix is organized in three tables:

Table A.1. Public meetings and presentations on this NRDA

Meeting or Presentation Description	Date	Location	Participants
Site-wide public meeting	11/9/2005	Saginaw	Public and NGOs
Environmental Policy class	1/31/2006	East Lansing	Michigan State students and faculty
Case-specific public meeting on restoration criteria	11/28/2007	Saginaw	Public and NGOs
Toxicology class	1/15/2008	Grand Rapids	Calvin College students and faculty
Environmental Policy class	2/6/2008	East Lansing	Michigan State students and faculty
Case-specific public meeting on Assessment Plan	4/17/2008	Midland	Public and NGOs
Case-specific Restoration Workshop	1/27/2009	Lansing	Multiple agencies and Ducks Unlimited
Environmental Policy class	4/14/2009	East Lansing	Michigan State students and faculty
Citizen Advisory Council (CAG)	5/17/2010	Freeland	Tittabawassee River Citizen's Advisory Council, local landowners and interested members of the public
Saginaw Bay Watershed Conference	3/16/2012	Saginaw	Public and NGOs
Saginaw Bay Coordinating Council	2/22/2013	Bay City	Local governments, agencies, elected representatives, NGOs
Contaminated Sediment Technical Advisory Group Meeting with stakeholders	9/23/2015	Saginaw	Agencies and NGOs
Citizen Advisory Council (CAG)	5/16/2016	Freeland	Tittabawassee River Citizen's Advisory Council, local landowners and interested members of the public

Table A.2. Additional stakeholder comments

Topic	Time Period	Stakeholders
Public comments on Assessment Plan	Summer of 2008	Saginaw Basin Land Conservancy, Saginaw County Chamber on behalf of at least 9 local units of government, Thomas Township, City of Bay City
Trustees specifically seeking restoration projects	Summer of 2008	Ducks Unlimited, Saginaw Bay Land Conservancy, Saginaw Bay WIN, The Nature Conservancy, Bay Sail, City of Chesaning, City of Frankenmuth, City of Bay City, City of Saginaw, Saginaw Township, Thomas Township, Tittabawassee Township, Zilwaukee Township, James Township, Koch Township, Bridgeport Charter Township, Saginaw County Chamber
Area restoration issues, low water concerns, NRDA generally	July of 2013 and 2015	Laura Ogar, Bay County
NRDA and restoration	November 2015	Terry Miller, Lone Tree Council
Case update following CAG meeting	May 2016	Laura Ogar and Terry Miller
NRDAs and restoration	March 2017	Bay City Times interview and article by Andrew Dodson
NRDAs and restoration	April-May 2017	Laura Ogar and Terry Miller
Specific restoration project communications	2008 - 2018	MDNR, USFWS, and MDEQ fisheries, Saginaw Bay Coastal Initiative, Saginaw Bay WIN, Thomas Township, The Nature Conservancy, Chippewa Nature Center, Saginaw County Parks and Recreation, USFWS Shiawassee NWR, BaySail, Saginaw River Marine Historical Society, Ducks Unlimited, Saginaw Basin Land Conservancy, Partnership for the Saginaw Bay Watershed, Michigan Nature Association, Bay City, Bay County, Saginaw Township, Conservation Fund, Maritime Heritage Center, see also Appendix D

Table A.3. Primary studies of public preferences

Study	Time Period	Participants
Recreational fishing angler focus groups	January 2008 – June 2009	Randomly selected licensed anglers from Midland, Saginaw, and Bay counties
Hunting focus groups	January 2008 – June 2009	Randomly selected licensed hunters from Midland, Saginaw, and Bay counties
Park user focus groups	January 2008 – June 2009	Randomly selected licensed residents from Midland, Saginaw, and Bay counties
Tribal member focus groups	July – August 2009	Participants invited by Saginaw Chippewa Indian Tribe
Outdoor parks survey – Pre-test	May – June 2012	Visitors to 11 parks in Midland, Saginaw, and Bay counties
Outdoor parks survey – Full survey	June – September 2012	Visitors to 11 parks in Midland, Saginaw, and Bay counties
Recreational fishing angler survey – Pre-test	February 2011 – May 2012	Stratified random sample of licensed anglers for 40 Michigan counties centered on Midland, Saginaw and Bay counties
Recreational fishing angler survey – Pilot	March 2012	Stratified random sample of licensed anglers for 40 Michigan counties centered on Midland, Saginaw and Bay counties
Recreational fishing angler survey – Full	June 2012 – April 2013	Stratified random sample of licensed anglers for 40 Michigan counties centered on Midland, Saginaw and Bay counties
Park managers phone survey	November – December 2016	Park managers in Midland, Saginaw, and Bay counties

Appendix B

Summary of Fish and Wild Game Consumption Advisories in the Tittabawassee River, Saginaw River, and Saginaw Bay Area

Contents

Legend for Fish Consumption Advisory Tables (Tables B-1 through B-5)

Meal or serving category codes:

1 = No consumption for general population. (Up to 2013, the general population was defined as males over age 15 and women who over childbearing age. In 2014, the general population included everyone who eats fish)

2 = No consumption for subpopulations. (Up to 2013, the subpopulation is defined as those at higher risk, e.g., pregnant or nursing women, women who plan on having kids, and small children. In 2014–2015, subpopulations were defined as persons with health problems like cancer or diabetes; women who are planning on having children in the next several years, who are currently pregnant, or breastfeeding; and persons under the age of 15.)

3 = Restricted consumption for general population, no more than 1 meal/week.

4 = Restricted consumption for general population, no more than 1 meal/month.

5 = Restricted consumption for general population, no amount specified.

6 = Restricted consumption for subpopulations, no more than 1 meal/week.

7 = Restricted consumption for subpopulations, no more than 1 meal/month.

8 = Restricted consumption for subpopulations, no more than 6 meals/year.

9 = Restricted consumption for subpopulations, no amount specified.

10 = Restricted consumption for general population, no more than 2 meals/year.

11 = Restricted consumption (everyone who eats fish), no more than 6 meals/year.

12 = Restricted consumption (everyone who eats fish), no more than 2 meals/month.

13 = Restricted consumption (everyone who eats fish), no more than 1 meal/month.

14 = Restricted consumption (everyone who eats fish), no more than 4 meals/month.

15 = Restricted consumption (everyone who eats fish), no more than 8 meals/month.

Note: In 2014, the MDHHS released fish consumption advisories in regional Eat Safe Fish Guides. All of the available and applicable fish tissue chemical data, for fish collected throughout the state, was reevaluated using updated fish consumption screening values and comparison methods. Fish consumption advisories prior to 2014 are not directly comparable to advisories issued in 2014 or beyond.

Symbol key:

⊕ For this species, location, and year, an advisory was issued naming a list of pollutants that may have caused the advisory: mercury, polychlorinated biphenyls (PCB), polybrominated biphenyls (PBB), dichlorodiphenyltrichloroethane (DDT), dieldrin, chlordane, toxaphene, and dioxin.

⊗ Advisory was issued for all populations, which includes general and subpopulations.

∅ For this species, location, and year, an advisory was issued; however, the advisory did not identify a pollutant.

Table B-1. Summary of fish consumption advisories (1977-1983)[1]

Fish species	Length	1977		1978		1979		1980		1981		1982		1983	
Tittabawassee River															
All fish	Unspecified									1, 2 ⊗	PBB, TCDD	1, 2 ⊗	∅	1, 2 ⊗	∅
Saginaw River															
All fish	Unspecified					1, 2 ⊗	PBB, TCDD	1, 2 ⊗	PBB, TCDD	1, 2 ⊗	PBB, TCDD	1, 2 ⊗	∅	1, 2 ⊗	∅
Saginaw Bay[2]															
Carp	> 17"	2, 3	PCB	2, 3	PCB										
	Unspecified					2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	∅	2, 3	∅
Catfish	> 17"	2, 3	PCB	2, 3	PCB										
	Unspecified					2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	∅	2, 3	∅
Salmon	Unspecified	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	∅	2, 3	∅
Trout	Unspecified											2, 3	∅	2, 3	∅
Muskellunge	Unspecified											2, 3	∅	2, 3	∅
Pine River															
Downstream from St. Louis															
All fish	Unspecified					1, 2 ⊗	PBB	1, 2 ⊗	PBB	1, 2 ⊗	PBB	1, 2 ⊗	∅	1, 2 ⊗	∅

1. TCDD is as 2,3,7,8- Tetrachlorodibenzo-*p*-dioxin
2. Some of the advisories were issued specifically for Saginaw Bay. Other advisories were issued for Lake Huron, in whole or in part, which includes Saginaw Bay

Table B-2. Summary table of fish consumption advisories (1984–1990)

Fish species	Length	1984		1985		1986		1987		1988		1989		1990	
Tittabawassee River															
Carp	Unspecified					1, 2 ⊗	⊕	1, 2 ⊗	⊕	1, 2 ⊗	∅	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin
Catfish	Unspecified					1, 2 ⊗	⊕	1, 2 ⊗	⊕	1, 2 ⊗	∅	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin
All other fish	Unspecified											7, 5	PCB, dioxin	7, 5	PCB, dioxin
All fish	Unspecified	1, 2 ⊗	⊕	1, 2 ⊗	⊕										
Saginaw River															
Carp	Unspecified					2, 3	⊕	1, 2 ⊗	⊕	1, 2 ⊗	∅	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin
Catfish	Unspecified							1, 2 ⊗	⊕	1, 2 ⊗	∅	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin
All other fish	Unspecified											7, 5	PCB, dioxin	7, 5	PCB, dioxin
All fish	Unspecified	1, 2 ⊗	⊕	1, 2 ⊗	⊕										
Saginaw Bay[3]															
Carp	Unspecified	2, 3	⊕	2, 3	⊕	2, 3	⊕	1, 2 ⊗	⊕	1, 2 ⊗	∅	1, 2 ⊗	PCB	1, 2 ⊗	PCB
Catfish	Unspecified	2, 3	⊕	2, 3	⊕	2, 3	⊕	1, 2 ⊗	⊕	1, 2 ⊗	∅	1, 2 ⊗	PCB	1, 2 ⊗	PCB
Salmon	Unspecified	2, 3	⊕	2, 3	⊕	2, 3	⊕								
Trout	Unspecified	2, 3	⊕	2, 3	⊕	2, 3	⊕								
Muskellunge	Unspecified	2, 3	⊕	2, 3	⊕	2, 3	⊕								
Brown trout	Unspecified							2, 3	⊕	2, 3	∅	2, 3	PCB	2, 3	PCB
Lake trout	Unspecified			2, 3	⊕	2, 3	⊕	2, 3	⊕	2, 3	∅	2, 3	PCB	2, 3	PCB
Rainbow trout	Unspecified							2, 3	⊕	2, 3	∅	2, 3	PCB	2, 3	PCB
Pine River															
Downstream from St. Louis, Gratiot and Midland counties															
All fish	Unspecified							1, 2 ⊗	⊕	1, 2 ⊗	∅	1, 2 ⊗	PBB	1, 2 ⊗	PBB
Downstream from St. Louis															
All fish	Unspecified			1, 2 ⊗	⊕	1, 2 ⊗	⊕								
St. Louis															
All fish	Unspecified	1, 2 ⊗	⊕												

3. Some of the advisories were issued specifically for Saginaw Bay. Other advisories were issued for Lake Huron, in whole or in part, which includes Saginaw Bay.

Table B-3. Summary table of fish consumption advisories (1991–1997)

Fish species	Length	1991		1992		1993		1994		1995		1996		1997	
Tittabawassee River															
White bass	6–14”													3	PCB
	6–22”													2	PCB
	14–22”													1	PCB
Carp	> 6”													1, 2	PCB, dioxin
	Unspecified	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin		
Catfish	> 6”													1, 2	PCB, dioxin
	Unspecified	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin				
Channel catfish	Unspecified											1, 2 ⊗	PCB, dioxin		
All other fish	Unspecified	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin		
Saginaw River															
White bass	6–22”													2, 3	PCB
Carp	> 6”													1, 2	PCB, dioxin
	Unspecified	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin		
Catfish	> 6”													1, 2	PCB, dioxin
	Unspecified	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin								
Channel catfish	Unspecified							1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB, dioxin		
All other fish	Unspecified	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin		
Saginaw Bay[4]															
Carp	> 6”													1, 2	PCB
	Unspecified	1, 2 ⊗	PCB	1, 2 ⊗	PCB	1, 2 ⊗	PCB	1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB	1, 2 ⊗	PCB		

4. Some of the advisories were issued specifically for Saginaw Bay. Other advisories were issued for Lake Huron, in whole or in part, which includes Saginaw Bay.

Fish species	Length	1991		1992		1993		1994		1995		1996		1997	
Catfish	> 6”													1, 2	PCB
	Unspecified	1, 2 ⊗	PCB	1, 2 ⊗	PCB	1, 2 ⊗	PCB								
Channel catfish	Unspecified							1, 2 ⊗	PCB, dioxin	1, 2 ⊗	PCB	1, 2 ⊗	PCB		
White bass	6–22”													2, 3	PCB
	Unspecified									2, 3	PCB	2, 3	PCB		
Brown trout	> 18”													2, 3	PCB
	> 21”									2, 3	PCB	2, 3	PCB		
	Unspecified	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB						
Lake trout	> 10”													2	PCB, chlordane, dioxin
	10–22”													3	PCB, chlordane, dioxin
	< 22”											2, 3	PCB, chlordane, dioxin		
	> 22”											1, 2 ⊗	Chlordane, dioxin	1	PCB, chlordane, dioxin
	< 26”							2, 3	PCB, dioxin	2, 3	PCB, dioxin				
	> 26”							1, 2 ⊗	PCB, chlordane, dioxin	1, 2 ⊗	PCB, chlordane, dioxin				
	Unspecified	2, 3	PCB	2, 3	PCB	2, 3	PCB, chlordane								
Rainbow trout	Unspecified	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB						
Pine River															
St. Louis Impoundment and downstream															
All fish	> 6”													1, 2	PBB, DDT
Downstream from St. Louis, Gratiot and Midland counties															
All fish	Unspecified	1, 2 ⊗	PBB	1, 2 ⊗	PBB	1, 2 ⊗	PBB, DDT	1, 2 ⊗	PBB, DDT	1, 2 ⊗	PBB, DDT	1, 2 ⊗	PBB, DDT		

Table B-4. Summary table of fish consumption advisories (1998–2007)

Fish species	Length	1998		1999		2000		2001		2002		2003		2004–2006		2007	
Tittabawassee River																	
White bass	6–10”	7	PCB														
	6–14”	3	PCB														
	6–22”			1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
	10–14”	8	PCB														
	14–22”	1, 2	PCB														
Carp	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
Catfish	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
White sucker	> 6”	7	PCB	7	PCB	7	PCB										
Walleye	6–22”															7	PCB
	> 14”	7	PCB	7	PCB	7	PCB										
	> 22”															3, 8	PCB
Smallmouth bass	14–30”							2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin
All other fish	> 6”							3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin
	Unspecified	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin										
Saginaw River																	
White bass	6–22”	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB
Carp	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
Catfish	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
All other fish	> 6”							3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin
	Unspecified	7, 5	PCB, dioxin	7, 5	PCB, dioxin	7, 5	PCB, dioxin										

Fish species	Length	1998		1999		2000		2001		2002		2003		2004–2006		2007	
Carp	> 6”	1, 2	PCB	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
Catfish	> 6”	1, 2	PCB	1, 2	PCB												
	6–14”					7	PCB										
	14–22”					8	PCB										
	18–22”					3	PCB										
	> 22”					1, 2	PCB										
Channel catfish	> 12”							2	PCB, dioxin	2	PCB, dioxin	2	PCB, dioxin	2	PCB, dioxin	2	PCB, dioxin
	12–18”							3	PCB, dioxin	3	PCB, dioxin	3	PCB, dioxin	3	PCB, dioxin	3	PCB, dioxin
	> 18”							1	PCB, dioxin	1	PCB, dioxin	1	PCB, dioxin	1	PCB, dioxin	1	PCB, dioxin
White bass	6–22”	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB	3, 8	PCB
	6–12”															7	PCB, dioxin
	12–22”															2, 3	PCB, dioxin
White perch	6–14”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB
Yellow perch	6–22”	6	PCB	6	PCB	6	PCB										
	6–18”							6	PCB	6	PCB	6	PCB	6	PCB	6	PCB
Northern pike	22–26”	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB
	> 26”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB
White sucker	6–14”	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB		
	> 14”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB		
Suckers	6–14”															6	PCB
	> 14”															7	PCB
Brown trout	10–18”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB
	> 18”	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB

Fish species	Length	1998		1999		2000		2001		2002		2003		2004–2006		2007	
Lake trout	> 10”	2	PCB, chlordane, dioxin	2	PCB, chlordane, dioxin	2	PCB, chlordane, dioxin	2	PCB, chlordane, dioxin	2	PCB, chlordane, dioxin	2	PCB, chlordane, dioxin	2	PCB, chlordane, dioxin	2	PCB, dioxin
	10–22”	3	PCB, chlordane, dioxin	3	PCB, chlordane, dioxin	3	PCB, chlordane, dioxin	3	PCB, chlordane, dioxin	3	PCB, chlordane, dioxin	3	PCB, chlordane, dioxin	3	PCB, chlordane, dioxin		
	10–26”															3	PCB, dioxin
	> 22”	1	PCB, chlordane, dioxin	1	PCB, chlordane, dioxin	1	PCB, chlordane, dioxin	1	PCB, chlordane, dioxin	1	PCB, chlordane, dioxin	1	PCB, chlordane, dioxin	1	PCB, chlordane, dioxin		
	> 26”															1	PCB, dioxin
Rainbow trout	> 10”	7	PCB	7	PCB	7	PCB	7	PCB, dioxin	7	PCB, dioxin	7	PCB, dioxin	7	PCB	7	PCB
Walleye	14–18”	6	PCB	6	PCB	6	PCB	6	PCB, mercury	6	PCB, mercury	6	PCB, mercury	6	PCB, mercury	6	PCB, mercury
	> 18”	7	PCB	7	PCB			7	PCB, mercury	7	PCB, mercury	7	PCB, mercury	7	PCB, mercury	7	PCB, mercury
	18–22”					7	PCB										
	> 22”					1, 2	PCB	3	PCB, mercury	3	PCB, mercury	3	PCB, mercury	3	PCB, mercury	3	PCB, mercury
Whitefish	6–18”			6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin
	> 18”							2	PCB, dioxin	2	PCB, dioxin	2	PCB, dioxin	2	PCB, dioxin	2	PCB, dioxin
	18–22”			7	PCB, dioxin	7	PCB, dioxin	3	PCB, dioxin	3	PCB, dioxin	3	PCB, dioxin	3	PCB, dioxin	3	PCB, dioxin
	> 22”			1, 2	PCB, dioxin	1, 2	PCB, dioxin	1	PCB, dioxin	1	PCB, dioxin	1	PCB, dioxin	1	PCB, dioxin	1	PCB, dioxin
Lake whitefish	6–22”	6	PCB														
	> 22”	7	PCB														
Chinook salmon	10–30”	7	PCB														
	> 10”			7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB
	> 30”	8	PCB														

Fish species	Length	1998		1999		2000		2001		2002		2003		2004–2006		2007	
Coho salmon	> 10”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB
Burbot	> 6”	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB
Pine River																	
Alma Impoundment																	
Carp	6–26”	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB
	> 26”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB
Largemouth bass	14–30”	3, 7	Mercury														
Downstream of Alma Dam																	
All fish	> 6”							1, 2	PBB, DDT	1, 2	PBB, DDT	1, 2	PBB, DDT	1, 2	PBB, DDT	1, 2	PBB, DDT
St. Louis Impoundment and downstream																	
All fish	> 6”	1, 2	PBB, DDT	1, 2	PBB, DDT	1, 2	PBB, DDT										
Sanford Lake																	
Channel catfish	12–26”							6	Mercury, PCB	6	Mercury, PCB	6	Mercury, PCB	6	Mercury, PCB	6	Mercury, PCB
	> 26”							3, 7	Mercury, PCB	3, 7	Mercury, PCB	3, 7	Mercury, PCB	3, 7	Mercury, PCB	3, 7	Mercury, PCB

Table B-5. Summary table of fish consumption advisories (2008–2016)

Fish species	Length	2008		2009		2010		2011		2012		2013[5]		2014[6]		2015[6]		2016[6]	
Tittabawassee River																			
White bass	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
Carp	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
Catfish	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	Dioxin	1, 2	Dioxin	1, 2	Dioxin
Largemouth bass	< 18”													11	PCB, dioxin	11	PCB, dioxin	11	PCB, dioxin
	> 18”													2, 10	PCB, dioxin	2, 10	PCB, dioxin	2, 10	PCB, dioxin
Walleye	14–18”	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin						
	> 18”	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin						
	Any size													11	PCB, dioxin	11	dioxin	11	dioxin
Smallmouth bass	> 14”	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin						
	< 18”													11	PCB, dioxin	11	PCB, dioxin	11	PCB, dioxin

5. 2013 advisories were not formally issued, and 2012 advisories remained in effect until 2014 (Kory Groetsch, Michigan Department of Community Health, personal communication, January 9, 2015).

6. According to the MDHHS Eat Safe Fish Guide (MDCH, 2014–2015; MDHHS, 2016), the number of servings per month can be doubled if the following criteria are met: (1) the serving suggestion is not listed as “Limited,” (2) the fish is cleaned properly (removing fat that could potentially store chemicals), (3) the fish is cooked via grilling or broiling as opposed to frying, and (4) mercury is not listed as a chemical of concern.

Fish species	Length	2008		2009		2010		2011		2012		2013[5]		2014[6]		2015[6]		2016[6]	
	> 18”													2, 10	PCB, dioxin	2, 10	PCB, dioxin	2, 10	PCB, dioxin
Sucker	Any size													11	PCB	11	PCB	11	PCB
Yellow perch	Any size													12	Dioxin	12	Dioxin	12	Dioxin
All other fish	> 6”	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin						
	Any size													11	PCB, dioxin	11	PCB, dioxin	11	PCB, dioxin
Saginaw River																			
Bluegill	Any size																	14	PFOS
White bass	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
Carp	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
Catfish	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	Dioxin	1, 2	Dioxin	1, 2	Dioxin
Walleye	14–18”	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin						
	> 18”	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin						
	Any size													11	dioxin	11	PCB, dioxin	11	Dioxin
Largemouth bass	< 18”																	12	PCB, mercury, PFOS
	> 18”																	13	Mercury

Fish species	Length	2008		2009		2010		2011		2012		2013[5]		2014[6]		2015[6]		2016[6]	
Smallmouth bass	< 18”																	12	PCB, mercury, PFOS
	> 18”																	13	Mercury
Smallmouth bass (cont.)	> 14”	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin						
Sunfish	Any size																	14	PFOS
Yellow perch	Any size													12	Dioxin	12	Dioxin	12	Dioxin
All other fish	> 6”	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin						
	Any size													11	PCB, dioxin	11	PCB, dioxin	11	PCB, dioxin
Saginaw Bay																			
Carp	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
Catfish	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	Dioxin	1, 2	Dioxin	2, 10	Dioxin
White bass	> 6”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	Any size													1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin
White perch	Any size													11	PCB	11	PCB	11	PCB
Yellow perch	6–18”	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB						
	Any size													12	Dioxin	12	Dioxin	12	Dioxin
Freshwater drum	> 6”			6	PCB	6	PCB	6	PCB	6	PCB	6	PCB						
	Any size													13	Mercury	13	Mercury	13	Mercury
Sucker	Any size													12	PCB	12	PCB	12	PCB
Brown trout	10–18”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB						
	> 18”	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB	2, 3	PCB						
	Any size													11	PCB	11	PCB	11	PCB

Fish species	Length	2008		2009		2010		2011		2012		2013[5]		2014[6]		2015[6]		2016[6]	
Lake trout	10–26”	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin												
	14–26”							2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin						
	> 26”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
	< 20													13	PCB, dioxin	13	PCB, dioxin	13	PCB, dioxin
	20–24”													11	PCB	11	PCB	11	PCB
	> 24”													2, 10	PCB	2, 10	PCB	2, 10	PCB
Rainbow trout	> 10”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB						
	Any size													11	PCB	11	PCB	11	PCB
Northern pike	Any size													13	PCB	13	PCB	13	PCB
Walleye	14–18”	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin	7	PCB, mercury, dioxin						
	> 18”	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin	2, 3	PCB, mercury, dioxin						
	Any size													11	PCB, dioxin	11	dioxin	11	, dioxin
Whitefish	6–18”	6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin	6	PCB, dioxin						
	18–22”	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin	2, 3	PCB, dioxin						
	> 22”	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin	1, 2	PCB, dioxin						
Lake whitefish	Any size													11	Dioxin	11	Dioxin	11	Dioxin
Chinook salmon	> 10”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB						
	Any size													11	PCB	11	PCB	11	PCB
Coho salmon	> 10”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB						
	Any size													11	PCB	11	PCB	11	PCB
Steelhead	Any size																	11	PCB

Fish species	Length	2008		2009		2010		2011		2012		2013[5]		2014[6]		2015[6]		2016[6]	
Burbot	> 6”	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB						
Smelt	Any size													14	PCB	14	PCB	14	PCB
All other fish	> 6”	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin	3, 7	PCB, dioxin						
	Any size													11	PCB, dioxin	11	PCB, dioxin	11	PCB, dioxin
Pine River																			
Alma Impoundment																			
Carp	6–26”	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB	6	PCB						
	> 26”	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB	7	PCB						
Downstream of Alma dam																			
All fish	> 6”	1, 2	PBB, DDT	1, 2	PBB, DDT	1, 2	PBB, DDT	1, 2	PBB, DDT	1, 2	PBB, DDT	1, 2	PBB, DDT						
	Any size													1, 2	DDT	1, 2	DDT	1,2	DDT
Sanford Lake																			
Channel catfish	12–26”	6	Mercury, PCB	6	Mercury, PCB	6	Mercury, PCB	6	Mercury, PCB	6	Mercury, PCB	6	Mercury, PCB						
	> 26”	3, 7	Mercury, PCB	3, 7	Mercury, PCB	3, 7	Mercury, PCB	3, 7	Mercury, PCB	3, 7	Mercury, PCB	3, 7	Mercury, PCB						
Catfish	Any size													12	Mercury	12	Mercury	12	Mercury
Black and white crappie	< 9”													15	Mercury	15	Mercury	15	Mercury
	> 9”													14	Mercury	14	Mercury	14	Mercury
Northern pike	< 30”													12	Mercury	12	Mercury	12	Mercury
	> 30”													13	Mercury	13	Mercury	13	Mercury
Rock bass	Any size													14	Mercury	14	Mercury	14	Mercury
Walleye	< 20”													12	Mercury	12	Mercury	12	Mercury
	> 20”													13	Mercury	13	Mercury	13	Mercury

Table B-6. Summary of wild game advisories for the Tittabawassee and Saginaw River floodplains (2004 to August 2015)

Animal/animal part	Advisory	Additional advice
Deer liver	No consumption(Tittabawassee River floodplain area only)	No one should eat the liver of while tail deer taken from the flood plain of the Tittabawassee River downstream of Midland.
Deer muscle meat	Limit Consumption Women of childbearing age and children under the age of 15 should eat only one meal of deer muscle meat per week	Trimming any visible fat will lower the level of dioxins in the cooked meat
Turkey	No consumption (Tittabawassee River floodplain south of Midland) No consumption of the meat, skin, and internal organs, such as the liver (Tittabawassee River and Saginaw River floodplains)	Remove skin and internal organs, such as the liver for turkey harvested in the Tittabawassee River and Saginaw River floodplains No one should eat turkey meat taken from the flood plain of the Tittabawassee River downstream of Midland.
Squirrel	Limit consumption (2004 advisory included the Tittabawassee River Area; 2008 revised to meat taken from near Imerman Park) Women of childbearing age and children under the age of 15 should eat only one meal of squirrel meat per week	
Canada goose or wood duck skin and organs	No consumption	Remove the skin of waterfowl before cooking and discard the liver and other internal organs
Cottontail Rabbit	No advisory	
Organ meat from “other game species”	No consumption	Given the levels of DLCs found in deer liver, no one should eat organ meats from other game species taken from this area.
Game Meat	Choose lean wild game meats.	Hunters and their families should choose lean wild game meats. DLCs accumulate in fatty tissues and trimming excess fat before cooking will lessen exposure. Additional studies of other wild game species in the Tittabawassee River flood plain (e.g., goose, duck) and other potentially affected areas downstream of the Tittabawassee should be considered.

Table B-7. Summary of wild game advisories for the Tittabawassee and Saginaw River floodplains (after August 2015)

Animal/animal part	Advisory	Additional advice
All animal organs (such as the liver, heart, brains, gizzards)	No consumption	Do not eat organs, including the liver, heart, brains, or gizzards
All animals	Trim fat; cook meat on a rack or grill	Trim away any fat you can see, and cook the meat on a rack or grill so any extra fat can drip away
Duck (with skin)	6 servings per year	
Duck (without skin)	2 servings per month	
Deer	8 servings per month	
Goose (with or without skin)	4 servings per month	
Rabbit	4 servings per month	
Squirrel	8 servings per month	
Turkey (with skin)	6 servings per year	
Turkey (without skin)	1 serving per month	

Reference list for advisories published or identified since the 2008 Assessment Plan

MDCH.2004. Petitioned Health Consultation: Dioxins in Wild Game Taken from the Tittabawassee River Floodplain South of Midland, Midland and Saginaw Counties, Michigan EPA ID# MID980994354. Prepared by: Michigan Department of Community Health under a cooperative agreement with Agency for Toxic Substances and Disease Registry.

MDCH. 2005. Petitioned Health Consultation: Dioxins in Wild Game Taken from the Tittabawassee Floodplain South of Midland, Midland and Saginaw Counties, Michgan. EPA ID# MID980994354. Prepared by Michigan Department of Community Health under a cooperative agreement with Agency for Toxic Substances and Disease Registry.

MDCH. 2008. 2008 Michigan Family Fish Consumption Guide: Important Facts to Know If You Eat Michigan Fish. Michigan Department of Community Health, Division of Environmental Health.

MDCH. 2008. State of Michigan Extends Advisories for Consuming Wild Game from the Tittabawassee And Saginaw River Floodplains. Michigan Department of Community Health

Dykema, L.D. 2008. Memorandum to David R. Wade, Manager Michigan Division of Environmental Health re: Wild Game Advisories for the Tittabawassee and Saginaw River Flood Plains. Michigan Department of Community Health, Lansing Michigan 48913.

MDCH. 2009. 2009 Michigan Family Fish Consumption Guide: Important Facts to Know If You Eat Michigan fish. Michigan Department of Community Health, Division of Environmental Health.

MDCH. 2010. 2010 Michigan Fish Advisory: A Family Guide to Eating Michigan Fish. Michigan Department of Community Health, Division of Environmental Health.

MDCH. 2011–2012. 2011–2012 Michigan Fish Advisory: A Family Guide to Eating Michigan Fish. Michigan Department of Community Health, Division of Environmental Health.

MDCH. 2014–2015. Michigan Department of Community Health's Eat Safe Fish Guide, Southeast Michigan 2014–2015. Michigan Department of Community Health.

MDHHS. 2015. Eat Safe Wild Game from the Saginaw Bay Area. Michigan Department of Health and Human Services. Available: http://www.michigan.gov/documents/mdch/Eat_Safe_Wild_Game_277942_7.pdf. Accessed 1/30/2018.

MDHHS. 2016. Michigan Department of Health and Human Services' Eat Safe Fish Guide, Southeast Michigan 2016. Michigan Department of Health and Human Services. Available: http://www.michigan.gov/documents/mdch/MDCH_EAT_SAFE_FISH_GUIDE_-_SOUTHEAST_MI_WEB_455358_7.pdf.

Appendix C

Summary of Soil and Sediment Advisories in the Tittabawassee River, Saginaw River, and Saginaw Bay Area

Contents

Table C-1. Summary of the 2003 soil movement advisory for private, public, and commercial projects related to the Tittabawassee River furan and dioxin floodplain soil and sediment contamination, as it pertains to human health exposure risk and personal precautions to take

Actions	Types of activities	Increases to human health exposure risk (workers and residential)	Personal precautions to take
Minor household soil movement	Flower gardening, crop gardening, tree planting, lawn work, post-hole digging, mowing, electrical and plumbing conduit trenching, etc.	Yes (residential only). Soil dermal contact, soil inhalation, and soil ingestion.	Minimize soil exposure. Avoid allowing children to play in soils. Wash hands and any other exposed body surfaces after any soil contact. Do not eat unwashed foods from your garden. Do not engage in other activities that may introduce soil into the mouth. Keep soil moist to control dust. Remove footwear before entering the house. Store all used gardening clothing outdoors.
Major household soil movement activities	Construction of ponds or berms, construction of footings for homes or outbuildings, installation of septic tanks or tile fields.	Yes (residential only). Dermal contact, inhalation, and ingestion of soil during construction/soil movement activities.	Avoid contact with soil during construction activity, insist that piles of disturbed/excavated soil be fully covered with plastic sheeting until they are properly disposed of, insist that only clean fill from outside of the floodplain area be used to bring any areas back up to grade.
Commercial soil movement activities	Sand mining, road construction/repair, bridge construction/repair, sewer/water line construction/repair, utility (electric, hard line phone) construction/repair, and underground storage tank repair/removal.	Yes. Worker safety issues related to dermal contact, soil inhalation, and soil ingestion during construction and soil movement activities. Yes. Residential exposures related to dermal contact, soil inhalation, and soil ingestion due to fugitive dust created during construction and soil movement activities.	Provide appropriate safety equipment and clothing to workers that are in contact with disturbed soil areas as guided and prescribed by the Michigan Occupational Safety and Health Act. Depending on the activity, safety equipment could include dust masks or other appropriate inhalation protection devices, gloves, and/or appropriate clothing to avoid dermal contact. Analytical testing may be needed to evaluate the soils at depth. Proper soil erosion techniques must be implemented including covering of disturbed soil piles with plastic sheeting until they are properly disposed of. Wash vehicles before transport and cover soils in the truck to prevent blowing.

Table C-1. Summary of the 2003 soil movement advisory for private, public, and commercial projects related to the Tittabawassee River furan and dioxin floodplain soil and sediment contamination, as it pertains to human health exposure risk and personal precautions to take

Actions	Types of activities	Increases to human health exposure risk (workers and residential)	Personal precautions to take
Sediment dredging activities	Boat launch maintenance, marina maintenance, bridge construction, and repair. Installation or removal of pilings.	Yes. Worker safety issues related to dermal contact, soil inhalation, and soil ingestion during dredging, sediment handling, and sediment movement activities. Yes. Residential exposures related to dermal contact, soil inhalation, and soil ingestion due to fugitive dust created during construction and soil movement activities.	Provide appropriate safety equipment and clothing to workers in contact with disturbed soil or sediment areas as guided and prescribed by the Michigan Occupational Safety and Health Act. Depending on the activity and the dredge equipment used, this safety equipment could include masks or other appropriate inhalation protection devices, gloves, and/or other appropriate clothing to avoid dermal contact. Proper soil erosion techniques must be implemented including the covering of disturbed soil piles with plastic sheeting until they are properly disposed of.
Commercial or large-scale farming	Commercial or large-scale farming, soil drainage, and tile system construction activities.	Yes. Worker safety issues related to dermal contact, soil inhalation, and soil ingestion during routine plowing, planting, and harvesting activities. Yes. Residential exposures related to dermal contact, soil inhalation, and soil ingestion due to fugitive dust created during the plowing, planting, and harvesting process; as well as from windblown erosion.	Refer to the Michigan Department of Agriculture (MDA) “Food, Farming, and Gardening Guidelines for Minimizing Dioxin Exposure,” on the Michigan Department of Environmental Quality (MDEQ) website. The MDA recommends utilization of minimum tillage and dust reduction practices in any production cycle, and following the personal risk reduction strategies recommended for gardening. Anyone raising livestock should contact the MDA.

Table C-2. Summary of the 2003 soil movement advisory for private, public, and commercial projects related to the Tittabawassee River furan and dioxin floodplain soil and sediment contamination, as it pertains to permits and potential environmental liability

Actions	Permits required	Potential environmental liability	Actions to avoid potential liability
Minor household soil movement	Generally no.	Part 115 (Waste Management), Part 31 (Water Resources), and Part 201 (Environmental Remediation) of the Northern Rockies Ecosystem Protection Act (NREPA), as amended.	Minimize or eliminate soil displacement and movement activities on property located within the floodplain. Dispose of any removed soil at the licensed landfill serving your area and only use clean fill or topsoil to regrade the area. Do not move soil from low-lying, more potentially contaminated areas to higher, potentially uncontaminated or less-contaminated areas. Immediately put in place measures sufficient to prevent soil erosion from wind and rain.
Major household soil movement activities	Yes. Part 31 (Water Resources) of the NREPA for all major household soil movement activities occurring within the floodplain/flood way. Part 91 (Soil and Erosion Control) of the NREPA.	Part 115 (Waste Management), Part 31 (Water Resources), and Part 201 (Environmental Remediation) of the NREPA. Note: A contractor hired by the homeowner or the owner of a disposal location could also acquire liability for mishandling contaminated soil.	Minimize or eliminate soil displacement and movement activities on property located within the floodplain. Avoid placement of outbuildings, or the expansion of the home, to areas within the floodplain. Dispose of any removed soil at the licensed landfill serving your area and only use clean fill or topsoil to regrade the area. Do not move soil from low-lying, more potentially contaminated areas to higher, potentially uncontaminated or less-contaminated areas. Immediately put in place measures to prevent soil erosion from wind and rain.

Table C-2. Summary of the 2003 soil movement advisory for private, public, and commercial projects related to the Tittabawassee River furan and dioxin floodplain soil and sediment contamination, as it pertains to permits and potential environmental liability

Actions	Permits required	Potential environmental liability	Actions to avoid potential liability
Commercial soil movement activities	Yes, Part 31 (Water Resources), Part 31 (Stormwater), Part 301 (Inland Lakes & Streams), Part 91 (Soil Erosion & Control), Part 41 (Sewer and Wastewater Systems), and Part 399 (Water Mains) of the NREPA, depending on the activity.	Part 115 (Waste Management), Part 31 (Water Resources), Part 301 (Inland Lakes & Streams), and Part 201 (Environmental Remediation) of the NREPA.	Dispose of all disturbed floodplain soil or river sediment at a licensed landfill, or in accordance with permit conditions. In situ testing of soil can be considered in lieu of disposal. Do not move soil from low-lying, more contaminated areas to higher elevation, potentially uncontaminated or less-contaminated areas. Do not move soil from the floodplain for use as fill at properties located outside of the floodplain. Immediately put in place soil erosion control measures to prevent soil movement from wind and rain.
Sediment dredging activities	Yes. Part 31 (Water Resources), Part 301 (Inland Lakes & Stream), Part 91 (Local Agency) of the NREPA, depending on the activity.	Part 115 (Waste Management), Part 31 (Water Resources), Part 301 (Inland Lakes & Streams), Part 201 (Environmental Remediation) of the NREPA.	Dispose of all disturbed floodplain soil or river sediment at a licensed landfill, upland disposal area, or in accordance with permit conditions. Do not use floodplain soil or sediment as fill at properties located outside of the floodplain. Immediately conduct measures sufficient to prevent soil erosion from wind and rain.
Commercial or large-scale farming	No. Anyone raising livestock for commercial or personal use should contact MDA.	Part 201 (Environmental Remediation) of the NREPA.	Follow MDA guidance on the utilization of minimum tillage and dust reduction in any production cycle.

Reference list for soil and sediment advisories

MDEQ. 2003. Soil Movement Advisory for Private, Public, and Commercial Projects. Michigan Department of Environmental Quality, Lansing. June. Available: https://www.fws.gov/midwest/es/ec/nrda/TittabawasseeRiverNRDA/documents/TittabawasseeRiverAdvisoryDioxinMichiganDEQ.pdf. Accessed 1/30/2018.

Appendix D. Restoration Projects Proposed to Trustees

This appendix provides a list of projects proposed to the Trustees since 2005.

The list in Table D.1 is divided into the following sections:

- Restoration and enhancement of habitat and natural resources
- Habitat protection and conservation
- Outdoor recreation and environmental education projects
- Projects that did not meet the restoration eligibility criteria (Draft RP/EA, section 5.1.1)

Table D-1. Restoration and enhancement of habitat and natural resources: project ideas and source organizations/individuals

Project description	Source organization(s)/individual(s)
Create a walleye spawning reef within Saginaw Bay to increase the natural reproduction and nursery habitat of walleye.	Michigan Department of Natural Resources (MDNR) and Michigan Department of Environmental Quality (MDEQ)
Install fish passage at the Frankenmuth Dam to restore fish spawning and nursery habitats.	MDNR, MDEQ, and Saginaw Bay Coastal Initiative (SBCI)
Install fish passage at the Chesaning Dam to restore fish spawning and nursery habitats.	MDNR, MDEQ, and SBCI
Install fish passage at the Dow/Midland Dam to restore fish spawning and nursery habitats.	MDNR, MDEQ, and SBCI
Restore natural flow regime at the Sanford Dam Hydroelectric Facility.	MDNR, MDEQ, and USFWS
Implement best management practices on drained farmland to slow runoff in the Pine and Chippewa watersheds.	MDNR, MDEQ, and USFWS
Restore the VanHove Tract in the Fish Point State Wildlife Area (SWA).	Ducks Unlimited (DU), MDNR, USFWS, and Shiawassee National Wildlife Refuge (SNWR)
Restore 100 acres in two coastal wetlands in the Quanicassee SWA.	DU, MDNR, USFWS, and SNWR
Replace the "C" pump and related infrastructure to restore 150 acres of wetlands in the Nayanquing Point SWA.	DU, MDNR, USFWS, and SNWR
Replace the "3" and "4" pump stations and related infrastructure to restore 350 acres of wetlands in the Fish Point SWA.	DU, MDNR, USFWS, and SNWR
Replace the siphon tube and related infrastructure to restore > 1,000 acres of wetlands in the Fish Point Shiawassee River State Game Area (SGA).	DU, MDNR, USFWS, and SNWR
Enhance 298 acres of wetlands within the Davis and Greenhead units of the Crow Island SGA.	DU, MDNR, USFWS, and SNWR
Enhance 250 acres of wetland habitat within the Baldpate Unit of the Crow Island SGA.	DU, MDNR, USFWS, and SNWR
Improve radial gate function to restore and enhance > 1,000 acres of wetlands in the Shiawassee River SGA.	DU, MDNR, USFWS, and SNWR
Enhance wetland flooding along Highway M-18 in Midland County (100 acres).	DU, MDNR, USFWS, and SNWR
Convert 370 acres of upland habitat to native warm season grasses in the SNWR.	DU, MDNR, USFWS, and SNWR
Enhance 500 acres of wetland habitat in Moist Soil Units 3 and 4 and the North Marsh located in the SNWR.	DU, MDNR, USFWS, and SNWR
Enhance 250 acres of wetland habitat in the Moist Soil Unit 1 located in the SNWR.	DU, MDNR, USFWS, and SNWR
Enhance 78 acres of wetland habitat in the Moist Soil Unit 6 located in the SNWR.	DU, MDNR, USFWS, and SNWR

Project description	Source organization(s)/individual(s)
Enhance 90 acres of wetland in Hart Marsh located in the SNWR.	DU, MDNR, USFWS, and SNWR
Improve pools 3 and 5 (300 acres) at Greentree Reservoir located in the SNWR.	DU, MDNR, USFWS, and SNWR
Restore 10 acres of shorebird wetland habitat located in the SNWR.	DU, MDNR, USFWS, and SNWR
Restore 20 acres of wetland habitat in Farm Unit 2 (south) in the SNWR.	DU, MDNR, USFWS, and SNWR
Restore 120 acres of wetland habitat in Farm Unit 2 (north) in the SNWR.	DU, MDNR, USFWS, and SNWR
Restore 150 acres of wetland habitat in Farm Unit 1 (northwest) in the SNWR.	DU, MDNR, USFWS, and SNWR
Restore 125 acres of wetland habitat in Farm Unit 1 (northeast) in the SNWR.	DU, MDNR, USFWS, and SNWR
Acquire private lands near Saginaw Bay along the 585-foot U.S. Datum Contour or create a wildlife corridor to protect coastal and riverine wetland habitats.	USDA, MDNR, USFWS, DU, SBLC, and Watershed Initiative Network (WIN)
Acquire conservation easements along the Tittabawassee River to restore wildlife corridors and create a river greenway.	WIN
Work with the U.S. Fish and Wildlife Service (USFWS) and the Partners for Fish and Wildlife Program to restore, enhance, and protect fish and wildlife habitats within the Saginaw Bay watershed.	DU and USFWS
Acquire Dow property in Bay City at the mouth of the Saginaw River to restore wetland habitat.	MDNR
Restore Saginaw Bay coastal wetlands below the 585-foot U.S. Datum Contour.	SBLC
Restore Saginaw Bay coastal wetlands above the 585-foot U.S. Datum Contour.	SBLC
Restore Tittabawassee and Saginaw river wetlands above 585-foot U.S. Datum Contour.	SBLC
Reduce phosphorous loading from urban and agricultural fertilizer application in the Saginaw Bay watershed to decrease nutrient loading to Saginaw River and Bay.	Partnership for the Saginaw Bay Watershed (PSBW) and MDEQ
Provide education, including demonstrations of Best Farming Practices and use of buffer strips, to reduce sediment loadings to the Saginaw Bay watershed.	PSBW and MDEQ
Provide funding to Saginaw Bay Area stormwater authorities to reduce pollutant loadings to the lower Saginaw River watershed.	SBCI and Bay City
Implement invasive species control measures (e.g., biological control, removal) for purple loosestrife, phragmites, or other invasive plant species to restore diversity in the Saginaw Bay watershed.	PSBW, DU, and MDEQ

Project description	Source organization(s)/individual(s)
Support the Bay Area Community Foundation's Saginaw Bay Watershed Restoration Fund to provide community and stakeholder education, watershed planning, and local capacity building; and enhance water quality using community-driven initiatives.	SBCI
Repair and upgrade the Bay City stormwater system and combined sewer overflows (CSOs),	Bay City
Restore self-reproducing Lake Sturgeon population in the Saginaw River watershed.	MDNR and USFWS
Restore and enhance culturally and ecologically significant plant communities within the Saginaw Bay watershed.	Saginaw Chippewa Indian Tribe of Michigan, DU, MDNR, and MDEQ

Table D-2. Habitat protection and conservation: project ideas and source organizations/individuals

Project description	Source organization(s)/individual(s)
Acquire the 180-acre Walker Tract for inclusion in the SNWR.	USFWS and DU
Acquire the 41-acre Kaufmann Tract for inclusion in the SNWR.	USFWS and DU
Acquire the 10-acre Vlasic Tract for inclusion in the SNWR.	USFWS and DU
Acquire the 79-acre Rice Tract for inclusion in the SNWR.	USFWS and DU
Acquire the 40-acre Rosenkranz Tract for inclusion in the SNWR.	USFWS and DU
Acquire the 65-acre Hart Tract for inclusion in the SNWR.	USFWS and DU
Acquire a 5-acre land parcel for inclusion in the Bay City Recreation Area.	MDNR and DU
Acquire the 30-acre Meyer Tract for inclusion in the Deford SGA.	MDNR and DU
Acquire the 220-acre Stockmeier Tract for inclusion in the Quanicassee SGA.	MDNR and DU
Acquire the 36-acre McRae Tact for inclusion in the Sanilac SGA.	MDNR and DU
Acquire the 205-acre Osentoski Property in Huron County for conservation.	The Nature Conservancy (TNC), MDNR, and DU
Acquire the 20-acre Rose Island Road Tract in Huron County for conservation.	MDNR, Michigan Nature Association (MNA), and DU
Acquire the 20-acre Dobby Tract in Huron County for conservation.	MDNR, SBLC, MNA, and DU
Acquire easements/agreements of land-based riverine corridors and bay coastal areas to protect habitat on private properties within the Saginaw Bay and Saginaw River watershed.	SBLC and SBCI
Provide support for the USFWS and the Partners for Fish and Wildlife Program to restore, enhance, and protect fish and wildlife habitats within the Saginaw Bay watershed.	DU
Provide support for the Saginaw Bay Conservation Program focused on wetland restoration.	DU
Provide support for the Saginaw Bay Conservation Program focused on grassland restoration.	DU
Provide support for the Saginaw Bay Conservation Program focused on wetland management and infrastructure improvements.	DU
Set back the levee in Hampton Township.	DU

Table D-3. Outdoor recreation and environmental education projects: project ideas and source organizations/individuals

Project description	Source organization(s)/individual(s)
Implement a pilot project to establish a useable swimming beach at the Bay City State Recreation Area.	SBCI
Improve the boat launch at Imerman Park.	Tim Braun and Bill McQuillan (Saginaw Township)
Remove the pilings from the river at the Gratiot Road Bridge to enhance recreational boating and fishing.	Bill McQuillan (Saginaw Township)
Clean up debris from previous construction of the Gratiot Road Bridge to enhance recreation on the river.	Bill McQuillan (Saginaw Township)
Create a cofferdam to keep river levels high enough for motor boating.	Bill McQuillan (Saginaw Township)
Create a new public park on the Tittabawassee River with a boat launch to enhance fishing and boating access to the river.	Russ Taylor, Bob Weise, and Tim Ader (Thomas Township)
Acquire the land along the Tittabawassee River for which Thomas Township has the first right of refusal with the Saginaw County Road Commission, and create a park.	Russ Taylor, Bob Weise, Ed Brosofski, Tim Ader, and Mike Thayer (Thomas Township)
Develop the River Park boat/canoe launch, wetlands with a boardwalk, viewing platforms, parking, and fishing/viewing decks.	Russ Taylor, Bob Weise, Ed Brosofski, Tim Ader, and Mike Thayer (Thomas Township)
Make improvements to the North Veterans Memorial Park, including shore fishing and small boat access and shore fishing.	Robert Belleman (Bay City, City Manager)
Expand the DNR Boat Launch at the mouth of the Saginaw River.	MDNR
Repair the Center Road Bridge (Saginaw to James Township) to connect the Rail Trail System.	Tim Braun and Bill McQuillan (Saginaw Township)
Create a walking/biking trail from Kochville and Saginaw townships, linked to Midland via Freeland Park.	Brian Kischnick (Tittabawassee Township)
Create parks and canoe launches along the Saginaw River in Zilwaukee Township.	Bruce VanBlarcom, Cathy VanBlarcom, and Mark Gottleber (Zliwaukee Township)
Create a river walk, including an Americans with Disabilities Act (ADA) paved path around the perimeter of the park land, and connect it to the Rail Trail.	Russ Taylor, Bob Weise, Ed Brosofski, Tim Ader, and Mike Thayer (Thomas Township)
Create a walking/riding bridge over the Tittabawassee River to connect Thomas Township's walks and paths to those in Saginaw Township.	Russ Taylor, Bob Weise, Ed Brosofski, Tim Ader, and Mike Thayer (Thomas Township)
Continue the Saginaw River Walk on the west side of the Saginaw River.	Carol Cottrell (City of Saginaw)
Create bicycle paths to continue the Rail Trail connectivity.	Crystal Kauer (Kochville Township)
Add an additional lane on the rail road bridge and connect, or cantilever and connect the lane at Saginaw Township Park.	Jerry Wieneke (James Township)
Create Rail Trail access from Center Road to Stroebel Road.	Jerry Wieneke (James Township)

Project description	Source organization(s)/individual(s)
Support the Conservation Fund to implement a Saginaw Bay Greenways/River Corridor Restoration Initiative.	Conservation Fund
Implement Wenomah Park improvements on Saginaw River in Bay City, as described in the Park Master Plan.	Bay City
Build an uptown river walk and a potential marina site in Bay City.	Bay City
Build a fishing pier out into Saginaw Bay, near Bay City	Bay County (Laura Ogar and others)
Provide support for the Great Lakes Discovery Center in the Shiawassee National Wildlife Refuge to enhance environmental stewardship and education opportunities.	SNWR
Provide support for the BaySail Environmental Education Center to enhance environmental stewardship and educational opportunities.	BaySail
Provide support for the Maritime Heritage Center to enhance education, local recreation, tourism, and economic development.	Maritime Heritage Center

Table D-4. Projects that did not meet the restoration eligibility criteria[1]: project ideas and source organizations/individuals

Project description	Source organization(s)/individual(s)
Remove the dredge site that is used to store sediments dredged from Saginaw River from Zilwaukee Township.	Sue Cameron (Zilwaukee Township)
Prohibit the Dow Chemical Company from using the Zilwaukee Township Dredging Facility for storage of any dredged materials from the Tittabawassee or Saginaw rivers.	Sue Cameron (Zilwaukee Township)
Build a municipal water system along Melbourne Road in Zilwaukee Township.	Sue Cameron (Zilwaukee Township)
Work to remove the "Facility" designation as a blanket designation along the Tittabawassee River floodplain.	Brian Kischnick (Tittabawassee Township)
Rescind the letter that was issued to all parks and school officials stating that all parks are unsafe for children.	Brian Kischnick (Tittabawassee Township)
Remove the "Facility" designation for homeowners along the Tittabawassee River floodplain.	Bob Weise, Ed Brosofski, Tim Ader, and Mike Thayer (Thomas Township)
Facilitate the involvement of Zilwaukee Township in the Saginaw River Dredge Site purchase and development process.	Pat Bradt and David Bradt (Zilwaukee Township)
Provide medical testing for a baseline public health assessment and provide retesting following Saginaw River dredging activities.	Bruce VanBlarcom, Cathy VanBlarcom, and Mark Gottleber (Zilwaukee Township)
Conduct an Environmental Impact Study before the groundwater discharge permit is issued on the Saginaw River Dredge Site.	Bruce VanBlarcom, Cathy VanBlarcom, and Mark Gottleber (Zilwaukee Township)
Address that there is no mitigated land left in Zilwaukee Township that would allow for development activities.	Pat Bradt and David Bradt (Zilwaukee Township)
Acquire Andersen Water Park within the City of Saginaw to enhance public access to outdoor recreation.	Carol Cottrell (City of Saginaw)
Provide funding to hire a consultant to update the Riverfront Master Plan.	Carol Cottrell (City of Saginaw)
Provide funding to maintain the Boundless playground and hire security staff.	Crystal Kauer (Kochville Township)
Provide compensation to the Frankenlust Township for loss of taxable value for the reduction of home values and for property taken from the township.	Hilda Dijak (Frankenlust Township)
Provide compensation for impacts to a road in the Frankenlust Township.	Hilda Dijak (Frankenlust Township)
Improve municipal water quality in and around areas affected by groundwater contamination in the Frankenlust Township.	Hilda Dijak (Frankenlust Township)
Enhance the municipal sewer system within the James Township.	Jerry Wieneke (James Township)
Implement infrastructure improvements, including a new fire station within the James Township.	Jerry Wieneke (James Township)

1. Restoration eligibility criteria are described in Draft RP/EA, section 5.1.1

Project description	Source organization(s)/individual(s)
Repair Melbourne Road in the Zilwaukee Township.	Pat Bradt and David Bradt (Zilwaukee Township)
Re-route Melbourne Road up to the abandoned railroad tracks in the Zilwaukee Township.	Pat Bradt and David Bradt (Zilwaukee Township)
Run municipal water for fire protection and to provide safe drinking water.	Pat Bradt and David Bradt (Zilwaukee Township)
Install a gas line along Melbourne Road in the Zilwaukee Township.	Bruce VanBlarcom, Cathy VanBlarcom, and Mark Gottleber (Zilwaukee Township)
Install a municipal water system along Melbourne Road in the Zilwaukee Township.	Bruce VanBlarcom, Cathy VanBlarcom, and Mark Gottleber (Zilwaukee Township)
Support the development of a committee made up of stakeholder townships to work toward a solution to contamination within the Saginaw Bay and River watershed.	Tittabawassee Township