Oak Ridge Reservation Natural Resource Damage Assessment: Restoration and Compensation Determination Plan/Environmental Assessment

Final | December 2022

prepared for:

Oak Ridge Reservation Natural Resource Trustees

-State of Tennessee Department of Environment and Conservation
-Tennessee Valley Authority
-United States Department of Energy
-United States Fish and Wildlife Service

prepared by:

Industrial Economics, Incorporated

[this page intentionally left blank]

TABLE OF CONTENTS

CHAPTER 3 | NATURAL RESOURCES AND CONTAMINANT-RELATED LOSSES

CHAPTER 4 | PROPOSED RESTORATION ALTERNATIVES

CHAPTER 5 | ALTERNATIVES EVALUATION AND SELECTION OF THE PREFERRED ALTERNATIVE

LIST OF EXHIBITS

LIST OF ACRONYMS

BSAF	Biota-Soil Accumulation Factor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of concern
DNAPL	Dense Nonaqueous Phase Liquid
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park (formerly Oak Ridge K-25 Site)
FCA	Fish Consumption Advisory
FWS	U.S. Fish and Wildlife Service
HEA	Habitat Equivalency Analysis
MCLs	Maximum Contaminant Levels
NEPA	National Environmental Policy Act
NRDA	Natural Resource Damage Assessment
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCBs	Polychlorinated biphenyls
RCDP/EA	Restoration and Compensation Determination Plan/Environmental Assessment
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RP	Responsible Party
SQG	Sediment Quality Guideline
Trustees	State of Tennessee Department of Environment and Conservation on behalf of the State of Tennessee, the Tennessee Valley Authority, the U.S. Fish and Wildlife Service on behalf of the U.S. Department of the Interior, and the U.S. Department of Energy
TDEC	State of Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
VOCs	Volatile Organic Compounds

EXECUTIVE SUMMARY

In the early 1940s, the United States Department of Energy (DOE) constructed three facilities on the approximately 37,000-acre Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee: Oak Ridge National Laboratory, Oak Ridge Y-12 Plant, and East Tennessee Technology Park (area and facilities together comprise the Site). Activities at these facilities have resulted in the release of hazardous substances including radionuclides, metals, and organic contaminants, leading to the contamination of natural resources both at the ORR and in the surrounding environment. In particular, PCBs, cadmium, chromium, mercury, and radionuclides (cesium-137, strontium-90, uranium-235, and uranium-238) have contaminated both aquatic and terrestrial habitat. The ORR was designated a Superfund Site by the United States Environmental Protection Agency (EPA) in 1989, leading to ongoing cleanup activities.

The Trustees for natural resources at the ORR are the State of Tennessee Department of Environment and Conservation (TDEC), the Tennessee Valley Authority (TVA), the United States Department of Energy (DOE), and the United States Fish and Wildlife Service (FWS) on behalf of the United States Department of the Interior (DOI). DOE, as the primary potentially responsible party and a Trustee, joined the other Trustees in forming a Trustee Council and conducting a Natural Resource Damage Assessment (NRDA) for the Site.

The goal of NRDA is to restore, rehabilitate, replace, and/or acquire the equivalent of (together referred to as restoration in this document) those natural resources injured or lost by the release of hazardous substances. The first step in this process is to understand what resources have been injured and what resource services have been lost.

The Trustees approached the NRDA for the ORR in two phases. The first phase focused on the impacts of ORR-related contamination to resources in Watts Bar Reservoir (this includes Watts Bar Reservoir downstream of its confluence with the Clinch River to the Watts Bar Dam and the Tennessee River arm upstream to the Fort Loudoun Dam). Natural resource service losses due to the presence of contamination include the reduction of ecological services in aquatic habitats (e.g., reproductive impairment in fish), as well as a direct reduction of human use services (e.g., fishing). As compensation for natural resource damages sustained in Watts Bar Reservoir, in 2009 DOE and the State of Tennessee, in agreement with the other natural resource Trustees, established the Black Oak Ridge Conservation Easement (BORCE). BORCE is approximately 3,000 acres of forested upland ridge that runs southwest-northeast just west of the ORR. BORCE includes multiple upland habitat types and supports a variety of threatened and endangered species. Poplar Creek flows through the BORCE, and wetlands exist along the southern edge of the BORCE area. In addition to ecological services, BORCE benefits groundwater resources and supports a suite of human use activities, such as trail use recreation and hunting. DOE also provided funding to design and implement projects that will improve existing recreational fishing by updating existing access sites and creating new fishing opportunities for the public.

The second phase of the ORR NRDA focused on terrestrial habitat within the ORR, the aquatic habitat of the adjacent Clinch River, the floodplain and aquatic habitat of several Clinch River tributaries, and the groundwater beneath and flowing off-site from ORR. Natural resources using these areas include a variety of fish, birds, mammals, and sediment-dwelling invertebrates. Measured and modeled data on contaminant levels in various resources exceeded site-specific and literature-based adverse effects thresholds, demonstrating that injury to natural resources has occurred. The existence of a contaminant-driven fish consumption advisory on the Clinch River and some of its tributaries that flow through the ORR also indicates injuries to natural resources. The Trustees determined that these injuries resulted in losses in ecological (aquatic and terrestrial), groundwater, and recreational (fishing and hunting) services.

Recently the Trustees agreed upon a Trustee Council Resolution directing the State of Tennessee Department of Environment and Conservation (TDEC) and DOE to enter into an Agreement in Principle (AIP) that $42 million is an amount sufficient to settle DOE's liability for the second phase of natural resource damages at the ORR. Approximately half of the total settlement would be funded through repurposing a perpetual care fund for the Environmental Management Waste Management Facility (EMWMF), the existing CERCLA landfill at the ORR. The EMWMF perpetual care fund was originally created to allow TDEC to perform limited post-closure operation and maintenance activities at the EMWMF. As a condition of TDEC repurposing the EMWMF perpetual care fund, DOE agrees to reassume full responsibility for all post-closure operation and maintenance obligations for the facility. The remainder of the $42 million settlement amount would be paid by DOE over a period not to exceed seven years. The AIP provides that the Trustees will oversee use of the settlement amount to select and fund projects described in this Restoration and Compensation Determination Plan/Environmental Assessment (RCDP/EA).

Restoration is expected to provide additional natural resource services of a similar type and quality to those lost in order to make the public whole. The Trustees developed this RCDP/EA to select a restoration alternative that will achieve that goal. Three alternatives were considered: Alternative A: No Action, Alternative B: Contaminant Cleanup, and Alternative C: Resource- and Resource Use-Based Restoration. Alternative A assumes all resources will naturally recover. Alternative B involves cleanup actions such as dredging/excavation, capping, and groundwater treatment that would occur *in addition to* ongoing and planned remedial actions as required by EPA. Alternative C encompasses a suite of different restoration actions, all targeted towards benefiting a specific resource or set of resources (i.e., surface water, sediment, aquatic invertebrates, fish, birds, reptiles, amphibians, mammals), as well as the human users of these resources. Projects are focused on generating ecological, groundwater, and recreational benefits, such as habitat creation/restoration/enhancement, groundwater infrastructure improvements, and improvements to recreational opportunities and access. These projects would be accomplished through careful design and implementation as well as public outreach to promote adequate understanding, coordination, and planning.

Each alternative was evaluated against site-specific Trustee restoration objectives (e.g., increase habitat connectivity), as well as the DOI NRDA restoration factors (43 CFR § 11.82(d)). To comply with the National Environmental Policy Act (NEPA), the Trustees also conducted an Environmental Assessment

(EA) evaluating the anticipated impacts of the restoration alternatives on the environment and determine the cumulative environmental consequences of each alternative. The Trustees concluded that Alternative C satisfies all site-specific restoration objectives, which allows for project opportunities with the entire priority geographic scope, is consistent with the regulatory restoration factors, and creates additional natural resource services to compensate the public for interim losses. Therefore, the Trustees selected Alternative C as the preferred restoration alternative.

Now that the RCDP/EA is final, the Trustees will begin to identify and evaluate specific project options based on the Alternative C. Each project will be evaluated against the same restoration priorities and factors described above, and, if needed, a further review of environmental consequences will be conducted. The Trustees will continue to inform the public of restoration project plans and progress and seek public and stakeholder participation and involvement, as appropriate.

CHAPTER 1 | INTRODUCTION

1.1 PURPOSE OF RCDP/EA

> **WHAT IS NRDA?**
>
> A Natural Resource Damage Assessment is a regulatory process to determine the appropriate amount and type of restoration and/or dollars needed to compensate the public for injuries to natural resources resulting from the release of hazardous substances into the environment.

Located in east Tennessee, the United States Department of Energy Oak Ridge Reservation (ORR) is bordered by the City of Oak Ridge to the north and east and by the Clinch River and Melton Hill Lake on the south and west (Exhibit 1-1). Activities at the ORR have resulted in the release of hazardous substances including radionuclides, metals, and organic contaminants, leading to the contamination of natural resources both at the ORR and in the surrounding environment. The ORR was designated a Superfund Site by the United States Environmental Protection Agency (EPA) in 1989, leading to ongoing cleanup activity. However, these remedial actions, while beneficial, do not themselves compensate the public for past, present, and future contaminant-related injuries to natural resources (e.g., fish consumption advisories [FCAs] on the Watts Bar Reservoir, Melton Hill Reservoir, and East Fork Poplar Creek).

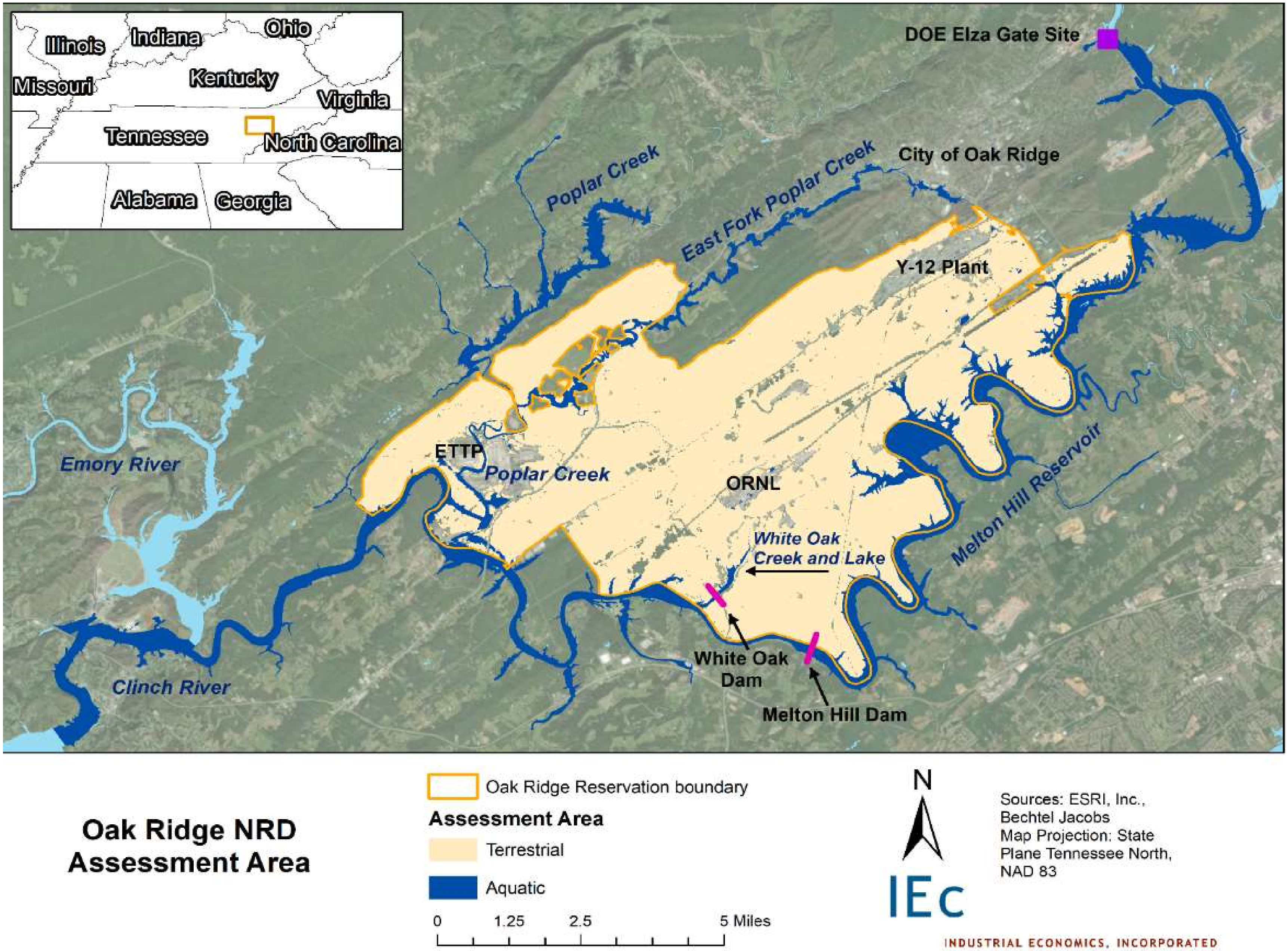
Therefore, as part of the natural resource damage assessment (NRDA) process, the Trustees developed this Restoration and Compensation Determination Plan/Environmental Assessment (RCDP/EA) to inform the public of the preferred restoration alternative that is expected to compensate for injuries to natural resources due to hazardous substance releases (43 CFR § 11.81). In this case, hazardous substances including radionuclides, metals, and organic contaminants have been released into the environment in and around the ORR as result of operations. Natural resources (e.g., sediments, soil, invertebrates, fish, birds, and mammals) have been exposed to and adversely affected by these contaminants, resulting in a loss in ecological, groundwater, and recreational services. Restoration is expected to provide additional natural resource services of a similar type and quality to those lost in order to make the public whole. To comply with the National Environmental Policy Act (NEPA), the Trustees also conducted an Environmental Assessment (EA) to evaluate the likely impacts of various restoration alternatives on the environment.

1.2 ORGANIZATION OF THIS CHAPTER

This chapter discusses the following:

- Trusteeship and coordination with the responsible party,
- An overview of the ORR, site history and remedial activities,
- Natural resource damage assessment activities and their relationship with remediation,
- The National Environmental Policy Act and compliance with other authorities,
- Public participation,
- The administrative record, and
- An outline of the remainder of this RCDP/EA.

EXHIBIT 1-1. ORR ASSESSMENT AREA



1.3 TRUSTEESHIP AND COORDINATION WITH RESPONSIBLE PARTY

Federal law authorizes trustees to act on behalf of the public to assess and recover natural resource damages, and to plan and implement actions to restore, replace, or acquire the equivalent of natural resources injured or lost as a result of the release of a hazardous substance (42 U.S.C. § 9601 *et seq.* Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); 43 CFR § 11). In addition, under Tenn. Code Ann. § 69-3-116, the Commissioner of the Department of Environment and Conservation may assess damages to the state resulting from any person's pollution or violation, failure, or neglect in complying with any rules, regulations, or standards of water quality promulgated by the board or permits or orders issued pursuant to the Tennessee Water Quality Control Act, T.C.A. §§ 69-3-101, *et seq*. The Commissioner of the Department of Environment and Conservation may assess damages to the state resulting from any person's violation of the Tennessee Solid Waste Disposal Act, T.C.A. §§ 68-211-101, *et seq.,* and the Tennessee Hazardous Waste Manage Act, T.C.A. §§ 68-212-101, *et seq.*

In this case, the Trustees for natural resources actually or potentially affected by contaminant releases from the ORR are:

- The State of Tennessee Department of Environment and Conservation (TDEC),
- The Tennessee Valley Authority (TVA),
- The United States Department of Energy (DOE), and
- The United States Fish and Wildlife Service (FWS) on behalf of the United States Department of the Interior (DOI).

In 1993, the Trustees formed a Trustee Council to conduct a NRDA, and in 1995 they signed a Memorandum of Understanding to "promote cooperation between the Trustees in exercising their natural resource trustee responsibilities" regarding releases of hazardous substances at ORR. These responsibilities include assessing "the injury to, loss of or destruction of natural resources and [determining] appropriate restoration and/or compensation for such injury, loss, or destruction" (Trustees 1995). Since then, the Trustees have regularly communicated and engaged in cooperative efforts to conduct the NRDA, relying on the extensive suite of existing data to inform injury and damage estimates.

At ORR, DOE is both a Trustee and the primary party responsible (RP) for discharges and releases of hazardous substances. Under CERCLA, the RP may be invited to participate in cooperative natural resource damage assessment and restoration efforts (43 CFR § 11.32(a)(2)). Cooperative assessments can reduce duplication of effort, expedite the assessment, and accomplish resource restoration earlier than might otherwise be the case. Therefore, as noted above, TDEC, TVA, and FWS invited DOE to join the Trustee Council, which collectively has agreed to follow a cooperative assessment and restoration process. In addition to participation in Trustee Council efforts, DOE's active involvement in the damage assessment and restoration planning process includes the following:

- Providing funding and assistance for assessment activities,
- Providing data and relevant literature,
- Participating in technical team discussions focused on assessing ecological, groundwater, and recreational losses, and
- Assisting with the identification and benefits assessment of restoration alternatives.

1.4 OVERVIEW OF ORR HISTORY AND REMEDIATION

In the early 1940s, DOE constructed three major facilities on ORR, including Oak Ridge National Laboratory (ORNL), Oak Ridge Y-12 Plant, and East Tennessee Technology Park (ETTP; formerly Oak Ridge K-25 Site) (Exhibit 1-1). These facilities conducted research, development, and processes in support of the Manhattan Project[1], focusing in particular on the enrichment of uranium[2] for use in atomic weapons. The Y-12 Plant was a production facility that enriched uranium-235 by an electromagnetic process[3]; at the former K-25 site enrichment occurred through gaseous diffusion[4] . Current activities at ORR include demolishing contaminated buildings and structures, processing nuclear materials, building treatment facilities, and other activities related to energy and national defense programs (DOE 2020a, Parr and Hughes 2006). In addition to continuing research in materials and chemical sciences, nuclear science, energy, and super-computing conducted at ORNL, numerous deteriorating, contaminated structures and hazardous wastes are still located on the Site (DOE 2020a).

Between the 1940s and 1970s, the principal mode of disposal of solid radioactive and other wastes (e.g., solid wastes such as scrap metal, concrete, soil, animal tissue, oils, powders, metal tanks, military equipment; liquid wastes contained in drums; and sludges from waste-water treatment plants) at ORNL and other areas at ORR was their burial in shallow trenches within the White Oak Creek drainage basin and Bear Creek Valley. By 1973, an estimated six million cubic feet of radioactive and other matter had been placed in six burial grounds in two valleys (Arora et al. 1981; Webster 1976; DOE 2020b). In contrast, some waste from Y-12 was discharged directly into East Fork Poplar Creek. Other types of releases included discharge to holding ponds and injection into the ground. These and other activities at ORR facilities resulted in the discharge of radioactive compounds and other hazardous substances, leading to the exposure of natural resources to elevated levels of contaminants both at ORR and in the surrounding environment, including adjacent waterbodies (EPA et al. 1992). Additional information about contaminant releases and environmental pathways is provided in Section 3.5.

Remedial activities at the Site have been ongoing since 1986 (EPA 2022a). Because surface water is the main pathway by which contaminants are transported within and off the ORR (e.g., all streams in the ORR eventually flow into the Clinch River), remedial actions have been identified for each relevant watershed. These watersheds include ETTP, Bear Creek Valley (Y-12), Upper East Fork Poplar Creek (Y-12), Chestnut Ridge (Y-12), Bethel Valley (ORNL), and Melton Valley (ORNL; Exhibit 1-2).

---

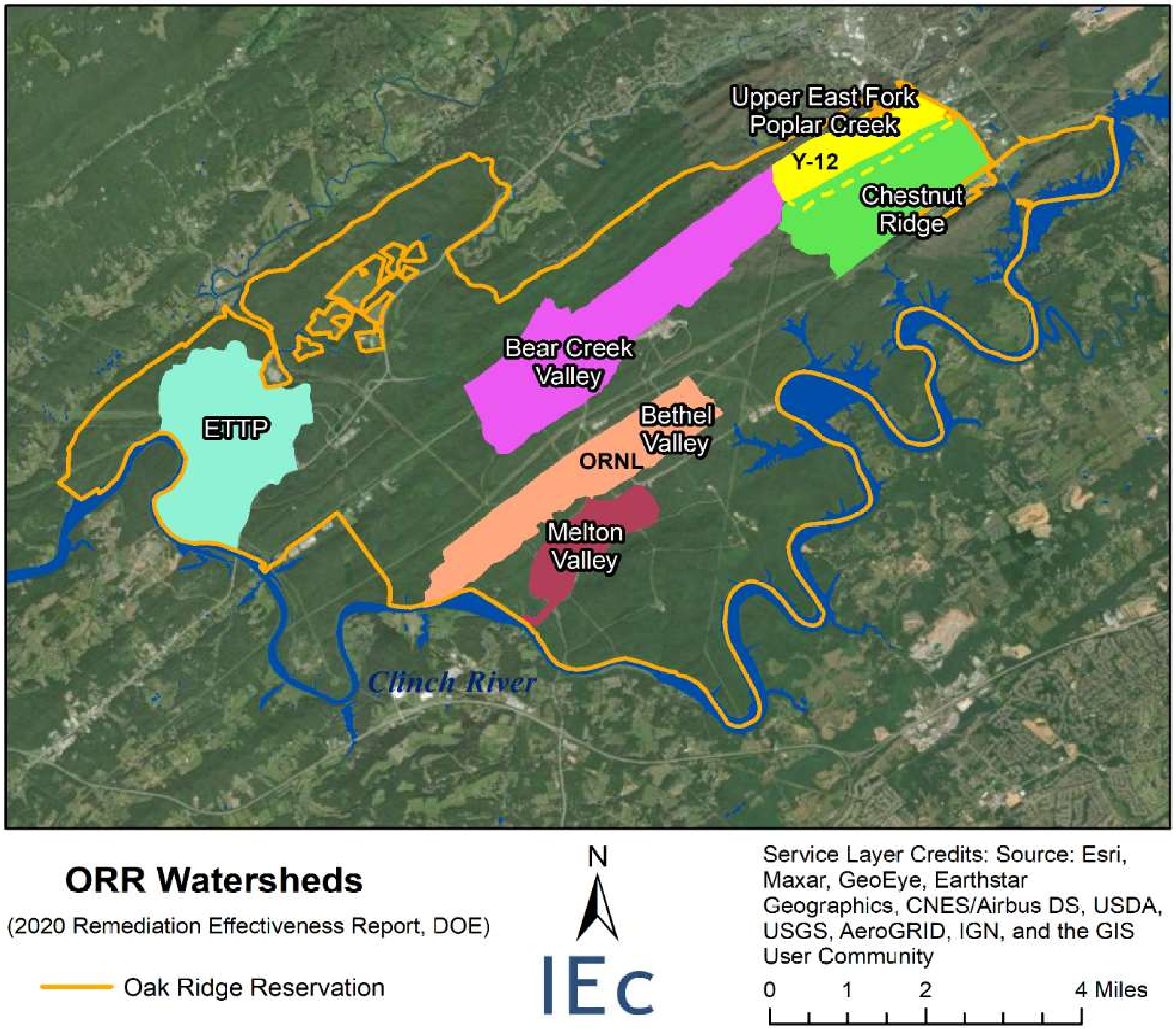
[1] The Manhattan Project was created in 1942 by the U.S. government to research and develop nuclear weapons. The ORR, along with other project sites in North America, was used to enrich uranium, conduct research, and manufacture weapon components as part of that Project.

[2] Uranium is enriched by increasing the percentage of the isotope uranium-235 in naturally mined uranium, which can then be split apart through fission to create nuclear fuel.

[3] The electromagnetic process uses large magnets to separate uranium ions in order to collect uranium-235, which can be used for fuel.

[4] Gaseous diffusion enriches uranium by using a porous barrier (a material with miniature holes) to separate lighter and heavier isotopes of uranium.

EXHIBIT 1-2. ORR WATERSHEDS



Required remedial activities are described in Records of Decision (RODs) developed by DOE, in cooperation with EPA and the State, and to-date include, but are not limited to (DOE 2020a, 2020b; EPA 2022a):

- Dredging and targeted excavations of sediments and soils. For example, 57,000 cubic yards of contaminated soil were removed from the Bear Creek Valley Watershed and placed in a landfill.
- Capping to isolate radioactive, non-radioactive and mixed (radioactive and non-radioactive) hazardous wastes. For example, at the Melton Valley Watershed, caps supplemented other activities to achieve hydraulic isolation[5] of wastes, and at the Bear Creek Valley Watershed, DOE used a cap to isolate the contaminated soil remaining after excavation.
- Building water treatment plants. For example, in the Upper East Fork Poplar Creek Watershed, a new water treatment plant at Outfall 200 is under construction to capture and treat significantly more mercury releases than is possible for the other treatment plants in the watershed (DOE 2013).
- Lowering the water table to separate contaminated soils and sediments from groundwater. For example, at a solid waste storage area in the Bethel Valley Watershed, the water table has been artificially lowered using wells to hydraulically isolate wastes.
- Creating stormwater/groundwater diversion systems to redirect and control contaminated water. For example, at the Melton Valley Watershed, a stormflow diversion trench area prevents contaminated stormwater from reaching aquifers.
- Removing contamination from storm drain basins. For example, at the Upper East Fork Poplar Creek watershed, surface water mercury discharges were almost six times the ROD goal, and along with demolition activities, resulted in a fish kill in 2018. The National Nuclear Security Administration proceeded to remove 7 – 7.5 pounds of elemental mercury from storm drain basins the same fiscal year.
- Implementing institutional controls.[6] Examples of institutional controls at ORR include dredging restrictions to prevent mobilization of residual subsurface contamination, and FCAs due to PCB and mercury contamination on East Fork Poplar Creek, the Clinch River arm of the Watts Bar Reservoir, and the Melton Hill Reservoir.

[5] Hydraulic isolation in this context means preventing water from coming into contact with contaminated soil/sediment.

[6] Institutional controls are a passive form of remedial action. They limit land or resource use and guide human behavior to minimize ecological and human health risks from exposure to residual contamination. For instance, zoning restrictions prevent land uses – such as residential uses – that are not consistent with the level of cleanup (EPA 2022a).

- Constructing on-site disposal facilities. For example, a land disposal facility constructed in the Bear Creek Valley watershed has been used to dispose of dismantled buildings, contaminated soils, and scrap metal piles. However, the facility's 2.2 million cubic yard-capacity is not enough to accommodate all wastes, and another on-site land disposal facility is planned for future waste disposal needs.

- Demolishing buildings. DOE is conducting a site-wide effort to demolish unused buildings with legacy contaminants. For example, the last remaining mega-structure at ETTP, built to test uranium enrichment capabilities, was demolished in 2020.

Although full delineation of the nature and extent of groundwater contamination is incomplete in many areas of the ORR, and no watershed-scale final groundwater decisions have been made to-date, a few groundwater remedial actions have been undertaken. For example, containment pump-and-treat systems and hydrologic isolation of wastes left in place by capping and in situ stabilization are used to prevent the spread of groundwater contamination (DOE 2020b).

In addition, activities to recover, excavate, and dispose of materials contaminated with mercury, uranium, strontium, cesium, and other contaminants are still underway at ORR (e.g., excavation of contaminated soil to protect groundwater at ETTP Watershed; DOE 2020a). Other current cleanup actions include the demolition of several buildings at Y-12 and ORNL, construction of a mercury treatment facility intended to support the demolition of mercury-contaminated buildings and subsequent soil remediation in the Upper East Fork Poplar Creek Watershed, and construction of a facility intended to process stored sludge transuranic waste[7] (DOE 2020a). In 2022, a record of decision (ROD) will be submitted to begin the construction of an on-site waste disposal facility that will receive soil and demolition/remediation debris resulting from future cleanup projects, as the original waste disposal facility is reaching its capacity (DOE & Oak Ridge Office of Environmental Management 2021).

While past and ongoing remedial actions have reduced the exposure of natural resources to ORR-related contaminants, some contaminant levels remain above ROD goals and relevant regulatory criteria (e.g., ambient water quality criteria, drinking water criteria). For example, in 2020, the following elevated levels and criteria exceedances were documented (DOE 2020b):

- Fish tissue exceeded EPA's fish-based ambient water quality criteria guidelines for polychlorinated biphenyls (PCBs), mercury, arsenic, and selenium across the ORR watersheds, and DOE reports elevated levels of cadmium, nickel, and uranium in fish.

[7] Transuranic waste is radioactive waste that contains elements heavier than uranium, resulting from nuclear fuel and weapons production.

- At the Bear Creek Valley, Chestnut Ridge, and ETTP Watersheds, groundwater exceeds maximum contaminant level (MCL)[8] for several contaminants, including uranium, volatile organic compounds (VOCs), alpha activity, chromium, and nickel (as measured in groundwater wells). At the ETTP Watershed, high VOC concentrations suggest the presence of dense nonaqueous phase liquid (DNAPL).
- At the Bear Creek Valley Watershed, creek discharges of uranium exceeded ROD goals and cadmium exceeded ambient water quality criteria.
- At the ETTP Watershed, PCBs and mercury exceeded ambient water quality standards and average radiological levels exceeded DOE Order standards in storm water outfalls.

More detail on remedial actions at ORR can be found in documents such as RODs, Remedial Investigation and Feasibility Studies (RI/FS), Remediation Effectiveness Reports and U.S. Environmental Protection Agency (EPA) Five-Year Reviews.[9]

1.5 NRDA AND RESTORATION AND THE ORR

Natural resources provide a variety of services, including ecological functions and human uses of those resources.[10] However, contaminants released from ORR have impaired the ability of natural resources to provide these services – that is, contamination has injured the resources. CERCLA, commonly known as Superfund (42 U.S.C. 9601 *et seq.*,), allows the public to be compensated for injuries to natural resources and resource services resulting from the release of hazardous substances into the environment. As natural resource trustees, Federal and state governments can act on behalf of the public to seek such compensation, or "damages," through a natural resource damage assessment (NRDA; 43 CFR § 11; Section 1.3).

WHAT IS INJURY?

In NRDA, injury refers to a decrease in a resource's ability to provide services due to contamination. Examples include, but are not limited to:

- Lower nesting success in birds,
- Groundwater exceeding drinking water contaminant thresholds,
- Wetlands unable to support vegetation and biota, and
- Decreased quality of fishing experience due to consumption advisories.

WHAT ARE DAMAGES?

In NRDA, damages refer to the amount of money needed to restore resources to their baseline condition (i.e., condition without contamination). Trustees seek these monies from parties responsible for contamination.

The goal of NRDA is to restore, rehabilitate, replace, and/or acquire the equivalent of (together referred to as restoration in this document) those natural resources injured by the release of hazardous substances (43 CFR § 11.82(b)). Restoration is achieved when: 1) the injured natural resources and the services they provide are returned to their baseline condition (i.e., the condition of the resource that would have existed had the release of the hazardous substance not occurred [43 CFR § 11.14(e)]), and 2) additional resource services have been created to compensate for losses incurred until that baseline is reached.

[8] MCLs are the maximum level of contamination allowed in drinking water. These are enforceable standards (EPA 2022c).

[9] To locate remediation documents and to request a specific document, please contact the DOE Information Center: https://www.energy.gov/orem/services/community-engagement/doe-information-center

[10] Services are defined as "the physical and biological functions performed by the resource, including the human uses of those functions, [that result from the resource's] physical, chemical, or biological quality" (43 CFR § 11.14(nn)).

Recently the Trustees agreed upon a Trustee Council Resolution directing the State of Tennessee and DOE to enter into an Agreement in Principle (AIP) that $42 million is an amount sufficient to settle DOE's liability for the second phase of natural resource damages at the ORR. Approximately half of the total settlement amount would be funded through repurposing a perpetual care fund for the Environmental Management Waste Management Facility (EMWMF), the existing CERCLA landfill at the ORR. The EMWMF perpetual care fund was originally created to allow the State of Tennessee to perform limited post-closure operation and maintenance activities at the EMWMF. As a condition of the State of Tennessee repurposing the EMWMF perpetual care fund, DOE agrees to reassume full responsibility for all post-closure operation and maintenance obligations for the facility. The remainder of the $42 million settlement amount would be paid by DOE over a period not to exceed seven years. The AIP provides that the Trustees will oversee use of the settlement amount to select and fund projects described in this RCDP/EA.

1.6 RELATIONSHIP TO REMEDIAL ACTIVITIES

NRDA is a process that occurs *in addition* to the remedial process conducted by regulatory agencies like DOE and EPA. These two processes have different goals. Remedial action objectives are risk-based, and are developed to protect human health and the environment from further unacceptable harm. Remedies are selected based on evaluation criteria that are used to compare remedial alternatives and may result in contamination remaining in the environment above levels that existed prior to its release. In contrast, the goal of NRDA is to restore injured resources to their baseline condition. Losses resulting from natural resource exposure to hazardous substances are estimated over time, including both past losses and, if post-remedy contaminant concentrations remain at levels sufficient to cause injury to natural resources, future losses.

There are components of NRDA and remedy however that overlap. For example, restoration must account for remedial responses that are underway or planned. That is, the extent to which remediation returns natural resources and the services they provide to their baseline condition should be considered in the NRDA process. Work to remedy a site may partially or completely restore injured natural resources, potentially resulting in injuries that persist in the future once remedial activities are complete, and NRDAs take this into account. In addition, remedial actions may cause "collateral injury" to habitat (e.g., physical disturbance or destruction of habitat), and assessment and restoration of this remedy-induced injury is also evaluated within NRDA.[11]

[11] Injuries from remedial actions are distinct from impacts associated with actions that are permitted and/or that have been reviewed through a non-NRDA regulatory process (e.g., Clean Water Act) and have separate mitigation requirements or allowances for environmental impacts.

1.7 THE NATIONAL ENVIRONMENTAL POLICY ACT

Actions undertaken by federal Trustees to restore natural resources or services under CERCLA are subject to the National Environmental Policy Act (42 U.S.C. § 4321, et seq.) and the regulations guiding its implementation (40 CFR Part 1500). NEPA sets forth a process of environmental impact analysis, documentation, and public review for federal actions, including restoration actions. Specifically, NEPA provides a mandate and a framework for federal agencies to consider all reasonably foreseeable environmental effects of their proposed actions and to inform and involve the public in their decision-making process.

In general, federal agencies proposing a major federal action must develop an environmental impact statement (EIS) if the action is expected to have significant impacts on the quality of the human environment. When it is uncertain whether a contemplated action is likely to have significant impacts, federal agencies prepare an environmental assessment (EA) to evaluate whether an action would have significant impacts and therefore necessitate an EIS. If the EA demonstrates that the proposed action will not significantly impact the quality of the human environment, the federal agencies issue a Finding of No Significant Impact (FONSI), which satisfies the requirements of NEPA, and no EIS is required. If a FONSI cannot be made, then an EIS is required.

The consideration of NEPA requirements in the context of the Trustees' identified restoration alternatives for the ORR NRDA is described in Chapter 5.

1.8 COMPLIANCE WITH OTHER AUTHORITIES

Coordination and evaluation of required compliance with specific Federal acts, executive orders, and other policies for the preferred restoration alternative is achieved, in part, through the coordination of this document with appropriate agencies and the public. All restoration alternatives described in this document will be conducted in compliance with NEPA, as well as all other applicable Federal, state, and local regulations, including the Endangered Species Act (ESA), 16 USC 1531, *et seq*.; the Migratory Bird Treaty Act, Title 50 Part 10.13; the Bald and Golden Eagle Protection Act, 16 USC 668-668c; the National Historic Preservation Act of 1966, 16 USC Section 470 *et seq*.; the Fish and Wildlife Coordination Act, 16 USC Section 661 *et seq*.; the Rivers and Harbors Act of 1899, 33 USC Section 403 *et seq*.; the Federal Water Pollution Control Act, 33 USC Section 1251 *et seq*.; Executive Order 11990, Protection of Wetlands; Executive Order 11988, Floodplain Management; the Tennessee Water Quality Control Act, Tenn. Code Ann. Section 69-3-101 *et seq*.; the Tennessee Solid Waste Disposal Act, Tenn. Code Ann. Section 68-211-101 *et seq*.; and the Tennessee Hazardous Waste Disposal Act, Tenn. Code Ann. Section 68-212-201 *et seq*. Compliance with the laws cited above, and any necessary permitting, will be undertaken during specific restoration project planning stages.

1.9 PUBLIC PARTICIPATION

Public participation and review are an integral part of the restoration planning process and are specifically mentioned in the DOI NRDA regulations (e.g., 43 CFR § 11.81(d)(2)). To facilitate public involvement in the planning process for ecological, groundwater, and recreation restoration, the Trustees encouraged the public to review and comment on the Draft RCDP/EA. The review period was from August 15 through October 12, 2022. The Trustees also held a public meeting on August 31 in Oak Ridge to present the RCDP/EA and provide another forum for the public to ask questions and provide comments. Responses to all public comments received during the public meeting and submitted in writing during the public comment period are provided in Appendix C, including additional information supporting the injury assessment, damage determination, and settlement in Appendix D.

Copies of this document are available from the DOE Information Center. The DOE Information Center can be accessed in person from 8 a.m. to 5 p.m. Monday through Friday at:

Building 1916-T1
1 Science Gov Way
Oak Ridge, TN 37831

Or contacted online at DOEIC@science.doe.gov

1.10 ADMINISTRATIVE RECORD

An administrative record, that is, a catalog of all documents the Trustees used to develop and make decisions related to the NRDA for this Site, including this RCDP/EA, is maintained by the Trustees, and is available at the DOE Information Center. The DOE Information Center can be accessed in person from 8 a.m. to 5 p.m. Monday through Friday at:

Building 1916-T1
1 Science Gov Way
Oak Ridge, TN 37831

Or contacted online at DOEIC@science.doe.gov

1.11 ORGANIZATION OF THE RCDP/EA

The remainder of this document is organized as follows:

- Chapter 2 describes the affected environment, including groundwater, habitat types, and aquatic and terrestrial species, as well as socioeconomic resources, cultural and historic resources, and climate change.
- Chapter 3 presents the geographic scope, contaminants of concern and pathway, baseline, and the injuries that have occurred to natural resources and resources services as a result of Site-related contamination.
- Chapter 4 provides descriptions of the proposed restoration alternatives and the types of projects that would be implemented to compensate for the injuries described in Chapter 3.
- Chapter 5 presents the Trustees' evaluation criteria and the assessment of environmental consequences for each of the restoration alternatives described in Chapter 4, concluding with the selection of their preferred alternative.

CHAPTER 2 | AFFECTED ENVIRONMENT

In order to both assess the impacts of contamination on natural resources in the ORR and determine priorities for future restoration actions, the Trustees needed to understand the various characteristics of the affected environment. Therefore, this chapter describes the physical and biological environments that are found in and around the ORR, the socioeconomic, cultural, and historic resources in the area, and the expected influence of climate change on the overall landscape.

2.1 PHYSICAL ENVIRONMENT

Situated in the Great Valley of East Tennessee between the Cumberland and Great Smoky Mountains, ORR currently encompasses approximately 32,260 acres of mostly contiguous, federally owned land in Anderson and Roane Counties. It is bordered by the Clinch River to the south and west and the City of Oak Ridge to the north and east (Exhibit 1-1). The Oak Ridge area is characterized by five ridges (and four valleys) that run parallel to one another in a northeast-to-southwest direction. From west-to-east, the five ridges are Black Oak Ridge, East Fork Ridge, Pine Ridge, Chestnut Ridge, and Haw Ridge (partially shown in Exhibit 3-1). Classified as a humid subtropical climate regime, the ORR experiences temperatures ranging from an average of ~38 degrees Fahrenheit (F) in winter to an average of ~78 degrees F in summer, and gets an average of 56 inches of precipitation per year (DOE 2021).[12] Below we provide more details on the surface waterbodies, groundwater, and land use associated with the ORR.

2.1.1 SURFACE WATERBODIES

The primary waterbodies within the ORR assessment area include the Clinch River and tributaries within multiple drainage basins (Exhibit 1-2). The watershed contains Poplar Creek, which flows southwest through the center of ETTP. East Fork Poplar Creek originates within the Y-12 Complex and discharges into Poplar Creek east of ETTP. White Oak Creek begins on Chestnut Ridge, flowing east and then southwesterly to the western portion of Melton Valley to form a confluence with Melton Branch. White

[12] Temperatures are the 30 year average reported in DOE (2021).

Oak Creek enters White Oak Lake, an impoundment formed by the White Oak Dam. All of these streams eventually discharge to the Clinch River, which flows south along the southern border of the ORR before joining the Tennessee River near Kingston, TN (Exhibit 1-1). Because water levels in the Clinch River are regulated by TVA, fluctuations in the river can affect some streams draining the ORR at their confluence with the Clinch River. However, most of the ORR is located above the probable maximum flood elevation along the Clinch River (Parr and Hughes 2006).

2.1.2 GROUNDWATER

Located within aquifers[13] in the subsurface, groundwater is water in the cracks and spaces within underground rock and soils. Groundwater hydrology and the associated geology at ORR are highly variable and complex. Local hydrologic conditions are classified into two broad hydrologic units, the Knox Aquifer, which consists of highly permeable[14] limestone, and the ORR aquitards[15] which consist of less permeable sediment (Parr and Hughes 2006). Characterized by sinkholes and caverns, the Knox Aquifer generates multiple springs and seeps (groundwater appearing at the ground surface) within the ORR. It is the primary source of groundwater for many streams and is considered an important regional water resource (Parr & Hughes 2006; DOE 2021).

Groundwater on ORR occurs both in a shallow, unsaturated[16] zone and within a deeper saturated zone[17] (Parr and Hughes 2006). Groundwater flow is affected by topography, surface cover, geologic structure, karst features[18], and rock type. For example, minimal groundwater flow occurs between approximately 50 to 100 feet underground, and more substantial, active groundwater flow can occur at substantial depths (300 to 400 ft). Flow paths in these active flow zones are relatively short, with the majority of groundwater discharging to local surface water drainages, including East Fork Poplar Creek, Poplar Creek, White Oak Creek and Lake, and the Clinch River (Parr & Hughes 2006; DOE 2021).

2.1.3 LAND USE

Land use throughout ORR is dominated by DOE's three major facilities - ETTP, ORNL, and the Oak Ridge Y-12 Plant - and the Oak Ridge National Environmental Research Park that protects the natural environment. With the exception of the City of Oak Ridge, which supports a 14,000-acre urban center, the land within five miles of the reservation is semirural and primarily used for residences, small farms, and cattle pasture. In this area, fishing, hunting, boating, water skiing, and swimming are all popular recreation activities (DOE 2020).

[13] An aquifer stores large volumes of groundwater in the subsurface.

[14] Permeability relates to the extent that water can pass through spaces in rocks and sediments.

[15] An aquitard is an underground area where little or no water can flow through.

[16] When an aquifer is unsaturated, pore spaces in rocks and sediments are not completely full of water. Conversely, saturation indicates that pore spaces in rocks and sediments are completely filled with water.

[17] Adjacent to surface water features or in valley floors the water table is found at shallow depths and the unsaturated zone is thin, while along ridge tops or topographic highs, the unsaturated zone is thick and the water table lies at considerable depth (Parr and Hughes 2006).

[18] Karst is a landscape that contains substantial limestone, which can be eroded, producing landforms such as fissures, ridges, and sinkholes.

Considering information about land use in ORR enables the Trustees to assess the conservation landscape, anthropogenic pressures, and the manner in which lands are used, all of which may affect the benefits expected from planned restoration. For example, land in and around the City of Oak Ridge is likely to be less available for restoration and more expensive to purchase than land farther from the City. Environmental quality in the area is expected to become increasingly degraded in concert with continuing urbanization and agricultural use, which can lead to increases in non-point source pollution from agricultural and urban runoff, industrial and municipal wastewater treatment plant discharges, stream channelization, dams, construction site erosion, and overall degradation of adjacent habitats.

2.2 BIOLOGICAL ENVIRONMENT

The biological environment within the ORR contains a diversity of wildlife including, but not limited to, invertebrates, reptiles and amphibians, fish, birds, and mammals. This wildlife uses a diversity of habitats within the ORR ranging from riparian corridors to forests and managed grasslands. Some species are of particular concern to the Trustees due to their threatened or endangered conservation status, their status as neo-tropical migratory birds, or because they are economically important. This section describes the biological environment within the affected area, with particular attention to the habitats and the species they support.

2.2.1 AQUATIC HABITAT AND ASSOCIATED SPECIES

Riverine, wetland, and floodplain systems of the Clinch River and its tributaries on the ORR comprise the aquatic habitat upon which many species depend. This includes about 600 acres of wetlands at low elevations that are classified as forested palustrine,[19] scrub/shrub, and emergent wetlands, primarily in riparian zones and in Clinch River embayments. The characteristic ridge and valley topography of the ORR naturally aligns streams and rivers roughly parallel along valley floors, with tributaries creating a trellis drainage pattern.[20] Smaller streams often contain limestone rubble, bedrock riffles, and silty, sand pool areas, whereas larger streams form extensive sand and gravel shoal areas, all of which are beneficial to aquatic species (Bilgili et al. 1996). Streams also contain a layer of sediment, which supports both vegetation and small invertebrates. The invertebrates are a vital source of food for fish living within the aquatic habitat. The fish themselves are then food for piscivorous (i.e., fish-eating) birds and mammals that are dependent on streams, wetlands, and floodplains for food and shelter. Examples of aquatic-dependent species found at ORR are presented in Exhibit 2-1.

[19] A palustrine wetland is a freshwater, inland wetland.

[20] A trellis drainage pattern refers to minor tributaries draining ridge slopes at a right angle, resulting in an almost rectangular drainage pattern.

EXHIBIT 2-1. EXAMPLES OF AQUATIC-DEPENDENT SPECIES AT ORR (UT-BATTELLE 2009, 2011A, 2011B, 2017A, 2017B, 2017C)

SPECIES TYPE	COMMON NAME	SCIENTIFIC NAME
Fish	White Bass	*Morone chrysops*
	Rock Bass	*Ambloplites rupestris*
	Striped Bass	*Morone saxatilis*
	Largemouth Bass	*Morone salmoides*
	Smallmouth Bass	*Micropterus dolomieu*
	Redbreast Sunfish	*Lepomis auritus*
	Redear Sunfish	*Lepomis microlophus*
	White Crappie	*Pomoxis annularis*
	Yellow Perch	*Perca flavescens*
	Banded Sculpin	*Cottus carolinae*
Reptiles and Amphibians	Common Map Turtle	*Graptemys geographica*
	Spotted Salamander	*Ambystoma maculatum*
	Northern Water Snake	*Nerodia sipedon*
Piscivorous Birds	Pied-billed Grebe	*Podilymbus podiceps*
	Great Blue Heron	*Ardea herodias*
	Great Egret	*Ardea alba*
	Belted Kingfisher	*Megaceryle alcyon*
Piscivorous Mammals	Raccoon	*Procyon lotor*
	Mink	*Mustela vison*
	Northern River Otter	*Lontra canadensis*

2.2.2 TERRESTRIAL HABITAT AND ASSOCIATED SPECIES

Terrestrial habitat at ORR is composed of the upland environment along and between the ridges crossing the site. The majority (approximately 70 percent) of ORR is forested habitat, consisting mostly of mature eastern deciduous forests comprised of oak-hickory, pine-hardwood, and pine plantations (Exhibit 2-2; Carter et al. 2019). Other forest habitats at ORR include northern hardwoods, eastern red cedar, hemlock, white pine, and floodplain forests (Carter et al. 2019). Managed native grasslands, forest edge, shrubland, riparian and floodplain forests, perennial and ephemeral wetlands, and unique habitats such as sphagnum bogs and cedar barrens[21] provide a diversity of habitat for wildlife species, including those that are endangered, threatened, or of importance to the State. The ORR is also botanically diverse, with over 1,1000 vascular plant species documented in the area (Parr and Hughes 2006).

The diverse terrestrial habitats of the ORR sustain a wide variety of invertebrates (e.g., earthworms, spiders). In turn, these invertebrates are food for a range of other upland species, including reptiles, amphibians, birds, and mammals. Examples of these species are presented in Exhibit 2-3.

[21] Cedar barrens are a rare ecosystem found in ORR that are characterized by a thin layer of soil overlying limestone, home to endemic species that depend on this habitat.

EXHIBIT 2-2. TERRESTRIAL HABITAT TYPES AT ORR (CARTER ET AL. 2019)

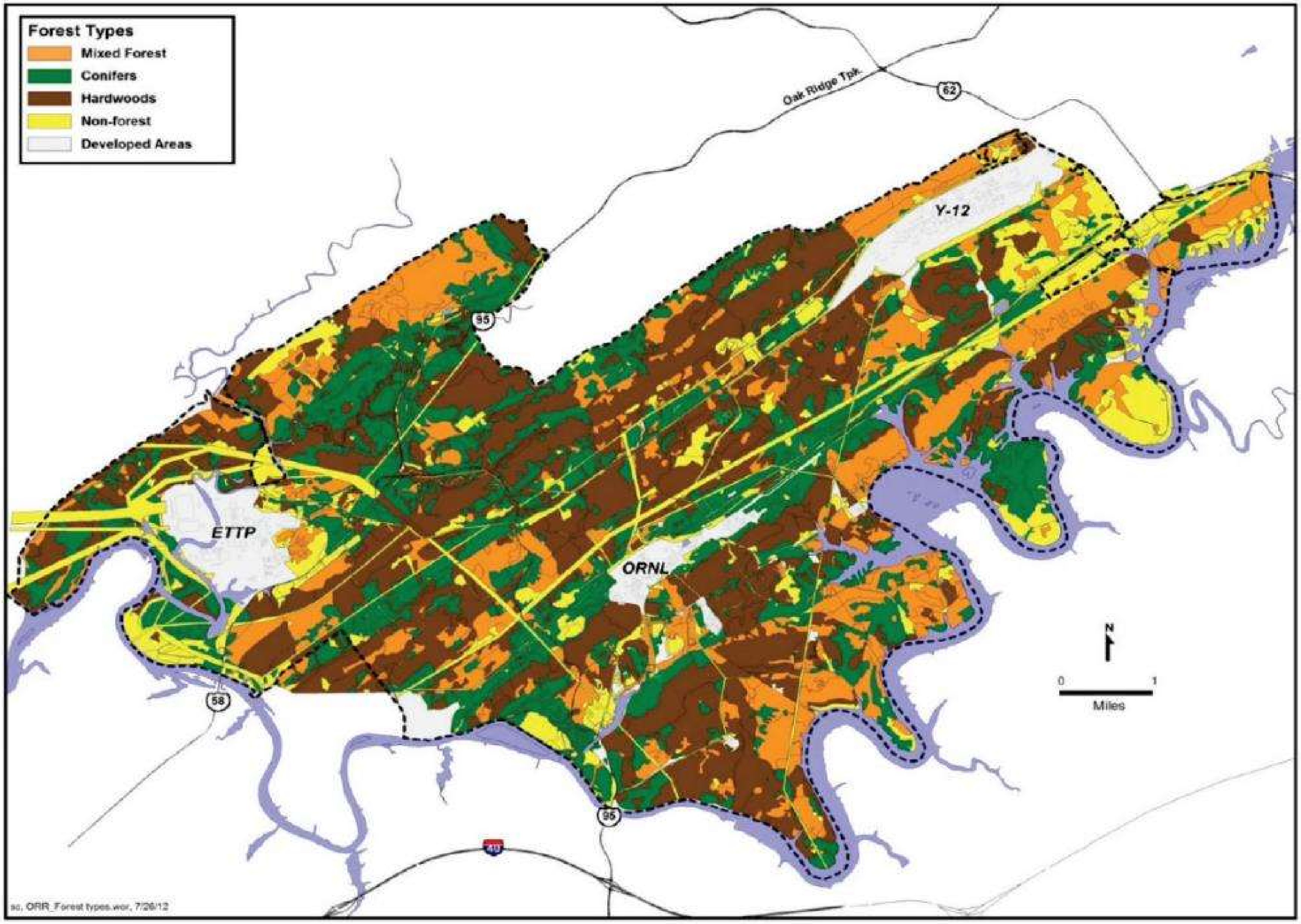


EXHIBIT 2-3. EXAMPLES OF TERRESTRIAL SPECIES AT ORR (UT-BATTELLE 2009, 2011A, 2011B, 2017A, 2017B, 2017C)

SPECIES TYPE	COMMON NAME	SCIENTIFIC NAME
Reptiles	Corn Snake	*Pantherophis guttatus guttatus*
	Marbled Salamander	*Ambystoma opacum*
Passerine Birds	Carolina Wren	*Thryothorus ludovicianus*
	Barn Swallow	*Hirundo rustica*
	Tufted Titmouse	*Baeolophus bicolor*
Raptors	Turkey Vulture	*Cathartes aura*
	Cooper's Hawk	*Accipiter cooperii*
	Peregrine Falcon	*Falco peregrinus*
	Barn Owl	*Tyto alba*
	Eastern Screech-owl	*Megascops asio*
Small Mammals	Northern Short-tailed Shrew	*Blarina brevicauda*
	Eastern Red Bat	*Lasiurus borealis*
	Meadow Vole	*Microtus pennsylvanicus*
Large Mammals	White-tailed Deer	*Odocoileus virginianus*
	Coyote	*Canis latrans*

2.2.3 THREATENED, ENDANGERED, AND SPECIES OF SPECIAL CONCERN

Certain wildlife species found within the ORR have been adversely impacted by regional environmental stressors (e.g., habitat degradation) to an extent that their long-term viability is uncertain. Many of these species are protected by federal and/or state legislation and are classified as threatened or endangered species. Rare species, species of concern, and small areas of high-quality natural communities have been documented within the ORR, associated streams, and the adjacent Clinch River. Examples of these species are presented in Exhibit 2-4.

EXHIBIT 2-4. EXAMPLES OF THREATENED, ENDANGERED, AND SPECIES OF SPECIAL CONCERN AT ORR (DOE 2021, PARR & HUGHES 2006)

SPECIES TYPE	COMMON NAME	SCIENTIFIC NAME
Fish	Tennessee Dace	*Phoxinus tennesseensis*
Reptiles and Amphibians	Hellbender	*Crytobranchus alleganiensis*
	Four-toed Salamander	*Hemidactylium scutatum*
Birds	Bald Eagle	*Haliaeetus leucocephalus*
	Little Blue Heron	*Egretta caerulea*
	Ring-necked Duck	*Aythya collaris*
	Golden-winged Warbler	*Vermivora chrysoptera*
Mammals	Long-tailed Shrew	*Sorex dispar*
	Gray Bat	*Myotis grisescens*
	Little Brown Bat	*Myotis lucifugus*
	Indiana Bat	*Myotis sodalist*
	Northern Long-eared Bat	*Myotis septentrionalis*
	Eastern Small-footed Bat	*Myotis leibii*
	Tri-colored Bat	*Perimyotis subflavus*
	Rafinesque's Big-eared Bat	*Corynorhinus rafinesquii*

2.3 SOCIOECONOMIC RESOURCES

ORR is located within Roane and Anderson Counties, about 25 miles west of Knoxville, TN. Roane and Anderson counties are included in the Knoxville Metropolitan Area, with populations of approximately 54,000 and 77,600, respectively (U.S. Census 2021).

In terms of land use, the majority of the land around ORR is classified as semirural (DOE 2021). Residences are both dispersed throughout the counties and concentrated in urban areas, such as Kingston, Rockwood, Harriman, Oak Ridge, Oliver Springs, Clinton, and Andersonville. Large swaths of land in Roane and Anderson Counties are designated for agriculture and timber production, and several plots of land within both counties are also designated for commercial and public use, such as Oak Ridge National Environmental Research Park and federal, state and local recreation areas. Several smaller tracts of land are designated for industrial use (Tennessee Comptroller of the Treasury 2022).

The four main employment industries in Roane and Anderson Counties are health care and social assistance; manufacturing; retail trade; and professional, scientific, and technical service occupations. The top production and exported goods are electronics, motorized vehicles, and pharmaceuticals.

Over the last six years, employment in the manufacturing and professional/scientific/technical services increased by ~100 and ~500 people, respectively (Data USA 2022). With around 4,400 workers, the ORNL facility remains a large employer in this field and within the community (DOE 2021).

2.4 CULTURAL AND HISTORIC RESOURCES

The first inhabitants in the ORR area were Native Americans that had occupied the area for at least 10,000 years and whose descendants, the Cherokee, Shawnee and Creek, inhabited the area when European settlers arrived in the late 1700s. Early European settlers founded four small communities named Elza, Robertsville, Wheat, and Scarborough and by the early 1940s, a thousand families inhabited the area. These families were forced to sell their homes and lands to the government in 1942, which subsequently designated the area as part of the Manhattan Project.

Rich prehistoric and historic cultural resources remain from the area's diverse settlers. Archaeological studies have identified more than 44 known prehistoric sites through evidence of former structures and artefacts, such as burial mounds, ceramics, knives, and arrowheads. ORR also contains 254 historic pre-World War II structures (e.g., cabins, log barns), 32 cemeteries, and several historically significant structures from the Manhattan Project era (Fielder 1974; DOE 2021). The National Defense Authorization Act of 2015 established one of three units of the Manhattan Project National Historical Park at Oak Ridge. Facilities and lands in the towns of Los Alamos, New Mexico, and Hanford, Washington comprise the other two units. The ORR section of the National Park includes the X-10 Graphite Reactor, Buildings 9731 and 9204-3 at the Y-12 Complex, and the K-25 Building Site at ETTP. DOE worked to create safe access to the site of the former K-25 Building, which was opened to the public in 2020. An online exhibit detailing the history of the building can be viewed here: http://www.k-25virtualmuseum.org/ (DOE 2021).

2.5 CLIMATE CHANGE

Although predicting the impacts of climate change is an inherently complex task, some climate-induced changes have already manifested in Tennessee and are likely to continue. For example, average rainfall and average temperatures have increased in the last five decades, with ORR warming by 2 degrees Fahrenheit since the 1970s (EPA 2016; DOE 2021). Climate models for Tennessee predict a five-degree Fahrenheit increase with lower emissions and a 10-degree Fahrenheit increase with higher emissions in Tennessee by 2100 (Runkle et al. 2022). More frequent floods resulting from greater precipitation, coupled with longer droughts due to increased temperatures will result in lower dissolved oxygen in surface water, threatening the health of aquatic ecosystems (EPA 2016). Of particular concern is the effect of precipitation and temperature fluctuations on at-risk biological resources in niche riparian and aquatic habitats. Altered climate conditions could also affect flow regimes, cause fluctuations in species compositions, and reduce habitat sustainability (e.g., if habitats cannot migrate or adapt to new climate conditions).

The Trustees will consider climate change impacts when developing future restoration projects. In this context, the Trustees will evaluate the capacity of an ecosystem to respond to a disturbance or deviation from typical conditions by resisting damage and recovering quickly. For example, each habitat type (e.g., wetland, riverine, floodplain) best succeeds under a specific set of environmental parameters. These include, but are not limited to, precipitation, air temperature, and flooding regime. The organisms that rely on these habitats also have preferred conditions, with some species, such as those that are threatened or endangered, able to succeed only under a narrow range of environmental characteristics. To increase the resiliency against climate change of the NRDA restoration program, the Trustees will consider factors such as location, project scope, the characteristics of adjacent areas, proximity to surface water, and affected habitats and species within the ORR.

As a result of releases of hazardous substances from ORR facilities and operations, natural resources have been exposed to metals, organic contaminants, and radionuclides at levels sufficient to cause adverse effects and reduce the level of services these resources would otherwise be expected to provide. This chapter describes the geographic scope of the assessment, contaminants of concern and relevant environmental pathways, baseline conditions, natural resource injury, and losses of ecological, recreational, and groundwater resource services as defined in the DOI NRDA regulations (43 CFR § 11.62).

3.1 ASSESSMENT AREA

The release of contaminants at ORR affected a broad area of complex hydrology and diverse aquatic and terrestrial habitat. A key component in the determination of natural resource injuries is the assessment area, which is based on the geographic scope within which trust resources have been directly or indirectly affected by the release of contaminants. The geographic scope of the ORR assessment area includes the terrestrial habitat within the ORR, the aquatic habitat of the adjacent Clinch River, the floodplain and aquatic habitat of several Clinch River tributaries, and the groundwater beneath and flowing off-site from ORR, all of which have been exposed to hazardous wastes released from ORR facilities (Exhibit 3-1):

- **Clinch River** from the DOE Elza Gate site downstream to the confluence with the Tennessee River - approximately 6,500 acres of riverine habitat and 1,400 acres of floodplain habitat along 51 river miles (U.S. Army Corps of Engineers 2022) (Exhibit 1-1; Exhibit 3-1).
- **Clinch River tributaries**, including East Fork Poplar Creek, Poplar Creek, White Oak Creek, White Oak Lake and other small streams and waterbodies within ORR. Together these tributaries support approximately 430 acres of riverine habitat and 510 acres of floodplain habitat (Exhibit 3-1).

- **ORR terrestrial habitat** within four inter-ridge areas across ORR (approximately 23,000 acres): Black Oak Ridge to Pine Ridge, Pine Ridge to Chestnut Ridge, Chestnut Ridge to Haw Ridge, and Haw Ridge to Copper Ridge (Exhibit 3-1).[22] Note that there are two additional inter-ridge areas: Walden to Black Oak Ridge on the northwestern side of ORR and Copper Ridge to Beaver Ridge on the southeastern side (Exhibit 3-1). Because there are no direct sources of contamination in these two inter-ridge areas, and soil sampling does not indicate elevated concentrations of contaminants, it is reasonable to conclude that injury to natural resources in these areas is unlikely and therefore was not a focus of the assessment.
- **ORR and Off-site groundwater,** including the Knox aquifer and aquitard hydrogeologic environments beneath ORR that have been affected by ORR contamination (i.e., contaminant plumes), and contaminated groundwater moving offsite near the Y-12 complex, ETTP, and Melton and Bethel Valleys (Exhibit 3-2).

3.2 CONTAMINANTS OF CONCERN

The contaminants of concern (COCs) in the assessment area are those hazardous substances (as defined by Section 101(14) of CERCLA) to which natural resources have been exposed as a result of releases from ORR. These include organic (e.g., synthetic carbon-based chemicals), inorganic (e.g., metals), and radionuclide contaminants. The Trustees identified PCBs, cadmium, chromium, mercury, and radionuclides (cesium-137, strontium-90, uranium-235, and uranium-238) as the primary COCs in the assessment area:

- **PCBs** are a class of compounds consisting of 209 chlorinated hydrocarbon chemicals (individually known as PCB congeners). The chemical structure of PCBs also allows these compounds to accumulate in the fatty tissues of organisms and bioaccumulate[23] and biomagnify[24] through food webs. In organisms, PCBs can cause a range of adverse health effects, including liver and dermal toxicity, developmental and other reproductive effects, and neurological effects (Eisler 2000).
- **Cadmium** is a heavy metal that is neither biologically essential nor beneficial. The element is found to build up in tissue, bioaccumulating in exposed organisms. Cadmium is most dangerous when absorbed orally or inhaled and can cause a range of adverse health effects in organisms such as cancer, developmental delay, immunological issues, systemic effects, and death (ATSDR 2012).
- **Chromium** exists in various oxidation states[25], with hexavalent chromium being the most toxic. While not believed to bioaccumulate or biomagnify, chromium still causes a wide variety of health effects in animals when they are exposed through ingestion, inhalation, or dermal contact. These effects include cancer, developmental delay, immunological issues, systemic effects, and death (ATSDR 2012).

---

[22] The calculated area of the terrestrial habitat does not include the Y-12, ORNL, or ETTP facilities, since the facilities do not provide ecological services.

[23] Bioaccumulation is the build-up of contaminants in an organism's tissue.

[24] Biomagnification is the increase of contaminants in organisms as a result of consumption of contaminated food.

[25] An oxidation state refers to the charge of an atom.

EXHIBIT 3-1. ORR AQUATIC AND TERRESTRIAL HABITAT

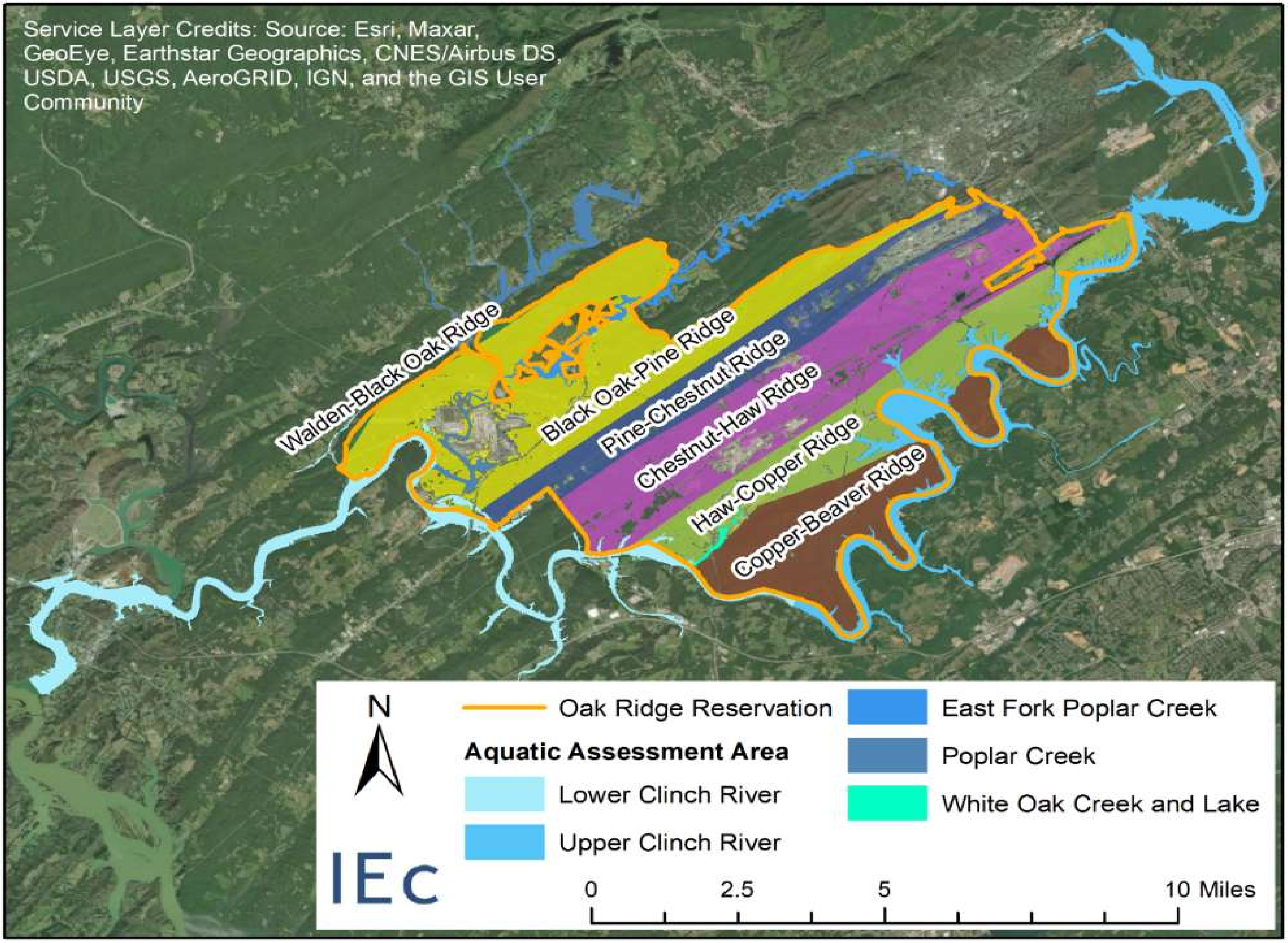
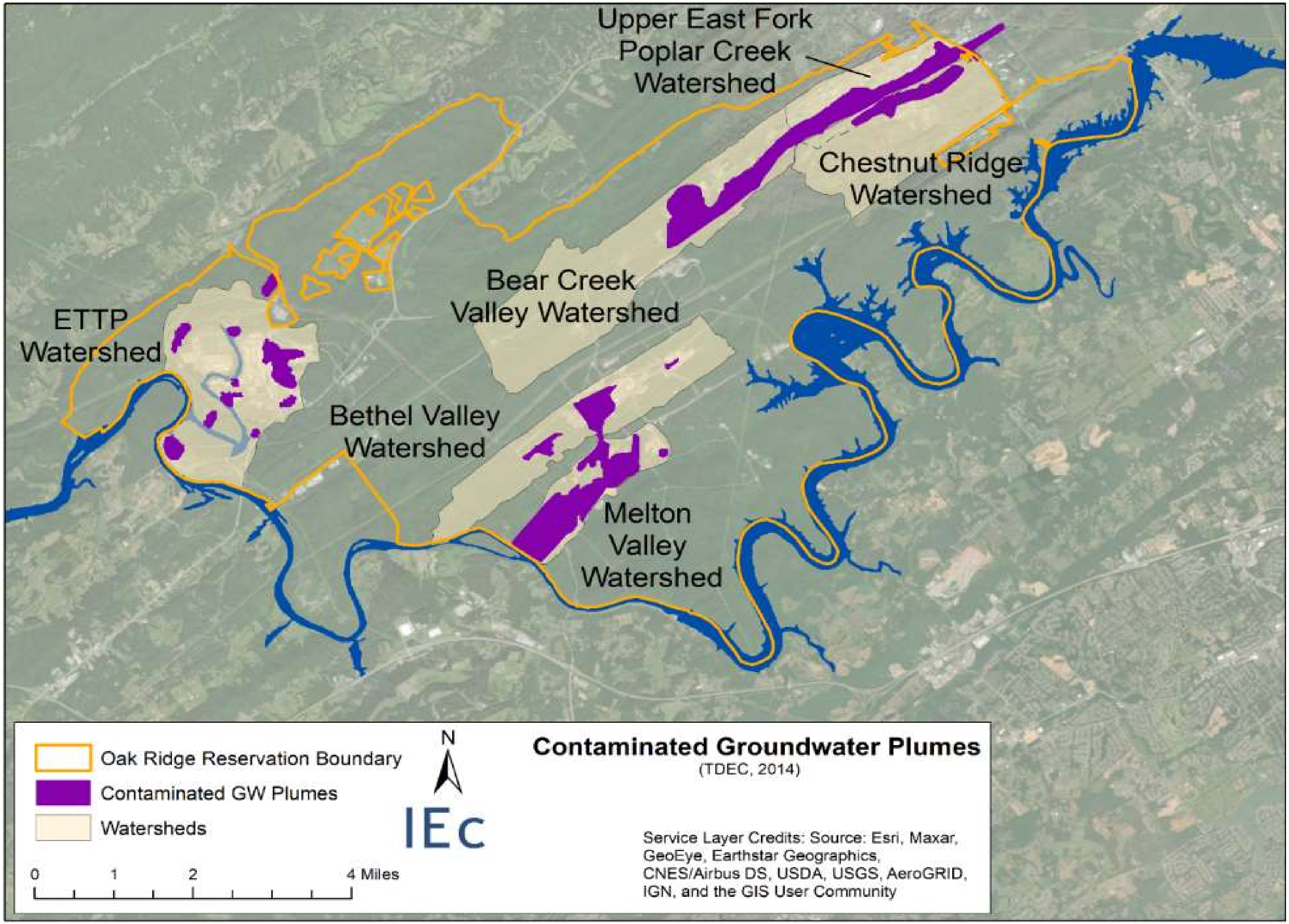


EXHIBIT 3-2. ORR GROUNDWATER PLUMES



- **Mercury** does not serve any biological function and is universally toxic in sufficient concentrations. Mercury can also bioaccumulate and biomagnify through food webs, affecting higher trophic level organisms. Even at low concentrations mercury can cause adverse impacts to reproduction, growth, development, behavior, neurological systems, blood chemistry, vision, and metabolism, and at high concentrations is lethal (Eisler 2000).
- **Radionuclides** are radioactive forms of elements that emit radiation and can be inhaled, ingested, or taken up via external exposure. Of the radionuclides that are the focus of this assessment, all bioaccumulate, but only Cesium-137 biomagnifies though food webs. Radionuclides can cause developmental effects, genetic mutations, and cancers in nearly any tissue or organ, with the probability of cancer increasing with increasing radiation dose. Laboratory animal research has shown that cancer induction is generally a delayed response (ATSDR 2004; EPA 2022b).

These contaminants are persistent in the environment (i.e., do not readily degrade), site-specific concentration data and relevant effects literature are readily available, and elevated concentrations have been measured throughout the assessment area. While other contaminants such as halocarbon solvents, tritium, and other metals including arsenic, lead, nickel, and zinc were also released from ORR operations, data are insufficient to assess injury resulting from natural resource exposure to these contaminants. In addition, it is expected that restoration actions will address any potential injuries resulting from these contaminants (e.g., ecological losses are assessed by individual resource but proposed restoration actions are focused on habitat metrics).

The toxicological implications of natural resource exposure to multiple contaminants are extremely complex. Interactions between various contaminants in abiotic media depend on environmental parameters such as organic carbon, pH, and alkalinity, and can vary over time and geographic area. In organisms, the toxicity of contaminant mixtures is affected by parameters such as species, life stage, and nutritional status. The COCs at ORR, however, all have different modes of toxic action and interact with natural resources in unique ways. For example, PCBs disrupt the endocrine system while mercury is a neurotoxin. Therefore, this analysis assumes that the toxicity caused by the COCs is additive and/or synergistic.

3.3 BASELINE

In order to measure injuries, and therefore determine damages and restoration activities, the baseline conditions (i.e., physical, chemical, and biological conditions) of the affected resources and associated services must be established. Baseline conditions include all environmental parameters, not only concentrations of the contaminants. Therefore, baseline at ORR is the condition of the site with the physical infrastructure and other changes resulting from the construction and operation of the facilities, plus the natural processes that have occurred within ORR habitats, without the associated contamination (43 CFR § 11.14(e)).

To understand site conditions at ORR without contamination, DOE uses concentrations at reference sites for several media to compare to on-site contaminant concentrations. For example, a reference location at Fort Loudoun Dam approximately six miles from ORR is used to measure background radiation rates, and numerous creeks upstream of ORR are used as reference sites for comparison of fish tissue contaminant concentrations (DOE 2020b, 2021). The contaminant levels at these reference sites are below levels expected to cause injury to natural resources. Therefore, the Trustees assume that baseline for ORR is a DOE facility without contamination of natural resources at injurious levels (i.e., physical structures would still have existed, but the baseline concentrations of contaminants would be below concentrations that cause a loss in resources services).

3.4 NATURAL RESOURCE INJURY

The natural resources described in Chapter 2 provide a variety of services, which are the natural physical and biological functions and qualities of the resource, including the human uses of those functions (43 CFR § 11.14 (nn)). For example, ecological services provided by benthic invertebrates include foraging opportunities for fish and birds and nutrient cycling. Similarly, wetland soils provide services by sequestering carbon, filtering runoff, and supporting healthy vegetation and diverse plant communities that in turn provide animals with foraging opportunities, nesting or denning areas, and protective cover. Examples of human use services provided by natural resources include opportunities for fishing, boating, hunting, and wildlife viewing and appreciation.

Injury has occurred when a resource's viability or function is impaired such that the type and/or magnitude of services provided by that resource is reduced as a result of contamination (43 CFR § 11.14 (v)). Determination of injury requires documentation that there is: 1) a viable pathway for the released hazardous substance from the point of release to a point at which natural resources are exposed to the released substance, and 2) that injury of exposed resources (i.e., sediment, soil, groundwater, biota) has occurred as defined in 43 CFR § 11.62. The first condition is satisfied based on clear documentation of known hazardous substance and other waste disposal into surface water and soil, which resulted in the movement of contaminants into groundwater and sediment (Section 3.5). The second condition is satisfied because measured and modeled concentrations of contaminants in assessment area resources exceed levels at which the literature reports adverse effects on endpoints such as reproduction, growth, and survival, and due to the presence of an FCA (Sections 3.6-3.8).

3.5 PATHWAY

Determination of injury requires documentation that there is a viable pathway for the released hazardous substance(s) from the point of release to a point at which natural resources are exposed to the released substance(s) (43 CFR § 11.14(dd)). Pathways are the physical connections in the environment that transport contaminants released from facility operations, waste management, and other practices into various media (i.e., sediment, soil, biota). ORR contaminants, including PCBs, cadmium, chromium, mercury, and radionuclides, have been released into the environment. For example (DOE 2021, Undated; Ashwood et al. 1986; Browder et al. 1959):

- Cooling water wastes from ORR's Gaseous Diffusion Plant K-25 at ETTP were discharged to a chromate holding pond.
- Laboratory drains discharged wastes high in metals, organic compounds, and uranium-238 to holding ponds.
- The waste from metal cleaning operations, containing high levels of metals and radioactive isotopes was discharged into a small stream that flows into Poplar Creek.
- Radioactive and non-radioactive wastes were buried in shallow trenches within the White Oak Creek drainage basin and Bear Creek Valley.

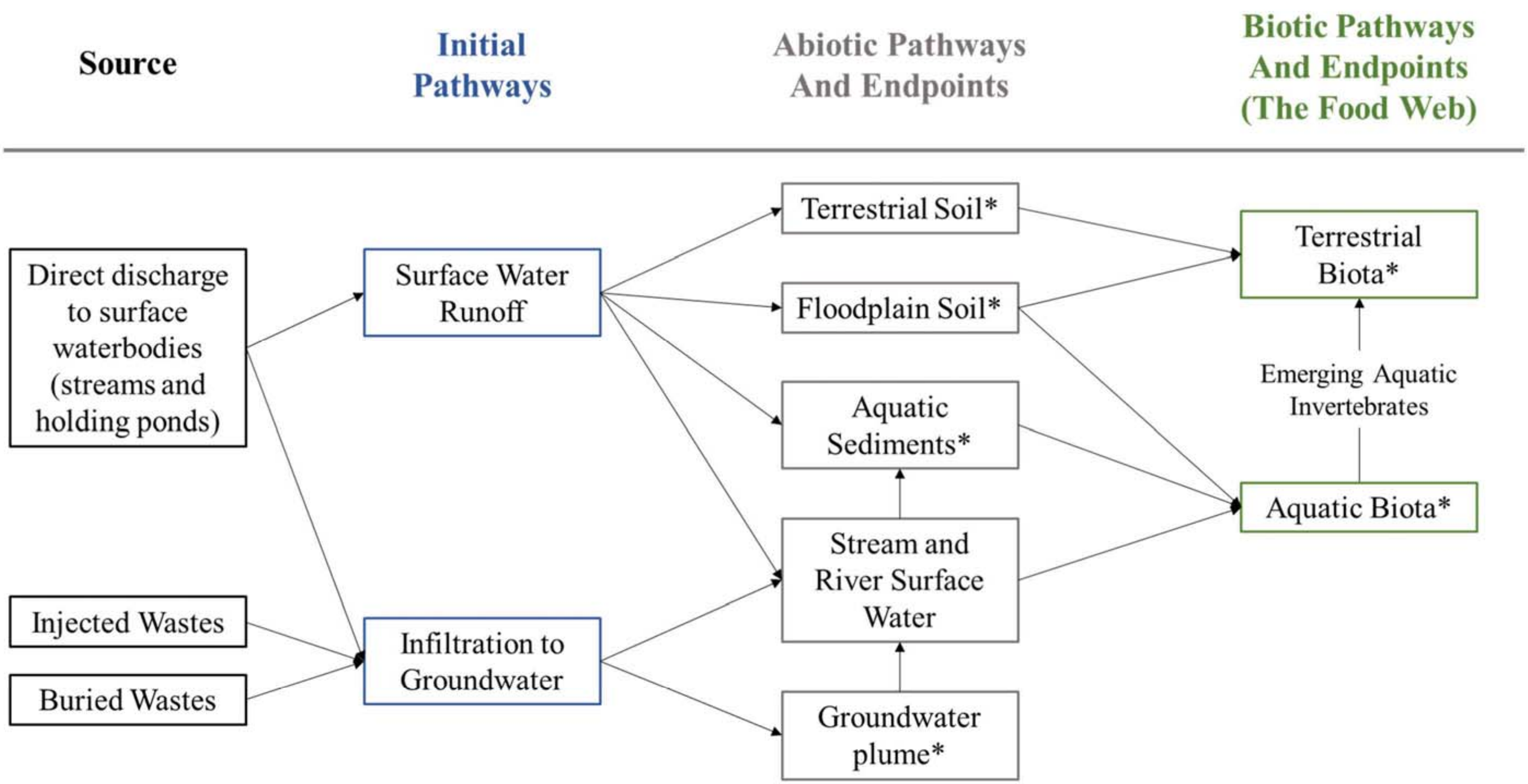
- A storm drain network in the Y-12 area discharged mercury directly to East Fork Poplar Creek.
- A subsurface injection process was used to dispose of low-level liquid nuclear waste at ORNL. The waste was pumped under pressure through an injection well into the underlying rock layers. As of the mid-1980s, ORNL had disposed of over 1.5 million Curies of radioactivity, with the principal contaminants being Strontium-90 and Cesium-137.

Contaminants released from ORR operations have been transported by pathways such as surface water runoff and infiltration to groundwater into terrestrial and aquatic soils and sediments, groundwater, and streams and rivers, directly exposing aquatic and terrestrial biota. Available documents and data indicate multiple pathways of contamination from ORR sources to trust resources (Exhibit 3-3). For example:

- Surface water is the primary pathway for offsite contaminant transport. ORR surface water systems, including the Clinch River and its tributaries, are fed by runoff from rainfall and by groundwater that continually discharges to surface streams via springs and seeps (DOE 2020b).
- Complex groundwater plumes that contain multiple contaminants (e.g., uranium, technetium, nitrate, VOCs, chromium) exist in the subsurface of the ORR, which transport contaminants through aquifers and can move off-site (DOE 2020b).
- Contaminants released from source sites at ORR accumulate in aquatic sediments and floodplain soils, a direct pathway to the terrestrial environment. Any remobilized contaminants or those that were not retained by soils and sediments are released to surface waters, which contribute to contaminant flux (DOE 2020b).
- Floodplain soils erode into adjacent streams during wet weather events, bringing contaminants into the aquatic system (DOE Undated).
- Contamination from deeply injected wastes and dense, contaminated liquids that have sunk downward through fractures at ORR experience longer distance and deeper groundwater migration pathways but are still transported to surface waters (DOE 2020b).
- Movement of water through buried waste resulted in radionuclide and metal releases to the nearby Clinch River via White Oak Creek (Arora et al. 1981; Webster 1976; DOE 2020b).

Once released to the environment, the physical and chemical properties of the COCs allow them to be taken up by biota, and, in the case of PCBs, cadmium, and mercury can bioaccumulate and biomagnify through the food web (Eisler 2000). Site-specific data document the COCs in sediment and in biological resources (e.g., fish) within the assessment area. Fish and other contaminated prey items then act as a pathway for contaminants to higher trophic level organisms.

EXHIBIT 3-3. KNOWN ORR PATHWAYS



*Indicates a natural resource being assessed in the NRDA process.

3.6 ECOLOGICAL INJURIES AND LOSSES

As described in Section 2.2, natural resources provide a suite of ecological services that are essential to the long-term sustainability and health of themselves and their habitats. Injury to a biological resource has resulted from the release of a hazardous substance if the concentration of the substance is sufficient to cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations (43 CFR § 11.62(f)(1)(i)), or exceed levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organism (e.g., FCAs) (43 CFR § 11.62(f)(1)(iii).

To assess the losses in ecological services as a result of natural resource exposure to and injury from Site-related hazardous substances, the Trustees used measured contaminant concentration data in combination with site-specific and literature-based toxicological study results. Together, these data informed the expected type and severity of the effects of relevant COCs on Trust resources such as sediment-dwelling invertebrates, soil invertebrates, fish, piscivorous birds and mammals, terrestrial songbirds, terrestrial small mammals, and bats (Exhibit 3-4). These injuries were then assessed on a habitat basis in order to facilitate the development of appropriate habitat-based restoration projects.[26]

EXHIBIT 3-4. REPRESENTATIVE RESOURCES BY HABITAT TYPE

HABITAT TYPE	RESOURCE	RESOURCE EXAMPLE
Aquatic	Sediment	Floodplain sediments, riverine sediments
	Fish	Striped bass, Walleye
	Piscivorous Birds	Osprey, belted kingfisher
	Piscivorous Mammals	Otter, mink
Terrestrial	Soil	Terrestrial soils
	Terrestrial Songbirds	Tree swallow, Carolina wren
	Terrestrial Small Mammals	Gray bat, Short-tailed shrew

3.6.1 AQUATIC INJURY

The Trustees evaluated injury to sediment-dwelling invertebrates, fish, piscivorous birds, and piscivorous mammals that were exposed to Site-related contamination in the aquatic habitat.

Sediment-Dwelling Invertebrates

Because promulgated sediment quality criteria do not exist, the Trustees compared site-specific contaminant concentrations in sediment to corresponding sediment quality guidelines (SQGs) and benchmarks set forth in the literature. These SQGs and benchmarks indicate concentrations above which adverse effects on sediment-dwelling invertebrates (e.g., reduced survival) are expected to occur. In this case, the Trustees used freshwater SQGs from MacDonald et al. (2000), which are the same SQGs used in the most recent Environmental Monitoring Plan for ORR (TDEC 2020a), and published benchmarks for

[26] Although other resources may also be impacted by contamination from the Site (e.g., reptiles and amphibians), exposure and effects data are not sufficient to quantify injury to these resources. However, because restoration will be habitat-based, restoration projects are expected to benefit these other resources.

radionuclides and mercury. Site-specific contaminant concentrations exceed the corresponding SQGs and benchmarks, demonstrating injury to sediment-dwelling invertebrates (Exhibit 3-5; Appendix A).

Fish

The Trustees evaluated injury to fish using two lines of evidence. First, they compared site-specific fish tissue concentrations of cadmium, chromium, mercury, total PCBs, and radionuclides to corresponding effects information in the peer-reviewed literature. These studies reported threshold contaminant concentrations in fish above which adverse effects on endpoints such as growth, reproduction, and/or survival are expected to occur. Contaminant concentrations in fish tissue exceed literature-based thresholds for PCBs, mercury, cadmium, and radionuclides, demonstrating injury to fish resources. Available data indicate that concentrations of chromium are below levels expected to cause injury (Exhibit 3-5; Appendix A).

In addition, mercury and PCB-related FCAs have been issued for waterbodies within the assessment area. For example, East Fork Poplar Creek, including the Poplar Creek embayment and Bear Creek, has a “do not eat” advisory for all fish due to mercury and PCB contamination. The current FCA on the Clinch River arm of the Watts Bar Reservoir has a “do not eat” advisory for striped bass and a precautionary advisory for catfish and sauger due to PCB contamination, and the FCA on the Melton Hill Reservoir is a “do not eat” advisory for catfish due to PCB contamination (TDEC 2020b). Consistent with the DOI NRDA regulations, the existence of an FCA constitutes an injury to fish.

Piscivorous Birds and Mammals

Because minimal data on contaminant concentrations in piscivorous bird and mammal tissue are available, the Trustees modeled contaminant exposure to these resources through consumption of contaminated fish and compared dietary intake of contaminants with literature-based adverse effects thresholds. These thresholds indicate contaminant concentrations in the diet above which adverse effects on endpoints such as behavior, reproduction, and/or survival are expected to occur. Some contaminant concentrations in assessment area fish exceeded corresponding thresholds. Based on this analysis, piscivorous birds likely have been injured due to cadmium, mercury, and PCBs, and piscivorous mammals have likely been injured due to exposure to mercury and cadmium.

Concentrations of chromium and radionuclides are below levels expected to cause injury (Exhibit 3-5; Appendix A).

EXHIBIT 3-5. AVERAGE CONTAMINANT CONCENTRATIONS IN AQUATIC SUB-AREAS AND CORRESPONDING ADVERSE EFFECT THRESHOLDS FOR SEDIMENT, FISH, AND PISCIVOROUS BIRDS AND MAMMALS

ASSESSMENT SUB-AREA	CADMIUM (PPM)	CHROMIUM (PPM)	MERCURY (PPM)	TOTAL PCBS (PPM)	RADIONUCLIDES (RADS/DAY)[1]
SEDIMENT THRESHOLDS[2]	**4.98**	**111**	**1.06**	**0.676**	**0.024**
Lower Clinch River	0.13	16.1	0.13	0.02	Mollusk **0.1**
Upper Clinch River	0.23	15.3	0.08	0.03	Mollusk **0.1**
East Fork Poplar Creek	0.97	33.2	**7.2**	0.06	Mollusk **0.29**
Poplar Creek	0.4	19.4	0.37	0.03	Mollusk **0.21**
White Oak creek	0.29	22.6	N/D	N/D	N/D
FISH[2,3]	**0.17**	**21**	**0.06**	**0.075**	**0.024**
Lower Clinch River	0.04	0.12	**0.11**	0.02	Fish **0.1**
Upper Clinch River	0.04	0.12	**0.07**	0.01	Fish **0.1**
East Fork Poplar Creek	**1.00**	0.24	N/D	**0.15**	Fish **0.29**
Poplar Creek	0.03	0.13	**0.28**	0.06	Fish **0.22**
White Oak creek	N/D	N/D	**0.18**	**0.79**	N/D
PISCIVOROUS BIRDS[2,3]	**0.5**	**5**	**0.1**	**0.5**	**N/A**
Lower Clinch River	0.03	0.12	**0.10**	0.08	N/A
Upper Clinch River	0.03	0.12	0.07	**0.05**	N/A
East Fork Poplar Creek	**1.03**	0.2	N/D	0.35	N/A
Poplar Creek	0.03	0.10	**0.31**	0.15	N/A
White Oak creek	N/D	N/D	**0.15**	**0.79**	N/A
PISCIVOROUS MAMMALS[2,3]	**0.44**	**5**	**0.22**	**1.86**	**0.024**
Lower Clinch River	0.03	0.12	0.10	0.08	Riparian mammal 0.02
Upper Clinch River	0.03	0.12	0.07	0.05	Riparian mammal 0.01
East Fork Poplar Creek	**1.03**	0.2	N/D	0.35	Riparian mammal 0.02
Poplar Creek	0.03	0.10	**0.31**	0.15	Riparian mammal 0.01
White Oak creek	N/D	N/D	0.15	0.79	N/D

Notes:
- N/D = data not available.
- Site-specific contaminant concentrations represent averages calculated using sampling data from the Oak Ridge Environmental Information System (OREIS) database (1984-2021).
- **Bolded** values indicate the concentration exceeds the applicable threshold.

[1] Radionuclide exposure is modeled as total Radiological Dose (rads/day), and includes cesium-137, strontium-90, uranium-235, and uranium-238.

[2] Threshold sources are provided in Appendix A.

[3] Site-specific fish tissue concentrations represent averages calculated using sampling data from the Oak Ridge Environmental Information System (OREIS) database (1984-2021). Site-specific tissue concentrations are not available for piscivorous birds and mammals; instead, fish tissue concentrations are compared to piscivorous animal dietary concentrations to determine and quantify injury.

Aquatic Injury Summary

Based on the analyses described above, aquatic resources (i.e., sediment, fish, and piscivorous birds and mammals) within the assessment area have been injured as a result of exposure to hazardous substances. As a result, the public has experienced and continues to experience a reduction in the aquatic services provided by these natural resources relative to the services that the resources would provide in their baseline condition. Through the proposed restoration activities described later in this RCDP/EA, the Trustees seek to ensure that natural resource services are provided, in the future, of a type and scale sufficient to compensate for this loss.

3.6.2 TERRESTRIAL INJURY

The Trustees evaluated injury to soil invertebrates, songbirds, and small mammals that were exposed to contamination in the ORR terrestrial habitat.

Soil Invertebrates

Because promulgated soil quality criteria do not exist, the Trustees compared site-specific contaminant concentrations in soil to corresponding literature-based earthworm toxicity data (PCBs and metals) or screening level benchmarks (radionuclides). These studies reported threshold contaminant concentrations in soil above which adverse effects on the growth and survival of soil invertebrates are expected to occur. Soil contaminant concentrations exceeded adverse effect thresholds for chromium and mercury, demonstrating injury. Available data indicate that soil injury due to cadmium, PCBs, and radionuclides is unlikely (Exhibit 3-6; Appendix A).

Terrestrial Songbirds

Terrestrial songbirds are found in both floodplain and upland habitat. Because site-specific terrestrial bird tissue data are limited, the Trustees modeled songbird exposure by multiplying site-specific soil contaminant concentrations by corresponding biota-soil accumulation factors (BSAF).[27] Resulting exposure estimates exceed literature-based adverse effects thresholds for mercury in East Fork Poplar Creek floodplain. These thresholds reflect contaminant concentrations in soil above which adverse effects on reproduction and growth are expected to occur. This demonstrates injury to songbirds in the ORR (Exhibit 3-6; Appendix A).

PCBs, cadmium, and radionuclides are below levels expected to cause injury to songbirds in other floodplain and upland habitat. Exposure to chromium in both floodplain and upland was not assessed because information on the toxicity of chromium to terrestrial birds is insufficient to determine injury (Exhibit 3-6; Appendix A).

Terrestrial Small Mammals

Similar to terrestrial songbirds, terrestrial small mammals utilize both floodplain and upland habitat. However, site-specific small mammal tissue contaminant data are lacking. Therefore, we multiplied contaminant concentrations in soil by site-specific small mammal accumulation factors (DOE 1996) to model contaminant concentrations in small mammals. Resulting exposure estimates exceed literature-based adverse effects thresholds for mercury in sub-areas of both floodplain and upland habitat. These

[27] The mercury BSAF was calculated by dividing the average whole body mercury concentrations in birds from ORR by the average soil concentrations in East Fork Poplar Creek floodplain (OREIS 2010). BSAFs for cadmium and PCBs were generated based on the peer-reviewed literature (EPA 1999; site-specific songbird data are insufficient for this calculation). A BSAF for chromium was not calculated, as information on the toxicity of chromium to terrestrial birds is insufficient to assess injury.

thresholds reflect contaminant concentrations in soil above which adverse effects on growth and survival are expected to occur. This demonstrates that injury to small mammals within the ORR has occurred (Exhibit 3-6; Appendix A).

Concentrations of PCBs, cadmium, and radionuclides are below levels expected to cause injury to small mammals in either floodplain or upland habitat (Exhibit 3-6; Appendix A). Exposure to chromium was not assessed because chromium is not considered to be toxic to small mammals (Irwin 1997).

Terrestrial Small Mammals of Special Concern

Several bat species found on the ORR are of special concern or endangered, including the gray bat, little brown bat, Indiana bat, Northern long-eared bat, Eastern small-footed bat, tricolored bat, and Rafinesque's big-eared bat (Exhibit 2-4; DOE 2021). Literature information on the effects of contaminants on bats is sparse, however, bat fur was sampled at East Fork Poplar Creek in 2011 to measure levels of mercury, and it was found that bats in this area have potentially harmful body burdens of mercury (Hatch et a. 2011).

Terrestrial Injury Summary

Terrestrial resources (i.e., soil, terrestrial songbirds, and terrestrial small mammals) within the assessment area have been injured as a result of exposure to hazardous substances. As a result, the public has experienced and continues to experience a reduction in the terrestrial services provided by these natural resources relative to the services that the resources would provide in their baseline condition. Through the proposed restoration activities described later in this RCDP/EA, the Trustees seek to ensure that natural resource services are provided, in the future, of a type and scale sufficient to compensate for this loss.

EXHIBIT 3-6. AVERAGE CONTAMINANT CONCENTRATIONS IN TERRESTRIAL SUB-AREAS AND CORRESPONDING ADVERSE EFFECT THRESHOLDS FOR SOIL, TERRESTRIAL SONGBIRDS, AND SMALL MAMMALS

ASSESSMENT SUB-AREA	CADMIUM (PPM)	CHROMIUM (PPM)	MERCURY (PPM)	TOTAL PCBS (PPM)	RADIONUCLIDES (RADS/DAY)[1]
SOIL THRESHOLDS[2,3]	20	0.4	0.1	5	0.024
Black Oak - Pine	0.56	**34.8**	**1**	0.04	Invertebrate 0.0
Pine - Chestnut	0.26	**13.1**	**0.1**	0.05	Invertebrate 0.0
Chestnut - Haw	0.2	**21.9**	**0.1**	0.02	Invertebrate 0.0
Haw - Copper	0.11	**5.6**	0.02	0.01	Invertebrate 0.0
East Fork Poplar Creek Floodplain[5]	1.79	**65.1**	Pre-remedy **58.4** Post-remedy **47.0**	0.19	Invertebrate 0.0
TERRESTRIAL SONGBIRDS[2,3]	2	N/A	0.5	2	N/A
Black Oak - Pine	<0.01	N/D	0.01	<0.01	N/A
Pine - Chestnut	<0.01	N/D	0.08	<0.01	N/A
Chestnut - Haw	<0.01	N/D	<0.01	<0.01	N/A
Haw - Copper	<0.01	N/D	<0.01	<0.01	N/A
East Fork Poplar Creek Floodplain	<0.01	N/D	**Pre-remedy 4.8** **Post-remedy 3.8**	<0.01	N/A
SMALL MAMMALS[2,3,4]	2	N/A	0.03	2.5	0.024
Black Oak - Pine	0.04	1.41	0.19	<0.01	Small mammal 0.0
Pine - Chestnut	0.02	0.75	0.019	<0.01	Small mammal 0.0
Chestnut - Haw	0.01	1.25	0.019	<0.01	Small mammal 0.0
Haw - Copper	0.03	1.60	<0.01	<0.01	Small mammal 0
East Fork Poplar Creek Floodplain[5]	0.12	3.7	**Pre-remedy 11** **Post-remedy 8.8**	<0.01	Small mammal $1.57x10^{-3}$

Notes:
N/D = data not available.
N/A = not applicable because contaminant-resource combination was not assessed.
- **Bolded** values indicate the concentration exceeds the applicable threshold.
[1] Radionuclide exposure is modeled as total Radiological Dose (rads/day), and includes cesium-137, strontium-90, uranium-235 and uranium-238.
[2] Threshold sources are provided in Appendix A.
[3] Terrestrial songbird and small mammal contaminant concentrations are modeled using site-specific soil contaminant concentrations and biota-soil accumulation factors.
[4] Although contaminant information is unavailable for the Walden to Black Oak Ridge area (farthest northwest) and the Copper to Beaver Ridge area (farthest southeast), it is unlikely that there is substantial ORR-related contamination in these areas, as COCs are unlikely to move across ridges.
[5] Mercury concentrations in soil were calculated pre- and post-1996 to account for remedial activities that occurred in that year.

3.7 GROUNDWATER INJURY AND LOSSES

Groundwater is a major component of the water cycle. It transports water from terrestrial to aquatic systems as rainfall infiltrates soil and then moves underground until it reaches a spring or seep. Groundwater may be a source of drinking water for nearby communities, although in this case groundwater contamination at the ORR renders it unusable: no groundwater extraction is occurring from the ORR and no private wells are in use because the land is zoned for industrial purposes (TDEC 2020).

There are several plumes of contaminated groundwater – that is, groundwater with contaminant concentrations greater than background – that originate within the assessment area. These contaminants include, but are not limited to, VOCs, cesium, strontium, uranium, nitrate, tritium, mercury, chromium, trichloroethylene, and cadmium. Groundwater studies also demonstrate that at some sampling locations, contaminant concentrations exceed the corresponding maximum contaminant levels (MCLs) developed by EPA (Exhibit 3-2).

Because the DOI NRDA regulations state that injury to groundwater has occurred when contaminant concentrations in groundwater exceed drinking water standards or water quality criteria, such as MCLs (43 CFR § 11.62(c)(1)(i-iv)), the Trustees concluded that injury to ORR groundwater has occurred. As a result, the public has experienced and continues to experience a reduction in the groundwater services provided by these natural resources relative to the services that the resources would provide in their baseline condition. Through the proposed restoration activities described later in this RCDP/EA, the Trustees seek to ensure that natural resource services are provided, in the future, of a type and scale sufficient to compensate for this loss.

3.8 RECREATIONAL LOSSES

In addition to ecological and groundwater services, natural resources also provide a suite of recreational services. Popular recreational activities at ORR include fishing, hunting, bird watching, biking, boating, water skiing, and swimming (DOE 2021). Available data allowed the Trustees to assess changes in recreational fishing and hunting services as a result of contamination, hunting regulations, and FCAs. Contaminant-related losses to these recreational opportunities are measured as the reduction in the value the public holds to participate in these activities. For example, FCAs exist on multiple waterbodies within the assessment area (Section 3.7.1), and hunters on ORR are required to have their take tested for radiological contamination. These restrictions indicate a loss of fishing and hunting opportunities to the public.

3.8.1 RECREATIONAL FISHING

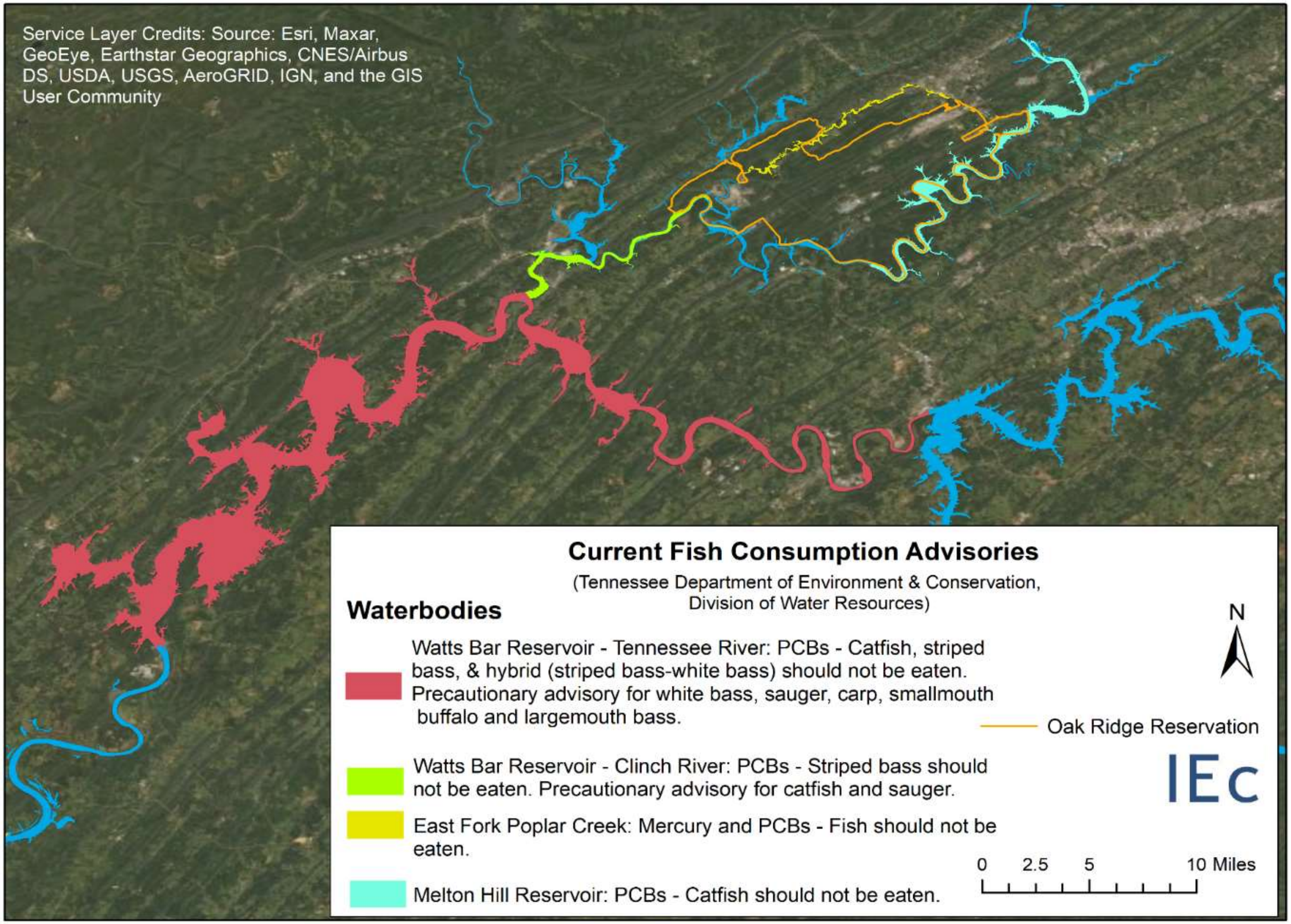
Recreational fishing in the vicinity of ORR takes place on the Clinch River, from its confluence with the Tennessee River upstream to the Melton Hill Dam (encompassing most of the Clinch River arm of Watts Bar Reservoir), and on the Melton Hill Reservoir, upstream from Melton Hill Dam. All streams on the ORR are classified for recreational fishing, including Poplar Creek and East Fork Poplar Creek.

FCAs have been and are present at multiple locations in and around ORR (Personal Communication, Tennessee Wildlife Resources Agency (TWRA; Exhibit 3-7; TDEC 2020b).

- The FCA on Watts Bar Reservoir associated with PCB contamination was first put into place in 1990. It recommended limiting consumption of sauger, carp, white bass, and smallmouth buffalo to no more than 1.2 pounds per month and limiting consumption of largemouth bass weighing over two pounds to no more than 1.2 pounds per month. After 1990, separate advisories were posted for the Tennessee River portion and the Clinch River arm of the reservoir:
  - On the Clinch River from Kingston (located at the confluence of the Tennessee and Clinch Rivers) to Melton Hill Dam specifically, the advisory recommended limiting consumption of catfish to no more than 1.2 pounds per month. This advisory is not in effect today.
  - In 1994, the advisory on the Clinch River arm of the Watts Bar Reservoir indicated that striped bass should not be consumed and included a precautionary advisory for catfish and sauger. This advisory remains in effect today.
- The advisory on the entirety of the Melton Hill Reservoir was established in 1990 and also remains in place today. The advisory is related to PCB contamination and recommends avoiding consumption of catfish.
- East Fork Poplar Creek, including the Poplar Creek embayment and Bear Creek has a "do not eat" advisory for all fish due to mercury and PCB contamination.

The presence of FCAs on the Clinch River arm of Watts Bar Reservoir, Melton Hill Reservoir, and East Fork Poplar Creek constitutes an injury (43 CFR § 11.62(f)(1)(iii)). As a result of the FCAs, recreational anglers fishing in these waterbodies may have a diminished recreational fishing experience, as they may be discouraged from keeping their catch, and/or decreased interest in taking trips to the assessment area. In the extreme case, some individuals who would otherwise fish may forego angling altogether because of the presence of contaminants. Injuries to anglers will continue until the advisories are lifted. Through the proposed restoration activities described later in this RCDP/EA, the Trustees seek to ensure that recreational fishing services are provided, in the future, of a type and scale sufficient to compensate for this loss.

EXHIBIT 3-7. FISH CONSUMPTION ADVISORY LOCATIONS



3.8.2 RECREATIONAL HUNTING

The public participates in deer and turkey hunting on ORR. Deer hunting has occurred on-site since 1985, typically over two to three weekends each fall. Both types of hunting are managed by TWRA where hunter participation is determined by an application process and quota system. Hunters are allowed to harvest two deer, with no more than one antlered. Deer harvested on ORR must be monitored for radiological contamination at a TWRA checking station. Since deer hunts began in 1985, TWRA has retained 218 out of 13,334 deer (1.7 percent) due to radiological levels that exceeded established standards (DOE 2021).

Turkey hunting has occurred on-site since 1997. There are two weekends per year when hunts take place, which are also organized by a quota system. Similar to deer, all turkeys are monitored for radiological contamination at a TWRA checking station. Since 1997, 3 out of 924 turkeys have been retained (0.3 percent); one in 1997, one in 2001, and one in 2005 (DOE 2021).[28]

Because there is some probability that hunters will not be permitted to keep their harvest, the value of hunting trips to the ORR is likely less than it otherwise would be. Through the proposed restoration activities described later in this RCDP/EA, the Trustees seek to ensure that recreational hunting services are provided of a type and scale sufficient to compensate for this loss.

[28] Game taken off-site may also be brought to the checking station at the hunters' discretion (Jim Evans, TWRA, personal communication).

CHAPTER 4 | PROPOSED RESTORATION ALTERNATIVES

The Trustees' objective in developing this RCDP/EA is to select a restoration alternative that will compensate the public for the natural resource injuries and associated service losses resulting from Site-related contamination. Consistent with the DOI NRDA regulations and NEPA, this RCDP/EA identifies reasonable restoration alternatives, describing the types of restoration actions that could potentially compensate for injuries to natural resources under each alternative. As summarized in Chapter 3, available information demonstrates that injuries have occurred to resources that utilize ORR-related aquatic, floodplain, and terrestrial habitats (e.g., sediment, fish, birds, mammals) and to groundwater, resulting in a loss of ecological, recreational, and groundwater services. Therefore, the Trustees evaluated restoration alternatives that will provide benefits that are linked directly to potentially injured natural resources or related service losses, and would not otherwise be generated (i.e., but for implementation of the NRDA restoration alternative the actions would not occur).

Consistent with the restoration planning guidance in the DOI NRDA regulations (43 CFR §11.82 (a)) and NEPA (42 U.S.C. § 4321, et seq., and the regulations guiding its implementation at 40 CFR Part 1500), the Trustees considered three restoration alternatives: Alternative A: No Action, Alternative B: Contaminant Cleanup, and Alternative C: Resource- and Resource Use-Based Restoration. These alternatives are described below and are evaluated based on the factors identified in the DOI NRDA regulations for trustee consideration when selecting an alternative (43 CFR § 11.82(d)), site-specific restoration objectives developed by the Trustees, and the potential for the alternative to significantly adversely impact the quality of the human environment.

4.1 ALTERNATIVE A: NO ACTION

In compliance with the DOI NRDA regulations, the Trustees must consider a No Action Alternative (43 CFR §11.84 (c)(2)). Under this Alternative, no restoration actions would be conducted. Any contamination remaining in the environment after active remediation activities were completed would be addressed through natural recovery.

4.2 ALTERNATIVE B: CONTAMINANT CLEANUP

Under Alternative B: Contaminant Cleanup, the Trustees would conduct additional contaminant removal or containment beyond what is required by the remedy. Remedial actions are focused on the footprints of the three ORR facilities - ORNL, ETTP, and Y-12 - and limited additional areas within ORR (e.g., East Fork Poplar Creek). The Trustees assume that these remedial actions, which are designed to protect human health and the environment from unacceptable risk, will be completed as planned (see Section 1.4 for a summary of remedial activities). However, even after current remedial actions are completed, contamination will remain in assessment area soils, sediments, and groundwater resulting in continued exposure of and injury to natural resources and losses of ecological and human use services. Therefore, the Trustees would design and implement actions to further reduce contamination levels in the ORR and relevant waterbodies faster than natural attenuation. The focus would be on areas that have higher levels of contamination, provide habitat for biota (and specifically species that are listed as threatened, endangered, or of special concern), provide recreational opportunities for the public, and/or are pathways for contaminants to move through the environment (e.g., to groundwater). These projects would supplement remedial activities that are ongoing and planned, and would involve coordination with DOE and other relevant parties. Example activities include (EPA 2021a, 2021b):

4.2.1 DREDGING/EXCAVATION

Dredging removes contaminated sediment from a water body without draining or diverting the water. Excavation removes contaminated material in drier conditions, such as sediment after the area has been dewatered, or soil from upland areas. The contaminated material is then disposed of in a landfill or a confined disposal facility. Highly contaminated sediment may be treated before disposal.

4.2.2 CAPPING

Capping involves the placement of clean material over contaminated soil or sediments. When contaminants are relatively immobile, a cap prevents biota and vegetation from contacting them. A relatively impermeable cap can also prevent surface water from infiltrating the contaminated sediment or soil, diverting it away from the contaminated area and thereby reducing groundwater contamination.

4.2.3 GROUNDWATER TREATMENT

Groundwater treatment under this alternative would include actions that are above and beyond both implemented and planned groundwater remedial requirements. These actions would remove additional contamination from groundwater resources. Techniques include:

- *Pump and treat*, in which groundwater is extracted and conveyed to an above-ground treatment system that removes the contaminants.
- *Containment pumping*, which draws contaminated water toward the wells, keeping the contaminant plume from spreading into drinking water wells, wetlands, streams, and other water bodies.
- *Containment barriers*, which are vertical, engineered, subsurface, impermeable barriers built below ground to control the flow of groundwater. They can be used to divert groundwater (e.g., around drinking water wells) or to contain and isolate contaminated soil and groundwater to prevent it from mixing with clean groundwater.
- *In situ treatment*, in which groundwater is treated in place, often with chemicals or biological organisms.

4.3 ALTERNATIVE C: RESOURCE- AND RESOURCE USE-BASED RESTORATION

Alternative C: Resource- and Resource Use-based Restoration encompasses a suite of different restoration actions, all targeted towards benefiting a specific resource or set of resources (i.e., surface water, sediment, aquatic invertebrates, fish, birds, reptiles, amphibians, mammals), as well as the human users of these resources. Projects are focused on generating ecological, groundwater, and recreational benefits, and would be accomplished through careful design and implementation as well as public outreach to promote adequate understanding, coordination, and planning. Each project type is described in more detail below.

4.3.1 ECOLOGICAL RESTORATION PROJECTS

To increase and improve ecological functions and benefit injured biological resources, the Trustees are considering habitat creation, restoration/enhancement, and preservation, with a specific focus on projects that increase connectivity and promote synergistic benefits with other habitat areas. The actions the Trustees propose under this Alternative would maximize use of low impact techniques. For example, where possible, invasive management would focus on removal of plants by hand (e.g., via digging, pulling, or cutting) rather than more impactful strategies such as mechanical removal with chainsaws, mowers, or other machinery, or targeted chemical removal.

Revegetation techniques would focus on preparing the seedbed by tilling or plowing; seeding or planting by hand or with mechanical equipment; and installing seeds, plants, or woody materials such as trees and shrubs. Grading would likely be done with heavy machinery to roughly prepare an area (e.g., earth moving, tilling, and compaction) and then using a grader to finish the surface. Note that these projects may also provide ancillary benefits to recreational users and groundwater.

Habitat Creation

Habitat creation involves converting one type of habitat to another, such as:

- A disturbed/non-habitat area is converted to habitat. For example, an abandoned parking lot could be cleared, graded, and planted with native vegetation. These actions would restore the area's natural hydrology, provide benefits to wildlife, and improve groundwater recharge.
- An area is restored to a historic habitat type. For example, a previously filled wetland could be excavated, re-graded, hydrologically reconnected to surface water or other wetlands, and replanted with native wetland vegetation. Increased connectivity with other high-quality habitat would maximize the benefit to natural resources (e.g., aquatic invertebrates, fish, reptiles). This type of project would also restore the natural hydrology, reducing runoff and increasing groundwater recharge.
- There is a specific need for a particular habitat type in an area. For example, if a species of concern requires a particular habitat type or habitat characteristic (e.g., four-toed salamanders need sphagnum bogs for survival and protection), and restoration for that species is a resource management priority. In the assessment area, sphagnum bogs may be sufficiently rare such that conversion of other habitat (e.g., riparian) to sphagnum bog(s) would be appropriate.

Habitat Restoration/Enhancement

Habitat restoration or enhancement involves the improvement of degraded habitat, ideally returning the area to conditions that better approximate "natural" conditions. These actions may also enhance habitat adjacent to the restored area, even if that adjacent habitat itself is not preserved. For example, if the hydrologic connectivity of an existing wetland is restricted by an undersized culvert, the existing culvert could be replaced with a larger, more wildlife-friendly culvert. Other examples of habitat restoration activities include, but are not limited to:

- Invasive species removal and restoration of native plant communities;
- Restoring land adjacent to high quality habitat to increase habitat connectivity;
- Increasing habitat complexity by placing woody structures, nest boxes, or turtle basking logs;
- Installing water control structures and removing drain tiles to restore natural hydrology; and
- Establishing new or expanding existing riparian vegetation corridors.

Habitat Preservation

This involves preservation of habitat that would otherwise be developed or degraded. Habitats may be preserved through land acquisition, land donations and/or transfers, or conservation easements, which could be held by a variety of entities (e.g., non-governmental organizations, municipal agencies). The Trustees would consider funding projects that may preserve wetland, riparian, and/or upland habitats essential to a variety of fish and wildlife species, including species that are the same as or similar to those injured by contaminant releases in the ORR. Habitat preservation activities could also include the acquisition of ecologically valuable habitat or establishment of conservation easements on riparian habitat along ecologically valuable waterways. Where possible, the Trustees would prioritize preservation of land that is adjacent to protected habitats to increase habitat connectivity and the benefits of preservation. The primary purpose of these preservation efforts is to protect fish and wildlife habitats. Other uses, such as recreational activities, may be permitted, but only in a manner that supports the goal of ecological preservation.

Final selection of specific lands that would be preserved would consider factors such as the ecological value of the wetland and riparian habitats, Trustee resource management priorities, inherent improvement of water quality, ownership/protection opportunities, geographic/ecological diversity, local/regional planning, citizens' concerns, and the ability for entities purchasing the land to find willing sellers.

4.3.2 GROUNDWATER PROJECTS

While habitat creation, restoration/enhancement, and preservation largely focus on ecological benefits, these project types are also expected to improve groundwater quality and flow through increased surface recharge, decreased runoff, and reduced contaminant transport. In addition, the Trustees are evaluating projects that specifically target improvements to groundwater quality, such as groundwater-related infrastructure. These projects could include, but are not limited to:

- Green parking lots, permeable pavements, and green streets (i.e., increasing the vegetative cover in these areas to encourage groundwater recharge);
- Bioswales and rain gardens as an alternative to stormwater runoff conveyance systems;
- Septic conversions to reduce the risk of contaminating the surrounding environment with sewage pathogens; and
- Capping abandoned wells to stop a direct pathway for contaminated surface waters to enter an aquifer.

4.3.3 RECREATION PROJECTS

Habitat creation, restoration/enhancement, and preservation projects may also provide additional or improved quality of recreation opportunities. These benefits could be derived directly from activities such as wildlife viewing or bird watching, or indirectly, such as improved recreational experiences as a result of water quality improvements through habitat restoration. In addition, the Trustees are evaluating projects that specifically target improvements in access to resources and the quality of the recreational experience. Examples include, but are not limited to:

- Constructing/improving (e.g., to make compliant with the Americans with Disabilities Act [ADA])/maintaining boat launches, ramps, fishing piers, and boating facilities;
- Purchasing and restoring land with access to water;
- Constructing/maintaining hiking and biking trails, wildlife and natural viewing areas;
- Providing additional parking and access opportunities; and
- Constructing/improving/maintaining recreation area amenities (e.g., restrooms, water fountains, trash control), including updating these amenities to comply with the ADA.

CHAPTER 5 | ALTERNATIVES EVALUATION AND SELECTION OF THE PREFERRED ALTERNATIVE

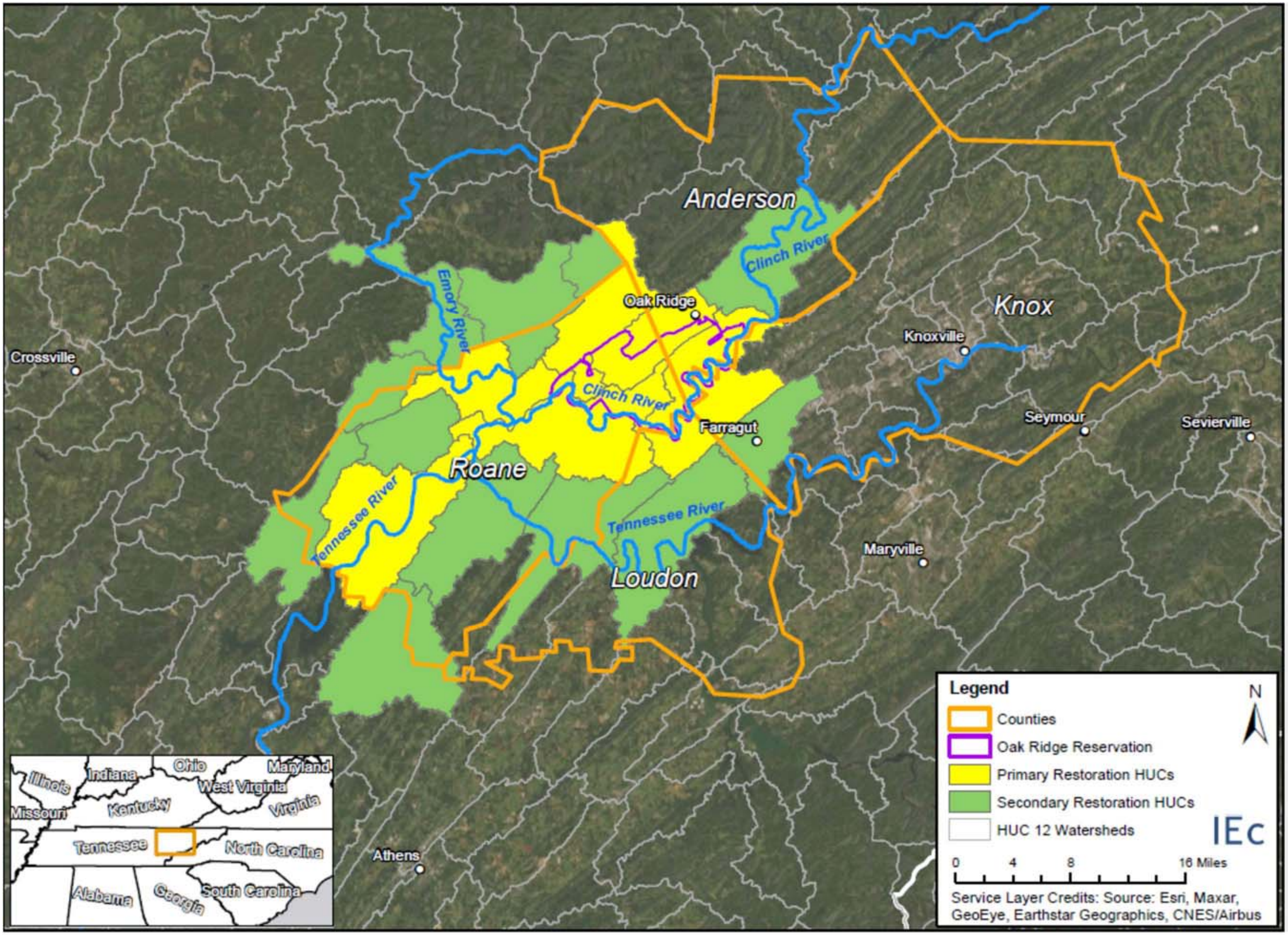
The Trustees' primary goal in this chapter is to evaluate the consequences of the Alternatives described in Chapter 4. This evaluation assisted the Trustees in identifying a preferred restoration alternative that is expected to achieve Trustee restoration objectives, is consistent with the DOI NRDA restoration factors, and compensates the public for natural resource injuries and associated losses resulting from contaminants released from the ORR. The Trustees determined whether implementation of any of the alternatives may significantly affect the quality of the human environment, particularly with respect to the physical, biological, socio-economic, or cultural environments associated with the assessment area and adjacent resources. Based on this evaluation, the Trustees selected the alternative that will maximize ecological and human use benefits while minimizing or eliminating project-related adverse environmental consequences.

5.1 SITE-SPECIFIC TRUSTEE RESTORATION OBJECTIVES

At this time, the Trustees are prioritizing restoration actions that satisfy one or more of the following objectives:

- Are located within the hydrological units associated with Anderson, Roane, Loudon, and Knox Counties that contain or are adjacent to the Clinch River from just upstream of ORR to the confluence with the Tennessee River, and/or the Tennessee River downstream to the border of Roane and Loudon Counties (Exhibit 5-1; Appendix B);
- Provide long-term, sustainable benefits accounting for climate change;
- Increase habitat connectivity;
- Improve water quality to support ecological function and recreational use;
- Provide benefits to listed species (federally/state listed and "at risk"); and
- Improve the public's access to and quality of recreational resources.

EXHIBIT 5-1. POTENTIAL GEOGRAPHIC SCOPE OF RESTORATION



5.2 DOI NRDA RESTORATION FACTORS

In order to ensure the appropriateness and acceptability of the proposed restoration alternatives, the Trustees evaluated each alternative against a suite of restoration criteria. These include ten factors that are listed within the NRDA regulations as considerations when evaluating a preferred alternative (43 CFR § 11.82(d)):

- Technical feasibility,
- The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources,
- Cost effectiveness,
- The results of actual or planned response actions,
- Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other services,
- The natural recovery period,
- Ability of the resources to recover with or without alternative actions,
- Potential effects of the action on human health and safety,
- Consistency with relevant Federal, state, and tribal policies, and,
- Compliance with applicable Federal, state, and tribal laws.

5.3 ENVIRONMENTAL ASSESSMENT

Actions undertaken to restore natural systems and the human uses of those systems are expected to have beneficial and/or adverse impacts to the physical, biological, socio-economic, and cultural environments of the area. In order to determine whether an action has the potential to result in significant impacts, the context and intensity of the action must be considered (40 CFR 1508.27). Context refers to area of impacts (local, state-wide, etc.) and their duration (e.g., whether they are short- or long-term impacts). Intensity refers to the severity of impact and could include factors such as the timing of the action (e.g., more intense impacts would occur during critical periods like wildlife breeding/rearing, etc.), the effect on public health and safety, and cumulative impacts. Intensity is also described in terms of whether the impact would be beneficial or adverse.

In the analysis below, the Trustees examine the likely beneficial and/or adverse impacts of Alternatives A, B, and C on the quality of the environment. If the Trustees conclude that the actions associated with the preferred alternative will not lead to significant adverse impacts, then the Trustees will issue a finding of no significant impact (FONSI). If significant impacts are anticipated, the Trustees will proceed with an Environmental Impact Statement to evaluate a reasonable range of restoration alternatives and the environmental consequences of those alternatives more specifically. The Trustees will continue to evaluate environmental impacts as specific projects are implemented under the preferred alternative. The following sections assess anticipated environmental consequences of the restoration alternatives in light of the site-specific and regulatory factors listed above.

5.3.1 SCOPE OF THE NEPA ANALYSIS

This RCDP/EA describes and compares the potential impacts of the proposed restoration alternatives, including the No Action Alternative, for the ORR NRDA. In particular, this RCDP/EA analyzes the potential direct, indirect, and cumulative ecological, social, and economic impacts associated with each alternative. The following definitions were used to generally characterize the nature of the various impacts:

- *Short-term or long-term impacts:* This characterization is determined on a case-by-case basis. Rather than referring to a specific timeframe, short-term impacts are expected to occur for a finite period, whereas long-term impacts are those that are more likely to be persistent.
- *Direct or indirect impacts:* A direct impact caused by a proposed action occurs at or near the action's location, whereas an indirect impact occurs later in time or at a more distant location. For example, streambank erosion may directly impact the water quality of the adjacent section of river, and may indirectly impact fish use of the downstream portion of the river because of the increased sediment load.
- *Minor, moderate, or major impacts:* These relative terms characterize the expected magnitude of an impact. Minor impacts may be perceptible but are sufficiently small such that they are not typically measurable. Moderate impacts are more perceptible and more likely to be quantified or measured. Major impacts are expected to be of sufficient intensity within a particular context (e.g., the affected region (40 CFR 1508.27)) such that an evaluation of the need for mitigation under NEPA is warranted.
- *Adverse or beneficial impacts:* An adverse impact has an unfavorable or undesirable outcome on the environment (artificial or natural), whereas a beneficial impact has positive outcomes on the environment. A single action may result in adverse impacts on one environmental resource and beneficial impacts on another resource.
- *Cumulative impacts:* NEPA regulations define cumulative impacts as the "impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7).

5.2 EVALUATION OF ALTERNATIVE A: NO ACTION

Alternative A, "No Action" would not initiate any NRDA-related restoration action. Instead, the ecosystem would begin to recover as a result of ongoing and planned remedial actions (which are not directed by the Trustees, see Section 1.5) and natural processes. However, remedial activities are not expected to immediately return natural resources to their baseline conditions (i.e., conditions but for the release of contamination) for two reasons: 1) some contamination will remain in remediated areas even after remedial activities are complete, resulting in reduced but continued exposure of natural resources and potentially reducing resource services (e.g., groundwater), and 2) Site-related contamination sufficient to injure natural resources has been measured in extensive areas for which no active remediation is planned (e.g., terrestrial habitat within ORR, aquatic habitat in the Clinch River adjacent to ORR). Therefore, contaminant concentrations and any associated natural resource losses in these areas will take decades to attenuate to baseline, given the persistence of these compounds in the environment (e.g., they do not readily degrade).

The No Action Alternative is also not expected to either satisfy the Trustees' restoration objectives or compensate the public for interim ecological, recreational, or groundwater service losses resulting from contaminants released into the assessment area (i.e., losses that occurred pre-remedy and continue until contaminant concentrations return to baseline). Without any additional actions, benefits such as long-term sustainability, habitat connectivity, and improvements to public recreational opportunities would not be realized. In addition, natural resource services above and beyond baseline would not be created to make up for past and future losses; therefore, the public is not made whole.

Lastly, the No Action Alternative is not consistent with Federal and state policies and laws. Settlement monies would not be spent on restoration or acquisition of the equivalent of lost resources and resource services, which is the purpose of damages collected through the NRDA process (43 CFR § 11.93(a)).

The net environmental consequences of the No Action Alternative are adverse to natural resources. While this Alternative does not result in physical disturbance to the environment, decades of residual contamination after ongoing and planned remedial actions are complete, and the lack of any additional remedial or restoration action, are expected to cause injury to natural resources and negatively affect the ecological and human use services provided by those resources. This Alternative serves as a point of comparison to determine the context, duration, and magnitude of environmental consequences resulting from the implementation of Alternatives B and C.

5.3 EVALUATION OF ALTERNATIVE B: CONTAMINANT CLEANUP

Alternative B, "Contaminant Cleanup" is expected to result in the faster recovery of natural resources and resource services than under the ongoing and planned remedial actions. To provide a direct comparison to Alternatives A and C, the Trustees evaluated Alternative B for consistency with the Trustees' restoration objectives and the DOI NRDA restoration factors, as well as net environmental consequences.

As described under Alternative A, even after ongoing and planned remedial actions are completed, some contamination will remain in the environment (e.g., in soil and sediment), and will continue to injure natural resources. Given the persistence of COCs in environmental media (e.g., they do not readily degrade), contaminant concentrations and any associated natural resource losses in these areas will take decades to attenuate to baseline. Additional contaminant cleanup, such as through dredging/excavation, capping, or groundwater treatment, would more quickly return resources to their baseline condition and reduce, if not eliminate, future natural resource injury. This is consistent with multiple factors described in Section 5.2; 43 CFR §11.82(d)).

Alternative B also satisfies the other DOI NRDA restoration factors outlined in Section 5.2 (43 CFR §11.82(d)). For example, some types of actions that cleanup contaminated material are technically feasible, as demonstrated by the completion of previous remedial actions. Depending on the underlying geology, implementation of additional cleanup actions under this Alternative could be cost effective, especially if the Trustees consider remedial actions already planned. Remedial activities not only have standard protocols to protect human health and safety while an action is ongoing (e.g., per the Occupational Safety and Health Administration [OSHA]), but would benefit long-term human health by reducing contaminant levels in resources that people may consume (e.g., fish). Cleanup activities would be conducted in compliance with federal and state regulations.

In addition, cleanup actions under this Alternative would achieve some of the Trustees' site-specific restoration objectives. For example, actions would be focused within and in areas adjacent to the ORR, which is consistent with the Trustees' priority restoration area (Exhibit 5-1). Cleanup actions are likely to improve water quality: less contamination in soil and sediment would reduce contaminant transport to surface water and groundwater, leading to improved ecological function and recreational use. Listed species would also benefit, as a reduction in contamination would both improve their health directly as well as improve the health of their prey communities. In contrast, benefits such as long-term habitat sustainability, habitat connectivity, and improvements to public access are unlikely to be incorporated into remedial project goals and therefore would not be realized.

Similar to the No Action Alternative, however, the Contaminant Cleanup Alternative is not expected to compensate the public for interim ecological, recreational, or groundwater service losses resulting from contaminants released into the assessment area (i.e., losses that occurred pre-remedy and continue until contaminant concentrations return to baseline). The supplemental remedial actions contemplated under this alternative would focus solely on removal, containment, or attenuation of contamination to reduce future exposure of natural resources; they would not create additional natural resource services above and beyond baseline. Therefore, this Alternative would not make the public whole.

The cumulative environmental impacts of this Alternative are expected to be beneficial. As noted above, contaminant removal will improve long-term environmental conditions, both directly (i.e., for the media that is remediated) and indirectly (i.e., biota exposed to the remediated soil or sediment). Jobs may be created in the short-term as design and implementation of the cleanup occurs, benefiting the local economy. To achieve these benefits, however, the Trustees expect that several short-term, moderate, direct and indirect impacts will be incurred. For example, soil excavation or sediment capping would remove substrate necessary for invertebrates, amphibians, reptiles, and other biota, eliminating those areas as viable habitat until recovery of the substrate and vegetative community has occurred. In addition, downwind or downstream areas could be impacted by increases in airborne particles or suspended sediment. Recovery would likely take a few years, with the exact timing dependent on the type and quality of backfilled material, installation of habitat layers, and planting activities.

5.4 EVALUATION OF ALTERNATIVE C: RESOURCE- AND RESOURCE USE-BASED RESTORATION

Alternative C, "Resource- and Resource Use-Based Restoration" is expected to provide relevant natural resource services through timely implementation of restoration within the ORR or in surrounding areas. Under this Alternative, project types include habitat creation, restoration, and enhancement; habitat preservation through land acquisition, donations, or conservation easements; groundwater quality improvement projects; and recreation enhancement projects. To provide a direct comparison to Alternatives A and B, the Trustees evaluated Alternative C for consistency with the Trustees' restoration objectives and the DOI NRDA restoration factors, as well as net environmental consequences.

Restoration projects actions under this alternative would achieve all of the Trustees' site-specific restoration objectives (Section 5.1). Actions would be focused within the geographic scope prioritized by the Trustees (Exhibit 5-1) and are likely to improve water quality. For example, improvement of shoreline habitat would reduce runoff and erosion, benefitting the adjacent aquatic habitat. This would lead to both improved ecological function and recreational use. Listed species could benefit from either targeted restoration or general habitat restoration, improving their condition by increasing the type and quality of ecological services provided by relevant habitat types. Projects would be designed for long-term habitat sustainability (e.g., using technical tools such as climate models and legal mechanisms such as conservation easements), habitat connectivity, and, where possible, the integration of ecological, recreational, and groundwater benefits.

Alternative C also satisfies the DOI NRDA restoration factors outlined in Section 5.2 (43 CFR §11.82(d)). For example, the Trustees would focus habitat and wildlife restoration efforts within the priority geographic area. They plan to rely on the state of the science for restoration of biota, habitat, groundwater, and recreation, and apply methods that have been successful in other locations to increase the probability of project success. This ensures that projects are both technically feasible and cost effective. Assuming projects are implemented in a timely manner, these benefits will not only enable injured resources to recover to baseline conditions faster than under Alternatives A or B, but benefit human health by improving the condition of resources that people may consume (e.g., fish). Restoration actions would be conducted in compliance with federal and state regulations and be designed to minimize any impacts on human health and safety.

Because restoration projects under Alternative C would create *additional*, future natural resource services similar to those lost due to contamination, this is the only Alternative under which the public would be compensated for natural resource injuries. For example, restored wetlands and riparian areas provide habitat for spawning fish and migratory birds, improve water quality by filtering sediments and pollutants from the water column, reduce erosion, and export detritus. These improvements in turn result in increased production of forage fish populations, which provide prey for larger fish, birds, reptiles, and mammals and increase the quality of recreational experiences. Restored grasslands and forest provide habitat for songbirds, small mammals, and larger mammals such as deer, which improves ecological function, groundwater recharge, and hunting opportunities for the public.

Finally, the cumulative environmental consequences of Alternative C are expected to be beneficial to natural resources. Below, the Trustees assess the potential environmental consequences of each of the proposed project types. In general, net impacts to ecological function, the physical environment, environmental justice, and socio-economic factors are expected to be beneficial; any adverse impacts would be short-term, direct, and minor to moderate. The Trustees would work to minimize any unavoidable adverse impacts through individual project plans, and additional project-specific NEPA analyses would be completed if proposed projects have expected adverse effects beyond the scope of those evaluated here.

5.4.1 HABITAT CREATION, RESTORATION, AND ENHANCEMENT

Habitat creation, restoration, and enhancement modify existing areas to improve the quality of ecological services provided, with potential supplemental benefits to groundwater and recreation. Invertebrates, amphibians, reptiles, fish, birds, and mammals would all benefit from these actions, as would the human users of these resources and their habitats. These types of projects create major, long-term, direct and indirect benefits within project footprints as well as the broader region, outweighing the short-term, localized adverse impacts described below.

The Trustees are considering three types of habitat creation: 1) converting a disturbed/non-habitat area to habitat (e.g., clearing an abandoned parking lot and planting it with native vegetation); 2) restoring an area to a historic habitat type (e.g., a previously filled wetland is excavated, re-graded, and hydrologically reconnected to surface water or other wetlands); and 3) creating a unique habitat for a species of concern (e.g., creation of sphagnum bogs for four-toed salamanders). These actions would result in a variety of localized impacts on natural resources such as soil, sediment, biota and vegetation in terrestrial, floodplain, and aquatic habitats (NOAA 2015). For example, existing areas would be substantially modified to create the hydrology, grade, soil type, and vegetation necessary for successful habitat creation projects. This would likely involve the use of heavy machinery and construction equipment for soil excavation and grading, which may result in increased air emissions from vehicles, removal or crushing of understory vegetation, soil compaction, increased soil erosion in the immediate area of construction operations, and unintentional introduction of non-native, potentially invasive, species. While some of these impacts are of moderate to major intensity, the Trustees expect them to be short-term and affect only the resources directly disturbed.

Habitat restoration or enhancement encompass several types of projects and would occur in a variety of habitat types. In terrestrial, floodplain, and wetland areas, projects would involve the removal of invasive species, planting of native species, and placement of material or structures to increase habitat complexity (e.g., woody structures, nest boxes, mink piles, turtle basking logs). Planting to restore existing habitat may cause direct, short-term, minor impacts to vegetation and soils at the restoration site (e.g., as existing vegetation is trampled or removed) (NOAA 2015). During subsequent management efforts, which may last for multiple seasons, the resource services provided by that area are likely to be reduced through physical disturbance or herbicide application.[29] This may result in direct, short-term, moderate, adverse impacts to soils, water, air, and biota, as well as recreation within the project area (NOAA 2015). No adverse impacts are expected to result from efforts that increase habitat complexity.

Aquatic restoration or enhancement would include restoration of hydrologic flow, stabilization of banks, improving habitat connectivity, and increasing habitat complexity. Project examples include installation of water control structures or drainage tiles, bank stabilization, culvert replacement, adding woody debris, and enhancing in-water substrate. Except for some habitat complexity elements, these projects would cause direct and indirect short-term, localized, minor to major adverse impacts on aquatic resources such as sediment invertebrates and fish. Use of heavy equipment (e.g., for bank restoration) and treatment of invasives would result in the same types and severity of impacts described above.

[29] Herbicides will be restricted to those least harmful to resources and will be applied by certified applicators.

In contrast, major long-term benefits are expected from these types of restoration activities and would be experienced by resources both within the project footprint (direct/localized) as well as in other areas affected by the project (indirect/general area). Habitat creation, restoration, and enhancement would generate benefits such as: 1) improved hydrological conditions that would support high quality habitat and re-establish connections between habitats (e.g., wetland and floodplain areas), 2) topography that would support native vegetative communities and corresponding biota, 3) improved groundwater recharge, and 4) restored natural hydrology. Long-term, moderate beneficial impacts to water resources and associated flora and fauna would also occur due to the reduced erosion and increased shelter provided by wetland plants, bank stabilization, and in-water habitat complexity. For example, habitat structures provide cover to increase survival of juvenile fish, spawning habitat to improve reproductive success, and complex substrate for colonization by benthic organisms (Bolding et al. 2004). These direct benefits to the invertebrate and fish communities result in indirect benefits to their predators within the aquatic and shore-based food webs. These structures are specifically designed to remain in place for decades, thereby providing ecological benefits throughout that extensive time period. In addition to ecological benefits, minor beneficial impacts related to socioeconomic resources "may result from increased tourism opportunities that could develop around an improved resource" (NOAA 2015 p.156).

5.4.2 HABITAT PRESERVATION

The Trustees are considering preservation of wetland, floodplain, and terrestrial habitats, prioritizing conservation of land that is adjacent to protected habitats to increase habitat connectivity and therefore project benefits. Preservation actions are expected to cause indirect, long-term, moderate to major beneficial impacts to natural resources that utilize the conserved area, providing ecological and human use services. "These impacts would result from new management of land and water resources and would prevent development of other degrading activities from taking place on the project site" (NOAA 2015 p.156). Beneficial impacts to natural resources "may occur from such restoration activities due to improved access to [aquatic and terrestrial] habitats, the creation of buffer zones between sensitive resources, altered or managed timing of water withdrawals, and other factors that could impact such resources. Depending on the nature of the land acquisition or protection action, land use overall could directly and moderately benefit over the long term, as fewer adverse environmental impacts occur at the project site. Recreational opportunities and land use practices would largely be improved as natural areas and ecosystems are preserved (e.g., through fee simple purchase of tracts of land or of water flows in rivers). Cultural and historic resources, if located on a protected parcel, would benefit from not being disturbed by development or other degrading activities that might otherwise occur." (NOAA 2015 p.157)

5.4.3 GROUNDWATER

To restore groundwater, the Trustees are targeting projects that will improve groundwater quality above and beyond current remedial requirements, specifically through infrastructure creation or improvement.[30] Project examples include green parking lots, bioswales, rain gardens, septic conversions, and capping of abandoned wells. These types of projects are expected to result in indirect, long-term, minor impacts due to the use of heavy machinery for construction. However, water quantity and quality would experience direct benefits, such as increasing groundwater recharge, a decrease in sewage pathogens, and a decrease in contamination entering aquifers from abandoned wells. Improved water quality due to increased natural

[30] For additional detail on the distinction between NRDA restoration and remedy, see Section 1.6.

recharge will also lessen the impact of climate change that causes increased surface runoff due to higher amounts of precipitation.

5.4.4 RECREATIONAL ENHANCEMENT PROJECTS

The Trustees are evaluating restoration projects targeted for improving recreational services. Such projects would include constructing or improving infrastructure such as boat launches, ramps, or fishing piers; facilitating purchase and restoration of land with access to water; constructing and maintaining hiking and biking trails, wildlife and natural viewing areas; providing additional parking opportunities; and constructing, improving, and maintaining recreation area amenities. Improvements to existing access areas and creation of new access areas within and adjacent to ORR boundaries would provide compensation for reduced recreational opportunities associated with site-related contamination. Compared to the "No Action Alternative", the environmental impacts of potential projects are anticipated to be minor and, in many cases, beneficial. Sites may range from existing formal and informal access areas to local riverside parks to new access opportunities. Improvements to roads, parking lots, trails, and boat ramps may cause minor short-term impacts to the environment as a result of construction activities but will help to reduce erosion, promote bank stabilization, reduce impacts to riparian vegetation, and improve user safety in the longer term. Negative impacts would primarily be associated with increased use, which can result in minor increases in traffic, noise, and litter.

This project type has the potential to positively impact the local economy. By increasing fishing access, it is likely that recreation in the area would increase, resulting in corresponding long-term benefits to the recreation, accommodation, and food services industries. In addition, additional fishing access would provide increased opportunities for local urban populations to participate in recreation activities. Enhancing local fishing access areas would offer urban populations opportunities that may not have been previously available and could be specifically tailored to benefit underserved communities.

5.5 PREFERRED RESTORATION ALTERNATIVE

The Trustees evaluated three general restoration alternatives against site-specific restoration objectives, regulatory restoration factors, and cumulative environmental consequences. Of particular note, Alternative B increases the rate at which natural resources will return to baseline, consists of projects that would be implemented mainly with the ORR, and provides net positive environmental consequences. However, Alternative B does not include restoration actions that will compensate the public for interim losses. In contrast, Alternative C satisfies all of the Trustees' site-specific restoration objectives, including allowing for project opportunities with the entire priority geographic scope (Exhibit 5-1), and creates additional natural resource services to compensate the public for interim losses. Therefore, the Trustees select Alternative C for implementation.

Based on this Final RCDP/EA, the Trustees will begin to identify and evaluate specific project options consistent with Alternative C. Each project will be evaluated against the same restoration priorities and factors described above, and, if needed, a further review of environmental consequences will be conducted. Any selected projects that are expected to have non-negligible impacts will be subject to a project-specific NEPA analysis prior to implementation. In addition, a Section 7 consultation (under the Endangered Species Act) will be completed for restoration projects that may affect threatened or endangered species and Section 106 of the National Historic Preservation Act will be followed for each restoration project that will be implemented.

The Trustees will continue to inform the public of restoration project plans and progress and seek public and stakeholder participation and involvement, as appropriate.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Are People Who Live Near The Oak Ridge Reservation Exposed To Contaminated Off-Site Groundwater? https://www.atsdr.cdc.gov/sites/oakridge/docs/factsheet1.pdf.

Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Toxicological Profile for Cesium. U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. April 2004. 305 pgs.

Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Toxicological Profile for Strontium. U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. April 2004. 445 pgs.

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Toxicological Profile for Cadmium. U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. September 2012. 487 pgs.

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Toxicological Profile for Chromium. U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. September 2012. 592 pgs.

Agency for Toxic Substances and Disease Registry (ATSDR). 2013. Toxicological Profile for Uranium. U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. February 2013. 526 pgs.

Arora, H.S., D.D. Huff, D.S. Ward, and O.M. Sealand. 1981. An Assessment of the Effect of a Bentonite Seal on Groundwater Storage in Underlying Waste Disposal Trenches at Oak Ridge National Laboratory. March.

Bernhoft, R.A. 2013. Cadmium toxicity and treatment. The Scientific World Journal, 2013.

Bilgili, A., Swift, M. R., & Celikkol, B. 1996. Shoal Formation in the Piscataqua River, New Hampshire. Estuaries, 19(3), 518–525. https://doi.org/10.2307/1352514

Bolding, B., Bonar, S.A., & Divens, M. (2004). Use of Artificial Structure to Enhance Angler Benefits in Lakes, Ponds, and Reservoirs: A Literature Review. Reviews in Fisheries Science, 12, 75 - 96.

Carter, E., N.R. Giffen, K. McCracken, S.E. Darling, A. Deck, and G. Byrd. 2019 Wildlife Management Plan for the Oak Ridge Reservation. Prepared by Oak Ridge Natural Laboratory and UT-Battelle, LLC for the U.S. Department of Energy. October.

Deloitte & Datawheel. 2019. Anderson County, USA. Data USA. Retrieved April 8, 2022, from https://datausa.io/profile/geo/anderson-county-tn#economy

Deloitte & Datawheel. 2019. Roane County, USA. Data USA. Retrieved April 8, 2022, from https://datausa.io/profile/geo/roane-county-tn#economy

DOE (U.S. Department of Energy). 2013. Strategic Plan for Mercury Remediation at the Y-12 National Security Complex – Oak Ridge, Tennessee. Prepared by Professional Project Services, Inc. March.

DOE. 2020a. 2020 Cleanup Progress – Annual Report to the Oak Ridge Regional Community.

DOE. 2020b. 2020 Remediation Effectiveness Report for the U.S. Department of Energy – Oak Ridge Site – Oak Ridge, Tennessee. Prepared by the Water Resources Restoration Program UCOR with Jacobs. March.

DOE. 2021. Oak Ridge Reservation Annual Site Environmental Report 2020. Prepared by UT-Battelle, LLC, Consolidated Nuclear Security, LLC, UCOR with Jacobs, and Professional Project Services, Inc. https://doeic.science.energy.gov/aser/aser2020/index.html. September.

DOE. Undated. Mercury contamination in East Fork Poplar Creek, Oak Ridge, Tennessee. G.R. Southworth, Environmental Science Division, Oak Ridge National Laboratory. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiXtIy5w4r3AhVSg4kEHVQkCmoQFnoECAYQAQ&url=https%3A%2F%2Fsouthriverscienceteam.org%2Fwp-content%2Fuploads%2F2018%2F08%2Fsouth-river-science-team-final.pdf&usg=AOvVaw06FuzpqG-5ZwRdlRWLouiQ

DOE and Oak Ridge Office of Environmental Management. 2021. Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation – Waste Disposal at the Environmental Management Disposal Facility – Oak Ridge, Tennessee. June.

Eisler, R. 2000. Handbook of Chemical Risk Assessment, Health Hazards to Humans, Plants, and Animals. Three volumes. Lewis Publishers. Boca Raton.

EPA (U.S. Environmental Protection Agency). 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities Peer Review Draft, Appendix D: Bioconcentration Factors (BCFs) for Wildlife Measurement Receptors. U.S. EPA Office of Solid Waste.

EPA. 2016. What Climate Change Means for Tennessee. EPA 430-F-16-044. August.

EPA. 2021a. How Superfund Cleans Up Sediment Sites. February 21. https://www.epa.gov/superfund/how-superfund-cleans-sediment-sites Accessed March 21, 2022.

EPA. 2021b. How Superfund Addresses Groundwater Contamination. March 1. https://www.epa.gov/superfund/how-superfund-addresses-groundwater-contamination Accessed March 21, 2022.

EPA. 2022a. Oak Ridge Reservation (USDOE) Oak Ridge, TN. https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.Cleanup&id=0404152#bkground. Accessed January 24, 2022.

EPA. 2022b. User's Guide: Radionuclide Carcinogenicity. https://www.epa.gov/sites/default/files/2015-02/documents/heast_ug_0401.pdf.

EPA. 2022c. National Primary Drinking Water Regulations. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations. Accessed January 26, 2022.

EPA, DOE, and Tennessee Department of Environment and Conservation (TDEC). 1992. Federal Facility Agreement for the Oak Ridge Reservation. DOE/OR-1014. January.

Etnier, D.A., and W.C. Starnes. 1993. The Fishes of Tennessee. The University of Tennessee Press/Knoxville.

Hatch, S., d. Yates, and T. Divoll. 2011. Pilot assessment of mercury exposure to bats in the watershed of Oak Ridge, Tennessee. Biodiversity Research Institute. Submitted to U.S. Fish and Wildlife Service (FWS). December.

Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese, and W. Basham. 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resource Division, Fort Collins, Colorado. Distributed within the Federal Government as an Electronic Document (Projected public availability on the internet or NTIS: 1998).

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology. DOI: 10.1007/s002440010075.

National Oceanic and Atmospheric Administration (NOAA). 2015. Programmatic Environmental Impact Statement. NOAA Restoration Center. June.

Oak Ridge Environmental Information System (OREIS). 2010 download. Available at: http://www-oreis.ettp.energy.gov/oreis/help/oreishome.html

Parr, P.D., G.S. Byrd, J.W. Johnston, JR., and N.R. Giffen. 2015. Forest Management Plan for the DOE Oak Ridge Reservation: An Interdisciplinary Approach for Managing a Heritage Resource. Oak Ridge National Laboratory, ORNL/TM-2015/98. Prepared by Oak Ridge Natural Laboratory and UT-Battelle, LLC for the U.S. Department of Energy. September.

Parr, P.D. and J.F. Hughes. 2006. Oak Ridge Reservation: Physical Characteristics and Natural Resources. Oak Ridge National Laboratory, ORNL/TM-2006/110. Prepared by Oak Ridge Natural Laboratory and UT-Battelle, LLC for the U.S. Department of Energy. September.

Runkle, J., K.E. Kunkel, D.R. Easterling, L.E. Stevens, B.C. Stewart, R. Frankson, L. Romolo, J. Neilsen-Gammon, T.A. Joyner, W. Tollefson. 2022. Tennessee State Climate Summary 2022. NOAA Technical Report NESDIS 150-TN. NOAA/NESDIS, Silver Spring, MD, 5 pp.

Tennessee Department of Environment and Conservation (TDEC). 2014. Contaminated Groundwater. Department of Energy Oversight Division.

TDEC. 2020a. Tennessee Department of Environment and Conservation – Division of Remediation Oak Ridge Office – Environmental Monitoring Plan – July 1, 2020 through June 30, 2021. August.

TDEC. 2020b. Posted Streams, Rivers, and Reservoirs in Tennessee – Tennessee Division of Water Resources. August

Trustees. 1995. Memorandum of Agreement.

U.S. Army Corps of Engineers. 2022. Downloadable Tennessee River Charts. https://www.lrn.usace.army.mil/missions/navigation/downloadable-tn-river-charts/. Accessed March 7, 2022.

U.S. Census Bureau. 2021. U.S. Census Bureau QuickFacts: Roane County, Tennessee; Anderson County, Tennessee; Knox County, Tennessee. https://www.census.gov/quickfacts/fact/table/roanecountytennessee,andersoncountytennessee,knoxcountytennessee/AGE775219?msclkid=e4aeb928b60811ecb41c5ff5bf294290

U.S. FWS (United States Fish and Wildlife Service). 2022. IPaC: Explore Location Resources. Information for Planning and Consultation. IPaC: Explore Location resources (fws.gov). Accessed 5/20/2022.

UT-Battelle. 2009. Animal species of special concern reported from the Oak Ridge Reservation. Oak Ridge National Laboratory. https://nerp.ornl.gov/wp-content/uploads/2018/07/Rare-Wildlife-List.pdf. Accessed 5/20/2022.

UT-Battelle. 2011a. Reptiles of the Oak Ridge Reservation. Oak Ridge National Laboratory. https://nerp.ornl.gov/wp-content/uploads/2018/07/orr_reptiles-2011.pdf. Accessed 5/20/2022.

UT-Battelle. 2017a. Mammals of the Oak Ridge Reservation (revised May 2017). Oak Ridge National Laboratory. https://nerp.ornl.gov/wp-content/uploads/2018/07/orr_mammals-2017.pdf. Accessed 5/20/2022.

UT-Battelle. 2017b. Oak Ridge Reservation Fishes (2017). Oak Ridge National Laboratory. https://nerp.ornl.gov/wp-content/uploads/2018/07/orrfishes_rtj_2017.pdf. Accessed 5/20/2022.

UT-Battelle. 2017c. Bird Populations of the Oak Ridge Reservation. Oak Ridge National Laboratory. https://nerp.ornl.gov/wp-content/uploads/2018/07/2017-ORR-Bird-List.pdf. Accessed 5/20/2022.

UT-Battelle. 2011b. Amphibians of the Oak Ridge Reservation. Oak Ridge National Laboratory. https://nerp.ornl.gov/wp-content/uploads/2018/07/orr-amphibians-2011.pdf. Accessed 5/20/2022

Webster. 1976. A Review of Hydrologic and Geologic Conditions related to the Radioactive Solid-Waste Burial Grounds at Oak Ridge National Laboratory, Tennessee. In cooperation with the U.S. Atomic Energy Commission.

RESOURCE	CONTAMINANT	THRESHOLD (PPM; RAD DOSE - RADS/DAY)	ENDPOINT	SOURCE(S)
Sediment-dwelling invertebrates	Cadmium	4.98	Growth and Survival	MacDonald et al. 2000
	Chromium	111	Growth and Survival	
	Mercury	1.06	Growth and Survival	
	PCBs	0.676	Growth and Survival	
	Radiological Dose	0.024	Reproduction, Survival, and Growth	Andersson et al. 2008
Fish	Cadmium	0.17	Growth	Hansen et al. 2004, Spehar 1976, Spehar et al. 1978, Cope et al. 1994 as cited in ERED 2003
	Chromium	21	Physical Deformity	Domingues et al., 2010; McCollum et al., 2011
	Mercury	0.06	Physical Deformity	Yang et al., 2010; McCollum et al., 2011
	PCBs	0.0075	Physical Deformity	Grimes et al., 2008; McCollum et al., 2011
	Radiological Dose	0.024	Reproduction, Survival, and Growth	Andersson et al. 2008
Piscivorous birds	Cadmium	0.5	Growth	Irwin 1997, Eisler 1985
	Chromium	26.59	Survival	Irwin 1997
	Mercury	0.1	Reproduction	Irwin 1997
	PCBs	0.5	Reproduction	Chapman 2003
	Radiological Dose	0.024	Reproduction, Survival, and Growth	Andersson et al. 2008
Piscivorous mammals	Cadmium	0.439	Reproduction	Irwin 1997
	Chromium	17.69	Survival	Irwin 1997
	Mercury	0.22	Reproduction	Halbrook et al. 1997, Wobeser et al. 1976
	PCBs	1.86	Reproduction	Hornshaw et al. 1983, Heaton et al. 1995, Jensen et al. 1997, Restum et al. 1998, Bursian et al. 2003
	Radiological Dose	0.024	Reproduction, Survival, and Growth	Andersson et al. 2008

RESOURCE	CONTAMINANT	THRESHOLD (PPM; RAD DOSE - RADS/DAY)	ENDPOINT	SOURCE(S)
Soil Invertebrates	Cadmium	20	Growth and Reproduction	Malecki et al. 198,; van Gestral et al. 1992
	Chromium	0.4	Survival	Efroymson et al. 1997
	Mercury	0.1	Reproduction	Beyer et al. 1985; Lock and Janssen 2001
	PCBs	5	Biochemistry Suppressed	Rodriguez-Grau et al. 1989
	Radiological Dose	0.024	Reproduction, Survival, and Growth	Andersson et al. 2008
Terrestrial songbirds	Cadmium	2	Physical Deformities	Eisler 1985
	Chromium	N/A	N/A	N/A[1]
	Mercury	0.5	Reproduction	Sample et al. 1996
	PCBs	2	Mortality	Neigh et al. 2006
	Radiological Dose	0.024	Reproduction, Survival, and Growth	Andersson et al. 2008
Small mammals	Cadmium	2	Reproduction	Levengood and Heske 2008
	Chromium	N/A	N/A	N/A[2]
	Mercury	0.03	Physical Deformities	Opresko et al. 1994
	PCBs	0.05	Growth	Johnson et al. 1994
	Radiological Dose	0.024	Reproduction, Survival, and Growth	Andersson et al. 2008

Notes:

[1] Effects of chromium on terrestrial songbirds were not assessed due to insufficient information on the toxicity of chromium to birds.

[2] Effects of chromium on small mammals are considered to be negligible. Chromium is one of the least toxic elements to mammals due to the fact that the pH in the stomach converts hexavalent chromium to trivalent chromium, which is less toxic since it cannot readily pass through membranes and is noncorrosive (Myers 1990 as cited in Irwin 1997). Mammals can typically tolerate up to 200 times the normal load of chromium without adverse effects (Moore *et al*. 1990 as cited in Irwin 1997).

REFERENCES

Andersson, P., Beaugelin-Seiller, K., Beresford, N.A., Copplestone, D., Della Vedova, C., Garner-Laplace, J., Howard, B.J., Howe, P., Oughton, D.H., Wells, C., and P. Whitehouse. 2008. Numerical benchmarks for protecting biota from radiation in the environment: proposed levels, underlying reasoning and recommendations. Protection of the Environment from Ionising Radiation in a Regulatory Context, Deliverable 5. European Commission, Community Research.

Beyer, W. N., Cromartie, E., and G. B. Moment. 1985. Accumulation of Methylmercury in the Earthworm, *Eisenia foetida*, and its Effect on Regeneration. *Bulletin of Environmental Contamination and Toxicology* 35: 157-162.

Chapman, J. 2003. Toxicity Reference Values (TRVs) for Mammals and Birds Based on Several Aroclors. Memorandum from James Chapman to Shari Kolar, USEPA.

Domingues, I., Oliveira, R., Lourenço, J., Grisolia, C. K., Mendo, S., & Soares, A. M. 2010. Biomarkers as a tool to assess effects of chromium (VI): comparison of responses in zebrafish early life stages and adults. Comparative biochemistry and physiology. Toxicology & pharmacology : CBP, 152(3), 338–345. https://doi.org/10.1016/j.cbpc.2010.05.010

Efroymson, R. A., Will, M.E., Suter, G. W. II, and A.C. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Publication Number ES/ER/TM-85/R3. Oak Ridge National Laboratory under contract DE-AC05-84OR21400 for the U.S. Department of Energy.

Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85(1.10).

Environmental Residue-Effects Database (ERED). 2003. *U.S. Army Corps of Engineers' Environmental Residue-Effects Database.* http://el.erdc.usace.army.mil/ered/index.html#misc

Fielder, Jr, G F. 1994. Archaeological survey with emphasis on prehistoric sites of the Oak Ridge Reservation, Oak Ridge, Tennessee. United States.

Grimes, A. C., Erwin, K. N., Stadt, H. A., Hunter, G. L., Gefroh, H. A., Tsai, H. J., & Kirby, M. L. 2008. PCB126 exposure disrupts zebrafish ventricular and branchial but not early neural crest development. Toxicological sciences : an official journal of the Society of Toxicology, 106(1), 193–205. https://doi.org/10.1093/toxsci/kfn154

Halbrook, R.S., L.A. Lewis, R.J. Aulerich, and S.J. Bursian. 1997. Mercury Accumulation in Mink Fed Fish Collected from Streams on the Oak Ridge Reservation. *Arch. Environ. Contam. Toxicol.* 33: 312-316.

Hornshaw, T.C., R.J. Aulerich, and H.E. Johnson. 1983. Feeding Great Reservoirs fish to mink: Effects on mink and accumulation and elimination of PCBs by mink. *J. Toxicol. Environ. Health* 11:933-946.

Irwin, R.J., M. VanMouwerik, L. Stevens, M.D. Seese, and W. Basham. 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resource Division, Fort Collins, Colorado. Distributed within the Federal Government as an Electronic Document (Projected public availability on the internet or NTIS: 1998).

Lock, K. and C. R. Janssen. 2001. Ecotoxicity of mercury to *Eisenia fetida, Enchytraeus albidus and Folsomia candida*. *Biology and Fertility of Soils* 34: 219-221.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology. DOI: 10.1007/s002440010075.

McCollum, C. W., Ducharme, N. A., Bondesson, M., & Gustafsson, J. A. 2011. Developmental toxicity screening in zebrafish. Birth defects research. Part C, Embryo today : reviews, 93(2), 67–114. https://doi.org/10.1002/bdrc.20210

Neigh, A. M., Zwiernik, M. J., Bradley, P. W., Kay, D. P., Jones, P. D., Holem, R. R., Blankenship, A. L., Strause, K. D., Newsted, J. L., and J. P. Giesy. 2006. Accumulation of Polychlorinated Biphenyls from Floodplain Soils by Passerine Birds. *Environmental Toxicology* 25: 1503-1511.

Opresko, D.M, B.E. Sample, and G.W. Suter II. Toxicological benchmarks for wildlife: 1994 Revision. Publication Number ES/ER/TM-86/R1. Oak Ridge National Laboratory, Oak Ridge, TN.

Rodriguez-Grau, J., Venables, B. J., Fitzpatrick, L. C., and A. J. Goven. 1989. Suppression of Secretory Rosette Formation by PCBs in Lumbricus terrestris: An Earthworm Assay for Humoral Immunotoxicity of Xenobiotics. Environmental Toxicology and Chemistry 8: 1201-1207.

Sample, B. E., Opresko, D. M., and G. W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Publication Number ES/ER/TM-86/R3. Oak Ridge National Laboratory under contract DE-AC05-84OR21400 for the U.S. Department of Energy.

Spehar, R. L. 1976. Cadmium and Zinc Toxicity to flagfish, *Jordanella floridae*. Journal of the Fisheries Research Board of Canada, 1976, 33:(9) 1939-1945, 10.1139/f76-247.

Spehar, R., E. Leonard, and D. DeFoe. 1978. Chronic effects of cadmium and zinc mixtures on flagfish (*Jordanella floridae*). U.S. Environmental Protection Agency, Washington, D.C., EPA/600/J-78/029 (NTIS PB284034).

van Gestel, C.A.M., E.M. Dirven-van Breemen, R. Baerselman, H.J.B. Emans, J.A.M. Janssen, R. Postuma, and P.J.M. van Vliet. 1992. "Comparison of sublethal and lethal criteria for nine different chemicals in standardized toxicity tests using the earthworm Eisenia andrei." Ecotoxicol. Environ. Saf. 23:206-220.

Wobeser, G., N.O. Nielsen, and B. Schiefer. 1976. Mercury and Mink I. The Use of Mercury Contaminated Fish as a Food for Ranch Mink. *Can. J. Comp. Med.* 40: 30-33.

Yang, Lixin & Ho, Nga & Müller, Ferenc & Strähle, Uwe. 2010. Methyl Mercury Suppresses the Formation of the Tail Primordium in Developing Zebrafish Embryos. Toxicological sciences : an official journal of the Society of Toxicology. 115. 379-90. 10.1093/toxsci/kfq053.

APPENDIX B | HUC 12 WATERSHED NUMBERS

HUC 12 WATERSHED NAME	HUC 12 NUMBER
Poplar Creek Lower	060102070303
Emory River Lower	060102080408
East Fork Poplar Creek	060102070302
Clinch River-Conner Creek	060102070404
Clinch River Outlet	060102070405
Watts Bar Lake Upper	060102010602
Clinch River-Wolf creek	060102070403
Little Emory River	060102080405
Clifty Creek	060102080407
Turkey Creek	060102010208
Caney Creek	060102010601
Big Sewee Creek	060200010101
Tennessee River-Riley Creek	060102010306
Tennessee River-Town Creek	060102010302
Whites Creek Lower	060102010403
Tennessee River-Hines Creek	060102010305

APPENDIX C | ORR RCDP/EA RESPONSE TO PUBLIC COMMENTS

The Oak Ridge Natural Resource Damage Assessment Trustees received comments from the public on the Draft Oak Ridge Restoration and Compensation Determination Plan/Environmental Assessment (August 2022) during the public comment period (August 15 – October 12, 2022). The Trustees grouped the comments by topics, including Process, Settlement Value, Geographic Scope, Assessment Detail, Restoration Detail, Restoration Process, Repurposing the Perpetual Care Fund, NEPA (National Environmental Policy Act), and General. Responses are provided below.

1.0 PROCESS

1.1 Comment: The RCDP/EA does not commit the trustees to any particular course of action.

Response: While the RCDP/EA does not identify specific restoration projects in specific locations, it does explicitly commit the Trustees to implement restoration consistent with Alternative C: Resource- and Resource-Based Restoration and that satisfies both the Trustees' site-specific restoration objectives as well as the U.S. Department of the Interior NRDA restoration factors (RCDP/EA Sections 5.1, 5.2, and 5.5). Restoration must generate ecological benefits through habitat creation, habitat restoration/enhancement, or habitat preservation; groundwater benefits through projects that improve groundwater quality; and recreation benefits through projects that improve access to resources and the quality of recreational experiences (RCDP/EA Section 4.3).

1.2 Comment: The RCDP is not consistent with CERCLA or NEPA.

Response: The draft RCDP contains the information described in the federal regulations at 43 CFR § 11.81 and 11.82, which require trustees to list a reasonable number of possible alternatives for restoration, and then to evaluate the alternatives from which they select a preferred alternative. To better address the requirements in 43 CFR § 11.83 and 11.84, such as cost and valuation methods, resource services, and discounting, we have provided additional information on the data, methodologies, results, and costs in Appendix D of the final RCDP. NEPA is addressed in Section 8.0 of this Appendix.

1.3 Comment: DOE is a responsible party and should not participate in the decision-making process associated with the settlement funds.

Response: In passing CERCLA, Congress gave DOE and other Federal agencies the joint role of both trustee and responsible party. The Secretary of the Department of Energy (DOE) is designated in the National Contingency Plan as the trustee for natural resources under its jurisdiction, custody, or control, which includes DOE's land holdings (in this case, the Oak Ridge Reservation; CERCLA §107(f)(2)(A) and Section 300.600 of the NCP). In addition, CERCLA regulations indicate the trustees should cooperate with the responsible party (43 CFR § 11.32(a)(2)). Therefore, it is appropriate for DOE to participate in NRDA discussions as both a trustee and a responsible party.

Note that for the ORR NRDA, the Trustees and DOE worked cooperatively to collectively determine the approach to the damage assessment and to develop this RCDP/EA.

1.4 Comment: A NRDA at the site is premature because remedial actions are not complete, contamination will persist into the future, and the nature and extent of that contamination is uncertain, especially groundwater and contamination from the future EMDF [Environmental Management Disposal Facility].

Response: The NRDA process has been underway since 1993, when the Trustees formed a Trustee Council to coordinate and implement NRDA activities. Since that time, the Trustees have assessed the type and scope of natural resource injuries and service losses resulting from the release of hazardous substances from DOE's operations at the Oak Ridge Reservation (ORR). The Trustees have also been evaluating restoration options that may be undertaken to make the public whole for such injuries and service losses.

At this time, the Trustees have sufficient information to understand the type and magnitude of injuries to trust natural resources, accounting for the type and timing of ongoing and planned remedial actions, as well as the uncertainty of the success of those remedial actions (see response to Comment 2.7 and Appendix D). In addition, because restoration is the goal of the NRDAR process, the Trustees have determined that restoration sooner is better than at an undetermined time in the future, as it will generate more benefits to natural resources and, by extension, the public, sooner as well.

1.5 Comment: Insufficient detail is provided regarding the assessment, preventing the public from being able to substantively comment on the $42 million settlement.

Response: We have included more information in Appendix D.

1.6 Comment: Settlement discussions should not be confidential because all trustees are public entities.

Response: We understand that the public would like additional information supporting the settlement and have added Appendix D.

1.7 Comment: The City of Oak Ridge should have been, and should be now and in the future, allowed to participate in the NRDA process as a partner to the trustees.

Response: While municipalities are not trustees per the CERCLA NRDA regulations, the Trustees have conducted outreach to and communicated with the City specifically because of the City's role in supporting their public. Going forward, the Trustees hope the City will submit project proposals when solicited through the Restoration Project Selection Procedure and engage in public participation when draft restoration plans are released for public review.

2.0 SETTLEMENT VALUE

2.1 Comment: $42 million is insufficient given the long timeframe and extent of contamination.

2.2 Comment: A discount rate should be applied to account for the change in monetary value over time.

2.3 Comment: Insufficient detail is provided regarding the breakdown of damages between injury categories (i.e., ecological, recreation, and groundwater).

2.4 Comment: Groundwater damages should be considered as the replacement cost of contaminated groundwater.

2.1-2.4 Response: The Trustees have included more information in Appendix D.

2.5 Comment: There is no explanation for the seven-year timeframe for distribution of settlement funds.

Response: The seven-year timeframe is for distribution to the Tennessee Department of Environment and Conservation for a portion (approximately half) of the funds from DOE, and is intended to provide some flexibility in the timing of those payments to account for the variability in appropriated funds (note that a minimum of $2 million will be paid each year). The other half of the funds are currently held by TDEC and will be applied to the settlement once TDEC and DOE modify the Fund Implementation Plan for the EMWMF perpetual care fund and the Consent Order is entered.

3.0 GEOGRAPHIC SCOPE

3.1 Comment: The extent of areas of contamination outside of ORR but included in the assessment of ORR are not adequately shown in maps.

Response: The Trustees have provided an additional map in Appendix D.

3.2 Comment: Restoration projects should not occur within ORR and should be restricted to waterbodies, lands, and communities directly impacted by contamination from ORR, including some sub-watersheds not listed in the RCDP.

Response: The Trustees' priority is to implement restoration projects that satisfy the restoration objectives described in Sections 5.1 and 5.2 of the RCDP, which include a nexus to injured resources and to the affected public.

3.3 Comment: Groundwater restoration actions should not be conducted on or near the boundary of ORR because of contamination.

Response: The Trustees are not considering projects that would increase contaminant transport in the environment or increase the exposure of natural resources to contaminants.

3.4 Comment: Settlement funds should not be spent on DOE remedial efforts.

Response: Settlement funds are specifically to be used for restoration, rehabilitation, replacement, and/or acquisition of equivalent resources and resources services (43 CFR § 11.13(e)(3)), consistent with Alternative C. The Trustees do not plan to use funds for remedial actions.

3.5 Comment: Insufficient support is provided for the identification of primary and secondary HUCs.

Response: The Trustees' goal in defining the restoration area is to focus on areas that have a direct nexus to the resources and resource services, including the human uses of those resources, that were injured as result of ORR-related contamination. One consideration is geographic proximity – it is often the case that injured resources are best benefited by restoration within or immediately adjacent to the area within which the injury occurred. However, the Trustees must also consider that restoration beyond the injured area may provide equal or greater benefits to injured resources (and the human users of those resources), and may be more likely to satisfy other restoration objectives and regulatory criteria.

Because injuries occurred to resources in the Clinch River, its tributaries, and associated floodplain habitat, as well as more upland habitats, the Trustees focused on Clinch River watershed units as reasonable boundaries for the restoration area. The primary restoration hydrologic unit codes (HUCs) depicted in Exhibit 5-1 are HUCs that include the Assessment Area (Exhibit 1-1) and the main stem of the Clinch River and associated tributaries downstream to the confluence with the Tennessee River (note that in order to capture the confluence of the Clinch and Tennessee River HUC 060102070403 Clinch River-Wolf Creek is included). Secondary restoration HUCs were identified as HUCs that are adjacent to a primary restoration HUC and within a county that overlaps substantially with the Assessment Area. The Trustees also included one secondary restoration HUC that includes a portion of the Clinch River upstream of the Assessment Area.

4.0 ASSESSMENT DETAIL

4.1 Comment: Description and quantification of baseline conditions is insufficient.

4.2 Comment: RCDP/EA lacks identification of Type A or B assessment.

4.3 Comment: There is insufficient detail regarding the damage approach and calculations. Therefore, there is no way to determine whether NRDA meets cost effectiveness considerations.

4.4 Comment: There is no consideration of organic solvents or other contaminants detected at ORR but not mentioned in the RCDP.

4.5 Comment: Locations where contaminants were disposed of should be considered as natural resource damages.

4.6 Comment: Groundwater on off-site property was not included in the NRDA.

4.1-4.6 Response: We understand that the public would like additional information supporting the settlement and have added Appendix D.

4.7 Comment: The types of damages included in the assessment are incomplete, as the RCDP describes representative parameters only and additional categories of damages may be identified in the future.

Response: The Trustees have assessed damages as comprehensively as is reasonable given the need to conduct a cost-effective assessment (43 CFR § 11.61(d)(2)). This includes ecological (which consists of benthic invertebrates, soil invertebrates, fish, birds, and mammals), recreational (which includes fishing and hunting), and groundwater losses. We have incorporated assumptions regarding future remedial actions and potential residual contamination into the analysis, described in Appendix D. In addition, restoration is focused on replacing or restoring the full suite of lost services, even those for which the Trustees were not able to quantify injury. For example, ecological restoration under Alternative C is focused on habitat-based restoration, which will benefit the natural resources for which injury was quantified, as well as resources that were exposed to contamination but for which information was insufficient to quantify losses (e.g., amphibians and reptiles).

However, should new information later become available that indicates potential injury to natural resources or resource services that are completely distinct from the injuries and restoration that are the basis of this RCDP, the non-DOE Trustees would meet to discuss whether any additional steps are appropriate and warranted.

4.8 Comment: Assumptions regarding effectiveness of remedial actions are likely unrealistic.

Response: Although the true outcome of remedial actions will not be known until the actions are complete (and sometimes even more years after the action): the remedial design (e.g., clean-up levels, extent of remedial area), and remedial requirements (e.g., TDEC, EPA) are the most reasonable information upon which the Trustees can base estimates of future contamination and associated losses. Even with this information, the Trustees accounted for uncertainty in the success of remedial actions and incorporated long-term future recovery timeframes into the quantification of natural resource damages (Appendix D).

5.0 RESTORATION DETAIL

5.1 Comment: The RCDP does not specify restoration projects, so public cannot evaluate whether the restoration funds will be spent appropriately.

5.2 Comment: There is insufficient information regarding who/which agencies can propose a restoration project.

5.3 Comment: No information regarding public involvement in project proposal/selection process, timeline for restoration, method for allocating and dispersing funds, or project oversight is provided.

5.4 Comment: Restoration projects should not be conducted under DOE environmental contracts.

5.5 Comment: It is unclear whether projects will require detailed NEPA reviews.

5.1-5.5 Response: The Trustees will develop an ORR Natural Resources Restoration Project Selection Procedure (RPSP). The RPSP will provide a framework for the solicitation, evaluation, and selection of resource- and resource-use based restoration projects. The framework will enable the Trustees to identify the projects that best restore natural resources and/or services provided by those resources, protect natural resources, and enhance the environment in and around the ORR. Consistent with Chapter 5 of the RCDP/EA, selected projects should:

- Provide benefits to resources and resource services that were injured as a result of ORR-related contamination.
- Encompass a suite of different restoration actions, all targeted towards benefiting a specific resource or set of resources, as well as the human users of these resources.
- Focus on generating ecological, groundwater, and recreational benefits, such as habitat creation/restoration/enhancement, groundwater infrastructure improvements, and improvements to recreational opportunities and access.

The RPSP will provide details for eligible applicants and project submittal requirements. Projects will be funded through the ORR Fund. For example, the Trustees expect that the RPSP will have a pre-application phase, then invite full proposals to prevent time and money expenditure for ineligible or non-priority projects. The pre-application will be built to screen for NEPA requirements (see responses in Section 8.0 below). The Trustees will make draft restoration plans available for public review and comment following each solicitation, evaluation, and selection.

5.6 Comment: No information regarding estimated costs of potential restoration, preventing evaluation of whether the $42 million is reasonable.

Response: We have included more information on potential restoration project types and costs in Appendix D.

6.0 RESTORATION PROCESS

6.1 Comment: The City of Oak Ridge should be treated as an injured party and intergovernmental partner rather than a general stakeholder.

Response: While municipalities are not trustees per the CERCLA NRDA regulations, the Trustees have conducted outreach to and communicated with the City specifically because of the City's role in supporting their public. Going forward, the Trustees hope the City will submit project proposals when solicited through the Restoration Project Selection Procedure and engage in public participation when draft restoration plans are released for public review.

6.2 Comment: NRDA funds should be easy to access with flexibility for projects to be designed as project proponents prefer.

Response: The Trustees agree.

6.3 Comment: How would NEPA be addressed?

Response: See response under Section 8.0 NEPA.

7.0 REPURPOSING PERPETUAL CARE FUND

7.1 Comment: Repurposing fund is appropriate as long as DOE is required to fund and conduct long-term care.

Response: A specific condition of the settlement is that DOE will still be required to fund and implement monitoring and maintenance of the Environmental Management Waste Management Facility (EMWMF).

7.2 Comment: How will the Trustees ensure that DOE gives the money from the perpetual care fund?

Response: TDEC already holds the money within the perpetual care fund. DOE and TDEC intend to modify the Fund Implementation Plan for the perpetual care fund to apply the funds to this settlement and legally affirm DOE's responsibility for long-term care of the EMWMF. Entry of the Consent Order will allow the Trustees to utilize these funds pursuant to the terms of the settlement and the procedures of the RPSP.

7.3 Comment: Repurposing the fund is inappropriate because that fund is supposed to satisfy the EMWMF ROD, not used to reduce DOE's NRDA liability.

Response: DOE will still be paying for the management and maintenance of the EMWMF; those moneys will now come from a source other than the perpetual care fund. That is, DOE will be paying for the long-term care of the EMWMF *in addition to* the NRD settlement.

8.0 NEPA

8.1 Comment: Nine environmental impacts required under NEPA should be addressed.

8.2 Comment: The EA is useless because the analysis considers broad project types rather than specific actions and therefore an EA/EIS would need to be conducted for all projects proposed through the grant process, which is time consuming and expensive.

8.3 Comment: NEPA requirements vary across agencies and the Trustees should have a plan for consolidating those requirements to simplify the process for assessing projects.

8.1-8.3 Response: The Trustees agree that effectively managing NEPA requirements will be essential to project success. Programmatic EAs, like the EA incorporated into the ORR RCDP, are often the first step in the NEPA process. They are typically developed when project-specific details are unknown, instead evaluating general environmental impacts for various project types. This overarching level of assessment is beneficial, in that it narrows the range of project types to be considered in the next phase of the restoration planning process and provides a framework upon which future project evaluations can build. As individual projects are proposed and site-specific details are known, they will be evaluated for necessary permitting and additional NEPA analysis consistent with standard practice.

9.0 GENERAL

9.1 Comment: The citation style (author-date) makes it difficult and time-consuming for the reader to find the relevant information in the citation. Are there any regulatory or contractual restrictions that prevent the use of page-precise citations?

Response: There are no restrictions of which we are aware.

APPENDIX D | OAK RIDGE RESERVATION NATURAL RESOURCE DAMAGE ASSESSMENT: SUMMARY OF ECOLOGICAL, GROUNDWATER, AND RECREATIONAL DAMAGES

1.0 OAK RIDGE RESERVATION NATURAL RESOURCE DAMAGE ASSESSMENT

The Oak Ridge Reservation (ORR) currently consists of approximately 32,260 acres of federally-owned land and is located in Oak Ridge, Tennessee on the Clinch River. The facilities on-site, constructed in the early 1940s, include the Oak Ridge National Laboratory (ORNL), Oak Ridge Y-12 complex, and East Tennessee Technology Park (ETTP). Activities at these facilities have resulted in the discharge of hazardous substances, including organic contaminants, metals, and radionuclides.

The objective of a Natural Resource Damage Assessment (NRDA) and the ultimate goal of the Trustees is to restore natural resources that have been injured by a hazardous substance(s) to baseline and obtain compensation for public losses pending restoration to that baseline condition. The Trustees conducted a NRDA that follows the CERCLA NRDA regulations (43 CFR Part 11). Their approach to and implementation of the ORR NRDA, including injury determination, injury quantification, and damage determination, are described below.

Under the regulations, Trustees have two NRDA method options (43 CFR § 11.33-11.36):

- Type A relies on a computer model that requires site-related inputs (e.g., mass or volume of the substance released, duration and location of the release, air temperature) and is applied when hazardous substance releases are relatively minor and of short duration.
- Type B which is conducted through the review of existing data and the collection of additional data to fill information gaps. Type B assessments are typically selected when a hazardous substance release occurs over a long timeframe, consists of multiple contaminants, or occurs in a complex system that cannot be simplified and accurately modeled by a computer program.

The ORR NRDA Trustees determined that a Type B assessment is most appropriate for this assessment, as there is no Type A model that can accurately calculate contaminant movement, natural resource exposure, and corresponding adverse effects at ORR. For example, Type A models are designed for coastal and aquatic environments, not upland environments, which would prevent assessment of injury and damages in the terrestrial habitats at the ORR (43 CFR § 11.40 (a)). In addition, even if a Type A model could be applied for all ORR habitats, the data inputs for that model are not available (e.g., mass or volume of the released substance; 43 CFR § 11.41(a,b)), as the type and duration of hazardous substance releases have varied throughout ORR history.

2.0 ASSESSMENT AREA

The Assessment Area includes all areas where contaminants have come to be located within aquatic and terrestrial habitats, whether through human activity (e.g., dumping, burial) or as a result of transport via environmental processes (e.g., groundwater movement, sediment transport). This is described in RCDP/EA Section 3.1.

3.0 NATURAL RESOURCES AND CONTAMINANTS OF CONCERN

Natural resources of concern include all natural resources that comprise or utilize aquatic and terrestrial habitat within the Assessment Area, including, but not limited to, surface water, sediment, soil, plants, insects, fish, amphibians, reptiles, birds, and mammals.

Contaminants of concern (CoCs) include polychlorinated biphenyls (PCBs), cadmium, chromium, mercury and radionuclides (cesium-137, strontium-90, uranium-235, and uranium-238). Other contaminants such as halocarbon solvents and tritium were also released from ORR operations, but data on contaminant concentrations and the effects of these contaminants on natural resources are insufficient to assess injury.

Note that the toxicological implications of natural resource exposure to multiple contaminants in the Assessment Area are variable. Interactions between contaminants in abiotic media depend on environmental parameters such as pH, alkalinity, and organic carbon, and therefore bioavailability and resultant exposures can change over time and geographic area. In organisms, the toxicity of contaminant mixtures can also be affected by parameters such as species, life stage, and nutritional status. Site-specific toxicological information is lacking. Therefore, we assume that the toxicity of these contaminants is additive due to the different modes of toxicity for the various contaminant classes (e.g., organic compounds, metals, and radionuclides).

4.0 REMEDIAL ACTIVITIES

Remedial activities to-date have reduced both hazardous substance releases from the ORR and resulting contaminant levels in the environment. These actions have correspondingly reduced the exposure of natural resources to ORR-related contaminants. For example, remediation activities in Bethel Valley substantially decreased mercury concentrations observed in White Oak Creek (DOE 2010). In addition, the interception and removal of contaminants (volatile organic compounds, metals, PCBs, and minimal alpha and beta radioactivity) from the discharge at the K-1070 C/D Spring, located in the ETTP, has reduced contaminant concentrations in Mitchell Branch (DOE 2007). Remedial actions are summarized in RCDP/EA Section 1.4 and described in more detail in documents such as Records of Decision (RODs), Remedial Investigation and Feasibility Studies (RI/FS), Remediation Effectiveness Reports and EPA 5-Year Reviews. Because the success of ongoing and future remedial actions is uncertain, we assumed a longer recovery period than remedial plans currently predict (see Temporal Scope below).

5.0 INJURY DETERMINATION

Available data indicate that resources within the assessment area have been injured (as defined by the CERCLA NRDA regulations) due to exposure to hazardous substances released from operations at ORR. Determination of injury to natural resources involves documentation that there is:

1) A viable pathway for the released substance from the point of release to a point at which natural resources are exposed to the released substance. A comprehensive summary of pathway information is provided in RCDP/EA Section 3.5.
2) Injury of site-related resources has occurred as defined in 43 CFR §11.62. That is, injury was determined by comparing contaminant concentrations in Assessment Area resources to toxicological data from the literature and regulatory criteria (e.g., water quality criteria), as well as based on the existence of fish consumption advisories.

Injured resources include surface water (surface water and sediment), geologic (soil), groundwater, and biological (aquatic invertebrates, fish, soil invertebrates, birds, and mammals) resources. Details are provided in RCDP/EA Sections 3.6.1, 3.6.2, 3.7, and 3.81.

6.0 INJURY QUANTIFICATION

Injuries in the Assessment Area are quantified based on lost resource services, accounting for baseline. Services are "the physical and biological functions performed by the resource" (43 CFR § 11.14 (nn)). A reduction in the ability of a resource to provide these services, as compared to the baseline level of services, is considered a service loss.

6.1 BASELINE

Baseline is "*the condition or conditions that would have existed at the study area had the…release of a hazardous substance…not occurred*" (43 CFR § 11.14 (e)), taking into account natural processes and changes resulting from human activities. Baseline conditions include all environmental parameters, not only concentrations of the contaminants. Because data from the Assessment Area prior to releases from ORR facilities is not available, the Trustees used data from reference locations to inform baseline conditions in the Assessment Area. These locations include Fort Loudoun Dam approximately six miles from ORR for background radiation rates, and numerous creeks upstream of ORR to inform baseline levels of contaminants in fish tissue (DOE 2020, 2021). The contaminant levels at these reference sites are below levels expected to cause injury to natural resources (see RCDP/EA Exhibit 3-6 for injury thresholds). Therefore, the Trustees determined that baseline for ORR is a DOE facility without contamination of natural resources at injurious levels (i.e., physical structures would still have existed, but the baseline concentrations of contaminants would be below levels that cause a loss in resources services). That is, all of the contaminant-related losses in ecological, recreational, and groundwater services calculated for Assessment Area resources are attributed to releases of hazardous substances from ORR.

6.2 ECOLOGICAL LOSSES

Because of its large spatial extent, the Assessment Area was divided into sub-sections based on environmental parameters (e.g., hydrology, topography; see RCDP/EA Exhibit 3-1). Within each sub-section, ecological losses were quantified for representative resources using COC concentration data in conjunction with literature-based adverse effects thresholds. For each COC, ecological service losses associated with contaminant concentrations were developed based on a weight-of-evidence in the literature of the severity and magnitude of effects on growth, reproduction, and/or survival at that contaminant concentration. Recovery was assumed to be complete in 2109 (100 years from the date of the analysis) based on the physical, chemical, and biological characteristics of the COCs.[31] Losses were combined across contaminants and representative resources within each sub-section. Habitat equivalency analysis (HEA), a standard method in NRDA (43 CFR § 11.83(c)(2)(x)) was then used to quantify losses across space and time.

The premise of HEA is that the public can be compensated for past and expected future losses in ecological services through the provision of additional ecological services in the future. These "compensatory" services are *in addition* to actions taken to restore the resource to its baseline condition (i.e., the condition it would have been in absent the harm), since simply restoring the resource to its baseline condition after an extended period of time will not make the public whole.

[31] In addition, the effect of discounting makes any losses past 100 years negligible.

Within equivalency analyses, both service losses and compensatory service gains are typically measured in terms of a "unit-time" (e.g., acre-years), which incorporates both the geographic and temporal nature of the injury. Each acre-year represents the existence of one acre of a particular habitat for one year. The concept of an acre-year allows the analysis to consider not only the *number* of acres lost as a result of the adverse effects, but also the fact that these acres have not had the baseline level of services *each year* for some period of time. Use of the acre-year metric also allows losses to be scaled with gains in ecological services from restoration (i.e., the services provided by an acre of restored habitat over a period of time.

This equivalency is established by determining the present value of each (i.e., compounding past losses and discounting future losses and gains). Current federal policies, available literature, and standard practice in NRDA indicate that a three percent real discount rate for the value the public holds for natural resources is reasonable (e.g., NOAA 2006, NOAA 1999, Unsworth and Bishop 1994, Freeman 1993, Unsworth and Peterson Undated).

For the ORR NRDA, injury to Assessment Area resources was quantified as the average percentage service loss across representative resources within each habitat, accounting for baseline. Although available data indicated that injury to additional natural resources that rely on these habitats may have occurred (e.g., bats, large mammals), data were insufficient to quantify these losses. However, because losses were calculated on a habitat basis, injuries to these other species groups were qualitatively incorporated. In addition, based on the restoration project types under the Preferred Alternative C, restoration projects implemented to compensate for damages will benefit all species groups associated with the restored or preserved habitat.

Results indicate that approximately 204,861 present value acre-years of aquatic and terrestrial habitat were lost.[32] Additional details are provided below and summarized in Exhibit D-1.

Aquatic

Sediment, fish, piscivorous birds, and piscivorous mammals were selected as representative resources for quantification of injury to the aquatic habitat. Using site-specific sediment and fish COC concentrations in each sub-assessment area, the average concentration for non-radionuclide COCs was calculated (1981-2010). Fish tissue concentrations were also used to estimate dietary exposure to piscivorous birds and mammals. Fish tissue contaminant concentrations are a reasonable indicator of piscivorous animals' dietary exposure, and much of the literature information on adverse effects is based on dietary concentrations. For radionuclides, average sediment concentrations were input into RESRAD-BIOTA to estimate the radiological dose to fish, aquatic invertebrates, and riparian animals. The RESRAD-BIOTA model estimates a total radiological dose per day to target organisms exposed to a suite of radionuclides. For all COCs, site-specific exposure and literature data were used to estimate service loss at the calculated average concentrations. Within each sub-area, service losses were combined across COCs,[33] then averaged across resources. Future losses were assumed to decline linearly to zero between 2010 and 2109. HEA results indicate that approximately 14,912 present value acre-years were lost (Exhibit D-1).

[32] Using a standard three percent discount rate.

[33] This analysis assumes that toxicity is additive, based on the assumption that different CoCs exhibit different modes of toxicity. However, the percentage of ecological services lost cannot exceed 100 percent for an area in any given year. Therefore, the percentage loss due to each contaminant is applied only to remaining services. For example, if PCBs cause a ten percent reduction in services and lead causes a 20 percent reduction in services, the 20 percent loss due to lead is applied only to the 90 percent of services remaining after accounting for PCB injury. Losses due to a third contaminant would then be applied to the services remaining after accounting for both PCBs and lead. Note that the resulting percentage service loss is the same irrespective of the order in which contaminants are assessed.

EXHIBIT D-1 SUMMARY OF ECOLOGICAL LOSSES

ASSESSMENT AREA	COCS DRIVING INJURY	REPRESENTATIVE RESOURCES INCURRING SERVICE LOSSES	AVERAGE SERVICE LOSS ACROSS REPRESENTATIVE RESOURCES	DISCOUNT SERVICE ACRE-YEARS LOST
AQUATIC				
Lower Clinch	Mercury, PCBs, Radionuclides	Sediment, fish	2%	2,489
Upper Clinch	PCBs, Radionuclides	Sediment, fish	2%	4,418
East Fork Poplar Creek	Mercury, Cadmium, PCBs, Radionuclides	Sediment, fish, piscivorous mammals, piscivorous birds	45%	1,906
Poplar Creek	Mercury, Cadmium, PCBs, Radionuclides	Sediment, fish, piscivorous mammals, piscivorous birds	35%	6,067
White Oak Creek	PCBs	Sediment, fish, piscivorous birds	2%	32
			Aquatic Sub-total	**14,912**
TERRESTRIAL				
Black Oak Ridge to Pine Ridge	Chromium, Mercury	Soil	21%	74,478
Pine Ridge to Chestnut Ridge	Chromium, Mercury	Soil, small mammals	21%	48,337
Chestnut Ridge to Haw Ridge	Chromium, Mercury	Soil	21%	37,603
Haw Ridge to Copper Ridge	Chromium	Soil	21%	14,203
EFPC Floodplain	Chromium, Mercury	Soil, small mammals	40% pre-remedy 28% post-remedy	15,328
			Terrestrial Sub-total	**189,949**

Terrestrial

Soil, terrestrial birds, and small mammals were selected as representative resources for injury to Assessment Area terrestrial habitat. For soil in each sub-section, an inverse-distance weighting approach was used to calculate the average concentration for COCs using available site-specific data (1981-2010). This accounts for the fact that sampling efforts for terrestrial areas within ORR have been, for the most part, clustered around facilities and operational activities, and ensures that those samples are not overly weighted in the analysis. Loss to soil was measured as adverse effects on soil invertebrates (e.g., earthworms). For non-radionuclide COCs, soil-to-biota accumulation factors were used to estimate exposure in birds and small mammals. For radionuclides, similar to the aquatic analysis average soil concentrations were input into RESRAD-BIOTA to estimate the radiological dose to small mammals. For all COCs, site-specific toxicity and literature data were used to estimate service loss at the calculated average concentrations. Within each sub-area, service losses were combined across COCs, then averaged across resources. Future losses were assumed to decline linearly to zero between 2010 and 2109. HEA results indicate that approximately 189,949 present value acre-years were lost (Exhibit D-1).

6.3 GROUNDWATER LOSSES

Injury to groundwater resources was quantified as the volume of groundwater contaminated above drinking water maximum contaminant levels (MCLs) within specific groundwater plumes (Exhibit D-2).[34] Groundwater volume was estimated using two approaches, depending on the location of the groundwater plume. For on-site areas where extensive use of groundwater did not occur in the past and is unlikely to occur in the future even in the absence of contamination, a stock volume was used. For publicly accessible areas where demand could occur (including Parcel A adjacent to Y-12, at ETTP, and near Melton and Bethel Valleys), a measure of flux was used. Local conditions were classified either as Knox aquifer or aquitard, and then typical flux and/or volumetric characteristics were applied to each type of hydrogeologic environment.

Stock was calculated by multiplying the area of the plume that exceeds the MCL by the estimated thickness of the useful contaminated zone and the effective porosity of the aquifer. Reported average values of effective porosity and discussions with Trustees resulted in the use of 0.6 percent as the effective porosity. The primary groundwater flow zones in both types of formations are confined to the upper 40 to 50 feet (i.e., weathered zone). Below that, fractures become smaller, less frequent, and there is very little permeability. An average of 44.5 feet was used for the affected thickness of all plumes. The stock volume is calculated as a one-time volume (1.01×10^7); that is, losses are not extrapolated into the future (Exhibit D-3).

Flux is estimated based on the horizontal flux of groundwater in the formation per unit formation width, using reported values of average groundwater discharge rates into surface water bodies at ORR (primarily the Clinch River and its tributaries), for both aquitard (1,545 ft^2/year/linear foot of stream) and Knox aquifer (5,772 ft^2/year/linear foot) formations. Loss volume due to flux estimates were computed by estimating the annual flux volume (3.86×10^7 ft^3/year) in present value terms from 1989 (the time when Parcel A was transferred from DOE to the City of Oak Ridge) until 2094 using a three percent discount rate. The total present value flux volume is 2.43×10^9 ft^3 (Exhibit D-3).

The total injured volume of groundwater is 2.44×10^9 ft^3 (Exhibit D-3).

[34] The entire volume of contaminated plumes was also evaluated. However, the difference between the total present value plume volume and the total present value volume of groundwater above MCLs was insignificant (<0.1 percent difference).

EXHIBIT D-2 GROUNDWATER PLUME MAP

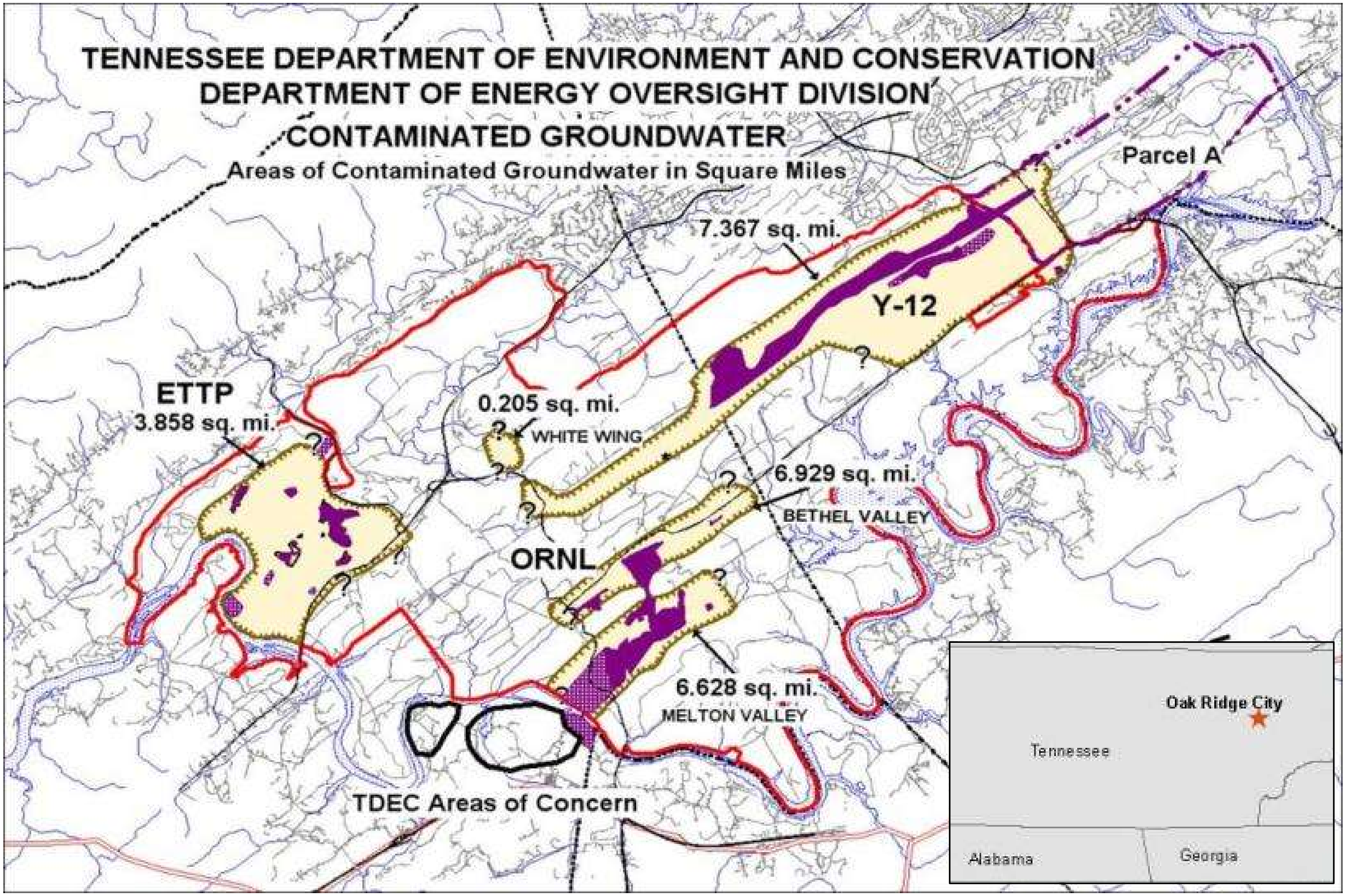


EXHIBIT D-3 INJURED GROUNDWATER VOLUME ESTIMATES

ORR SUB-AREA	FLUX, FT^3/YEAR
ETTP	1.67×10^7
Melton Valley	4.21×10^6
Parcel A (off-site near Y-12)	2.89×10^6
TDEC (two areas off-site)	1.47×10^7
Sub-total	**3.86×10^7**
Total Present Value flux volume (from 1989 - 2094)	**2.43×10^9**
ORR SUB-AREA	**STOCK VOLUME, FT^3**
Melton Valley	7.35×10^5
Bethel Valley	1.54×10^6
Bear Creek Valley	7.85×10^6
Parcel A (off-site near Y-12)	1.07×10^4
Sub-total	**1.01×10^7**
Total Injured Groundwater (flux + stock volume)	**2.44×10^9 ft^3**

6.4 RECREATIONAL LOSSES

The release of COCs from ORR has impaired recreational services on ORR and in adjacent areas. In particular, the presence of fish consumption advisories (FCAs) on the Clinch River and Melton Hill Reservoir, as well as periodic retention of deer and turkey taken from the reservation due to radiological contamination have reduced the value of fishing and hunting opportunities. Fishing and hunting losses were estimated using site-specific estimates of fishing and hunting effort in conjunction with valuation information from the economics literature in a standard application of the benefit transfer methodology, which is identified in the CERCLA NRDA regulations as an acceptable method for damage determination (43 CFR § 11.83(c)(2)(vi)). Benefits transfer involves adapting research estimating economic values under one set of circumstances to an alternate situation. In this manner, existing valuation research was combined with estimates of recreational fishing to develop a damage estimate. Total present value losses associated with lost recreational opportunities are approximately $6.6 million.

Review of available information indicated that losses to boaters and additional costs associated with 26(a) permits due to ORR-related contamination were unlikely. Therefore, the Trustees did not quantify these types of losses.

FISHING

In accordance with the CERCLA NRDA regulations, the Trustees' approach to quantifying recreational fishing losses on the Clinch River arm of the Watts Bar Reservoir and Melton Hill Reservoir focused on estimating economic welfare losses associated with the presence of FCAs, measured as a reduction in consumer surplus. Consumer surplus reflects the benefit that accrues to consumers when the amount they must spend to enjoy a good or service is less than the maximum amount they would be willing to spend. If the amount a consumer must spend for a good or service increases, or the maximum amount they would be willing to pay decreases, the consumer experiences a loss of value (referred to as an “economic welfare loss”).

For the ORR NRDA, we relied on existing valuation research conducted in similar contexts and combined this information with site-specific data to develop an estimate of recreational fishing losses.

The economics and social science literature contains numerous examples of anglers’ behavioral responses to FCAs, including changes in avidity, site choice, and preparation and cooking methods. These behavioral changes, as well as others, may lead to economic welfare losses. Using existing creel survey data and economic literature, we estimated two categories of damages:

- **Diminished experience.** Anglers fishing in the waterbodies around ORR may suffer a diminished experience because they are discouraged from keeping their catch.
- **Decreased avidity.** Anglers may take fewer trips to the assessment area as a result of the FCAs. In the extreme case, some individuals who would otherwise fish may forego angling altogether because of the presence of contaminants.

Angler Effort

We estimated the number of anglers on the Melton Hill Reservoir and Watts Bar Reservoir using information from creel surveys conducted from 1999 to 2009 by the Tennessee Wildlife Resources Agency (TWRA).

Melton Hill Reservoir (Melton Hill Dam to Elza Gate)

The Melton Hill Reservoir extends from Melton Hill Dam to the town of Clinton, Tennessee, which is the upstream boundary of the creel survey.[35] The Assessment Area, extending from the Melton Hill Dam upstream to the DOE Elza Gate site (Elza Gate is downstream of Clinton), is approximately 4,200 acres. Because approximately 85 percent of the reservoir is included in the Assessment Area, we adjusted annual angler trips accordingly, calculating 19,648 trips per year (roughly 4.6 trips per acre) based on the average of creel data from 2004-2009 (Exhibit D-4). For 2004 to 2009, we used the actual numbers provided in the creel surveys. We assumed constant pressure in the past, from 1990 (year the FCA was put in place) to 2016.[36]

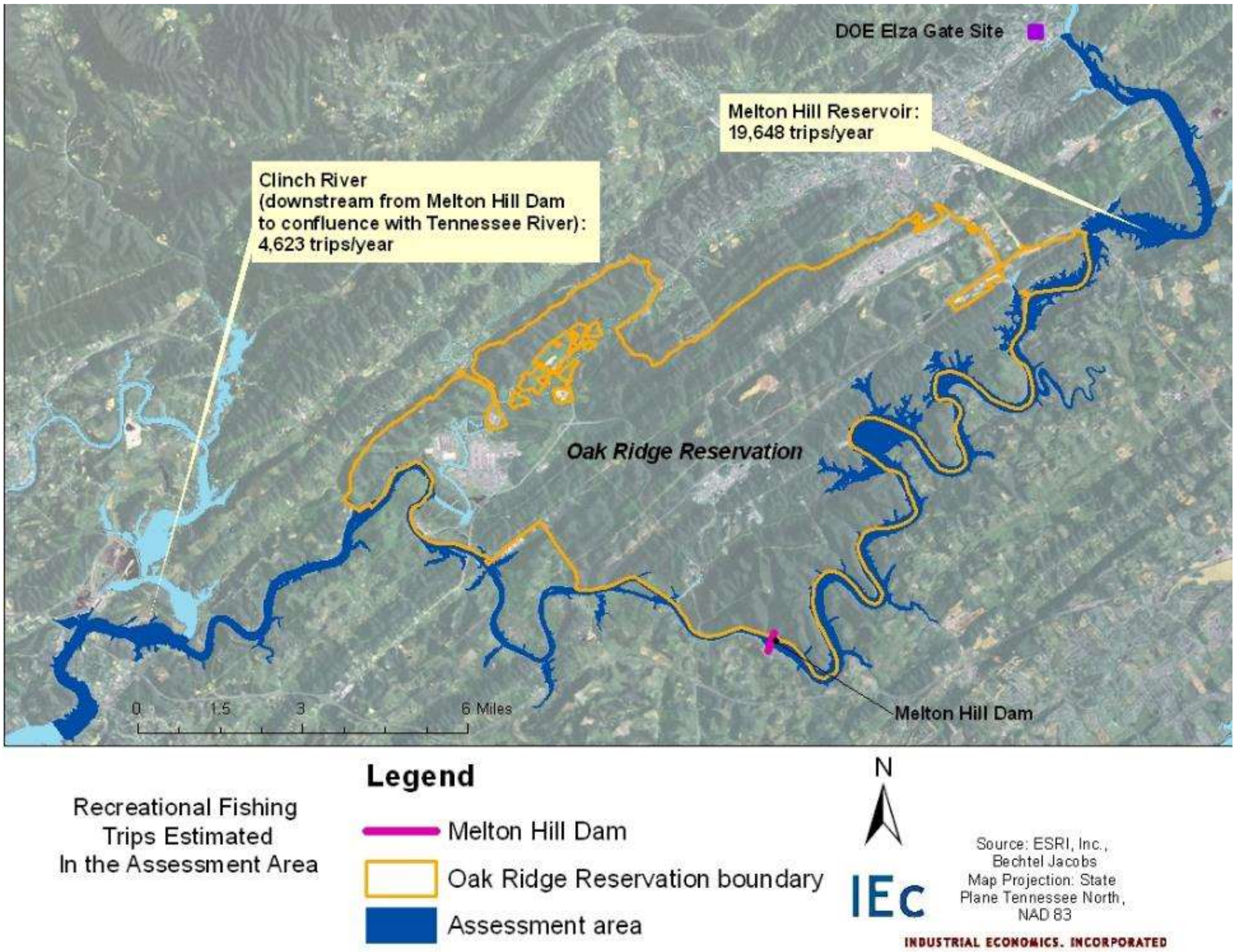
Clinch River, downstream (Melton Hill Dam to the confluence)

The Clinch River extends from the Melton Hill Dam to the confluence of the Tennessee River. This area encompasses most of the “Clinch River arm” of Watts Bar Reservoir. We calculated this area to be slightly over 2,200 acres and that approximately 5 percent of the Reservoir is included in the Assessment Area, resulting in a corresponding adjustment to annual angler trips.

Using the average angler pressure estimates from 2004 to 2009, we calculated that there were 4,623 trips per year in the Assessment Area, or approximately two trips per acre (Exhibit D-4). For 2004 to 2009, we used the actual numbers provided in the creel surveys. We assumed constant pressure from 1990-2003 and from 2010-2016.

[35] Personal communication with Jim Negus, TWRA.
[36] Creel survey data exist from 2002 and 2003. However, 2002 appears to be an outlier (nearly twice the effort of some subsequent years) and 2003 includes only five months of data.

EXHIBIT D-4 ESTIMATED RECREATIONAL FISHING TRIPS IN THE ASSESSMENT AREA



Economic Values

A literature search was conducted to identify existing studies that would support an estimate of losses associated with diminished angler experience and decreased avidity. These studies utilize data on angler site choices to determine how anglers trade off quality attributes (i.e., water quality, FCAs, catch rates, and access conditions) with travel costs, or, in some cases, elicit these preferences from anglers directly. The estimated economic values represent the per-trip gain associated with improving contaminated conditions and/or removing/reducing FCAs, or for purposes of this analysis, the loss associated with their presence. Similarly, some of these studies provided estimates of the likely change in the number of fishing trips taken in light of site improvements.

Best-practice guidelines for benefit transfer analyses emphasize the similarity of resources and valuation context when selecting relevant studies. Thus, we considered only those that examine changes in FCAs specifically, as opposed to general changes in water quality or scenarios not explicitly describing changes in FCAs. Of these studies, three rely on data from Tennessee reservoirs that are the most similar to the Clinch River and Melton Hill Lake in terms of angler experience (Exhibit D-5).

EXHIBIT D-5 SUMMARY OF RELEVANT RECREATIONAL FISHING VALUATION LITERATURE - EFFECT OF CHANGES IN FCAS ON TRIP VALUES AND PARTICIPATION

AUTHORS	STUDY LOCATION	SCENARIO EVALUATED	CHANGE IN VALUE ($2010)	CHANGE IN PARTICIPATION
Jakus et al. 1997	Tennessee reservoirs	Remove FCAs	$2.55 to $3.95 per trip	3.4% increase in number of trips
Jakus et al. 1998	Tennessee reservoirs	Remove FCAs at 6 of 14 sites	$1.98 to $9.68 per trip	Not reported
Parsons et al. 1999	Middle Tennessee reservoirs	Remove FCAs at 2 of 14 sites	$2.47 to $2.57 per trip	0.6% to 2.7% increase in number of trips
Note: Values adjusted to current dollars (mid-year 2010$) using the GDP Implicit Price Deflator				

Based on the TN reservoir studies, we applied a loss per trip of $3.50, which is reasonable for the Assessment Area and is close to the average of the three study results. Similarly, the Trustees calculated the expected number of trips taken to the river to be 2.5 percent greater, but for the FCAs, consistent with the average of values from Jakus et al. (1997, 1998) and Parsons et al. (1999).

To identify an appropriate baseline per-trip value for fishing in the assessment area (to quantify losses associated with foregone trips), the Trustees reviewed the economics literature for valuation studies addressing sites with similar attributes (e.g., region, species, water type, etc.). Exhibit D-6 summarizes value estimates from the three most relevant studies. Based on these studies, we applied a value of $30.00 per lost trip (consistent with the average of the three studies).

EXHIBIT D-6 SUMMARY OF RECREATIONAL FISHING VALUATION LITERATURE - BASELINE PER DAY/TRIP VALUES

AUTHORS	COMMODITY VALUED	VALUE ESTIMATE ($2010)
McCollum et al. 1990	Total consumer surplus per day associated with warmwater fishing in Forest Service Region 9 (includes Tennessee)	$18.83 per day
Jakus et al. 1997	Total consumer surplus per trip associated with Tennessee reservoir angling	$34.64 per trip
FWS 2006	Total consumer surplus per day associated with bass fishing for Tennessee residents	$35.71 per day
Note: Values adjusted to $2010 using the GDP Implicit Price Deflator		

Temporal Scope of Damages

We estimated losses on the Clinch River and Melton Hill Reservoir beginning in 1990 when FCAs were first put in place, through 2016 (five years after the analysis was conducted). Since 2006, the average PCB concentrations in fish have been at or below approximately 0.02 parts per million (ppm). According to 21 CFR § 109.30, the tolerance for PCBs in the edible parts of fish and shellfish (excluding head, scales, viscera and inedible bones) is two ppm.

Fish tissue PCB concentration data are insufficient to estimate a trend in PCB levels over time. While PCB concentrations fluctuate due to natural variability, without any remedial actions planned in the Clinch River or Melton Hill Reservoir, (which may resuspend or rerelease additional PCBs to the system), it is unlikely the fluctuations will be sufficient to cause fish PCB concentrations to exceed 2 ppm. Therefore, we assumed that five additional years of PCB concentrations below the tolerance level would be sufficient for the FCA to be removed in 2016.

Damage Estimation

In this section, the valuation information on fishing trips diminished and forgone was combined with the estimates of fishing pressure to estimate aggregate recreational fishing losses on an annual basis using the following steps:

- **Step 1: Calculated Diminished Trip Losses.** Diminished trip losses were calculated by multiplying the number of annual trips by the estimated per-trip decrement in value ($3.50).
- **Step 2: Calculated Forgone Trip Losses.** Forgone trip losses were calculated by applying the percentage of trips not taken (2.5%) to the total number of annual trips (constant over time). The number of trips was then multiplied by the per-trip value ($30).
- **Step 3: Sum Annual Losses.** In the final step, annual losses were summed over the relevant time period and expressed as of 2010 using a three percent discount rate. Losses begin in 1990 and were assumed to end in 2016 based on an estimated date of removal of the FCA.

We estimated total losses from recreational fishing days lost and forgone on the Melton Hill Reservoir of approximately $2.8 million. On the Clinch River from the Melton Hill Dam to the confluence, total losses are nearly $700,000. Total losses on both rivers combined, from both fishing trips lost and forgone is approximately $3.5 million.

HUNTING

Both deer and turkey hunting take place on ORR (also known as the Oak Ridge Wildlife Management Area). Deer hunting has occurred on-site since 1985, typically over three to five weekends each fall. Hunter participation is determined by an application process and quota system. As of 2010, hunters were allowed to take two deer, no more than one antlered. Each deer taken on the reservation must be monitored for radiological contamination at a checking station. Between 1985 when the hunts began through 2010, 197 out of 10,669 deer have been retained (1.8 percent).

Turkey hunting has occurred on-site since 1997. There are two weekends per year when hunts take place, which are also organized by a quota system. Similar to deer, all turkeys are monitored for radiological contamination at a checking station. Between 1997 and 2010, 3 out of 530 turkeys have been retained (0.5 percent).[37]

[37] Game taken off-site may also be brought to the checking station at the hunters' discretion (Jim Evans, TWRA, personal communication).

Approach

Hunters must have deer and turkeys taken from ORR evaluated for radiological contamination and their harvest may be retained if levels exceed established standards. This restriction constitutes an injury to recreational hunting resources. Because there is some probability that hunters will not be permitted to keep their harvest, the value of hunting trips to the ORR is less than it otherwise would be.

Hunter Effort

Information on quotas and annual harvest are available in the TWRA Big Game Hunting Reports. In 1986 and 1987, there were five deer hunt weekends, four in 1988. Since 1989, there have been three weekends per year. Each weekend features a mix of archery and gun hunts. The total number of quotas per year generally ranges from 2,500 to 4,650. Between 2005 and 2010, quotas have generally been around 3,000. We expected quota numbers in the future will be similar to the previous five years, and projected quotas of 3,300 for each year into the future.[38]

The Big Game reports provide information on the estimated number of deer hunters each weekend for certain years, and we used this as the number of trips taken to ORR in those years. Note that a quota does not necessarily imply a trip. In years where actual hunter estimates are not available, we assumed that 90 percent of the quotas are fulfilled for the first weekend hunt, 80 percent for the second, 70 percent for the third, 60 percent for the fourth, and 50 percent for the fifth.[39]

Turkey hunting began on the reservation in 1997. There are two weekends with approximately 200 quotas, all of which are fulfilled.[40]

Economic values

A literature search was conducted to identify existing studies that would support an estimate of losses associated with diminished probability of a successful hunt (e.g., the potential for harvest to be retained due to contamination). While the economics literature contains numerous examples of per-trip values for a variety of hunting opportunities, relatively few studies examine the value of marginal (incremental) changes in success. Of particular relevance, Mackenzie (1990) estimates the marginal value of a one percent increase in the probability of bagging a deer as $6.84. Adjusting this value to 2010$ and applying the average annual 1.8 percent probability that a taken deer may be retained, we derived a reduced value of ORR deer hunting trips of $19.12. In the absence of comparable estimates specific to turkey or other smaller game, we utilized the same value adjusted for the average annual 0.5 percent probability, or $5.31 per trip.

Temporal Scope of Damages

We calculated losses from 1985 onwards for deer, and 1997 onwards for turkey. No hunts took place on the reservation in 2001. We projected losses through 2040, and assume the same retention rates throughout.

Damage Estimation

In this section, the Trustees combined the valuation information on diminished hunting trips with the number estimated trips to determine hunting losses on an annual basis. The specific steps taken to calculate losses were:

---

[38] Deer hunt data were not available for the years 1985 and 1995. Data from 1986 and 1994, respectively, were substituted as a proxy.
[39] Based on estimates provided by Jim Evans, TWRA.
[40] Personal communication with Jim Evans, TWRA.

- **Step 1: Calculated Diminished Trip Losses.** Diminished trip losses were calculated by multiplying the number of annual trips by the estimated per-trip decrement in value ($19.12). The annual number of trips for turkey and deer is assumed to remain constant in the future.
- **Step 2: Sum Annual Losses.** Annual losses were summed over the relevant time period and expressed as of 2010 using a three percent discount rate. Losses were assumed to begin in 1985 for deer and 1997 for turkey, and were assumed to conclude in 30 years (2040).

We calculated total losses from diminished deer hunting trips of approximately $3.0 million. For turkey, losses are approximately $75,000.

7.0 DAMAGE DETERMINATION

With an understanding of the type and magnitude of natural resource damages due to contamination from ORR, the State of Tennessee, the Tennessee Valley Authority, and the U.S. Fish and Wildlife Service estimated the compensation sufficient to offset those damages and make the public whole.

The settlement proposal of $42 million is based on the cost of restoration of ecological and groundwater services of similar type and quality as those lost due to ORR-related contamination, the value of lost recreational opportunities, plus the estimated cost of restoration planning, adjusted to account for the passage of time between when the analysis was conducted and when the settlement was reached (Exhibit D-7). This does not include past assessment costs.

EXHIBIT D-7 PROPOSED ORR NRDA SETTLEMENT

RESOURCE SERVICE		COST OF COMPENSATION ($M)[1]
Ecological	Terrestrial	$19.7[2]
	Aquatic	$2.1
Recreation	Fishing	$3.5
	Deer	$3.0
	Turkey	$0.1
Groundwater	Groundwater[3]	$9.7
Total[4]		**$38.1**
Total Adjusted for Passage of Time[4]		**$42.0**

Notes:
1. Ecological and groundwater compensation was based on average restoration project costs and benefits. Recreational compensation was based on the value of lost and diminished trips.
2. Includes the cost of restoration planning for all project types.
3. Assumes the cost of groundwater restoration is $4 per 1000ft^3.
4. Total does not include past assessment costs.

7.1 ECOLOGICAL COMPENSATION

The types of projects used to generate an average cost and quantity of ecological benefit per acre of restoration included land acquisition, conservation easements, aquatic habitat restoration, and invasive species control in aquatic and terrestrial habitats. Based on project information provided by the Trustees, the average cost of terrestrial and aquatic restoration is approximately $878 and $2,126 per acre, respectively, and corresponding average benefits are approximately eight and 15 DSAYs per acre. In order to provide sufficient ecological services to compensate for losses, approximately 22,620 acres of terrestrial habitat and 1,009 acres of aquatic habitat need to be restored, at a cost of approximately $19.7 million and $2.1 million, respectively. The terrestrial estimate includes an additional $0.2 million for bat cave restoration, as bats require specific habitat characteristics that would not be generated as part of the project types described above, and $0.2 million for restoration planning for all project types.[41]

7.2 GROUNDWATER COMPENSATION

The types of projects used to generate unit costs of groundwater restoration include stormwater management, wellhead protection, and sealing of abandoned oil and gas wells. Based on project information provided by the Trustees and other relevant parties, average cost per 1000 ft^3 of groundwater protection is estimated to be up to $4, and corresponding average benefits per acre are 720,000 present value ft^3. In order to provide sufficient groundwater services to compensate for losses, approximately $2.4x10^9$ ft^3 of groundwater need to be restored, at a total cost of approximately $9.7 million. The restoration planning costs included in the ecological compensation estimate are also sufficient to include planning for groundwater restoration.

7.3 RECREATION COMPENSATION

Compensation for recreational losses associated with diminished or forgone fishing and hunting trips is estimated as the lost value of those trips. As described above, losses total approximately $6.6 million, including $3.5 million for fishing and $3.1 million for hunting. The restoration planning costs included in the ecological compensation estimate are also sufficient to include planning for recreational restoration.

REFERENCES

DOE (United States Department of Energy). 2007. 2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee, DOE/OR/01-2289&D3, U.S. Department of Energy, Environmental Sciences Division, Oak Ridge, TN.

DOE. 2010. 2010 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee. Data and Evaluations. Prepared by the Water Resources Restoration Program with Bechtel Jacobs Company LLC. September.

DOE. 2020. 2020 Remediation Effectiveness Report for the U.S. Department of Energy – Oak Ridge Site – Oak Ridge, Tennessee. Prepared by the Water Resources Restoration Program UCOR Jacobs. March.

[41] These restoration planning funds will also be used for evaluating groundwater and recreational projects.

DOE. 2021. Oak Ridge Reservation Annual Site Environmental Report 2020. Prepared by UT-Battelle, LLC, Consolidated Nuclear Security, LLC, UCOR with Jacobs, and Professional Project Services, Inc. https://doeic.science.energy.gov/aser/aser2020/index.html. September.

Freeman, A.M. 1993. Measurement of Environmental and Resource Values: Theory and Methods.

FWS (U.S. Fish and Wildlife Service). 2006. Net Economic Values for Wildlife-Related Recreation in 2006 Addendum to the 2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation. Report 2006-5.

Jakus, P.M., M. Downing, M.S. Bevelhimer and J.M. Fly, 1997. Do Sportfish Consumption Advisories Affect Reservoir Anglers' Site Choice. *Agricultural and Resource Economics Review,* 26(2).

Jakus, P. M., D. Dadakas, and J.M. Fly. 1998. Fish Consumption Advisories: Incorporating Angler-Specific Knowledge, Habits, and Catch Rates in a Site Choice Model. *American Journal of Agricultural Economics.* 80(5). 1019-24.

Mackenzie, John. "Conjoint Analysis of Deer Hunting." *Northeastern Journal of Agricultural and Resource Economics* 19,1(1990):109-117.

McCollum, D.W., G.L. Peterson, J.R. Arnold, D.C. Markstrom and D.M. Hellerstein, 1990. The Net Economic Value of Recreation on the National Forests: Twelve Types of Primary Activity Trips Across Nine Forest Service Regions, U.S. Forest Service Research Paper RM-289.

NOAA (National Oceanic and Atmospheric Administration). 2006. Habitat Equivalency Analysis: An Overivew. Damage Assessment and Restoration Program.

NOAA. 1999. Discounting and the Treatment of Uncertainty in Natural Resource Damage Assessment. Technical Paper 99-1. Damage Assessment and Restoration Program. February 19.

Parsons, G.R., P.M. Jakus and T. Tomasi, 1999. A Comparison of Welfare Estimates from Four Models for Linking Seasonal Recreational Trips to Multinomial Logit Models of Site Choice. *Journal of Environmental Economics and Management,* 38, 143-57.

Unsworth, R.E. and Bishop, R.C. 1994. Assessing natural resource damages using environmental annuities. *Ecological Economics* 11:35-41.

Unsworth R. and T. Peterson. Undated. A Manual for Conducting Natural Resource Damage Assessment: The Role of Economics. Prepared for the Division of Economics, Fish and Wildlife Service, U.S. Department of the Interior.