Final Restoration Plan and Programmatic Environmental Impact Statement for Restoration Resulting from the Kalamazoo River Natural Resource Damage Assessment

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Prepared for:

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Michigan Department of Environmental Quality,
Michigan Attorney General,
U.S. Fish and Wildlife Service,
and
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August 2016

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Acronyms and Abbreviations

AQCR	Air Quality Control Region
CAA	Clean Air Act
CE	Categorical Exclusion
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R.	Code of Federal Regulations
CWA	Clean Water Act
dBA	A-weighted decibels
DOC	U.S. Department of Commerce
DOI	U.S. Department of the Interior
D.O.O.	Department Organization Order
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
F.R.	Federal Register
GIS	geographic information system
GLRI	Great Lakes Restoration Initiative
Kalamazoo River Superfund Site	Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site
KRE	Kalamazoo River Environment
M.C.L.	Michigan Compiled Laws
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
NAAQS	National Ambient Air Quality Standards
N.A.O.	NOAA Administrative Order
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRDA	natural resource damage assessment

OPA	Oil Pollution Act
OSHA	Occupational Safety and Health Administration
OU	operable unit
PAS	Preassessment Screen
PCB	polychlorinated biphenyl
PEIS	Programmatic Environmental Impact Statement
PM	particulate matter
ROD	Record of Decision
RP	Restoration Plan
SARA	Superfund Amendments and Reauthorization Act
SHPO	State Historic Preservation Officer
Trustees	Michigan Department of Natural Resources, Michigan Department of Environmental Quality, Michigan Attorney General, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WCS	water control structure

Executive Summary

Natural resources in Michigan have been injured by releases of polychlorinated biphenyls (PCBs) from Kalamazoo-area paper mills that contaminated sediments, floodplain soils, water, and living organisms in and near Portage Creek and the Kalamazoo River. The Michigan Department of Natural Resources, the Michigan Department of Environmental Quality, the Michigan Attorney General, the U.S. Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration (collectively referred to as the Trustees) are in the process of determining the extent of injuries to natural resources caused by these releases of PCBs, and how to restore these injured natural resources and the services they provide to both other natural resources and the public. This evaluation is known as a natural resource damage assessment (NRDA), which is authorized under the Comprehensive Environmental Response, Compensation, and Liability Act (more commonly known as the federal "Superfund" law) [42 United States Code (U.S.C.) §§ 9601–9675].

In this document, the Trustees analyze a suite of habitat restoration actions that they believe will most effectively compensate the public for losses caused by releases of PCBs. These restoration projects are presented as an NRDA restoration program that will be implemented by the Trustees with funding from previous bankruptcy settlements or from future settlements with the companies that have liability for the releases of PCBs. The NRDA restoration program will focus on restoring the types of natural resources and services affected by PCB contamination and would benefit the wide suite of species that have been injured by PCBs.

This Restoration Plan and Programmatic Environmental Impact Statement (RP/PEIS) was previously released to the public as a draft document to inform and solicit comments from members of the public on restoration alternatives, including whether the Trustees should implement such a restoration program at sites only directly associated with the contaminated and remediated sections of the Kalamazoo River and Portage Creek or, as the Trustees proposed, over the broader area of the Kalamazoo River watershed. In either case, project selection will be based on criteria that include a preference for projects that most directly benefit natural resources and services that have been affected by the releases of PCBs. In addition to the programmatic restoration alternatives, the public was asked to comment on two specific proposed restoration projects: the removal of the Otsego City Dam and the removal of the Otsego Dam. This final RP/PEIS includes comments received from the public and the Trustees' response to those comments (Appendix D). This document provides a programmatic-level environmental analysis under the National Environmental Policy Act (NEPA) to support the Trustees' proposed efforts to conduct restoration to compensate the public for losses caused by releases of PCBs. As such, the programmatic analysis in this RP/PEIS takes a broad look at issues and programmatic-level alternatives (as opposed to a document for a specific project or action) and provides guidance for future restoration activities to be carried out by, or conducted under the oversight of, the

Trustees. In addition to providing a programmatic analysis, the Trustees intend to use this document to approve future site-specific actions, including the two specific restoration projects proposed herein, so long as the activity proposed is within the range of alternatives and scope of potential environmental consequences analyzed within this RP/PEIS. The Trustees anticipate that most impacts will be the same or less than the impacts identified in this RP/PEIS. However, for future Trustee proposals that fall outside of the range of alternatives and scope of analysis evaluated in this RP/PEIS, subsequent additional NEPA analysis would be conducted that would tier off of this RP/PEIS, as allowed by the Council on Environmental Quality's NEPA regulations at 40 Code of Federal Regulations (C.F.R.) § 1502.20. This will increase efficiency of the federal Trustees' NEPA process, by reducing repetitive discussions of broader information applicable to the entire NRDA restoration program [see 40 C.F.R. § 1502.20].

This RP/PEIS contains seven chapters:

- ***Chapter 1 – Introduction*** provides an overview of the Kalamazoo River NRDA and a description of relevant environmental laws and regulations, as well as describes the purpose and need for the analysis.
- ***Chapter 2 – Description of the Proposed Action*** describes the general restoration strategy proposed by the Trustees and provides information on how projects would be evaluated and how monitoring and performance evaluations would be addressed. It also includes descriptions of two potential projects under consideration: the removal of the Otsego City Dam and the removal of the Otsego Dam.
- ***Chapter 3 – Development and Analysis of Alternatives*** presents a detailed overview of the types of restoration project categories proposed by the Trustees, and presents three alternatives. The first is a "no action" alternative included in this analysis to present a restoration baseline for the comparison of the impacts of the other alternatives (Alternative A). The second and third alternatives would both include all of the restoration project categories, but focus on different geographic extents. The second alternative would consist of restoration of the 129-kilometer (80-mile) stretch of the Kalamazoo River corridor and the 4.8-kilometer (3-mile) stretch of Portage Creek within the Kalamazoo River Superfund Site (Alternative B), whereas the third alternative would also include restoration within the 5,230-square kilometer (2,020-square mile) Kalamazoo River watershed (Alternative C). This chapter also includes a discussion of alternatives that were considered but not carried forward for detailed analysis.
- ***Chapter 4 – Environmental Setting/Affected Environment*** describes the physical, biological, and human environments of the Kalamazoo River watershed that could be affected by the alternatives.

- ***Chapter 5 – Environmental Consequences*** describes the reasonably foreseeable consequences of implementing the three alternatives described in Chapter 3 on the affected environment described in Chapter 4.

- ***Chapter 6 – Cumulative Impacts*** provides an analysis of how other past, present, and reasonably foreseeable future actions could interact with the environmental consequences of the proposed program described in Chapter 5.

- ***Chapter 7 – Coordination and Consultation*** provides a summary of Trustee actions to coordinate and consult with the public and with federal and state agencies.

Table S.1 provides a summary of the potential impacts of Alternatives A, B, and C. The environmental impacts would occur over a greater area under Alternative C due to the larger geographic extent that the alternative covers. Impacts under Alternative B would also be delayed compared to Alternative C.

Appendices to the document provide additional detail on fish species, scientific names, other regional and local restoration plans, and comments from the public.

Table S.1. Summary of environmental impacts

Resource area	Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
Water resources and water quality	No impacts on water resources or water quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C. No long-term impacts would be expected.	Short-term, minor to moderate, adverse impacts on water resources and water quality would be expected during restoration activities. Long-term, moderate to major, beneficial impacts on water resources and water quality would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.
Geological resources and sediment quality	No impacts on geologic resources or sediment quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C. No long-term adverse impacts on sediment quality would be expected. No impacts on geologic resources would be expected.	Short-term, moderate, adverse impacts on sediment quality would be expected during restoration activities. Long-term, moderate to major, beneficial impacts on sediment quality would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation. No impacts on geologic resources would be expected.
Biological resources	**Fish**		
	No impacts on fish would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on fish would be expected during barrier removals. Long-term, direct and indirect, minor to moderate, beneficial impacts on fish would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

Table S.1. Summary of environmental impacts (cont.)

Resource area	Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
Biological resources	**Aquatic invertebrates**		
	No impacts on aquatic invertebrates would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on aquatic invertebrates would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor, adverse impacts on aquatic invertebrates could occur as a result of barrier removals if they allow the spread of invasive species into new areas. Long-term, minor to major, beneficial impacts on aquatic invertebrates would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.
	Wildlife		
	No impacts on wildlife would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor to moderate, adverse impacts on wildlife would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor to major, beneficial impacts on wildlife would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

Table S.1. Summary of environmental impacts (cont.)

Resource area	Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
Biological resources	**Vegetation**		
	No impacts on vegetation would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on vegetation would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor to major, beneficial impacts on vegetation would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.
	Indiana bat and northern long-eared bat		
	No impacts on Indiana bat or northern long-eared bat would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, moderate to major, adverse impacts are unlikely but could occur if there were a loss of trees during riparian and wetland habitat restoration activities during bat breeding season. Long-term, minor to moderate, beneficial impacts would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and habitat conservation.
	Karner blue butterfly, Mitchell's satyr butterfly, copperbelly water snake, and eastern massasauga		
	No impacts on Karner blue butterfly, Mitchell's satyr butterfly, copperbelly water snake, and eastern massasauga would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, moderate, adverse impacts are unlikely but could occur from vegetation removal during riparian and wetland habitat restoration, depending on the timing and location of construction activities. Long-term, moderate, beneficial impacts would be expected from increased and improved wetland, bog, and fen habitats.

Table S.1. Summary of environmental impacts (cont.)

Resource area	Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
Air quality	No impacts on air quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor, adverse impacts from increased air emissions and particulate matter of vehicles, machinery, and construction equipment. No long-term impacts on air quality would be expected.
Socioeconomic resources and environmental justice	No impacts on socioeconomic resources or environmental justice populations would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	No short- or long-term impacts on population would be expected. Short- and long-term, minor to moderate, beneficial impacts on the local economy would be expected.
Recreation and land use	No impacts on recreation and land use would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor to moderate, adverse impacts from the temporary closure of recreational areas would be expected. Long-term, minor to moderate, beneficial impacts from increased recreational opportunities would be expected. No short- or long-term impacts on land use would be expected.
Noise	No impacts on the noise environment would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor, adverse impacts from increased noise of equipment and vehicles during restoration activities would be expected. No long-term impacts on the noise environment would be expected.
Cultural resources	No impacts on cultural resources would be expected.	Impacts would be similar in nature but could be greater if restoration actions were concentrated in a smaller geographical area than those described for Alternative C. They would differ from Alternative C in terms of timing.	Short-term, direct, negligible to minor, adverse impacts from visual impacts and increased noise of equipment and vehicles during restoration activities would be expected. Long-term, moderate, beneficial impacts on cultural resources would be expected.

1. Introduction

Natural resources in Michigan have been injured by releases of polychlorinated biphenyls (PCBs) from Kalamazoo-area paper mills that contaminated sediments, floodplain soils, water, and living organisms in and near Portage Creek and the Kalamazoo River. PCBs are organic chemical compounds that can cause death, cancerous tumors, chromosome alterations, decreased fertility, reduced growth, physical deformations, endocrine system malfunctions, immune system impairment, and other biochemical changes in living organisms (MDEQ et al., 2005a). Because of concerns about the persistence and toxicity of PCBs in the environment, Congress banned their manufacture and distribution in the late 1970s [Public Law 94-469; 40 Code of Federal Regulations (C.F.R.) § 761].

The Michigan Department of Natural Resources (MDNR), the Michigan Department of Environmental Quality (MDEQ), the Michigan Attorney General, the U.S. Fish and Wildlife Service (USFWS), and the National Oceanic and Atmospheric Administration (NOAA) (collectively referred to as the Trustees) are in the process of determining the extent of injuries to natural resources caused by these releases of PCBs, and how to restore these injured natural resources and the services they provide to both other natural resources and the public. This evaluation is known as a natural resource damage assessment (NRDA), which is authorized under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; more commonly known as the federal “Superfund” law) [42 United States Code (U.S.C.) §§ 9601–9675].

This Restoration Plan and Programmatic Environmental Impact Statement (RP/PEIS) was prepared pursuant to the National Environmental Policy Act (NEPA) of 1969, the Council on Environmental Quality’s (CEQ’s) Regulations for Implementing NEPA (40 C.F.R. §§ 1500–1508), CERCLA (42 U.S.C. §§ 9601–9675), and NOAA environmental review procedures [NOAA Administrative Order (N.A.O.) 216-6, as preserved by N.A.O. 216-6A]. It was designed to solicit public opinion on a proposed restoration program for the Kalamazoo River NRDA. In the draft version of this RP/PEIS, the Trustees solicited input on the analysis of three alternatives: a No Action alternative and two restoration alternatives that differ in geographic scope. The Trustees also solicited input on two proposed dam removal restoration projects (Otsego City Dam and Otsego Dam) that could be a part of either of the two restoration alternatives. Comments received from the public and the Trustees’ responses to those comments are presented in Appendix D.

The scale of restoration activity that will be implemented under this RP/PEIS is not yet known, and will depend upon the resolution of natural resource damage claims with the parties responsible for the PCB releases. Under CERCLA, settlements received by the Trustees, either through negotiated or adjudicated processes, must be used to restore, rehabilitate, replace, and/or acquire the equivalent of those natural resources that have been injured [42 U.S.C. § 9607(f)(1)].

This RP/PEIS will guide future Trustee decision-making regarding the expenditure of settlements and the implementation of restoration activities.

The remainder of this introductory chapter provides important background information for understanding the rest of the document, including an overview of the Kalamazoo River NRDA (Section 1.1), a description of related environmental laws and regulations (Section 1.2), an explanation of the purpose and need for action by the Trustees (Section 1.3), an explanation of what the Administrative Record is and how members of the public can access it (Section 1.4), and an overview of the subsequent chapters and appendices of this document (Section 1.5).

1.1 Overview of the Kalamazoo River NRDA

Industrial activities in the Kalamazoo area have released PCBs into the environment. The primary source of these PCB releases was the recycling of carbonless copy paper at several area paper mills (Figure 1.1). Carbonless copy paper manufactured from 1954 to 1971 contained PCBs (Appleton Papers, 1987). Waste from the recycling of such paper conducted at Kalamazoo-area paper mills also contained PCBs. This PCB-containing waste was disposed of by several methods that resulted in releases of PCBs into the environment. These PCBs have migrated downstream in surface waters and have contaminated sediments, the water column, and biota in and adjacent to an approximately 129-kilometer (80-mile) stretch of the Kalamazoo River, the lower three miles of Portage Creek, and Lake Michigan. PCBs are also present in paper residuals disposed of in landfills and lagoons and other areas associated with former mill operations along the stream corridor.

PCBs are persistent in the environment and degrade slowly. PCBs have been present in the Kalamazoo River Environment (KRE) for decades since the original releases and are likely to remain present for many more. PCBs in the environment are re-released through erosion and diffusion from the floodplain and former impounded area soils, banks, and instream sediments. Biological organisms throughout the KRE are exposed to PCBs in the water, soils, sediments, and in their diet, resulting in the accumulation of PCBs in exposed organisms' tissues. Organisms at the top of the food chain accumulate the greatest concentrations of PCBs. Humans can also be exposed, primarily by eating fish contaminated with PCBs. PCBs are present in every component of the KRE ecosystem that has been studied to date, including in the aquatic, terrestrial, and wetlands-based food chains (MDEQ et al., 2005a).

Due to the potential risks the PCB releases posed to the environment and to human health, the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Kalamazoo River Superfund Site) was added to the National Priorities List (NPL) on August 30, 1990. At the time, the Kalamazoo River Superfund Site was described as involving PCB contamination of (1) an Allied Paper, Inc. property in Kalamazoo, Kalamazoo County, Michigan; (2) a 4.8-kilometer (3-mile) stretch of Portage Creek from Kalamazoo to where the creek meets the Kalamazoo River; and

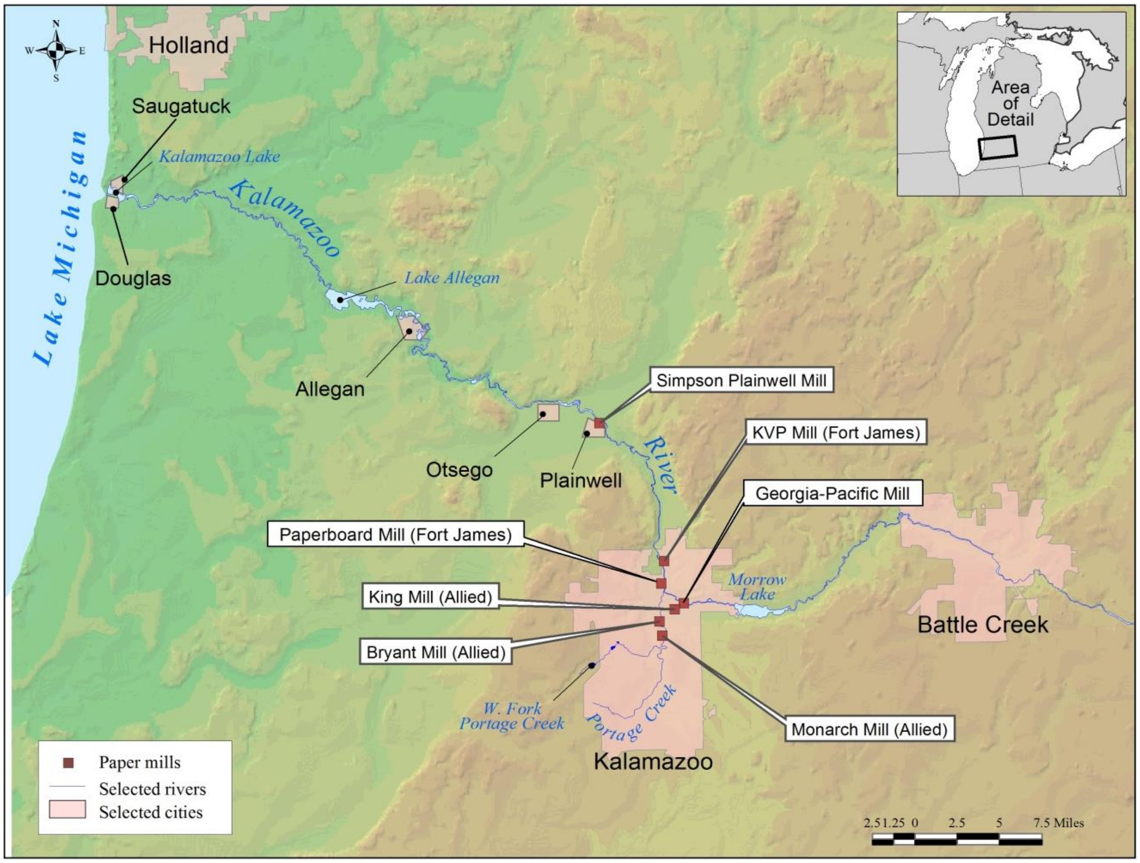

Figure 1.1. Location of current and former paper mill facilities.

(3) a 56-kilometer (35-mile) stretch of the Kalamazoo River. Subsequently, the U.S. Environmental Protection Agency (EPA) and MDEQ have expanded the description of the Kalamazoo River Superfund Site to 129 kilometers (80 miles) of the Kalamazoo River (from Morrow Dam to Lake Michigan), including the river banks and formerly impounded floodplains, as well as a 4.8-kilometer (3-mile) stretch of Portage Creek and four paper residual landfills (Figure 1.2). Within the Kalamazoo River Superfund Site, several operable units (OUs) have been identified for response actions to date, including the Allied Paper, Inc. Landfill (OU1); the Willow Boulevard/A-Site Landfill (OU2); the King Highway Landfill (OU3); the 12th Street Landfill (OU4); and 129 kilometers (80 miles) of the Kalamazoo River, including a stretch of Portage Creek (OU5). OU5 is further broken down into seven areas (Figure 1.2; Table 1.1). Additionally, former paper mill properties have been identified as potential sources of PCBs to the Kalamazoo River Superfund Site (U.S. EPA, 2007).

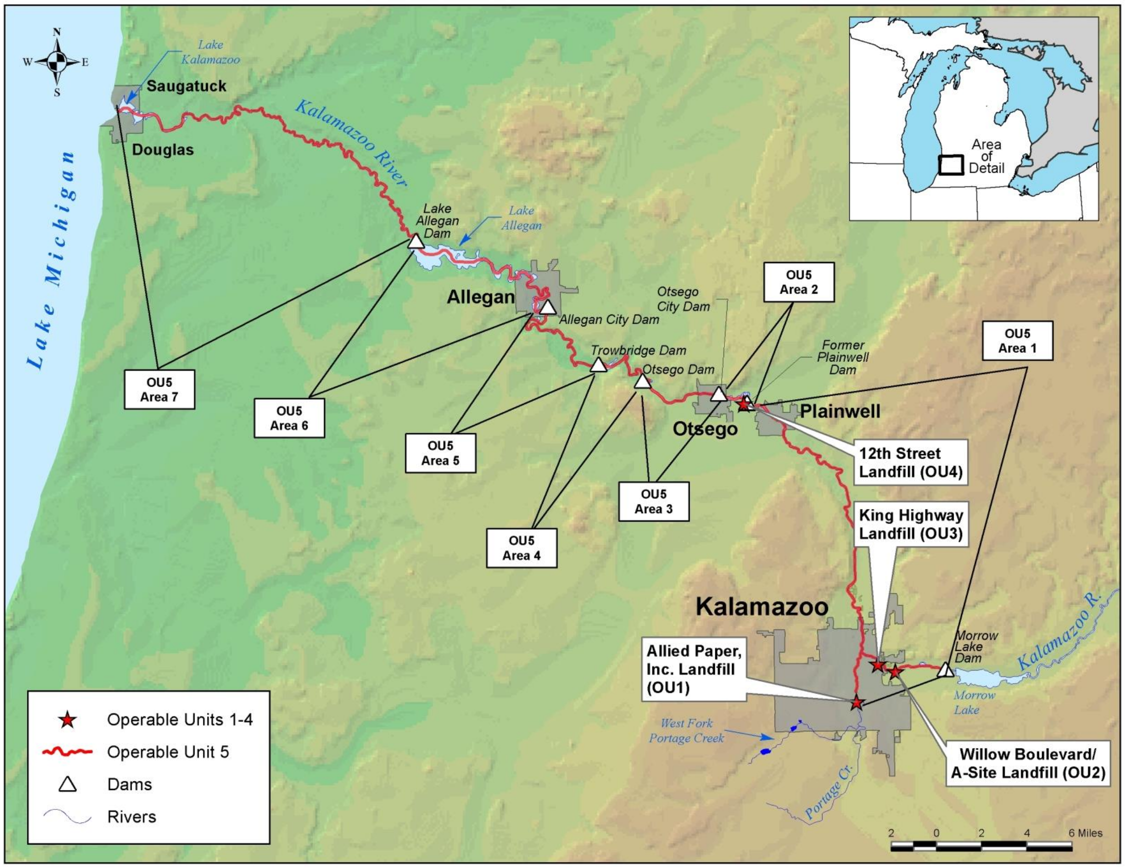

Figure 1.2. Kalamazoo River Superfund Site OUs. The red line indicates the length of OU5, but is not inclusive of all areas where PCBs have come to be located.

Table 1.1. Summary of Areas 1–7 of OU5. Note that the Portage Creek portion of Area 1 is described separately in this table.

Area and description	Average water depth (feet)	Length (miles)	Average river width (feet)	Area (acres)
Area 1: Morrow Dam to former Plainwell Dam	3.4	21.9	181	487
Area 1: Portage Creek	2.3	2.0	32	8
Area 2: Former Plainwell Dam to Otsego City Dam	2.5	1.7	450	96
Area 3: Otsego City Dam to Otsego Dam	3.8	3.4	200	83
Area 4: Otsego Dam to Trowbridge Dam	5.0	4.7	248	131
Area 5: Trowbridge Dam to Allegan City Dam	4.3	9.1	292	317
Area 6: Allegan City Dam to Lake Allegan Dam	6.7	9.8	1,500	1,650
Area 7: Lake Allegan Dam to Lake Michigan	5.5	26.0	212	670

The Trustees are using the term "Kalamazoo River Environment" in this document to represent the entire NRDA assessment area. The KRE encompasses the Kalamazoo River Superfund Site along with any area where hazardous substances released from the Kalamazoo River Superfund Site have come to be located (MDEQ et al., 2005a; Figures 1.2 and 1.3).

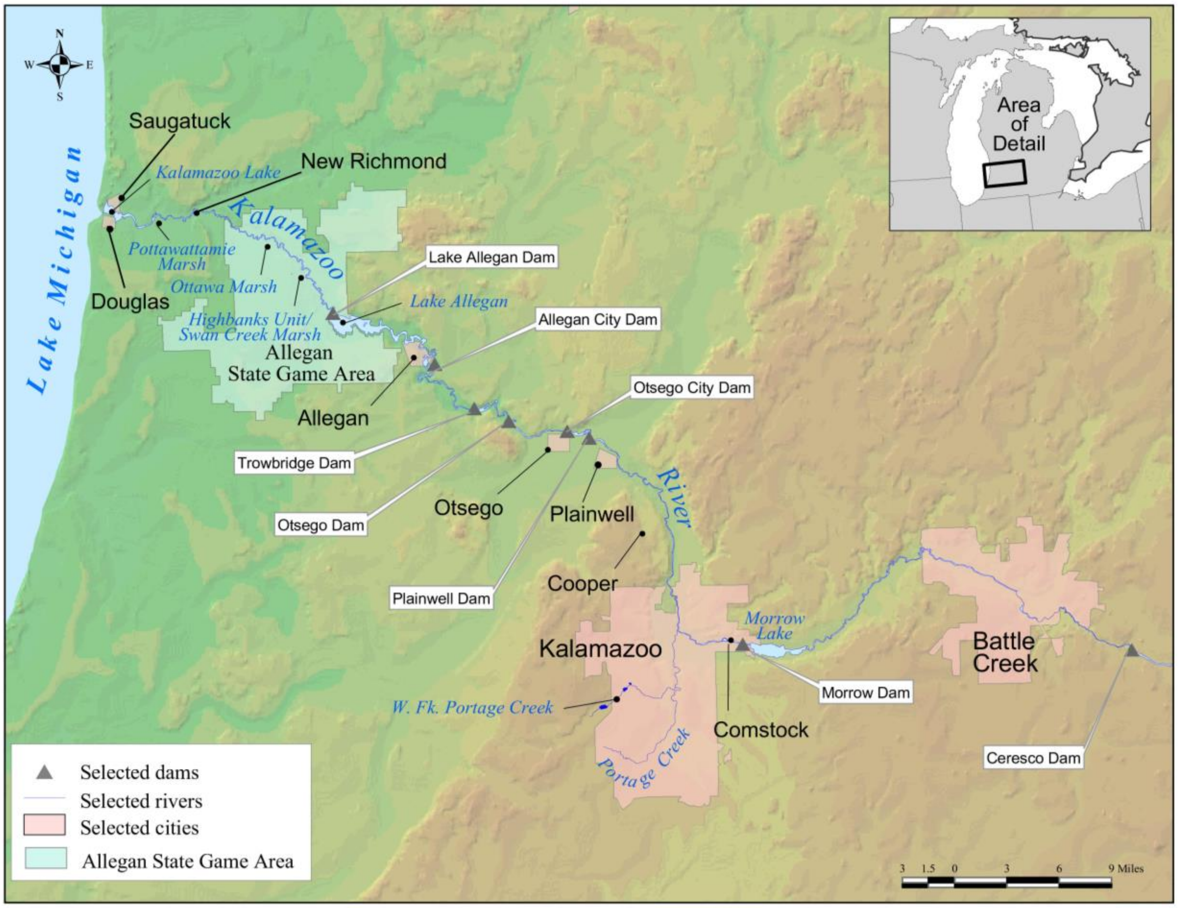

Figure 1.3. Overview of the KRE assessment area.

1.2 Environmental Laws and Regulations

Natural resource trustees act on behalf of the public to manage, protect, and restore natural resources. Under CERCLA, the United States of America, U.S. states, and Indian tribes (as trustees) may act on behalf of the public for natural resources under their trusteeship. These resources include land, fish, wildlife, biological resources, air, water, groundwater, drinking water supplies, and other similar resources [42 U.S.C. § 9601(16)].

Natural resources provide services to ecosystems and to humans. For example, surface water provides ecosystem services such as habitat, food, and nutrients to a variety of biological organisms; nutrient cycling; geochemical exchange processes; primary and secondary productivity; and a migration corridor. For people, surface water provides services such as drinking water, fishing, and other water-based recreation.

In the context of NRDAs, trustees are responsible for assessing injuries to natural resources from releases of hazardous substances, quantifying the extent of such injuries, and seeking commensurate compensation from potentially responsible parties[1] for restoration of natural resources. Authority to act on behalf of the public is given to trustees in CERCLA [42 U.S.C. §§ 9601–9675]; the National Contingency Plan [40 C.F.R. §§ 300.600–300.615]; the Federal Water Pollution Control Act [33 U.S.C. §§ 1251–1387 (Clean Water Act, CWA)]; and Part 31, Water Resources Protection, and Part 201, Environmental Remediation, of the Michigan Natural Resources and Environmental Protection Act (Public Act 451, as amended).

The natural resource trustee agencies involved in developing this RP/PEIS are the U.S. Department of the Interior (DOI) represented by USFWS; the U.S. Department of Commerce (DOC) represented by NOAA; and the State of Michigan represented by MDNR, MDEQ, and the Michigan Attorney General. NOAA and USFWS are acting as co-leads for this NEPA process. DOI conserves, protects, and enhances fish, wildlife, and their habitats. DOI provides trusteeship for resources including, but not limited to, migratory birds, threatened and endangered species, and their supporting ecosystems.[2] NOAA's trust resources in the Great Lakes include aquatic natural resources and their supporting ecosystems, water, and sediments.[3] The trust resources of the State of Michigan include state lands, fish and wildlife habitats, and water, including groundwater.

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1. The term "potentially responsible parties" as used in this document refers to parties potentially liable for cleanup costs or natural resource damages under CERCLA and/or under Section 20126a(1)(c) of Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, Michigan Compiled Laws (M.C.L.) § 324.20126.

2. The statutory bases for DOI's trusteeship include, but are not limited to, the Migratory Bird Treaty Act [16 U.S.C. § 703 *et seq.*], the Bald Eagle Protection Act [16 U.S.C. § 668 *et seq.*], the Fish and Wildlife Coordination Act [16 U.S.C. § 661 *et seq.*], and the CWA [33 U.S.C. § 1251 *et seq.*].

3. The Secretary of Commerce acts as the trustee for natural resources managed or controlled by DOC, including their supporting ecosystems [40 C.F.R. § 300.600(b), (b)(1)]. The Secretary of DOC has delegated authority to the Administrator of NOAA to act as trustee [Department Organization Order (D.O.O.) 15-10 § 3.01 (mm)]. Pursuant to this delegation, NOAA has trusteeship for the natural resources in the KRE and Lake Michigan. Pursuant to the Great Lakes Critical Programs Act of 1990 [33 U.S.C. § 1268] and the Great Lakes Water Quality Agreement of 1978, as amended by the Water Quality Agreement of 1987, the United States, in part through DOC, manages and/or controls the water and sediments of the Great Lakes system.

These agencies established the Kalamazoo River Natural Resource Trustee Council, which operates under a 2003 memorandum of agreement,[4] to conduct the KRE NRDA and plan and implement natural resource restoration actions.

Actions undertaken by the federal trustees to restore natural resources or services under CERCLA and other federal laws are subject to the 1969 NEPA, 42 U.S.C. §§ 4321–4370, and the regulations guiding its implementation at 40 C.F.R. Parts 1500–1508. This RP/PEIS was developed in accordance with NEPA. It was designed to inform the public of the decision-making process and incorporate public input regarding the selection and implementation of the natural resource restoration required to compensate the public for hazardous substance-related injuries associated with the KRE. As a programmatic document under NEPA, this final RP/PEIS will expedite and provide a reference for future area-specific restoration projects within the Kalamazoo River watershed, and facilitate the development of additional project-specific NEPA documents as needed. Such documents would focus on issues specific to the potentially affected sub-area of the watershed and address general matters by incorporating this final RP/PEIS by reference [40 C.F.R. § 1508.28].

This document also serves as the restoration plan required under CERCLA regulations for implementing restoration alternatives. The Trustees will follow the criteria presented in Section 2.3 to evaluate and prioritize projects when opportunities arise to implement restoration actions in conjunction with remedial actions or when funding is available to conduct restoration. If warranted, the Trustees may also issue a supplement to this document to solicit additional public input on restoration project selection.

1.2.1 NEPA

The NEPA process is intended to help federal agencies make decisions that appropriately consider environmental consequences of actions that may affect the environment [40 C.F.R. § 1500.1(c)]. To comply with NEPA, the federal trustees, in consultation with the co-Trustees, prepared a draft RP/PEIS, which included a description of the purpose and need for action, the affected environment, the proposed action, alternatives to the proposed action (including a No Action Alternative), and the environmental consequences of both the proposed action and the alternatives.

As a programmatic document, this final RP/PEIS describes the potential impacts resulting from the implementation of restoration actions in the Kalamazoo River watershed. Other than the proposed removal of the Otsego and Otsego City dams, specific projects have not yet been selected. Given that opportunities for projects may arise in conjunction with response activities,

4. The 2003 memorandum of understanding was amended in 2004 to designate MDNR as a co-trustee.

this evaluation is largely being conducted at a programmatic level. The Trustees anticipate that most impacts will be the same or less than the impacts identified in this RP/PEIS. However, for future Trustee proposals that fall outside of the range of alternatives and scope of analysis evaluated in this RP/PEIS, subsequent additional NEPA analysis would be conducted that would tier off of this RP/PEIS, as allowed by CEQ's NEPA regulations, at 40 C.F.R. § 1502.20. This will increase efficiency of the federal Trustees' NEPA process by reducing repetitive discussions of broader information applicable to the entire NRDA restoration program [see 40 C.F.R. § 1502.20].

1.2.1.1 Additional supporting NEPA documents

In 2013, the Trustees released a final Restoration Plan and Environmental Assessment (RP/EA) for natural resource damages related to the Allied Paper, Inc. Landfill/Bryant Mill Pond Area and the Portage Creek portion of the Kalamazoo River Superfund Site (OU1 RP/EA: http://www.fws.gov/midwest/es/ec/nrda/KalamazooRiver/index.html). The OU1 RP/EA includes descriptions of restoration projects to serve as compensation for injuries to natural resources related to releases of PCBs at and from the Allied Paper facility – the OU1 RP/EA is a complementary document to this RP/PEIS. The Trustees will implement restoration projects as described and prioritized in the OU1 RP/EA: the first project is the removal of the Alcott Street Dam on Portage Creek in Kalamazoo, which will improve connectivity and stream habitat.

1.2.1.2 Public participation

Public participation and input are important parts of the restoration planning process, and are required under NEPA [40 C.F.R. § 1503.1(a)(4) and § 1506.6]. The Trustees solicited public input on restoration during the development of the Stage I assessment report (MDEQ et al., 2005a, 2005b) and during the public review of the OU1 RP/EA (Stratus Consulting, 2013).

On February 18, 2014, the Trustees issued a Notice of Intent to prepare the RP/PEIS and conduct restoration planning in the Federal Register (F.R. Volume 79, Number 32); EPA provided comments on the Notice of Intent that indicated EPA's preference for aquatic, riparian, and upland habitat restoration projects within the Kalamazoo River watershed (Westlake, 2014). On September 14, 2015, the Trustees issued a Notice of Availability of the draft RP/PEIS and a Request for Comments in the Federal Register (F.R. Volume 80, Number 177). In addition, the Trustees used several outlets to notify the public that the RP/PEIS had been released for review and comment, including press releases and direct communications that resulted in an article in the *Kalamazoo Gazette*, posting to the MDEQ calendar, and distribution via email listserves through the MDNR and the Kalamazoo River Watershed Council that collectively reached over 40,800 people directly. The Trustees described the draft RP/PEIS and discussed it with the public at a public meeting held September 15, 2015 at the Kalamazoo Nature Center. Copies of the draft RP/PEIS were available at the following locations:

Allegan Public Library
331 Hubbard Street
Allegan, MI 49010

Saugatuck-Douglas District Library
10 Mixer Street at Center Street
Douglas, MI 49406

Kalamazoo Public Library
315 South Rose Street
Kalamazoo, MI 49007

Waldo Library-Western Michigan University
1903 West Michigan Avenue
Kalamazoo, MI 49008

Otsego District Public Library
219 South Farmer Street
Otsego, MI 49078

Charles A. Ransom District Library
180 South Sherwood Avenue
Plainwell, MI 49080

An electronic version of the draft and this final RP/PEIS was posted on the following websites: http://www.fws.gov/midwest/es/ec/nrda/KalamazooRiver/index.html and https://darrp.noaa.gov/hazardous-waste/kalamazoo-river.

Comments on the draft RP/PEIS were accepted for a period of 45 days after the federal register notice was published (October 29, 2015).

Information disseminated by federal agencies to the public after October 1, 2002 is subject to information quality guidelines developed by each agency pursuant to Section 515 of Public Law 106-554. These guidelines are intended to ensure and maximize the quality of such information (i.e., its objectivity, utility, and integrity). This RP/PEIS is an information product subject to the information quality guidelines established by NOAA and DOI for this purpose. The information contained herein complies with applicable guidelines.

1.2.2 CERCLA

CERCLA, commonly known as the Superfund Act (42 U.S.C. §§ 9601–9675), was enacted by Congress in 1980 and later amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 [Public Law 99-499 (Oct. 17, 1986; 100 Stat. 1613)]. CERCLA created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites, provided for liability of persons responsible for releases of hazardous waste at these sites, and established a trust fund to provide for cleanup when no responsible party could be identified. Two types of response actions are authorized under CERCLA: short-term removals and long-term remedial response actions. Short-term removals are taken when a prompt response to a hazardous substances release is required. A long-term remedial response action is an action that permanently and significantly reduces the dangers associated with the release of hazardous substances. A long-term remedial response occurs at sites listed on EPA's NPL, such as the Kalamazoo River Superfund Site addressed in this RP/PEIS.

1.2.2.1 Superfund cleanup

The cleanup of PCBs at the Kalamazoo River Superfund Site is underway and is being coordinated by EPA. EPA's approach to the river cleanup focuses on first controlling ongoing sources of PCBs to the river, and then addressing instream sediments. EPA is also addressing PCB risk in the floodplain and formerly impounded areas.

The Kalamazoo River Superfund Site comprises six OUs as defined by EPA. Table 1.2 summarizes the status of remedial actions at each OU, which are described in further detail below.

EPA issued a Proposed Plan and Record of Decision (ROD) for OU1 in September 2015 and will review comments before making a final decision on a cleanup plan. Remedial actions at OUs 2–4 are largely complete, and a five-year review determined that the respective remedies are protective (U.S. EPA, 2012). Time-critical removal actions were completed in the Former Plainwell Impoundment (2009), Plainwell No. Dam Area (2010), and Portage Creek (2013) portions of OU5 (U.S. EPA, 2013c, 2013d). EPA is addressing contamination in the remainder of Area 1, the sediments of Portage Creek, and the Kalamazoo River downstream to the former Plainwell Dam through remedial actions under a ROD approved by EPA in September 2015 (see Figure 1.2). EPA is currently directing investigations in Areas 2, 3, and 4 of OU5. Remedial actions have yet to be determined for Areas 2 through 7. EPA issued a ROD for OU7, the Simpson Plainwell Mill site in 2015.

The following specific response actions have been taken at the Kalamazoo River Superfund Site:

- Approximately 150,000 cubic yards of PCB-containing residuals and sediments were excavated from the former Bryant Mill Pond in 1998 and 1999 and reconsolidated at OU1.

- Approximately 5,000 cubic yards of soils and residuals were excavated from the King Street Storm Sewer in June 1999 and reconsolidated at OU3, after which the area was backfilled, graded, revegetated, and stabilized with 550 feet of riprap.

- Approximately 11,000 cubic yards were excavated from the former King Mill in the fall of 1999 and reconsolidated at OU3, after which the area was backfilled, graded, and revegetated.

Table 1.2. Summary of OUs[a]

OU/area	Title	Remedial status
OU1	Allied Paper Inc. Landfill/Bryant Mill Pond Area	Remedial action not complete; anticipated after 2018
OU2	Willow Boulevard/A-Site Landfill	Remedial actions largely complete
OU3	King Highway Landfill	Remedial actions largely complete
OU4	12th Street Landfill	Remedial actions largely complete
OU5	Portage Creek and Kalamazoo River sediments[b]	
Area 1	Morrow Dam to former Plainwell Dam	Remedial action not complete; anticipated after 2018
Area 1	Former Plainwell Impoundment	Time-Critical Removal Action completed in 2009
Area 1	Plainwell No. 2 Dam Area	Time-Critical Removal Action completed in 2010
Area 1	Portage Creek	Time-Critical Removal Action completed in 2013
Area 2	Former Plainwell Dam to Otsego City Dam	Investigations ongoing; remedial action to be determined
Area 3	Otsego City Dam to Otsego Dam	Investigations ongoing; remedial action to be determined
Area 4	Otsego Dam to Trowbridge Dam	Investigations ongoing; remedial action to be determined
Area 5	Trowbridge Dam to Allegan City Dam	Remedial action to be determined
Area 6	Allegan City Dam to Lake Allegan Dam	Remedial action to be determined
Area 7	Lake Allegan Dam to Lake Michigan	Remedial action to be determined
OU7	Simpson Plainwell Mill site	Remedial action not complete; anticipated after 2015

a. The Kalamazoo River Superfund Site currently does not have an OU6. This OU designation is reserved in case of an event that source investigation activities at any of the remaining paper mill properties result in a determination that it is a source of contamination at the Kalamazoo River Superfund Site (U.S. EPA, 2012).
b. Pursuant to a 2007 EPA Administrative Order on Consent, OU5 is further broken down into seven areas (Figure 1.2 shows these areas, which are summarized in Table 1.1).

- The storm water sewers were cleared at the Plainwell, Inc. Mill in December 1995 and October 1996. Approximately 5,000 cubic yards of PCB material were removed from the mill property. The first phase of the Remedial Investigation, a cursory groundwater investigation, was completed in December 2008. Weyerhaeuser Company subsequently conducted Phase 2 of the Remedial Investigation at the Plainwell Mill in the summer of 2011, and submitted the draft Remedial Investigation report to EPA in August 2011. Additional soil and groundwater sampling as a part of the Phase 2 Remedial Investigation was completed during the summer of 2012. The revised Remedial Investigation report for the Plainwell Mill was submitted to EPA for review in November 2012 and approved in the summer of 2013. The Feasibility Study report, which evaluates various cleanup alternatives, was submitted to EPA in June 2013, and a revised Feasibility Study report was submitted to EPA in July 2014.

- Response actions were taken at OU1, including stabilization of disposal area berms along Portage Creek, removal and disposal of PCB-containing residuals and sediments and construction of a landfill cap over former residuals dewatering lagoons occupying approximately 22 acres of the Kalamazoo River Superfund Site, extraction and treatment of surface water, and implementation of an erosion control plan. A Feasibility Study of landfill capping options was released in 2014. A final Feasibility Study, a Proposed Plan, and ROD are expected in 2015.

- Approximately 12,000 cubic yards of PCB-containing sediments were consolidated at OU3, the King Highway Landfill, in the fall of 1999, after which the area was backfilled, revegetated, and stabilized with 700 feet of riprap. The 23-acre King Highway Landfill was capped and closed in 2000. Cap construction at the King Highway Landfill was completed in the fall of 2001. On June 26, 2013, MDEQ certified that the landfill remedy construction was completed and that the remedy is operating properly and successfully.

- In 1998 and 1999, interim response actions were taken at OU2. A sheet pile wall was installed at OU2 to stabilize the berm that separates the A-Site Landfill from the Kalamazoo River. Approximately 7,000 cubic yards of PCB-containing sediments were excavated along the western bank of the Willow Boulevard Landfill and from the former Olmstead Creek confluence with the Kalamazoo River and were consolidated onsite. The Willow Boulevard Landfill was then graded and temporarily capped with a 6-inch-thick sand layer and a geotextile cover. A final Remedial Investigation/Focused Feasibility Study was completed in December 2004 for OU2, and in September 2006, a ROD was signed for OU2. The ROD required consolidation of waste materials, construction of a permanent landfill cap, and installation of a groundwater monitoring system. Capping activities at Willow Boulevard/A-Site Landfill were completed in the fall of 2013. Long-term monitoring of groundwater will continue into the future.

- A final Remedial Investigation/Feasibility Study was completed in July 1997 for OU4, and the decision by the MDEQ on the remedial action to be implemented at OU4 was embodied in a final ROD, executed on September 28, 2001. EPA concurred with the remedy selected by the MDEQ. The remedy includes excavation of PCB residuals that have migrated from the 12th Street Landfill and consolidation of those residuals back into the landfill, stabilization of the side slopes of the landfill, installation of a cap, and long-term monitoring of groundwater. Landfill consolidation and capping were completed in December 2010. Landfill cap maintenance activities were conducted in the summer of 2011 and long-term monitoring of groundwater will continue into the future.

- Approximately 38,000 cubic yards of PCB-containing residuals were excavated from the Georgia-Pacific Corporation Kalamazoo Mill Lagoons between November 1998 and September 1999 and disposed of at OU3. The area was then backfilled, graded, revegetated, and stabilized with 400 feet of riprap.

- From 2007 to 2009, PCB-contaminated sediment and soil were removed from the former Plainwell Impoundment, and from 2009 to 2010, additional PCB-contaminated sediment and soil were removed from an area just upstream of downtown Plainwell.

- Approximately 24,000 cubic yards of PCB-contaminated sediment and soil were removed from Portage Creek and its floodplains between Reed Street and the confluence with the Kalamazoo River during September 2011 through November 2013.

1.2.2.2 NRDA

Regulations promulgated pursuant to Section 301(c) of CERCLA provide for the assessment of natural resource damages, known as a natural resource damage assessment or an NRDA. An NRDA is conducted to calculate the monetary cost, or “damages,” of restoring natural resources that have been injured by releases of hazardous substances. Damages to natural resources are evaluated by identifying the functions or “services” provided by the resources, determining the baseline level of the services provided by the injured resource(s) absent the releases, and quantifying the reduction in service levels as a result of the contamination.

The NRDA process follows a series of steps to identify and quantify injuries to natural resources and the services they provide from releases of hazardous substances; determine what restoration is necessary to restore, rehabilitate, replace, and/or acquire the equivalent resources and services; and implement that restoration. The Trustees are following regulations promulgated by DOI at 43 C.F.R. Part 11 to conduct the NRDA for the KRE.

The **first phase** in the NRDA process is a Preassessment Phase to evaluate whether there is sufficient evidence that natural resources have been injured to initiate an NRDA. This is typically evaluated through the preparation of a Preassessment Screen (PAS) document, which presents a review of readily available information. The Trustees developed a PAS in May 2000 (MDEQ et al., 2000a). Based on its conclusions, the Trustees determined that there was a reasonable basis for a natural resource damages claim and proceeded with the preparation of an assessment plan.

The **second phase** in the NRDA process is the Assessment Planning Phase. The Trustees decided to conduct the assessment for the KRE in stages to better coordinate with the remedial process. The Stage I assessment entailed the development of initial conclusions regarding the types and magnitudes of injury and damages resulting from hazardous substance releases into the

KRE. In Stage I, the Trustees relied on existing data and information to develop reasonable conclusions about injuries in the KRE. The Trustees may opt to pursue a more detailed Stage II assessment in the future, which may include additional focused work or study to address uncertainties identified in Stage I.

The Trustees developed the KRE Stage I assessment plan in November 2000 (MDEQ et al., 2000b), which further documented that surface water, sediment, groundwater, soils, and biological resources had been exposed to PCBs. The plan also described the approaches and methods to be used in the Stage I assessment. The Trustees indicated that PCB concentrations in the environment would be compared to regulatory standards and thresholds indicative of injuries to natural resources, and that site-specific field and laboratory studies on adverse effects would be evaluated during the assessment. The plan also noted that injuries associated with fish consumption advisories issued by the State of Michigan because of PCBs in fish tissue would be evaluated during the assessment.

The Stage I assessment plan indicated that the Trustees planned to use a method called "benefits-transfer" to estimate the natural resource damages for recreational service losses (MDEQ et al., 2000b). Benefits-transfer estimates the value of losses using a combination of site-specific information and existing information from detailed valuation studies in other locations.

The **third phase** in the NRDA process is the Assessment Phase, which is intended to determine the amount of injuries caused by the hazardous substance releases and the damages required to be able to restore natural resources to baseline conditions and compensate for past and future losses. The injury assessment relied on a variety of methodologies, including evaluations of existing data and information, site-specific scientific studies, and site-specific economic studies. The Assessment Phase is not complete, in part because EPA continues to develop remedial actions for the various OUs and sections of the Kalamazoo River Superfund Site. The Trustees prepared two Stage I assessment reports: a Stage I injury assessment (MDEQ et al., 2005a) and a Stage I economic assessment (MDEQ et al., 2005b). The Stage I assessment reports were based primarily on data known and available to the Trustees through approximately 2003, as well as some additional information the Trustees became aware of as the reports were being written in 2004 and early 2005.

In the Stage I injury assessment (MDEQ et al., 2005a), the Trustees found that approximately 2.2 to 4.4 million pounds of PCBs were released from potentially responsible party facilities into the KRE. The PCBs originated in carbonless copy paper and were discharged with the effluent and other waste from potentially responsible party facilities into Portage Creek and the Kalamazoo River. These PCBs migrated downstream and have contaminated natural resources throughout the KRE. The Stage I injury assessment also presented preliminary conclusions about the nature and extent of natural resource injuries resulting from PCB releases into the KRE. The Trustees concluded that natural resources injured in the KRE included living resources (including fish, bald eagles, mink, and invertebrates), surface water (defined by the regulations to include water and sediments), and geologic resources, namely floodplain soils. The Trustees also identified potential injuries that may require additional study, including injuries to waterfowl, other birds, and other mammals.

Additionally, as discussed in Chapter 8 of the Stage I injury assessment (MDEQ et al., 2005a), indirect injuries to natural resources have occurred and may continue to occur as a result of previous interim response actions taken to address PCB contamination in the KRE. For example, indirect injuries resulted from the construction of sheet pile walls to contain PCB contamination along the banks of the river. Construction of the sheet pile walls destroyed riparian and near-shore aquatic habitats. Indirect injuries also resulted from the inability of the State of Michigan to remove dam structures to enhance resources and human uses of the KRE because of the presence of PCBs in the sediments behind the structures. Therefore, the inability to remove the dams caused indirect injuries, including the loss of ecological and human-use services that would be present if the river were returned to a more natural, free-flowing state. These injuries are in addition to PCB toxicological injuries.

In the Stage I economic assessment (MDEQ et al., 2005b), the Trustees presented analyses of the compensable value of damages resulting from recreational fishing service losses. A quantitative estimate of recreational fishing damages resulting from PCB fish consumption advisories included \$9.4 million to \$19.8 million in past damages (through 2002, in 2001 dollars) and between \$3.6 million and \$10.9 million in future damages (from 2003 on, in 2001 dollars). The ranges depended on the consideration of alternative assumptions and uncertainty about the level of cleanup. Although the Trustees assumed that losses resulting from fish consumption advisories were and are likely to remain the largest active-use damage category for the KRE, these losses do not include all of the human-use services provided by injured resources in the KRE. Therefore, the recreational fishing damages estimate is only a portion of the total human-use service damages in the KRE.

In the Stage I economic assessment (MDEQ et al., 2005b), the Trustees also presented the results of preliminary focus groups intended to qualitatively evaluate a broader range of service losses and to inform restoration planning. The results showed clear evidence that the participants were aware of and concerned about PCB contamination in the KRE. Further, the participants were interested in restoring recreational fishing and a wide variety of other services that are affected by PCBs, such as ecological services and non-fishing recreational uses. Participants preferred PCB removal to other types of restoration programs, but were also supportive of ecologically based actions such as wetlands restoration or nonpoint source runoff control. Recreational facilities were less valued by the participants.

The Stage I economic assessment also included information on restoration planning. In the Stage I economic assessment, the Trustees compiled information on potential restoration projects based on ideas solicited from resource managers, members of the community and environmental groups, and private citizens (see Appendix A in MDEQ et al., 2005b). As part of the Stage I restoration planning process, the Trustees developed criteria for evaluating projects. These criteria are described in Section 2.3 of this document, as well as in Chapter 4 of the Stage I economic assessment. The criteria include a set of threshold criteria to determine whether potential restoration projects are acceptable.

In 2009, the Trustees issued an update to the Stage I economic assessment (Stratus Consulting, 2009), which considered new and updated data on fishing activity and fish consumption advisories, and updated the recreational fishing damage estimates to be expressed in 2009 dollars. The revised estimates in 2009 dollars included $15.3 million to $31.2 million in past damages (through 2008), and between $3.4 million and $8.6 million in future damages (from 2009 on).

The **final phase** in the NRDA process is the Post-Assessment Phase. Under the NRDA regulations at 43 C.F.R. Part 11, this phase includes developing a restoration plan, implementing restoration, and monitoring its effectiveness. The results of the assessment are used to develop a restoration plan that outlines alternative approaches to restore natural resources and services, and to compensate for their loss or impairment over time. Acceptable restoration actions include restoration, rehabilitation, replacement, or acquisition of the equivalent natural resources and services. Trustees work with the public to select the appropriate restoration projects. This RP/PEIS was developed at this time to enable the Trustees to implement restoration as opportunities arise during, and adjunct to, the remedial actions that will be continuing over many years.

1.2.2.3 Working with response agencies and potentially responsible parties

The Trustees believe it is important to coordinate NRDA restoration planning with the remedial process. EPA is the lead regulatory agency directing remediation of the Kalamazoo River Superfund Site, with support from MDEQ. The Trustees are working with these response agencies both to provide input on the remedy and to coordinate restoration actions with the remedy.

In the Stage I assessment plan, the Trustees described how information from the remedial process would be considered in developing the assessment, and in turn the Trustees would provide information about how the remedial alternatives would affect the magnitude of the injuries (MDEQ et al., 2000b). For example, a remedial action that requires artificial bank stabilization would result in a loss of habitat that would not occur from a remedial action that allows for a natural shoreline.[5] The Trustees continually work with EPA to determine specific

5. Section 8 of the Trustees' Stage I injury assessment report provides more information on indirect injuries (MDEQ et al., 2005a).

elements of proposed remedial actions that can be developed to maximize the long-term benefits to natural resources and services.

For example, the Trustees coordinated with EPA and two paper companies (Georgia-Pacific and Millennium Holdings) to plan the Former Plainwell Impoundment Time Critical Removal Action cleanup. This cleanup, which occurred between 2007 and 2009, included the removal of the Plainwell Dam and approximately 4,000 pounds of PCBs from a 1.5-mile segment of the Kalamazoo River upstream of it. Original proposals for the cleanup included leaving the aging dam in place and armoring the banks of the river to prevent erosion. The State of Michigan and the Trustees provided input that eventually led to removal of the dam and implementation of mitigation to address environmental impacts associated with response actions that included re-establishing native vegetation and following natural channel design principles (see Section 3.1.1.1). The Trustees' involvement in this process resulted in a removal action that is protective of natural resources, minimizes continuing injuries, and provides for a river that flows in its natural channel. More recently, the Trustees worked with EPA on revegetation and monitoring components of a removal action in Portage Creek (Williams, 2012) and with Georgia-Pacific on optimizing wetland contours and vegetation following removal actions near the A-Site Landfill.

1.2.2.4 Settlements and OU1 RP/EA

LyondellBasell Industries (the parent of Millennium Holdings, LLC), the primary potentially responsible party for releases of hazardous substances from the Allied Paper property, filed for bankruptcy in January 2009, and emerged from Chapter 11 bankruptcy in May 2010. As part of the bankruptcy settlement, an environmental trust was established into which $2 million was deposited to be used for restoration related to natural resource injuries at OU1.[6] While the Trustees received some additional funds from the bankruptcy claim, it is uncertain whether the bankruptcy trust may make any future payout.

The Trustees are currently moving forward with restoration to benefit natural resources injured by releases of PCBs from OU1. This restoration is funded with approximately $2 million from the bankruptcy settlement with LyondellBasell Industries. The Trustees issued a final OU1 RP/EA for this restoration in August 2013 (Stratus Consulting, 2013). The Trustees' top priorities for this funding are projects that are located in or near Portage Creek. Restoration projects proposed include dam removal and restoration of riparian, wetland, and upland habitats along Portage Creek.

6. These funds are distinct from the settlement funds received by EPA for remediation at OU1.

In 2005, the Trustees also received approximately $900,000 from a bankruptcy settlement with Plainwell, Inc. and Plainwell Holding Company. To date, the Trustees have not used these funds and may decide to use some or all of these funds toward the restoration activities described in this RP/PEIS.

These partial settlements of natural resource damage liability are intended to compensate for ecological and human use service losses.

1.3 Purpose and Need

The purpose of the proposed action is to restore or enhance ecological services in aquatic, riparian, and upland habitats of the Kalamazoo River watershed, which would benefit the types of natural resources injured by PCBs in the KRE and increase services provided to humans. This RP/PEIS describes alternative restoration categories that meet the legal requirements of the NRDA process, namely, to restore, replace, rehabilitate, or acquire the equivalent of natural resources and services injured or lost because of releases of PCBs into the KRE.

The federal actions are needed because the response actions alone will not be sufficient to compensate the public for the ecological functions and natural resource services lost due to injuries from the PCB releases that began decades ago.

1.4 Administrative Record

Documents referenced in this RP/PEIS or which otherwise formed the basis for the Trustees' decisions and actions are part of the Administrative Record. Such documents include the determination of injuries, the selection of assessment techniques, the quantification of injuries, and restoration planning activities and decisions that were prepared by and for the Trustees.

The Administrative Record for the NRDA, including documents related to this NEPA process, is maintained by MDEQ, the Lead Administrative Trustee, and can be viewed at:

Michigan Department of Environmental Quality
525 W. Allegan Street, Lansing, MI 48909
Contact: Judith Alfano – Alfanoj@michigan.gov

1.5 Document Organization

In the remainder of this document, the Trustees provide important information on their proposed restoration program.

Chapter 2 presents a description of the proposed action for the Trustees' restoration program for the Kalamazoo River NRDA. Chapter 3 presents the development and analysis of alternatives. Chapter 4 describes the environmental setting of the proposed action and the affected environment. In Chapter 5, the Trustees present an evaluation of the environmental consequences of the alternatives, and Chapter 6 describes the cumulative impacts of the alternatives when added to other past, present, and reasonably foreseeable future actions. Chapter 7 provides a summary of Trustee actions to coordinate and consult with the public and with federal and state agencies, and Chapter 8 contains a list of the preparers of this document. These chapters are followed by four appendices: Appendix A presents fish species lists for the Kalamazoo River and Portage Creek, Appendix B lists the scientific names of all species mentioned in this report, Appendix C is a summary of other regional and local restoration plans, and Appendix D presents comments on the draft RP/PEIS provided by the public and the Trustees' responses to those comments.

2. Description of the Proposed Action

This chapter presents the proposed action for the Trustees' restoration program for the Kalamazoo River NRDA. This proposed action is the preferred alternative from the alternatives analyzed in Chapter 3. In Section 2.1, the Trustees describe the elements of the proposed action. The remaining sections of this chapter include an overview of the Trustees' general programmatic restoration strategy and objectives (Section 2.2) and evaluation criteria for future projects under this program (Section 2.3), as well as an overview of restoration project monitoring and performance criteria (Section 2.4).

2.1 Proposed Action

As their restoration program for the Kalamazoo River NRDA, the Trustees propose conducting restoration actions within the Kalamazoo River watershed. This program will restore the types of natural resources and services affected by the PCB contamination and will benefit the wide suite of species that have been injured by PCBs. Other than the proposed removal of the Otsego and Otsego City dams, the specific projects that will be implemented as part of this program are not yet known. The remainder of this section presents a general description of the proposed action.

PCBs were released into and transported by the Kalamazoo River and Portage Creek, and injured sediments, the water column, and biota in and adjacent to these streams (see Section 1.1). The focus of this proposed NRDA restoration program is on restoring the types of natural resources injured and services lost as a result of the contamination. Injuries to natural resources can be offset by restoring or protecting habitats with characteristics similar to those habitats that support the injured natural resources. Restoration actions can contribute both to restoring injured resources to baseline condition, defined as the condition that the resources would be in absent the release of PCBs, and to compensating the public for interim losses to the resources and services that have occurred in the past and that will continue to occur in the future until resources are restored to baseline condition.

Restoration activities will focus on restoring or enhancing ecological services in **aquatic**, **riparian**, and **upland habitats**, as described below. Restoration of these types of habitats will benefit the types of natural resources injured by PCBs and increase services provided to humans. Restoration projects will provide ecological functions similar to, but not necessarily the same as, those injured by PCBs. Although NRDA only quantifies injuries resulting from the release of hazardous substances, restoration with NRDA funding can be used to address other types of habitat degradation that have occurred as long as the restoration would benefit the types of natural resources and services injured by the hazardous substances.

Aquatic habitat restoration or enhancement projects will focus on reestablishing or providing improved habitats for benthic invertebrates, fish, and fish-eating birds and mammals.

A number of factors have contributed to the degradation of aquatic habitat in the Kalamazoo River watershed, including the release of hazardous substances, nonpoint sources of agricultural and urban pollution, dam-related impoundments, and development activities. A combination of these factors has led to stream channelization and habitat degradation or destruction. These projects will provide restoration opportunities that will benefit the types of natural resources injured by PCBs.

The Trustees anticipate a range of possible aquatic habitat restoration activities, including:

- Restoring the hydrological connection among upland, wetland, and aquatic ecosystems
- Reestablishing stream sinuosity and/or floodplains in degraded, channelized streams or rivers
- Enhancing benthic invertebrate and fish habitat quality and diversity by introducing rock riffles, habitat structures, or vegetation
- Reestablishing native species
- Improving the connectivity of fish habitat through the removal of dams (such as the Otsego and Otsego City dams) or other barriers or the installation of fish passage structures at dams, where appropriate to do so, and with appropriate controls on invasive species.

Riparian habitat protection, restoration, or enhancement projects will focus on protecting, creating, or improving habitat along the shoreline of the Kalamazoo River and its tributaries. Riparian areas provide critical habitat for resident and migrating birds and resident mammals and shading for streams and rivers. Fallen tree limbs and plant rooting systems associated with riparian habitats can also help to improve aquatic habitat for fish.

Riparian areas in the vicinity of the Kalamazoo River and its tributaries have been affected by development-related habitat destruction and the introduction of invasive species, and are continually threatened by both of these as well. These areas of degraded habitat, therefore, provide increased potential for restoration.

The Trustees anticipate a range of possible riparian habitat restoration activities, including:

- Enhancing existing riparian habitat by restoring native vegetation and controlling invasive species
- Reestablishing native riparian vegetation in degraded or denuded areas

- Stabilizing stream banks with vegetation and other natural materials
- Reestablishing riparian habitat by removing hard structures along shorelines
- Reestablishing native species
- Extending riparian corridors for wildlife
- Protecting existing riparian forests under near-term development threats.

Upland habitat protection, restoration, or enhancement projects will focus on protecting, creating, or improving upland grassland or forests within the Kalamazoo River watershed. Forests and grasslands provide important habitat for birds and mammals and provide recreational opportunities for hikers, wildlife viewers, and hunters. Threats to grasslands and forests in the Kalamazoo River watershed are similar to those described for riparian habitat (i.e., development and invasive species).

The Trustees anticipate a range of possible restoration activities, including:

- Protecting grasslands or forests under near-term development threats
- Enhancing existing upland habitat through supplemental plantings and/or invasive species removals
- Reestablishing grassland or forest vegetation in degraded or denuded areas.

In Section 3.1, the Trustees present a detailed description of proposed categories of restoration projects and techniques they may use to implement them.

2.2 General Restoration Strategy and Objectives

The Trustees plan to significantly improve the Kalamazoo River watershed through this proposed NRDA restoration program. The overall goal of this program is to contribute to restoring and maintaining a riverine ecosystem with structural and functional components similar to those of the historical Kalamazoo River corridor, before it was degraded by dams and waste disposal. This includes improving habitat quality and enhancing the fish and wildlife of the Kalamazoo River watershed, as well as improving human-use services. In this process, the Trustees will coordinate with other regional and local restoration plans in the Kalamazoo River watershed (see Appendix C).

To guide the restoration process, the Trustees developed preliminary restoration objectives for the Kalamazoo River NRDA (Table 2.1; Stratus Consulting, 2013). The Trustees are proposing the preferred alternative (described in Section 2.1) because it allows the most flexibility to meet these objectives, both in terms of geographic locations and timing (see Section 3.3, Identification of Preferred Alternative).

Table 2.1. Preliminary restoration objectives for the Kalamazoo River NRDA (adapted from Stratus Consulting, 2013)

Ecological	1.	Create a diverse healthy ecosystem dominated by native or naturalized species (i.e., a naturally vegetated riparian zone).
	2.	Create a habitat that meets requirements for semi-aquatic species, such as turtles, amphibians, and reptiles, minimizing riprap or other hard synthetic surfaces.
	3.	Conduct restoration in the "riparian zone" that encompasses the river valley between the upland forest on each side of river (not limited to a specifically delineated floodplain).
	4.	Create riverine habitat that supports diverse, healthy mussel beds and key mussel host fish.
	5.	Restore instream movement of fish to the maximum extent possible (pursuant to the MDNR management goals).
	6.	Ensure that the habitat supports important native predators, such as mink, otter, and eagles.
	7.	Strive for continuity of restored or protected riparian and forested habitats with protected habitat at the Yankee Spring State Recreation Area near Gun Lake and Fort Custer State Recreation Areas (to preserve genetic diversity of plant and animal communities that could be threatened by habitat fragmentation).
	8.	Ensure that a variety of wetland habitats are productive and harbor a natural suite of plants and wildlife.
Geophysical/ chemical	1.	Enhance degraded areas and protect existing areas that provide important surface water/groundwater interchange (the hyporheic zone), often associated with diverse plant communities.
	2.	Restore natural river flow dynamics and channel-forming geophysical forces (such as sediment transport) to allow for a meandering channel and connected floodplain.
	3.	Provide substrate that supports ecosystem and species management objectives (not artificial or non-supporting material).
	4.	Restore water, nutrient, and particulate input and flow to be consistent with the types and amounts of input and flow associated with a healthy, vegetated watershed.
	5.	Achieve reductions in nonpoint source pollutant loading.
Recreational access	1.	Increase public access pursuant to decisions by State of Michigan land managers.
	2.	Provide access without degradation to existing (or restored) habitat.

Table 2.1. Preliminary restoration objectives for the Kalamazoo River NRDA (adapted from Stratus Consulting, 2013) (cont.)

Other restoration goals	1.	Eliminate loading of PCBs to Lake Michigan.
	2.	Eliminate the fish consumption advisory for PCBs on the Kalamazoo River.
	3.	Balance short-term habitat losses with overall restoration objectives.
	4.	Consider potential habitat uses in contained areas (e.g., prairie within established recreation areas).
	5.	Ensure that the remedy does not create problems in adjacent areas.

The Trustees will follow the guidance presented in Section 2.3, Project Evaluation Criteria, to prioritize projects when opportunities arise to implement restoration actions in conjunction with remedial actions or when funding is available to conduct restoration. Monitoring and performance of restoration projects would follow the guidance described in Section 2.4.

To fulfill the Trustees' authority under CERCLA to make the public and environment whole, NRDA restoration must benefit the natural resources and services that have been injured as a result of releases of PCBs into the KRE. This includes the type of restoration, as well as the location of restoration, in relation to the injured resources and services.

Types of restoration that will not be considered in the NRDA process include:

- Projects located outside of the Kalamazoo River watershed
- Projects within the Kalamazoo River watershed that do not benefit injured resources
- Projects that do not restore natural ecosystem processes (e.g., preferential use of hard armoring over soft engineering technology, which can limit riparian habitat, alter hydrologic and temperature regimes, affect sediment transport, and impact human use)
- Projects that are solely focused on human-use services and do not include ecological benefits.

Additionally, the Trustees anticipate that recreational and other uses will improve as an indirect consequence of ecological restoration. The Trustees prefer ecological restoration projects that include a water-related recreational or other human-use component over projects that are solely focused on improving human uses. Restoration of human use should enhance the overall services that a restoration project provides, while not conflicting with the ecological services it provides. The Trustees anticipate a range of restoration projects with human-use components. These may include:

- Observation blinds for bird watching at wetlands or riparian restoration project sites in conjunction with wetland restoration
- Raptor-nesting platforms that improve bird watching at restoration project sites
- Enhanced recreational access, including boating navigation associated with dam- or barrier-removal projects
- Public education relating to affected resources, invasive/nuisance species, Kalamazoo River history, and other natural resource topics at restoration and land-protection project sites.

2.3 Project Evaluation Criteria

Under the proposed alternative, the Trustees will evaluate and prioritize specific projects using a set of evaluation criteria. These criteria and descriptions of how they will be applied are presented in Table 2.2. These criteria are consistent with the NRDA regulations at 43 C.F.R. Part 11, and Trustee mandates and preferences. The evaluation criteria fall into two categories: threshold criteria that need to be met for a project to be considered, and additional criteria that inform the selection process by identifying desirable qualities to be considered to rank alternatives if sufficient funding is not available to execute all the acceptable actions.

2.4 Restoration Project Monitoring and Performance Criteria

Monitoring of restoration projects is necessary to (1) evaluate project effectiveness by determining whether the project has met its goals and objectives, and (2) guide adaptive management actions to keep the restoration project on a successful trajectory. Key components of a monitoring plan include the selection of monitoring parameters to track changes in project conditions, as well as the establishment of criteria by which project performance can be assessed. To be able to adequately gauge project progress and success, monitoring should be conducted at least annually for at least the first three years, and then potentially less frequently in subsequent years. Where possible, the Trustees will strive for consistency in monitoring activities across restoration sites, so that projects could be evaluated individually as well as collectively. This combined evaluation of multiple restoration projects will allow the Trustees to evaluate overall benefits from the implemented restoration actions and will help inform future restoration planning, design, and implementation.

Table 2.2. Summary of Trustee criteria for evaluating restoration projects (adapted from MDEQ et al., 2005b)

	Criteria	Description
Threshold acceptance criteria	A1: Complies with applicable and relevant federal, state, local, and tribal laws and regulations.	Projects must be legal, likely to receive required permits, and must consider public health, welfare, and the environment.
	A2: Addresses resources injured by hazardous substances or services lost because of injuries in the KRE.	Projects must restore, rehabilitate, replace, or acquire the equivalent of injured natural resources, as measured by their physical, chemical, or biological properties or their services.
	A3: Is technically feasible.	Projects must be likely to meet Trustee objectives within a reasonable period of time.
Project focus criteria	F1: Onsite restoration.	Projects most directly benefiting resources associated with the Kalamazoo River and Portage Creek are preferred over projects with less direct or more distant benefits.
	F2: Addresses/incorporates restoration of "preferred" trust resources and services, as evidenced in Trustee mandates and priorities based on law and policy.	Trustee priorities include dynamic floodplain/riverine habitats, wetlands, habitat continuity, water quality, soil/sediment quality, state game and recreation areas, threatened and endangered species, native species, important food-web species, and recreationally significant species.
	F3: Focuses restoration on resources that are unlikely to be addressed by other programs.	Ecologically valuable restorations that are often not considered because they need long-term inputs will be favored over quicker, more routine actions typically addressed by other programs.
Project implementation criteria	I1: Benefits can be measured for success by evaluation/comparison to restoration baseline (no action) condition.	Projects will be evaluated in terms of whether the benefits can be quantified and the success of the project determined.
	I2: Benefits achieved at reasonable cost (i.e., project is cost-effective).	Projects will be evaluated as to whether (1) they will achieve desired benefits at a reasonable cost, and (2) they are cost-effective relative to other projects that could provide the same or similar benefits.
	I3: Uses established, reliable methods/technologies known to have a high probability of success.	Project methodology will be evaluated for likelihood of success. 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 wholly experimental methods, research, or unproven technologies will be given lower priority.

Table 2.2. Summary of Trustee criteria for evaluating restoration projects (adapted from MDEQ et al., 2005b) (cont.)

Criteria		Description
Project implementation criteria (cont.)	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 onsite during remediation, if possible, and to avoid damage to the restoration project by any subsequent response actions.
	I5: Takes into account regional planning and federal and state policies.	Projects will be evaluated for consistency with federal and state policies. Projects should also be justified relative to existing regional plans, such as species recovery plans and fisheries management plans.
Project benefits criteria	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.
	B2: Provides benefits not being provided by other restoration projects being implemented/funded under other programs.	Preference is given to projects, or aspects of existing projects, that are not already being implemented or have no planned funding under other programs. Although the Trustees may use restoration planning efforts by other programs, preference will be given to projects that would not otherwise be implemented without NRDA restoration funds.
	B3: Aims to achieve environmental equity and environmental justice.	Low-income and ethnic populations (including Native Americans) may be affected the most by environmental pollution, and sometimes benefit the least from restoration programs. Therefore, restoration should not have disproportionately high costs or low benefits to low-income or ethnic populations. Further, where these populations experience specific service losses such as subsistence fishing, restoration programs should attempt to address these losses.
	B4: Maximizes the time over which benefits accrue.	Preference is given to projects that provide benefits sooner and for a longer period of time. Projects that incorporate resiliency to the impacts of climate change, and therefore provide longer-term benefits, are preferred.

Project monitoring could be paid for with settlement funds and included in the project budget, or monitoring could be conducted by the potentially responsible parties if they are implementing restoration projects under Trustee oversight. Funding sources for monitoring will likely vary across projects.

2.4.1 Performance criteria

Project managers will use performance criteria to measure project success and the need for adaptive management actions. Performance criteria used will directly reflect the project goals and objectives, and consist of a quantitative or clearly defined target to be reached at a specific time. The selection of performance criteria may be based either on desired conditions of the restoration site, conditions at an appropriate reference site, or on literature values. Since most restoration projects take many years to reach full function, performance criteria may include conditions representative of intermediate recovery. Establishment of interim milestones will help project managers determine if the project is improving at an acceptable pace. For potentially responsible party-implemented projects, all performance criteria and monitoring plans will be reviewed and approved by the Trustees before construction could begin.

2.4.2 Adaptive management

Adaptive management is a feedback process that relies on "learning by doing" and adjusting management actions based on improved understanding. Adaptive management allows project managers to proceed with incomplete knowledge; as uncertainties are narrowed with experience and updated information, management decisions become better informed (Walters and Holling, 1990). As described by the National Research Council (2004, p. 1-2), "Adaptive management promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing."

Adaptive management is an iterative process that involves the collection, evaluation, and feedback of information. The establishment of project goals, objectives, and performance criteria will help guide the adaptive management process. Key steps of this process include [modified from the National Research Council (2004) and Williams et al. (2009)]:

- ***Identifying goals and objectives***: With stakeholder input, goals and objectives should be established, and frequently revisited and revised.

- ***Improving knowledge of system condition and dynamics***: The collection of baseline information and the use of conceptual and/or predictive models can help improve knowledge of system condition and dynamics, evaluate project assumptions, and predict potential outcomes of restoration actions.

- ***Planning and implementing restoration actions***: Based on the established program goals and objectives, project managers should design and implement restoration actions, and establish project-specific performance criteria for which project success would be evaluated.

- ***Monitoring and evaluating system response***: Collecting and evaluating monitoring information allows project managers to track changes in natural resource conditions and determine progress toward meeting restoration objectives and performance criteria.

- ***Making adjustments if necessary***: The feedback of information helps project managers determine whether modifications or adjustments to the restoration project are necessary. New and updated information also improves future project planning, design, and implementation.

An adaptive management plan is a critical component of any restoration project. All restoration projects have some degree of uncertainty such as quantifying benefits and gauging adverse impacts, and a strategy should be developed to adjust the restoration project depending on how closely it is meeting project goals. For example, a dam removal project may be implemented with the primary goal to open a river passage to migratory and resident fish populations; however, increased flow velocities at the project site may also result in unanticipated channel and stream bank erosion. Potential management actions that could address these unintended consequences may include:

- Replanting vegetation along the stream bank

- Installing additional erosion control devices (e.g., brush mattresses, root wads) along the stream bank

- Stabilizing the channel with instream structures (e.g., boulders, logs).

For potentially responsible party-implemented projects, adaptive management plans that detail potential restoration or management actions for a site will be reviewed and approved by the Trustees prior to project implementation.

2.4.3 Monitoring parameters

Project-specific monitoring parameters should relate to the project's objectives and performance criteria, and allow project managers to gauge the progress and success of restoration actions. Monitoring parameters may be based on structural or functional characteristics, and should be able to capture anticipated changes at the restoration site. For example, potential structural and functional parameters for a dam removal project included the following (Collins et al., 2007):

- Structural parameters
    - Channel cross-sections
    - Longitudinal profile
    - Sediment grain-size distribution
    - Stream discharge
    - Structural diversity (e.g., large woody debris)
- Functional parameters
    - Survival of vegetative plantings
    - Vegetation percent cover and species composition
    - Fish abundance and species composition
    - Macro-invertebrate abundance and species composition
    - Water quality
    - Sediment quality.

Given the potential diversity of restoration actions, the selected monitoring parameters will likely vary depending on the restoration type. At a minimum, the Trustees will include monitoring of baseline pre-restoration action condition, monitoring of the impacts of the restoration project, and monitoring for compliance. However, where possible, consistency of monitoring activities should try to be achieved so that comparisons made over time are a valid reflection of the changes observed at the site and not due to changes in either the data collected or the method of data collection.

2.4.4 Reporting requirements

The Trustees will require documentation of monitoring activities for all restoration projects. At a minimum, this will include:

- A project-specific monitoring plan and performance criteria (prior to project implementation)
- An adaptive management plan (prior to project implementation)

- An as-built construction survey (once construction is complete)
- Regular monitoring reports and adaptive management actions that need to be taken.

2.4.5 Long-term stewardship

The goal of long-term stewardship is to ensure that a restoration project continues to meet its objectives for the expected lifespan of the project. Long-term stewardship that includes monitoring, maintenance, and adaptive management will be required at the restoration sites.

Long-term stewardship may include tasks such as:

- Making regularly scheduled visits to observe and document site conditions (but typically less frequent than monitoring done upon completion of the restoration project)
- Monitoring sediment composition, vegetation survival, and other parameters that indicate restoration effectiveness
- Managing invasive species and maintaining native species, including fencing or other mechanisms for native species protection
- Correcting and preventing human disturbance, such as cleanup and removal of debris at a site
- Maintaining community relations and engagement, including fostering positive relations with landowner or easement holder, neighbors, and the broader community
- Ensuring appropriate and legal public and private land uses.

These stewardship activities are particularly important given the urbanized and altered Kalamazoo River watershed, where habitat is subjected to disturbances associated with invasive species and human presence. In the absence of long-term stewardship and adaptive management, these stressors could decrease the likelihood that restoration projects would achieve desired long-term benefits.

Since the long-term function of restoration projects may require long-term stewardship, necessary long-term monitoring, maintenance, and operation costs must be included in project budgets. Funding requirements for long-term stewardship and the entity undertaking the stewardship will vary across projects. Long-term stewardship will either be implemented by the potentially responsible parties or their designees or will be paid for with NRDA funds provided by potentially responsible parties.

3. Development and Analysis of Alternatives

The Trustees considered a range of alternatives for restoring natural resources injured by PCBs in the KRE. Restoration alternatives must be appropriate for NRDA restoration and then analyzed for direct, indirect, and cumulative impacts under NEPA. The Trustees developed restoration alternatives in a step-wise fashion. First, the Trustees identified categories of restoration projects appropriate for NRDA restoration and then identified the restoration techniques for each category that may be incorporated (either singly or in combination) into specific projects in the future (see Section 3.1). Next, the Trustees developed two restoration alternatives that would apply the restoration project categories to different geographic regions. These two alternatives, plus a No Action Alternative, were carried forward for analysis (see Section 3.2). Finally, the Trustees evaluated all of the alternatives and identified a preferred alternative (see Section 3.3). The Trustees also considered additional alternatives that were not carried forward for detailed analysis (see Section 3.4).

Since this is a programmatic document, the alternatives reflect general approaches to restoring natural resources and services; the analysis in this document applies to the alternatives and the categories of restoration projects, but does not consider specific restoration projects, with the exception of two potential dam removal projects. Specific restoration projects will be evaluated against the criteria presented in Section 2.3, and additional NEPA documentation may be developed to inform the public of any impacts specific to an individual project in excess of those described here.

3.1 Restoration Project Categories

During the Stage I assessment, the Trustees solicited input on restoration projects from the public (Appendix A in MDEQ et al., 2005b). Since the Stage I assessment was published, the Trustees have continued to collect restoration project ideas from the public, in particular, in completing the RP/EA for OU1, participating in restoration planning for the Kalamazoo River Area of Concern, and reviewing public comments submitted on the *Draft Damage Assessment and Restoration Plan/Environmental Assessment for the July 25–26, 2010 Enbridge Line 6B Oil Discharges near Marshall, MI* (USFWS et al., 2015; see Section 4.1.2 for additional information on the Enbridge oil spill).

The Trustees have also reviewed watershed plans, including the Kalamazoo River Watershed Council Watershed Management Plan (Kalamazoo River Watershed Council, 2011) and the Rice Creek Watershed Management Plan (Calhoun Conservation District, 2003). The restoration categories described in this section incorporate many of the broad ideas and projects that are considered important for the environment and the public's enjoyment of the environment in the Kalamazoo River watershed.

The Trustees are interested in implementing a diverse portfolio of restoration actions that provide the maximum benefit to the resources impacted by the contamination of the KRE; these restoration actions would focus on restoring, replacing, rehabilitating, or acquiring the equivalent of natural resources and services injured or lost because of releases of PCBs into the KRE. These project categories are not related to remediation of the contamination. Although the public has expressed support for remediation of PCBs as restoration, EPA has overseen substantial removal and remedial actions (as described in Section 1.2.2.1) and the Trustees are not including additional PCB remediation projects as an additional NRDA restoration category. The restoration categories proposed by the Trustees are being evaluated for their potential to restore natural resource functions lost or impaired due to the releases of PCBs. This section outlines four restoration project categories, namely, aquatic habitat restoration (Section 3.1.1), riparian and wetland habitat restoration (Section 3.1.2), barrier removal (Section 3.1.3), and habitat conservation (Section 3.1.4), which collectively represent the primary types of restoration that the Trustees expect to implement to compensate the public for site-related hazardous substance injuries. Individual restoration projects may include components of more than one restoration category (e.g., a dam removal project, which primarily belongs to the barrier removal restoration category, may also include aquatic habitat restoration components). The Trustees could also consider other project types for inclusion; however, clear and specific benefits to natural resources and services injured by the site-related PCBs would need to be shown. The Trustees may also consider recreational service benefits associated with ecological restoration projects.

In the following sections, we describe each of the restoration project categories and respective restoration techniques that the Trustees may use when implementing projects.

3.1.1 Aquatic habitat restoration

Natural stream corridors, including associated riparian zones, support diverse habitat types and a rich biological community. Many riverine species utilize a variety of different habitat types that are created by various combinations of stream water velocity; water depths; woody structure provided by fallen trees, other woody debris, and rock; and different types of riparian and instream vegetation.

Dams, diversions, and channelization have altered the Kalamazoo River. This alteration has led to a reduced diversity of channel features and vegetative structure and a general increase in simpler, wider, and shallower channels (Wesley, 2005). Stream channelization and channel instability can cause degradation and erosion of stream banks. Restoration of stream banks can help return a river to its pre-channelized condition, reduce stream channel instability, and support a natural dynamic but stable channel that has a reduced sediment load, improved water quality, and increased quality and diversity of instream and riparian habitats. Stream bank damage affects water quality and results in habitat, land, and sediment losses. Hard structures, including road crossings, culverts, and rip-rap or other stabilizing materials, may be effective at protecting stream banks in the immediate location. However, such structures can redirect energy to unprotected stream banks and the river bottom, resulting in erosion and scouring elsewhere. A cycle of damage and artificial material to “correct” the damage thwarts the natural geomorphic processes that protect the river channel from this accelerated erosion (MDEQ et al., 2005a).

Invasive species are non-native or exotic species that harm an ecosystem, altering habitat characteristics, changing predator-prey dynamics, and competing with native species to the point that they may be lost. Invasive species may also have negative effects on human uses such as recreation and angling. Where they occur, invasive species also have potential to directly prey upon native species and damage property. Table 3.1 summarizes common invasive aquatic species in the Kalamazoo River watershed. Some of these species are currently limited to portions of the watershed and pose a threat of migration to unaffected areas. Others are already found throughout the watershed.

In the mainstem of the Kalamazoo River, the Trustees seek to reestablish stream structure and ecosystem function, especially following the removal of dams and other small barriers (see Section 3.1.3) and the remediation of contaminated sediments. The Trustees also seek to restore tributaries, improve habitat in channelized ditches or streams, and improve reaches of the mainstem that contamination has not altered.

For any given aquatic habitat restoration project, the Trustees would rely on a variety of restoration techniques. The following sections discuss specific techniques that the Trustees may use to restore stream channels (Section 3.1.1.1), restore stream banks (Section 3.1.1.2), reintroduce and enhance native aquatic species (Section 3.1.1.3), and control invasive aquatic species (Section 3.1.1.4).

3.1.1.1 Techniques for instream restoration

Channel design approaches and restoration techniques that restore natural stream functions and enhance habitat for fish and other aquatic organisms would be considered for instream restoration. To be successful and lasting, these projects often need to be accompanied by stream bank restoration and riparian restoration (see Sections 3.1.1.2 and 3.1.2.1, respectively). Along the mainstem of the Kalamazoo River, instream restoration may be most practical when done in conjunction with response actions or with a barrier removal project (Section 3.1.3).

Preferred design approaches would establish a stable channel (i.e., one that is self-sustaining and does not require intervening measures such as the use of rip-rap for erosion control). A stable channel is not a fixed channel; it can migrate over time and still be considered stable in that its overall shape and cross-sectional area do not change appreciably (USDA-NRCS, 2007). The extent of potential migration needs to be considered in the design. As a result of severe storm events or changes in the watershed, restored stream channels may aggrade or degrade over time and may still require some corrective action.

Table 3.1. Common invasive aquatic animal species in the Kalamazoo River watershed

Parasitic sea lamprey attached to a trout  Source: USFWS, 2013.	Sea lampreys are invasive predatory fish that attach to host fish and feed on their blood and bodily fluids. Michigan has had success in controlling this species; however, total elimination of the species is unlikely (USFWS, 2013). Currently, lampreys are found in the Kalamazoo River downstream of Lake Allegan Dam (Wesley, 2005).
Common carp  Source: USFWS National Digital Library.	Carp are large omnivorous invasive fish; they dislodge and consume aquatic plants and stir up sediments, harming native vegetation and water quality (Nico et al., 2015). These habitat effects have potential to harm native fish, vegetation, and waterfowl. Carp are long-lived and often thrive in contaminated areas; thus they often bioaccumulate toxins. This species is well-established throughout the Kalamazoo River watershed, reaching high densities within impoundments (Wesley, 2005).
Asian clams  Source: Photograph taken by N.M. Burkhead, USGS; Foster et al., 2012.	Invasive Asian clams are prolific, competitive, and displace native species (USFWS, 2012). The exact means of introduction and the mechanism of dispersal of Asian clams are unknown. They also damage intake pipes in power plants and water treatment facilities, causing economic damage (Foster et al., 2012). Asian clams were found throughout the Kalamazoo River watershed by 2000 (Mulcrone and Mehne, 2001).
Zebra mussels  Source: Photograph taken by A. Benson, USGS; Benson et al., 2012.	Zebra mussels first appeared in the Great Lakes in 1988. By 1990, they had dispersed to all of the Great Lakes and by 2005, this species was well-established downstream of Lake Allegan and in several lakes within the Kalamazoo River watershed (Wesley, 2005). Zebra mussels have significantly reduced the biomass of phytoplankton, which supports most aquatic life in the region. They also damage intake pipes in power plants and water treatment facilities, causing economic damage (Benson et al., 2012).

A wide variety of approaches exist for designing a natural stable channel (e.g., alluvial and threshold channel design[1]; USDA-NRCS, 2007); these can be combined to create hybrid designs. Below are detailed descriptions of two of these hybrid designs, the **two-stage channel design approach** and the **Rosgen natural channel design approach**. Other design approaches may also be appropriate for various stream reaches in the Kalamazoo River watershed. In selecting a design approach, the Trustees would consider the project goals, channel types, and site conditions and characteristics.

The Trustees may apply a **two-stage channel design approach** in channelized streams or agricultural drainage ditches to better mimic natural fluvial processes. The two-stage channel design differs from the conventional trapezoidal drainage channel design in that it has an inset channel (first stage) for the main discharge and upper benches (second stage) that function as a floodplain (Ward et al., 2011; Figure 3.1). This approach improves both drainage and ecological functions: the system is able to transport sediment more effectively, it is more self-sustaining, it has the potential to create and maintain better habitat, and it may improve water quality (Ward et al., 2004). This approach is not appropriate for natural, unaltered stream channels. A number of resources exist to assist with designing two-stage channel systems (see Ward et al., 2004, 2011; USDA-NRCS, 2007).

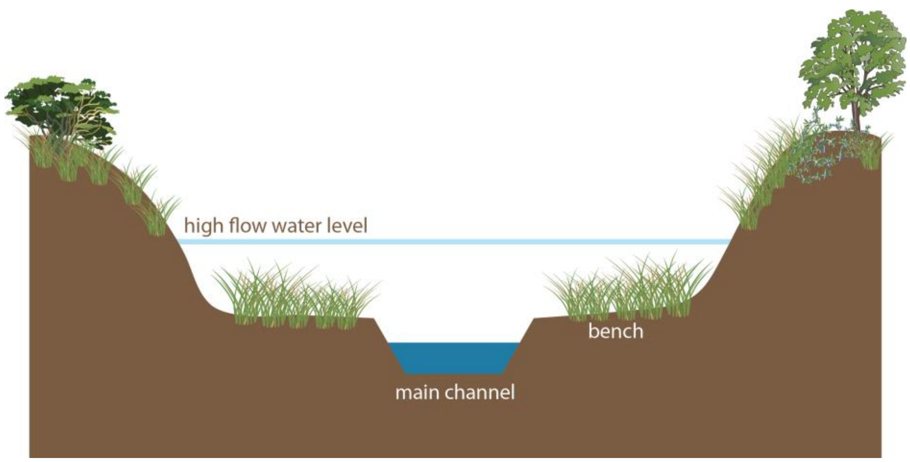


Figure 3.1. Two-stage channel design.

1. Alluvial channel design is an approach where the channel configuration is selected such that "there is an exchange of material between the inflowing sediment load and the bed and banks of the stream" (USDA-NRCS, 2007, p. 7-3), whereas threshold channel design is an approach where the channel configuration is selected such that "stress applied during design conditions is below the allowable stress for the channel boundary" (USDA-NRCS, 2007, p. 8-1).

The Trustees also may apply a **Rosgen natural channel design approach** in streams and rivers. This approach focuses on applying information on the river's flow and geomorphology to restore stream shape, size, and sinuosity. The Rosgen design approach requires that practitioners possess a strong background in geomorphology, hydrology, and engineering expertise, as well as experience in restoration implementation. The intent of this approach is to provide restoration solutions that enable the river to be self-maintaining and to create sustainable and optimal habitat conditions (USDA-NRCS, 2007). The methodology for implementing a natural channel design under the Rosgen approach is made up of eight sequential phases:

1. Define restoration goals and objectives for the stretch of stream to be restored. Common objectives include improvements in water quality and aesthetics, stream bank stability, improvements in fish habitat, increases in biological diversity, and creation of a self-maintaining system.

2. Evaluate the stream section to be restored and the respective reference reach in terms of its geomorphic characterization, hydrology, and hydraulics. This includes understanding the type of valley where the channel runs (ranging from steep V-shaped canyons to broad flat deltas); the type of channel (describing factors such as the degree of entrenchment, the ratio of width to depth, the sinuosity, the slope, and the channel material); and the hydrology (including information on velocity, flow durations, and flood-frequency data).

3. Conduct a watershed or river assessment to determine historical and current river channel conditions, as well as potential future conditions.

4. Evaluate opportunities for natural recovery solutions (e.g., passive restoration through changes in land use management, and flood control measures).

5. If natural recovery cannot meet restoration goals and objectives, develop a natural channel design based on the Rosgen geomorphic channel design methodology and the information gathered in the previous phases (see USDA-NRCS, 2007).

6. Select river stabilization and enhancement structures or methodologies that will improve grade control and stabilize the stream bank (structures and methodologies must be compatible with the curvature and streambed features of the river system, and generally use native materials such as boulders, logs, root wads, or vegetation).

7. Implement the design created in previous phases (note that the design layout is crucial and may include incorporating onsite adjustments as needed; identifying staging areas for materials, structure placement, and controls for water quality; and providing continuous oversight of construction).

8. Design and implement a monitoring and maintenance plan.

Under any design approach, the Trustees may use a range of instream restoration techniques. Table 3.2 illustrates several techniques that the Trustees may select to support instream restoration in the Kalamazoo River watershed. The appropriate technique or combination of techniques would depend on stream characteristics and project goals.

Table 3.2. Potential instream restoration techniques[a]

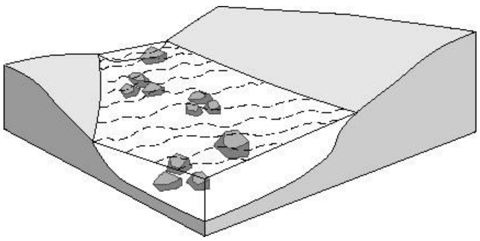
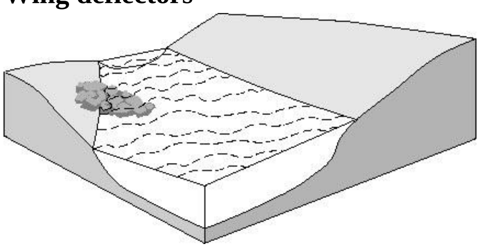
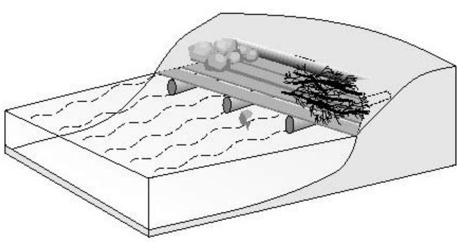
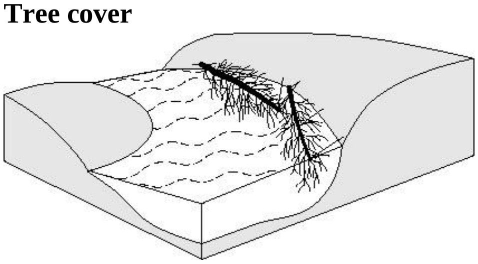
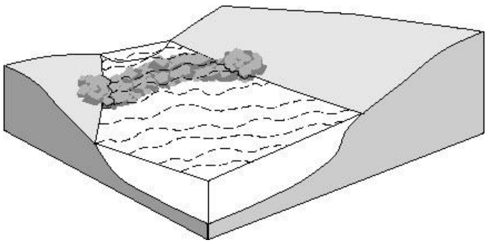
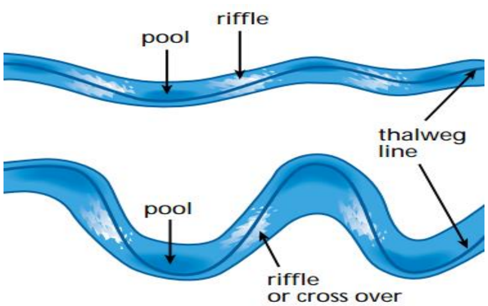
Boulder clusters  Source: FISRWG, 1998, Appendix A.	Strategically placing boulders or large woody structures in streams can reduce or diversify water velocity, improve fish and aquatic habitats, and improve aquatic benthic diversity. This technique is most effective in wide, shallow streams with gravel or rubble beds. These instream placements may also be combined with structural changes to the streambed to increase pool frequency or depth, thereby creating a larger area of more diverse habitat.
Wing deflectors  Source: FISRWG, 1998, Appendix A.	Wing deflectors are solid triangular structures of river stone, logs, or woody debris that extend from the stream bank but do not reach across the entire channel. These structures may be installed as single deflectors, as shown, or as double deflectors. They are used to increase flow velocities, direct flow toward or away from the bank, create scour pools, or restore meanders in altered channels that are wide, shallow, and stagnant.
Log/brush/rock shelters  Source: FISRWG, 1998, Appendix A.	A combination of logs, brush, and rocks may be attached to the lower portion of a stream bank to provide cover for fish and aquatic species, increase shade and cooling effects, and create habitat for aquatic organisms. This technique is typically most appropriate where streams are stable and not experiencing bank erosion but are considered to be lacking in structural diversity.
Tree cover  Source: FISRWG, 1998, Appendix A.	Development and management of a woody structure over the channel and along the riparian area (e.g., trees, shrubs, other riparian vegetation) can maintain cooler stream temperatures. In addition, felled woody debris and log or rock structures in the stream channel can provide aquatic organisms with substrate and habitat, direct flows, and increase seedbed deposition and drift catchment. This technique also provides stream bank habitat and erosion-control benefits.

Table 3.2. Potential instream restoration techniques (cont.)

Rock weirs  Source: FISRWG, 1998, Appendix A.	Rock structures placed across the stream channel create hydrologic diversity and pool habitat, slow stream flow, and stabilize or protect stream banks. Rock weirs can provide fish passage; however, they can also act as a low-flow fish barrier.
Pools and riffles  Source: FISRWG, 1998.	Pools and riffles create hydrologic diversity; pools are deeper areas that form on the outside bank of bends, whereas riffles are steeper and shallower areas that form in the straight portion of the channel. Coarser sediment particles are found in riffle areas, while smaller particles occur in pools.

a. This table illustrates a few of the instream restoration techniques that use soft engineering and may be appropriate in the Kalamazoo River watershed. Other techniques may be used depending on the specifics of a site. For a more comprehensive list, see FISRWG, 1998.

Many of the instream restoration techniques described here would require the excavation of sediment and rock, logs, trees, and human-created materials like riprap or pilings. They may also require the placement of rocks and boulders, trees, and logs. This type of work may require the use of vehicles, heavy mechanical equipment, and power tools. Vehicles and heavy equipment that may be used include dredges, barges, bulldozers, graders, backhoes, cranes, dump trucks, and flatbed trucks. Smaller equipment could include chainsaws, power augers, and bobcats. This equipment would need to be transported to the restoration sites by barge from existing commercial facilities, over land on established transportation routes such as roads and highways, or over temporary access roads constructed to facilitate access to the restoration sites. The Trustees recognize that each of these methods would entail environmental impacts, and consistent with the criteria identified above, prefer to access the project sites with barges from existing commercial facilities or over land on established transportation routes such as roads and highways. The Trustees will strive to avoid the use of heavy equipment in stream channels whenever possible.

These restoration techniques would require the designation of a work zone and a staging area (FISRWG, 1998). Some instream restoration actions would require the use of areas for temporary storage of materials removed from instream locations, and for temporary storage of new materials, such as boulders, trees, and rocks, which would be used for restoration actions. To the extent possible, laydown areas for these materials would be established in areas that are already disturbed and are suitably zoned for construction actions. Laydown and storage areas would be returned to the conditions that existed prior to use after all restoration actions are completed. The Trustees would use fencing or other markers to delineate the work zone and contain the impact footprint to the designated areas.

In some areas, instream restoration may generate dredge spoils or human-made materials that would require off-site disposal. However, some instream restoration may not generate waste. At this time, the volume of dredge spoils and other waste is not known, but any spoils will be disposed of in existing disposal facilities, licensed for the types of materials that would be deposited. Material for restoration such as boulders and stones for weirs would be purchased from local rock quarries. To the greatest extent possible, material extracted from restoration sites would be reused in stream recontouring actions. Wood and trees for shelters and cover would be locally sourced, and use of new materials will be avoided if possible.

3.1.1.2 Techniques for stream bank restoration

After the removal of a dam, the local water level upstream is lowered, potentially causing the river to cut into unconsolidated sediment, which increases erosion upstream (DeGraff and Evans, 2013). Downstream, a dam removal causes increased flow and sediment-carrying capacity that can lead to incision of stream banks. To prevent excessive erosion after a dam removal and to further facilitate the restoration of the Kalamazoo River, the Trustees intend to use several stream bank stabilization techniques where necessary. The Trustees propose to use soft engineering approaches in restoration projects (described below) and, where appropriate, remove and replace hard stream bank structures (e.g., rip-rap, concrete, sheet pile) with more natural banks. These more natural banks would allow the riparian zone to build up, which filters pollutants from runoff and traps sediments (Caulk et al., 2000). Additionally, soft engineering techniques tend to absorb energy from the stream rather than reflect it downstream, and thus reduce stream-flow velocities and erosive forces downstream (Gordon et al., 2004). These techniques rely on natural materials along the stream bank that, if constructed properly, also create dynamic stream bank refuge habitat for fish and other aquatic species as well as allowing access to the stream channel by wildlife (Donat, 1995). The use of soft-engineering techniques also develops multi-purpose stream banks, allowing for greater public access to the riverside and increased recreational opportunities (Caulk et al., 2000). Lastly, reducing excessive erosion can help reduce, limit, or avoid the process of stream aggradation (i.e., when the elevation of the streambed rises), leading to a decrease in channel capacity, a decline in fish habitat, and elevated stream temperatures (U.S. EPA, 2011).

Table 3.3 illustrates several techniques that the Trustees may use to support stream bank restoration in the Kalamazoo River watershed. As appropriate, the Trustees propose to employ these or similar techniques as part of an integrated natural channel restoration approach. A mix of engineering techniques would be chosen to create non-uniformity in order to preserve the natural variability of the river (Gordon et al., 2004). The Trustees would appropriately identify and select methods of stream bank restoration based on site investigations and engineering analyses, including technical analysis of flows and soils, as well as consideration of site access, maintenance, and availability of materials.

Table 3.3. Potential stream bank restoration techniques[a]

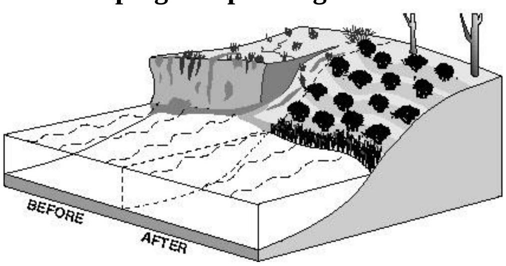
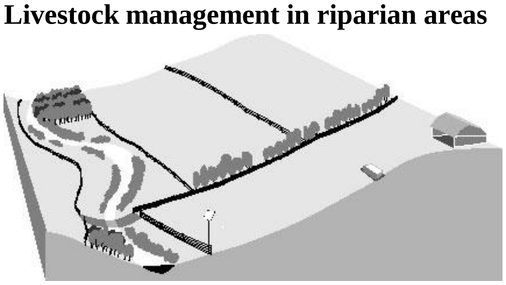
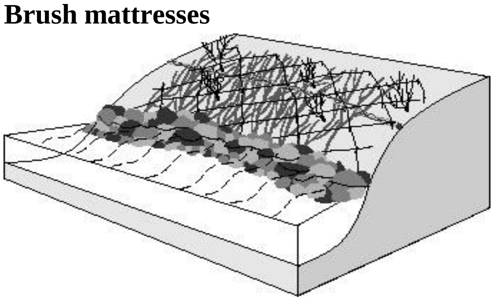
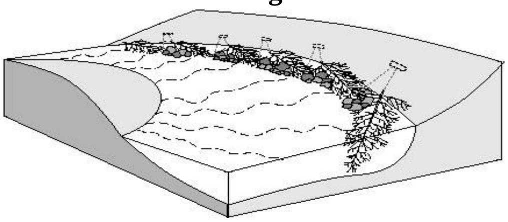
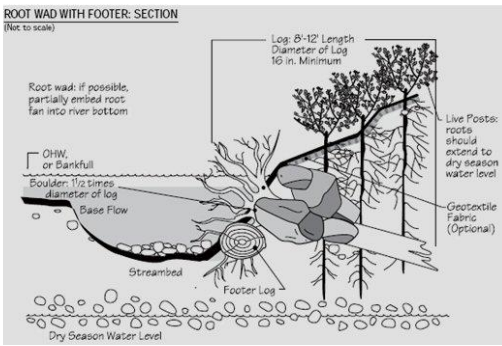
Bank shaping and plantings  Source: FISRWG, 1998, Appendix A.	Where there are low to moderate levels of erosion, bank shaping and planting may be the most appropriate technique to restore banks. This technique includes regrading the bank to a stable slope, placing soil and other materials needed for sustained plant growth, and establishing appropriate plant species. Bank shaping and plantings may be combined with other techniques if stream flows exceed the tolerable range for the newly established plant species.
Livestock management in riparian areas  Source: FISRWG, 1998, Appendix A.	Livestock use of streams for water, forage, and shade can lead to overgrazing or trampling of stream banks. This overuse may reduce stream bank stability and riparian vegetation, resulting in declining water quality and eroded soil. In locations where livestock grazing is negatively affecting the stream corridor, managing grazing or eliminating livestock from streams and other riparian areas can improve habitat. Livestock access to streams may be reduced or eliminated through a number of best management practices, including fencing, alternative watering systems, and stabilized livestock stream crossings (Allegan Conservation District, 2009).
Brush mattresses  Source: FISRWG, 1998, Appendix A.	A brush mattress is an effective technique for slowing the current and reducing bank erosion. It can also allow the water to deposit silt and sand along the bank, creating a seedbed along the river and providing coverage for fish and wildlife. Materials may include live branch cuttings, live or dead stakes, fascines (i.e., bundles of dormant, live cuttings bound together in a cylindrical form), and soil. The dormant branches are laid in a crisscross pattern and secured with dead posts or twine. The live cuttings and fascines may be installed for additional protection and vegetation.

Table 3.3. Potential stream bank restoration techniques[a] (cont.)

Anchored trees and logs  Source: FISRWG, 1998, Appendix A.	Whole tree trunks can also be anchored to the stream bank to slow stream flows and decrease erosion. This technique can be used in conjunction with stones to ensure stability while reducing stream flow. The logs may eventually rot, creating a dynamic natural bank that allows for refuge habitats. This technique requires that trees and logs are secure and will not break away and cause downstream damage.
Geotextiles  Source: Indiana General Assembly, 2012.	Use of natural, biodegradable materials, such as jute or coconut fiber, can control erosion; when combined with seeding or placing plants through slits in the fabric, this technique can rebuild and vegetate eroded stream banks.
Improving bottlenecks caused by undersized culverts  Source: ACEC, 2011.	Undersized culverts can cause water to back up and flood upstream areas, often scouring the streambed and banks. Improvements can include widening culverts or replacing culverts with larger box culverts or bridges. There may also be opportunities to stabilize the stream hydrology to prevent sediment from blocking culverts. For example, the Southwest Michigan Regional Airport's runway extension required rerouting Sand Creek with a 600-foot-long culvert. Fish likely could not swim the entire length of the culvert. The culvert was designed as a meandering, two-stage channel, with resting pools and riffles within the culvert (see photograph at left). For a discussion on barrier removal and retrofits, see Section 3.1.3.

a. This table illustrates a few of the stream bank restoration techniques that use soft engineering and may be appropriate in the Kalamazoo River watershed. Other techniques may be used depending on the specifics of a site. For a more comprehensive list, see FISRWG, 1998.

The stream bank restoration techniques discussed here would require the use of similar materials and equipment as the instream restoration techniques (described in Section 3.1.1.1) and would likely be conducted in any given location at the same time as instream restoration. This would minimize the duration of impacts and reduce the amount of transportation required to bring in materials and dispose of waste. Wherever possible, native plants and seeds for revegetation would be procured from local sources or acquired from the site itself by collecting and salvaging cuttings and plants in a sustainable manner that would not harm existing populations (Gordon et al., 2004). The Trustees may use non-native species of annual cover crops to help stabilize restoration sites while the native vegetation gets established, but would not use invasive species for revegetation. Areas of focus for bank restoration measures include the outside banks of existing bends and bank areas that existed with the former channel areas (URS, 2011).

3.1.1.3 Techniques for reintroduction and enhancement of native aquatic species

The Trustees may take actions to reintroduce or enhance existing populations of native aquatic species, including fish, mussels, reptiles, and other species. The productivity and survival of native animal species may be improved using a variety of techniques, including stocking and streamside rearing. To be successful, these techniques or management tools would need to be conducted in areas with suitable habitat to support the species.

Stocking is currently the main direct aquatic species management tool used in the Kalamazoo River for some species of fish (Wesley, 2005; Hayes and Caroffino, 2012). Stocking entails raising aquatic species in a hatchery or other facility and releasing them into a suitable habitat. **Streamside rearing** is an alternate method of stocking, designed to improve the chances that migratory species will return to the target river, by allowing the individuals to "imprint" to the river's water. It typically involves collecting wild eggs or larvae, rearing them in a facility that uses water pumped directly from the target river, and then releasing the species (Smith, 2010). Stocking and streamside rearing can protect juvenile species from predation, releasing the animals in locations appropriate to their life stage.

The enhancement of freshwater mussels and lake sturgeon are priorities in the Kalamazoo River. Specific approaches for enhancing these species are described below.

- Twenty-three species of mussels have been documented in the Kalamazoo River watershed (Mulcrone and Mehne, 2001; Wesley, 2005). Mussels are indicator species that can provide information about ecosystem health and water quality. However, their populations are declining as a result of habitat degradation, river connectivity, and pressure from exotic species (e.g., zebra mussels). To reduce predation during early life stages, mussels can be propagated in laboratories or along the stream and then deployed to rivers and streams. Mussel silos and bunkers are two systems that can be used to rear mussels instream. Mussel silos (see Figure 3.2) are portable cage systems that provide mussels with a place to grow; they can be deployed in rivers on coarse substrate so that water enters from underneath. Mussel bunkers are larger, less portable cage systems (Barnhart, 2008).

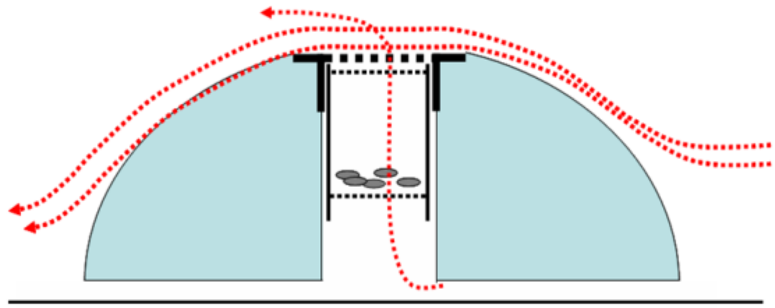


Figure 3.2. Diagram of a mussel silo.

Source: Barnhart, 2008.

- Lake sturgeon are found in the lower mainstem segment of the Kalamazoo River, downstream of the Lake Allegan Dam; however, reduced access to spawning habitat continues to limit their success. Inadequate gravel and cobble substrate habitat in this reach further limits the spawning success of lake sturgeon (Smith, 2010). The Michigan Lake Sturgeon Rehabilitation Strategy identifies the Kalamazoo River as a priority area for rehabilitation of lake sturgeon (Hayes and Caroffino, 2012). Because of the long lifecycle of lake sturgeon, stocking may be an appropriate management tool to increase the abundance and improve the age structure of the species (Hayes and Caroffino, 2012). In addition, lake sturgeon streamside rearing facilities have been successful in the Great Lakes region (Mann, 2013) and are being implemented in the Kalamazoo River (USFWS, 2011). Streamside rearing may minimize the mixing of distinct populations of sturgeon by imprinting them to return to the target stream.

  Native mussels and sturgeon would be acquired from local sources that are already rearing these species. Reintroduction and enhancement of native species would likely require minimal use of vehicles to transport the organisms to reintroduction areas, but would not require the use of heavy equipment, staging areas, or the production of waste that would require special handling.

3.1.1.4 Techniques for controlling invasive aquatic species

The State of Michigan has an aquatic invasive species control plan to manage species such as those described in Table 3.1 (MDNR, 2013). Its goals are to (1) prevent introductions of aquatic invasive species to Michigan waters, (2) limit the dispersal of established populations of aquatic invasive species throughout Michigan waters, (3) develop a statewide interagency early detection and rapid response program to address new invasions of aquatic invasive species, and (4) manage and control aquatic invasive species to minimize the harmful environmental, economic, and public health effects resulting from established populations (MDNR, 2013).

Given that invasive animal species are difficult to eliminate once established, control techniques generally focus on preventing and limiting dispersal from affected to unaffected habitats or reducing and controlling current populations to minimize environmental and property damages (MDNR, 2013). Below are examples of control techniques that are currently practiced or are potentially useful in the Kalamazoo River watershed and that the Trustees could implement.

Invasive species can invade and disperse within the Kalamazoo River watershed through three general pathways: boating, habitat alteration, and the use and trade of organisms (MDNR, 2013). The best techniques for preventing and limiting dispersal of these species from affected to unaffected habitats depend on the target species. For example, the installation of mechanical and electrical barriers can limit sea lamprey migration and spawning to lower tributary reaches (USFWS, 2013). Currently, the Lake Allegan Dam is an effective barrier for sea lamprey migration up the Kalamazoo River. In addition, mechanical management of Asian clams, such as suction dredging or covering populations with plastic sheets to reduce oxygen and food availability, can be effective in discrete areas with high densities (Wittmann et al., 2012).

A combination of control efforts, adaptive management, and restoration can minimize the impact of invasive animal species on habitats and properties (MDNR, 2013). For example, common carp control techniques involve reducing established populations. Biological control techniques for common carp may include fluctuating water levels to disrupt spawning and introducing piscivorous species, such as pike or bass, which could prey upon smaller-sized carp. Another example of control efforts addresses sea lamprey: adult fish may be trapped and captured at barriers during their spawning migrations and either euthanized or sterilized prior to spawning. Trapping success may be high when traps are strategically placed or enhanced using pheromones as attractants.

These invasive-species control techniques would require minimal use of motor vehicles and boats for transportation, but would likely not require the use of heavy equipment or staging areas. If adult fish from the Kalamazoo River are euthanized, they would be properly disposed of in existing, licensed disposal facilities.

3.1.2 Riparian and wetland habitat restoration

The riparian zone encompasses the river valley between the upland forest habitat on each side of river and is not limited to the floodplain. Riparian habitat is the interface between land and water and can occur where water is perennial, intermittent, or ephemeral. Typically, riparian ecosystems support a greater diversity of plants and animals than upland ecosystems. Many wildlife species depend on riparian habitat at some time during their lifecycles. Riparian restoration includes wetland, floodplain, and off-channel habitat restoration. Restoration techniques for these unique riparian habitat types are similar; therefore, they have been combined in this section. Following is a brief description of these habitats and potential restoration approaches.

Wetlands provide many benefits, including habitat for a broad range of fish and wildlife species, retention of floodwater, water-quality protection and replenishment of groundwater supplies, and reduced soil erosion. The Kalamazoo River watershed supports several dispersed wetland habitats, most of which are found in the headwaters of the Kalamazoo River (for additional information, see Chapter 4; Great Lakes Commission, 2000). In 2001, the Trustees conducted public outreach in Kalamazoo, Michigan, to gauge the public perception and value of restoration planning for the Kalamazoo River NRDA (MDEQ et al., 2005b). Results of this outreach indicated a general awareness of the importance of wetlands and a desire for wetland preservation and restoration projects. Residents were in favor of preserving and enhancing existing wetlands over restoring wetlands that had been drained previously (MDEQ et al., 2005b).

Floodplains are a natural extension of the river during high-flow events. Floodplains are extremely valuable in storing floodwater, filtering runoff, facilitating sediment deposition, and providing important wildlife habitat. Broad floodplains are a characteristic of the lower Kalamazoo River watershed. Bottomland hardwood forest and marshy wetlands originally dominated these floodplains. Although many parts of the floodplains in the watershed have been altered, large areas of the floodplains are still forested and are well-connected to rivers and streams (e.g., Allegan State Game Area and Fort Custer State Recreation Area; Allegan Conservation District, 2009; Kalamazoo River Watershed Council, 2011).

Off-channel aquatic features are portions of the river and its floodplains that have surface water but that are separate from the river channel for at least part of the year. These areas have important ecological functions for large rivers and provide habitat for organisms. Species may seek off-channel habitat for food, to escape fast water, or to avoid predation.

In addition, off-channel habitats may have unique physical or water-quality characteristics that attract mussels, birds, and amphibians. Off-channel features may include side channels, oxbow lakes, vernal pools, and ponds. Vernal pools, or temporary pools of water, provide distinctive habitat and serve as breeding ponds for aquatic invertebrates and amphibians (Kost et al., 2007).

Riparian habitats in the Kalamazoo River watershed have been affected by the conversion of land to agricultural, industrial, residential, and recreational uses; nutrient loading from agriculture; exotic species invasion; dumping and illegal filling; and chemical pollution. Invasive plant species are non-native or exotic species that tend to advance and dominate sites rapidly; their presence diminishes habitat quality and has ecological, social, or economic costs (Higman and Campbell, 2009). In the Kalamazoo River watershed, invasive species, such as purple loosestrife, *Phragmites* (common reed), glossy buckthorn, and narrow-leaved cattail, may displace native species that are more valuable to wildlife; simplify and disrupt food web systems;

and diminish recreational opportunities such as bird watching, hiking, and fishing (Higman and Campbell, 2009). Table 3.4 summarizes common invasive plant species in the Kalamazoo River watershed.

Table 3.4. Common invasive plant species in the Kalamazoo River watershed

<table>
<tr><td>Purple loosestrife

Source: Photograph taken by B.S. Walters; Reznicek et al., 2011.</td><td>Purple loosestrife is native to Europe and Asia and likely came to the United States in the early 1800s on ship ballasts. It is an invasive perennial that has colonized wetland habitats in the United States, including along the Kalamazoo River. Because of its aggressive growth in wetland ecosystems, purple loosestrife out-competes native vegetation and alters the food supply for wildlife (Stackpoole, 1997; Blossey, 2002).</td></tr>
<tr><td>Phragmites

Source: Photograph taken by L. Wallis; Reznicek et al., 2011.</td><td>Two subspecies of Phragmites are found in Michigan: a native subspecies and an introduced subspecies. The introduced subspecies was first collected in Michigan in 1979 and is concentrated in the developed region of southern Michigan and around Saginaw Bay. The aggressive growth of the introduced subspecies makes it frequent in ditches, urban wetlands, and other disturbed habitats (Reznicek et al., 2011).</td></tr>
<tr><td>Narrow-leaved cattail

Source: Photograph taken by B.S. Walters; Reznicek et al., 2011.</td><td>Narrow-leaved cattail is a non-native wetland plant that crowds out the native variety, broad-leaved cattail, and reduces wetland biodiversity. Narrow-leaved cattail can also hybridize with the native cattail to produce an invasive hybrid plant, which can also become a dominant species and limit biodiversity in wetland habitats (Reznicek et al., 2011).</td></tr>
</table>

Table 3.4. Common invasive plant species in the Kalamazoo River watershed (cont.)

Glossy buckthorn  Source: Photograph taken by B.S. Walters; Reznicek et al., 2011.	Glossy buckthorn is native to Europe and Asia and was first collected in Michigan in 1934. The aggressive growth of this species has made it a pest in wetland habitats, including bogs and fens (Reznicek et al., 2011).
Garlic mustard  Source: Photograph taken by D. Dister; Reznicek et al., 2011.	Garlic mustard is a native of Europe and Asia. It often grows along roads, in moist forests, and in swamps (Reznicek et al., 2011).

For any given riparian or wetland habitat restoration project, the Trustees would rely on a variety of restoration techniques. The following sections discuss specific techniques that the Trustees may use to restore and enhance riparian and wetland habitats (Section 3.1.2.1), reintroduce and enhance native species (Sections 3.1.2.2 and 3.1.2.3), and control invasive species (Section 3.1.2.4).

3.1.2.1 Techniques for riparian and wetland restoration

Riparian habitat restoration and enhancement aims to restore the ecological functions and species diversity of degraded wetland, floodplain, and off-channel habitats. Depending on the habitat condition, the project goal may be to return the riparian habitat to historical or pre-disturbance conditions. Actions may include restoration of natural hydrology, reintroduction of periodic natural disturbances, protection of existing vegetation, reestablishment of native vegetation and animal species, and control of invasive species.

Restoration of natural hydrologic processes can improve surface and groundwater resources for wetlands, including prairie fens (Kost and Hyde, 2009); floodplains; and off-channel habitat. Restoration may include best management practices, such as managing or eliminating livestock grazing, planting or restoring native vegetation buffer strips between riparian and agricultural or residential lands, and restoring natural meanders to streams. Restoring oxbow cutoffs, removing fill to create vernal pools, and recreating floodplain contours can improve natural hydrologic processes as the river and floodplain interact.

Respondents to the 2001 public outreach effort (MDEQ et al., 2005b) considered restoring previously drained wetland riparian habitats to be less desirable than preserving existing wetlands; however, there may be instances where this type of restoration would be appropriate for wetlands or floodplains in the Kalamazoo River watershed. The Trustees may explore restoration actions that include breaking drain tiles or plugging ditches that drain riparian areas for agriculture or other development, and regrading land to restore the historical hydrologic connectivity between the river and riparian habitat. Previously drained wetlands have been identified in sub-watersheds of the Kalamazoo River (FTC&H, 2004; Allegan Conservation District, 2009).

Natural disturbances (e.g., fires and flooding) are an important component of wetland and forested floodplain habitats in the Kalamazoo River watershed (Kost et al., 2007; Bassett, 2011). **Reintroduction of periodic disturbances** to wetlands (e.g., prescribed burns, cutting and mowing woody vegetation), particularly prairie fen habitats and forested floodplains, can maintain open conditions, facilitate nutrient cycling, and maintain community structure. In the absence of disturbance, invasive species and tall trees or shrubs can dominate the riparian habitat and crowd out native species. In prairie fen wetland habitat, use of prescribed fire as a management tool should include setting aside significant portions of fen to remain unburned in any given year; this helps lessen the effects on fire-sensitive species (Kost et al., 2007).

Removing large trees may be necessary in areas where PCBs are excavated during remedial actions. To preserve the diverse age structure of trees in riparian habitat near these removal areas, **protection of large trees and other vegetation** is a priority. A potential threat to remaining trees is beaver felling, which is a natural process. However, in priority areas, applying latex paint and sand to the bark of selected large trees near their base, or creating cylindrical cages around the base of trees, can provide protection from undesirable beaver activity for a period of time (BWW, Undated; Materkowski, Undated).

The riparian and wetland restoration techniques discussed here would require the use of similar materials and equipment as instream restoration techniques (described in Section 3.1.1.1), and would likely be conducted in any given location at the same time as any instream and stream bank restoration to minimize the duration of impacts and reduce the amount of transportation required to bring in materials and dispose of waste. Periodic prescribed burns would require the use of ignition agents (typically drip torches with a mixture of diesel and gasoline) under controlled conditions, vehicles, and water pumps and hoses for fire suppression, and would generate smoke (McPherson et al., 1986). Cutting and mowing disturbances would require the use of mowers as well as chainsaws and large clippers.

3.1.2.2 Techniques for reintroduction and enhancement of native plants

Native plants are an important component of ecosystem health and function. Healthy native plant communities help prevent invasive species from becoming established; plant community restoration is often conducted in conjunction with the removal of invasives. Revegetation can reduce erosion and instream sediment loading, provide instream shade and inputs of food and nutrients, filter contaminants, and provide habitat (FISRWG, 1998). Restoring natural plant communities within the stream corridor is a priority for the Trustees. Thus, the Trustees propose to incorporate native species revegetation as part of other restoration actions, and may also conduct restoration projects focused specifically on revegetation with native species.

Generally, native species revegetation involves selecting a combination of plant and tree species that are appropriate for a site's conditions. Native seeds and plants can be collected locally or sourced from a nursery. It is extremely difficult to establish the full range of native species at a given location. A common approach is to plant the dominant species of a community and those that are unlikely to colonize readily (FISRWG, 1998). Many restoration projects first focus on reestablishing native trees, and then on introducing understory species once the trees have sufficiently matured. In environments where water is limited, irrigating the plants can improve survival rates. Additionally, protecting new plantings from deer and other herbivores until they are well-established can help improve survival rates (FISRWG, 1998).

Revegetation of native plants can speed the recovery of riparian habitat, provide a buffer against surface runoff and erosion, and stabilize stream channels. Successful revegetation may be achieved through native seed collection and planting, as well as live plantings of native species. Revegetation may also include planting larger trees and a variety of plant species to establish different age and size structures. The best approach depends on the specific riparian habitat and historical and desired conditions.

Reintroduction and enhancement of native species would likely require minimal use of vehicles to transport the organisms to reintroduction areas, but are not likely to require the use of heavy equipment, staging areas, or the production of waste that would require special handling.

3.1.2.3 Techniques for reintroduction and enhancement of native animals

The Trustees may take actions to reintroduce or enhance existing populations of native animal species, including birds, bats, reptiles, and other species. The productivity and survival of native animal species that use riparian and wetland habitats may be improved using a variety of techniques, including the construction of **artificial structures**, described below.

Artificial nest structures can be used where natural nesting habitat for avian and bat species is limited. Such structures might include raptor-nesting platforms, duck or bird nesting boxes or baskets, or bat houses. Structures are typically designed to meet the needs of the target species; however, they may also provide roosting and winter cover for non-target species (NRCS, 2001). In designing and implementing an artificial nest structure, the Trustees would consider location, position, box design, and building and nesting materials to ensure nest success and minimize predation and competition (Ducks Unlimited, 2005). Artificial nesting structures are most effective when they are in close proximity to reliable sources of food and water, adequate cover, and other habitat elements of the target species (NRCS, 2001). Artificial nest structures require routine maintenance, including annual replacement of nesting materials (Ducks Unlimited, 2005).

Artificial hibernation structures for snakes, bats, or other hibernating animals can provide refuge during the cold months of winter and the extreme heat of summer. Artificial hibernation structures are typically underground chambers or protective coverings made of rocks, logs, and other natural or manmade materials. For snakes, hibernation structures must be below the frost line and close to the water table during cold, dry winters. In the Kalamazoo River watershed, these structures may be beneficial for the eastern massasauga snake.

Reintroduction and enhancement of native species would likely require minimal use of vehicles to transport the structures to restoration areas, but are not likely to require the use of heavy equipment, staging areas, or the production of waste that would require special handling.

3.1.2.4 Techniques for controlling invasive species

The State of Michigan has developed an invasive species management plan specific to vegetative invasive species such as those described in Table 3.4 (Higman and Campbell, 2009). The goals of this plan are to (1) improve inter-agency coordination; (2) build management and treatment options on a foundation supported by research; (3) prevent introduction and spread; (4) develop early detection and rapid response protocols; (5) control, manage, and restore existing established populations; and (6) improve education and outreach (Higman and Campbell, 2009). Techniques for controlling invasive plant species include preventing or limiting potential invaders from a habitat and controlling current populations.

Preventing or limiting potential invaders in high-value sites may be the most cost-effective approach to invasive plant species. Seeds and plant fragments spread to new areas on people and animals; on boats and other equipment; and in soils, fill, and mulch. Educating people and limiting such pathways can help minimize the spread of invasive plants. Another way to prevent the spread of invasive plants is to monitor for common species and eradicate them before they can establish.

Although few invasive plants can be completely eradicated, infestations can be minimized by **controlling current populations**. Techniques for invasive plant control include the use of biological methods, fire, mechanical controls, chemicals to stop plant reproduction and dispersal, and other methods:

- Biological control techniques use natural enemies of an invasive species to regulate populations. For instance, researchers have studied the use of root-boring weevils and leaf-eating beetles to control purple loosestrife; these insects are highly host-specific and cause only minor damage to non-target plants (Stackpoole, 1997; Blossey, 2002).

- Controlled burns, sometimes in combination with herbicide treatments, can help control invasive species. An herbicide and burn treatment may be used to increase the canopy of native species and decrease *Phragmites* plants (Higman and Campbell, 2009); however, the timing of burning is important since fire can stimulate the growth of *Phragmites* plants during certain periods of the plants' lifecycle (Avers et al., 2007). If the Trustees use controlled burns, a burn plan would be prepared to avoid impacts on non-target resources such as threatened and endangered species and residential and other structures.

- Mechanical controls, including mowing, cutting, and hand-cutting, can be effective for removing *Phragmites* (Avers et al., 2007). Hand pulling, especially in new stands or when combined with other methods such as chemical control, may be effective for purple loosestrife (Stackpoole, 1997).

- Application of herbicides or other pesticides can directly kill invaders. Typical methods include spraying from a backpack to target the application and reduce drift to unintended areas. As an example, purple loosestrife may be controlled through the application of glyphosate, an herbicide (Stackpoole, 1997). However, chemical control is often most effective when used with other control techniques. For example, application of herbicides on *Phragmites* may be most effective when combined with fire or mechanical controls (Higman and Campbell, 2009). Chemical control may not be desired in some situations because of the negative impacts on non-target species and the invaders' ability to evolve resistance to the chemicals.

- Various other methods may be effective in controlling invasive plants. Water-level management can control invasive plants and favor native species (e.g., inundating *Phragmites* for long periods of time can control this invasive species; Avers et al., 2007). Additionally, managed flooding for purple loosestrife can prevent seed germination (Stackpoole, 1997).

Combined treatments of the controls listed above may be the most effective technique for limiting or eradicating invasive plant species. The Trustees propose to select the most appropriate techniques with the least negative impacts. In some cases this may include the targeted and limited application of herbicides or other pesticides. Controlled burns would require the use of ignition agents under controlled conditions and would generate smoke. Cutting and mowing disturbances would require the use of mowers as well as chainsaws and large clippers. These techniques would require the use of motor vehicles to transport materials and staff, but would not require the use of heavy equipment or staging areas. Any invasive plants removed from the restoration area would need to be properly disposed of in existing, licensed disposal facilities.

3.1.3 Barrier removal

Barriers, such as dams and culverts, have detrimental effects on riverine ecosystems, including restricting fish movement, fragmenting river habitat, impairing water quality, and altering channel geomorphology (Bednarek, 2001).

Large dams, as well as small barriers, have significant negative effects on aquatic resources. For instance, barriers have reduced habitat for freshwater species, including lake sturgeon that historically used the Kalamazoo River and its tributaries for spawning (Wesley, 2005). Barriers can also result in fish mortality because fish exhaust themselves attempting to jump the barriers. In addition, large and small barrier removals can benefit freshwater mussels, which are an important ecological component of the Kalamazoo River and require fish hosts for dispersal in their juvenile life stage. Lack of upstream fish passage has significantly reduced the diversity of mussel species above each dam when compared to mussel diversity below each dam. Thus, the dam removal should increase mussel diversity in the Kalamazoo River (Spoelstra, 2009). Barriers also alter or limit the downstream movement of sediment, woody debris, and organic material, which can change stream temperatures and degrade aquatic habitat in both the stream and the impounded waters created behind the dam.

The Kalamazoo River Superfund Site originally included six dams on the Kalamazoo River: Lake Allegan Dam, Allegan City Dam, Trowbridge Dam, Otsego Dam, Otsego City Dam, and Plainwell Dam (Figure 1.2). The Plainwell Dam was removed in 2009 in conjunction with the

Time-Critical Removal Action that also removed PCB-contaminated sediments and soils in the former impoundment area. Two additional dams (Morrow Dam and Ceresco Dam) are upstream of the Kalamazoo River Superfund Site and are not part of the proposed restoration actions discussed in this RP/PEIS. Morrow Dam is a functioning hydroelectric dam. The Ceresco Dam was removed during 2013–2014 in conjunction with the removal of sediments contaminated by oil discharges from Enbridge Energy’s Line 6B pipeline in 2010.

Lake Allegan Dam is a functioning hydroelectric dam that is licensed by the Federal Energy Regulatory Commission (FERC) to remain in operation until 2040 (FERC, 2014); it bars the movement of fish from Lake Michigan into the Kalamazoo River. The Trustees are not considering removal of this dam. The other four existing dams (Allegan City Dam, Trowbridge Dam, Otsego Dam, and Otsego City Dam) are retired hydroelectric dams built between 1880 and 1910. The Trustees are considering restoration actions to remove these four dams. Water levels upstream of the Trowbridge and Otsego dams were lowered in 1970 and the dam structures above the sill levels were removed in 1987 (Wesley, 2005). Today, these two dams are significantly deteriorated. Table 3.5 summarizes information on all five remaining dams in the Kalamazoo River Superfund Site, including their ownership and the potential degree of hazard associated with their failure. The hazard ranking in this table reflects the extent of anticipated damage in the event of dam failure and is not a reflection of the dam’s condition.

The sediments impounded behind these dams contain PCBs. EPA is currently overseeing the cleanup of sediments and soil at the Kalamazoo River Superfund Site. Removal of these contaminated sediments, which are located both in the stream channel and the floodplain of the river, is required before the retired dams can be removed. As sediments are addressed during this process, the removal of these four retired dams and the restoration of the stream and floodplain become feasible. The removal of contaminated sediments and floodplain soils can be coordinated with the dam removal, as was done for the Plainwell Dam, a retired sill-level dam, and the sediment and soils in the area previously impounded behind it (Williams, 2011).

In addition to the large hydroelectric dams described above, many small manmade barriers exist in the Kalamazoo River watershed, including small dams and weirs, road and railroad crossings that restrict streams, and other engineered structures on the Kalamazoo River and its many smaller tributaries. In the Great Lakes region, there are at least 7,091 dams and 268,818 road crossings on tributaries that are potential barriers to fish movement (Januchowski-Hartley et al., 2013). Based on case studies in the region, Januchowski-Hartley et al. (2013) estimate that only 36% of these road crossing are fully passable to fish.[2] Thus, more than 60% of the existing road crossings in the Great Lakes region may be actively impairing the ecological connectivity of rivers and streams, and there is no reason to believe that the Kalamazoo River watershed is any different.

2. Fully passable crossings are defined by Januchowski-Hartley et al. (2013) as those that all native fish species can pass through during most stream flows.

Table 3.5. Background information on existing dams within the Kalamazoo River Superfund Site. Dams are listed from upstream to downstream.

Name	Date built	Current purpose	Owner	Head (ft)	Current impoundment area (acres)	Hazard type[a]
Otsego City Dam	1886[b]	Retired hydroelectric	Otsego City	9	73	High
Otsego Dam	1904	Retired hydroelectric	MDNR	5	67[c]	High
Trowbridge Dam	1899	Retired hydroelectric	MDNR	11	59[c]	High
Allegan City Dam	1900	Retired hydroelectric	City of Allegan	12	135	High[d]
Lake Allegan Dam	1930	Hydroelectric	Private	33	1,587	Low

a. These hazard types were developed by the Dam Safety section of the Water Resources Bureau, MDEQ. On a statewide level, high hazard means that loss of human life would probably occur if the dam failed, and low hazard means that large amounts of property damage would probably not occur if the dam failed. For the Kalamazoo River, these rankings are not associated with potential loss of human life, but rather are associated with the potential for release of PCBs (Sharon Hanshue, MDNR, personal communication, February 19, 2015). The hazard types have not changed since 1995 for all dams except Allegan City Dam (see table note d).
b. Note that Rheaume et al. (2004) indicate that the Otsego City Dam was originally built in the 1840s; this date, as indicated in Wesley (2005), may refer to the date of construction of a predecessor dam.
c. Before the dams were reduced to sill level, the impoundment area of the Otsego Dam was approximately 77 acres and the impoundment area of the Trowbridge Dam was approximately 374 acres (Blasland, Bouck & Lee, 2000).
d. The hazard type for the Allegan City Dam was reevaluated and changed from Low to High in 2000 (Lucas Trumble, Water Resources Division, MDEQ, personal communication, September 14, 2014).

Source: Table modified from Wesley (2005); based on data from MDEQ, Land and Water Management.

For any given barrier removal project, the Trustees would rely on one or more restoration techniques. The following sections discuss specific techniques that the Trustees may use to remove dams (Section 3.1.3.1), remove small barriers (Section 3.1.3.2), and make other modifications that enhance aquatic connectivity (Section 3.1.3.3).

3.1.3.1 Techniques for dam removal

Removal of one or more of the four remaining retired hydroelectric dams in the Kalamazoo River Superfund Site would likely follow a similar process to that used for the Plainwell Dam removal. The Plainwell Dam, a retired sill-level dam located on the Kalamazoo River, was removed in 2009 in conjunction with a Time-Critical Removal Action in the former Plainwell Impoundment. Because the Plainwell Dam has characteristics similar to those of the other retired hydroelectric dams currently considered for removal, documentation on the removal of the Plainwell Dam provides useful information for identifying potential technical elements of other dam removal projects within the Kalamazoo River Superfund Site (U.S. EPA, 2009; Williams, 2011).

In some cases, dam removal could be necessary to facilitate efficient sediment removal or remediation. In other cases, the Trustees might seek dam removal as a component of compensatory restoration. Removal of the following three dams are priorities for the Trustees at this time: Otsego City Dam, Otsego Dam, and Trowbridge Dam. Detailed descriptions of the proposed removal of the Otsego City Dam and Otsego Dam are presented in Sections 3.1.3.1.1 and 3.1.3.1.2 of this document. The Trustees anticipate developing a proposal for the removal of the Trowbridge Dam in coordination with EPA's remedial process for OU5. PCB-contaminated sediments impounded behind each dam would be removed or stabilized to achieve acceptable risk levels through the EPA sediment remediation process, with the risk evaluation taking into account that the dam would be removed.

Precautionary water control, dewatering, and/or sediment removal would be necessary as a part of the dam removal to reduce sediment resuspension and transport downstream during construction and removal activities (American Rivers and Trout Unlimited, 2002). Potential methods to control water levels and/or dewater the reservoir include (1) the construction of cofferdams to redirect the main river channel and allow excavation of the dewatered dam impoundment (U.S. EPA, 2009; Williams, 2011; URS, 2012), and/or (2) the construction of water control structures (WCS) to control and lower water levels during removal of impounded sediments (U.S. EPA, 2009; URS, 2011; Williams, 2011). Contaminated sediment would need to be removed under EPA's supervision as a precondition to the dam removal restoration project. The entire dam or a portion of it would be removed with heavy equipment (e.g., an excavator equipped with a hydraulic hammer; American Rivers and Trout Unlimited, 2002). Following removal of the dam structure, any temporary WCS or cofferdams would be removed and the natural flow of the river would be restored using aquatic habitat restoration techniques described in Section 3.1.1.

The following describes the likely dam removal sequencing that would occur. First, the WCS would be constructed upstream of the dam. Next, sediments between the dam and the WCS would be removed, followed by removal of the dam. This would be followed by the removal of contaminated sediments upstream of the WCS. Finally, the channel and floodplain would be restored and the WCS would be removed (e.g., URS, 2011).

The removal of PCB-contaminated sediments upstream of the dams would not be part of the Trustees' proposed restoration action but would be a precondition to the feasibility of removal of the dams. As such, the use of heavy equipment for the development of staging areas for sediment removal and handling of contaminated sediment waste would not be associated with dam removal restoration actions. As described above, the Trustees would conduct the dam removals in conjunction with EPA-directed contaminated sediment removals and, therefore, would not need to construct any additional WCS, staging areas, or temporary roads. In some cases, the channel design might require removal of additional sediment or soil that is not contaminated with PCBs; however, this removal would be coordinated with the removal of contaminated sediments through the EPA-directed sediment remediation process and would likely not require any additional staging areas or temporary roads. The dam removals would likely require the use of an excavator with a hydraulic hammer or similar equipment, as well as vehicles such as dump trucks and flatbed trucks; the Trustees do not anticipate the use of explosives (URS, 2011). Concrete, rock, and metal from the dams would likely need to be transported off-site and disposed of in existing, licensed disposal facilities.

3.1.3.1.1 Removal of the Otsego City Dam

Under this proposed project, if the Otsego City Dam is not removed as part of the remedial actions themselves, then the dam would be removed as a restoration project following EPA-directed remedial actions as described above. As shown in Figure 1.2, the Otsego City Dam is on the mainstem of the Kalamazoo River within the Kalamazoo River Superfund Site. It was originally built in the 1840s to create a freight business on the Kalamazoo River (Rheaume et al., 2004), and it was subsequently rebuilt and repaired over time and put to different uses, such as water and power generation. The power generation infrastructure has been removed and the tailraces, which formerly conveyed water around both sides of the dam, have been filled (SME, 2010; URS, 2011). The dam currently consists of three masonry piers between four spillway bays with capped masonry abutments at both sides (Figure 3.3). In its current condition, the dam creates a head of approximately 9 feet and an impoundment area of 73 acres (Wesley, 2005; SME, 2010).

Figure 3.3. Otsego City Dam. Photograph facing southeast.

Source: URS, 2011.

The Otsego City Dam no longer serves its historical purposes. The dam has been proposed for removal by MDNR and the City of Otsego to benefit the human and natural environment (Rheaume et al., 2004; URS, 2011). The Otsego City Dam impedes upstream fish passage (Williams, 2012) and decreases the water velocity upstream of the dam, which makes the river wider and shallower, causes increased deposition of fine sediments, and increases water temperature (Wesley, 2005). These changes serve to decrease the heterogeneity of microhabitats within the impoundment created by the dam (Wesley, 2005). This loss of heterogeneity adversely affects fish and other species that require a variety of habitats (Wesley, 2005). The dam also interferes with free navigation and recreation on the Kalamazoo River (Wesley, 2005). Removal of the dam would allow fish to move more freely throughout this section of the river; allow for a more natural channel, with associated habitat complexity, in the reach upstream of the dam; and remove an impediment to recreational boating.

Prior to the dam removal, all required federal and state permits, or permit equivalents for activities conducted on-site as part of the EPA-directed remedial actions, would be obtained. Michigan requires that contractors obtain a Dam Safety Permit for the removal of any regulated dam (MDEQ, 2014). Michigan must also issue a CWA Section 401 Water Quality Certification, stating that the proposed dam removal will not violate any water-quality standards. There are numerous federal permits and consultations required for the dam removal. The CWA Section 404 Permit is issued by the U.S. Army Corps of Engineers (USACE) for all activities involving the discharge of dredged or fill materials (Lindloff and Wildman, 2006). The Rivers and Harbors Act Section 10 Permit would also be obtained, since the Kalamazoo River is defined as a “navigable water” under the CWA. Consultations would also be conducted to ensure compliance with the Endangered Species Act (ESA), if listed species could be affected by the dam removal. Consultations with the Michigan State Historic Preservation Officer (SHPO) would be conducted to comply with Section 106 of the National Historic Preservation Act. All required permits would be obtained before any progress is made on the dam removal restoration project.

The dam removal itself would not require construction of a WCS, access roads, or staging areas – instead, it would use those already constructed for an EPA-directed sediment remedial action.

The dam would be removed from north to south (URS, 2011). Removal of the dam would be completed using an excavator with an attached hydraulic hammer (or similar). The engineering company performing the removal would choose the correct size hammer based on the structural integrity of the dam (Bennink, 2013). It is estimated that it would take 200 hours to remove the dam with an excavator. Additional equipment needed for the dam removal would include rubber track dump carriers, barges, handheld power tools, cement trucks, and hydraulic cranes. The demolition waste would be taken to nearby landfills that have the capacity and capability of handling these materials.

There are many negative environmental impacts associated with a dam removal process. Soil compaction, caused by the use of heavy machinery, is a concern during restoration projects because of the negative impact it has on vegetation health. In order to mitigate soil compaction, eight inches of chipped wood mulch and a geotextile mat would be placed along the river access path. This is an effective method for preventing compaction in areas of medium traffic, such as a staging area (Alabama Cooperative Extension System, 2013). To minimize water pollution threat caused by potential leaks during construction, a zinc-free, non-toxic, and biodegradable anti-wear oil would be used to minimize the consequences of a potential leak, thereby posing no serious threat to fish or aquatic species (Bennink, 2013). A second pollution concern during construction is that of air pollution, primarily fine particulate matter ($PM_{2.5}$), particulate matter (PM_{10}), sulfur dioxide, nitrogen oxide, and carbon monoxide emissions (CDFG and U.S. DOI, 2012). To limit the amount of pollution, construction equipment would be required to meet the latest respective model year emissions standards, depending on the type of equipment (i.e., off-road construction equipment would meet model year 2015 standards for diesel engines, on-road equipment would meet model year 2000 standards, and trucks would meet model year 2010 or later standards; CDFG and U.S. DOI, 2012). Many mitigation options could be used to decrease noise levels during the project. To the extent feasible, construction would be restricted to occur during daylight hours, newer machinery would be used, and noisy operations would take place concurrently so as to limit the amount of time of high noise levels (U.S. DOT, 2006). Lastly, the construction would be timed to occur during low-flow periods so that water velocities and downstream impacts are minimized (American Rivers and Trout Unlimited, 2002).

3.1.3.1.2 Removal of the Otsego Dam

Under this proposed project, if the Otsego Dam is not removed as part of remedial actions, then the dam would be removed as a restoration project following the EPA-directed removal of PCB contaminated sediments as described for the Otsego City Dam in Section 3.1.3.1.1. As shown in Figure 1.2, the Otsego Dam is on the mainstem of the Kalamazoo River within the Kalamazoo River Superfund Site and downstream of the Otsego City Dam. It was built in 1904 to generate power. The power generation infrastructure has been removed and the dam is now owned by MDNR (AECOM, 2015). The dam currently is approximately 700-feet-wide, consisting of a 170-foot-long earthen embankment, a 128-foot-wide concrete spillway, a 135-foot-long center earthen section, a 110-foot-long former hydroelectric generation station, and a 157-foot-long earthen embankment (Figure 3.4; AECOM, 2015). It creates a head of approximately 5 feet and an impoundment area of about 67 acres (AECOM, 2015).

Figure 3.4. Otsego Dam. View from the southern bank of the Kalamazoo River.

Source: URS, 2012.

The Otsego Dam no longer serves its historical purpose and dam inspections conducted between 2010 and 2013 indicate that it is in "very poor condition." As a result of these findings, MDNR has proposed to remove the dam and conduct restoration of the aquatic, riparian, and wetland habitats for roughly 1.4 miles upstream of the current dam (URS, 2012; AECOM, 2015). The Otsego Dam is negatively impacting the river in the same ways as the Otsego City Dam (described above) and its removal would allow fish to move more freely throughout this section of the river, allow a more natural and complex channel to develop upstream of the dam, and remove an impediment to recreational boating.

Prior to the dam removal, all required federal and state permits would be obtained, as described in Section 3.1.3.1.1 for the Otsego City Dam.

Similar to the proposed Otsego City Dam removal described above, the Otsego Dam removal restoration project would make use of the WCS, access roads, and staging areas installed under an EPA-directed sediment remedial action. As such, all work would be conducted during low-flow conditions. The dam removal would be similar to that described in Section 3.1.3.1.1 for the Otsego City Dam (URS, 2012). At the time of this writing, MDNR has recently constructed a WCS immediately upstream of the Otsego Dam in anticipation of future sediment removal.

The potential negative environmental impacts of removal of the Otsego Dam would be similar to those described above for the removal of the Otsego City Dam, and similar mitigation measures would be taken to reduce those impacts.

3.1.3.2 Techniques for small barrier removal and replacement

There may be opportunities to remove or retrofit small barriers to improve fish passage and riparian habitat. Restoration may include participating in local utility plans to improve road crossings such as replacing a culvert that is too small with a bridge, or removing debris or ballast from abandoned railroad crossings. In some instances, utility crossings that were originally beneath the streambed may have become exposed and now act as velocity barriers; these situations would likely need to be addressed by the utility, although it is possible that the Trustees could augment such a project by funding stream restoration beyond what the utility might normally do. Similar to the larger dam removals, these smaller projects may require evaluating and addressing contaminated sediments and soils that the barrier has impounded before restoration of the stream and its riparian habitat are possible.

Small barrier removal and replacement would require the use of vehicles, heavy mechanical equipment, and power tools. Vehicles that may be used would include bulldozers, graders, backhoes, dump trucks, and flatbed trucks. Smaller equipment would include chainsaws, power augers, and small excavators. This equipment would be transported to the site using existing roads and would require a small work zone and staging area, which would be returned to the site conditions that existed before this work started. Small barrier removal would generate some waste materials, such as rebar, concrete, and riprap, which would require off-site disposal in licensed disposal facilities.

3.1.3.3 Techniques for other fish passage modifications

Where it is not feasible to remove dams and small barriers, fish passage may be improved through engineered technologies, such as fish ladders and retrofits of dams and culverts; or through a more natural approach, such as natural bypass channels. Stream channels with high-quality habitat (e.g., high pool frequency, high wood loading, low gradients) produce greater benefits to fish and other organisms; therefore, in prioritizing modifications, the Trustees may consider the habitat quality upstream of the barrier. Additional details on rock ramps, replacing and retrofitting culverts, fish ladders, and natural bypass channels are provided below.

Rock ramps typically consist of stepped pools that slow the water, decrease ascent angles, and provide resting locations so that fish can easily negotiate the change in water elevation at the dam. Rock ramps may be constructed of boulders across the entire river downstream of the face of a dam (Figure 3.5), and may also be used to replace a low-height dam. These are becoming more common in locations where it is important to maintain existing impoundment elevations for some reason, while still attempting to improve aquatic connectivity as much as possible. A number of rock ramps have recently been constructed in Michigan, including ones on the Thornapple River in the Grand River watershed, on the Shiawassee River in the Saginaw River watershed, and on the River Raisin in southeast Michigan.

Figure 3.5. Rock ramp on the Thornapple River Village of Nashville, Michigan. This rock ramp replaced the Nashville Dam, which was removed in 2009, opening up 60 miles of stream to fish passage.

Source: Terry Heatlie, NOAA, personal communication, November 19, 2013.

Culverts are rigid structures in a dynamic stream environment. As a stream channel changes over time, the culvert is unable to change with it. **Replacing or retrofitting culverts**, as described in the bullets below, can increase stream connectivity and improve fish passage.

- Undersized culverts can cause water to back up and flood upstream areas, scouring the streambed and banks. Widening culverts or replacing them with larger box culverts or bridges may reduce these impacts.
- Culverts perched above the stream channel are a common barrier to fish passage in small streams. Raising the water elevation of the pool downstream of the culvert can help maintain water levels across the culvert. To reduce erosion, rock ramps can be placed below the culvert or at the inlet and outlet of the culvert. Figure 3.6 shows an example of a culvert before and after such restoration.
- Culverts can also be retrofitted with natural designs that better simulate a natural streambed. Natural retrofits include placing stones, rocks, or artificial materials on the culvert floor, or using an open-bottom culvert that maintains the natural substrate of the stream channel. In addition to habitat benefits, natural streambed retrofits also reduce water-flow speeds through culverts.

Figure 3.6. Replacement of perched culverts. The "perched" culverts in the figure on the left prevent upstream fish movement, whereas fish can move through the natural stream channel bottom under the concrete arch in the figure on the right.

Source: Dale Higgins, U.S. Department of Agriculture (USDA) Forest Service. Available: http://www.rivercare.org/local/upload/file/P_Sol_Summer_13.pdf.

Where appropriate, the Trustees may consider using **fish ladders,** which are intended to allow passage of migratory fish upstream and downstream of artificial barriers that they otherwise could not pass (Figure 3.7). Ladders are designed for the needs and capabilities of one or more species of fish; a range of designs are available. Vertical slot weirs constructed at dams along the Kalamazoo River could allow a wide range of fish species to pass upstream and downstream (Aggarwal et al., 2012). However, lake sturgeon are apparently unable to use fish ladders to pass upstream; this species requires a natural bypass channel, described below (Aggarwal et al., 2012).

Natural bypass channels that circumvent an impounded section of a stream and closely mimic its natural substrate and hydraulic conditions can improve fish passage (Figure 3.8). Typically, only a portion of the stream water is diverted through the bypass channel. The large surface area required for construction of the bypass is the main disadvantage of this approach, but bypass channels may still be appropriate in some cases.

The barrier modifications discussed here would require use of similar materials and equipment as instream restoration techniques (described in Section 3.1.1.1) and small barrier removal and replacement (described in Section 3.1.3.2). They would likely be conducted in any given location at the same time as instream restoration to minimize the duration of impacts and reduce the amount of transportation required to bring in materials and dispose of waste.

Figure 3.7. Image of a vertical slot fishway.

Source: MDNR, 2014.

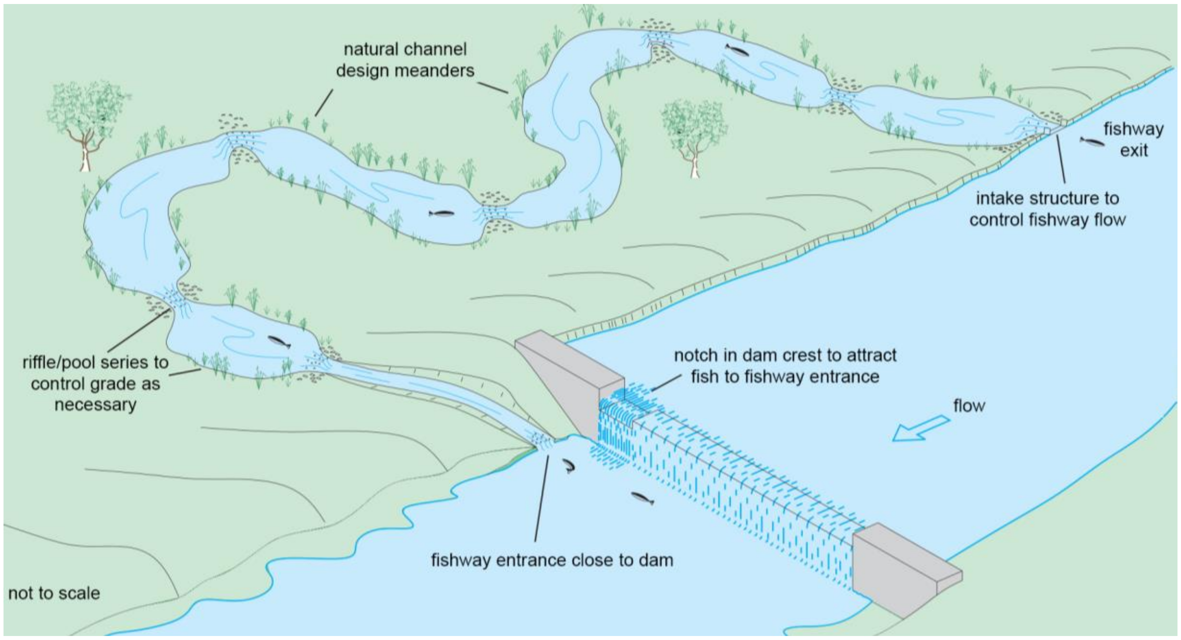


Figure 3.8. Conceptual layout of natural bypass channel, also called a bypass fishway.

Source: Adapted from Thorncraft and Harris, 2000.

3.1.4 Habitat conservation

The Trustees may protect habitat to ensure that it is not at risk from future development or conversion to undesirable land uses. Protection of land parcels can increase or maintain connectivity of habitat along the river and its tributaries and provide buffers that improve water quality; conservation efforts that focus on preserving and managing these existing riparian habitats can be critical in conserving the biodiversity and ecological processes in the watershed. They also offer benefits for recreation, including fishing, birding, or hiking; and help maintain the beauty of the region.

In the Kalamazoo River watershed, opportunities may exist to conserve rare or unique floodplain forests, wetlands, and off-channel habitat. Wetlands comprise nearly 13% of the Kalamazoo River watershed (NOAA CSC, 2006), natural floodplains span much of the watershed, and numerous off-channel habitats are found throughout the watershed. The Trustees intend to prioritize high-quality habitats, such as floodplains that are forested and are well-connected to rivers and streams, for preservation and management. Preferred projects would protect habitat in the Kalamazoo River watershed, preserve the continuity of the river corridor, reduce fragmentation and improve/preserve connections among large areas of habitat (e.g., connecting the Kalamazoo River corridor with the Gun Lake area), and improve or protect water quality and quantity in the Kalamazoo River. Techniques for habitat conservation are described below.

3.1.4.1 Techniques for habitat conservation

The Trustees may be able to preserve and manage high-quality riparian habitats through conservation easements or land purchases. Opportunities may also exist to acquire adjacent uplands to ensure that future development does not affect adjacent riparian habitats. Additionally, protection of such upland habitats can provide important habitat for animals that use both uplands and riparian habitats, such as birds and turtles. Habitat conservation would not require the use of any equipment and would not generate waste materials. However, there could be changes in land ownership status or land use as a result of habitat conservation actions.

3.2 Alternatives Carried Forward for Analysis

To develop the restoration alternatives, the Trustees considered what types of restoration would meet both the specific objectives described in Table 2.1 (Section 2.2) and their overall goal for NRDA restoration: to restore and maintain a riverine ecosystem with structural and functional components similar to those of the historical Kalamazoo River corridor, before it was degraded by dams and waste disposal. If an alternative was considered but did not meet these objectives, it was not evaluated in detail. Several alternatives that were initially considered but eliminated in this step are described in Section 3.4.

The Trustees carried forward three alternatives for in-depth analysis in this RP/PEIS. No restoration actions would be implemented under Alternative A, which provides a restoration baseline for comparing the two restoration alternatives. Both Alternatives B and C could include all of the restoration project categories and the specific projects described in Section 3.1; however, they differ in the geographic scope in which these types of restoration project categories would be implemented. Alternative B, described in Section 3.2.2, includes restoration projects conducted only on the Kalamazoo River and Portage Creek within the Kalamazoo River Superfund Site. Alternative C, described in Section 3.2.3, includes all the categories of projects outlined in Alternative B within the Kalamazoo River Superfund Site, but also includes restoration projects conducted in the broader Kalamazoo River watershed to create an alternative source for the ecological services lost or injured by the release of PCBs into the KRE. Alternatives B and C would likely include different amounts of each restoration project category and would likely differ in when the majority of the restoration would be conducted.

3.2.1 Alternative A: No Action Alternative

Under the No Action Alternative, required by the NEPA [40 C.F.R. § 1502.14(d)], the Trustees would not initiate any specific actions to restore injured natural resources or compensate the public for losses from ongoing natural resource injuries from the release of PCBs into the KRE. State and federal agencies would continue to manage, conserve, and protect the Kalamazoo River watershed, as outlined in current programs and regulations, other than the NRDA, and within current budget constraints. This alternative is included in this analysis to present a restoration baseline for the comparison of the impacts of the other two alternatives.

3.2.2 Alternative B: Restoration of the Kalamazoo River corridor within the Kalamazoo River Superfund Site

Alternative B would consist of restoration of the 129-kilometer (80-mile) stretch of the Kalamazoo River corridor and the 4.8-kilometer (3-mile) stretch of Portage Creek within the Kalamazoo River Superfund Site (Figure 3.9). This restoration alternative would primarily focus on longitudinal connectivity of the river and its riparian corridor, but may also address lateral connectivity of the Kalamazoo River with its floodplain and surrounding watershed.

Under this alternative, the Trustees would conduct restoration actions in coordination with and adjunct to EPA-directed response actions (see Section 1.2.2.1). As such, the Trustees could conduct restoration in areas that have already been remediated (e.g., the former Plainwell Impoundment) and in areas that are upstream of all planned remediation. As EPA-directed remediation moves downstream, restoration could continue in newly remediated areas; ideally, the Trustees would conduct such restoration in coordination with EPA to maximize efficiencies

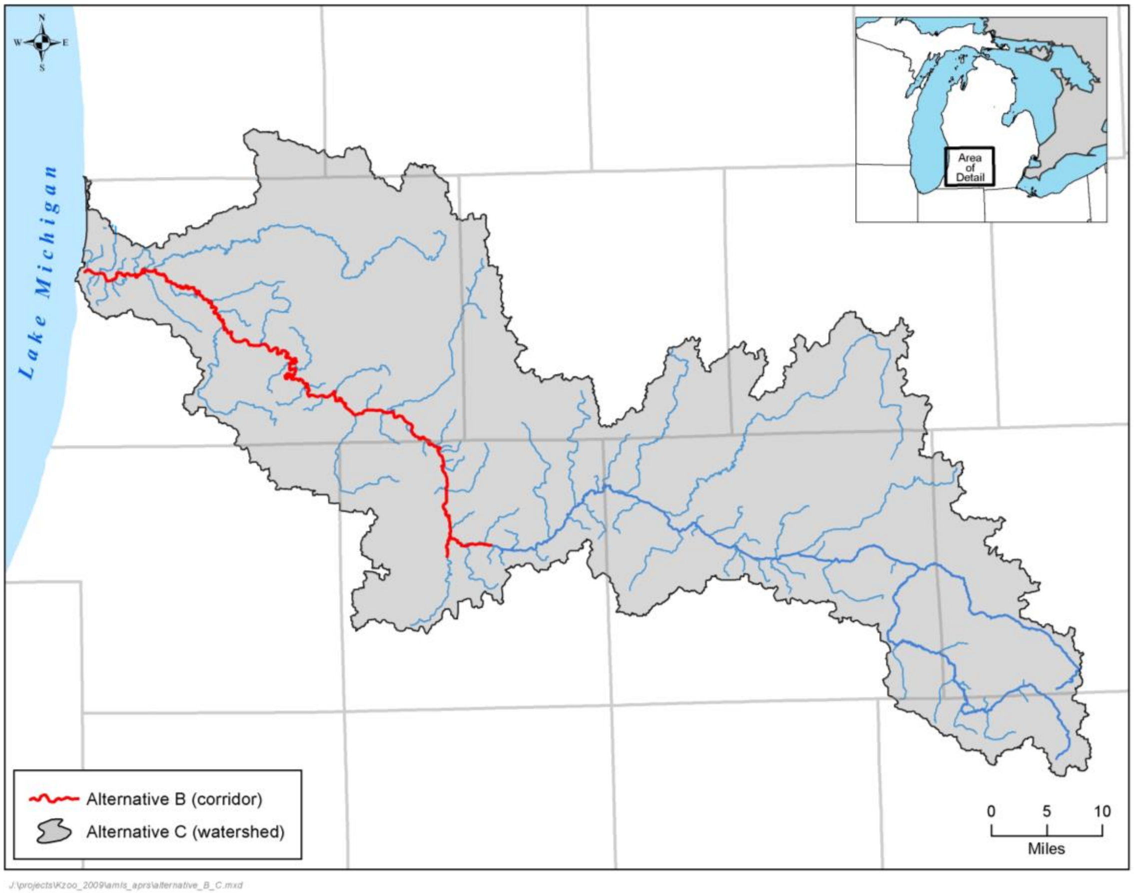


Figure 3.9. Comparison of geographic scope of Alternatives B and C.

in design, equipment, and labor. Restoration actions could include any of the desired restoration project categories discussed in Section 3.1. This alternative is constrained in terms of space (within the Kalamazoo River Superfund Site and along the Kalamazoo River corridor) and time (restoration must be in areas that have been remediated by EPA and areas upstream of the planned remedy).

3.2.3 Alternative C: Restoration within the Kalamazoo River watershed

Alternative C would consist of restoration as described in Alternative B, but also could include additional restoration actions of a similar nature in the 5,230-square kilometer (2,020-square mile) Kalamazoo River watershed, including projects in tributaries in addition to Portage Creek (Figure 3.9). Because of the inclusion of the broader watershed, this alternative places a greater emphasis on lateral connectivity to the Kalamazoo River than Alternative B. Under this alternative, the Trustees could conduct restoration actions in locations that have not been affected by PCBs, including projects in tributaries other than Portage Creek, and in remediated areas that were previously contaminated with PCBs. Currently, the Trustees could conduct restoration in the former Plainwell Impoundment and in areas in the watershed that are upstream of PCB contamination. As EPA-directed remediation moves downstream, restoration could continue in newly remediated areas; ideally, such restoration would be conducted in coordination with EPA to maximize efficiencies in design, equipment, and labor.

Projects in the Kalamazoo River corridor within the Kalamazoo River Superfund Site are similarly constrained in terms of time and geography as in Alternative B. However, under this alternative, there are more opportunities for earlier restoration actions and for restoration in a larger area not directly affected by PCB releases, but which would still provide benefits to injured natural resources through overall improvements in water quality and available habitat.

3.3 Identification of Preferred Alternative

The No Action Alternative (Alternative A) is the only alternative that does not respond to the purpose and need for the action (Section 1.3) and would not achieve the preliminary restoration objectives presented in Table 2.1. Existing environmental degradation that is not directly related to PCB releases would continue to occur, and perhaps worsen under Alternative A.

Alternatives B and C are both consistent with the purpose and need for the action, and the Trustees’ preliminary restoration objectives. Alternative B could potentially meet most of the preliminary restoration objectives. However, because restoration projects would be constrained to a smaller portion of the watershed, Alternative B provides fewer opportunities for the continuity of habitats within the watershed, ensuring that a variety of habitats are productive, and achieving reductions in nonpoint source pollutant loading. Alternative B is also constrained in terms of timing; the majority of potential restoration locations have not yet been remediated and currently the Trustees would be limited to conducting restoration in the former Plainwell Impoundment and in areas in the Kalamazoo River corridor within the Kalamazoo River Superfund Site that are upstream of PCB contamination.

Alternative C could potentially meet all of the Trustees’ preliminary restoration objectives. The Trustees have identified Alternative C, restoration within the Kalamazoo River watershed, as their preferred alternative because it allows the most flexibility to meet the restoration objectives, both in terms of geographic locations and timing.

3.4 Alternatives Not Considered for Detailed Analysis

The Trustees considered some alternatives for restoration that were not carried forward for detailed analysis in this RP/PEIS. These include removal of PCBs, a species-specific restoration approach (as opposed to a habitat-specific restoration approach), and solely artificial propagation of populations.

To the extent that PCBs are causing injuries to natural resources, the elimination of exposure of the injured resources to PCBs could be a part of restoring the resources to baseline over time (i.e., the condition the resources would have been in had the PCB releases not occurred). **Removal of PCBs** can reduce the number of years that fish consumption advisories are in place, that water-quality standards are exceeded, and that injuries to natural resources occur. However, EPA is in the process of removing a substantial amount of PCBs from the KRE; the Trustees expect that the response actions will likely move ecosystem recovery toward the natural resources baseline to the extent practicable. Removal of additional PCBs, residual to the EPA response actions, would likely not be cost-effective nor would additional actions be likely to provide a significant incremental reduction in the risk of future injury. Therefore, the Trustees are not pursuing additional PCB removal actions as a restoration alternative. The Trustees would continue to coordinate with EPA to maximize the benefits of the response actions, as they did during the Plainwell Impoundment Time-Critical Removal Action in 2007–2009 (see Section 1.2.2.3).

The Trustees also considered **species-specific restoration**, which would consist of planning and implementing individual restoration projects to benefit individual species or groups of similar species that have been injured by PCBs. Restoration would focus on the specific habitats that are critical to the survival and reproduction of the target species. This type of restoration would benefit key species, and could accelerate the recovery of some of the natural resources that were most severely affected by PCBs. However, this type of restoration would likely be inefficient at restoring the broader range of affected natural resources and services. It would also not be particularly effective at achieving the Trustees' objectives, which are focused on restoring the interconnected functions of habitats (presented in Table 2.1, Section 2.2).

Artificial propagation of populations ("stocking"), with or without habitat restoration, can maintain populations in aquatic systems. Stocking of hatchery species and selective breeding are components of this approach. The Trustees did not elect to evaluate this method alone as it was insufficient to achieve the Trustees' goals, but the Trustees may incorporate it as a component of certain restoration projects under the preferred alternative (see Section 3.1.2.2, which describes techniques for reintroduction and enhancement of native plants and Section 3.1.2.3, which describes techniques for reintroduction and enhancement of native animals).

4. Environmental Setting/Affected Environment

This chapter describes the baseline environmental setting that could be affected by the restoration alternatives.

The proposed natural resource restoration activities would be implemented in the Kalamazoo River watershed. As discussed in Chapter 3, the Trustees are considering two different geographic alternatives for the implementation of restoration projects. When discussing implementation of restoration projects, the potentially affected environment for Alternative B is the KRE, which is a geographical subset of the Kalamazoo River watershed. The environment potentially affected by Alternative C is the Kalamazoo River watershed. To address the effects of either alternative, this chapter describes the environmental setting of the watershed and the areas that may be affected by the proposed restoration.

In compliance with NEPA, CEQ, and NOAA regulations and guidelines, the description of the affected environment and the environmental consequences of the alternatives (discussed in Chapter 5) focus on those areas that are potentially impacted by anticipated restoration actions. These include:

- Water resources and water quality
- Geologic resources and sediment quality
- Biological resources
- Air quality
- Socioeconomic resources and environmental justice
- Recreation and land use
- Noise
- Cultural resources.

We have omitted areas where impacts of the alternatives are not anticipated or are insignificant, as well as areas that are considered irrelevant to the anticipated actions. Additional NEPA analysis would be conducted if a proposed project has adverse effects that would affect these areas. These include:

- ***Aesthetics, light, and glare***: Impacts on aesthetics, light, and glare from restoration would either be non-existent or minor. Impacts on aesthetics such as disturbed soils and the storage of equipment would be insignificant as the Trustees would use best management practices to manage solid waste and debris, maintain a neat and organized work site, and provide appropriate sanitation facilities. Light pollution refers to excessive or obtrusive artificial light and glare refers to conditions where visibility is impaired by light pollution. The Trustees do not anticipate any impacts associated with light and glare unless restoration work is done at night. However, nighttime restoration work would be required to comply with local light and glare regulations and follow best management practices to minimize light and glare pollution.

- ***Public services and utilities***: Public services include transportation, police, fire, and other emergency services; and utilities include electric power, gas/steam/oil, telecommunications, water facilities, storm drainage, and sanitary sewer systems. The restoration activities would not disrupt, damage, or cause any impact to these services and utilities. The Trustees would conduct a review of the locations of buried power lines and other utilities during the project design and work with utility companies before projects are implemented to avoid accidental impacts.

- ***Energy and natural resources***: There would be no anticipated effects on energy and natural resources. The restoration alternatives involve no long-term consumption of energy resources. Landowners have historically harvested small amounts of timber from private land in the basin (see Osteen and Chappelle, 1982). However, this restoration program would be unlikely to affect private timber harvest lands because it would be focused on the stream corridor and limited associated uplands. Additionally, because the lower Kalamazoo River was designated a Wild and Scenic River in 1981, any new development, exploration, or production of oil, gas, salt brine, sand/gravel, or minerals is not permitted within 300 feet of the designated river or tributaries (MDNR, 1981).

- ***Hazardous materials and wastes***: Restoration would not involve the use of hazardous materials, cause any releases of hazardous substances, or generate hazardous waste. As discussed in the description of dam removal techniques (Section 3.1.3.1), the Trustees would conduct restoration only in any areas where remediation of PCBs has already occurred, or in conjunction with a removal action conducted by regulatory agencies (e.g., a dam removal following removal of contaminated sediments).

- ***Health and safety***: Human health and safety risks include any hazardous, unhealthy, or unsanitary conditions causing unreasonable threats to health, safety, and welfare. Health and safety risks for the general population include those associated with exposure to bodies of water (i.e., drowning, hypothermia), hazardous weather, trips and falls, illnesses/sickness, contact with wildlife, and exposure to contaminants. Health and safety risks associated with transportation and construction activities would also include physical injuries and exposure to construction-related contaminants. Safety hazards to the general public would be insignificant because construction activities would control access to the restoration site. The Occupational Safety and Health Administration (OSHA) sets standards to assure healthy and safe working conditions. Under OSHA requirements, restoration actions would be required to have associated health and safety plans that detail concerns and address best practices to protect workers. If necessary, an analysis of potential health and safety impacts would be conducted on a project-specific basis.

4.1 Water Resources and Water Quality

4.1.1 Water resources

The Kalamazoo River watershed encompasses approximately 5,230 square kilometers (2,020 square miles; Figure 4.1) and was formed after the retreat of glaciers approximately 10,000 years ago (Farrand and Eschman, 1974). The glaciation left behind moraine and outwash deposits that influence local hydrology, channel morphology, and stream gradients. The watershed contains sands, gravels, loam, and clays associated with glacial outwash and moraines, as well as lake (i.e., lacustrine) deposits. Areas with finer sediments associated with outwash and moraines are typically used for agriculture, whereas steeper-sloped moraines with coarser material are usually forested because they are unsuitable for agriculture.

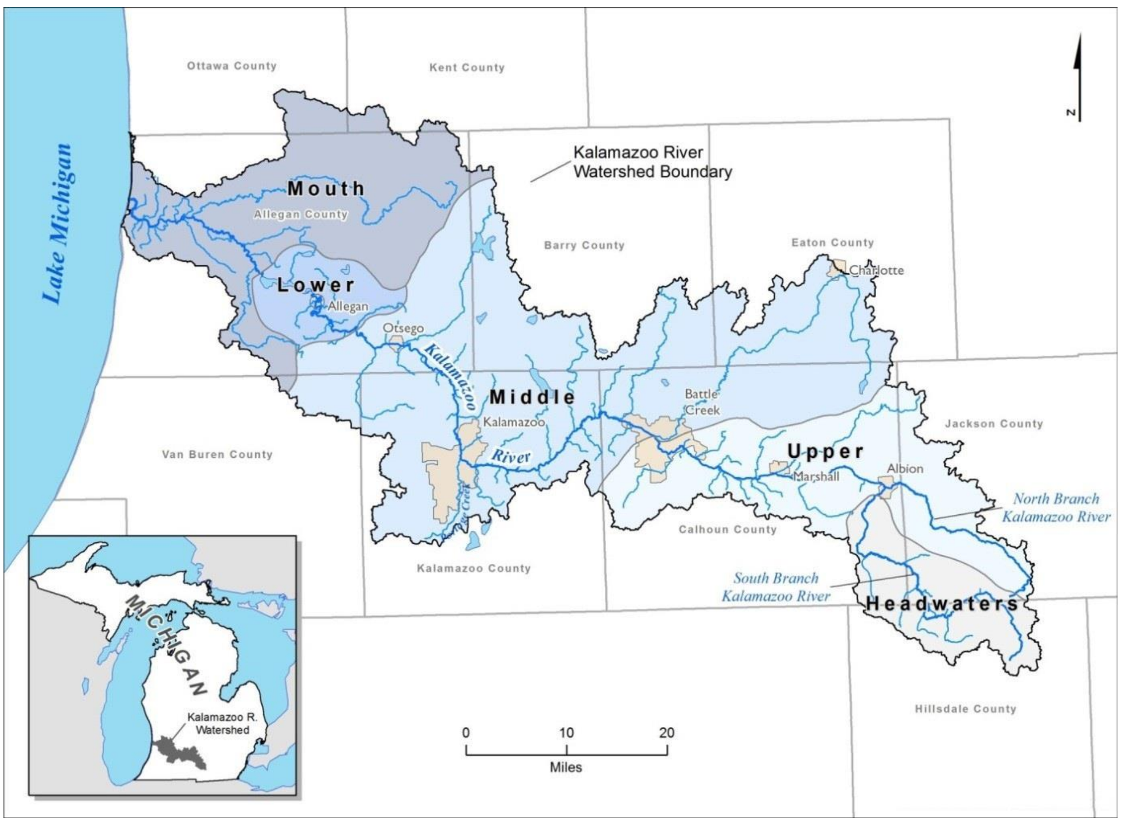


Figure 4.1. Kalamazoo River watershed. Watershed subdivided into five mainstem segments with distinct characteristics and natural resources.

Source: Wesley, 2005.

The mainstem of the Kalamazoo River is approximately 198 kilometers (123 miles) long and flows from the Town of Albion, Michigan, to Lake Michigan near the City of Saugatuck, Michigan (MDNR, 1981). The north and south branches of the Kalamazoo River originate at more than 305 meters (1,000 feet) above sea level, join at Albion, and drop to approximately 177 meters (580 feet) above sea level at the mouth of the river. The watershed contains approximately 872 kilometers (542 miles) of stream tributaries, most notably Rice Creek, Battle Creek River, Portage Creek, and Rabbit River (MDNR, 1981).

The physical environment of the Kalamazoo River watershed changes over the course of the river from its headwaters to its mouth (see Figure 4.1). The river originates as a spring-fed pond in Hillsdale County, Michigan. The South Branch Kalamazoo River headwaters segment begins as a small stream and increases in flow as it meanders through a broad glacial-fluvial valley for 72 kilometers (45 miles). Downstream of the confluence with the North Branch Kalamazoo River, the Kalamazoo River is joined by Wilder, Rice, and Harper creeks, which further increase the flow. This upper segment has relatively stable flows and meanders freely for another 48 kilometers (30 miles). Between the confluence with the Battle Creek River to the City of Otsego, the Kalamazoo River flow increases further because of inputs from Wabascon Creek, Augusta Creek, Portage Creek, Battle Creek River, the Gun River, and groundwater inflows. In this 80-kilometer (50-mile) middle segment, the river channel meanders between moraine features and broad valleys. Downstream of Otsego, the Kalamazoo River is constrained through a relatively narrow, glacial-fluvial valley for approximately 39 kilometers (24 miles) until it reaches Lake Allegan Dam (lower segment). Downstream of Lake Allegan Dam, the Kalamazoo River shifts to a very low gradient and warmer temperatures as it meanders across a lacustrine plain along large wetlands for 42 kilometers (26 miles) until it reaches Lake Michigan (mouth segment). This section of the river has been designated a Wild and Scenic River by the Michigan Natural Resources Commission under the Natural Rivers Act (now Part 305 of the Natural Resources and Environmental Protection Act, Act 451 of the Public Acts of 1994; MDNR, 1987).

Approximately 889 millimeters (35 inches) of precipitation falls in Kalamazoo County each year, with the majority of it falling between April and September (NOAA, 2013). Precipitation in the headwaters of the Kalamazoo River averages 889 millimeters (35 inches) per year, is lower in the middle reaches (averaging 813–864 millimeters, 32–34 inches per year), and is highest at an average of 914 millimeters (36 inches) per year in the lower reaches. Snowfall in the upper reaches averages 1,016 millimeters (40 inches) per year, whereas the lower reaches average 2,032 millimeters (80 inches) per year, largely because of increases in cloudiness associated with Lake Michigan (Wesley, 2005).

There are 110 dams in the Kalamazoo River watershed that are registered with MDEQ, 14 of which are on the mainstem (Wesley, 2005).[1] There may also be any number of small unregistered dams in the watershed. Between Morrow Lake, just upstream of the City of Kalamazoo and the river mouth, the river alternates between free-flowing sections and a series of low-head dams. The Plainwell, Otsego, and Trowbridge dams were lowered to their sill levels in the early 1970s, and by lowering the water level, sediments that were formerly in the impoundments became floodplain soils (Blasland, Bouck & Lee, 1992). The Plainwell Dam was eventually removed, but downstream of Plainwell the river is still impounded by the Otsego City (see Figure 4.2), Otsego, Allegan City, and Lake Allegan (or Calkins) dams. These dams, which no longer serve any of their historical purposes with the exception of Lake Allegan Dam which is being used for hydropower, alter the natural gradients of the river, block fish passage, fragment the river system, and eliminate many rapid and riffle areas that are important for fish spawning. The dams decrease the water velocity upstream, which makes the river wider and shallower, and cause increased deposition of fine sediments and increased water temperatures (Wesley, 2005). Additionally, the dams affect water quality by increasing downstream temperatures, decreasing dissolved oxygen, and storing suspended sediments. The dams disrupt the natural patterns of discharge and flooding of the river, increasing erosion and decreasing inputs of nutrients to the floodplain. The dams also interfere with human uses of the river, including recreational navigation.

From May 1 to October 31 each year, all waters of Michigan, including the Kalamazoo River, are designated for the following uses: agriculture, navigation, industrial water supply, public water supply, warmwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, and total body contact recreation (MDEQ, 1994; Kalamazoo River Watershed Council, 2011). Water from the Kalamazoo River and its tributaries is used for irrigating crops and watering livestock, as well as for industrial water supplies. The Kalamazoo River also receives discharge from industry and municipal sewage treatment facilities. There are no municipal drinking water intakes on the river; the main source of drinking water is groundwater. The lowest two-mile reach of the Kalamazoo River closest to Lake Michigan is designated as a federal channel, and is maintained by USACE through dredging (USACE, 2014).

1. The Plainwell Dam was removed during the 2007–2009 Time-Critical Removal Action. The Ceresco Dam was removed during 2013–2014 as restoration for injuries due to the Enbridge oil spill in 2010.

Figure 4.2. Current condition of the Otsego City Dam. Photograph aiming north; upstream is to the right and downstream is to the left.

Source: URS, 2011.

4.1.2 Water quality

Water in the Kalamazoo River watershed has historically been affected by discharges from industries and municipalities, nonpoint sources of pollution associated with agriculture and urban development, and aerial deposition (Wesley, 2005; Kalamazoo River Watershed Council, 2011). Water quality is generally good in the headwaters and upper mainstem segments (Wesley, 2005). The middle segment flows through the major urban areas of Battle Creek and Kalamazoo, and has historically experienced low dissolved oxygen levels caused by excessive nutrients from wastewater discharges. Water quality in the lower mainstem segment is affected by inputs upstream and the City of Allegan. Lake Allegan has a long history of nutrient problems and eutrophication. High phosphorous concentrations in Lake Allegan contribute to excessive algal growth and seasonally low dissolved oxygen levels (Wesley, 2005).

There are 94 permitted municipal and industrial discharges to surface waters in the Kalamazoo River watershed (Wesley, 2005). These discharges, permitted by the State of Michigan through the National Pollution Discharge Elimination System, include effluent from municipalities (e.g., wastewater treatment plants, storm sewers), industrial discharges (e.g., cooling water, process wastewater), and other sources such as discharges from campgrounds, animal feeding operations, and rest areas. The permits contain limits for parameters that affect water quality (e.g., metals, organics, dissolved oxygen, solids, nutrients, oil and grease, temperature, chlorine). The limits are set with the intention of maintaining water quality in the receiving waters. Nonpoint sources of pollution, such as urban and agricultural runoff and uncontrolled sediment runoff from construction activities, also contribute to water-quality problems in the Kalamazoo River watershed (Wesley, 2005).

In addition to these general water-quality concerns, surface water is also affected by PCBs released from Kalamazoo-area paper mills. In the Stage I assessment (MDEQ et al., 2005a), the Trustees found that PCB concentrations measured in surface water downstream of facilities owned by the potentially responsible parties exceeded water-quality standards for the protection of wildlife and the protection of humans against cancer.

The Kalamazoo River has also been affected by a pipeline oil spill. In July 2010, a 30-inch-diameter oil pipeline owned by Enbridge Energy ruptured near Marshall, Michigan, and released crude oil into a wetland area and Talmadge Creek, and from there into the Kalamazoo River. Enbridge Energy has estimated it discharged over 843,000 gallons of crude oil (NTSB, 2012), but other estimates are substantially greater. Much of the oil entered the Kalamazoo River, contaminating at least 38 miles of the river downstream into the impoundment formed by Morrow Dam. This dam is the upstream boundary of the Kalamazoo River Superfund Site. Although oil from the Enbridge spill has not been detected downstream of Morrow Dam, areas upstream of the dam that had previously been used as reference areas for PCB studies related to the Kalamazoo River Superfund Site were impacted by this oil spill.

In general, Kalamazoo River water quality has improved and continues to improve as a result of laws intended to protect water quality and provide for the remediation of contaminated sediments. Surface water in the Kalamazoo River watershed is protected by Michigan Water Quality Standards (Part 31 of 1994 Public Act 451). MDEQ monitors water quality to determine compliance with the law. However, some areas within the watershed are not attaining their designated uses. Under Section 303(d) of the CWA, states are required to develop lists of impaired waters that are too polluted or degraded to meet water-quality standards and designated uses. These impaired waterways are then prioritized, and the State of Michigan establishes limits for pollutant loadings (referred to as Total Maximum Daily Loads) that are intended to reduce instream concentrations to acceptable levels.

Designated uses that have been identified as impaired in portions of the Kalamazoo River watershed include fish consumption, warmwater fishery, other aquatic life and wildlife, and body contact recreation (Kalamazoo River Watershed Council, 2011). These impairments are caused by contaminants such as PCBs and mercury, nutrients such as phosphorus, physical alterations to substrate and flow regimes, sedimentation and siltation, and the presence of bacteria (e.g., *E. coli*). The designated uses of agriculture, industrial water supply, and navigation are being met throughout the watershed, and the designated use of public water supply is not applicable because surface water is not used as a community water source. In 2001, MDEQ established a Total Maximum Daily Load intended to reduce concentrations of phosphorus in Lake Allegan to less than 60 micrograms per liter (MDEQ, 2001).

4.2 Geologic Resources and Sediment Quality

Soils in the Kalamazoo River watershed range from clay and silt to sand and organic materials (Kalamazoo River Watershed Council, 2011). About 70% of the watershed is covered with coarse-textured soils that are relatively permeable to infiltration of water (Kalamazoo River Watershed Council, 2011). According to soil maps of the watershed, approximately 52% of the soils are sandy, loamy sand, or sandy loam; 34% of the soils are silt loam or loam; and 14% of the soils are clay loam, silty clay loam, sandy clay, silty clay, or clay (see Figure 4.3; Wesley, 2005).

Sediments in the Kalamazoo River consist of variable proportions of particles, ranging from fine clay to large boulders, as well as organic matter (CDM, 2003). The former impoundment areas are associated with increased siltation and decreased particle sizes relative to most of the rest of the river (CDM, 2003). Areas with cobbles and gravel substrates are unevenly distributed throughout the river.

Because of their chemical properties, the majority of PCBs released to the environment tend to accumulate in sediments rather than being dissolved in the water column. In the Stage I assessment (MDEQ et al., 2005a), the Trustees found that sediments are and have been injured by PCBs in Portage Creek and the lower 129 kilometers (80 miles) of the Kalamazoo River. PCB concentrations in portions of the Kalamazoo River watershed are high enough to cause toxic effects in benthic invertebrates, mink, and bald eagles.

The Trustees concluded in the Stage I injury assessment report that, based on the history of PCB releases from the facilities and the history of PCB concentrations reflected in sediment core data, it is likely that PCB concentrations in sediment have been sufficient to have caused injuries from as early as the 1950s and will continue to cause injuries until the sediment PCB-to-receptor pathway is broken by remedial actions (see Section 1.2.2.2; MDEQ et al., 2005a). Actions taken by EPA to date have reduced PCB concentrations in sediments in some areas of Portage Creek and Area 1 of OU5 (see Section 1.2.2.1).

Figure 4.3. Generalized map of Kalamazoo River watershed soil types. Group A = sandy, loamy sand, or sandy loam; Group B = silt loam or loam; Group C = clay loam, silty clay loam, sandy clay, silty clay, or clay.

Source: Wesley, 2005, Figure 22.

Kalamazoo River sediments are also affected by nonpoint sources of pollution and atmospheric deposition of pollutants (Kalamazoo River Watershed Council, 2011). These are discussed further in Section 4.1.2.

4.3 Biological Resources

The Kalamazoo River watershed comprises a diversity of habitats that support a broad range of species. Aquatic habitat consists of surface water and sediments that support all or a portion of the lifecycles of benthic invertebrates, fish, and birds and mammals that feed on aquatic organisms. Riparian zones and wetlands along the Kalamazoo River provide food and cover for both aquatic organisms and terrestrial organisms (MDEQ et al., 2005a). The Kalamazoo River watershed is also home to unique wetlands, including prairie fens that occur in glacially deposited, mineral-rich soil that is only found in southern Michigan and other glaciated Midwest states. Prairie fens are typically part of a large wetland complex that supports a variety of wetland communities (Kost et al., 2007). Restoration projects conducted under this plan may be evaluated under subsequent tiered documents for compliance with laws and regulations that protect biological resources as needed (see Section 7.2).

4.3.1 Fish

As of 2005, MDNR identified 102 species of fish in the Kalamazoo River watershed (Section A.1 in Appendix A, Table 18; Wesley, 2005). The species that inhabit different portions of the watershed are determined in large part by the temperature of the water and the nature of the stream substrate and available habitat. Figure 4.4 shows the classifications of the main stream segments of the Kalamazoo River watershed developed by the Fisheries Division of MDNR.

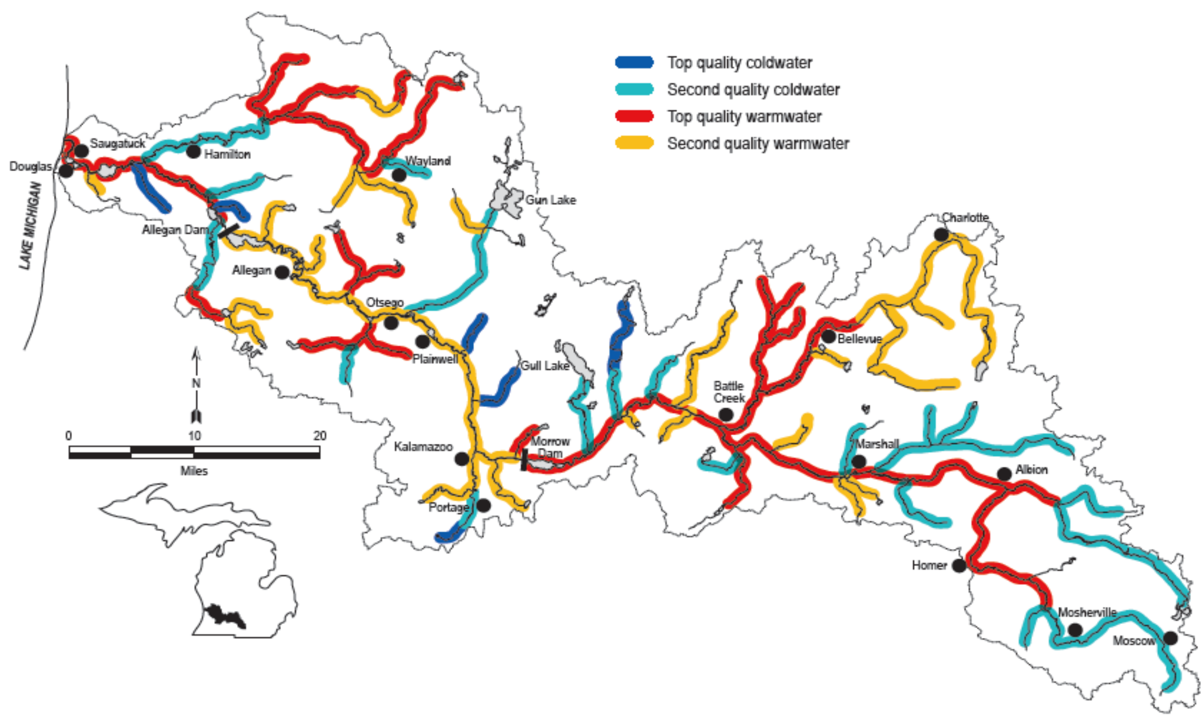


Figure 4.4. Stream classifications of Kalamazoo River watershed.

Source: Wesley, 2005, Figure 30.

The fish community changes as the aquatic habitat changes from the headwaters to the mouth of the Kalamazoo River (see Figure 4.1 for segment boundaries). In the cool to cold waters of the headwaters mainstem segment and Portage Creek, the fish community is dominated by brown trout, mottled sculpin, white sucker, stonecat, and rock bass. In the upper river segment, which is also relatively cool compared to downstream reaches, northern hog sucker, white sucker, and stonecat are common. Game species in this segment include rock bass, smallmouth bass, and northern pike. The middle mainstem segment is classified as warmwater and supports a different mixture of fish species, including white sucker, golden redhorse, common carp, common shiner, striped shiner, smallmouth bass, and rock bass. The distribution of fish species in Portage Creek is similar to those found in the headwaters of the Kalamazoo River but is affected by a series of dams on the creek. Data from a fish survey of Portage Creek is included in Section A.2 in Appendix A (Smith, 2011). Bluegill and common carp are the most abundant species in Morrow Lake, which also supports game species such as channel catfish, smallmouth bass, northern pike, and walleye. Common carp, white sucker, and blackside darter are commonly found in the lower mainstem segment, a large warmwater stream. Lake Allegan, which is also in the lower segment, contains a degraded warmwater fish community, dominated by common carp and channel catfish. The fish community in the mouth segment reflects the large size of that segment and its barrier-free connection to Lake Michigan. The dominant species in this reach include flathead catfish, walleye, quillback carpsucker, freshwater drum, gizzard shad, alewife, and various migratory salmon species; lake sturgeon are also found in this segment. Appendix B provides a complete list of the common and scientific names of all species identified in this report. Additional ecological characteristics of the dominant fish species in the Kalamazoo River is in Table 4.1.

Table 4.1. Kalamazoo River dominant fish species ecological characteristics

Species	Physical/general description	Nativity and distribution	Diet/impact to ecosystem relevance
Flathead catfish	One of the largest members of the catfish family. Flathead catfish have a slender, elongated body that becomes moderately robust in adults. The protruding lower jaw is an important characteristic when identifying the species as it distinguishes flathead catfish from other catfish and contributes to flathead catfish being placed in their own genus.	Non-native to the Kalamazoo River. Flathead catfish are native to central parts of the continent but have been intentionally introduced to eastern and western areas. The native range of flathead catfish includes a broad area west of the Appalachian Mountains encompassing large rivers of the Mississippi, Missouri, and Ohio basins; it extends as far north as North Dakota, as far west as New Mexico, and as far south as eastern Mexico.	Flathead catfish prey heavily on native fish and their introduction is recognized as the most biologically harmful of all fish introductions in North America. Flathead catfish have carnivorous food habits and the ability to disperse rapidly with a rapid population growth rate, causing concern among ichthyologists and management agencies.

Table 4.1. Kalamazoo River dominant fish species ecological characteristics (cont.)

Species	Physical/general description	Nativity and distribution	Diet/impact to ecosystem relevance
Walleye	Although walleye are the largest member of the perch family, they are considered a fairly small predatory fish. They may grow to be 21 inches in length and weigh 3 to 4 pounds.	Native to the Kalamazoo River. Overall, walleye are native to freshwater rivers and lakes of the northern United States and Canada.	Walleye are a voracious predator, and preys on small bass, trout, pike, perch, and sunfishes. Walleye feed actively all winter, providing a year-round sport fishery.
Quillback carpsucker	Quillback carpsucker have a subterminal mouth with no barbels. They have a white belly with yellow or orange lower fins, and a tail and dorsal fin that are usually gray or silver. Quillback carpsucker get their common name from the long quill that is formed via the first several fin rays of their dorsal fin.	Native to the Kalamazoo River, their native range includes the Great Lakes and St. Lawrence River, Hudson Bay, and Mississippi River basins from Quebec to Alberta and south to Louisiana.	Quillback carpsucker are an important component of the food chain, serving as prey for numerous species, especially northern pike and muskellunge. They are omnivores and bottom feeders with a diverse diet consisting of insect larvae and various aquatic vegetation, crustaceans, algae, leaves, clams, and mollusks.
Freshwater drum	Freshwater drum are a laterally compressed, silver, deep-bodied fish with a long dorsal fin relative to their total length. Their mouth is sub-terminal with a blunt rounded snout. Freshwater drum closely resemble their saltwater relative, the red drum.	Native to the Kalamazoo River, their native range includes east of the Rocky Mountains in the St. Lawrence-Great Lakes, Hudson Bay, and Mississippi River basins from Quebec to northern Manitoba and southern Saskatchewan in Canada, and south to the Gulf of Mexico.	An adult freshwater drum diet consists mainly of immature insects, minnows, amphipods, crayfish, and mollusks, while young fish feed on zooplankton. Freshwater drum will feed throughout all hours of the night. They are managed mainly as a sportfish throughout the Great Lakes region.
Gizzard shad	Gizzard shad have a short, wide upper jaw and a weak, relatively smaller lower jaw. They have a highly reduced lateral line system, a feature shared by other members of the herring family.	Native to the Kalamazoo River, their native range includes St. Lawrence-Great Lakes, Mississippi, Atlantic, and Gulf Slope drainages from Quebec to central North Dakota and New Mexico, and south to central Florida and Mexico.	Gizzard shad consume phytoplankton and zooplankton. Because of their feeding habits and abundance, they can affect primary productivity, thereby indirectly affecting the food source of other planktivorous fish. Gizzard shad have been widely used as a food source for game fish, with varied success in management of this species.

Table 4.1. Kalamazoo River dominant fish species ecological characteristics (cont.)

Species	Physical/general description	Nativity and distribution	Diet/impact to ecosystem relevance
Alewife	Alewife are a small herring with a dark dorsal side that is bluish to greenish, and light sides with horizontal darker stripes.	Non-native to the Kalamazoo River, these fish are native to the Atlantic Coast from Red Bay (Labrador, Canada) to South Carolina, and found in many landlocked populations. Alewife were intentionally placed in the Great Lakes and stocked in Michigan inland waters.	Alewife can be disruptive to indigenous food webs. The disappearance of native planktivorous salmonids, such as whitefish in the Great Lakes, has been attributed in part to the introduction of alewife, which reduced zooplankton populations. Alewife are a very important species in the history of biological invasions in the Great Lakes. Periodic large-scale die-offs littered the beaches of the Great Lakes with rotting fish in the 1960s; such die-offs can pose both a nuisance and a health hazard.
Lake sturgeon	Lake sturgeon are a bottom feeder with a partly cartilaginous skeleton, with a streamlined shape and skin-bearing rows of bony plates on their sides and back, resembling an armored torpedo. They use their elongated snout to stir up sediments on the beds of rivers and lakes while feeding.	Native to the Kalamazoo River, their range is from the St. Lawrence-Great Lakes, Hudson Bay, and Mississippi River basins from Quebec to Alberta, and south to Alabama and Louisiana.	Lake sturgeon are vulnerable to population declines through overfishing due to their extremely slow reproductive cycle. Environmental detriment has also led to the recent decline of lake sturgeon populations. There are currently many sturgeon fishing limitations in place in Michigan water bodies and other states across the United States.

Sources: MDNR, 1994; USDA, 2015; USGS, 2015.

MDNR has managed the recreational fishery in the Kalamazoo River since the late 1880s (Wesley, 2005). In the past, MDNR has stocked various reaches with recreational species, such as brook, brown, and rainbow trout; northern pike; tiger muskellunge; smallmouth bass; walleye; channel catfish; rainbow smelt; Atlantic salmon; and Chinook salmon. The Kalamazoo River system is generally conducive to a warmwater fishery, although a number of tributaries are cool enough to support a quality trout fishery. An anadromous fish-stocking program was initiated on the lower Kalamazoo River in 1969. The chinook fishery (in the fall) and the steelhead fishery (throughout the winter and early spring) are generally productive. Brown trout are also fished during the fall and winter at the Lake Allegan Dam and in the lower river areas (MDNR, 2002).

The South Branch of the Kalamazoo River has been popular with mainly local anglers since the early 1950s, when trout stocking began. The river was stocked with legal-size rainbow trout from 1950 through 1954, and with brown trout yearlings from 1973 through 1993. The South Branch of the Kalamazoo River is classified as a second-quality trout feeder stream. It is one of only five designated trout streams in the Jackson Fisheries District. The section of the South Branch of the Kalamazoo River that has historically been managed for brown trout is approximately 7 miles long. Although there is a considerable amount of favorable trout habitat in the managed section of the South Branch, significant amounts of sand limit production in this stream. Sand covers 30–90% of the stream bottom in the area managed for trout, which negatively impacts the fish community. In addition to physical degradation, the Kalamazoo River has never been chemically rehabilitated since the wide array of PCBs were dumped in the river as a result of carbonless paper production before these chemicals were banned in the 1970s (MDNR, 1994).

Fish in the Kalamazoo River watershed are affected by water-quality problems, alterations or barriers to movement, habitat degradation, and the introduction of invasive species (Wesley, 2005). Despite increasingly effective wastewater treatment facilities and enforcement efforts, pollution problems still occur in the Kalamazoo River. Contaminants in the watershed, including PCBs and mercury, are present in fish tissue at concentrations sufficient to issue fish consumption advisories for the protection of human health and pose risks to piscivorous (i.e., fish-eating) wildlife (MDEQ et al., 2005a). Fishing for warmwater fish in the lower Kalamazoo River would be significantly more popular if overall water quality were improved.

The Michigan Department of Community Health has issued an advisory warning against eating fish obtained from the Kalamazoo River (Kalamazoo to Saugatuck) because of the known high PCB levels, which exceed USDA limits. Legislation to control PCBs in Michigan was initiated by Part 147, PCB Compounds, of the 1994 Public Act 451. This law limited concentrations of chemicals and regulated the sale, labeling, transportation, and disposal of PCB products in the State of Michigan. PCBs are also controlled at the federal level by the Toxic Substances Control Act, Public Law 94-469. This law became effective on January 1, 1977 and prohibited the manufacture, processing, distribution, and use of PCBs after July 2, 1979, unless specifically exempted by EPA. These strict measures will control future introductions of PCBs in the Kalamazoo River watershed, but PCBs will continue to be an environmental contaminant for some time due to their persistence in the environment and historical widespread use (MDNR, 2002).

4.3.2 Aquatic invertebrates

Macroinvertebrates are organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate). They inhabit all types of running waters, from fast-flowing mountain streams to slow-moving murky rivers. Benthic invertebrates (e.g., clams, snails, mussels, and the larval forms of some insects, such as dragonflies, midges, and mayflies) live or feed on the bottom of aquatic habitats. Most aquatic invertebrates live part or most of their lifecycle attached to submerged rocks, logs, or vegetation.

These invertebrates are vital in the aquatic food chain, playing essential roles in energy and nutrient transfer from primary producers, such as algae and phytoplankton, to predatory fish and as decomposers. They are also frequently used as indicators of water and habitat quality. The presence of sensitive species, such as mayflies, caddisflies, and stoneflies, is indicative of good water quality. According to EPA, aquatic macroinvertebrates are good indicators of water quality for the following reasons (U.S. EPA, 2015):

- They are affected by physical, chemical, and biological conditions of a stream
- They cannot escape pollution and show effects of short- and long-term pollution events
- They may show cumulative impacts of pollution
- They may show impacts of habitat loss not detected by traditional water-quality assessments
- They are a critical part of a stream's food web
- Some are very intolerant of pollution
- They are relatively easy to sample and identify.

However, pollution and ongoing environmental degradation severely limit aquatic invertebrate production. Extremely polluted waters that receive high inputs of organic matter or nutrient enrichment tend to have a low diversity of macroinvertebrates. The quality of the macroinvertebrate community varies throughout the watershed (Wesley, 2005). It is generally good to excellent in the headwater, upper, and middle segments, where sensitive species can be found. Wesley (2005) was unable to find any surveys of the invertebrate community in the lower and mouth segments.

As benthic macroinvertebrates tend to remain in their original habitat, they are affected by local changes in water quality. Some are capable of tolerating greater loads of pollution than others. If pollution in an area is severe, or is moderate but sustained over time, the whole community structure may simplify in favor of tolerant species. Although the abundance of certain species may increase, the diversity and the number of different species in a given area decrease. By assessing indicator species, diversity, and functional groups of the benthic macroinvertebrate community, it is possible to determine water quality (U.S. EPA, 2015). Turbidity reduces light penetration and submerged aquatic plant productivity, in turn, affects macroinvertebrates depending on plant matter for food and predator macroinvertebrates that rely heavily on visual location of prey. In addition, filtering mechanisms of filter feeders may be blocked by sediment.

Bivalves (e.g., mussels and clams) are indicator species that generally cannot tolerate high turbidity. Mussels eat by filtering bacteria, protozoans, algae, and other organic matter from the water. They draw water into their body through their incurrent siphon, remove food and oxygen with their gills, and then expel the filtered water through their excurrent siphon. Food particles are carried to the mussel's mouth by tiny hair like cilia located on the gills. As filter-feeders, large quantities of sediments and free-flowing organic matter can prevent bivalves such as mussels from feeding sufficiently (USDA, 2015).

Twenty-three species of mussels have been documented in the Kalamazoo River watershed (Mulcrone and Mehne, 2001; Wesley, 2005). As previously stated, because mussels cannot move very far and are sensitive to pollution and siltation, their presence is an indicator of good water quality. Mulcrone and Mehne (2001) found that the diversity of mussel species was lowest in the middle reaches of the river, from Plainwell to below Allegan City Dam, and hypothesized that this might result from the presence of impoundments and historically poor water quality in these reaches. Mucket were the most abundant species across all of the locations that Mulcrone and Mehne (2001) surveyed between Battle Creek and Saugatuck. Mucket are vulnerable to habitat degradation and catastrophic events, such as oil spills. The majority of the mucket's lifespan is spent buried in the bottom sediments of the water body and they often live in multi-species communities called mussel beds.

The white heelsplitter and pocketbook mussels were also common in the Kalamazoo River watershed. Downstream of Lake Allegan Dam the mussel community is dominated by the mapleleaf. Mulcrone and Mehne (2001) did not find any mucket in their survey of the lower reaches, although historical records indicate that they were previously found in Saugatuck. The absence of mucket may be related to limitations of fish hosts or unsuitable habitat conditions. Several species were found only downstream of Lake Allegan Dam, including the mapleleaf, the pimpleback, the fawnsfoot, and the deertoe. Two invasive species were collected by Mulcrone and Mehne (2001): zebra mussels were found downstream of Lake Allegan Dam and in Lake Allegan, and Asian clams were found at multiple locations upstream of Lake Allegan Dam. Zebra mussels are small shellfish named for the striped black and pale pattern of their shells. Color patterns can vary to the point of having only dark or light-colored shells and no stripes. They are typically found attached to any stable substrate, even to other mussels by threads extending from underneath their shells. Zebra mussels are native to Europe in the Black, Caspian, and Azov seas. Zebra mussels were first discovered in 1988 in the Great Lakes in the Canadian waters of Lake St. Clair, a water body connecting Lake Huron and Lake Erie. By 1990, zebra mussels had been found in all of the Great Lakes. The following year, zebra mussels moved into the Illinois and Hudson rivers (USGS, 2015).

Asian clams are native to temperate to tropical southern Asia west to the eastern Mediterranean; Africa, except in the Sahara Desert; and the southeast Asian islands south into central and eastern Australia. Since this species was introduced to the United States in 1938, Asian clams have spread into many of the major waterways across the country, encompassing 38 states and the

District of Columbia. Asian clams have the ability to reproduce rapidly and an adaptable tolerance of cold temperatures (2–30°C) has resulted in rapid swings in population sizes from year-to-year in northern water bodies. The most prominent effect of the introduction of the Asian clam into the United States has been biofouling, especially of complex power plant and industrial water systems. In addition to competing with native species for resources, Asian clams have also been documented to alter benthic substrates and cause problems in irrigation canals, pipes, and drinking water sources (USGS, 2015).

The presence of these invasive species may affect the ability of native species to survive by reducing available habitat, covering the valves of native mussels, and decreasing their ability to feed (Wesley, 2005). Specifically, zebra mussels can reduce filtration rates by requiring more frequent interruption of filtering or slower pumping rates. In addition to the effect of zebra mussels on the aquatic ecosystem, these bivalves can have costly negative effects on human infrastructure. Navigational buoys have been sunk under the weight of attached zebra mussels. Fishing gear can be irreversibly damaged by mussel encrusting if left in the water for long periods of time. The deterioration of dock pilings has increased when they are encrusted with zebra mussels. The continued attachment of zebra mussels can cause corrosion of steel and concrete, affecting the structural integrity of water supply pipes of hydroelectric and nuclear power plants, public water supply plants, and industrial facilities (USGS, 2015).

4.3.3 Wildlife

A wide variety of wildlife also uses the Kalamazoo River basin. Many of these species are dependent on the river and its tributaries for cover, water, and food.

4.3.3.1 Birds

Many birds use the Kalamazoo River watershed for nesting, feeding, and resting. More than 218 resident and migratory species are regularly found in the watershed (Wesley, 2005).[2] These include a variety of aquatic birds (e.g., dabbling and diving ducks, swans, grebes, herons, sandpipers, mergansers, cormorants, osprey, kingfishers, gulls), songbirds, upland game birds (e.g., turkeys, pheasant, grouse), and raptors (e.g., bald eagles, hawks, owls).

2. A complete list of these species can be found in Table 28 of Wesley, 2005.

4.3.3.2 Amphibians and reptiles

Fifty-four species of amphibians and reptiles have been found in the Kalamazoo River watershed, including turtles, snakes, salamanders, lizards, frogs, and toads (Wesley, 2005).[3]

4.3.3.3 Mammals

There are at least 40 mammal species known to use the area, including rodents, bats, beaver, otter, muskrat, mink, raccoon, fox, and deer (Wesley, 2005).[4]

4.3.4 Vegetation

The Kalamazoo River watershed currently has remnants of the historical oak savanna (characterized by grassy prairie-type ground cover beneath an open tree canopy) and prairie (i.e., tallgrass) habitats that once dominated the landscape. The dominant terrestrial vegetation communities in the Kalamazoo River watershed include:

- Dry southern hardwood forest – forests of dry upland sites with burr oak, black oak, or white ash dominating
- Moist southern hardwood forest – forests that occur in richer and moister soils and are dominated by beech and sugar maple
- Wet lowland forest – forests characterized by willow, cottonwood, or bottomland floodplain forest, including sycamore, silver maple, and ash
- Grassland-savanna complex – includes the combination of prairies, sedge meadows, and savannas, characterized as treeless or with scattered trees and dominated by grasses or wet or dry sedges (Chapman and Brewer, 2008; Kalamazoo River Watershed Council, 2011).

Approximately 13% of the Kalamazoo River Watershed is forested and non-forested wetlands (Kalamazoo River Watershed Council, 2011). The Kalamazoo River watershed also contains prairie fens, a type of wetland habitat with high rates of groundwater through-flow that is found only in the glaciated Midwest (Kalamazoo River Watershed Council, 2011). These fens typically contain switchgrass, Indiangrass, big bluestem, sedges, rushes, Indian plantain, and prairie

3. A complete list of these species can be found in Table 27 of Wesley, 2005.

4. A complete list of these species can be found in Table 29 of Wesley, 2005.

dropseed. The upland edges of these fens also support tamarack, dogwood, bog birch, poison sumac, and the invasive glossy buckthorn.

4.3.5 Federally listed species

The ESA [16 U.S.C. §§ 1531–1544] provides protection for species in danger of extinction throughout all or a significant portion of their range, as well as designation of critical habitat for those species. A number of federally listed threatened and endangered species under DOI's jurisdiction have been identified by the USFWS as occurring in the counties of the Kalamazoo River watershed (Table 4.2; USFWS, 2015b). There are no federally protected species under NOAA's jurisdiction in the Great Lakes. Based on occurrence records and specific habitat requirements, none of the restoration alternatives are expected to affect the following species: rufa red knot, Powesheik skipperling, snuffbox, clubshell, Pitcher's thistle, and Eastern prairie fringed orchid. Therefore, they will not be analyzed in this document.

Table 4.2. Federally listed endangered, threatened, and candidate species in the vicinity of the Kalamazoo River watershed

Common name	Federal status	Critical habitat identified/ preferred habitat	Counties affected
Indiana bat	Endangered	No critical habitat identified in Michigan. Inhabit caves for winter hibernacula and trees for summer roosts.	Kalamazoo, Ottawa, Allegan, Van Buren, Kent, Barry, Eaton, Calhoun, Jackson, and Hillsdale
Northern long-eared bat	Threatened, but an interim final rule is in place to protect the species	No critical habitat rules have been published. Inhabit caves for winter hibernacula and trees for summer roosts.	Kalamazoo, Ottawa, Allegan, Van Buren, Kent, Barry, Eaton, Calhoun, Jackson, and Hillsdale
Karner blue butterfly	Endangered	Critical habitat defined. Inhabit pine barrens dominated by pitch pines and scrub oak.	Allegan and Kent
Mitchell's satyr butterfly	Endangered	No critical habitat rules have been published. Inhabit Prairie Fens (117 are located in Michigan).	Kalamazoo, Van Buren, Barry, and Jackson
Poweshiek skipperling[a]	Endangered	Proposed critical habitat. Inhabit high-quality remnant (untilled), wet-mesic to dry tallgrass prairies, moist meadows, or prairie fen habitat.	Jackson and Hillsdale

Table 4.2. Federally listed endangered, threatened, and candidate species in the vicinity of the Kalamazoo River watershed (cont.)

Common name	Federal status	Critical habitat identified/ preferred habitat	Counties affected
Snuffbox[a]	Endangered	No critical habitats have been published. Inhabit small- to medium-sized creeks in areas with a swift current. Also found in Lake Erie and some larger rivers.	Kent
Clubshell[a]	Endangered	No critical habitat rules have been published. Inhabit clean, coarse sand, and gravel in runs, often just downstream of a riffle, in streams and small rivers.	Hillsdale
Rufa Red knot[a]	Threatened	No critical habitat rules have been published. Transient species in this area of Michigan.	Ottawa, Allegan, and Van Buren
Pitcher's thistle[a]	Threatened	No critical habitat rules have been published. Inhabit stabilized dunes and blowout areas (areas where blowing sand has migrated inland).	Ottawa, Allegan, and Van Buren
Eastern prairie fringed orchid[a]	Threatened	No critical habitat rules have been published. Inhabit mesic prairie areas and wetlands such as sedge meadows, marsh edges, even bogs.	Eaton
Copperbelly water snake	Threatened	No critical habitat rules have been published. Inhabit wooded and permanently wet areas such as oxbows, sloughs, brushy ditches, and floodplain woods.	Calhoun, Hillsdale, and Eaton
Eastern massasauga	Candidate	No critical habitat rules have been published. Inhabit shallow wetlands and adjacent upland habitat.	Kalamazoo, Allegan, Van Buren, Kent, Barry, Eaton, Calhoun, Jackson, and Hillsdale

a. While this species occurs within the listed county or counties, it has not been observed within the portion of the county or counties that is within the Kalamazoo River watershed (L. Williams, USFWS, personal communication, July 9, 2015). Based on the occurrence records and the specific habitat requirements of this species, none of the restoration alternatives are expected to affect this species and impacts on this species will not be analyzed in this document.

Source: USFWS, 2015b.

Several species on this list can be found in drier upland habitat. The Indiana bat, for example, is known to occupy wooded areas that are located along or within one to three miles of small-to-medium river and stream corridors or upland forests, as well as lowland, floodplain forests. The northern long-eared bat, a threatened species, hibernates in caves during the winter and roosts in trees during the summer (USFWS, 2015a). Both the Indiana bat and the northern long-eared bat inhabit a variety of intact and altered woodland habitats and hibernate in caves and mines. The Karner blue butterfly is found in pine barrens and oak savannas, where its larvae's only known food source, wild lupine, is located.

Several of the threatened and endangered species are associated with wetland and riparian areas. The Mitchell's satyr butterfly is found in fens and wetlands with carbonate-rich water. The copperbelly water snake is found in wooded, permanently wet areas such as oxbows, sloughs, ditches, and wooded floodplains. The eastern massasauga rattlesnake, a candidate species, also lives in wet areas such as wet prairies, marshes, and low riparian areas along rivers and lakes.

4.4 Air Quality

Sources of air pollutants include fuel combustion (stationary and mobile), industrial processes, solvent uses, agriculture, dust, and fires. The Clean Air Act [CAA; 42 U.S.C. §§ 7401–7626] regulates air emissions from stationary and mobile sources to protect human health and the environment. Under the CAA, EPA sets National Ambient Air Quality Standards (NAAQS) for pollutants that are harmful to public health and the environment, such as ozone and particulate pollution. EPA is responsible for establishing primary and secondary NAAQS for six criteria pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. Under the CAA, each state has the authority to establish stricter air-quality standards, which Michigan has established under state law, Part 55 (air Pollution Control) of the Natural Resources and Environmental Protection Act, Public Act 451 of 1994 (U.S. EPA, 2014). The Air Quality Division of the MDEQ is responsible for developing and implementing state requirements, and enforcing compliance with state and federal air-quality requirements. Federal regulations designate Air Quality Control Regions (AQCRs) as nonattainment areas if concentrations of one or more of the criteria pollutants exceed the NAAQS. Attainment areas are AQCRs with levels below the NAAQS.

Michigan has a network of air monitors maintained under its State Implementation Plan that demonstrate attainment with the NAAQS, provide the public with real-time air-quality measurements, track trends, and assist with the development of air pollution abatement strategies (MDEQ, 2015). The Kalamazoo River watershed is primarily in AQCR 125: South Central Michigan, with small portions falling in AQCR 122: Central Michigan, and AQCR 82: South Bend/Benton Harbor. The counties in which the Kalamazoo River watershed is located are in attainment with the NAAQS for carbon monoxide, sulfur dioxide, lead, ozone, particulates, and nitrogen dioxide; there are no nonattainment areas in the Kalamazoo River watershed (MDEQ, 2016).

There is one air-quality monitoring station in the Kalamazoo River watershed, located in Kalamazoo, which monitors low-level ozone and particulate matter; the monitoring station is maintained and operated by MDEQ (2013). In 2012, ozone concentrations at this station slightly exceeded the EPA air-quality standard of 0.075 parts per million on several occasions, but the particulate matter readings were below relevant standards (MDEQ, 2013).

4.5 Socioeconomic Resources and Environmental Justice

4.5.1 Socioeconomic resources

The Kalamazoo River flows through 10 counties in southwest Michigan (Allegan, Barry, Calhoun, Eaton, Hillsdale, Jackson, Kalamazoo, Kent, Ottawa, and Van Buren). As of 2000, approximately 400,000 people lived in the watershed (Kalamazoo River Watershed Council, 2011). The majority of this population resides in the municipalities of Kalamazoo (74,262) and Battle Creek (52,347; U.S. Census Bureau, 2014). In 2012, approximately 80% of the population of Kalamazoo County was White, 11% was Black, 4% was Hispanic, 2% was Asian, and a small percentage was of Native American or mixed race (U.S. Census Bureau, 2014).

The Kalamazoo River watershed currently supports a mixture of agricultural production, light and heavy industry, and recreational businesses (Kalamazoo River Watershed Public Advisory Council, 1998). The median household income in the City of Kalamazoo in 2008–2012 was $31,189, and the median value of owner-occupied housing was $99,900 (U.S. Census Bureau, 2014). The region’s strongest economic sectors are agriculture and tourism. The area has experienced manufacturing job losses in recent years; however, growth in population in the area is expected over the next few decades and the economy has been shifting toward the service sector. Growth in the low carbon/new energy economy is expected to provide additional opportunities in the coming years (Kalamazoo River Watershed Council, 2011).

4.5.2 Environmental justice

The State of Michigan developed an Environmental Justice Plan (MDNRE, 2010) to promote fair economic development for all communities and people in Michigan. The *Environmental Justice Plan for the State of Michigan and Michigan Department of Natural Resources and Environment* identified the state’s Environmental Justice Areas of Concern. There are three areas of concern in the Kalamazoo River watershed: Kalamazoo, Springfield, and Battle Creek.

4.6 Recreation and Land Use

According to the 2005 and 2006 land use and land cover dataset developed by NOAA, land use in the Kalamazoo River watershed is dominated by agriculture, which represents 50% of the watershed (NOAA CSC, 2006). Forested land comprises 22% and urban areas comprise about

9%, whereas wetlands comprise nearly 13% of the watershed. Agriculture dominates in the upper watershed, forest dominates in the lower watershed, and the majority of urban areas are located in the middle reaches (Figure 4.5). Because of the historical development of mills and other industries along the river, urban areas are located along the river corridor and therefore have a disproportionate impact on water quality (Kalamazoo River Watershed Council, 2011).

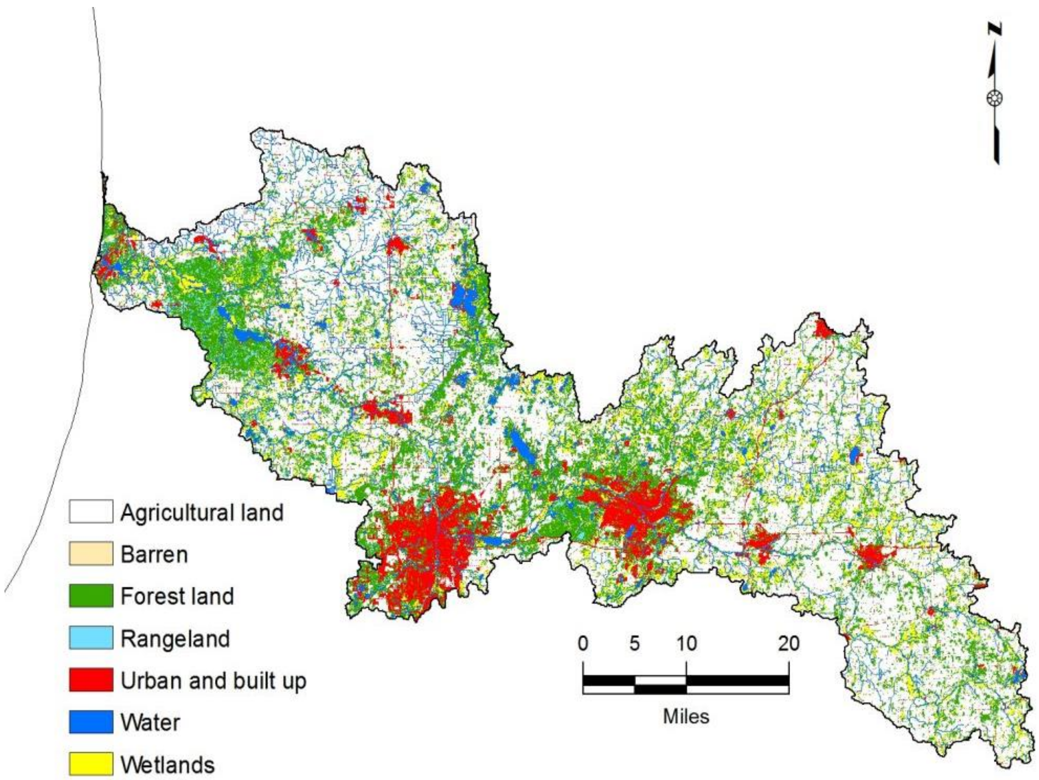


Figure 4.5. Land use and land cover in the Kalamazoo River watershed.

Source: NOAA CSC, 2006.

Approximately 223 square kilometers (86 square miles) in the Kalamazoo River watershed are publicly owned (Kalamazoo River Watershed Council, 2011). Public lands include the Allegan State Game Area (194 square kilometers, 75 square miles), the Fort Custer Recreation Area (12 square kilometers, 4.7 square miles), and about one-fifth of the Yankee Springs Recreation Area (4 square kilometers, 1.6 square miles) (Kalamazoo River Watershed Council, 2011).

The main agricultural crops are corn, soybeans, wheat, and oats; specialty crops include fruit, maple syrup, honey, wine, nursery plants, and Christmas trees (Kalamazoo River Watershed Public Advisory Council, 1998). Dairy and beef cattle, sheep, pigs, and poultry are also raised in the watershed. Industries include paper products, pharmaceuticals, cereal and food products, automobile and aircraft parts, and office furniture. Commercial areas are centered in Kalamazoo and Battle Creek. Recreational businesses include golf courses, archery ranges, horseback riding, boat and canoe rentals and charters, marinas, fishing, skiing, snowmobiling, and sledding.

The river provides important natural resource and recreational services year-round. In addition to the public lands described above, the watershed also has city and county parks and paths, some of which provide access to the riverfront, and nature areas and preserves (including the W.K. Kellogg Biological Station run by Michigan State University, the Kalamazoo Nature Center, and the Binder Park Zoo in Battle Creek). The paved multi-purpose Kalamazoo River Valley Trail is currently being developed; 17 of the planned 35 miles have been constructed (Kalamazoo County Government, 2014). When complete, it will link more than 140 miles of trail connecting the Battle Creek Linear Park, the Kal-Haven State Park Trail, and the Portage Bicentennial Park Trail. A broad array of recreational opportunities are available in the Kalamazoo River watershed, including camping, fishing, skiing, sledding, snowmobiling, horseback riding, golf, wildlife observation, hunting, canoeing, and boating (MDNR, 1981). Sport fishing is a popular recreational activity in Michigan. In the lower part of the Kalamazoo River below Lake Allegan Dam, anglers target coldwater sport fish such as Chinook salmon and rainbow trout, as well as walleye, smallmouth bass, bluegill, and catfish (MDEQ et al., 2005b). Warmwater species caught farther upstream include largemouth bass, panfish, carp, and suckers (MDNR, 1981).

4.7 Noise

Typical outdoor noise levels vary depending on the location and land use type. Sound levels that can be sensed by the human ear are measured in A-weighted decibels (dBA). In urban areas, noise sources include transportation (e.g., vehicles, trains, aircraft), industrial facilities, and construction activities, which typically range from 60 to 65 dBA. In agricultural areas, the use of heavy equipment and vehicles can be a source of noise. In portions of the watershed that are natural areas with limited development, ambient noise levels are relatively low (typically 50 dBA). Noise levels can differ depending on the source and duration, the existing site conditions, and existing ambient noise levels. Typical ambient noise levels that people are exposed to on a daily basis range from 50 to 55 dBA. Construction equipment can cause an increase in noise levels of up to 30 to 35 dBA from ambient levels. Table 4.3 provides sound levels of typical construction equipment that could be used during the restoration activities.

Table 4.3. Noise levels of construction equipment

Construction equipment	Noise level at 50 feet (dBA)
Bulldozer	85
Crane	85
Excavator	85
Dump truck	84
Generator	82
Compactor	80
Front-end loader	80

Source: FHWA, 2011.

4.8 Cultural Resources

Prior to contact with European explorers, areas around Kalamazoo were occupied by a series of tribes, including mound-builders who left their distinctive marks in the surrounding areas. By the later 1600s when the first European explorers transited the area, the land was occupied by the Potawatomi Tribe, a branch of the greater Algonquin people (Kalamazoo Public Library, 2015). The first permanent settlements by Europeans came in the early 1800s, and Kalamazoo and the surrounding area became an agricultural center linked to trade centers, initially by river travel and subsequently by railroads. As the area industrialized in the later 1800s, the river was used as a power source for mills, and beginning in the early 1900s, the river powered electrical generating stations. By the mid-1900s a number of paper mills were located on the river, and the pollution from the mills became an issue both locally and nationally (Kalamazoo River Watershed Council, 2011).

The Area of Potential Effect for the proposed action includes the streambeds and riparian areas that would be subject to restoration activities and the area within one mile of the proposed action area for potential visual impacts on listed and eligible historic properties. Within one mile of the project area there are approximately 65 properties that are either listed or documented as being eligible for listing in the National Register of Historic Places. Most of the properties are historic buildings or districts, but also include river bridges and historic sites. There are no listed prehistoric sites within the project area, but because of the importance of the river to indigenous people, prehistoric artifacts may be discovered by ground-disturbing actions in the streambeds and riparian areas.

5. Environmental Consequences

In this chapter the Trustees describe the reasonably foreseeable consequences of implementing the alternatives proposed in Chapter 3 on the physical, biological, and human environment described in Chapter 4.

As remedial investigations and the selection of remedial actions are ongoing for the Kalamazoo River Superfund Site, the entirety of the potentially responsible parties' natural resource damages liability has not yet been resolved. As remediation progresses downriver, the Trustees and the potentially responsible parties will have opportunities for additional natural resource damage settlements that could provide for additional funding to implement restoration projects. Other than the proposed removal of the Otsego and Otsego City dams, specific projects have not yet been selected. Given that opportunities for projects may arise in conjunction with response activities, this evaluation is largely being conducted at a programmatic level. The Trustees anticipate that most impacts would be the same or less than the impacts identified in this RP/PEIS, and in that situation, an EA or Categorical Exclusion (CE) could be developed that tiers off of this RP/PEIS, as allowed by CEQ's NEPA regulations at 40 C.F.R. § 1502.20.

Potential impacts would be reduced in several ways. First, the Trustees' project evaluation criteria (Table 2.2, Section 2.3) encourage the selection of projects that do not negatively impact the environment. Upon selecting projects, the Trustees would employ a variety of mitigation measures to reduce the limited short-term environmental impacts of the restoration alternatives (see Appendix D of NOAA, 2015, for guidance on mitigation measures). Mitigation measures include avoiding impacts by not taking a certain action or parts of an action; limiting the degree or magnitude of the action; reducing or eliminating the impact over time by preservation and maintenance actions; and rectifying or compensating for the impact by repairing, rehabilitating, restoring, or replacing the affected environment [40 C.F.R. § 1508.20]. In addition to specific mitigation measures that are discussed in the sections that follow, the Trustees would use adaptive management techniques to minimize impacts and would conduct project monitoring and rectify problems as they arise (see Section 2.4).

The following sections discuss potential impacts of the various restoration project categories anticipated under each of the alternatives on each resource area described in Chapter 4.

5.1 Characteristics of Potential Impacts

The potential environmental impacts of the alternatives are discussed in terms of their **type**, **duration**, and **significance**. The **types** of impacts caused by an action include direct (i.e., occurring contemporaneously at or near the place of that action) and indirect (i.e., occurring later or at a distance from the place of the action due to cascading effects, but still reasonably foreseeable). Additionally, impacts are also classified as either adverse (i.e., having a negative impact on the environment) or beneficial (i.e., having a positive impact on the environment). The **duration** of impacts is presented in terms of short- and long-term timeframes. Short-term impacts are generally associated with the implementation of the action, whereas long-term impacts are generally associated with the lasting impacts of the action after it is complete. The **significance** of impacts describes the magnitude of the impact and is assessed qualitatively as either *no impact, minor* (i.e., small magnitude impacts that are likely to not be measurable), *moderate* (i.e., impacts that are more observable, and potentially more amenable to quantification or measurement, but would not be considered severe), or *major* (i.e., severe impacts). This document also discusses beneficial impacts on habitat. **Cumulative** impacts resulting from the incremental impact of the proposed action added to other past, present, or reasonably foreseeable future actions are discussed separately in Chapter 6.

5.2 Water Resources and Water Quality

5.2.1 Alternative C (Preferred Alternative)

5.2.1.1 Aquatic habitat restoration

Long-term, moderate to major, beneficial impacts would be expected from the establishment of a functioning and healthy aquatic habitat. The removal of sediment overburden, the establishment of proper grade lines and a flow regime, and the establishment of proper bed sediments and banks would decrease sediments and nutrient loading of the river, both decreasing algae and eventually increasing water clarity.

Short-term, moderate, adverse impacts would be expected from the effects of restoration activities, such as erosion and sedimentation. The Trustees would adopt best management methods for sediment management, such as not using heavy equipment in the stream and using matting and fencing to prevent erosion while vegetation is being reestablished. They would also time removal activities during typical low-flow periods to minimize short-term negative impacts on surface water quality.

5.2.1.2 Riparian and wetland habitat restoration

Long-term, moderate to major, beneficial impacts would be expected from the establishment of riparian buffers and wetland habitat. Riparian buffers often utilize mechanisms to ensure water quality and protect water resources from excess nutrient influx and sedimentation. The establishment of wetlands and emergent aquatic vegetation would enable plants to utilize some nutrients in the river and minimize the dissolved nutrients responsible for algae blooms, water color, and odors.

Short-term, moderate, adverse impacts on water quality and water resources would be expected from the restoration of riparian and wetland habitats. Sediment and nutrient releases would cause cloudy water and perhaps algae blooms. There could be intermittent, short-term interruption of flow and a concurrent loss of the water volume flow due to the use of coffer dams, dikes, and other restoration techniques. The Trustees would minimize erosion by using temporary erosion controls and limiting disturbance to the minimum area and length of time necessary, as well as by ceasing work when conditions would disturb erosion control measures.

5.2.1.3 Barrier removal

Long-term, moderate, beneficial impacts would be expected from barrier removal. Impoundments are a major source of water loss on the environment due to evaporation and cause water temperatures to increase. The removal of dams and other barriers would return the base flow of the river and feeder streams to their near-natural flow regimes.

Short-term, minor to moderate, adverse impacts on water quality and water resources would be expected from the removal of dams, which can cause temporary sedimentation and erosion. Short-term adverse effects of a dam removal are generally short-lived and can be minimized by adopting best management practices for sediment management, such as conducting activities during low-flow periods (The Heinz Center, 2002; Stanley and Doyle, 2003) and using matting and fencing to prevent erosion while vegetation is being reestablished. Erosion would be minimized by using temporary erosion controls and limiting disturbance to the minimum area and length of time necessary, as well as by ceasing work when conditions would disturb erosion control measures.

5.2.1.4 Habitat conservation

The establishment of habitat conservation areas would have a long-term, major, beneficial impact on water resources and water quality. The establishment of healthy vegetative communities rather than disturbed earth and development would improve water quality in the Kalamazoo River watershed.

No short-term impacts would be expected from habitat conservation since no construction activities would occur and the action is to preserve habitat.

5.2.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.2.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage

Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.2.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing water resources and water quality conditions would remain as described in Section 4.1. No effects on water resources or water quality would be expected (Table 5.1).

Table 5.1. Water resources and water quality summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on water resources or water quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C. No long-term impacts would be expected.	Short-term, minor to moderate, adverse impacts on water resources and water quality would be expected during restoration activities. Long-term, moderate to major, beneficial impacts on water resources and water quality would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

5.3 Geologic Resources and Sediment Quality

5.3.1 Alternative C (Preferred Alternative)

Alternative C would have no impact on geologic resources in the area and thus will not be further discussed in this section. Sediment quality impacts would be expected, and are analyzed below.

5.3.1.1 Aquatic habitat restoration

Long-term, moderate, beneficial impacts on sediment quality would be expected from aquatic habitat restoration activities. A critical goal of the restoration would be to provide appropriate sediment structure to enhance habitat. Headwaters restoration should be expected to establish riffle/pool habitat to enhance habitat opportunities for a number of organisms by allowing short sections of rapid flow, alternating with stretches of slower, deeper, cooler waters.

Short-term, moderate, adverse impacts would be expected from restoration activities. Mitigation measures such as those described in Section 5.2.1 would be used to avoid erosion and sedimentation and surveys would be conducted prior to construction to identify river reaches that would not require extensive re-grading after the flow regime is altered.

5.3.1.2 Riparian and wetland habitat restoration

Long-term, major, beneficial impacts on sediment quality would be expected from riparian and wetland habitat restoration. The establishment of riparian buffer zones and healthy wetlands would reduce sediment in stormwater runoff and vastly decrease the amount of instream sedimentation from normal rainfalls.

Short-term, moderate, adverse impacts would be expected from siltation created by construction and restoration activities (i.e., from erosion and runoff) while establishment of these habitats is completed. Mitigation measures such as those described in Section 5.2.1 would be implemented to intercept runoff and prevent additional sedimentation. Compaction of soils would be minimized by using existing roads when possible. Where feasible, heavy equipment would be used in less-sensitive areas and would be operated in ways that minimize impacts (e.g., using low pressure tires or temporary mats to protect sensitive soils).

5.3.1.3 Barrier removal

Long-term, major, beneficial impacts on sediment quality would be expected from barrier removal. Rivers naturally convey sediment through cycles of accretion and erosion. Barriers can rob downstream reaches of sediment and result in excess erosion downstream. Likewise, areas immediately above barriers contain excess fine sediments over potentially large areas that then have reduced diversity of benthic habitat types. Sediment deposited upstream of barriers can also be released suddenly in large quantities during extreme events such as torrential rain or barrier failure. The suddenly released sediment can then bury and suffocate organisms downstream. Removal of barriers would eliminate these impacts and restore the natural distribution and dynamics of sediments both upstream and downstream of the barrier. The elimination of physical barriers and reestablishment of higher river-flow velocities would increase sediment transport to the river reaches downstream of the dam (Doyle et al., 2000, 2005; Bednarek, 2001; Hart et al., 2002). By mobilizing fine sediments, coarser substrates such as sand, gravel, and cobbles would be exposed and riffle-pool sequences may be restored (Bednarek, 2001). For example, following a dam removal on the Milwaukee River in Wisconsin, Kanehl et al. (1997) observed a significant increase in rocky substrate, which is a preferred habitat for many native aquatic organisms, within the area of the former dam impoundment.

Short-term, moderate, adverse effects would be expected from construction and restoration activities and sediment release during excavation. Mitigation measures such as those described in Section 5.2.1, and using technologies such as caissons and clam-shell dredging, would minimize sediment release.

5.3.1.4 Habitat conservation

Establishment of habitat conservation areas would have a long-term, major, beneficial impact on sediment quality. The establishment of healthy vegetative communities rather than disturbed earth and development would minimize the amount of sediment runoff in stormwater and increase the chemical quality of the sediment that reaches the river. A reduction in nutrient releases would be expected as well.

No short-term impacts would be expected from habitat conservation since no construction activities would occur and the action is to preserve habitat.

5.3.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.3.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.3.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.2. Cobbles and gravelly areas would become inundated with finer-grained sediments and habitat for aquatic insects and other invertebrates, including endangered and threatened fresh-water mussels, would continue to be degraded (Table 5.2).

Table 5.2. Geological resources and sediment quality impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on geologic resources or sediment quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C. No long-term adverse impacts on sediment quality would be expected. No impacts on geologic resources would be expected.	Short-term, moderate, adverse impacts on sediment quality would be expected during restoration activities. Long-term, moderate to major, beneficial impacts on sediment quality would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation. No impacts on geologic resources would be expected.

5.4 Biological Resources

5.4.1 Fish

5.4.1.1 Alternative C (Preferred Alternative)

5.4.1.1.1 Aquatic habitat restoration

Long-term, minor, beneficial impacts on fish would be expected from aquatic habitat restoration activities. The overall restoration of the Kalamazoo River instream habitat combined with restoration that reduces water temperature improves river habitat and fish survival. Adequate water quality for fish health is a necessity, and long-term improved water quality would be expected from the restorative efforts. Aquatic habitat restoration would improve water quality, and result in a beneficial impact for fish currently dwelling in areas of the river with poorer quality. Under the preferred alternative, an increase in reproduction would be expected to occur in restored river habitats, leading to a sustainable increase in the total amount of fishes over time.

Short-term, minor, adverse impacts on some non-target species could occur as a result of actions to control invasive aquatic species. The Trustees would mitigate the adverse impacts of controlling invasive species by returning non-target species to the environment whenever possible and carefully washing equipment to prevent the accidental spread of invasive species.

5.4.1.1.2 Riparian and wetland habitat restoration

Long-term, direct and indirect, minor to moderate, beneficial impacts on fish would be expected from riparian and wetland habitat restoration activities. Wetlands, and the area where the water meets dry land, known as the “riparian zone” or “riparian buffer,” are critical to the health of any water body. Restored riparian zones aid in filtering pollutants out of rainwater before they reach the river, providing a healthier aquatic environment for fish. Healthy wetlands and riparian zones slow the runoff of rainwater, thus reducing flooding, and providing higher-quality habitat for a wide variety of fish species in the water. Aquatic habitat restoration measures considerably change river morphology and create more natural conditions by improving habitat diversity. The resulting restored riparian areas aid in flood control, purify water, and provide an overall better habitat for fish species, including off-channel rearing and spawning habitat.

Short-term, minor, adverse impacts on fish would be expected from riparian and wetland habitat restoration. Riparian restoration would result in short-term sedimentation and turbidity, which would affect fish populations and reproduction throughout the duration of the riparian restoration action. However, these short-term, minor, adverse impacts would be negligible when compared to the long-term beneficial impacts of improved fish habitat and overall improvement to the health of the water body and riparian areas.

5.4.1.1.3 Barrier removal

Long-term, moderate, beneficial impacts on fish would be expected from the removal of barriers. Migratory fish in the Kalamazoo River, such as walleye and white sucker, would greatly benefit from barrier removal as a result of increased mobility in the river system. Barrier removal could also increase the abundance and diversity of fish species by providing a broader range of habitat and substrate and may reduce conditions favorable to invasive species (Bednarek, 2001). These improvements to the complexity and quality of habitat would also provide direct and indirect long-term benefits to biological resources, such as higher productivity, increased feeding opportunities, and lower predation rates.

Short-term, minor, adverse impacts on fish would be expected during barrier removal activities. The dam removal would not occur until all contaminated sediments were remediated. Therefore no toxic materials would be expected to migrate downstream following the dam removal. In general, the movement of anadromous fish, riparian species, and plant seeds would be restricted during barrier removal activities. The natural meandering and flow of streams and rivers is often compromised by barrier removal efforts, directly impacting the spawning and migratory patterns of some fish species. As a result of the possible changes in variable flow rate and the changes in temperature, some individuals downstream may not be able to adapt or survive. Mitigation and best management practices for reducing negative impacts of fish passage barrier modifications that might be implemented include installation of fish ladders, replacement of culverts with free-span crossings, and recreation of step plunge pools for migration and spawning.

Short-term, minor, adverse impacts on fish would be expected during the dam removal because of increases in turbidity, the physical disturbance of aquatic habitats, the temporary displacement or disturbance of fish, and indirect changes in habitat. Mitigation measures such as those described in Section 5.2.1, as well as scheduling activities to avoid important life history phases of sensitive fish species, would minimize these impacts.

5.4.1.1.4 Habitat conservation

In the future, climate change and population growth would increase stress on river systems, making it difficult to achieve existing levels of water resource benefits and environmental protection. Under the preferred alternative, there would be long-term, minor, beneficial impacts on fish from habitat conservation in the Kalamazoo River. In the long-term, habitat conservation would lead to the reduction of sand in parts of the river where trout are managed. A reduction in sand would provide a better habitat for fish species, specifically trout that struggle to adapt to the sandy river bottom.

5.4.1.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.4.1.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.4.1.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.3.1. No impacts on fish would be expected (Table 5.3).

Table 5.3. Fish impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on fish would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on fish would be expected during barrier removals. Long-term, direct and indirect, minor to moderate, beneficial impacts on fish would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

5.4.2 Aquatic invertebrates

5.4.2.1 Alternative C (Preferred Alternative)

5.4.2.1.1 Aquatic habitat restoration

Long-term, minor, beneficial impacts on aquatic invertebrates would be expected from aquatic habitat restoration activities. The overall restoration of the Kalamazoo River aquatic habitat, combined with restoration activities that reduce water temperature, would be expected to improve river habitat and aquatic invertebrate survival.

Short-term, minor, adverse impacts on aquatic invertebrates would be expected during habitat restoration because of the increases in human presence, turbidity, physical disturbance of aquatic habitats, temporary displacement or disturbance of aquatic invertebrates, and indirect changes in habitat. Mitigation measures such as those described in Section 5.2.1 would be used to avoid erosion and sedimentation that could affect aquatic invertebrates. Additionally, freshwater mussels that might be impacted by instream habitat improvement work would be relocated, and projects would be scheduled to avoid important life history phases of sensitive species.

5.4.2.1.2 Riparian and wetland habitat restoration

Long-term, minor to major, beneficial impacts of the restoration of natural channels and stream banks would be expected and would directly improve water resources and water quality by reestablishing natural suspended sediment patterns and temperature regimes. Similarly, riparian and wetland restoration would directly benefit aquatic invertebrates by improving the quality of the sediment by removing artificial fill and restoring vegetation to prevent erosion of soils. It would also improve water resources and quality by restoring the hydrologic functioning of the riparian and wetland habitats to pre-disturbance conditions and providing filtration of pollutants and nutrient inputs to the wetland habitat and the adjacent aquatic habitat.

Short-term, minor, adverse impacts on aquatic invertebrates would be expected during riparian and habitat restoration efforts because of the increases in turbidity, physical disturbance of aquatic and riparian habitats, temporary displacement or harassment of organisms, and indirect changes in habitat. Mitigation measures such as those described in Section 5.2.1 would be used to avoid erosion and sedimentation that could affect aquatic invertebrates.

5.4.2.1.3 Barrier removal

Overall, barrier removal would improve water quality and habitat for aquatic invertebrates by eliminating the adverse impacts of the dams, including the Otsego and Otsego City dams, such as increased water temperatures, decreased dissolved oxygen, and trapping of sediments that would otherwise move downstream.

Long-term, minor, adverse impacts on aquatic invertebrates could occur as a result of barrier removal through the spread of invasive species. Depending on the location of the barrier relative to the existing populations of invasive species like zebra mussels and Asian clams, barrier removal has the possibility of allowing the spread of invasive species to areas of the river or tributaries that are currently not inhabited by these species.

Mussels might be adversely affected by the physical impacts of the dam removal in the short-term. However, this minor short-term impact could be mitigated by relocating mussels away from the impoundment prior to construction and returning mussels to the site after the site has been stabilized.

5.4.2.1.4 Habitat conservation

Long-term, moderate, beneficial impacts on aquatic invertebrates in the Kalamazoo River would be expected from habitat conservation. In the long-term, habitat conservation would lead to greater biodiversity, improving the ecosystem food web and ensuring a consistent habitat. Greater health of the ecosystem for aquatic invertebrates is mutually beneficial for other organisms, since many aquatic invertebrates are filter feeders that contribute to the improved health of the ecosystem.

5.4.2.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.4.2.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.4.2.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.3.2. No effects on aquatic invertebrates would be expected (Table 5.4).

Table 5.4. Aquatic invertebrates impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on aquatic invertebrates would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on aquatic invertebrates would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor, adverse impacts on aquatic invertebrates could occur as a result of barrier removals if they allow the spread of invasive species into new areas. Long-term, minor to major, beneficial impacts on aquatic invertebrates would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

5.4.3 Wildlife

5.4.3.1 Alternative C (Preferred Alternative)

5.4.3.1.1 Aquatic habitat restoration

Long-term, direct, moderate, beneficial impacts on wildlife that rely on aquatic systems, such as mammals, reptiles, birds, and amphibians, would be expected from increasing the connectivity of aquatic habitats, restoring bank vegetation used as habitat, and establishing natural water temperatures and conditions. The connectivity of the river would provide an expansion of available food resources within the ecosystem food web, while improving the overall health and functionality of the river ecosystem. Long-term, indirect, minor, beneficial impacts on water quality would be expected from restoring the aquatic habitat of the river and would also benefit wildlife by providing a safer, healthier drinking water source, and reducing sickness and mortality rates.

Short-term, indirect, minor, adverse impacts on wildlife could be expected as a result of increased turbidity and stirring up sedimentation as a result of restoration activities. In addition, disturbances associated with Alternative C activities could result in temporary displacement of individuals.

5.4.3.1.2 Riparian and wetland habitat restoration

Long-term, minor to moderate, beneficial impacts on the survival and reproduction rate of amphibians and reptiles would be expected from the increased presence of wetlands and prairie fens from riparian and wetland habitat restoration. After successful establishment, riparian vegetation would aid in the long-term improvement of overall water quality of the watershed. Targeted species, including raptors, ducks, other birds, bats, and snakes, would also benefit from enhancement techniques like artificial nest structures and hibernation structures.

Short-term, minor to moderate, adverse impacts on wildlife would occur as a result of implementing Alternative C. River banks and shorelines would be disturbed as a result of human presence and restorative efforts. Depending on the seasonal timeframe and duration of implementation, restoration activities could disturb nest beds and reproductive activities among wildlife. To reduce these potential impacts, the Trustees would use mitigation efforts such as fencing around the construction site, reducing the total duration of the project by planning concurrent construction activities, and establishing a road management plan for easy access to the site. Short-term adverse impacts on wildlife habitat (aquatic and land-based) may be anticipated; however, this adversity is negligible compared to the overall long-term improvements of the micro and macro habitats.

5.4.3.1.3 Barrier removal

Long-term, moderate, beneficial impacts on wildlife would be expected from the restoration of the river’s natural flow and conditions and increasing the quantity of available habitat. Barrier removal would also enhance species habitat by reconnecting the river to its floodplains, allowing a greater area for population and community distribution of species.

Short-term, direct, minor, adverse impacts on wildlife would be expected from the use of construction equipment and access roads by blocking migration corridors for species traveling along the river shore, or impeding access to nesting sites. Direct mortalities could occur from wildlife interaction with construction activities and/or materials; indirect mortalities could occur from stress, reproductive failure, or avoidance of feeding due to increased human activity and noise. Short-term, indirect, minor, adverse impacts, such as reduced reproduction, population growth, and survival among species could also occur as a result of dam removal activities. To reduce the potential effects to wildlife, the Trustees would use mitigation measures to avoid negative impacts. Examples of mitigation efforts would include installing fencing around the construction site perimeter, reducing the total duration of the project by planning concurrent construction activities, and establishing a road management plan for controlled access to the site.

5.4.3.1.4 Habitat conservation

Long-term, moderate to major, beneficial impacts on wildlife from habitat conservation activities would be expected. Habitat conservation efforts would preserve and manage existing vegetation and habitats, which would benefit wildlife. Increased habitat and wildlife would improve the aesthetic quality of the area and provide improved recreational opportunities, such as fishing, birding, and hiking.

5.4.3.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.4.3.1). The extent of impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. A smaller area of upland habitat would be affected by construction activities, wildlife migration corridors would not be impeded, and there would not be an increased threat from exotic or invasive species. However, complete connectivity would not be established and sections of riparian habitat would not be restored, both of which would negatively impact wildlife in the area. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.4.3.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.3.3. No action would be taken to restore habitat and wildlife, and existing conditions would persist. Sensitive habitats could further degrade without restoration techniques, fish migration would not be improved, and wildlife dependent on wetlands and prairies would suffer (Table 5.5).

Table 5.5. Wildlife impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on wildlife would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor to moderate, adverse impacts on wildlife would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor to major, beneficial impacts on wildlife would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

5.4.4 Vegetation

5.4.4.1 Alternative C (Preferred Alternative)

5.4.4.1.1 Aquatic habitat restoration

Long-term, minor to major, beneficial impacts on vegetation would be expected from aquatic habitat restoration because of improvements to bank habitat as well as to water quality, habitat complexity, and sediment regimes.

Short-term, minor, adverse impacts on aquatic vegetation would be expected from the reestablishment of the stream structure by opening up the passageway, allowing for the potential of invasive plant species to move freely down the river bank. Despite the current presence of multiple invasive plant species in the stream structure, the expansion could result in a larger area for the potential spread of existing invasive species and the possible introduction of new invasive species. However, potential impacts would be mitigated by preemptively planting native species along the banks and by employing soft engineering techniques for stream bank stabilization that could absorb energy from the river.

5.4.4.1.2 Riparian and wetland habitat restoration

Long-term, moderate, beneficial impacts on vegetation in the Kalamazoo River watershed would be expected from riparian and wetland habitat restoration activities. The restoration would enhance riparian vegetation throughout the project area by reestablishing the river’s natural flow and allowing for a more diverse community of vegetation to grow and thrive, as well as direct restoration of native plants, and controls on invasive species.

Short-term, minor, adverse impacts on vegetation would be expected from riparian and wetland habitat restoration, including the use of controlled burns, herbicides or other pesticides, and water-level management. The use of controlled burns as a management tool would include setting aside significant areas to remain unburned in any given year to help lessen the effects on fire-sensitive species (Kost et al., 2007). Additionally, the introduction of biological control species could adversely impact non-target vegetation, although the Trustees would only use insects that are highly host-specific and cause only minor damage to non-target plants.

5.4.4.1.3 Barrier removal

Short-term, minor, adverse impacts on vegetation would be expected during barrier removal activities. During construction, some vegetation would be temporarily disturbed, reducing habitat quality. Areas exposed by draw down of water levels often revegetate quickly (Aspen Institute, 2002). Planting of cover crops and native vegetation would be used to accelerate and enhance revegetation.

To minimize potential impacts of soil compaction and erosion, mulch and geotextile mats would be used where appropriate, topsoil and drainage patterns would be restored to preconstruction (or better) conditions, existing access roads would be used wherever possible, and best management practices would be implemented to minimize and mitigate impacts on areas that would be difficult to restore. For sensitive vegetation that is not going to be directly disturbed by construction, a buffer zone would be established around the vegetation to prevent soil compaction near the roots.

Changes in hydrology associated with a barrier removal would cause changes in wetland habitat along the stream upstream of the former barrier and may include the elimination of some wetland areas around the former margins of the impounded area (NOAA, 2006). Although wetlands may decrease at the former boundary of the impoundment, they could redevelop both above and below the former barrier (NOAA, 2006). In some cases, removal of a dam may cause plant species that prefer river-like conditions to outcompete those plants that prefer lake-like conditions. This change in vegetation diversity would have indirect impacts on wildlife that relied on lake plants for habitat. Long-term, minor beneficial impacts on vegetation would be expected following completion of the dam removal by reconnecting instream habitat and restoring more natural and self-sustaining vegetation communities. Because of these benefits, under their administrative rules for wetland mitigation, MDEQ can waive wetland mitigation for dam removal projects where there is a benefit to wetland and stream habitat overall.

5.4.4.1.4 Habitat conservation

Long-term, moderate to major, beneficial impacts on vegetation from habitat conservation activities would be expected. Habitat conservation efforts would preserve and manage the existing vegetation and habitats, which could benefit wildlife. Increased habitat and wildlife would improve the aesthetic quality of the area and provide improved recreational opportunities, such as fishing, birding, and hiking.

5.4.4.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.4.4.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.4.4.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.3.4. No beneficial impacts on vegetation would be expected. No habitat would be restored and habitat connectivity would remain unchanged. There would be no increased risk from exotic or invasive species. The KRE would continue to experience problems associated with habitat fragmentation. The areas of the proposed project would not benefit from restoration of riparian vegetation and the associated ecological benefits (Table 5.6).

Table 5.6. Vegetation impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on vegetation would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on vegetation would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor to major, beneficial impacts on vegetation would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

5.4.5 Federally listed species

Federally listed species within the proposed project area include those that are directly dependent upon aquatic resources (i.e., live or feed in or near waters and adjacent wetlands) and those indirectly dependent on upland habitats in the Kalamazoo River watershed.

Table 4.2 lists the federally listed endangered, threatened, and candidate species that occur in the vicinity of the Kalamazoo River watershed (USFWS, 2015b). Their habitat preferences greatly influence the nature of potential impacts on these species as a result of implementing the preferred alternative (Alternative C), Alternative B, or the No Action Alternative (Alternative A).

5.4.5.1 Alternative C (Preferred Alternative)

5.4.5.1.1 Aquatic habitat restoration

Alternative C would provide long-term, indirect, minor to moderate, beneficial impacts for federally listed species, such as the Indiana bat, northern long-eared bat, Karner blue butterfly, and Mitchell’s satyr butterfly that utilize aquatic and bank environments. The connectivity of the river would provide an expansion of available food resources within the ecosystem food web, while improving the overall health and functionality of the river ecosystem for listed species.

5.4.5.1.2 Riparian and wetland habitat restoration

Long-term, moderate, beneficial impacts on listed species in the Kalamazoo River watershed would be expected from riparian and wetland habitat restoration activities. Alternative C would enhance riparian and wetland vegetation including habitat for the Karner blue and Mitchell's satyr butterflies throughout the project area by reestablishing wetlands, bogs, and fens, and allowing for a more diverse community of vegetation to grow and thrive.

Depending on the timing and location of construction activities, short-term, moderate, adverse impacts on listed species could occur from the removal of existing vegetation during construction activities. Site-specific project plans would be developed to avoid incidental impacts on listed species. For example, in order to avoid impacts on the Indiana bat and the northern long-eared bat, bat surveys would be completed prior to any tree removal in the summer months when reproductive colonies of the bats are present, or tree removal would be scheduled and completed in the fall and winter months.

5.4.5.1.3 Barrier removal

No long-term impacts would be expected from barrier removal on listed species (i.e., the Karner blue and Mitchell's satyr butterflies, Indiana bat, northern long-eared bat, copperbelly water snake, and eastern massasauga).

5.4.5.1.4 Habitat conservation

Long-term, minor, beneficial impacts on vegetation would be expected from habitat conservation activities. Habitat conservation efforts would preserve and manage the existing vegetation and habitats, which would benefit listed species.

5.4.5.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.4.5.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.4.5.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.3.5. No beneficial impacts on listed species would be expected. No habitat would be restored and habitat connectivity would remain unchanged. The KRE would continue to experience problems associated with habitat fragmentation. The areas of the proposed project would not benefit from restoration of riparian habitat useful to listed species (Tables 5.7 and 5.8).

Table 5.7. Indiana bat and northern long-eared bat impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on Indiana bat and northern long-eared bat would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, moderate to major, adverse impacts are unlikely but could occur if there were a loss of trees during riparian and wetland habitat restoration activities during bat breeding season. Long-term, minor to moderate, beneficial impacts would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and habitat conservation.

Table 5.8. Karner blue butterfly, Mitchell's satyr butterfly, copperbelly water snake, and eastern massasauga impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on Karner blue butterfly, Mitchell's satyr butterfly, copperbelly water snake, and eastern massasauga would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, moderate, adverse impacts are unlikely but could occur from vegetation removal during riparian and wetland habitat restoration, depending on the timing and location of construction activities. Long-term, moderate, beneficial impacts would be expected from increased and improved wetland, bog, and fen habitats.

5.5 Air Quality

5.5.1 Alternative C (Preferred Alternative)

Short-term, direct, minor, adverse impacts on air quality would be expected from the use of vehicles, machinery, and construction equipment for habitat restoration (aquatic, riparian, and wetland habitats), barrier removal, and habitat conservation. Following the completion of the restoration activities, no long-term impacts would be expected. The short-term adverse impacts would be limited to the extent and duration of the restoration activity and area in which the restoration occurred. Impacts from the combustion of fossil fuels would include the release of greenhouse gases (i.e., carbon dioxide and nitrogen oxides), volatile organic compounds, ozone, smoke, and other pollutants. Additionally, increased particulate matter would be expected from construction vehicle traffic and controlled burns. However, the Kalamazoo River watershed is located in AQCRs that are in attainment with NAAQS and the increase in emissions from the vehicles, machinery, and construction equipment would be minimal.

Best management practices (USDA-NRCS, 2007) would be implemented to minimize dust and limit the amount of fossil fuels used in vehicles and restoration equipment. Since current standards for fuel sulfur content and engine efficiency for non-road equipment engines have become more stringent, typical construction equipment would have to run cumulatively for thousands of hours to reach the de minimus levels that would require detailed analysis and modeling of emissions. As an example, the largest project under consideration, the Otsego Dam removal, is estimated to require approximately 200 hours to complete. A large excavator would fall into the EPA emissions limits for non-road vehicles of 225 to 450 kilowatts (U.S. EPA, 2013b). Assuming that the excavator was operated continuously for the entire 200 hours, it would generate a maximum of 91 kilograms (200 pounds) of nitrogen oxides that would contribute to ozone formation, 5 kilograms (12 pounds) of particulate matter, and 113 kilograms (250 pounds) of carbon monoxide (U.S. EPA, 2013b). The de minimus emissions level set by EPA that would require that a federal agency perform a conformance analysis to ensure that the emissions would not contribute to degradation of the NAAQS is 91 metric tons (100 tons) per year for each pollutant. Therefore, assuming several large machines, continuous operation, and the highest emissions allowed for older engines, there is little potential to have more than minor air quality impacts. Where feasible, the Trustees would use electric or hybrid vehicles to further reduce any impacts on air quality. All restoration activities would be performed in compliance with all applicable federal and Michigan air pollution control regulations.

5.5.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.5.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage

Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.5.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.4. No effects on air quality would be expected (Table 5.9).

Table 5.9. Air quality impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on air quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor, adverse impacts from increased air emissions and particulate matter of vehicles, machinery, and construction equipment. No long-term impacts on air quality would be expected.

5.6 Socioeconomic Resources and Environmental Justice

5.6.1 Alternative C (Preferred Alternative)

No long-term impacts on population levels would be expected under Alternative C. Local construction workers would be available for restoration actions and heavy equipment would most likely be procured from local suppliers. No new residents would be expected to relocate to or from the Kalamazoo River watershed as a direct result of the proposed action. Short-term, direct, minor, beneficial impacts on the local economy would be expected from the purchase of goods and materials by the contractor completing the restoration activities. Additional beneficial impacts from construction workers' wages and taxes and expenditures for building materials would be expected. Short-term, direct, moderate, beneficial impacts from the increase of demand on the local workforce and industry would also be expected.

The proposed restoration activities would improve the quality of the Kalamazoo River and allow for increased use of the river for recreational purposes (i.e., golfing, boat and canoe rentals and charters, marinas). Therefore, long-term, minor, beneficial impacts would be expected from increased recreational opportunities and associated impacts on the local economy from the purchase of goods and materials. Watershed restoration can generate between 15.7 and 23.8 jobs per $1 million spent and can result in additional economic benefits of 1.4 to 2.4 times that amount as the investment cycles through the economy (Nielsen-Pincus and Moseley, 2010).

The *Environmental Justice Plan for the State of Michigan and Department of Natural Resources and Environment* (MDNRE, 2010) identified three areas of concern in the Kalamazoo River watershed: Kalamazoo, Springfield, and Battle Creek. Proposed restoration activities under Alternative C is expected to provide direct and indirect, long-term, minor, beneficial impacts on the communities and environmental justice populations that live and work in the Kalamazoo River watershed. Long-term, minor, beneficial impacts would be expected as a result of reduced flood risks, aesthetic benefits to the Kalamazoo River watershed, improved commercial and fishery resources, reduced dam maintenance costs, and increased local economic activity from recreational opportunities and tourism.

5.6.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.6.1). The extent of the impacts would differ in terms of geographic scope and timing because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.6.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.5. No short-term benefits from the expenditures on local goods or the increase in demand on the local workforce and industry would be expected. No long-term benefits from increased tourism and recreational opportunities would be expected (Table 5.10).

Table 5.10. Socioeconomic resources and environmental justice impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on socioeconomic resources or environmental justice populations would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	No short- or long-term impacts on population would be expected. Short- and long-term, minor to moderate, beneficial impacts on the local economy would be expected.

5.7 Recreation and Land Use

5.7.1 Alternative C (Preferred Alternative)

Following completion of the restoration activities, long-term, minor to moderate, beneficial impacts would be expected from the increased recreational opportunities on the Kalamazoo River and the surrounding area. Aquatic habitat restoration, riparian and wetland habitat restoration, and habitat conservation would increase the native vegetation and wildlife in the area. These improvements would create additional opportunities for camping, fishing, skiing, sledding, snowmobiling, horseback riding, golf, wildlife observation, hunting, canoeing, and boating at local parks and trails. Boating in particular would benefit from increased connectivity of the river associated with barrier removals because of the reduced need to portage around dams.

Short-term, direct, minor to moderate, adverse impacts on recreational areas would be expected during the restoration activities proposed under Alternative C. Restoration activities would be completed in a phased approach; therefore, certain areas of the Kalamazoo River could be temporarily closed, or have access restrictions, during a particular activity. Recreation in a particular area could be restricted during that time, or be degraded by increased dust and noise; however, access to the river would be permitted following completion of the restoration activity. Projects would also be designed and implemented to minimize the amount of time that recreational uses are impacted.

There would be no change in any land-use designations; therefore, no short- or long-term impacts on land use would be expected under Alternative C.

5.7.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.7.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.7.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.6. No long-term benefits from increased tourism and recreational opportunities would be expected (Table 5.11).

Table 5.11. Recreation and land use impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on recreation and land use would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor to moderate, adverse impacts from the temporary closure of recreational areas would be expected. Long-term, minor to moderate, beneficial impacts from increased recreational opportunities would be expected. No short- or long-term impacts on land use would be expected.

5.8 Noise

5.8.1 Alternative C (Preferred Alternative)

Short-term, direct, minor, adverse impacts from the increased noise levels during restoration activities would be expected under Alternative C. The ambient noise environment in the Kalamazoo River Watershed area ranges from 50 to 65 dBA, depending on land use type and activities that occur in that area. Noise levels can increase up to 35 dBA from construction equipment depending on noise source, distance from the equipment, and duration (see Table 4.3). During restoration, wildlife near the restoration activity that can relocate (e.g., birds) may move to a quieter area; however, these species would be expected to return once the noise has stopped. See Section 5.4.3 for additional discussion of impacts on wildlife. No long-term impacts on the noise environment would be expected from the implementation of Alternative C.

5.8.2 Alternative B

Impacts under Alternative B would be similar in nature to those described under Alternative C (Section 5.8.1). The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs.

5.8.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.7. No short-term adverse impacts on the noise environment would be expected (Table 5.12).

Table 5.12. Noise impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on the noise environment would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor, adverse impacts from increased noise of equipment and vehicles during restoration activities would be expected. No long-term impacts on the noise environment would be expected.

5.9 Cultural Resources

5.9.1 Alternative C (Preferred Alternative)

5.9.1.1 Aquatic habitat restoration

Long-term moderate beneficial impacts would be expected from the restoration actions. The river and riparian areas would be returned to more natural states, providing a more pleasing view from nearby historic properties.

Short-term negligible to minor adverse impacts on cultural resources would be expected from aquatic habitat restoration, riparian and wetland restoration, barrier removal, and habitat conservation under the preferred alternative. It is unlikely that there would be visual disturbance to eligible historic places from the aquatic restoration activities since they would be limited to instream work, but for each specific project, an area of potential effect would be evaluated for nearby historic sites and a “viewshed analysis” conducted to determine if construction activities would be visible from the site or if noise from construction activities would impact historic sites. If potential effects would be possible, then consultation with the Michigan SHPO would be initiated. The consultation process would ensure that potential impacts would be minimized. Prior to the start of construction activities, the Trustees would prepare an Unanticipated Discoveries Plan and review it with the SHPO. Construction personnel would be instructed to call attention to any artifacts uncovered by excavation or dredging and appropriate action would be taken in accordance with the plan.

5.9.2 Alternative B

Impacts under Alternative B would be similar in nature but could be greater than those described under Alternative C (Section 5.9.1) if the restoration activities were concentrated in a smaller area in close proximity to places listed or eligible for listing as historic properties. The extent of the impacts would differ in terms of geographic scope because the area affected by Alternative B would only include the Kalamazoo River corridor and Portage Creek within the Kalamazoo

River Superfund Site. The timing of the impacts would also be later because restoration opportunities under Alternative B would be limited to areas that are upstream of all planned remediation or where EPA has remediated PCBs. As with Alternative C, potential impacts would be evaluated and consultation with the SHPO initiated as necessary.

5.9.3 Alternative A

Under the No Action Alternative, the proposed action would not be implemented and existing conditions would remain as described in Section 4.8. No short-term or long-term adverse impacts on cultural resources would be expected. No long-term benefits to cultural resources would be expected (Table 5.13).

Table 5.13. Cultural resource impacts summary

Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
No impacts on cultural resources would be expected.	Impacts would be similar in nature but could be greater if restoration actions were concentrated in a smaller geographical area than those described for Alternative C. They would differ from Alternative C in terms of timing.	Short-term, direct, negligible to minor, adverse impacts from visual impacts and increased noise of equipment and vehicles during restoration activities would be expected. Long-term, moderate, beneficial impacts on cultural resources would be expected.

5.10 Summary of Environmental Impacts

The level of impact to the affected environment is dependent on the alternative selected. Table 5.14 summarizes the potential impacts of Alternatives A, B, and C. The environmental impacts would occur over a greater area under Alternative C due to the larger geographic extent that the alternative covers. Impacts under Alternative B would also be delayed compared to Alternative C.

Table 5.14. Summary of environmental impacts

Resource area	Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
Water resources and water quality	No impacts on water resources or water quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C. No long-term impacts would be expected.	Short-term, minor to moderate, adverse impacts on water resources and water quality would be expected during restoration activities. Long-term, moderate to major, beneficial impacts on water resources and water quality would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.
Geological resources and sediment quality	No impacts on geologic resources or sediment quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C. No long-term adverse impacts on sediment quality would be expected. No impacts on geologic resources would be expected.	Short-term, moderate, adverse impacts on sediment quality would be expected during restoration activities. Long-term, moderate to major, beneficial impacts on sediment quality would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation. No impacts on geologic resources would be expected.
Biological resources	**Fish**		
	No impacts on fish would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on fish would be expected during barrier removals. Long-term, direct and indirect, minor to moderate, beneficial impacts on fish would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

Table 5.14. Summary of environmental impacts (cont.)

Resource area	Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
Biological resources	**Aquatic invertebrates**		
	No impacts on aquatic invertebrates would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on aquatic invertebrates would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor, adverse impacts on aquatic invertebrates could occur as a result of barrier removals if they allow the spread of invasive species into new areas. Long-term, minor to major, beneficial impacts on aquatic invertebrates would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.
	Wildlife		
	No impacts on wildlife would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor to moderate, adverse impacts on wildlife would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor to major, beneficial impacts on wildlife would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.

Table 5.14. Summary of environmental impacts (cont.)

Resource area	Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
Biological resources	**Vegetation**		
	No impacts on vegetation would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, minor, adverse impacts on vegetation would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and barrier removals. Long-term, minor to major, beneficial impacts on vegetation would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, barrier removals, and habitat conservation.
	Indiana bat and northern long-eared bat		
	No impacts on Indiana bat or northern long-eared bat would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, moderate to major, adverse impacts are unlikely but could occur if there were a loss of trees during riparian and wetland habitat restoration activities during bat breeding season. Long-term, minor to moderate, beneficial impacts would be expected from aquatic habitat restoration, riparian and wetland habitat restoration, and habitat conservation.
	Karner blue butterfly, Mitchell’s satyr butterfly, copperbelly water snake, and eastern massasauga		
	No impacts on Karner blue butterfly, Mitchell’s satyr butterfly, copperbelly water snake, and eastern massasauga would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, moderate, adverse impacts are unlikely but could occur from vegetation removal during riparian and wetland habitat restoration, depending on the timing and location of construction activities. Long-term, moderate, beneficial impacts would be expected from increased and improved wetland, bog, and fen habitats.

Table 5.14. Summary of environmental impacts (cont.)

Resource area	Alternative A (No Action)	Alternative B	Alternative C (Preferred Alternative)
Air quality	No impacts on air quality would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor, adverse impacts from increased air emissions and particulate matter of vehicles, machinery, and construction equipment. No long-term impacts on air quality would be expected.
Socioeconomic resources and environmental justice	No impacts on socioeconomic resources or environmental justice populations would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	No short- or long-term impacts on population would be expected. Short- and long-term, minor to moderate, beneficial impacts on the local economy would be expected.
Recreation and land use	No impacts on recreation and land use would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor to moderate, adverse impacts from the temporary closure of recreational areas would be expected. Long-term, minor to moderate, beneficial impacts from increased recreational opportunities would be expected. No short- or long-term impacts on land use would be expected.
Noise	No impacts on the noise environment would be expected.	Impacts would be similar in nature but differ in terms of geographic scope and timing than those described for Alternative C.	Short-term, direct, minor, adverse impacts from increased noise of equipment and vehicles during restoration activities would be expected. No long-term impacts on the noise environment would be expected.
Cultural resources	No impacts on cultural resources would be expected.	Impacts would be similar in nature but could be greater if restoration actions were concentrated in a smaller geographical area than those described for Alternative C. They would differ from Alternative C in terms of timing.	Short-term, direct, negligible to minor, adverse impacts from visual impacts and increased noise of equipment and vehicles during restoration activities would be expected. Long-term, moderate, beneficial impacts on cultural resources would be expected.

6. Cumulative Impacts

Cumulative environmental impacts are those combined effects on the quality of the human environment that result from the incremental impact of the alternative when added to other past, present, and reasonably foreseeable future actions [40 C.F.R. §§ 1508.7, 1508.25(a), and 1508.25(c)]. NEPA requires an evaluation of the cumulative significance of this action in conjunction with other such actions [40 C.F.R. § 1508.27(b)(7)]. This chapter describes how past, present, and reasonably foreseeable future actions could interact with the environmental consequences of the proposed program (Section 6.1) and describes what is currently known about climate change impacts in the affected area (Section 6.2). These sections are followed by discussions of controversial aspects of the alternatives (Section 6.3), the degree to which possible effects of implementing the alternatives are highly uncertain or involve unknown risks (Section 6.4), the precedential effects of the alternatives (Section 6.5), the relationship between short-term human uses of the environment and the enhancement of long-term productivity (Section 6.6), and irreversible and irretrievable commitment of resources (Section 6.7).

6.1 Past, Present, and Reasonably Foreseeable Future Actions

By definition, cumulative impacts analysis includes a consideration of reasonably foreseeable future activities in the affected environment. Such impacts may occur at individual project sites – as these have yet to be determined, attempting to analyze these in detail is not realistic or informative in determining actual cumulative impacts. However, the Trustees have attempted to identify other reasonably foreseeable actions that could contribute to cumulative effects on the natural or human environment. These actions are briefly discussed in Sections 6.1.1–6.1.5.

6.1.1 Remedial actions

In the short-term there would be potential for cumulative impacts with anticipated remedial actions under CERCLA. Although the overall size of the restoration program remains undetermined, its footprint would likely be much smaller than that of the anticipated remediation. Where feasible, the Trustees would minimize short-term cumulative adverse impacts by coordinating the timing and nature of restoration projects with remedial projects being directed by EPA. This coordination would minimize the duration of short-term disturbances and the need for disturbing an area more than once. Additionally, the Trustees would coordinate with EPA to ensure that NRDA habitat restoration does not occur on sites with remaining contamination injurious to wildlife or above ecologic action levels or at locations that will be indirectly impacted by future remedial actions. The Trustees would also consider cumulative impacts during any future NEPA evaluations of specific projects, as necessary. Any significant, unanticipated negative cumulative adverse effect identified before project implementation could result in reconsideration of the project by the Trustees.

6.1.2 Other ongoing habitat restoration actions

This NRDA restoration program could provide cumulative benefits to the environment and to human uses of the environment, together with long-term impacts of the remedial actions, and with other restoration, watershed management, and soil conservation programs in the Kalamazoo River watershed (see Appendix C). Cumulatively, such actions and the proposed action would result in a long-term net improvement in fish and wildlife habitats, the restoration of natural stream processes that have been altered by human disturbance, and in improvement in the human use and non-use services provided by fish and wildlife in the region.

6.1.3 Federal maintenance of channel

USACE will likely conduct maintenance dredging in the navigational channel of the lower Kalamazoo River. The federally authorized navigation channel only involves the lowest two miles of the river, whereas the proposed restoration would occur throughout the watershed and the Trustees would avoid conducting stream channel restoration in the navigation channel area. Because of this, impacts from the restoration program described in this RP/PEIS would be unlikely to overlap significantly with maintenance dredging activities.

6.1.4 Development

Development of the Kalamazoo River watershed is likely to increase over time in conjunction with population growth. Degradation of existing natural areas and disruption of natural processes could impact the affected area and restoration project sites, most likely after restoration has been completed. Inclusion of habitat conservation as part of the restoration program would provide an opportunity to limit these impacts in important habitats.

6.1.5 Natural and anthropogenic disasters

Natural disasters might include floods and droughts, while anthropogenic disasters might include oil spills or other releases of hazardous substances. These types of disasters could cause adverse impacts on the natural and human environment in the Kalamazoo River watershed. It is impossible to know if, where, and when such incidents may occur. Such impacts could provide opportunities for restoration projects under this program, or limit the locations in which restoration projects could be implemented. They could also negatively affect or nullify the beneficial effects of restoration projects.

6.2 Climate Change Impacts in the KRE

In November 2013, President Obama issued an Executive Order about preparing the United States for climate change [Executive Order 13653, 78 F.R. 66817]. This order discussed the need to manage U.S. lands and waters for climate preparedness and resilience (i.e., the capacity to respond to change), promote climate resilience and carbon sequestration, and reduce the sources of climate change. Federal agencies are responsible for identifying and assessing climate change-related impacts on and risks to their missions, operations, and programs. Additionally, in January 2015, President Obama issued an Executive Order requiring that all federally funded construction projects take into account the flood risks linked to climate change [Executive Order 13690, 80 F.R. 6425]. This Executive Order states that "where possible, an agency shall use natural systems, ecosystem processes, and nature-based approaches when developing alternatives for consideration."

Although predicting exactly how climate change will interact with the restoration actions proposed under this program is impossible, there is reasonable evidence that climate variability and change will cause impacts that merit consideration in restoration planning decision-making. This section describes the currently available information on climate change that is relevant to the affected environment and how it will be taken into consideration when planning restoration projects.

A number of climate change-related changes have already been observed in the Great Lakes region, including increases in annual temperatures, increases in summer extreme heat events, increases in the duration of the growing season, shifts in the timing and intensity of precipitation events, and decreases in the amount and duration of snow cover and lake ice formation (Kling et al., 2003; Hayhoe et al., 2010; NOAA, 2011).

In the future, climate change is expected to affect the region in multiple ways. Various climate change projections depend on different estimated rates of greenhouse gas emissions over time, uncertainty in underlying relationships and various feedback loops, and different assumptions about other model inputs. However, scientists estimate that Michigan will likely experience higher temperatures and increased winter and spring precipitation in the future (Kling et al., 2003; Hayhoe et al., 2010; NOAA, 2011). Summers are expected to be hotter and drier; models predict that summers in Michigan will feel progressively more like summers experienced by states to the southwest (Figure 6.1). Although precipitation is expected to increase over time, Michigan is expected to experience more of its precipitation as rainfall and less as snow (Hayhoe et al., 2010; NOAA, 2011). Between 1961 and 1990, Michigan averaged more than 45 days with snowfall each year. By the end of the 21st century, snow days are expected to drop to approximately 20 to 30 days per year, depending on the greenhouse gas emissions scenario (Hayhoe et al., 2010).

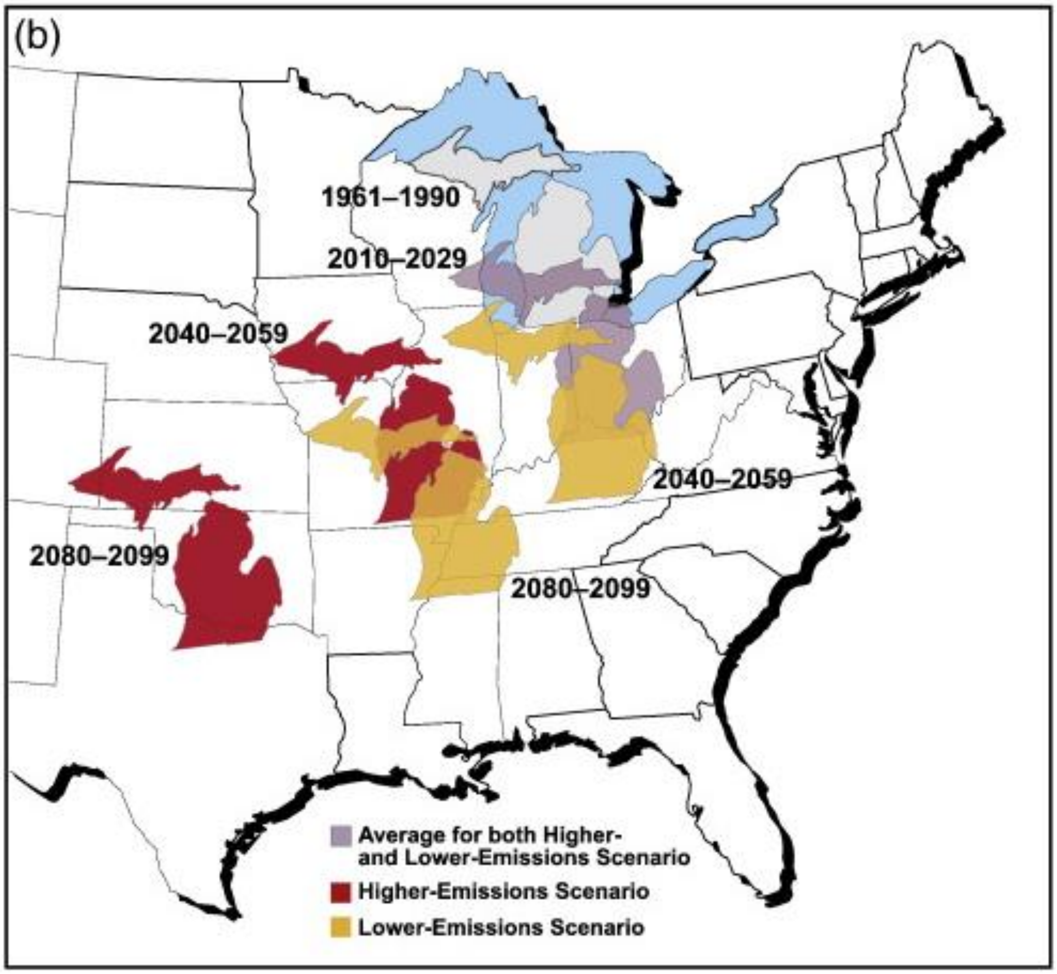


Figure 6.1. Projected future conditions in Michigan based on a range of climate change scenarios. Numbers in the figure refer to years and the colors refer to different climate change scenarios. Climate change models project that the climate of Michigan will feel like it has moved south and west over the remainder of the 21st century – higher emissions scenarios (in red) project more dramatic changes in the climate.

Source: Hayhoe et al., 2010.

Scientists have also considered the potential effects of climate change on the elevations of the Great Lakes. Projections of future Great Lakes water levels represent an area of evolving research and uncertain findings – even whether average lake levels will rise or fall is uncertain. Under elevated greenhouse gas emissions scenarios, some researchers have projected that the average elevation of Lake Michigan could decrease by over 0.5 meters (1.5 feet) by the end of the 21st century, but under lower greenhouse gas emissions scenarios there would be little net change (Hayhoe et al., 2010). However, newer evaluations project only a slight decrease or even a small rise in average lake levels regardless of the greenhouse gas emissions scenario considered (Angel and Kunkel, 2010; MacKay and Seglenieks, 2012; Gronewold et al., 2013). Gronewold et al. (2013) concluded that earlier models likely exaggerated the feasible losses from evapotranspiration. The International Upper Great Lakes Study Board (2012) reviewed several of these modeling efforts and concluded that changes in lake levels over the next 30 years are likely to remain within the historical range – but that more extreme high and low water levels in Lake Michigan may occur. Thus, although the long-term average changes may be uncertain, the studies suggest a rise in the variability of water levels.

The impacts of climate change on the hydrology of the Kalamazoo River are more challenging to predict than temperature or precipitation because they involve using the outputs of climate change models as inputs to other complex hydrologic models. Such an analysis was developed for several Lake Michigan watersheds, including the Grand River, just to the north of the Kalamazoo River (Cherkauer and Sinha, 2010). This model predicted that the Grand River, as well as all of the other rivers considered, will experience increases in annual peak and mean flow by the late 21st century regardless of the emissions scenario considered. It also predicted that rapid responses in flow during storm events will increase.

These anticipated changes to the regional climate will likely have secondary effects on the environment (Kling et al., 2003; NWF, 2007; Glick et al., 2011; NOAA, 2011). Higher flow rates and more rapid rises and falls in water levels are likely to result in greater erosion rates. Increased water temperatures may result in more frequent algal blooms. Reduced summer water levels may result in reductions of wet habitat, including small streams and wetland areas. The distribution of forests and other vegetation is likely to change, affecting the distributions of species that depend on these habitats. There may be shifts in the timing of reproduction of some species. 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. The distributions of fish and other aquatic species will also likely change, and invasions by non-native species that prefer warmer temperatures may become more likely. It is possible that fish will grow larger and increase their feeding rates, leading to greater accumulation of contaminants in the aquatic food chain. In turn, increased exposure to contaminants can decrease the thermal tolerance ranges of fish, and thus their ability to adapt to the increasing temperatures (Glick et al., 2011). Increased exposure to contaminants like PCBs also suppresses the immune function (Grasman, 2002), and may make some species more susceptible to diseases that expand into the area with climate change.

Human uses of the environment will also be affected by climate change. There will likely be greater uncertainty about water supply, and therefore more need for water storage. This may also lead to an increase in the use of groundwater for agricultural irrigation. A variety of changes that affect agriculture are also likely, including the increased variability of rainfall, longer growing seasons, and the introduction of new pests and diseases. Recreational and tourism uses of the environment will also change: there are likely to be fewer winter recreational activities, but the season for warm-weather recreation will likely increase.

During the implementation of projects under the restoration alternatives, the use of machinery and vehicles that run on fossil fuels would result in some limited emissions of greenhouse gases. The magnitude of these emissions is unknown at this time, but would not likely be significant because of the limited number of restoration projects that would be conducted under this program. However, measures would be taken to minimize these impacts. Measures include using vehicles and machinery that are more efficient where possible, limiting the amount of soil or material that would need to be relocated on trucks, and restricting idling. Obtaining and transporting materials for restoration projects can also be a source of greenhouse gas emissions. Where possible, the Trustees would seek to locally source plants and other materials to minimize the carbon footprint of the restoration projects.

Although there is a high degree of uncertainty regarding the effects of climate change on restoration, precautionary approaches can be taken to consider a range of possible effects and increase the resiliency of the restoration program. Potential changes that could affect the success of restoration projects include changes in water temperatures and flow regimes, changes in species composition, and compounding effects of climate change with existing stressors like the toxicity of contaminants. The Trustees would consider the potential resiliency of projects to climate change in the project evaluation process (see Table 2.2, Section 2.3). Additionally, restoration project design would follow guidance to address expected changes in climate, such as guidance developed by the National Wildlife Federation (Glick et al., 2011) for the Great Lakes and guidance that was developed by NOAA (2010) for coastal habitats.

Several aspects of the types of restoration that the Trustees propose would improve the resiliency of the Kalamazoo River watershed and are in line with climate change adaptation principles such as prioritizing habitat connectivity, reducing existing stressors, protecting key ecosystem features, and maintaining diversity (NOAA, 2010). Increasing connectivity of habitat, the focus of restoration under the restoration alternatives, would allow for habitat and species adaptation as climate changes. Additionally, reductions in other stressors associated with stream corridor alteration would help lessen the compounding effects of climate change. Restoration would also protect key ecosystem features and maintain diversity of habitats and species in the Kalamazoo River watershed, as well as increase resiliency to flooding and other natural disasters.

6.3 Controversial Aspects of the Alternatives

Habitat restoration in the Kalamazoo River watershed is generally not controversial. The Trustees solicited public comments on the OU1 RP/EA; these comments were supportive of restoration in general and offered constructive input on how and where the Trustees should focus their efforts (Stratus Consulting, 2013). Similarly, the public has not expressed concerns about the nature of other restoration planning occurring in the watershed (see Appendix C).

Selecting the No Action Alternative could be controversial in that the Trustees would not be fulfilling the previously stated goal of using their NRDA authority to compensate the public for losses associated with the PCBs.

6.4 Degree to Which Possible Effects of Implementing the Alternatives Are Highly Uncertain or Involve Unknown Risks

As mentioned previously, this RP/PEIS is intended to provide the Trustees and the public with a programmatic plan for NRDA restoration moving forward. Because the NRDA process is ongoing, there is considerable uncertainty about the scale, timing, and specific nature of projects that could be implemented under the restoration alternatives as NRDA funding becomes available. This plan is intended to reduce some of that uncertainty by providing a geographic scope for restoration, specific types of restoration that would be considered, goals and objectives of the restoration program, and criteria for selecting restoration projects.

There is a risk that restoration efforts would not be successful. However, the restoration techniques being considered in Chapter 3 involve established methodologies that are commonly used in successful restoration projects. Some of these techniques were implemented in the Kalamazoo River as mitigation required under EPA response authority during the Plainwell Dam removal, including channel restoration, establishment of native vegetation, and invasive species controls. The Trustees would consider the potential success of projects during the project evaluation phase; projects would need to be technically feasible and the methodology would be evaluated for the likelihood of success. Once a project is selected, the design phase would include site investigation and design steps that would minimize the risk of encountering problems.

The No Action Alternative would not involve any risks.

6.5 Precedential Effects of the Alternatives on Future Actions that May Significantly Affect the Human Environment

The restoration alternatives would not set a precedent for future actions that may affect the human environment. To the contrary, implementation of habitat restoration has already occurred in this watershed. Additional new restoration would provide additional benefits to natural resources and the people who use them, and could encourage additional improvements to habitat in the Kalamazoo River watershed.

Selecting the No Action Alternative would set an unacceptable precedent of the Trustees by forgoing their NRDA authority to compensate the public under CERCLA.

6.6 Relationship between Short-Term Human Uses of the Environment and the Enhancement of Long-Term Productivity

The restoration alternatives would cause short-term, localized effects on human uses of the environment. However, these losses would be offset by the expected, significant long-term increases in the productivity of habitats and their ability to provide human-use services such as recreation and aesthetic enjoyment.

The No Action Alternative would not provide any increases in human-use services of the environment. No adverse effects to long-term productivity would be expected from any of the alternatives.

6.7 Irreversible and Irretrievable Commitment of Resources

Projects implemented under the restoration alternatives would consume time, fuel, and materials that could not be replaced. The scale of this commitment would be minor. Habitat conservation projects would commit specific parcels of land to long-term conservation and could change the long-term uses of some of these parcels. No other irreversible and irretrievable commitments of natural resources would be anticipated under the types of restoration considered in this RP/PEIS.

The No Action Alternative would not result in any irreversible and irretrievable commitment of resources.

7. Coordination and Consultation

This chapter provides a summary of Trustee actions to coordinate and consult with the public and with federal and state agencies.

7.1 Public Involvement

The Trustees issued a Notice of Intent to prepare the RP/PEIS in the F.R. [Volume 79, Number 32 (Tuesday, February 18, 2014)]. EPA provided comments on the Notice of Intent that indicated EPA's preference for aquatic, riparian, and upland habitat restoration projects within the Kalamazoo River watershed (Westlake, 2014).

The Trustees solicited public review and comment on the draft RP/PEIS and have responded to comments received as described in Appendix D. As described in Section 1.2.1.2, the Trustees issued a Notice of Availability of the draft RP/PEIS and a Request for Comments in the Federal Register (F.R. Volume 80, Number 177) on September 14, 2015. In addition, the Trustees used several outlets to notify the public that the RP/PEIS had been released for review and comment, including press releases and direct communications that resulted in an article in the *Kalamazoo Gazette*, posting to the MDEQ calendar, and distribution via email listserves through the MDNR and the Kalamazoo River Watershed Council that collectively reached over 40,800 people directly. NOAA, USFWS, and MDEQ posted the document on their websites. The Trustees described the draft RP/PEIS and discussed the comment period with the public at a public meeting held September 15, 2015 at the Kalamazoo Nature Center. That meeting was reported on by WMUK (NPR) radio (including their website) and the Trustee presenter was interviewed by local TV channel 3.

The Trustees have engaged the public directly in restoration planning in a variety of ways since initiating the Kalamazoo River NRDA with the release of a PAS and a Stage I assessment plan in 2000. As part of the Stage I NRDA process, the Trustees met with the public, solicited restoration project ideas, spoke directly with individuals and organizations such as the Kalamazoo River Protection Association and the Kalamazoo River Watershed Council, provided findings at a public meeting, and made the draft Stage I assessment report available for public review and comment before finalizing the report (MDEQ et al., 2005a). The Stage I assessment report provided an overview of restoration planning, criteria for evaluating potential restoration alternatives, and examples of potential restoration actions. As restoration planning moves forward, the Trustees would coordinate with other parties who are also conducting restoration in the watershed to avoid conflicts and to explore opportunities for coordination and collaboration (see Appendix C).

In addition, the Trustees have participated in numerous public meetings hosted by MDEQ and EPA related to the Kalamazoo River Superfund Site. Most recently, the Trustees released the OU1 RP/EA, which is available on the USFWS website at http://www.fws.gov/midwest/es/ec/nrda/KalamazooRiver and on the NOAA website at https://casedocuments.darrp.noaa.gov/greatlakes/kalamazoo/admin.html. The Trustees solicited public comment on the draft OU1 RP/EA during the spring of 2012 and met with the public on May 1, 2012. In doing so, the Trustees received updated input from individuals, the Kalamazoo River Watershed Council, the Calhoun Conservation District, the Kalamazoo Nature Center, and the Kalamazoo River Cleanup Coalition. These interactions informed the scope of restoration planning for broader NRDA restoration program for the Kalamazoo River watershed and helped identify significant issues to be evaluated in this RP/PEIS.

7.2 Compliance with Agency Consultation Requirements

The following federal, state, and local laws, regulations, and policies could affect the planning, design, and completion of restoration actions. All NRDA restoration project sponsors, including the Trustees, would be responsible for obtaining necessary permits and complying with relevant local, state, and federal laws; policies; and ordinances.

7.2.1 Federal laws

7.2.1.1 National Environmental Policy Act, 42 U.S.C. §§ 4321–4370

NEPA requires that federal agencies consider the environmental impacts of proposed actions and reasonable alternatives to those actions. The Trustees prepared solicited comments on the draft RP/PEIS to comply with NEPA. Other than the proposed removal of the Otsego and Otsego City dams, specific projects have not yet been selected. Given that opportunities for projects may arise in conjunction with response activities, this evaluation is largely being conducted at a programmatic level. The Trustees anticipate that most impacts would be the same or less than the impacts identified in this RP/PEIS, and in that situation, an EA or CE could be developed that tiers off of this RP/PEIS as allowed by CEQ's NEPA regulations at 40 C.F.R. § 1502.20.

7.2.1.2 Federal Water Pollution Control Act, 33 U.S.C. §§ 1251–1387 (also known as the Clean Water Act)

The CWA is intended to protect surface water quality, and regulates discharges of pollutants into waters of the United States. Any proposed restoration projects under the proposed action would comply with CWA requirements, including obtaining any necessary permits for proposed restoration actions. Restoration projects that move material in or out of waterways and wetlands, or result in alterations to a stream channel, typically require CWA Section 404 permits. Dam removal actions also require 404 permits. All such permits would be obtained before restoration work begins.

As part of the Section 404 permitting process, consultation under the Fish and Wildlife Coordination Act, 16 U.S.C. § 661 *et seq*., generally occurs. This act requires that federal agencies consult with the USFWS, the National Marine Fisheries Service, and state wildlife agencies to minimize adverse impacts of stream modifications on fish and wildlife habitat and resources.

Compliance with the Rivers and Harbors Act, 33 U.S.C. § 401 *et seq*., generally occurs as part of the Section 404 permitting process. The Rivers and Harbors Act prohibits unauthorized obstruction or alteration of navigable waters. Any required permits under the Rivers and Harbors Act are generally included with the Section 404 permitting process.

7.2.1.3 Clean Air Act of 1970, as amended, 42 U.S.C. §§ 7401–7626

The CAA regulates air emissions from stationary and mobile sources to protect human health and the environment. The Trustees would ensure that any activities associated with restoration projects that would result in air emissions, such as construction projects, would be in compliance with the CAA and any local air quality ordinances.

7.2.1.4 Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9601–9675, and the Superfund Amendments and Reauthorization Act of 1986 (Public Law 99-499)

CERCLA provides authorization to EPA to seek the cleanup of uncontrolled or abandoned hazardous waste sites, as well as emergency releases of pollutants and contaminants into the environment. As discussed previously in this document, the Trustees would ensure that restoration projects are coordinated with CERCLA-authorized remedial actions at the Kalamazoo River Superfund Site.

7.2.1.5 Endangered Species Act of 1973, as amended, 16 U.S.C. §§ 1531–1544

The ESA was designed to protect species that are threatened with extinction. It provides for the conservation of ecosystems upon which these species depend and provides a program for identification and conservation of these species. Federal agencies are required to ensure that any actions are not likely to jeopardize the continued existence of a federally listed threatened or endangered species. Federally listed endangered, threatened, and candidate species in the vicinity of the Kalamazoo River are listed in Table 4.2 in this document. The Trustees expect that the types of projects under the preferred alternative would either have no effect on threatened and endangered species or are not likely to adversely affect them. Projects would be designed to avoid locations where threatened and endangered species reside, or would occur at times of the year when these species are not present. For example, if the Trustees needed to remove trees where the endangered Indiana bat roosts, they would cut them in the winter when bats are not present (and only where alternative roosting trees would be available). Because the status and location of listed species can change over time, the USFWS would determine whether proposed projects may affect any of those species during the project design phase. If no species are affected, no further consultation would be required. If they may be affected, consultation with the USFWS would be required. Guidance on this process is available at http://www.fws.gov/midwest/endangered/section7/s7process/index.html.

7.2.1.6 Fish and Wildlife Conservation Act, 16 U.S.C. §§ 2901–2911

The Fish and Wildlife Conservation Act authorizes financial and technical assistance to state governments to develop, revise, and implement conservation plans and programs for nongame fish and wildlife. The Trustees would seek to coordinate their restoration efforts with relevant conservation plans and programs in the State of Michigan.

7.2.1.7 Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661–667e

The Fish and Wildlife Coordination Act authorizes the involvement of the USFWS in evaluating impacts on fish and wildlife from proposed water resource development projects. Federal agencies that construct, license, or permit water resource development projects are required to consult with the USFWS, and in some instances with the NOAA National Marine Fisheries Service, concerning the impacts of a project on fish and wildlife resources and potential measures to mitigate these impacts. If appropriate, The Trustees would coordinate with USFWS and the NOAA National Marine Fisheries Service.

7.2.1.8 Migratory Bird Treaty Act of 1918, as amended, 16 U.S.C. §§ 703–712

The Migratory Bird Treaty Act protects all migratory birds and their eggs, nests, and feathers and prohibits the taking, killing, or possession of migratory birds. The proposed action would not result in the taking (i.e., harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting) or possession of any migratory birds.

7.2.1.9 Migratory Bird Conservation Act, 16 U.S.C. § 715

The Migratory Bird Conservation Act established a commission and conservation fund to promote the conservation of migratory waterfowl and offset or prevent serious loss of important wetlands and other waterfowl habitat. The Migratory Bird Conservation Fund could potentially provide a source of additional funding to expand on Trustee efforts to conserve or restore migratory waterfowl habitat.

7.2.1.10 National Historic Preservation Act of 1966, as amended, 16 U.S.C. § 470-470w-6

The National Historic Preservation Act is intended to preserve historical and archaeological sites. Compliance with the National Historic Preservation Act would be undertaken through consultation with the Michigan SHPO. If an eligible historic property is within the area of the proposed restoration project, then an analysis would be made to determine whether the project would have an adverse effect on this historic property. If the project would have an adverse effect on historic properties, then the agency proposing the restoration project would consult with the SHPO to minimize the adverse effect.

7.2.1.11 Occupational Safety and Health Act of 1970, as amended, 29 U.S.C. §§ 651–678

The Occupational Safety and Health Act governs the health and safety of employees from exposure to recognized hazards, such as exposure to toxic chemicals, excessive noise, mechanical dangers, and unsanitary conditions. All work conducted on the proposed restoration actions would comply with Occupational Safety and Health Act requirements.

7.2.1.12 Information Quality Act of 2001 (guidelines issued pursuant to Public Law 106-554)

Information disseminated by federal agencies to the public after October 1, 2002 is subject to information quality guidelines developed by each agency pursuant to Section 515 of Public Law 106-554; the guidelines are intended to ensure and maximize the quality of such information (i.e., the objectivity, utility, and integrity of such information). This RP/PEIS is an information product covered by information quality guidelines established by NOAA and DOI for this purpose. The information contained herein complies with applicable guidelines.

7.2.2 State laws

7.2.2.1 Natural Resources and Environmental Protection Act, 1994, Public Act 451, as amended (M.C.L. 324.101–324.90106)

Michigan's environmental protection and natural resource management authorities have been codified in the Natural Resources and Environmental Protection Act. Several parts of the Natural Resources and Environmental Protection Act would be applicable to restoration work undertaken by the Trustees. The most significant parts are described below. The MDEQ administers permits, where required; permit application and review requirements would be consolidated whenever possible. All restoration actions undertaken by the Trustees would comply with relevant provisions of this act, which are described below.

Part 31, Floodplain Regulatory Authority Water Resources Protection, requires that a permit be obtained prior to any alteration or occupation of the 100-year floodplain of a river, stream, or drain. The Floodplain Regulatory Authority regulates the floodplains of rivers, streams, and drains that have a drainage area of two square miles or greater. A permit is not required under Part 31 for alterations within the floodplains of the Great Lakes, inland lakes, or watercourses that have a drainage area of less than two square miles.

Part 55, Air Pollution Control, provides authority to the MDEQ to engage in a variety of activities to protect air quality, including the regulation of fugitive dust sources and emissions, in accordance with the provisions of M.C.L. 324.5524.

Part 91, Soil Erosion and Sedimentation Control, requires that a permit be obtained to protect against the loss of soil to surface waters including wetlands. A permit is generally required for any earth change that disturbs one or more acres or is within 500 feet of a lake or stream. Counties have the primary responsibility for issuing permits. In some cases, cities, villages, and townships have assumed permitting responsibility within their jurisdictions. Permit applications can be obtained from the respective county or municipal agencies.

Part 115, Solid Waste Management, regulates companies and businesses that dispose of solid waste. The solid waste program performs inspection, evaluation, permitting, and licensing of solid waste disposal areas in the state, including evaluation of groundwater monitoring data and corrective actions associated with releases from solid waste landfills.

Part 201, Environmental Remediation, provides legislative authority for Michigan's cleanup program for sites where hazardous substances have been released into the environment. The purpose of this authority is "to provide for appropriate response activity to eliminate unacceptable risks to public health, safety, or welfare, or to the environment from environmental contamination at facilities within the state" (M.C.L. 324.20102). The authority also includes "additional administrative and judicial remedies to supplement existing statutory and common law remedies" (M.C.L. 324.20102), including making claims against liable parties for "the full value of injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing the injury, destruction, or loss resulting from the release" (M.C.L. 324.20126a).

Part 301, Inland Lakes and Streams, requires a permit from MDEQ for certain construction activities on inland lakes and streams. The Inland Lakes and Streams program is responsible for the protection of the natural resources and public trust waters of inland lakes and streams in the state. The program oversees the following activities: dredging, filling, constructing, or placing a structure on bottomlands; constructing or operating a marina; interfering with the natural flow of water; and connecting a ditch or canal to an inland lake or stream.

Part 303, Wetlands Protection, requires permits to perform certain activities in a wetland (Table 7.1).

Table 7.1. Examples of types of activities that require a wetlands protection permit

Activity type	Example activities (partial list only)
Deposit or permit the placing of fill material	Bulldozing, grading, dumping
Dredge, remove, or permit the removal of soil or minerals	Removing tree stumps, bulldozing, digging a pond
Construct, operate, or maintain any use or development	Constructing buildings, structures, boardwalks; mining peat; treating water
Drain surface water	Diverting water to another area via ditch, pump, or drain

The programs in MDEQ that administer these activities have the objective of protecting human health and the environment in Michigan. MDEQ and USACE established a joint state and federal permit process for projects in areas that have both state and federal jurisdiction.

Part 365, Endangered Species Protection, requires permits from the MDNR if a project may take or harm any endangered or threatened fish, plant, or wildlife. As described above, the proposed action is not expected to have any effect on state-listed threatened or endangered species, or is not likely to adversely affect them. Because the status and location of listed species can change over time, during project design the MDNR would work with project sponsors to determine whether actions may affect any of those species and apply for a permit if necessary.

7.2.2.2 Michigan Occupational Safety and Health Act, 1975, Public Act 154 (M.C.L. 408.1001–408.1094)

The Michigan Occupational Safety and Health Act is an act to prescribe and regulate working conditions, and places and conditions of employment to provide for occupational health and safety. All activities conducted under the proposed action would comply with provisions of this act.

7.2.3 Local laws

As appropriate, restoration actions would consider and comply with local plans and ordinances. Relevant local plans could include shoreline and growth management plans. Relevant ordinances could include zoning, construction, noise, and wetlands.

7.2.4 Federal policies and directives

The following federal policies and Presidential Executive Orders could be relevant to restoration projects under the proposed action:

- **USFWS Mitigation Policy (USFWS Manual, 501 FW 2)**

  This policy of the USFWS seeks to ensure "no net loss" of fish and wildlife habitat as a result of USFWS actions. The Trustees would not anticipate that the proposed action would result in long-term adverse impacts on habitat.

- **Executive Order 11514 – Protection and Enhancement of Environmental Quality, as Amended by Executive Order 11911 Relating to Protection and Enhancement of Environmental Quality**

  These Executive Orders require federal agencies to monitor, evaluate, and control their activities to protect and enhance the quality of the nation's environment. These Executive Orders also require agencies to inform the public about these activities and to share data on environmental problems or control methods, as well as to cooperate with other governmental agencies. The proposed action would address the intent of these Executive Orders.

- **Executive Order 11988 – Floodplain Management**

  This Executive Order directs federal agencies to avoid the occupancy, modification, and development of floodplains, when there is a practical alternative. For all projects, the Trustees would work to ensure that any floodplain impacts are minimized.

- **Executive Order 11990 – Protection of Wetlands**

  This Executive Order instructs federal agencies to avoid adverse impacts associated with destruction or modification of wetlands. The Trustees would work to ensure that projects minimize any wetlands impacts and that all necessary permits are obtained.

- **Executive Order 12898 – Environmental Justice**

  This Executive Order instructs federal agencies to assess whether minority or low-income populations would be disproportionately impacted by agency actions. The proposed action would not be expected to adversely affect the environment or human health for any environmental justice populations in the vicinity of the proposed projects. The Trustees reached out to minority and low-income populations for public comment on the draft RP/PEIS and their input was both welcomed and encouraged; the State of Michigan has an Environmental Justice Plan that provides guidance on fair, non-discriminatory treatment and meaningful involvement (MDNRE, 2010). The draft RP/PEIS was available both on the internet and at multiple public libraries (see Section 1.2.1.2). The Trustees will hold any meetings in accessible locations to facilitate participation and documents related to the NRDA are available at MDEQ in Lansing, Michigan (see Section 1.4).

- **Executive Order 12962 – Aquatic Systems and Recreational Fisheries**

  This Executive Order requires that federal agencies, where practicable and permitted by law, work cooperatively to improve the quantity, function, sustainable productivity, and distribution of aquatic resources for increased recreational fishing opportunities. The Trustee agencies worked cooperatively to identify potential projects that would benefit aquatic resources and recreational fishing opportunities, in compliance with the intent of this Executive Order.

- **Executive Order 13112 – Invasive Species**

  This Executive Order requires that federal agencies, where practicable and permitted by law, should identify any actions that may affect the status of invasive species and take actions to address the problem within their authorities and budgets. Agencies also are required not to authorize, fund, or carry out actions that they believe are likely to cause or promote the introduction or spread of invasive species, unless a determination is made that the benefits of actions outweigh potential harms and measures are taken to minimize harm. The Trustees would not expect to select any restoration projects that would promote the introduction or spread of invasive species.

- **Executive Order 13186 – Protection of Migratory Birds**

  This Executive Order requires federal agencies to evaluate the effects of their actions on migratory birds, to take actions to avoid or minimize the impacts of their actions on migratory birds, and to help promote conservation of migratory birds if actions are likely to have a measurable negative effect on migratory bird populations. The proposed action would not be expected to have a negative effect on migratory bird populations.

- **Executive Order 13653 – Preparing the United States for the Impacts of Climate Change**

  As described in Section 6.2, the proposed action described in this RP/PEIS would address the intent of this Executive Order.

- **Executive Order 13690 – Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input**

  As described in Section 6.2, the proposed action described in this RP/PEIS would address the intent of this Executive Order.

- **DOI Departmental Manual, Parts 517 and 609 – Pesticides and Weed Control**

  Implementation of the proposed action would be consistent with DOI policy to use integrated pest management strategies for control of insect and weed pests. Pesticides would only be used after a full consideration of other control alternatives; the material selected and method of application would be the least hazardous of available options.

- **DOI Departmental Manual, Part 518 – Waste Management**

  If implementation of any alternatives generate waste, the Trustees would comply with all relevant DOI directives and policies.

- **DOI Departmental Manual, Part 602 – Land Acquisition, Exchange, and Disposal**

  If the federal government acquires any real property through implementation of these restoration projects, the acquiring agency would comply with appropriate pre-acquisition standards – particularly the American Society for Testing and Materials standard for Environmental Site Assessments for Commercial Real Estate.

7.2.5 State and local policies

Proposed restoration projects would consider and comply with other relevant state and local policies and directives.

8. List of Preparers

This RP/PEIS was prepared by:

Name	Role	Professional discipline/contribution	Degrees	Years of experience
Sims, Julie	Great Lakes Regional Coordinator, NOAA	RP/PEIS document preparation, editing and coordination; technical review; Great Lakes issues	MS in Natural Resource Management, Michigan State University BS in Environmental Biology and Zoology, Michigan State University	13
Goeks, Todd	Regional Resource Coordinator, Great Lakes; case team lead; NOAA	Environmental contaminant fate and transport; investigation design; remedial, removal, and restoration alternative technologies and design; database design and management; NRDA under CERCLA; for this RP/PEIS specifically – technical contributions, editing, and review	BA, Cum Laude, in Biology and Geology-Ecology, Ripon College	29
Williams, Lisa	Environmental Contaminants Branch Chief, East Lansing Field Office, USFWS; lead trustee representative on behalf of DOI	Environmental toxicology including chemistry, fate and effects of PCBs and other organochlorine compounds; ecological risk assessment; NRDA under CERCLA and the Oil Pollution Act (OPA); spill response; for this RP/PEIS specifically – technical contributions and review	PhD in Fisheries and Wildlife/Environmental Toxicology, Michigan State University MS in Fisheries and Wildlife from Michigan State University BA, Summa Cum Laude, in Biology, Chemistry, and Environmental Science from Bradley University	23
Mistak, Jessica	Habitat Management Unit Supervisor, MDNR	RP/PEIS technical review	MS in Fisheries and Wildlife, Michigan State University BS, Natural Resources with distinction in Fisheries Management, The Ohio State University	16
Alfano, Judie	Environmental Quality Specialist	RP/PEIS technical review/contractor oversight	BS in Geology, Western Michigan University	23

Name	Role	Professional discipline/contribution	Degrees	Years of experience
Hanshue, Sharon	Assistant Administrator, MDNR (retired 2/2015)	NRDA under CERCLA and OPA; spill response; for this RP/PEIS specifically – technical contributions and review	BS in Zoology and Environmental Sciences, Michigan State University	36
Peers, Jennifer	Consultant, Abt Associates (formerly Stratus Consulting)	RP/PEIS document preparation	MA in Physical Geography, University of Colorado BA in Environmental Studies, Middlebury College	16

References

ACEC. 2011. 2011 2011 ESE Awards. American Council of Engineering Companies of Michigan. Available: http://www.acecmi.org/2011-ese-projects.html. Accessed August 13, 2014.

AECOM. 2015. Draft Preliminary Design Technical Memorandum – Otsego Township Dam Temporary Sediment Control Structure. Prepared for Michigan DNR and Michigan DEQ. June 12.

Aggarwal, K., B. Chatha, J. Kessner, M. Vaishnav, E. Wolkowitz, and J. Worl. 2012. Fishing for the Future: Re-imagining the Kalamazoo River to Create Regional Economic Development Strategies for the City of Plainwell and Allegan County. Gerald R. Ford School of Public Policy at the University of Michigan-Ann Arbor. Applied Policy Seminar. December.

Alabama Cooperative Extension System. 2013. A Guide to Preventing Soil Compaction During Construction. Raising Trees. PP 14-18. Available: http://www.aces.edu/pubs/docs/A/ANR-1455/ANR-1455.pdf. Accessed June 9, 2015.

Allegan Conservation District. 2009. Rabbit River Watershed Management Plan. Project No. G06302. Prepared for Allegan County Drain Commissioner. July. Available: http://allegancd.org/wp-content/uploads/2012/12/Master-WMP_finalized82609_Part1.pdf. Accessed April 15, 2013.

Allegan Conservation District. 2012. Upper Rabbit River Watershed Management Plan. Available: http://kalamazooriver.org/wp-content/uploads/2013/01/ess-nps-wmp-upper-rabbit_209163_7.pdf. Accessed March 11, 2014.

Allegan County Parks Commission. Undated. Parks and Recreation Master Plan, 2010–2015.

American Rivers and Trout Unlimited. 2002. Exploring Dam Removal: A Decision Making Guide. Available: http://scrcog.org/wp-content/uploads/hazard_mitigation/background_material/dam_removal/Exploring_Dam_Removal-A_Decision_Making_Guide.pdf. Accessed June 3, 2015.

Angel, J.R. and K.E. Kunkel. 2010. The response of Great Lakes water levels to future climate scenarios with an emphasis on Lake Michigan-Huron. *Journal of Great Lakes Research* 36:51–58. doi:10.1016/j.jglr.2009.09.006.

Appleton Papers. 1987. The Birth of Carbonless: NCR Paper Brand. Appleton, WI. February.

Aspen Institute. 2002. Dam Removal: A New Option for a New Century. The Aspen Institute, Program on Energy, the Environment, and the Economy, Washington, DC. Available:

http://www.aspeninstitute.org/sites/default/files/content/docs/ee/damremovaloption.pdf. Accessed February 16, 2016.

Avers, B., R. Fahlsing, E. Kafcas, J. Schafer, T. Collin, L. Esman, E. Finnell, A. Lounds, R. Terry, J. Hazelman, J. Hudgins, K. Getsinger, and D. Scheun. 2007. A Guide to the Control and Management of Invasive *Phragmites*. Interagency Collaboration: Michigan Department of Natural Resources, Michigan Department of Environmental Quality, Ducks Unlimited, U.S. Fish and Wildlife Service, U.S. Army Engineer Research and Development Center, and Michigan Department of Transportation. Available: http://www.michigan.gov/documents/deq/deq-ogl-ais-guide-PhragBook-Email_212418_7.pdf. Accessed February 10, 2014.

Barnhart, M.C. 2008. Methods for Laboratory Culture and Field Caging of Freshwater Mussels. Missouri State University, Biology Department, Springfield, MO. Available: http://unionid.missouristate.edu/documents/poster_for_Frankie.ppt. Accessed February 20, 2014.

Bassett, T. 2011. Annotated Checklist of the Flora of the Kalamazoo Nature Center with Natural Community Descriptions. The Michigan Botanist. Available: http://quod.lib.umich.edu/cgi/p/pod/dod-idx/annotated-checklist-of-the-flora-of-the-kalamazoo-nature.pdf?c=mbot;idno=0497763.0050.201. Accessed February 26, 2014.

Battle Creek River Watershed Project. 2004. Battle Creek Watershed Management Plan. September. Available: http://www.michigan.gov/documents/deq/ess-nps-wmp-battle-creek-river_208908_7.pdf. Accessed March 18, 2014.

Bednarek, A.T. 2001. Undamming rivers: A review of the ecological impacts of dam removal. *Environmental Management* 27(6):803–814.

Bennink, C. 2013. Dam Removal Calls for Specialized Tools. *ForConstructionPros.com*. Equipment Today. Available: http://www.forconstructionpros.com/article/10838269/illinois-constructors-uses-specialized-equipment-on-the-hofmann-dam-removal-project. Accessed June 3, 2015.

Benson, A.J., D. Raikow, J. Larson, and A. Fusaro. 2012. *Dreissena polymorpha*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Available: http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=5. Revision date: June 6, 2012. Accessed February 18, 2014.

Blasland, Bouck & Lee. 1992. Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site Description of the Current Situation: Volume 1 of 7. Draft. Prepared for Kalamazoo River Study Group. July.

Blasland, Bouck & Lee. 2000. Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site RI/FS. Remedial Investigation Report – Phase 1. Draft for State and Federal Review. October.

Blossey, B. 2002. Purple loosestrife. In *Biological Control of Invasive Plants in the Eastern United States*, R. Van Driesche, S. Lyon, B. Blossey, M. Hoddle, and R. Reardon (eds.). USDA Forest Service Publication FHTET-2002-04. Available: http://www.fs.fed.us/foresthealth/technology/pdfs/BiocontrolsOfInvasivePlants02_04.pdf. Accessed March 4, 2014.

BWW. Undated. Trees & Plantings: How to Protect Trees from Beavers. Beavers: Wetlands & Wildlife. Available: http://www.beaversww.org/solving-problems/trees-and-plantings/. Accessed February 24, 2014.

Calhoun Conservation District. 2003. Rice Creek Watershed Project, Watershed Management Plan. July 1, 2013. In cooperation with Calhoun County Drain Commission, Calhoun County MSU Extension, Jackson County MSU Extension, Albion College. MDEQ Water Division. USDA NRCS. Available: http://www.michigan.gov/documents/deq/ess-nps-wmp-rice-creek_208927_7.pdf. Accessed March 11, 2014.

Caulk, A.D., J.E. Gannon, J.R. Shaw, and J.H. Hartig. 2000. Best Management Practices for Soft Engineering of Shorelines. Greater Detroit American Heritage River Initiative. Available: http://www.fws.gov/uploadedFiles/BestManPracticesManual2000.pdf. Accessed June 9, 2015.

CDFG and U.S. DOI. 2012. Klamath Facilities Removal Final EIS/EIR. State Clearinghouse #2010062060.

CDM. 2003. Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site Baseline Ecological Risk Assessment. Final (Revised).

Chapman, K.A. and R. Brewer. 2008. Prairie and Savanna in southern lower Michigan: History, classification, ecology. *The Michigan Botanist* 47:1–48. Available: http://quod.lib.umich.edu/cgi/p/pod/dod-idx/prairie-and-savanna-in-southern-lower-michigan-history.pdf?c=mbot;idno=0497763.0047.101. Accessed February 1, 2015.

Cherkauer, K.A. and T. Sinha. 2010. Hydrologic impacts of projected future climate change in the Lake Michigan region. *Journal of Great Lakes Research* 36(2)33–50.

City of Allegan. 2010. A Community Master Plan. Originally adopted March 2004. Updated April.

City of Allegan Parks Commission and Allegan Township Planning Commission. Undated. City of Allegan & Allegan Township Joint Recreation Plan 2014–2018. Available: http://www.cityofallegan.org/reports/Allegan-Recreation-Plan.pdf. Accessed March 18, 2014.

City of Battle Creek. 2014. Parks and Recreation Master Plan 2014–2018. Available: https://mi-battlecreekparksandrec.civicplus.com/DocumentCenter/View/400. Accessed March 18, 2014.

City of Battle Creek. Undated. Comprehensive Plan.

City of Otsego. 2010. Community 5 Year Recreation Plan for the City of Otsego, Otsego Township and Otsego Public Schools. January. Available: http://www.cityofotsego.org/pdfs/5yearplan.pdf. Accessed March 18, 2014.

City of Otsego. 2014. Master Plan. Available: http://www.cityofotsego.org/pdfs/OtsegoMasterPlan.pdf. Accessed March 18, 2014.

City of Plainwell. 2003. Land Use Plan 2002. With assistance of McKenna Associates, Inc. February.

Collins, M., K. Lucey, B. Lambert, J. Kachmar, J. Turek, E. Hutchins, T. Purington, and D. Neils. 2007. Stream Barrier Removal Monitoring Guide. Gulf of Maine Council on the Environment. December. Available: http://www.gulfofmaine.org/streambarrierremoval/Stream-Barrier-Removal-Monitoring-Guide-12-19-07.pdf. Accessed March 26, 2013.

DeGraff, J.V. and J.E. Evans (eds.). 2013. The Challenges of Dam Removal and River Restoration. Geological Society of America. Boulder, Colorado.

Donat, M. 1995. Bioengineering Techniques for Streambank Restoration: A Review of Central European Practices. Watershed Restoration Project Report No. 2. Available: http://www.env.gov.bc.ca/wld/documents/wrp/wrpr_2.pdf. Accessed June 9, 2015.

Doyle, M.W., E.H. Stanley, M.A. Luebke, and J.M. Harbor. 2000. Dam removal: Physical, biological, and societal consideration. In *Proceedings of the 2000 Joint Conference on Water Resources Engineering and Water Resources Planning and Management*, R.H. Hotchkiss and N. Glade (eds.). American Society of Civil Engineers, New York.

Doyle, M.W., E.H. Stanley, C.H. Orr, A.R. Selle, S.A. Sethi, and J.M. Harbor. 2005. Stream ecosystem response to small dam removal: Lessons from the heartland. *Geomorphology* 71:227–244.

Ducks Unlimited. 2005. Wetland Habitat Management: A Guide for Landowners. Ducks Unlimited, Great Lakes/Atlantic Regional Office.

Farrand, W.R. and D.F. Eschman. 1974. Glaciation of the southern peninsula of Michigan: A review. *Michigan Academician* 7:31–56.

FERC. 2014. Active Licenses Since 2007. Federal Energy Regulatory Commission. Updated 3/18/2014. Available: http://www.ferc.gov/industries/hydropower/gen-info/licensing/active-licenses.asp. Updated June 10, 2016. Accessed August 5, 2016.

FHWA. 2011. Highway Traffic Noise: Construction Noise Handbook. U.S. Department of Transportation Federal Highway Administration. Available: http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook09.cfm. Accessed August 10, 2015.

FISRWG. 1998. Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S. government). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN 3/PT.653. ISBN-0-934213-59-3. Available: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?cid=stelprdb1043244. Accessed February 6, 2014.

Fongers, D. 2008. Kalamazoo River Watershed Hydrologic Study. Hydrologic Studies Unit, Land and Water Management Division, Michigan Department of Environmental Quality. March 27. Available: http://kalamazooriver.org/wp-content/uploads/2012/12/DEQ-Kalamazoo-River-Hydrologic-Study-2008.pdf. Accessed March 17, 2014.

Foster, A.M., P. Fuller, A. Benson, S. Constant, D. Raikow, J. Larson, and A. Fusaro. 2012. *Corbicula fluminea*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Available: http://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=92. Revision date: May 10, 2012. Accessed February 18, 2014.

Four Townships Water Resources Council. 2010. Gull and Augusta Creeks Watershed Management Plan: The Four Township Watershed Area. Available: http://www.ftwrc.org/publications/FTWA_WMP_final.pdf. Accessed March 11, 2014.

FTC&H. 2004. Gun River Watershed Management Plan. Prepared for Allegan Conservation District. Fishbeck, Thompson, Carr, & Huber, Inc., Grand Rapids, MI. February. Project No. G01339. Available: http://www.michigan.gov/documents/deq/ess-nps-wmp-gun-river_208913_7.pdf. Accessed March 11, 2014.

FTC&H. 2009. Rabbit River Watershed Management Plan. Prepared for Allegan County Drain Commissioner. Fishbeck, Thompson, Carr, & Huber, Inc., Grand Rapids, MI. July. Project No. G06302. Available: http://allegancd.org/programs/rabbit-river-watershed-project/rabbit-river-watershed-management-plan/. Accessed March 11, 2014.

FTC&H. 2011. Engineering Report For: Davis Creek Phosphorus Reduction Study. Prepared for Kalamazoo County Drain Commissioner. Fishbeck, Thompson, Carr, & Huber, Inc., Grand

Rapids, MI. September. Project No. G090661TS. Available: http://kalamazooriver.org/wp-content/uploads/2013/01/MASTER_Davis-Creek-Engineering-Report_2011_0916.pdf. Accessed March 11, 2014.

Glick, P., J. Hoffman, M. Koslow, A. Kane, and D. Inkley. 2011. Restoring the Great Lakes' Coastal Future: Technical Guidance for the Design and Implementation of Climate-Smart Restoration Projects. National Wildlife Federation, Ann Arbor, MI. Available: http://www.habitat.noaa.gov/pdf/final_restoring_the_great_lakes_coastal_future_2011.pdf. Accessed February 17, 2014.

Gordon, N.D., B.L. Finlayson, and T.A. McMahon. 2004. Stream Hydrology: An Introduction for Ecologists. John Wiley and Sons. P 342. Available: https://books.google.com/books?id=_PJHw-hSKGgC&pg=PA342&lpg=PA342&dq=soft+engineering+techniques+absorb+energy+along+banks&source=bl&ots=lSUjJdHrgl&sig=aKGUk_a_geQJCbPZXMaDUdEJZBE&hl=en&sa=X&ei=L9uCVYWRJcjzsAWpkILQCA&ved=0CCoQ6AEwAg#v=onepage&q=soft%20engineering%20techniques%20absorb%20energy%20along%20banks&f=false. Accessed June 9. 2015.

Grasman, K.A. 2002. Assessing immunological function in toxicological studies of avian wildlife. *Integrative and Comparative Biology* 42:34–42.

Great Lakes Commission. 2000. Assessment of the Lake Michigan Monitoring Inventory. A Report on the Lake Michigan Tributary Monitoring Project. August. Available: http://glc.org/files/docs/2000-assessment-lake-michigan-monitoring.pdf. Accessed February 28, 2013.

Great Lakes Restoration. 2015. GLRI Projects. Available: https://www.glri.us/projects/index.html. Accessed February 15, 2015.

Gronewold, A.D., V. Fortin, B. Lofgren, A. Clites, C.A. Stow, and F. Quinn. 2013. Coasts, water levels, and climate change: A Great Lakes perspective. *Climatic Change* 120:697–711.

Hart, D.D., T.E. Johnson, K.L. Bushaw-Newton, R J. Horwitz, A.T. Bednarek, D.F. Charles, D.A. Kreeger, and D.J. Velinsky. 2002. Dam removal: Challenges and opportunities for ecological research and river restoration. *Bioscience* 52(8):669–682.

Hayes, D.B. and D.C. Caroffino. 2012. Michigan's Lake Sturgeon Rehabilitation Strategy. State of Michigan Department of Natural Resources. SR62. July. Available: http://www.michigandnr.com/PUBLICATIONS/PDFS/ifr/ifrlibra/Special/Reports/sr62/SR62.pdf. Accessed February 28, 2014.

Hayhoe, K., J. VanDorn, T. Croley II, N. Schlegal, and D. Wuebbles. 2010. Regional climate change projections for Chicago and the US Great Lakes. *Journal of Great Lakes Research* 36(2):7–21.

Higman, P. and S. Campbell. 2009. Meeting the Challenge of Invasive Plants: A Framework for Action. Michigan Department of Natural Resources Wildlife Division. Available: http://mnfi.anr.msu.edu/invasive-species/InvasivesDNREStrategicPlan.pdf. Accessed February 10, 2014.

Indiana General Assembly. 2012. Natural Resources Commission. Information Bulletin #71. April 1. Available: http://www.in.gov/legislative/iac/20120404-IR-312120154NRA.xml.html. Accessed February 26, 2014.

International Upper Great Lakes Study Board. 2012. Lake Superior Regulation: Addressing Uncertainty in Upper Great Lakes Water Levels. Final Report to the International Joint Commission. March. Ottawa, ON.

Januchowski-Hartley, S.R., P.B. McIntyre, M. Diebel, P.J. Doran, D.M. Infante, C. Joseph, and D.J. Allan. 2013. Restoring aquatic ecosystem connectivity requires expanding inventories of both dams and road crossings. *Frontiers in Ecology and the Environment* 11(4):211–217.

Kalamazoo County Government. 2014. Kalamazoo River Valley Trail. Available: http://www.kalcounty.com/parks/krvt/index.html. Accessed August 14, 2014.

Kalamazoo Public Library. 2015. Kalamazoo's First Residents: Our Native Americans. Available: http://www.kpl.gov/local-history/general/native-americans.aspx. Accessed August 10, 2015.

Kalamazoo River Mainstem 3 Corridor Steering Committee. 2006. Kalamazoo River Mainstem 3 Corridor Watershed Management Plan. Prepared by The Kalamazoo River Mainstem 3 Corridor Steering Committee, with Technical Assistance from Kieser & Associates, LLC and Environmental Consulting & Technology, Inc. On Behalf of Kalamazoo County, Kalamazoo County Drain Commissioner, Kalamazoo County Road Commission, City of Kalamazoo, City of Portage, City of Galesburg, City of Parchment, Comstock Township, Cooper Township, Oshtemo Township, Pavilion Township. December 21.

Kalamazoo River Watershed Council. 2011. Kalamazoo River Watershed Management Plan. Version 1.0. March.

Kalamazoo River Watershed Council. 2013. Kalamazoo River Watershed Council, Subwatershed Plans. Available: http://kalamazooriver.org/?page_id=232. Accessed April 1, 2013.

Kalamazoo River Watershed Public Advisory Council. 1998. The Kalamazoo River: Beauty and the Beast. Remedial and Preventive Action Plan for the Kalamazoo River Watershed Area of Concern. Last major revision: April 21 1998. Available: http://kalamazooriver.org/wp-content/uploads/2012/12/Kalamazoo-River-RAP-1998.pdf. Accessed March 17, 2014.

Kanehl, P.D., J. Lyons, and J.E. Nelson. 1997. Changes in the habitat and fish community of the Milwaukee River, Wisconsin, following removal of the Woolen Mills Dam. *American Journal of Fisheries Management* 17:387–400.

Kling, G.W., K. Hayhoe, L.B. Johnson, J.J. Magnuson, S. Polasky, S.K. Robinson, B.J. Shuter, M.M. Wander, D.J. Wuebbles, D.R. Zak, R.L. Lindroth, S.C. Moser, and M.L. Wilson. 2003. Confronting Climate Change in the Great Lakes Region: Impacts on our Communities and Ecosystems. Union of Concerned Scientists, Cambridge, Massachusetts, and Ecological Society of America, Washington, DC. Available: http://www.ucsusa.org/assets/documents/global_warming/greatlakes_final.pdf. Accessed February 28, 2013.

Korleski, C. 2012. Letter to Ms. Patricia Birkholz, Director, Office of Great Lakes, Michigan Department of Natural Resources, re: "Degradations of Aesthetics." U.S. EPA. April 3. Available: http://www.michigan.gov/documents/deq/EPA_concurrence-Kzoo_Raisin_Aesthetics_382906_7.pdf. Accessed August 13, 2014.

Kost, M.A. and D.A. Hyde. 2009. Exploring the Prairie Fen Wetlands of Michigan. Michigan State University Extension. E-3045. December. Available: http://www.miwaterstewardship.org/Portals/0/docs/MSUE%20Bulletins/Exploring.the.Prairie.Fen.Wetlands.of.Michigan.pdf. Accessed February 23, 2014.

Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007. Natural Communities of Michigan: Classification and Description. Prepared for Michigan Department of Natural Resources Wildlife Division and Forest, Mineral and Fire Management Division. Available: http://mnfi.anr.msu.edu/reports/2007-21_Natural_Communites_of_Michigan_Classification_and_Description.pdf. Accessed March 25, 2013.

Lindloff, S.D. and L.A.S. Wildman. 2006. Permitting Dam Removal: The State of (Several) States. American Rivers. Available: https://s3.amazonaws.com/american-rivers-website/wp-content/uploads/2016/06/24142947/Permitting_Dam_Removal-The_State_of_Several_States.pdf. Accessed June 9, 2015.

MacKay, M. and F. Seglenieks. 2012. On the simulation of Laurentian Great Lakes water levels under projections of global climate change. *Climatic Change* 117:55–67. doi:10.1007/s10584-012-0560-z.

Mann, K. 2013. Juvenile Lake Sturgeon Gill Netting a Success!! U.S. Fish and Wildlife Service, Fisheries, Midwest Region. Available: http://www.fws.gov/midwest/fisheries/fishlines-2013-10-24/feature2.html. Accessed February 24, 2014.

Materkowski, S. Undated. Protecting Trees from Beaver Damage. Urban Drainage and Flood Control District. Available: http://alert5.udfcd.org/fhn/fhn2003/03beavers.htm. Accessed February 24, 2014.

McPherson, G.R., G.A. Rasmussen, H.A. Wright, and C.M. Britton. 1986. Getting Started in Prescribed Burning. Management Note 9: Range and Wildlife Management, College of Agricultural Sciences, Texas Tech University. Available: https://tpwd.texas.gov/publications/nonpwdpubs/media/prescribedburn.pdf. Accessed January 30, 2015.

MDEQ. 1994. Natural Resources and Environmental Protection Act 451, Part 31, Part 4, R 323.1064. Dissolved Oxygen in Great Lakes, Connecting Waters, and Inland Streams. Michigan Department of Environmental Quality. Available: http://www.michigan.gov/documents/deq/wrd-rules-part4_521508_7.pdf. Accessed March 28, 2014.

MDEQ. 2001. Total Maximum Daily Load (TMDL) for Total Phosphorus in Lake Allegan. Michigan Department of Environmental Quality, Surface Water Quality Division. March 23. Available: http://www.michigan.gov/documents/deq/wrd-swas-tmdl-allegan_450908_7.pdf. Accessed August 14, 2014.

MDEQ. 2009. Kalamazoo River Ceresco Reach Watershed Management Plan. Department of Environmental Quality Project # 2009-0043. Available: http://www.michigan.gov/documents/deq/wrd-nps-krcr-wmp_430184_7.pdf. Accessed March 11, 2014.

MDEQ. 2013. 2012 Annual Air Quality Report. Michigan Department of Environmental Quality. July. Available: http://www.michigan.gov/documents/deq/DEQ-AQD-AMU-AnnualAirQualityReport-2013_428972_7.pdf. Accessed March 17, 2014.

MDEQ. 2014. State License Search: Dam Safety Permit. Available: http://www.michigan.gov/statelicensesearch/0,4671,7-180-24786_24810-244634--S,00.html. Accessed June 3, 2015.

MDEQ. 2015. Monitoring: Air Quality Division. Michigan Department of Environmental Quality. Available: http://www.michigan.gov/deq/0,4561,7-135-3310_4195---,00.html. Accessed January 30, 2015.

MDEQ. 2016. Michigan NAAQS Attainment Status. Michigan Department of Environmental Quality. July 18. Available: http://www.michigan.gov/documents/deq/deq-aqd-aqe-mi_attainment_status_map_407842_7.pdf. Accessed August 5, 2016.

MDEQ, Michigan Attorney General, USFWS, and NOAA. 2000a. Preassessment Screen, Kalamazoo River Environment Site, Michigan. Prepared for Michigan Department of Environmental Quality, Michigan Attorney General, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration by Stratus Consulting Inc., Boulder, CO. May 30.

MDEQ, Michigan Attorney General, USFWS, and NOAA. 2000b. Stage I Assessment Plan, Kalamazoo River Environment Site. Prepared for Michigan Department of Environmental Quality, Michigan Attorney General, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration by Stratus Consulting Inc., Boulder, CO. November.

MDEQ, Michigan Attorney General, USFWS, and NOAA. 2005a. Stage I Assessment Report, Volume 1 – Injury Assessment: Kalamazoo River Environment. Prepared for Michigan Department of Environmental Quality, Michigan Attorney General, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration by Stratus Consulting Inc., Boulder, CO.

MDEQ, Michigan Attorney General, USFWS, and NOAA. 2005b. Stage I Assessment Report, Volume 2 – Economic Assessment: Kalamazoo River Environment. Final Report. Prepared for Michigan Department of Environmental Quality, Michigan Attorney General, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration by Stratus Consulting Inc., Boulder, CO. March 15.

MDNR. 1981. Lower Kalamazoo River Natural River Plan: Allegan County. Michigan Department of Natural Resources. July.

MDNR. 1987. Kalamazoo River Remedial Action Plan. Second Draft. Prepared by Michigan Department of Natural Resources, Lansing. December.

MDNR. 1994. Status of the Fishery Resource Report 94-1, 1994. "South Branch of the Kalamazoo River." Michael P. Herman, 1994.

MDNR. 2002. Existing Uses and Recreational Opportunities. Available: http://www.michigan.gov/documents/dnr/existing_uses_rec_opps_184226_7.pdf. Accessed June 12, 2015.

MDNR. 2012. Strategic Management Plan for Allegan State Game Area. Michigan Department of Natural Resources, Wildlife Division, Southwest Management Unit, Allegan State Game Area Field Office.

MDNR. 2013. Michigan's Aquatic Invasive Species State Management Plan 2013 Update. Michigan Department of Natural Resources. Available: http://www.michigan.gov/documents/deq/wrd-ais-smp-public-review_380166_7.pdf. Accessed February 10, 2014.

MDNR. 2014. What is a Fish Ladder and Weir? Michigan Department of Natural Resources. Available: http://www.michigan.gov/dnr/0,4570,7-153-10364_52259_19092-46291--,00.html. Accessed February 23, 2014.

MDNRE. 2010. Environmental Justice Plan for the State of Michigan and Department of Natural Resources and Environment. December 17. Available: http://newwarriorsforearth.files.wordpress.com/2011/04/mi_ej_plan.pdf. Accessed June 24, 2014.

Mulcrone, R.S. and C. Mehne. 2001. Freshwater Mussels of the Kalamazoo River, Michigan, from Battle Creek to Saugatuck. Prepared for Lisa Williams, U.S. Fish and Wildlife Service. Available: http://www.fws.gov/midwest/es/ec/nrda/KalamazooRiver/documents/mussels.pdf. Accessed March 5, 2013.

National Research Council. 2004. Adaptive Management for Water Resources Project Planning. National Academy of Sciences, Washington, DC. Available: http://www.nap.edu/catalog.php?record_id=10972. Accessed March 26, 2013.

Nico, L., E. Maynard, P.J. Schofield, M. Cannister, J. Larson, A. Fusaro, and M. Neilson. 2015. *Cyprinus carpio*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Available: http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=4. Revision date: July 15, 2015. Accessed August 5, 2016.

Nielsen-Pincus, M. and C. Moseley. 2010. Ecosystem Workforce Program, Briefing Paper Number 23, Spring. Institute for a Sustainable Environment, University of Oregon.

NOAA. 2006. Supplemental Programmatic Environmental Assessment of NOAA Fisheries' Implementation Plan for the Community-Based Restoration Program. June. Available: http://www.habitat.noaa.gov/pdf/s_pea_june_2006_final_62306.pdf. Accessed February 16, 2016.

NOAA. 2010. Programmatic Framework for Considering Climate Change Impacts in Coastal Habitat Restoration, Land Acquisition, and Facility Development Investments. May.

NOAA. 2011. Adapting to Climate Change: A Planning Guide for State Coastal Managers – A Great Lakes Supplement. National Oceanic and Atmospheric Administration Office of Ocean and Coastal Resource Management. Available: https://coast.noaa.gov/czm/media/adaptationgreatlakes.pdf. Accessed February 28, 2013.

NOAA. 2013. Annual Climatological Surveys for Gull Lake Biology Station, MI US. Available: http://www.ncdc.noaa.gov/cdo-web/datasets/ANNUAL/locations/FIPS:26077/detail. Accessed March 17, 2014.

NOAA. 2015. Final Programmatic Environmental Impact Statement for Habitat Restoration Activities Implemented throughout the Coastal United States. NOAA Restoration Center, Silver Spring, MD. June. Available: http://www.habitat.noaa.gov/pdf/NOAA_Restoration_Center_Final_PEIS.pdf. Accessed July 8, 2015.

NOAA CSC. 2006. 2006-Era Land Cover Classification. National Oceanic and Atmospheric Administration Coastal Services Center. Available: https://coast.noaa.gov/dataservices/Metadata/TransformMetadata?u=https://coast.noaa.gov/data/Documents/Metadata/Imagery/harvest/CCAP_2006_Parent.xml&f=html. Accessed February 27, 2013.

NRCS. 2001. Artificial Nesting Structures. Fish and Wildlife Habitat Management Leaflet. National Resources Conservation Service, Wildlife Habitat Management Institute. No. 20. January.

NTSB. 2012. Enbridge Incorporated Hazardous Liquid Pipeline Rupture and Release, Marshall, Michigan, July 25, 2010. Pipeline Accident Report NTSB/PAR-12/01. National Transportation Safety Board. Washington, DC.

NWF. 2007. Climate Change and Great Lakes Water Resources. National Wildlife Federation. November. Available: http://online.nwf.org/site/DocServer/Climate_Change_and_Great_Lakes_Water_Resources_Report_FI.pdf. Accessed February 28, 2013.

Osteen, C. and D.E. Chappelle. 1982. Forest management options and policy implications in the Kalamazoo River Basin of Michigan. *Journal of Forestry* 80(5):287–290.

Reznicek, A.A., E.G. Voss, and B.S. Walters. 2011. Michigan Flora Online. University of Michigan. Available: http://michiganflora.net/photos.aspx. Accessed February 12, 2014.

Rheaume, S.J., D.L. Hubbell, C.M. Rachol, A. Simard, and L.M. Fuller. 2004. Sediment Characteristics and Configuration within the Otsego City Dam Impoundment on the Kalamazoo

River, Michigan, 2001–02. United States Geological Survey Water-Resources Investigations Report 03-4218. Available: http://pubs.usgs.gov/wri/wrir03-4218/pdf/wrir03-4218_report.pdf. Accessed October 23, 2012.

Riley, J. 2012. Stage 2 Remedial Action Plan Kalamazoo River Area of Concern. Office of the Great Lakes, Great Lakes Management Unit, Michigan Department of Environmental Quality. January. Available: http://kalamazooriver.org/wp-content/uploads/2012/12/deq-ogl-aoc-KalamazooRiverStage2RAP_378185_7.pdf. Accessed March 17, 2014.

Sims, J.A. 2007. The Michigan Department of Environmental Quality Biennial Remedial Action Plan Update for the Kalamazoo River Area of Concern. Michigan Department of Environmental Quality. Last updated February 6, 2007. Available: http://kalamazooriver.org/wp-content/uploads/2012/12/2007_KalamazooRvrRAPUpdate.pdf. Accessed March 28, 2014.

SME. 2010. 2010 Safety Inspection Report for Otsego City Dam (Formerly Menasha Paper Company Dam). Prepared for City of Otsego by Soil and Materials Engineers, Inc. October 21.

Smith, K. 2010. Lake Sturgeon Rehabilitation in the Kalamazoo River. Michigan Department of Natural Resources. January.

Smith, K. 2011. Portage Creek Fish Survey. Michigan Department of Natural Resources, Fisheries Division, Plainwell, MI.

Spoelstra, J. 2009. Kalamazoo River Area of Concern: Restoration Plan for the "Loss of Fish and Wildlife Habitat" and "Degradation of Fish and Wildlife Populations" Beneficial Use Impairments. Kalamazoo River Watershed Council. June 18. Available: http://kalamazooriver.org/wp-content/uploads/2012/12/Final-Kzoo-Fish-Wildlife-BUI.pdf. Accessed October 23, 2013.

Stackpoole, S. 1997. Purple Loosestrife in Michigan: Biology, Ecology, and Management. Sea Grant Michigan; Michigan State University Extension. Bulletin E-2632. Available: http://www.miseagrant.umich.edu/downloads/ais/fs-97-501_purple_loosestrife.pdf. Accessed February 10, 2014.

Stanley, E.H. and M.W. Doyle. 2003. Trading off: The ecological effects of dam removal. *Front. Ecol. Environ* 1(1):15–22.

Stratus Consulting. 2009. Stage I Assessment Report, Volume 2 – Economic Assessment: Kalamazoo River Environment. Recreational Fishing Update. Prepared for Michigan Department of Environmental Quality, Michigan Attorney General, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration. Stratus Consulting Inc., Boulder, CO. July 16.

Stratus Consulting. 2013. Restoration Plan and Environmental Assessment, Portage Creek and Operable Unit 1 – Allied Paper Property, Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site. Prepared for Michigan Department of Natural Resources, Michigan Department of Environmental Quality, Michigan Attorney General, U.S. Fish and Wildlife Service, and National Oceanic and Atmospheric Administration. August. Stratus Consulting Inc., Boulder, CO. Available: http://www.fws.gov/midwest/es/ec/nrda/KalamazooRiver/pdf/KzOU1_RPEAfinalAug2013.pdf. Accessed March 18, 2014.

The Forum of Greater Kalamazoo. 1996. Davis Creek Watershed Management Plan. Prepared by The Forum of Greater Kalamazoo, in partnership with the Kalamazoo Conservation District. August.

The Forum of Greater Kalamazoo. 2006. Portage & Arcadia Creeks Watershed Management Plan. Transition Grant #2003-0028. USEPA Nine Elements Update. Prepared by The Forum of Greater Kalamazoo, with Technical Assistance from Kieser & Associates, LLC. On Behalf of The Portage & Arcadia Creeks Steering Committee. February 1. Available: http://kalamazooriver.net/portage-arcadia-creek-watershed-plan/portage-arcadia-creek-homepage/watershed-management-plan. Accessed March 11, 2014.

The Heinz Center. 2002. Dam Removal: Science and Decision Making. H. John Heinz III Center for Science, Economics and the Environment, Washington, DC.

Thorncraft, G. and J.H. Harris. 2000. Fish Passage and Fishways in New South Wales: A Status Report. Office of Conservation NSW Fisheries, Sydney. Cooperative Research Centre for Freshwater Ecology Technical Report 1/2000. May.

URS. 2011. Otsego City Dam – Dam Removal and Channel Restoration – Engineering Design Report. Prepared for Michigan Department of Natural Resources and Department of Technology, Management and Budget. October 21.

URS. 2012. Otsego Township Dam – Dam Removal and Channel Restoration – Engineering Design Report. Prepared for Michigan Department of Natural Resources and Department of Technology, Management and Budget. June 26.

URS. 2013. Feasibility Study Report. Alcott Street Dam Removal: Kalamazoo, Kalamazoo County, Michigan. URS Project No.: 13651712. Prepared for the Michigan Department of Environmental Quality by URS, Southfield, MI. July.

USACE. 2014. Fact Sheet: Saugatuck Harbor and Kalamazoo River, MI. U.S. Army Corps of Engineers. March. Available:

http://w3.lre.usace.army.mil/OandM/factsheets/SaugatuckHarborandKalamazooRiver.pdf. Accessed March 17, 2014.

U.S. Census Bureau. 2014. State and County QuickFacts. Data derived from Population Estimates, Census of Population and Housing, Small Area Income and Poverty Estimates, State and County Housing Unit Estimates, County Business Patterns, Nonemployer Statistics, Economic Census, Survey of Business Owners, Building Permits, and Consolidated Federal Funds Report. Available: http://quickfacts.census.gov/qfd/states/. Last revised March 27, 2014. Accessed March 28, 2014.

USDA. 2015. Invasive Aquatic Species. United States Department of Agriculture. Available http://www.invasivespeciesinfo.gov/aquatics/. Last revised March 2, 2015. Accessed June 12, 2015.

USDA-NRCS. 2007. Stream Restoration Design (National Engineering Handbook 654). United States Department of Agriculture – Natural Resources Conservation Service. Available: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/?cid=stelprdb1044707. Accessed February 6, 2014.

U.S. DOT. 2006. Construction Noise Handbook. Chapter 7: Mitigation of Construction Noise. Available: http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook07.cfm. Accessed June 9, 2015.

U.S. EPA. 2007. Administrative Settlement Agreement and Order on Consent for Removal Action, In the Matter of Allied Paper/Portage Creek/Kalamazoo River Superfund Site, Allegan and Kalamazoo Counties, Michigan. Available: http://www.epa.gov/Region5/cleanup/kalproject/pdfs/kalproject_aoc_200702.pdf. Accessed October 23, 2013.

U.S. EPA. 2009. Former Plainwell Impoundment Time-critical Removal Action. Presentation at U.S. Environmental Protection Agency Public Meeting. February 26. Available: http://www.epa.gov/region5/cleanup/kalproject/pdfs/kalproject_slides_20090226.pdf. Accessed September 12, 2012.

U.S. EPA. 2011. Recovery Potential Metrics Summary Form, Indicator Name: BANK STABILITY/SOILS. September 1. Available: https://www.epa.gov/sites/production/files/2015-11/documents/rp1bankstabsoils1109.pdf. Accessed August 4, 2016.

U.S. EPA. 2012. Second Five-Year Review Report for Allied Paper Inc./Portage Creek/Kalamazoo River Superfund Site, Allegan and Kalamazoo Counties, Michigan. October. Available: http://www.epa.gov/Region5/cleanup/kalproject/pdfs/2ndfyr_partone.pdf and http://www.epa.gov/Region5/cleanup/kalproject/pdfs/2ndfyr_parttwo.pdf. Accessed October 23, 2013.

U.S. EPA. 2013a. Great Lakes Areas of Concern. Kalamazoo River AOC Boundary Map. Available: http://www.epa.gov/greatlakes/aoc/kalriv/pdfs/Kalamazoo_Final_State_Approved.pdf. Accessed March 28, 2014.

U.S. EPA. 2013b. Nonroad Compression-Ignition Engines – Exhaust Emission Standards. Available: http://www.epa.gov/otaq/standards/nonroad/nonroadci.htm. Accessed August 10, 2015.

U.S. EPA. 2013c. PCB Cleanup of Portage Creek is Complete. Allied Paper/Portage Creek/Kalamazoo River Site. Kalamazoo, Michigan. November. Available: http://www.epa.gov/region05/cleanup/kalproject/pdfs/kalproject-fs-201311.pdf. Accessed June 24, 2014.

U.S. EPA. 2013d. Portage Creek Area Time-Critical Removal Action: Progress Update: Public Meeting. U.S. Environmental Protection Agency. January 9. Available: http://www.epa.gov/region05/cleanup/kalproject/pdfs/kalproject-ppt1-20130109.pdf. Accessed March 14, 2013.

U.S. EPA. 2014. National Ambient Air Quality Standards (NAAQS). U.S. Environmental Protection Agency. October 21, 2014. Available: https://www3.epa.gov/ttn/naaqs/. Accessed August 5, 2016.

U.S. EPA. 2015. Aquatic Indicators. Available: https://www.epa.gov/national-aquatic-resource-surveys/indicators-benthic-macroinvertebrates. Last updated September 25, 2015. Accessed August 5, 2016.

USFWS. 2011. Field Notes Entry: Lake Sturgeon Growing Well in Kalamazoo River Streamside Rearing Trailer. U.S. Fish and Wildlife Service. June 30. Available: http://www.fws.gov/fieldnotes/regmap.cfm?arskey=29919. Accessed March 25, 2014.

USFWS. 2012. Nevada Fish & Wildlife Office: Asian Clams. U.S. Fish and Wildlife Service. Available: http://www.fws.gov/nevada/nv_species/invasive_species/asian_clams.htm. Last updated: April 16, 2014. Accessed August 4, 2016.

USFWS. 2013 Fisheries Program: Sea Lamprey Management. United States Fish and Wildlife Service. Available: http://www.fws.gov/midwest/fisheries/sea-lamprey.html. Accessed February 10, 2014.

USFWS. 2015a. Fact Sheet: Northern Long-eared Bat *Myotis septentrionalis*. Available: http://www.fws.gov/midwest/Endangered/mammals/nleb/nlebFactSheet.html. Accessed July 9, 2015.

USFWS. 2015b. Michigan. County Distribution of Federally-listed Threatened, Endangered, Proposed, and Candidate Species. U.S. Fish and Wildlife Service. Available: http://www.fws.gov/midwest/Endangered/lists/michigan-cty.html. Revised May 28, 2015. Accessed July 9, 2015.

USFWS, Nottawaseppi Huron Band of the Potawatomi Tribe, and Match-E-Be-Nash-She-Wish Band of the Pottawatomi Indians. 2015. Draft Damage Assessment and Restoration Plan/Environmental Assessment for the July 25–26, 2010 Enbridge Line 6B Oil Discharges near Marshall, MI. Available: http://www.fws.gov/midwest/es/ec/nrda/MichiganEnbridge/. Accessed July 14, 2015.

USGS. 2015. Nonindigenous Aquatic Species Database. Gainesville, Florida. U.S. Geological Survey. Available: http://nas.er.usgs.gov/queries/. Last updated June 22, 2102. Accessed June 12, 2015.

Walters, C.J. and C.S. Holling. 1990. Large-scale management experiments and learning by doing. *Ecology* 71(6):2060–2068.

Ward, A., D. Mecklenburg, G.E. Powell, L Brown, and A. Jayakaran. 2004. Two-stage Channel Design Procedures. Conference Proceedings for the ASAE Specialty Conference *Self-Sustaining Solutions for Streams, Wetlands, and Watersheds.* September 12–15, St. Paul, MN.

Ward, A., G.E. Powell, A.D. Jayakaran, J.D. Witter, J.L. D'Ambrosio, and D. Mecklenburg. 2011. Selecting and Sizing a Two-stage Channel System in an Agricultural Landscape. Great Lakes Regional Water Program.

Wesley, J.K. 2005. Kalamazoo River Assessment. Fisheries Division Special Report 35. Ann Arbor, MI. Michigan Department of Natural Resources. September. Available: http://www.dnr.state.mi.us/publications/pdfs/IFR/ifrlibra/Special/Reports/sr35/sr35_text.pdf. Accessed March 14, 2012.

Westlake, K.A. 2014. Letter to Lisa Williams re: Scoping for a Programmatic Environmental Impact Statement: Riverwide Restoration Plan – Allied Paper/Portage Creek/Kalamazoo River Superfund Site; Allegan and Kalamazoo Counties, Michigan. NEPA Implementation Section, Office of Enforcement and Compliance Assurance, U.S. EPA. March 17.

White House Council on Environmental Quality, U.S. Department of Agriculture, U.S. Department of Commerce, U.S. Department of Health and Human Services, U.S. Department of Homeland Security, U.S. Department of Housing and Urban Development, U.S. Department of State, U.S. Department of the Army, U.S. Department of the Interior, U.S. Department of Transportation, and U.S. Environmental Protection Agency. 2010. Great Lakes Restoration Initiative Action Plan: FY2010–FY2014. February 21. Available: https://www.glri.us//pdfs/glri_actionplan.pdf. Accessed March 24, 2014.

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. Available: http://www.usgs.gov/sdc/doc/DOI-%20Adaptive%20ManagementTechGuide.pdf. Accessed March 26, 2013.

Williams, L. 2012. Letter to Paul Ruesch, U.S. Environmental Protection Agency re: Restoration Plan for Portage Creek Area Time-Critical Removal Action. May 24.

Williams, L.L. 2011. Plainwell Dam Removal on the Kalamazoo River: Removing More than Physical Barriers to Restoration. Presentation at AOC Conference. October 12.

Wittmann, M.E., S. Chandra, J.E. Reuter, S.G. Schladow, B.C. Allen, and K.J. Webb. 2012. The control of an invasive bivalve, *Corbicula fluminea*, using gas impermeable benthic barriers in a large natural lake. *Environmental Management* 49(6):1163–1173.