Assessment Plan: Smurfit-Stone/Frenchtown Mill Site
Frenchtown, Montana

Prepared for:

Montana Natural Resource Damage Program
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Acronyms

ALC	aquatic life criteria
AM	Assessment Manager
AOC	Administrative Order on Consent
BERA	Baseline Ecological Risk Assessment
BT	benefits transfer
CAA	Clean Air Act
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CMC	Criterion Maximum Concentration
COC	chain of custody
COPEC	contaminant of potential ecological concern
CV	contingent valuation
CWA	Clean Water Act
DOI	U.S. Department of the Interior
DQO	data quality objective
DSAY	discounted service acre-year
Eco-SSL	Ecological Soil Screening Level
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
FCA	fish consumption advisory
FEMA	Federal Emergency Management Agency
FS	feasibility study
FTL	Field Team Leader
FWPCA	Federal Water Pollution Control Act
HEA	habitat equivalency analysis resource equivalency analysis
IBA	Important Bird Area
MCL	Maximum Contaminant Level
MDEQ	Montana Department of Environmental Quality
MDHES	Montana Department of Health and Environmental Services
MDPHHS	Montana Department of Public Heath and Human Services
MFISH	Montana Fisheries Information System
MFWP	Montana Fish, Wildlife, and Parks
MPDES	Montana Pollutant Discharge Elimination System
MRL	Montana Rail Link
MTNHP	Montana Natural Heritage Program

NCP	National Contingency Plan
NPL	National Priorities List
NRDA	natural resource damage assessment
NRDP	Natural Resource Damage Program
NWPCC	Northwest Power and Conservation Council
ORNL	Oak Ridge National Laboratory
OU	operable unit
PCB	polychlorinated biphenyl
PI	Principal Investigator
PM	Project Manager
PRP	potentially responsible party
PSD	passive sampling device
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RCDP	Restoration and Compensation Determination Plan
RCRA	Resource Conservation and Recovery Act of 1976
REA	resource equivalency analysis
RI	remedial investigation
RIWP	Remedial Investigation Work Plan
RPD	Relative Percent Difference
SAP	sampling and analysis plan
SDWA	Safe Drinking Water Act
SLERA	Screening Level Ecological Risk Assessment
SMCL	Secondary Maximum Contaminant Level
SOP	standard operating procedure
SRM	standard reference materials
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TCDF	2,3,7,8-tetrachlorodibenzofuran
TEF	Toxic Equivalency Factor
TEQ	toxic equivalency
tpd	tons per day
TRV	toxicity reference value
UM	University of Montana
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
ww	wet weight

1. Introduction

The Smurfit-Stone/Frenchtown Mill Site (the Site) is a former pulp and paper mill in Frenchtown, Montana, approximately 11 miles northwest of Missoula. The mill property lies adjacent to the Clark Fork River and is partially within its floodplain (Figure 1.1).[1] It was an operating pulp and paper mill from 1957 to 2010, mainly producing kraft linerboard that was in turn used to manufacture corrugated cardboard (NewFields, 2015; U.S. EPA, 2017c). The U.S. Environmental Protection Agency (EPA) proposed adding the Site to the National Priorities List (NPL) on December 12, 2013 (U.S. EPA, 2013); it has not yet been listed (U.S. EPA, 2021b). In 2015, EPA entered into an Administrative Order on Consent (AOC) with potentially responsible parties (PRPs; see Section 1.3) to conduct a remedial investigation (U.S. EPA, 2015). EPA, the Montana Department of Environmental Quality (MDEQ), and the PRPs have been conducting remedial investigation and site characterization activities.

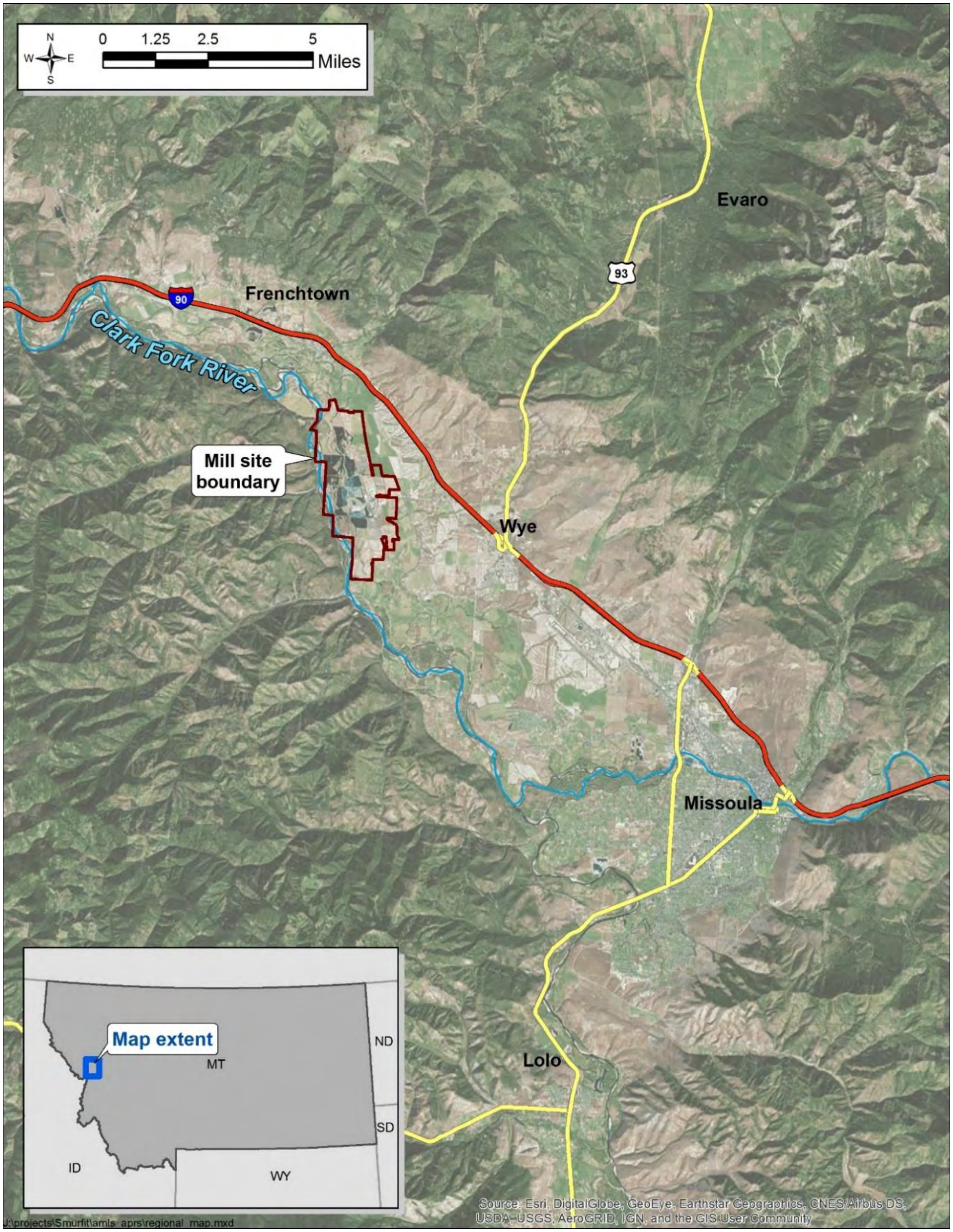
The Trustees of natural resources at the Site include the Governor of the State of Montana, represented by the Montana Natural Resource Damage Program (NRDP); the U.S. Fish and Wildlife Service (USFWS), acting on behalf of the U.S. Department of the Interior (DOI); the U.S. Department of Agriculture (USDA) Forest Service; the Confederated Salish and Kootenai Tribes; and the Kalispel Tribe. Collectively, these natural resource Trustees (the Trustees) are assessing natural resource damages resulting from hazardous substance releases from the Site. When hazardous substances harm (or “injure”) natural resources that are held in trust for the public, Federal and State laws provide mechanisms that authorize natural resource Trustees to seek compensation from PRPs for those injuries. Regulations outlining a process for conducting natural resource damage assessments (NRDAs) for the release of hazardous substances have been promulgated by the DOI at 43 CFR Part 11 (hereafter, the DOI regulations). These regulations are not mandatory; however, assessments performed in compliance with these regulations have the force of a rebuttable presumption under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [42 USC § 9607(f)(2)(C)].

Following the DOI regulations, the Trustees conducted a preliminary review of existing data and published a Preassessment Screen (Abt Associates, 2018). The Trustees made the determination to proceed with the NRDA, concluding that hazardous substances have been released from the mill property, natural resources are likely to have been exposed to and injured by these hazardous substances, and the data required to perform an assessment can be obtained at a reasonable cost.

In the DOI regulations, the next document that Trustees produce for public review after the Preassessment Screen is the Assessment Plan [43 CFR Part 11 Subpart C]. This Assessment Plan confirms exposure of natural resources to hazardous substances released from the Site, and describes the proposed plan for assessing injuries to natural resources and determining damages resulting from hazardous substances released from the Site.

1. In this document, the mill property refers to the 3,150 acres where the mill operated in Frenchtown, including the former industrial area; solid waste and wastewater treatment areas; and the former wastewater holding ponds. The Site includes the mill property as well as groundwater impacted by hazardous substance releases and the Clark Fork River where hazardous substances have come to be located.

Figure 1.1. Smurfit-Stone/Frenchtown Mill Site. The full extent of the Site includes areas in the Clark Fork River where released hazardous substances have come to be located, which is not yet known.



1.1 Potentially Responsible Parties

PRPs at the Site include past owners and operators of the mill, past property owners, and railroad companies that transported materials to and from the mill. Waldorf Paper Products (Waldorf) originally built the mill in 1957. Waldorf merged with Hoerner Boxes, Inc. in 1966 to create the Hoerner Waldorf Corporation (Hoerner Waldorf). Hoerner Waldorf merged with Champion International Corp. (Champion) in 1977, and Champion operated the mill until Stone Container purchased the property in 1986. The International Paper Company (International Paper) purchased Champion in 2000 and is a PRP at the Site (U.S. EPA, 2015; Briggeman, 2017).

Stone Container operated the mill after the 1986 purchase. Stone Container merged with the Smurfit Corporation in 1998 to form Smurfit-Stone Container, which operated the mill until it closed in 2010. RockTenn acquired Smurfit-Stone Container in 2011. WestRock CP, LLC (WestRock) is the successor to RockTenn and is a PRP at the Site (U.S. EPA, 2015).

In 2011, Wakefield Kennedy, LLC, which is part of The Evans Company and Wakefield Properties (Evans Wakefield), loaned $29 million to M2Green Redevelopment, LLC (M2Green), an affiliate of Green Investment Group, Inc., allowing M2Green to purchase the mill property with the aim of future redevelopment (Green Investment Group, 2011). Most of the industrial structures were removed by 2013. The company rebranded the property as the Frenchtown Technology and Industrial Center (Briggeman, 2017). M2Green owns three parcels covering over 1,240 acres of the mill property, including most of the industrial areas (Missoula County, 2021). M2Green is a PRP.

In 2019, M2Green defaulted on loan payments and Wakefield Kennedy, LLC sued to foreclose on the property (Lundquist, 2019). The foreclosure has not yet occurred.

Evans Wakefield created MLH Montana, LLC in 2017, also with the goal of redeveloping the mill property. MLH Montana, LLC owns 15 parcels surrounding the industrial areas on the mill property (Missoula County, 2021). EPA has not yet determined whether MLH Montana, LLC is also a PRP.

PA Prospect Corporation owns 2 parcels covering 240 acres at the south end of the mill property (Missoula County, 2021). In April 2021, PA Prospect Corporation applied to MDEQ for an open cut gravel mine permit. The mine would be called the Clark Fork Pit and would cover 135 acres. In July 2021, MDEQ issued a permit for the Clark Fork Pit (MDEQ, 2021). EPA has not yet determined whether PA Prospect Corporation is also a PRP.

The Site includes a railroad spur that was used for transporting raw materials to the mill and finished products from the mill. Northern Pacific Railway, which originally constructed the spur in 1957, is now the BNSF Railway Company (BNSF). In 1987, BNSF entered into an agreement with Montana Rail Link (MRL) that gave MRL rights to use the spur. MRL used the spur to transport materials to and from the mill. BNSF and MRL are also PRPs at the Site (U.S. EPA, 2015).

1.2 Trusteeship Authority

As noted previously, the Trustees of natural resources for the Site include State, Federal, and Tribal Trustees, including the Governor of Montana, represented by the Montana NRDP;

USFWS, acting on behalf of the DOI; the USDA Forest Service; the Confederated Salish and Kootenai Tribes; and the Kalispel Tribe.

CERCLA, as amended [42 USC §§ 9601 et seq.]; the Federal Water Pollution Control Act (FWPCA), as amended [33 USC §§ 1251 et seq.]; and Federal regulations at 40 CFR § 300.600(2) authorize Trustees to act on behalf of the public for natural resources within Trustee jurisdiction:

- State Trustees are authorized to act on behalf of the public for natural resources within the boundary of a state or belonging to, managed by, controlled by, or appertaining to such state.
- The U.S. Secretary of the Interior is authorized to act as Trustee for natural resources managed, controlled by, or appertaining to the DOI.
- The U.S. Secretary of Agriculture is authorized to act as Trustee for natural resources located on, over, or under land administered by the USDA, including Forest Service lands.
- An Indian Tribe is authorized to act as Trustee for natural resources belonging to, managed by, controlled by, or appertaining to such Tribe, or held in trust for the benefit of such Tribe, or belonging to a member of such Tribe, if such resources are subject to a trust restriction on alienation. The chairman of an Indian Tribe is authorized to act as Trustee on behalf of the Tribal members.

1.3 Decision to Perform a Type B Assessment

Under federal guidance for NRDA, the Trustees can elect to perform a Type A or Type B assessment [43 CFR § 11.33]. Type A assessments are "simplified procedures that require minimal field observation" [43 CFR § 11.33(a)]. Use of the Type A assessment is generally limited to the assessment of relatively minor, short duration discharges or releases that occur in a coastal/marine or Great Lakes environment [43 CFR § 11.34(a)].

Type B assessments require "more extensive field observation than the Type A procedures" [43 CFR § 11.33(b)]. Type B assessments include three phases: injury determination, injury quantification, and damage determination [43 CFR § 11.60(b)]. The Trustees may incur reasonable costs in the Assessment Phase of the Type B damage assessment [43 CFR § 11.60(d)]. A Type B assessment is warranted when the simplified procedures for a Type A assessment are not applicable [43 CFR §§ 11.24–11.35].

The Trustees have determined that a Type B assessment is warranted in this case because:

- The release was not of a short duration
- The release was not minor
- The release did not occur in a coastal, marine, or Great Lakes environment
- The release resulted in levels of contamination beyond the levels appropriate for a simplified Type A assessment requiring minimal field observation.

1.4 Natural Resource Damage Assessment Process

NRDA is a process by which natural resource Trustees determine compensation for natural resource injuries that have not been, or are not expected to be, addressed by response actions

[43 CFR § 11.10]. The measure of such compensation is the "cost of restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and the services those resources provide" and may also include the "compensable value of all or a portion of the services lost to the public for the time period from the . . . release until the attainment of the restoration, rehabilitation, replacement, and/or acquisition of equivalent of the resources and their services to baseline" [43 CFR § 11.80(b)], where baseline is the condition of the resources and services that would exist had the release of hazardous substances not occurred.

The Trustees intend to follow the guidance provided in the DOI regulations for conducting this NRDA, to the extent practicable. The four major phases in the Type B NRDA process are the "preassessment phase," the "assessment plan phase," the "assessment phase," and the "post-assessment phase."

1.4.1 Preassessment Phase

The preassessment phase of an NRDA is the first step described in the NRDA regulations. Trustees must rapidly review available data and determine whether or not to proceed with an assessment [43 CFR § 11.13(b)], and then document this decision in a Preassessment Screen determination [43 CFR § 11.23(c)]. The Preassessment Screen for this assessment area has been completed (Abt Associates, 2018). In accordance with the Preassessment Screen criteria at 43 CFR § 11.23(e), the Trustees determined that:

- A release of hazardous substances has occurred
- Natural resources for which the Trustees may assert trusteeship under CERCLA have been or are likely to have been adversely affected
- The quantity of the release is sufficient to potentially cause injury
- Data to perform an assessment are available or obtainable at a reasonable cost
- Response actions do not or will not sufficiently remedy the injury to natural resources without further action.

Thus, the Trustees concluded that they should proceed with the NRDA to develop a damage claim.

1.4.2 Assessment Plan Phase

After deciding to perform an NRDA, the Trustees prepare an Assessment Plan. The purpose of the Assessment Plan is to ensure that the assessment is well-planned and conducted systematically, and that the selected methods for assessment demonstrate reasonable cost [43 CFR § 11.13(c)]. According to 43 CFR Part 11, the Assessment Plan describes the natural resources and geographical areas involved (Chapters 2 and 3 of this Assessment Plan), confirms exposure of natural resources to hazardous substances (Chapter 4 of this Assessment Plan), and describes the objectives of any testing and sampling for injury or pathway determination and provides an approach for quantifying injuries and damages (Chapters 5 and 6 of this Assessment Plan). The plan should also provide a quality assurance project plan (QAPP) to ensure quality control in testing and sampling (Chapter 7 of this Assessment Plan) [43 CFR §§ 11.31(c)(1)–(3)].

The Assessment Plan may also include a Restoration and Compensation Determination Plan (RCDP). However, if insufficient information is available to develop the RCDP at the time of Assessment Plan preparation, the RCDP may be developed at a later time before the completion of injury determination and quantification [43 CFR § 11.31(c)(4)]. This Assessment Plan contains an approach to conduct restoration planning and scaling (Chapter 5); the Trustees may develop the RCDP at a later time.

1.4.3 Assessment Phase

The assessment phase is when the evaluation of injuries and damages is conducted. The parts of a Type B assessment are summarized here and described in detail in Chapters 5 and 6.

1. **Injury determination**: An assessment determines what natural resources have been injured as a result of the release of hazardous substances [43 CFR § 11.13(e)(1)]. It also involves determining the pathway, or route, through which the hazardous substances were transported from sources to the injured resource [43 CFR § 11.61(c)(3)].

2. **Quantification**: An assessment also quantifies the relationship between losses caused by determined injuries and available gains from natural resource restoration opportunities. The extent and degree of injuries, the ability of the resource to recover, and the reduction in services are included in quantification [43 CFR § 11.71(c)]. The "interdependent services" provided by natural resources are identified to "avoid double counting in the damage determination phase and to discover significant secondary services that may have been disrupted by the injury" [43 CFR § 11.71(b)(4)].

3. **Damage determination**: An assessment also determines the appropriate compensation for the injuries [43 CFR § 11.13 (e)(3)] as dollars.[2] Damages are measured as the cost or value of sufficient restoration to offset all of the public losses caused by natural resource injuries.

1.4.4 Post-Assessment Phase

The post-assessment phase is the final step in the NRDA process. After the assessment is complete, the Trustees produce a report of assessment containing the results of the NRDA [43 CFR § 11.90]. The Trustees may then seek recovery of damages from the PRPs [43 CFR § 11.91], and such damages may include direct and indirect costs "necessary to complete all actions identified in the selected alternative for restoration, rehabilitation, replacement, and/or acquisition of equivalent resources" [43 CFR § 11.83(b)]. If damages are received, an account is established for the damages recovered [43 CFR § 11.92], and a restoration plan is developed and implemented using the recovered damages [43 CFR § 11.93].

1.5 Natural Resource Damage Coordination with Response Actions

To the extent practical, an NRDA should be conducted in coordination with investigations undertaken as part of National Contingency Plan (NCP) response actions, including, for

2. Although the regulations describe a process that ends with a demand for dollars, Trustees may allow PRPs to resolve their liability through direct restoration activities at costs that may not be known by the Trustees. In these cases, metrics other than dollars are used to scale the amount of required restoration to losses caused by natural resource injuries.

example, remedial investigation/feasibility study (RI/FS) work [43 CFR § 11.31(a)(3)]. The goals of this coordination are to avoid duplication, reduce costs, and achieve dual objectives where practical.

The Trustees have been participating and will continue to participate in reviewing and commenting on the objectives of removal actions, RI/FS activities, and remedial actions. The Trustees intend to use pre-existing data from other studies where relevant and reliable to determine injuries and quantify losses in the assessment area. When the Trustees conduct original data collections at the Site, they will explicitly coordinate damage assessment activities. In addition, the Trustees will ensure that, whenever practicable, appropriate consideration is given to parties undertaking remediation or restoration activities that satisfy the Trustees' NRDA objectives.

1.6 Public Review and Comment

The Trustees intend for this Assessment Plan to communicate the assessment approach to the public, so that the public can become engaged and actively participate in, or comment on, assessment activities. Public input may also provide the Trustees with new information and ideas that they may incorporate into their assessment.

The Assessment Plan is available for public review and comment [43 CFR § 11.32]. The public comment period will last for at least 60 days, with a reasonable extension granted, if appropriate. Any comments received by the Trustees, together with responses to those comments, will be included as a part of the Report of Assessment. Comments on this Assessment Plan may be submitted in writing to:

Smurfit Assessment Plan Comments
Attn: Mr. Brian Bartkowiak
Montana Natural Resource Damage Program
PO Box 201425
Helena, MT 59620-1425

Or via email:
NRDP@mt.gov.

The Assessment Plan may be modified at any stage of the assessment as new information becomes available. Any significant modification to the Assessment Plan will be made available for additional public comment and review.

1.7 Organization of the Assessment Plan

Chapter 2 of this Assessment Plan provides an overview of the assessment area and the natural resources within the assessment area. Chapter 3 briefly summarizes the operational history of the mill and hazardous substances released. Chapter 4 confirms that natural resources have been exposed to hazardous substances released from the mill site, and Chapter 5 presents the assessment approach that the Trustees will use to quantify natural resource injuries and damages. Chapter 6 outlines additional studies the Trustees plan to conduct to address some data gaps. Chapter 7 presents the QAPP and the final chapter contains references cited in the text.

2. Description of the Assessment Area

This chapter provides an overview of the assessment area. It includes a discussion of natural resources potentially exposed to hazardous substances.

The mill property is located in the Clark Fork River drainage, adjacent to the Clark Fork River (see Figure 1.1), and partially falls within the river's 100-year floodplain. Topography at the mill property is relatively flat, ranging in elevation from approximately 3,070 feet near the core industrial area, to approximately 3,040 feet at the Clark Fork River (URS, 2012). Regionally, the Clark Fork River drainage is approximately 3,000–3,200 feet above sea level and is encircled by mountain ranges with elevations of 5,000–8,000 feet above sea level (URS, 2012; NewFields, 2015).

The mill property covers 3,150 acres, with approximately 3.6 miles of river frontage (URS, 2012). A 15-foot-wide berm separates wastewater holding ponds from the Clark Fork River (Figure 2.1). The berm is 3.7 miles long and ranges from 2 to 25 feet in height above the ground surface. This berm provides flood protection under "seasonally normal flows" (NewFields, 2015, p. 7). However, the river berm required stabilization and reinforcement in May and June 2018, when the Clark Fork River exceeded flood stage for 5½ days (NewFields, 2019).

There is also a higher inner berm at the mill property, with a distance from the river that varies from approximately 0.5 to 2 miles (Figure 2.1). This inner berm was not breached on May 18, 1997, when the Clark Fork River discharge was 55,100 cubic feet per second (cfs), the largest flood event to occur since 1930 (NewFields, 2015; USGS, 2021).

The land immediately surrounding the mill property is primarily agricultural, used for cultivating feed for livestock, growing alfalfa and grain crops, and cattle grazing, interspersed with some residential areas (URS, 2012).

The Assessment Area includes not only the "mill property" but also groundwater which can extend beyond the mill property boundary and the Clark Fork River which might include many miles of the CFR where hazardous substances have come to be located.

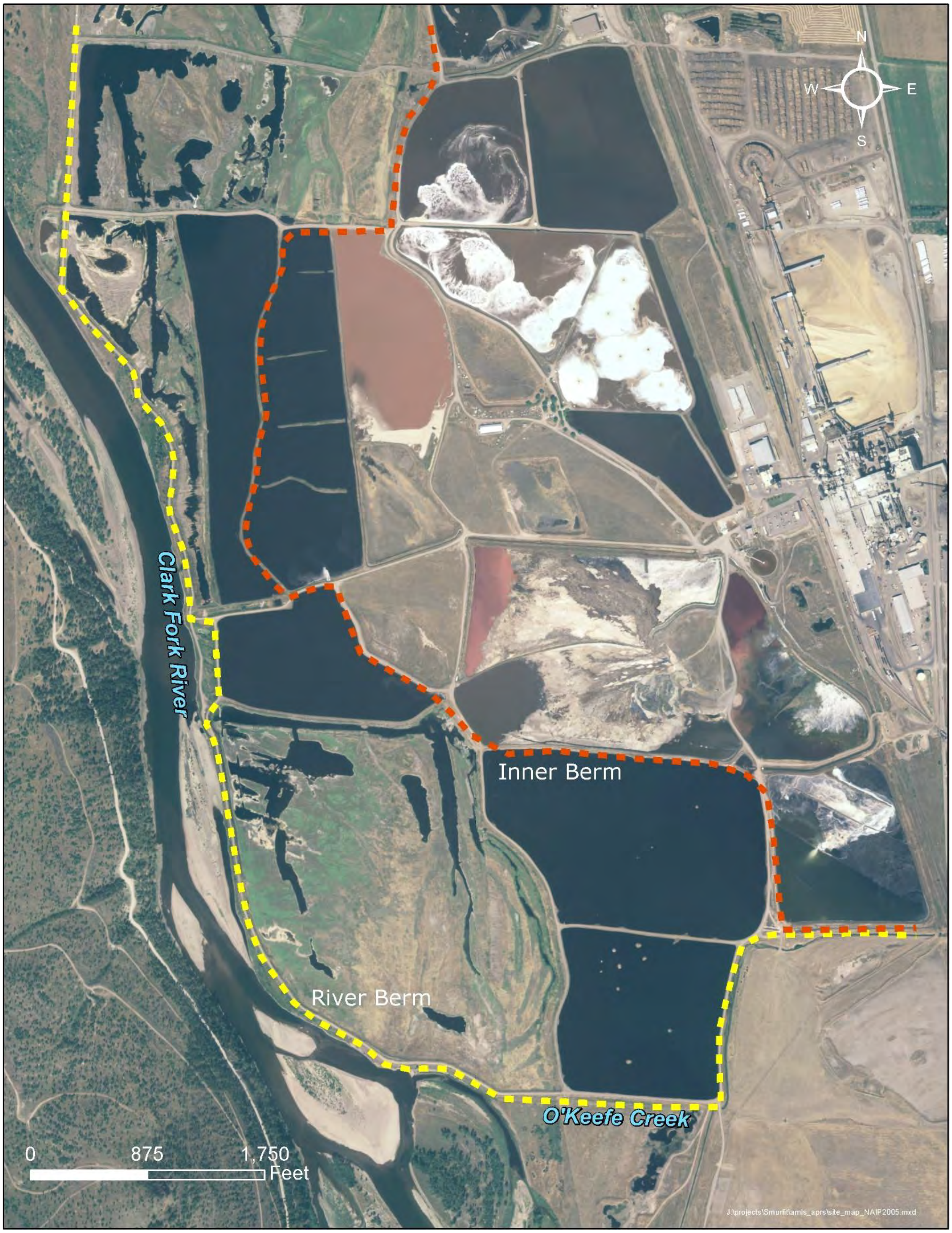
The following sections describe the groundwater, surface water, habitats, and biota within the assessment area.

2.1 Groundwater

The mill property sits predominately on alluvial sediments of the Clark Fork River drainage, within the northwestern portion of the Missoula Valley. During the Pleistocene Epoch, the Missoula Valley experienced successive glaciation and interglaciation events, which flooded and drained the valley. Approximately 12,000 years ago, the Missoula Valley was covered by Lake Missoula, a glacial lake nearly 2,000-feet deep. When this lake receded, it left behind clay and silt deposits. These glacial lake deposits are now overlain by the more recently deposited unconsolidated alluvial sediments associated with the Clark Fork River, and underlain by a deeper geologic unit of unconsolidated cobbles (URS, 2012; NewFields, 2015).

Groundwater is found within two geologic units at the mill property. This includes the shallow groundwater, found within Clark Fork River deposits of unconsolidated sands, gravels, and cobbles. Below the shallow groundwater is an unconsolidated cobble unit, deposited during the period of successive glaciation and interglaciation events, which contains the deeper groundwater. These two units are separated by the finer-grained (silty-clay) Lake Missoula deposits (URS, 2012; NewFields, 2015).

Figure 2.1. Berms at the south end of the mill property (2005 photograph).



Depth to the shallow groundwater varies across the mill property, ranging from less than 5 feet to more than 25 feet below the ground surface (URS, 2012; NewFields, 2015). The shallowest depths occur close to the Clark Fork River. These groundwater elevations fluctuate seasonally, responding to spring runoff and return flows from agriculture, varying by at least one foot or more. The deeper aquifer is approximately 100–150 feet below the ground surface. The groundwater beneath the mill property is unconfined and generally flows from east to west, discharging to the Clark Fork River (NewFields, 2015). Recent studies suggest shallow groundwater may follow preferential pathways, with areas of groundwater upwelling adjacent to the mill property that have been identified using both thermal (Podrasky, 2020) and radon (Forsland, 2020) tracers.

The deeper aquifer has notably high yield, having produced 15 million gallons per day of process water via 14 supply wells when the mill was operating. The yield in the shallow aquifer is lower than the yield in the lower aquifer, although it has not been thoroughly investigated. Except for monitoring wells, there are no wells completed in the shallower groundwater on the mill property (NewFields, 2015).

2.2 Surface Water

The Clark Fork River, which flows northwest along the western boundary of the mill property (see Figures 1.1 and 2.1), is the largest river by volume in Montana. It sustains agricultural operations, provides community drinking water, and supports recreational activities including angling and boating (Clark Fork River Coalition, 2018). The Clark Fork River begins at the junction of Warm Springs Creek and Silver Bow Creek near Anaconda and ends at Lake Pend Oreille in Idaho. The portion of the river within west-central Montana drains an area of 22,150 square miles. Major tributaries upstream of the Site include the Bitterroot River (~ 10 miles upstream) and the Blackfoot River (~ 20 miles upstream).

The Clark Fork River has a mean daily flow of 156 cfs at its headwaters, increasing to 2,590 cfs near the mill property. Peak flows in this reach have exceeded 50,000 cfs five times since 1930, most recently in May 2018. The river reaches a mean daily flow of 22,389 cfs by the time it reaches Lake Pend Oreille, about 190 river miles downstream of the mill property (NewFields, 2015; USGS, 2021).

O'Keefe and Lavalle creeks flow through the southern end of the mill property and drain into the Clark Fork River. They are part of the Site. Because of the presence of westslope cutthroat trout and bald eagle nesting habitat, the Northwest Power and Conservation Council (NWPCC) has named O'Keefe Creek a "protected area," where the council believes hydroelectric development would have unacceptable risks of loss to fish and wildlife species of concern, their productive capacity, or their habitat (NWPCC, 2017).

2.3 Habitats

The mill property has multiple diverse habitats. During mill operations, the wastewater treatment and holding ponds on the mill property were flooded at different times, depending on wastewater discharge and storage needs. Today, the upper ponds outside of the 100-year floodplain remain mostly dry, providing meadow habitat. This habitat is utilized by birds, small mammals, and terrestrial invertebrates (U.S. EPA, 2017a). The lower ponds within the 100-year floodplain support wetland habitat for at least part of the year, providing potential habitat for aquatic macroinvertebrates, waterfowl, and other biota (U.S. EPA, 2017a).

When the water table is elevated, groundwater sustains the surface water in these lower ponds. Floodplain areas on the mill property overlap with wetland habitat areas designated in the National Wetlands Inventory (U.S. EPA, 2017a). Further, U.S. EPA (2017a) describes the core industrial area at the mill property as an attractive nuisance area, with attributes that attract wildlife, including low-lying areas that fill with water after rain events, and grasses growing in open areas that provide roosting and nesting areas.

A portion of the mill property is agricultural land, which also provides habitat for birds, mammals, and invertebrates, including, for example, nesting and foraging habitat for passerine birds. The Clark Fork River and O'Keefe and Lavalle creeks provide both riparian and aquatic habitats. Portions of the floodplain habitat include forested and shrubby riparian areas adjacent to the creeks and the river. Forested areas along the Clark Fork River include sparsely distributed ponderosa pines, with an open understory, low-lying shrubs, and snags (U.S. EPA, 2018).

2.4 Biota

Many different species of vertebrate and invertebrate biota are present in or near the Site. U.S. EPA (2017a) identified 36 invertebrate species, as well as 20 fish species, 243 bird species, 3 amphibian species, 3 reptile species, and 30 mammal species in Missoula County.

Site-specific species information includes information from fish and bird surveys, and onsite observations. Schmetterling and Selch (2013) collected northern pike and rainbow trout in the backwaters, sloughs, and margins of the Clark Fork River immediately downstream of the mill property. U.S. EPA (2017a) reports additional fish species found in the river adjacent to the mill property, according to the online database for the Montana Fisheries Information System (MFISH). Common species in Clark Fork River reaches associated with the Site include largescale and longnose suckers, longnose dace, mountain whitefish, and rainbow trout. Fish species that MFISH classifies as "rare" include brook trout, brown trout, pumpkinseed, westslope cutthroat trout, bull trout, largemouth bass, yellow perch, peamouth, Rocky Mountain sculpin, and northern pike (although as noted previously, Schmetterling and Selch [2013] found northern pike immediately downstream of the mill property).

Onsite observations of wildlife include many species of small birds, water birds (mallards, herons, grebes), and raptors (hawks, owls, ospreys, golden eagles, bald eagles). Onsite mammal observations include rabbits, whitetail deer, elk, coyote, fox, river otters, badgers, beavers, and other rodents. In the industrial area, owls nesting in buildings, small birds drinking and washing in puddled water, raptors hunting small mammals, and bats roosting in the buildings have also been observed (U.S. EPA, 2017a). Along the Clark Fork River, large snags provide perches for eagles and osprey. Great blue herons, kingfisher, and a variety of passerine birds and waterfowl have been observed along the riverbanks (U.S. EPA, 2018).

Several sensitive species may also occur at the Site. In Missoula County, USFWS (2021) has identified five listed threatened species and one Bird of Conservation Concern that may occur (Table 2.1), and the Montana Natural Heritage Program (MTNHP) has listed the westslope cutthroat trout as a species of concern (MTNHP, 2021). Of this list, EPA reports that the threatened bull trout is known or expected to occur at the Site. The USFWS has designated critical habitat for bull trout in the Clark Fork River [74 FR 2269], including the reach adjacent to the mill property and downstream reaches likely within the Site (U.S. EPA, 2017a).

Table 2.1. Listed threatened species and Bird of Conservation Concern in Missoula County

Common name	Scientific name	Status
Grizzly bear	*Ursus arctos horribilis*	Listed threatened
Canada lynx	*Lynx canadensis*	Listed threatened
Bull trout	*Salvelinus confluentus*	Listed threatened
Yellow-billed cuckoo	*Coccyzus americanus*	Listed threatened
Red knot	*Calidris canutus rufa*	Listed threatened
Cassin's finch	*Carpodacus cassinii*	Bird of Conservation Concern

Source: USFWS, 2021.

The Site lies within the Montana Audubon Clark Fork River – Grass Valley Important Bird Area (IBA). The National Audubon Society has documented 16 bird species of conservation priority within the IBA, including 6 pairs of bald eagles, Lewis's woodpeckers, red-naped sapsuckers, and willow flycatchers (URS, 2012; U.S. EPA, 2017c). The MTNHP has also identified 29 bird species of concern in Missoula County (MTNHP, 2021).

3. Site History and Hazardous Substance Releases

This chapter describes the mill operations and waste disposal practices that created sources of hazardous substances at the Site. First it describes the history of the mill operations and the waste streams. It then discusses waste disposal, and evidence that the waste from the former mill operations was and continues to be a source of hazardous substances.

3.1 Mill Operations

The mill operated as a pulp and paper mill from 1957 to 2010. It primarily used virgin pulp to produce rolls of kraft linerboard, which was then used to manufacture corrugated containers. The milling operation created pulp from wood chips that were hauled to the mill or wood that was chipped at the mill. Onsite chipping often created waste bark and wood (i.e., hog fuel), which was eventually burned in a multi-fuel boiler. Beginning in 1990, up to 30% of the raw pulp was created from the recycling of old corrugated containers at an onsite recycled fiber plant (NewFields, 2015; U.S. EPA, 2017a, 2017c).

To create the pulp, wood chips were washed and sent to digesters, where they were "cooked" in white liquor (sodium hydroxide and sodium sulfate). Spent digester liquor and pulp washing fluids were collected from these digesters and concentrated to solids, which were then burned in recovery boilers. This process recovered some process chemicals (e.g., sodium carbonate, sodium sulfate), which were used to regenerate white liquor (NewFields, 2015).

Power boilers and lime kilns at the mill produced stack emissions. After the Clean Air Act (CAA) of 1970, MDEQ required the monitoring of regulated emissions and a renewal of the mill's CAA Title V operating permit every five years (NewFields, 2015).

When the mill opened in 1957, production capacity was 250 tons per day (tpd) of kraft pulp. This capacity expanded multiple times over the years, to 600 tpd in 1960, to 1,150 tpd in 1966, and to 1,850 tpd in 1977. Production apparently peaked at 1,900 tpd in 1993, declining to 1,600 tpd in the early 2000s before operations ceased in 2010 (URS, 2012). Most of the pulp was used to produce unbleached linerboard; however, from 1960 to 1999, operations included the production of bleached pulp and white linerboard. In the preliminary assessment of the Site, URS (2011) reported that the mill produced 150 tpd of bleached pulp starting in 1960 and maintained that production level after the expansion in 1966. As will be discussed in subsequent sections, U.S. EPA (1990) found that bleached pulp mills are a substantial source of dioxins and furans released into the environment.

NewFields (2015) stated that bleached pulp was 6% of the total production over the lifetime of the mill. If bleached pulp production averaged 150 tpd, it would have been more than 6% of the total production, suggesting that the mill may have produced less than 150 tpd of bleached pulp in some years between 1960 and 1999. If the plant operated 350 days per year at the production levels listed above, and bleached pulp was 6% of the total production, the quantity of bleached pulp produced from 1960 to 1999 would have been about 1.6 million tons.

3.1.1 Wastewater and Sludge

When operating, the mill used about 15 million gallons of water per day from 2 well fields located in the southern portion of the mill property. This groundwater was used in various process and recovery systems throughout the mill that resulted in a similar amount of wastewater generated daily (NewFields, 2015).

The wastewater system at the mill evolved over time. At the beginning of operations in 1957, wastewater mixed with paper fiber solids (sludge) was discharged into the Clark Fork River without treatment. After complaints of foam, discoloration, and fish kills in the river, the first wastewater ponds (known as settling or sludge ponds) were constructed in 1958 (URS, 2012). Wastewater and sludge from pulp production (including bleached pulp sludge starting in 1960) were discharged into these unlined ponds until a primary clarifier was installed in 1969 (URS, 2012) or 1970 (NewFields, 2015), which removed sludge from the wastewater. The solids from the clarifier were deposited in Settling Ponds P3, P4, and P5; while the liquid waste stream was directed to other holding ponds (Figures 3.1 and 3.2).

In 1974 and 1975, Hoerner Waldorf installed secondary treatment aeration basins, tertiary polishing ponds, and additional holding ponds. After sludge was removed from the clarifier, the wastewater was transferred to aeration basins. Aeration basins AB1 and AB2 were constructed in 1974–1975, and aeration basin AB3 was constructed in 1990 (Figure 3.2). Supplemental nutrients (i.e., nitrates and phosphates) were added to these basins to assist with the water treatment process (URS, 2011; NewFields, 2015).

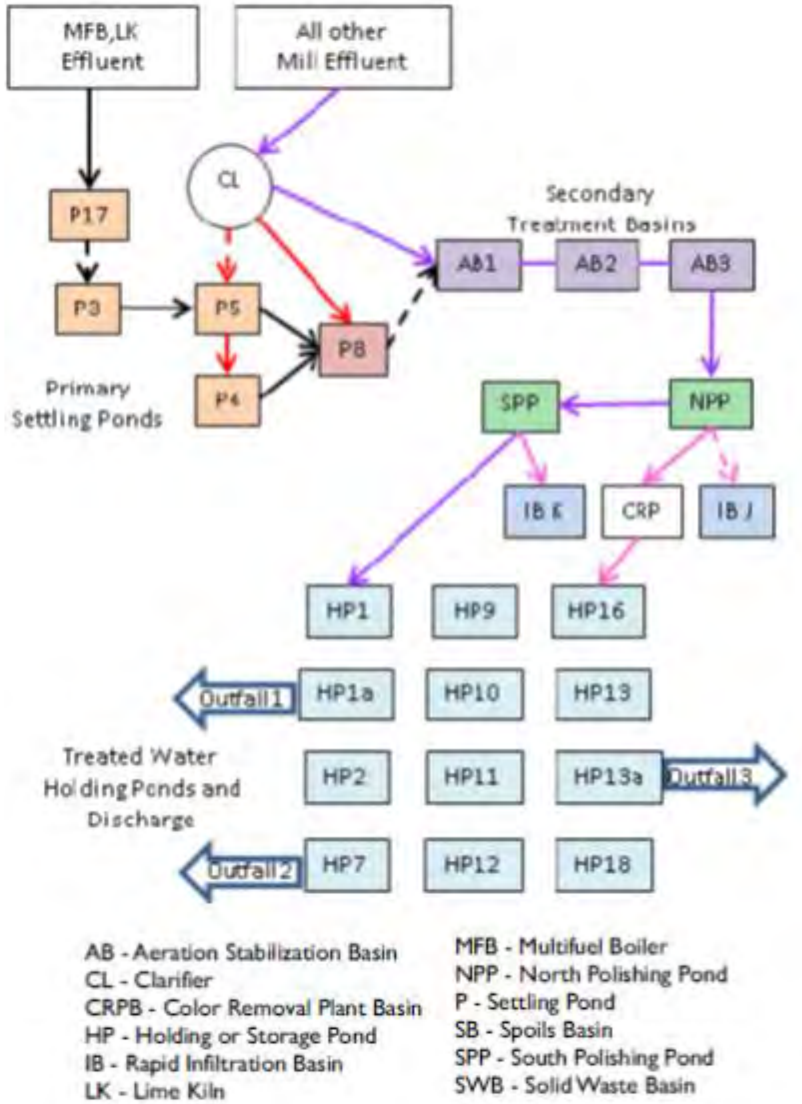
After aeration, the wastewater was transferred to polishing ponds that allowed for further settling of solids. After polishing, the treated wastewater was diverted to 1 of 12 holding ponds and discharged through Montana Pollutant Discharge Elimination System (MPDES) permitted outfalls. The MPDES permit allowed for direct discharge of wastewater to the Clark Fork River during spring high flows (MDHES, 1986), or when flows exceeded 1,900 cfs (URS, 2011).

A Color Removal Plant (Figures 3.1 and 3.2) was constructed in 1988 (NewFields, 2015). If needed, wastewater from the north polishing pond could be diverted to the Color Removal Plant to reduce color before discharge to the holding ponds. This mainly occurred before 1999, when bleaching operations were still occurring, as the bleaching process contributed a large amount of color to the wastewater (URS, 2011).

Solids from the Color Removal Plant were collected in holding tanks, blended with spent (black) liquor, and burned in recovery boilers. Occasionally, the holding tanks in the Color Removal Plant were flushed out into the Color Removal Plant Basin (NewFields, 2015). When treated effluent in the holding ponds met temperature and color standards, mainly during high-flow events, it was discharged to the Clark Fork River.

Three rapid infiltration basins were used from 1974 to 1983. When the holding ponds were at capacity, the treated wastewater was moved to the rapid infiltration basins. In 1977, 63% of the mill wastewater was routed through rapid infiltration ponds (URS, 2011). While none of the ponds or basins were lined, these infiltration basins were specifically designed to allow for rapid infiltration into groundwater (URS, 2012).

Figure 3.1. Schematic diagram of the mill wastewater treatment system, after the construction of the dewatering plant.



Source: NewFields, 2015, Figure 4.

Figure 3.2. Mill property wastewater treatment ponds, basins, and landfills in July 2007. See Figure 3.1 for acronym and abbreviation definitions (LF = landfill).

Background image: 7/10/2007, © DigitalGlobe.

In 1997, Stone Container installed a sludge dewatering plant, and dewatered solids became fuel for the multi-fuel boiler, reducing the need to dispose of sludge in the ponds. An emergency spill pond was also constructed at the mill property for use if a spill or other disruption occurred in the industrial process. In these cases, flows could be diverted to the pond before they reached the wastewater treatment system (Smurfit-Stone Container, 2004, as cited in URS, 2011). The dates of use of this pond are unknown (URS, 2011).

3.1.2 Solid Wastes

For most of the mill's operational history, general refuse, construction waste, hog fuel ash, lime kiln waste, and some asbestos-containing materials were placed into one of six solid waste basins (i.e., landfills; see Figure 3.2). Most of the solid waste basins were closed in 1993; one basin remained open and received inert materials (e.g., wood, gravel, log yard wastes, bricks) after 1993 (NewFields, 2015). Dredge spoils from the secondary treatment (aeration) basins were placed into one of two spoils basins. Spoils from the primary settling ponds may also have been placed into these spoils basins (NewFields, 2015).

3.2 Hazardous Substance Repositories

Areas with hazardous substances at the mill property include sludge ponds, the emergency spill pond, aeration basins, polishing ponds, wastewater storage ponds, landfills, the industrial area, a land farm, and storage tanks (above and below ground). This section summarizes information from existing Site documents; however, the full extent of the materials buried in waste areas at the mill property is not known.

3.2.1 Sludge Ponds

From 1958 until the primary clarifier was installed in 1969–1970, sludge ponds received untreated waste, including waste from bleached pulp production starting in 1960. Waldorf generated approximately 20,000 tons of sludge a year, which were pumped into 4 sludge ponds (Ponds 3, 4, 5, and 17). From 1960 to 1966, about 25% of the total pulp production (150 of 600 tpd) was bleached; if the mill produced 20,000 tons of sludge per year, roughly 5,000 tons per year of bleached pulp sludge was pumped into these unlined ponds. The 4 ponds vary in depth (7–14 feet) and cover approximately 91 acres. These ponds were constructed before the enactment of modern regulations that require such waste repositories to be lined and monitored; wastewater has infiltrated through the bottom of the ponds into the shallow aquifer (URS, 2011).

The sludge consisted of fiber solids, inorganic solids, and fly ash. The sludge dewatering facility, constructed in 1997, removed excess liquid from the sludge, providing a fuel source for the multi-fuel boiler and reducing the need for sludge disposal (Smurfit-Stone Container, 2004, as cited in URS, 2011).

Kidston (2018) published historical photographs taken when the mill was operating, including a photograph that appears to be a sludge pond with an unidentified and decomposed drum present (Figure 3.3). To date, the investigations of the Site have not included a detailed analysis of the waste in the sludge ponds or other solid waste ponds (Nielson, 2016).

3.2.2 Emergency Spill Pond

The emergency spill pond on the mill property was built to contain a spill or other disruption in the industrial process (Smurfit-Stone Container, 2004, as cited in URS, 2011). The pond comprises a wet cell and a dry cell. In June 2011, during a reconnaissance study, EPA noted a breach in the northwest corner of the wet cell, as well as no engineered liner or runoff controls (URS, 2011). Thus, the spill pond may be a source of hazardous substances. The dates and use of this pond are unknown (URS, 2011).

Figure 3.3. Historical photograph of a sludge pond. The contents of the drum and the date of the photograph are unknown.

Source: Kidston, 2018.

3.2.3 Infiltration Basins, Aeration Basins, Polishing Ponds, and Holding Ponds

The infiltration basins received large quantities of wastewater that became a source of hazardous substances to the underlying groundwater. They were designed to dispose of wastewater via rapid infiltration through the bottom of the ponds into the shallow aquifer (Smurfit-Stone Container, 2004, as cited in URS, 2011).

As discussed previously, the wastewater treatment system at the mill property included aeration basins, polishing ponds, and holding ponds, none of which were lined. Any hazardous substances released to these basins and ponds may have been transported to underlying soils or alluvial groundwater. Some of the ponds were constructed to a depth below the water table (URS, 2012), and those parts of the ponds are seasonally inundated. In addition, many of the holding ponds are located within the Federal Emergency Management Agency (FEMA, 2015) 100-year floodplain.[1]

1. The Trustees are evaluating the FEMA 100-year floodplain delineation.

3.2.4 Solid Waste Landfills

As described previously, solid wastes generated at the mill were placed into four onsite landfills until 1993. Disposal mainly occurred in three areas (Stone Container, 1992, as cited in URS, 2011; see Figure 3.3):

- Landfill A received general refuse, including paper, plastic, scrap metal, wood, glass, and food
- Landfills 6 and C received hog fuel ash and lime (Landfill C also received ragger wire, which is the baling wire and twine that hold bales of recycled cardboard)
- Landfill F received asbestos-contaminated waste.

These areas were formally closed in 1995 after being capped with 18 inches of clay and 6 inches of topsoil (MDEQ, 1995, as cited in URS, 2011). After October 1993, all Class II waste (e.g., general refuse, ragger wire, boiler ash) was taken offsite, while Class III waste (e.g., saw dust, wood chips, kiln bricks) was placed into the new Landfill G.

3.2.5 Industrial Area

The former industrial area housed the pulp and paper production facilities. The production of pulp and paper at the mill used and produced many hazardous chemicals, including bleaching chemicals, liquid sulfur dioxide, liquid ammonia, sodium hydroxide, sodium salts, dimethyl disulfide, methyl sulfide, liquors of high pH, turpentine, acids, and non-condensable gases. Additionally, bulk petroleum products were stored onsite. Large hydraulic equipment was used at the facility, some of which may have contained polychlorinated biphenyls (PCBs) as additives (URS, 2011).

The pulping process at the mill relied heavily on the recovery and reuse of chemicals; however, any leaks, spills, and overflows from the transfer, handling, and storage systems were directly transferred to the primary clarifier (Smurfit-Stone Container, 2004, as cited in URS, 2011). Large spills of petroleum or chemicals could be manually rerouted to the emergency pond before reaching the primary clarifier (U.S. EPA, 1993, as cited in URS, 2011).

3.2.6 Land Farm

The mill property includes a 23-acre parcel adjacent to O'Keefe Creek that was used as a land farm for the onsite treatment of petroleum-contaminated materials (NewFields, 2015).

3.2.7 Storage Tanks

The mill property included four above-ground and four below-ground storage tanks. Three of these tanks contained bunker oil, while the contents of the remaining five tanks are unlisted. MDEQ reported evidence of leaks in one of the tanks with bunker oil and two of the tanks with unlisted contents (MDEQ, 2011a, as cited in URS, 2011).

3.3 Hazardous Substances Released

NewFields (2015, 2017a, 2018) and U.S. EPA (2013, 2017b, 2017c) have identified numerous hazardous substances of potential concern at the Site that have been released from the above-described sources, including metals, PCBs (Aroclors and dioxin-like coplanar congeners), and dioxins/furans (Table 3.1). Additional data on hazardous substance releases and the potential exposure of natural resources are discussed in Chapter 4.

Table 3.1. Hazardous substances identified at the Site

Soil	Surface water	Sediment	Groundwater
Dioxins/furans[a, c]	Dioxins/furans[a, c]	Dioxins/furans[a, c]	Dioxins/furans[d, e]
Aluminum[a, c]		Arsenic[a, c]	Arsenic[d, e]
Antimony[c]		Cadmium[c]	Manganese[b, d, e]
Aroclor 1254[c]		Chromium[c]	
Aroclor 1260[c]		Copper[a, c]	
Arsenic[c]		Manganese[c]	
Barium[a, c]		Mercury[c]	
Cadmium[c]		Silver[c]	
Chromium[a, c]		Zinc[a, c]	
Copper[a, c]			
Lead[a, c]			
Manganese[a, c]			
Mercury[c]			
Nickel[c]			
PCB congeners[f]			
Selenium[a, c]			
Vanadium[a, c]			
Zinc[a, c]			

a. U.S. EPA, 2017b.
b. U.S. EPA, 2013.
c. U.S. EPA, 2017c.
d. NewFields, 2015.
e. NewFields, 2017a.
f. NewFields, 2018.

Hazardous substances released at the Site include chlorinated dioxins and furans, including 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) and 2,3,7,8-tetrachlorodibenzofuran (TCDF). These compounds are persistent organic pollutants that do not readily degrade in the environment and are highly toxic. In the late 1980s, EPA and the paper industry conducted a study incorporating sampling data from all 104 bleaching kraft paper mills in the United States (U.S. EPA, 1990). This study found that 97% of sludge samples contained detectable TCDD and 100% of sludge samples contained detectable TCDF. Similarly, 85% of wastewater effluent samples contained detectable TCDD and 94% of wastewater samples contained detectable TCDF (U.S. EPA, 1990). As discussed previously, this mill produced about 1.6 million tons of bleached pulp between 1960 and 1999. Bleached pulp sludge was placed in unlined ponds, which could be ongoing sources of TCDD and TCDF.

3.4 Remedial Actions

As noted previously, EPA and three PRPs (International Paper, WestRock, and M2Green) entered into an AOC to conduct formal investigation activities in 2015 (U.S. EPA, 2015). The AOC defines three operable units (OUs) at the Site (Figure 3.4):

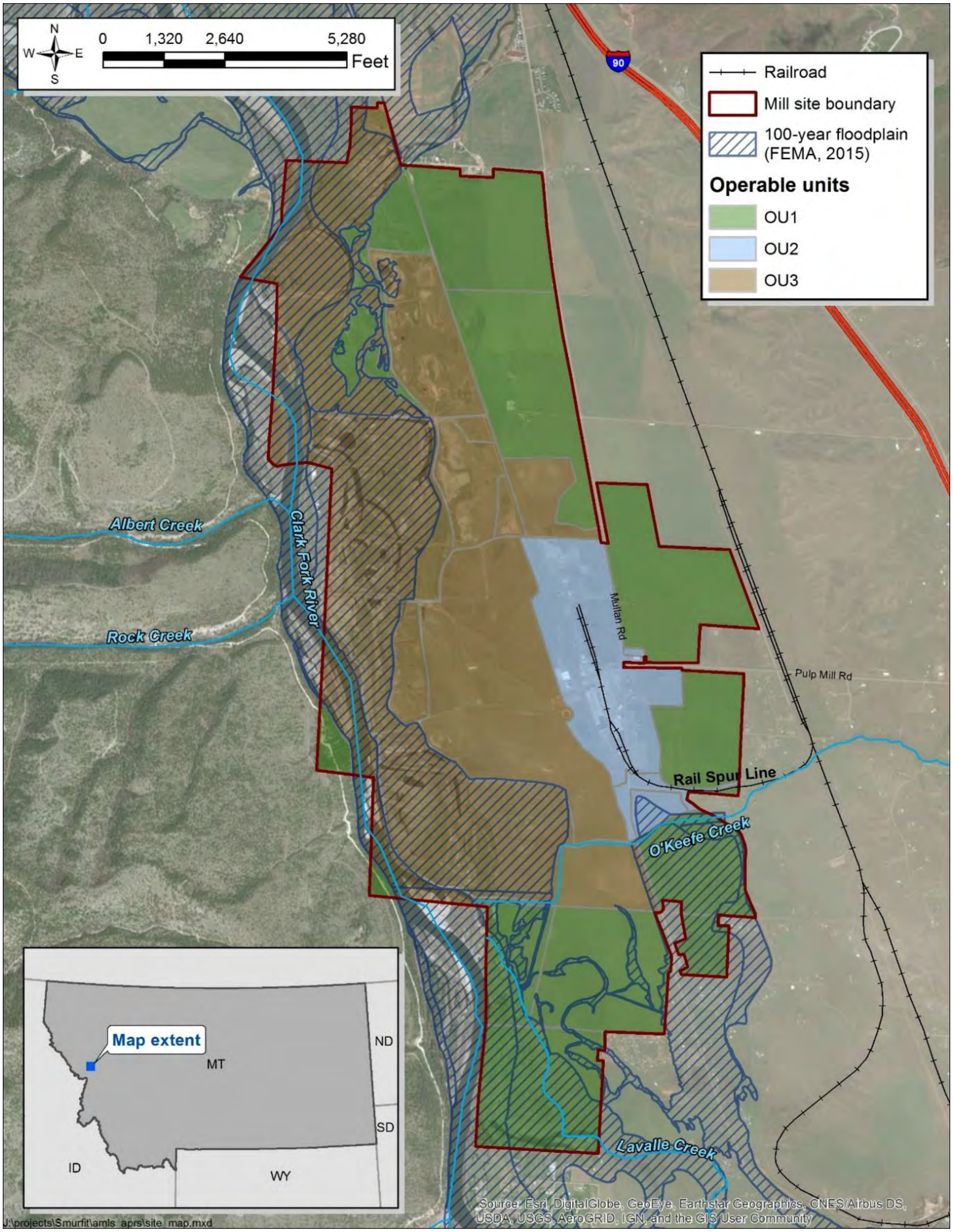
1. OU1 is defined in the AOC as several parcels of agricultural land located along perimeters of the Site to the north, south, and east, totaling approximately 1,570 acres. OU1 generally includes areas within the mill property boundary that were not used for industrial purposes. OU1 is mostly grasslands for cattle grazing, and irrigated grain and alfalfa fields.
2. OU2 is the former industrial area, including the former mill building and process areas. OU2 covers approximately 255 acres of the Site.
3. OU3 comprises the areas where liquid and solid wastes were stored and treated, including the wastewater treatment system (i.e., settling ponds, secondary aeration basins, polishing ponds, holding ponds, and infiltration basins) and the solid waste repositories (i.e., solid waste landfills and spoils basins). OU3 covers approximately 1,700 acres of the mill property, including areas along the Clark Fork River within the river's 100-year floodplain (Figure 3.4). Although not depicted in Figure 3.4 and subsequent figures, OU3 also includes Site-wide groundwater impacted by hazardous substances from mill activities, and locations in the Clark Fork River (many yet to be investigated) where hazardous substances from mill activities have come to be located.

EPA conducted an initial Site investigation in 2011 as part of the assessment to determine a hazard-ranking score for possible listing on the NPL. This effort included the collection and analysis of soil, sediment, surface water, and groundwater samples near the waste ponds and adjacent to the Clark Fork River (URS, 2012). The PRPs challenged the validity of the URS (2012) data (RockTenn, 2014), and EPA subsequently excluded those data from their database of Site samples.

In 2014, the PRPs' contractor (NewFields) collected soil, waste material, and groundwater samples, focusing on areas that were not included in the 2011 investigation, primarily in OU1 and OU2 (NewFields, 2015). In November and December 2015, NewFields conducted follow-up sampling of soil and groundwater in the three OUs, following an EPA-approved Remedial Investigation Work Plan (RIWP). NewFields (2016c) summarized this collection effort in a 2016 data summary report.

In June 2016, NewFields conducted a groundwater sampling event following the RIWP (NewFields, 2015) and Addendum 1 to the RIWP (NewFields, 2016a). They collected samples during a period of seasonally high groundwater elevations and presented the results of this work in a data summary report (NewFields, 2017a). NewFields has continued collecting groundwater samples semiannually; data collected through fall 2019 are summarized in the NewFields (2020) Groundwater Conceptual Site Model. Data collected in spring and fall 2020 are available in the EPA Scribe database.

Figure 3.4. OUs at the Site. OU3 also includes locations in the Clark Fork River where hazardous substances from the Site have come to be located.



In 2016, NewFields conducted a soil investigation of PCBs (Aroclors) in OU2. The samples were collected in accordance with Addendum 2 to the RIWP (NewFields, 2016b), and the results were summarized in a 2017 PCB soils investigation report (NewFields, 2017b). This study only examined Aroclors from transformer oil leaks; it did not investigate the potential presence of dioxin-like coplanar PCB congeners onsite.

NewFields (2018) conducted supplemental soil sampling in OU2 and OU3 to address some data gaps. This included nine composite soil samples from OU2 (each sample composited soil from a grid cell covering 10 or 20 acres) from which PCB congeners were analyzed. Dioxin-like coplanar PCB congeners were detected in every sample.

EPA completed an Ecological Risk Assessment (ERA) and a Human Health Risk Assessment on OU1 (U.S. EPA, 2017a, 2017b). They identified contaminants of potential ecological concern (COPECs) in soils, surface waters, and sediments (U.S. EPA, 2017a). In the ERA, they determined which COPECs were site-related, and characterized the potential risk of these COPECs to several ecological receptors.

EPA also completed a Screening Level Ecological Risk Assessment (SLERA) for OU2 and OU3 in which they identified COPECs in OU2 and OU3 soils, and in surface water and sediments of the Clark Fork River (U.S. EPA, 2017c). The data collection for the Baseline Ecological Risk Assessment (BERA) was conducted in 2018. U.S. EPA and SRC (2020) published a draft BERA for OU2 and OU3, in which they identified manganese as the primary COPEC driving risk in onsite ponds and the Clark Fork River. Barium and vanadium also posed risks to certain receptors, and mercury and aluminum were identified as risk drivers for terrestrial biota (U.S. EPA and SRC, 2020). For all receptors, U.S. EPA and SRC (2020) concluded that the risks of adverse effects from exposure to site COPECs was low or low-to-moderate. The Trustees have provided EPA with comments on the draft BERA, which were focused primarily on the inadequate assessment of the sources, pathways, and risks from dioxins/furans, and no follow-up data on potential sources, pathways, and risks from dioxin-like coplanar PCBs after these contaminants were found in the supplemental soil sampling.

Ongoing investigations at the Site include incorporating comments and finalizing the BERA, monitoring groundwater quality, and drafting the RI/FS document.

4. Confirmation of Exposure

Federal regulations state that an Assessment Plan should confirm that "at least one of the natural resources identified as potentially injured in the Preassessment Screen has in fact been exposed to the released substance" [43 CFR § 11.37(a)].

A natural resource has been exposed to hazardous substances if "all or part of [it] is, or has been, in physical contact with . . . a hazardous substance, or with media containing . . . a hazardous substance" [43 CFR § 11.14(q)]. The regulations also state that "whenever possible, exposure shall be confirmed using existing data" from previous studies of the assessment area [43 CFR § 11.37(b)(1)]. The following sections provide confirmation of exposure of natural resources to hazardous substances in the assessment area, based on a review of the available data.

4.1 Groundwater

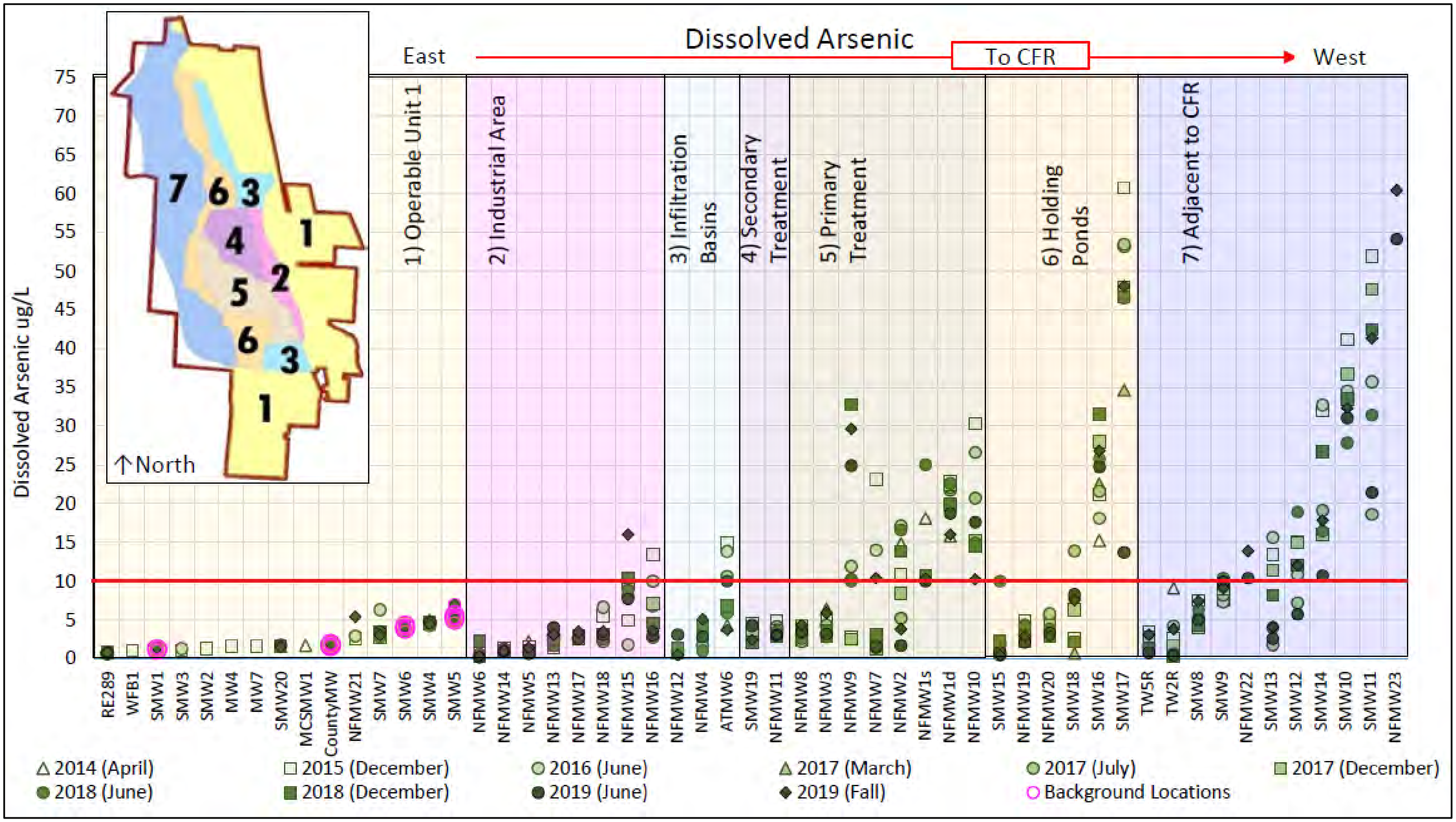
The DOI regulations define groundwater as "water in a saturated zone or stratum beneath the surface of land or water and the rocks or sediments through which ground water moves. It includes ground water resources that meet the definition of drinking water supplies" [43 CFR § 11.14 (r)]. As discussed in Chapter 2, groundwater near the mill property includes a shallow alluvial aquifer and a deeper aquifer that was the source of process water for the mill.

Existing data confirm that hazardous substances released at the Site have contaminated the shallow alluvial groundwater underlying OU2 and OU3. NewFields (2020) has identified manganese, arsenic, and dioxins/furans as groundwater contaminants of concern in the shallow aquifer. In 2018, elevated manganese concentrations were also found in the deep aquifer (NewFields, 2020).

The arsenic groundwater quality standard under both Montana Circular DEQ-7 Numeric Water Quality Standards (MDEQ, 2019) and the EPA Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL; U.S. EPA, 2021a) is 10 µg/L. NewFields (2020) shows that arsenic concentrations in groundwater wells upgradient of the Site do not exceed this standard, but onsite, at least 20 wells have had arsenic concentrations exceeding this standard, with concentrations as high as 60 µg/L (Figure 4.1). During the 2011 Site Inspection for EPA, URS (2012) collected groundwater samples from 27 wells and reported several wells with arsenic measured above the 10-µg/L standard, with a maximum reported concentration of 133 µg/L.

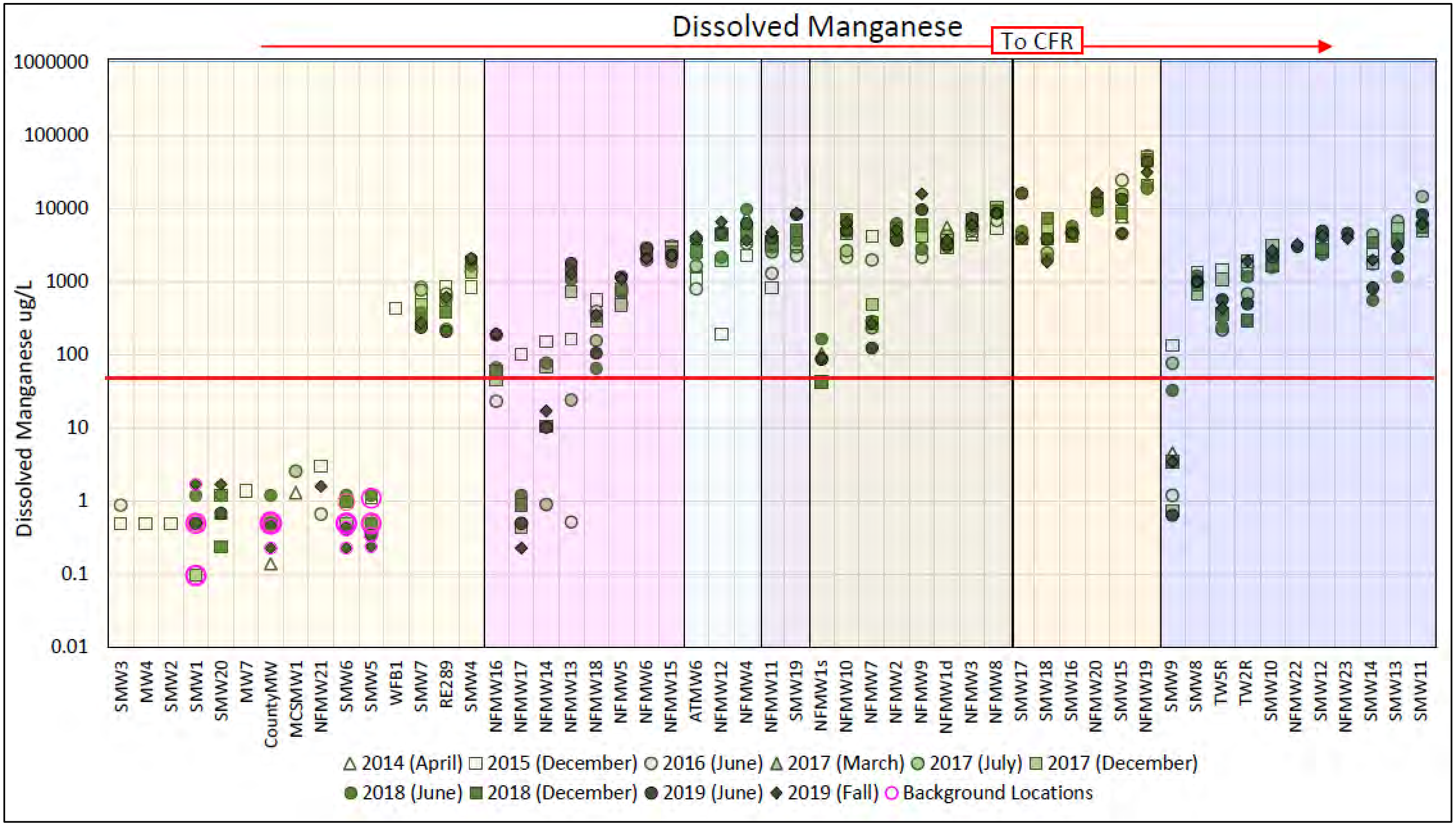
The EPA SDWA Secondary MCL (SMCL) for manganese is 50 µg/L (U.S. EPA, 2021a). NewFields (2020) showed no exceedances in wells upgradient of the Site, and over 40 wells onsite that exceed this standard. Several wells have manganese concentrations that exceed 10,000 µg/L (Figure 4.2). During the 2011 Site Inspection for EPA, URS (2012) similarly reported elevated manganese concentrations, with a maximum concentration of 14,600 µg/L. The highest concentrations of both arsenic and manganese are downgradient of the primary and secondary water treatment ponds (NewFields, 2017), suggesting that the Site wastewater stream is the source of the contamination.

Figure 4.1. Arsenic concentrations in shallow groundwater. The arsenic MCL (10 µg/L) is depicted with a red line.



Source: NewFields, 2020, Figure 31 (modified).

Figure 4.2. Manganese concentrations in shallow groundwater. The manganese SMCL (50 µg/L) is depicted with a red line. The Y axis is on a logarithmic scale.



Source: NewFields, 2020, Figure 31 (modified).

Dioxins and furans are typically reported together in terms of TCDD toxic equivalency (TEQ) rather than reporting concentrations of individual congeners.[1] The TCDD TEQ groundwater quality standard under Montana Circular DEQ-7 Numeric Water Quality Standards is 2 pg/L (MDEQ, 2019). NewFields (2020) showed no detectable TCDD TEQ in wells upgradient of the Site. Dioxins/furans were detected in most wells in OU2 and OU3, with maximum TCDD TEQ concentrations exceeding 2 pg/L in four wells (Figure 4.3). One well in the primary treatment area has consistently had TCDD TEQ concentrations exceeding 2 pg/L, with a maximum of 16 pg/L (Figure 4.3).

4.2 Surface Water Resources

The DOI regulations define surface water resources as "the waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline… This term does not include ground water or water or sediments in ponds, lakes, or reservoirs designed for waste treatment under the Resource Conservation and Recovery Act of 1976 (RCRA), 42 U.S.C. 6901–6987 or the Clean Water Act (CWA), and applicable regulations" [43 CFR § 11.14 (pp)]. The mill property includes water and sludge treatment ponds in OU2 that were designed for waste treatment. Hundreds of acres of holding ponds in the OU3 floodplain received Site water after the point of compliance for wastewater treatment. Water and sediments in these OU3 holding ponds meet the definition of surface water resources.

The potential exposure of surface water resources (including sediments) in the Clark Fork River, O'Keefe Creek, and Lavalle Creek has been the subject of Site investigations. Previous sediment samples collected from ponds in OU3 confirm exposure of surface water resources to hazardous substances. Several metals exceeded the risk-based SLERA thresholds (which were the same as soil thresholds, discussed in the following section; U.S. EPA, 2017c). Arsenic, cadmium, manganese, mercury, and zinc exceeded the SLERA thresholds (NewFields, 2018). The TCDD TEQ threshold in the SLERA is 0.85 ng/kg. All of the onsite sediment samples exceeded this threshold, some by two orders of magnitude (Figure 4.4), confirming exposure of natural resources to dioxins/furans in these floodplain ponds. As part of the assessment, the Trustees will review appropriate sediment reference data to confirm that the mill waste stream was the source of elevated concentrations of dioxins/furans in OU3 surface water resources.

4.3 Geologic Resources

The DOI regulations define geologic resources as "those elements of the Earth's crust such as soils, sediments, rocks, and minerals … that are not included in the definitions of ground and surface water resources" [43 CFR § 11.14(s)]. In this assessment, geologic resources are soils, including soils that were dry when originally exposed to contamination, as well as areas in former sludge ponds and holding ponds that were inundated when originally exposed and have since dried out.

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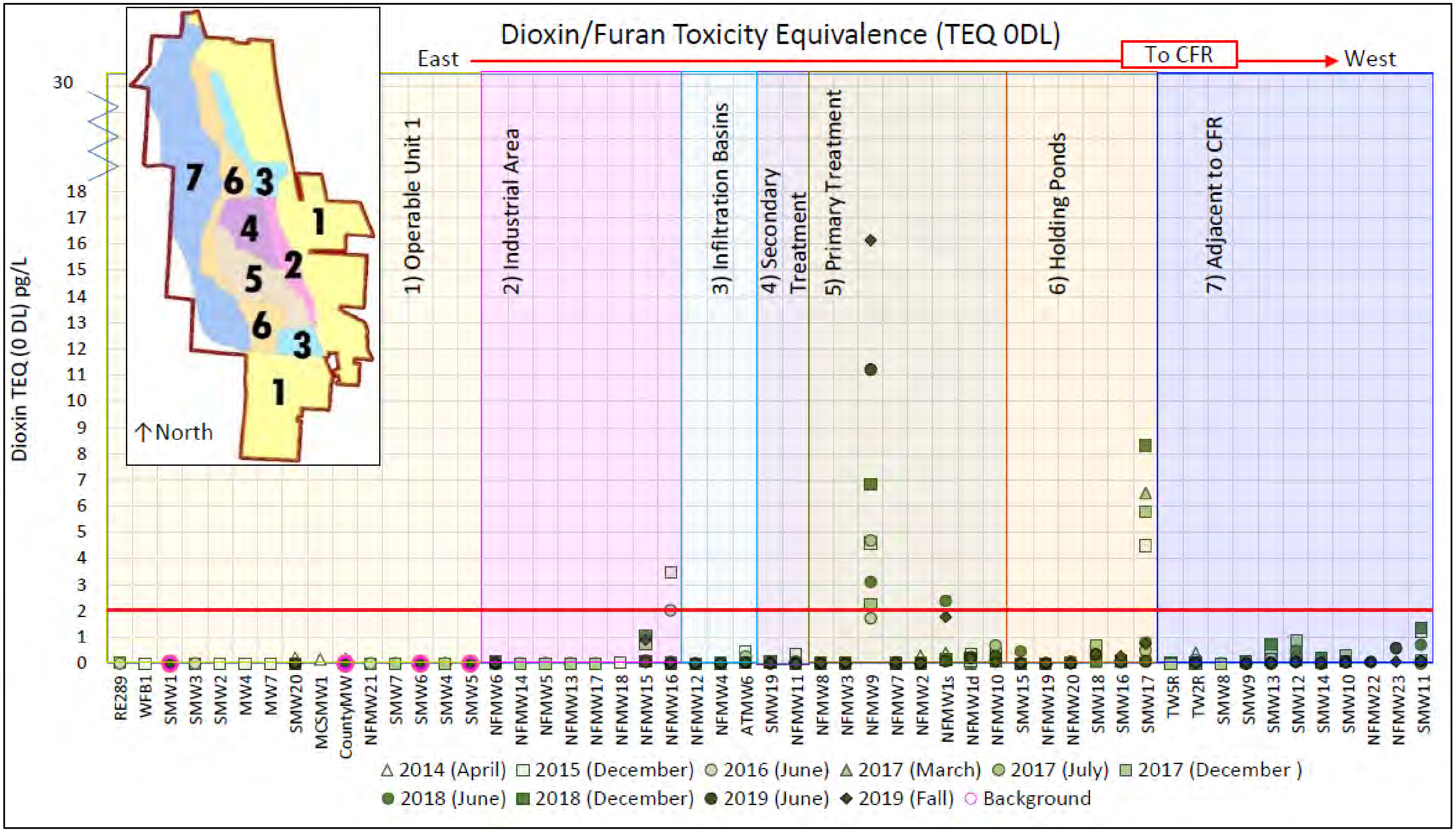
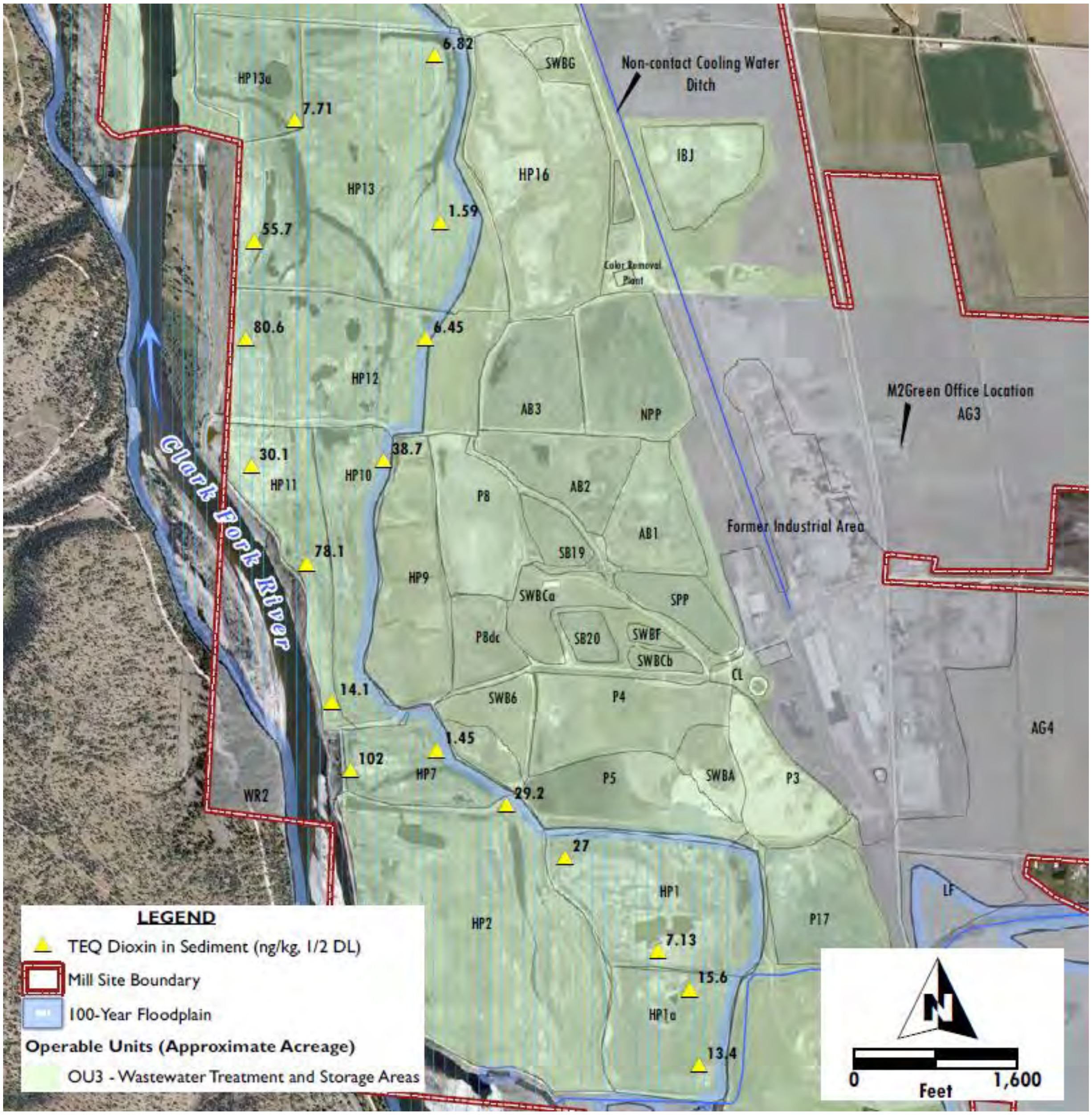
1. TEQ is calculated by multiplying the concentration of each congener by a Toxic Equivalency Factor (TEF) and then adding the TEF-modified concentration for each congener. The World Health Organization has developed TEFs for commonly analyzed dioxin and furan congeners, including different TEFs for mammals, birds, and fish (Van den Berg et al., 2006). TEQ calculations in this report use the mammal TEFs unless referring specifically to fish tissues. When congeners are below detection limits, one can calculate the TEQ assuming non-detected congeners are zero, or assuming they are present at one-half the detection limit. Unless otherwise specified, TEQs in this report are calculated with non-detects set to zero.

Figure 4.3. Dioxin/furan (TCDD TEQ) concentrations in shallow groundwater. The Montana DEQ-7 water quality standard (2 pg/L) is depicted with a red line. "0 DL" means congeners below the detection limit were set to zero when calculating the TEQ.



Source: NewFields, 2020, Figure 27 (modified).

Figure 4.4. Dioxin/furan (TCDD TEQ) concentrations (ng/kg) in OU3 pond sediments. The risk-based threshold from the SLERA is 0.85 ng/kg. NewFields (2016c) used half the detection limit (1/2 DL) for undetectable congeners, but nearly all analyzed congeners were detectable in all samples. OU3 also includes locations in the Clark Fork River where hazardous substances from the Site have come to be located.



Source: Modified from NewFields, 2016c, Figure 18.

EPA contractors performed a Site Inspection in 2011 that included a chemical analysis of soil samples (URS, 2012). For this preliminary analysis, in which EPA was collecting data for a hazard-ranking score, sites with hazardous substance concentrations more than three times the concentrations of background samples were considered sources of contamination. They concluded that four sludge ponds (3, 4, 5, and 17 in OU3), emergency spill pond 8 (OU3), an exposed soil pile adjacent to Landfill A (OU3), holding pond 2 (OU3), and the land farm (OU2) were sources of metals and dioxins/furans (URS, 2012). The highest concentrations of hazardous substances were typically found in Sludge Pond 3 and Landfill A (Table 4.1).

Table 4.1. Hazardous substances present at more than three times background levels in the Site Inspection

Analyte	Background concentration (mg/kg)	Maximum concentration (mg/kg)	Location of maximum concentration
Arsenic	8.5	71.4	Sludge Pond 3
Cadmium	1.5	17.9	Sludge Pond 3
Chromium	11	45.1[b]	Landfill A
Dioxins/furans[a]	2.16×10^{-6}	2.93×10^{-4}	Sludge Pond 3
Lead	19.6	108	Sludge Pond 3
Manganese	435	6,840	Sludge Pond 3
Nickel	9.8	80.3[b]	Landfill A
Silver	1.1[b]	3.6	Sludge Pond 17
Zinc	235	1,300	Sludge Pond 3

a. Expressed as 2,3,7,8-TCDD TEQ.
b. Estimated value (J qualifier).
Source: URS, 2012.

In the 2017 SLERA for OU2 and OU3, U.S. EPA (2017c) identified numerous COPECs that exceeded risk-based ecological benchmarks for soil. At least 14 different analytes exceeded SLERA thresholds in surface soils (generally 0–2 feet below-ground), including aluminum, antimony, arsenic, barium, cadmium, copper, lead, manganese, mercury, nickel, selenium, dioxins/furans (expressed as TCDD TEQ), vanadium, and zinc (Table 4.2). The SLERA compared measured concentrations of contaminants in soils to conservative thresholds that suggest potential risk to sensitive flora and fauna. As shown in Table 4.2, concentrations of hazardous substances in some samples exceed the SLERA thresholds by more than an order of magnitude, and the maximum TCDD TEQ exceeds the SLERA threshold by more than three orders of magnitude. These data confirm that soils have been exposed to hazardous substance releases from the mill.

The highest concentrations of hazardous substances measured on the mill property are generally in the area of primary treatment ponds (i.e., settling ponds or sludge ponds) and holding ponds closest to the primary treatment ponds. Concentrations of cadmium, manganese, mercury, and zinc exceed the SLERA thresholds by at least a factor of 4 in many samples from those locations, with maximum concentrations ranging from 14 to 80 times higher than the SLERA threshold (Figures 4.5–4.8; Table 4.2). This spatial distribution of elevated metals concentrations suggests that the mill wastewater stream is the source of contamination.

Table 4.2. Exceedences of surface soil benchmarks used in the SLERA (U.S. EPA, 2017c), based on data collected between 2014 and 2017. The maximum magnitude of exceedance is the ratio of the highest measured concentration to the benchmark.

Analyte	Benchmark (mg/kg)	Number of exceedances	Maximum magnitude of exceedance	Benchmark source[a]
Aluminum	50	213	614	Oak Ridge National Laboratory (ORNL) soil benchmark for plants
Antimony	0.27	31	14	Mammal Ecological Soil Screening Level (Eco-SSL)
Arsenic	10	12	4	ORNL plants
Barium	330	39	4	Soil Invert Eco-SSL
Cadmium	0.36	48	23	Mammal Eco-SSL
Copper	28	44	4	Bird Eco-SSL
Dioxin TEQ	1.99×10^{-7}	118	3,800	EPA Region 5 ecological screening level
Lead	11	92	9	Bird Eco-SSL
Manganese	220	150	14	Plant Eco-SSL
Mercury	0.1	34	80	ORNL soil invertebrate
Selenium	0.52	38	4	Plant Eco-SSL
Vanadium	2	212	60	ORNL plants
Zinc	46	149	15	Bird Eco-SSL

a. See U.S. EPA (2017c) for a discussion of the benchmarks selected for the SLERA.
Data source: EPA Scribe database, June 2021.

Dioxin contamination is more widespread (Figure 4.9). In surface soils, 118 samples had dioxin concentrations exceeding the TCDD TEQ threshold of 0.199 ng/kg (or 1.99×10^{-7} mg/kg), with the maximum concentration exceeding the threshold by a factor of 3,800 (Table 4.2). The TCDD TEQ threshold in the SLERA is lower than the Montana statewide background dioxin concentration of 3.7 ng/kg (or 3.7×10^{-6} mg/kg; MDEQ, 2011b). In the surface soil data in the EPA Scribe database, 46 samples contained TCDD TEQ concentrations that exceeded this Statewide background concentration. Concentrations in those samples range from 3.8 to 756 ng/kg of TCDD TEQ (Figure 4.9).

MRL evaluated dioxin/furan contamination in surface soils along the Rail Spur Line, in the area where the spur bridges OU1 and OU2 (see Figure 3.4). In November 2015, dioxin/furan concentrations in the upper 2 inches of soil ranged from 39 to 84 ng/kg TCDD TEQ, and concentrations between 2 and 6 inches ranged from 5.3 to 23 ng/kg TCDD TEQ (Olympus, 2017). Thus, all samples from this area exceeded both the SLERA threshold and the Statewide background concentration.

Site investigations of PCB releases focused on Aroclors, such as those in oil leaking from transformers. Coplanar (dioxin-like) PCB congeners have a similar mode of toxicity as dioxins and furans, and therefore are often included in a calculation of TCDD TEQ. Detection limits for analyses of PCB congeners are orders of magnitude lower than detection limits for PCBs in Aroclors. Site investigations of dioxin-like PCBs are limited.

Figure 4.5. Surface soil samples where cadmium concentrations exceeded the SLERA risk-based threshold, highlighting samples exceeding the threshold by at least a factor of 4. OU3 also includes locations in the Clark Fork River where hazardous substances from the Site have come to be located.

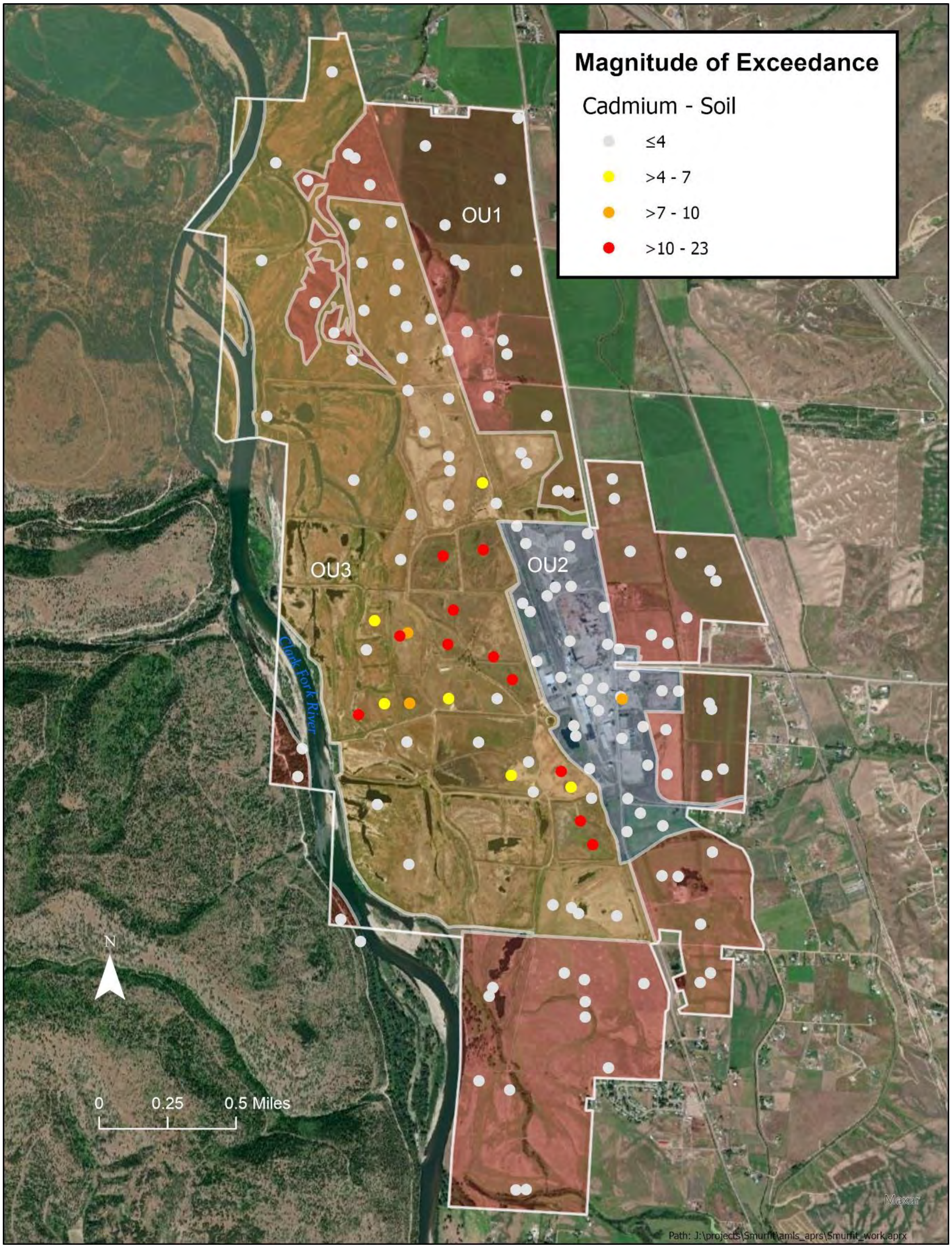


Figure 4.6. Surface soil samples where manganese concentrations exceeded the SLERA risk-based threshold, highlighting samples exceeding the threshold by at least a factor of 4. OU3 also includes locations in the Clark Fork River where hazardous substances from the Site have come to be located.

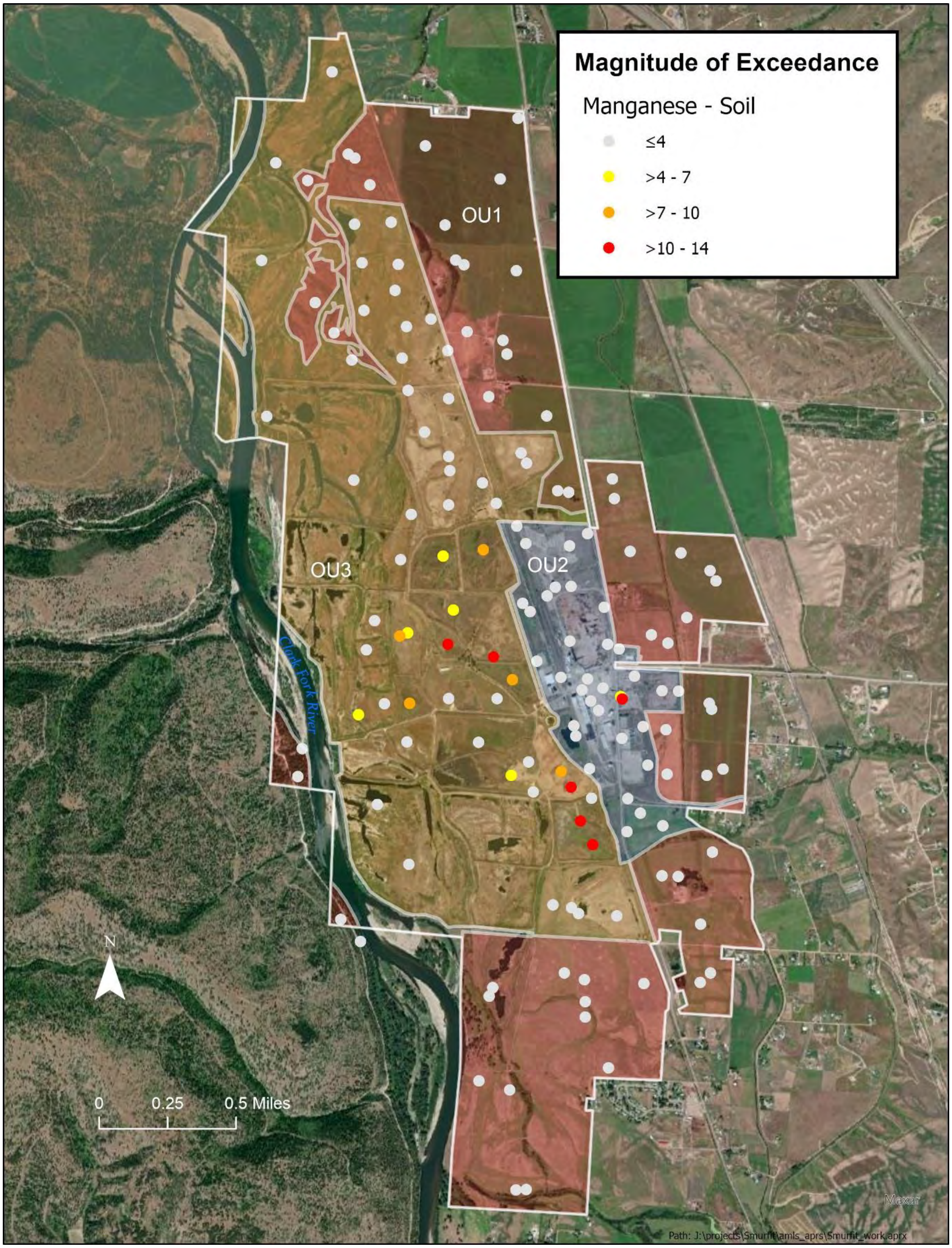


Figure 4.7. Surface soil samples where mercury concentrations exceeded the SLERA risk-based threshold, highlighting samples exceeding the threshold by at least a factor of 4. OU3 also includes locations in the Clark Fork River where hazardous substances from the Site have come to be located.

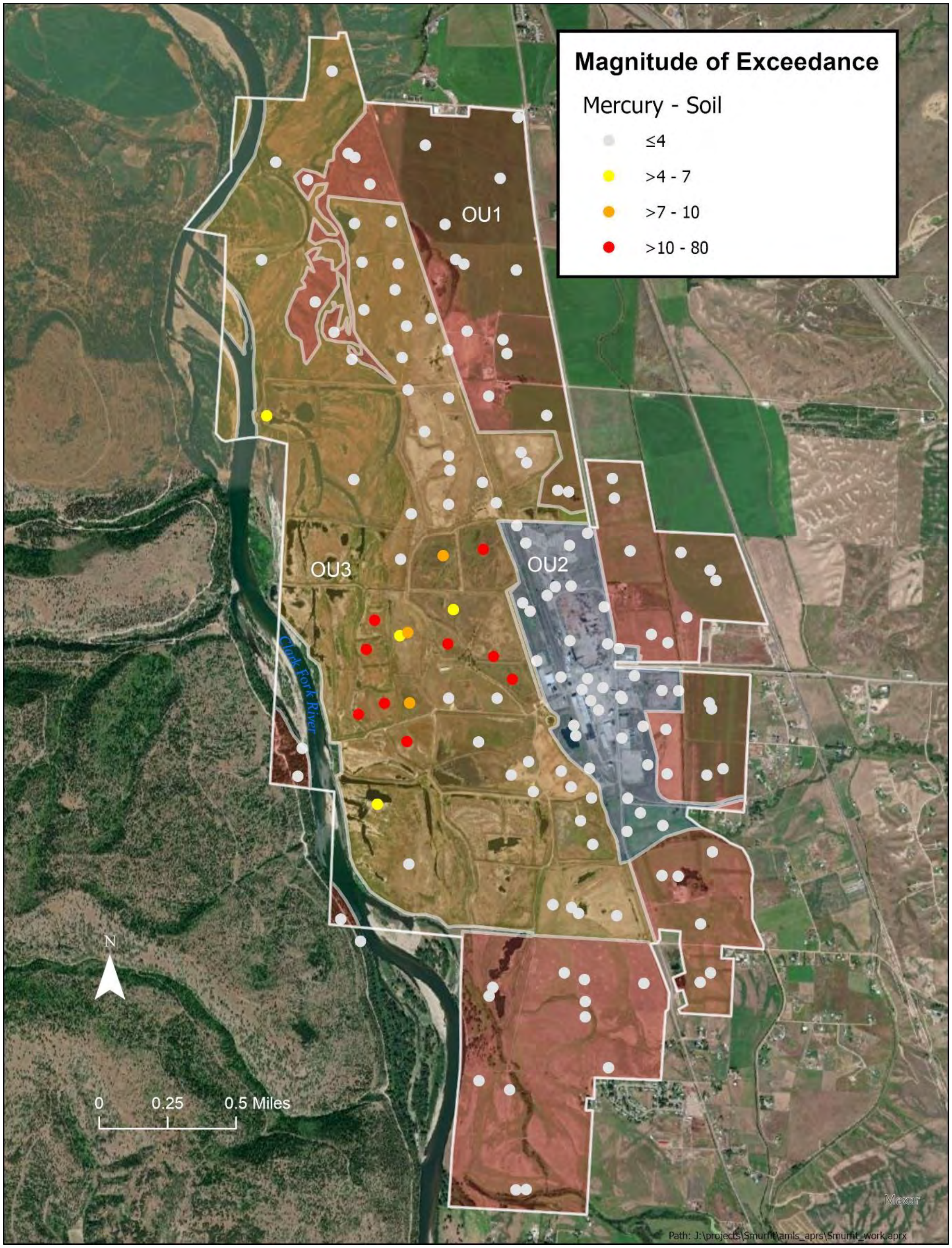


Figure 4.8. Surface soil samples where zinc concentrations exceeded the SLERA risk-based threshold, highlighting samples exceeding the threshold by at least a factor of 4. OU3 also includes locations in the Clark Fork River where hazardous substances from the Site have come to be located.

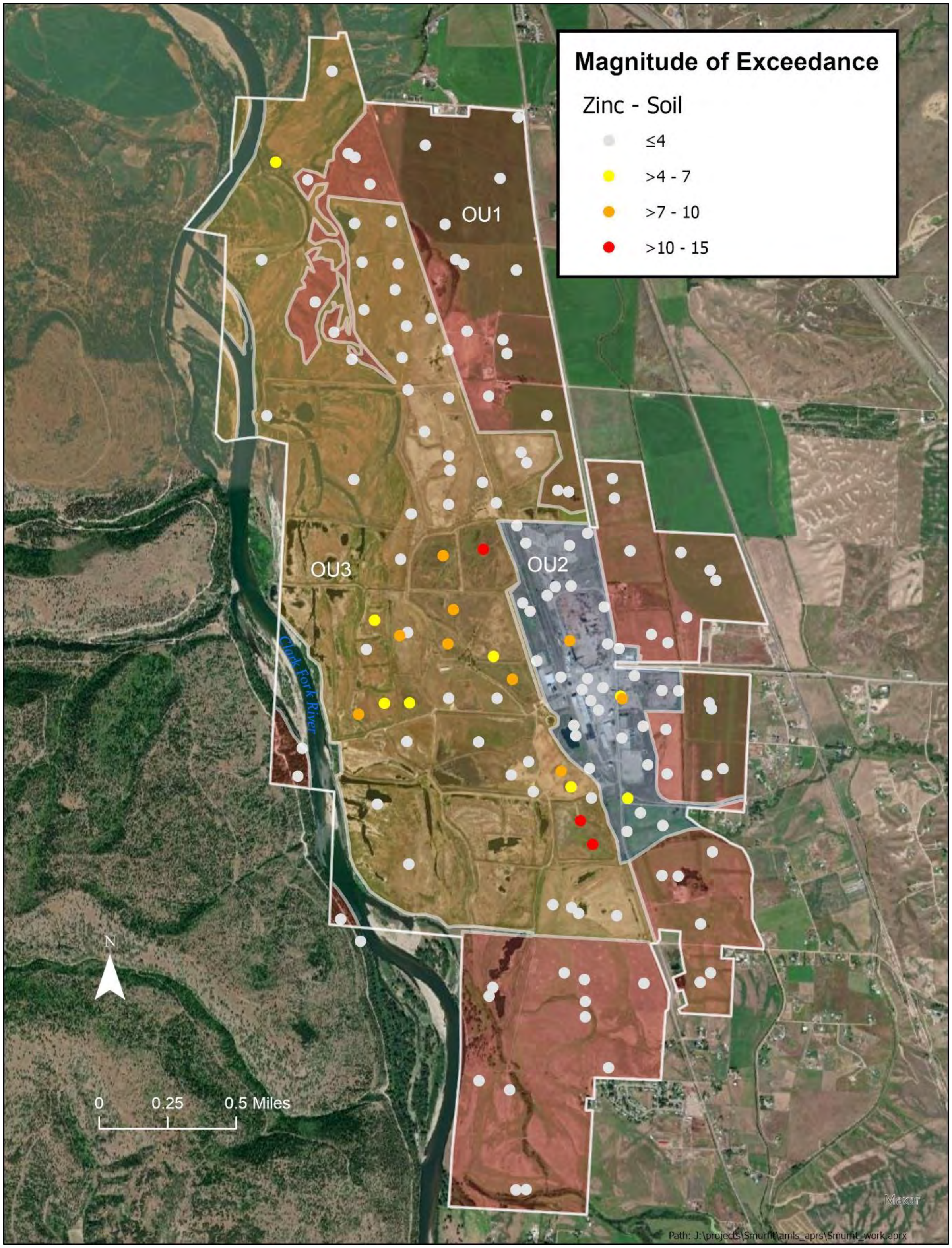
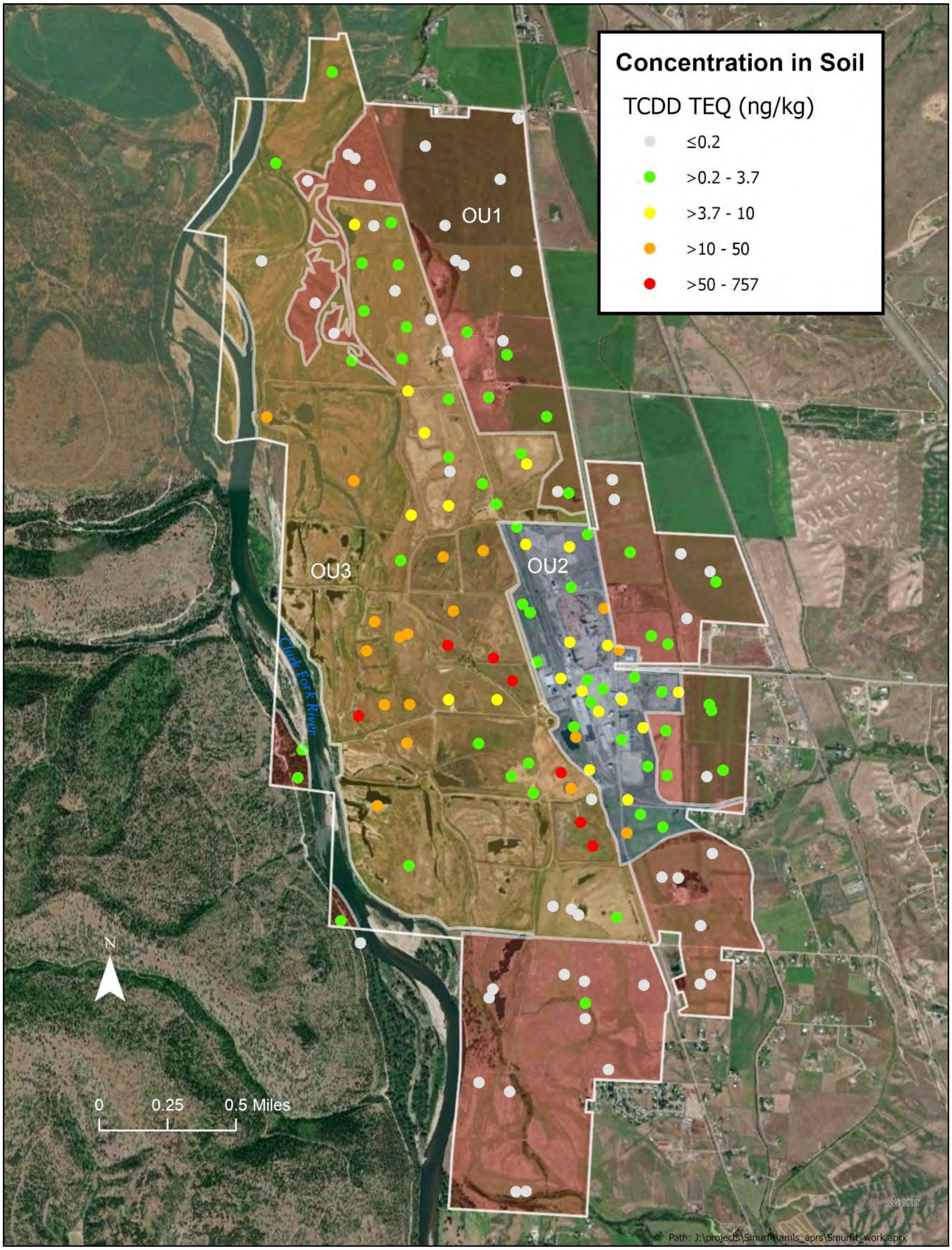


Figure 4.9. Surface soil samples where TCDD TEQ concentrations exceeded the SLERA risk-based threshold and the Statewide background concentration. The risk-based threshold in the SLERA is 0.199 ng/kg, and the Statewide background concentration is 3.7 ng/kg (MDEQ, 2011b). OU3 also includes locations in the Clark Fork River where hazardous substances from the Site have come to be located.



The only samples that included PCB congeners of any media from the Site were from the 2018 OU2 supplemental soil sampling. This study included PCB congeners from 9 composite samples, where each composite covered either 10 or 20 acres. Coplanar PCBs, including PCB-126 (the most toxic coplanar PCB congener), were detected in all nine samples. In four of the samples, PCB congeners comprised more than 50% of the TCDD TEQ; and in two samples, PCBs comprised nearly 80% of the TCDD TEQ. These preliminary data suggest that the Site is a potential source of dioxin-like coplanar PCBs.

4.4 Biological Resources

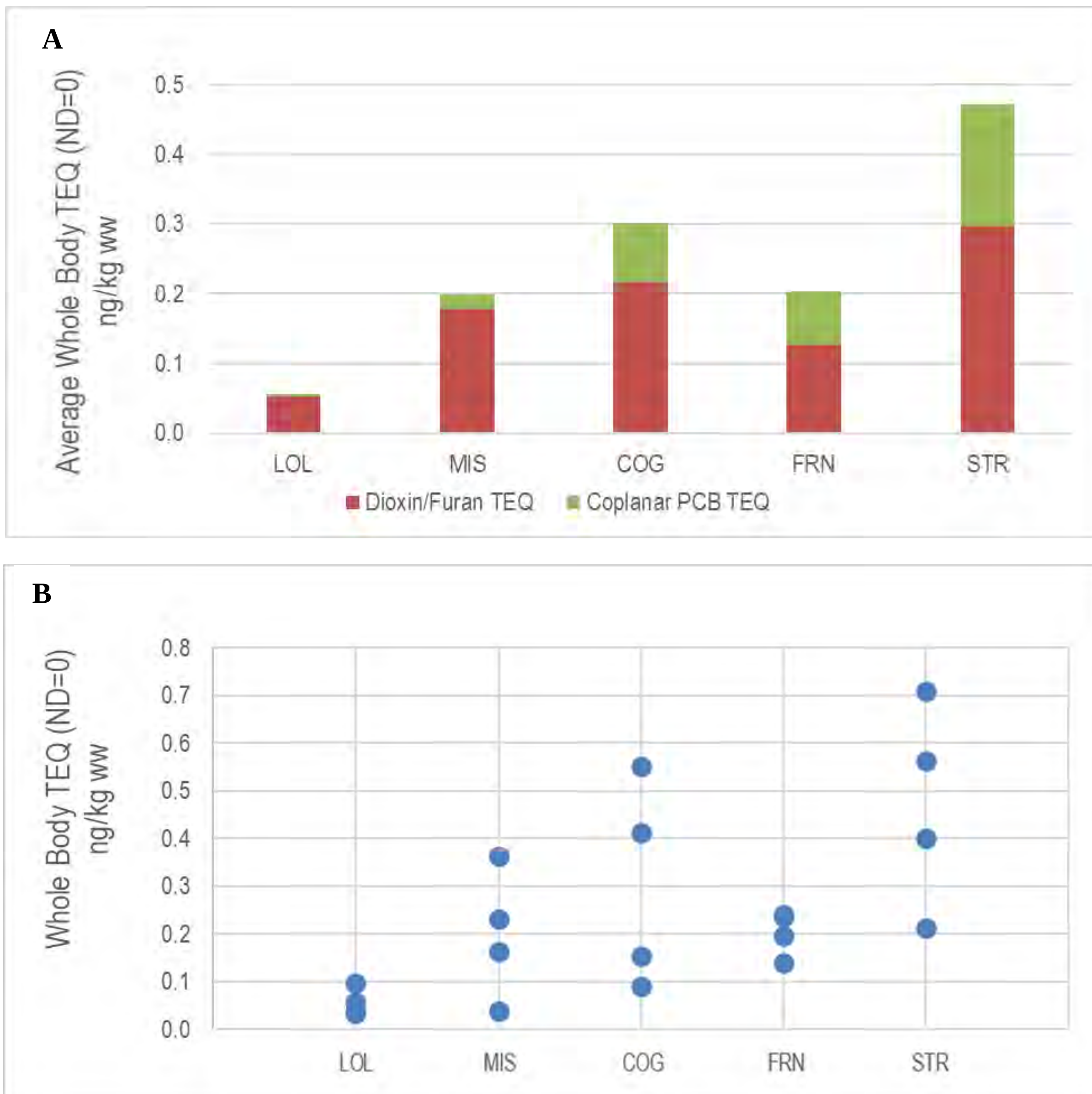
According to the DOI regulations, biological resources are "those natural resources referred to in section 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition" [43 CFR § 11.14(f)]. Fish in the Clark Fork River downstream of the mill property have been exposed to dioxins/furans, which are hazardous substances known to have been released at the mill.

Montana Fish, Wildlife, and Parks (MFWP) personnel evaluated potential exposure of fish to metals and dioxins/furans downstream of the mill property in 2013, quantifying dioxins/furans, PCBs, selenium, and mercury in muscle tissues of sport fish in the Clark Fork River (Schmetterling and Selch, 2013). They collected northern pike in backwater sloughs within 10 km downstream of the mill property, and rainbow trout from the main channel of the Clark Fork River immediately downstream of the mill property. The objective was to assess potential health risks to recreational anglers by analyzing contaminants in skin-off fillets that anglers typically eat. Dioxins are lipophilic and thus most likely to accumulate in fatty tissues, which were not analyzed. Regardless, TCDD concentrations in just the muscle tissue of all composite samples were sufficient to warrant fish consumption advisories (FCAs) for both rainbow trout and northern pike. The data confirmed exposure of fish to hazardous substances known to have been released at the mill property. As a result of the study, MDEQ, the Montana Department of Public Health and Human Services (MDPHHS), and MFWP posted a "do not eat" advisory for large northern pike and a "limit consumption to four meals per month" advisory for rainbow trout in the reach of the Clark Fork River near the mill property (MFWP, 2013; MDEQ et al., 2015).

Selch (2015) analyzed skin-off fillets of northern pike from Noxon Reservoir, on the Clark Fork River about 145 river miles downstream of Frenchtown. TCDD TEQ concentrations in fillets of large northern pike were sufficient to require a "do not eat" consumption advisory for large fish, and various monthly consumption limits for smaller fish (MDEQ et al., 2015). Six of the 13 dioxin and furan congeners detected in northern pike near the mill property were also detected in northern pike in Noxon Reservoir (Selch, 2015). Although additional research is required, the data suggest that fish many miles downstream of the mill property may have been exposed to hazardous substance releases from the mill.

As part of BERA assessment activities, MFWP collaborated with EPA to collect additional rainbow trout and northern pike in 2018 and 2019 upstream and downstream of the Site (e.g., U.S. EPA, 2020). In the draft BERA, U.S. EPA and SRC (2020) relied on the 2019 data, citing data quality issues with the 2018 sampling. The 2019 sampling for rainbow trout included three upstream locations, one location in Frenchtown near the Site, and one in St. Regis well downstream of the Site (Figure 4.10). Despite the limited dataset, the 2019 data generally show an increasing trend in TEQ concentrations, including higher dioxins/furans and higher dioxin-like PCBs in trout from St. Regis downstream of the Site.

Figure 4.10. TCDD TEQ (ng/kg wet weight, or ww) in composite rainbow trout samples ("whole body," i.e., fillet + carcass) collected in 2019. Non-detectable congeners were assumed to be zero (ND = 0). The sample locations are shown upstream to downstream (left to right on the X axis), including Lolo (LOL), Missoula (MIS), Council Grove (COG), Frenchtown (FRN), and St. Regis (STR). (A) Average TCDD TEQ in each reach. (B) TCDD TEQ (dioxin/furan/PCBs) in individual composite samples.



As a result of the 2018 and 2019 sampling, MDEQ et al. (2021) updated the FCA for the Clark Fork River from the Bitterroot River confluence in Missoula to the Flathead River confluence downstream of St. Regis. The FCA is now "do not eat" for all fish species and sizes in this reach, because of potential exposure to dioxin/furans and PCBs. While the data from the fish tissue studies confirm exposure of downstream biological resources to elevated dioxins/furans and coplanar PCBs, they may not be sufficient to determine the source of these contaminants. As will be discussed in subsequent chapters, the Trustees propose addressing some of these potential data gaps.

5. Assessment Approach

As described in Chapter 1, the DOI regulations specify three interrelated parts of an assessment: injury determination, injury quantification, and damage determination. For this NRDA, the existing information may be insufficient to determine and quantify injury. The Trustees may therefore pursue cost-effective data collection to address potential data gaps.

The Trustees will conduct the assessment using existing data and potentially using data from new studies. Existing data will primarily be used to develop preliminary conclusions regarding the types and magnitudes of injury and damages resulting from releases from the mill property. In addition, the Trustees will continue to engage as stakeholders in the RI/FS process in hopes that any ongoing data collection addresses both remediation and damage assessment goals to the extent possible.

Consistent with the DOI regulations, injuries will be evaluated on a resource-by-resource basis. However, natural resources and the ecological services they provide are interdependent. For example, surface water and sediments, floodplain soils, and riparian vegetation together provide habitat – and lateral and longitudinal connectivity between habitats – for aquatic biota, semi-aquatic biota, and upland biota. Hence, injuries to individual natural resources may cause habitat- or ecosystem-level impacts. The DOI regulations define these habitat- and ecosystem-level functions as natural resource services, specifically "the physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource" [43 CFR § 11.14(nn)]. While this assessment will be conducted on a resource-by-resource basis, the quantification of injury and damage determination may also incorporate ecosystem processes that encompass a broader scope of losses within and across these natural resources.

The following sections present the Trustees' approach to this NRDA. First, Section 5.1 lists existing data sources that are available for assessing injuries and damages. Subsequent sections describe the approach for pathway determination (Section 5.2), injury determination (Section 5.3), injury quantification (Section 5.4), and damage determination (Section 5.5). Additional assessment studies the Trustees may conduct are described in Chapter 6.

5.1 Data Sources

Data sources that will be evaluated in the injury assessment include:

- Articles published in the peer-reviewed literature
- State and Federal government data and reports
- Industry data and reports
- RI/FS data and reports
- ERAs conducted for the OUs, including supporting studies and information.

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

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

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

5.1.1 Supplemental Data Collection

The Trustees have concluded that additional data may be needed to determine dioxin/furan and coplanar PCB releases, fate and transport, natural resource exposure, and injuries. Chapter 6 of this Assessment Plan presents four studies that the Trustees are considering to address these data gaps. The Trustees may decide to conduct additional studies in the future; the public will be provided the chance to review sampling plans for any substantial data collection activities in the future.

5.1.2 Procedures for Sharing Data

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

The PRPs share RI/FS data with the Trustees via EPA's Scribe database. All potentially relevant data, reports, and studies are provided to State, Federal, or Tribal agencies if requested. The Trustees will provide the PRPs and the public with any Trustee-collected data once the data have been validated. The specific sharing procedure will be included in Trustee sampling plans.

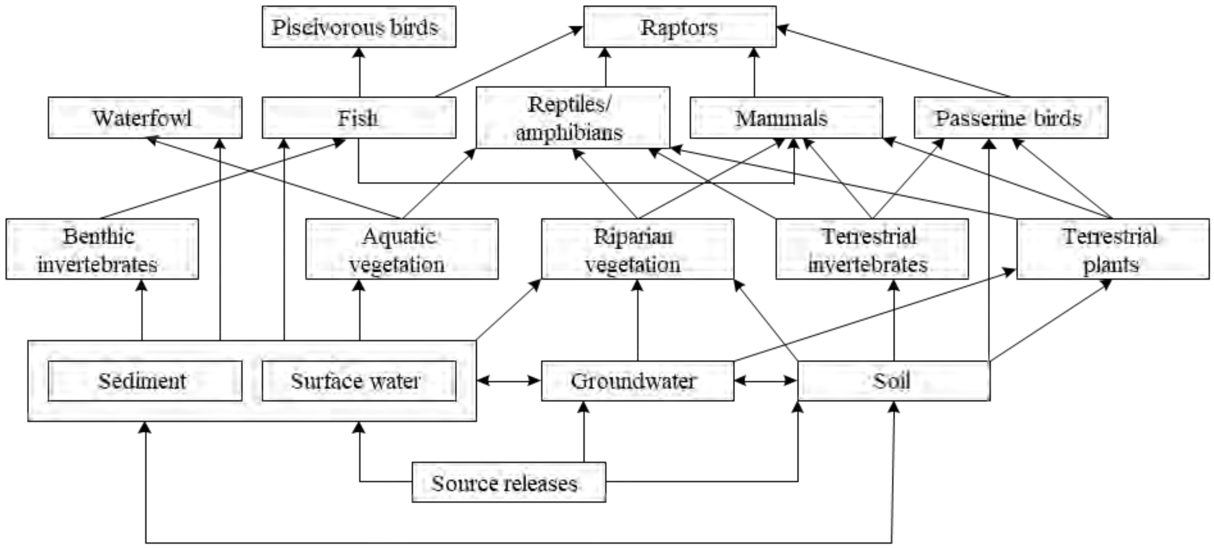
5.2 Pathway Determination

The Trustees presented a preliminary pathway evaluation in the Preassessment Screen (Abt Associates, 2018), which is reiterated here. As part of assessment activities, the Trustees will evaluate additional data that determine pathways of hazardous substances from source areas to natural resources.

Specifically, pathways will be determined using a combination of information about the nature of transport mechanisms of the hazardous substances and data documenting the presence of the hazardous substance in the pathway resource. The Trustees will rely on existing data to the extent possible and collect new data when necessary to determine whether hazardous substances are present in "sufficient concentrations" in pathway resources to have served as pathways [43 CFR § 11.63 (a)(2)]. This will allow the Trustees to link hazardous substance sources at the Site to natural resource exposure to those hazardous substances.

As described in Chapter 3, potential sources of hazardous substances at the mill include sludge ponds, the emergency spill pond, aeration basins, polishing ponds, wastewater storage ponds, landfills, the industrial area, the land farming area, and storage tanks. These sources have contaminated groundwater, soils, sediments, and surface water that can in turn act as secondary sources of hazardous substances to Trustee natural resources. Hazardous substances released from these primary and secondary sources may be transported to natural resources by groundwater, surface water, aerial transport, and food chain pathways (Figure 5.1). Pathways of hazardous substance transport at the Site are described in more detail below.

Figure 5.1. Pathways by which Trustees resources are potentially exposed to hazardous substances at the Site.



5.2.1 Pathways to Soils

When mill waste containing hazardous substances is deposited on the ground surface, soils are exposed to hazardous substances through direct contact. Similarly, when mill waste containing hazardous substances is deposited into inundated waste ponds and the ponds are subsequently drained, the substrate at the bottom of the pond becomes soil exposed to hazardous substances via contaminated surface water and solids that were present when the pond was inundated.

The landfill areas and land farm area are all areas where mill waste was directly deposited on the soil. The sludge ponds, the emergency spill pond, and the holding ponds are areas where hazardous substances were likely entrained in wastewater and deposited in sediment, which became soil after the ponds were drained. Surface runoff from ponds, the landfill, and the land farm area during snowmelt and precipitation events also serve as pathways of hazardous substances to soils.

Aerial deposition from stack emissions may have occurred when the mill was operating, and aerial redistribution of contaminated surficial soils through wind events may also occur. As far as the Trustees are aware, air sampling data are not available to confirm an air pathway for hazardous substances currently found in soil and other resources at the Site. However, historical observations confirm that an air pathway existed at the Site during operations. For example, the Site was nationally known for poor air quality from stack emissions when it operated (e.g., National Geographic, 1970). In general, waste gases from kraft mills include hydrogen sulfide, which is highly malodorous (Versar, 1977), and sulfur dioxide. Carlson et al. (1974) documented 5,200 acres of Douglas fir trees with sulfur damage in the Clark Fork River valley near Frenchtown in 1972–1973. While these historical observations clearly demonstrate an aerial deposition pathway to soils and vegetation for sulfur, it is unclear from existing data if the emissions plume from the stack may have also deposited other hazardous substances that are currently measured in soil and other natural resources at the Site. In the future, the Trustees may evaluate the potential deposition of airborne persistent hazardous substances by sampling soils in the vicinity of the trees that were exposed to airborne sulfur.

Soils exposed to hazardous substances either directly from deposited mill waste or through runoff or aerial transport can provide a pathway of exposure to surface water, groundwater, and biological resources.

5.2.2 Pathways to Groundwater

The pathway to groundwater at the Site is primarily through the percolation of wastewater through the bottom of the unlined ponds. The Montana Department of Health and Environmental Services (MDHES; the predecessor to MDEQ) reported that pond wastes entered both the shallow aquifer underlying the ponds and the deep aquifer near the plant (MDHES, 1974, as cited in URS, 2011). From 1974 to 1983, much of the wastewater was placed in rapid infiltration basins designed to transport wastewater into shallow groundwater. In 1977, 63% of the wastewater was routed through these rapid infiltration ponds (URS, 2011). Additional contamination to the groundwater may have occurred from leaks and spills from the storage tanks. The contaminated groundwater can provide a pathway of exposure to surface water, sediment, and biota in the Clark Fork River, where groundwater enters the river through springs and upwelling through the streambed. The contaminated groundwater may also provide a pathway to soils in the vadose zone. In addition, soils may periodically come into direct contact with the water table due to groundwater fluctuations resulting from storm events, spring runoff, and irrigation return flows.

5.2.3 Pathways to Surface Water Resources

Surface water resources at the Site include surface water and sediment in the Clark Fork River and O'Keefe and Lavalle creeks, as well as water and sediment in the ponds within the Clark Fork River floodplain. O'Keefe and Lavalle creeks flow through the southern end of the mill property before discharging into the Clark Fork River, which runs adjacent to the mill property (see Figures 1.1 and 2.1). Surface water and sediments in the Clark Fork River may have been directly exposed to hazardous substances through the discharge of wastewater or contaminated groundwater.

Some holding ponds in the floodplain have become seasonal wetlands (U.S. EPA, 2017c). Surface water and sediments in these ponds have been exposed to hazardous substances via direct discharge of contaminated wastewater and discharge of contaminated groundwater. The ponds may have been exposed to aerial deposition from stack emissions when the mill was operating. The ponds may also be exposed to hazardous substances via surface runoff from contaminated soils during snowmelt and precipitation events, and aerial deposition of windblown contaminated soil.

In addition, hazardous substances in ponds, the industrial area, landfill areas, the land farm area, and contaminated soils may be transported to the Clark Fork River and nearby creeks by surface runoff during spring snowmelt, seasonal precipitation, and storm events. The surface water and sediment in the Clark Fork River subsequently serve as a transport pathway to downstream natural resources. The extent of downstream transport and exposure is not yet known.

5.2.4 Pathways to Biological Resources

Terrestrial biota (e.g., invertebrates, birds, mammals) may be exposed to hazardous substances through dermal contact, inhalation, ingestion, and food chain pathways. For example, passerine birds may be exposed by ingesting contaminated invertebrates living in the soils of dry ponds. Terrestrial vegetation may be exposed to hazardous substances in soil and soil pore water through root uptake (Figure 5.1).

Aquatic biota in the Clark Fork River, Lavalle and O'Keefe creeks, and any aquatic biota that may be in the floodplain ponds may come into direct contact with hazardous substances through exposure to contaminated surface water, porewater, or upwelling groundwater; direct contact with contaminated sediment; and food chain pathways. Potentially exposed aquatic biota include fish, mammals, and benthic macroinvertebrates. In addition, piscivorous birds, waterfowl, and mammals may be exposed to hazardous substances in aquatic resources via direct contact, ingestion, and aquatic food chain pathways (Figure 5.1).

Food chain pathways are particularly relevant for dioxins, furans, and dioxin-like PCBs, which are toxic to exposed biological resources and have been shown to bioaccumulate and biomagnify through the food chain. These compounds have caused multiple species of birds, fish, reptiles, and mammals to exhibit developmental toxicity, reproductive impairment, compromised immunologic function, and other adverse effects (Jones et al., 1993; White and Birnbaum, 2009; King-Heiden et al., 2012).

5.3 Injury Determination

Chapter 4 confirmed that natural resources, including surface water resources, groundwater, soils, and biological resources, have been exposed to hazardous substances released from the mill. The assessment will determine the nature and extent of injuries to these resources.

This section includes discussions of injury assessment approaches for specific resources. These approaches include resource-specific injury definitions contained in the DOI regulations for conducting an NRDA. For each resource, the injury definition is followed by examples of injury determination methods.

5.3.1 Geological Resources

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

Injury Definition

Injury definitions for geologic resources in the DOI regulations include the following:

- Concentrations of substances sufficient to cause a toxic response to soil invertebrates [43 CFR § 11.62(e)(9)]
- Concentrations of substances sufficient to cause a phytotoxic response such as retardation of plant growth [43 CFR § 11.62(e)(10)]

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

Methods for Injury Determination

Potential injury determination methods for geological resources include the comparison of Site soil hazardous substances concentrations to reference concentrations, toxicity reference values (TRVs), adverse effects levels from the published literature for animals and plants, and standards and criteria for surface water and groundwater (Table 5.1). TRVs are threshold values above which a contaminant is toxic to select biota. Injuries to soils will be determined using existing TRVs from the literature that indicate when hazardous substance concentrations in soils are sufficient to cause injury. Examples of TRVs for soil invertebrates and plants (the first two injury definitions above) may include Eco-SSLs and other values indicative of toxicological effects in plants, invertebrates, birds, and wildlife. The Trustees may also compare soil levels to adverse effects levels established in published literature.

If necessary, the Trustees may fill data gaps by conducting additional studies, which could include the collection of soil samples for chemical analysis, field assessments of vegetation, and/or bioassays.

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

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

5.3.2 Groundwater Resources

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

Injury Definition

Injury definitions for groundwater resources in the DOI regulations include:

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

- Concentrations of substances in excess of water quality criteria, established by Section 1401(1)(d) of the SDWA, or by other Federal or State laws or regulations that establish such criteria for public water supplies, in groundwater that before the discharge or release met the criteria and is a committed use, as the phrase is used in this part, as a public water supply [43 CFR § 11.62(c)(1)(ii)].
- Concentrations of substances in excess of applicable water quality criteria, established by Section 304(a)(1) of the CWA, or by other Federal or State laws or regulations that establish such criteria for domestic water supplies, in groundwater that before the discharge or release met the criteria and is a committed use as that phrase is used in this part, as a domestic water supply [43 CFR § 11.62(c)(1)(iii)].
- Concentrations and duration of hazardous substances sufficient to have caused injury to surface water, air, geologic, or biological resources, when exposed to groundwater [43 CFR § 11.62(c)(1)(iv)].

Methods for Injury Determination

Table 5.2 provides examples of approaches that may be used to determine and quantify injury to groundwater resources. Methods for assessing injury to groundwater will focus on the review of available groundwater quality data, comparing hazardous substance concentrations to Montana Circular DEQ-7 Numeric Water Quality Standards (MDEQ, 2019) and U.S. EPA (2021a) SDWA standards or other groundwater injury thresholds defined as a part of the assessment. Site groundwater concentrations will also be compared to baseline concentrations. Groundwater exceeding these thresholds will be considered injured.

Table 5.2. Examples of groundwater injury definitions and evaluation approaches

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

The groundwater injury evaluation may include the identification of committed uses and potability of groundwater resources [43 CFR § 11.62(c)(1)(i–iii)], examination of concentrations and duration of hazardous substances in groundwater, and identification of exceedances of State or Federal drinking water standards and criteria. Concentrations of hazardous substances in groundwater will also be evaluated to determine if groundwater is a significant pathway of exposure to other natural resources.

5.3.3 Surface Water Resources

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

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

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

Injury Definition

Definitions of injury to surface water resources (including surface water and sediments) in the DOI regulations include:

- Concentrations and duration of hazardous substances in excess of drinking water standards as established by Sections 1411–1416 of the SDWA, or by other Federal or State laws or regulations that establish such standards for drinking water, in surface water that was potable before the release [43 CFR § 11.62(b)(1)(i)].
- Concentrations and duration of substances in excess of water quality criteria established by Section 1401(1)(D) of the SDWA, or by other Federal or State laws or regulations that establish such criteria for public water supplies, in surface water that before the discharge or release met the criteria and is a committed use, as the phrase is used in this part, as a public water supply [43 CFR § 11.62(b)(1)(ii)].
- Concentrations and duration of hazardous substances in excess of applicable water quality criteria established by Section 304(a)(1) of the CWA, or by other Federal or State laws or regulations that establish such criteria, in surface water that before the release met the criteria and is a committed use as habitat for aquatic life, water supply, or recreation [43 CFR § 11.62(b)(1)(iii)].
- Concentrations and duration of hazardous substances sufficient to have caused injury to groundwater, air, geologic, or biological resources, when exposed to surface water [43 CFR § 11.62(b)(1)(v)].

Methods for Injury Determination

Potential approaches to evaluate injury to surface water and sediment resources are provided in Table 5.3. The relevant injury thresholds for surface water in the assessment area may include hazardous substance concentrations in excess of EPA aquatic life criteria (ALC; Section 304 of the CWA) or Montana Circular DEQ-7 Numeric Water Quality Standards (MDEQ, 2019). It may also include a comparison to adverse effects levels published in scientific peer-reviewed literature.

Table 5.3. Examples of surface water and sediment resource injury definitions and evaluation approaches

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

ALC are expressed as acute and chronic criteria.[1] The acute criterion is an estimate of the highest concentration of a substance in surface water to which an aquatic community can be exposed briefly without an unacceptable effect. The chronic criterion is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without an unacceptable effect [63 FR 68364, December 10, 1998].

Unlike for surface water, no national sediment quality criteria have been developed to establish contaminant concentrations that protect aquatic life. Various Federal, State, and provincial agencies in North America have developed numerical sediment quality guidelines; and several research groups have conducted sediment toxicity texts to assess the quality of freshwater and marine sediments. The sediment quality guidelines currently being used in North America have been developed using a variety of approaches. The approaches that have been selected by individual jurisdictions depend on the receptors considered, the degree of protection afforded, the geographic area to which the values are intended to apply, and the intended uses of the values. As part of the assessment, the Trustees will review existing sediment quality guidelines established by State and Federal agencies, and relevant literature to evaluate concentrations of site-specific hazardous substances that are likely thresholds for causing injury to surface water resources. If existing thresholds and toxicity literature are not sufficiently reflective of Site-specific conditions, the Trustees may collect additional data to assess potential toxicity thresholds for hazardous substances in sediments.

5.3.4 Biological Resources

Biological resources include fish, wildlife, benthic macroinvertebrates, other biota, and vegetation. More specifically, biological resources relevant to the Site include freshwater aquatic species such as fish, shellfish, and aquatic plants; terrestrial species such as plants, birds, and wildlife; game, nongame, and commercial species; and threatened, endangered, and state-sensitive species [43 CFR § 11.14(f)]. Ecosystem services provided by fish, birds, and wildlife include, but are not limited to, prey for carnivorous and omnivorous wildlife, and nutrient and energy cycling. Human use services include various types of recreation (fishing, hunting, birdwatching), food sources, and Tribal subsistence and other cultural uses.

Injury Definition

Injury definitions for biological resources in the DOI regulations include the following:

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

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

- Concentrations of substances sufficient to exceed levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organism [43 CFR § 11.62(f)(1)(iii)].

Methods for Injury Determination

Multiple methods may be used to determine injury in biological resources. Methods that could be employed include a comparison of biological receptor tissue concentrations to applicable tissue-based TRVs, measured or modeled dietary exposure to applicable TRVs, biological community conditions and densities compared to reference conditions, and assessment of fish and wildlife consumption advisories. Relevant injury definitions and injury determination and quantification methods for biological resources are summarized in Table 5.4. The Trustees may design and implement Site-specific studies to evaluate biological injuries if existing data are insufficient to make a determination of injury.

Table 5.4. Examples of biological resource injury definitions and evaluation approaches

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

5.3.5 Indirect Injuries

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

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

5.4 Injury Quantification

This section of the Assessment Plan describes how the Trustees will use results from the injury determination part of the assessment to quantify losses in the assessment area in order to determine what restoration is appropriate to compensate for those losses. The evaluation described in this section is intended to provide the Trustees with sufficient information to design and implement the tasks necessary to, for instance, "quantify for each resource determined to be injured and for which damages will be sought, the effect of the discharge or release in terms of the reduction from the baseline condition in the quantity and quality of services" [43 CFR§ 11.70(a)(1)]. However, assessment methods may integrate analyses of different natural resources, and could also look at a variety of metrics related to natural resource quantity and quality, as well as the cost or value of offsetting the losses. The process described below is an example of how the Trustees will determine the compensation to provide the "restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resource and the services those resources provide" [43 CFR § 11.80(b)].

Quantification will include evaluation of the:

- Spatial and temporal extent of injury
- Determination of baseline
- Estimation of losses
- Estimation of recovery to baseline.

5.4.1 Spatial and Temporal Extent of Injuries

The Trustees will quantify the spatial extent, the temporal extent (past, present, and expected future), and the degree of injuries in the assessment area. Approaches to estimate the extent and degree of injury may include the use of chemical, toxicological, biological, and human use and enjoyment data; historical records; geographic information and spatial analysis; and modeling.

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

5.4.2 Determination of Baseline

Baseline conditions are the conditions that would have existed had the releases of hazardous substances not occurred [43 CFR § 11.72(b)(1)]. The difference between natural resources, services, or values provided under baseline conditions and those provided under injured conditions can be used to calculate the natural resource damages incurred by the public. The assessment will quantify losses by evaluating how natural resources, services, or values that are normally available under baseline conditions have been or will be disrupted by the release [43 CFR § 11.71(b)].

The Trustees recognize that restoring natural resource services to baseline levels at the assessment area is dependent on the final remedies implemented at the Site. The Trustees will attempt to estimate the trajectory of improvements in natural resource services resulting from any future remedial actions at the Site. This evaluation will compare the trajectory of baseline ecological and human services provided by natural resources at the assessment area to the trajectory of services anticipated with the implementation of remedial alternatives.

The regulations suggest using historical data, if available, to evaluate baseline conditions [43 CFR § 11.72(c)]. Data from control areas may also be used [43 CFR § 11.72(d)]. Because hazardous substance releases from the mill began in the 1950s, no quantitative baseline data are available from before the beginning of the releases. The Trustees propose to use data from control areas to characterize baseline conditions. Control areas will be selected based on their similarity to the assessment area and lack of exposure to the release [43 CFR § 11.72(d)(1)]. Because baseline services can be affected by conditions and activities that are not related to the release (e.g., roads, construction, permitted land uses), control areas will be evaluated to ensure that they are appropriate in terms of relevant physical, chemical, and biological conditions.

5.4.3 Estimation of Losses

The difference between baseline services and the services provided by the injured resource is used to quantify injury to natural resources. This quantification will serve as the basis for determining the amount of damages necessary to restore natural resources on behalf of the public. The Trustees will quantify service loss by evaluating how the services that are normally provided by the natural resources under baseline conditions have been and will be disrupted by the hazardous substance releases [43 CFR § 11.71(b)].

Service losses are incurred when concentrations of hazardous substances exceed defined injury thresholds and when hazardous substances prevent human use or enjoyment of natural resources. More details on methods used to estimate service losses are provided in Section 5.5.

5.4.4 Resource Recovery Analysis

The Trustees will estimate the time needed for recovery of injured resources and the services they provide to baseline levels. A recovery period is defined as either the longest length of time required to return the services of the injured resource to their baseline condition, or a lesser period of time selected by the Trustees and documented in the Assessment Plan [43 CFR § 11.14(gg)]. The following factors may be considered in estimating recovery times [43 CFR § 11.73(c)(2)]:

- Ecological succession patterns in the area
- Growth or reproductive patterns, life cycles, and ecological requirements of biological species involved, including their reaction or tolerance to the hazardous substance involved

- Bioaccumulation and extent of hazardous substances in the food chain
- Chemical, physical, and biological removal rates of the hazardous substance from the media involved.

Natural resources in the assessment area will remain exposed to hazardous substances as long as environmental media such as soils, sediments, groundwater, and surface water remain contaminated and continue to operate as exposure pathways. Although the RI process is ongoing and the final remedy for the Site has not been determined, the Trustees estimate that recovery to baseline conditions will likely require many decades.

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

5.5 Damage Determination

Natural resource damages are directly related to the quantification of natural resource injuries. Damage determination is intended to "establish the amount of money to be sought in compensation for injuries to natural resources resulting from a . . . release of a hazardous substance" [43 CFR § 11.80(b)]. Damages are defined as ". . . the amount of money sought by the natural resource trustee as compensation for injury, destruction, or loss of natural resources as set forth in Section 107(a) or 111(b) of CERCLA" [43 CFR § 11.14(l)]. Damages include:

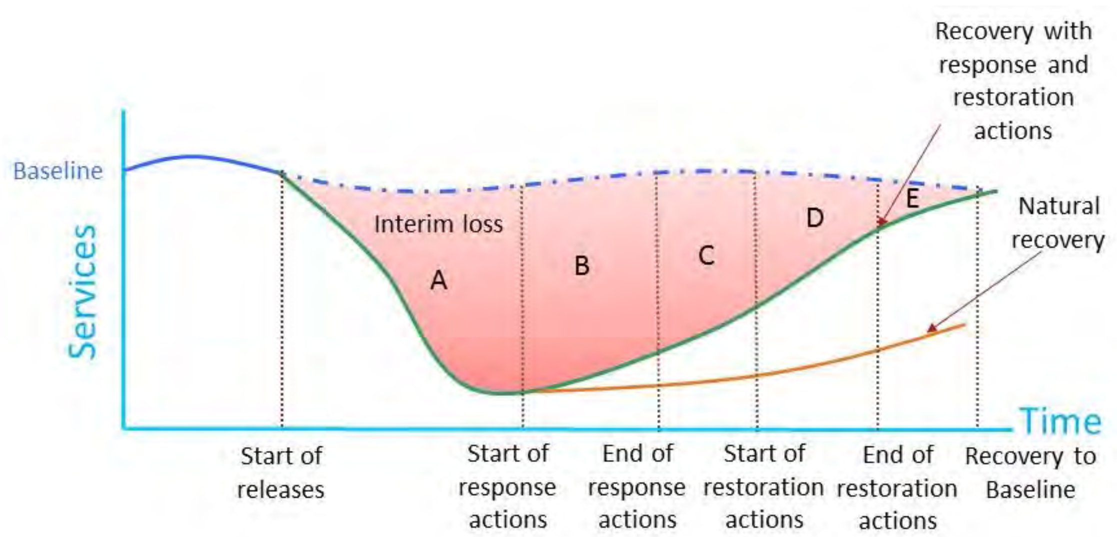
- The cost or value of sufficient restoration to accelerate the return to baseline conditions
- The cost or value of restoration to offset losses between the time of release and the time when baseline conditions are restored ("compensable value")
- The cost to undertake the assessment process.

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

Compensable values for interim losses are the dollar values of the resources and services lost because of the hazardous substance releases. In the damage determination, existing information will be used, potentially supplemented by new site-specific data collection efforts, to assess compensable values for interim losses.

Compensable values of the injuries to natural resources and services lost to the public accrue from the time of discharge or release until the attainment of the restoration, replacement, and/or acquisition of the equivalent of the resources and their services to baseline conditions. *Interim* *losses* include all losses over time. *Past damages* are those that accrue from the earliest point that injuries from releases can be determined, or authorization of the statute, up to the present. *Future damages* are those that accrue from the present until the resource and its services are restored to baseline conditions. In the hypothetical scenario shown in Figure 5.2, total losses are quantified as the present value of the sum of Areas A, B, C, D, and E. Area A represents unmitigated natural resource injuries that are worsening over time. Then, response actions are undertaken that may stabilize the site, reduce human health risk, and begin to restore natural resources (Area B). The slow recovery of natural resources continues after response actions are completed (Area C). Subsequently, restoration activities (onsite or offsite) accelerate the recovery to baseline conditions (Area D). Finally, Area E represents any residual losses that may exist after restoration actions are completed. In this example, natural recovery, absent any response or restoration activities, would result in minor increases in lost services over time, but baseline service levels would never be achieved.

Figure 5.2. Timeline for natural resource injuries and lost services over time.



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

The determination of damages will include the following:

- **Valuation of natural resources.** Cost estimation or valuation methodologies are used to estimate the value of the resources and/or services lost because of injury [43 CFR § 11.83].
- **Selection of alternatives for restoration**. Alternatives for potential restoration options to restore, rehabilitate, replace, and/or acquire the equivalent of the injured resources are developed and selected [43 CFR § 11.82].
- **Development of the RCDP**. The RCDP lists possible restoration alternatives and the methodologies for determining the costs of different alternatives and the compensable value

of the services lost to the public [43 CFR § 11.81]. If existing data are insufficient for developing the RCDP when the Assessment Plan is published, it may be published separately after the injury assessment is completed [43 CFR § 11.81(c)].

The selection of restoration alternatives to compensate for losses caused by injuries requires a means of ensuring that the scale of the restoration projects is commensurate with the amount of past and future injuries resulting from the hazardous substance releases. The Trustees have multiple options for determining damages, including restoration-based options (restoring the equivalent of what was injured) and value-based options (determining damages based on the value of the losses). The Trustees have included multiple alternatives in this Assessment Plan. The specific methods that the Trustees use in this assessment will be determined during the assessment phase, based on the available data and any new data collection. Trustees commonly use a restoration-based approach to damage determination, such as habitat equivalency analysis (HEA) or resource equivalency analysis (REA), as described in Section 5.5.1. Quantifying lost human services such as reduced fishing value resulting from consumption advisories may require one of several economic value-based approaches, as described in Section 5.5.2.

5.5.1 Equivalency Analyses

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

Habitat Equivalency Analysis

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

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

HEA is based on the ecological and human use services that the habitat provides. Because it is impossible to measure every service that habitats provide, certain quantifiable metrics are selected to determine service loss from injuries and equivalent service gain from restoration. Metrics are sometimes based on biological data, such as the density of certain plants or animals; or toxicological data, such as the magnitude of exceedance of a toxic threshold. Appropriate metrics for evaluating service losses and gains will be determined as part of the assessment.

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

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

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

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

Resource Equivalency Analysis

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

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

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

5.5.2 Value-Based Methods

Value-based methods are often used when lost resources or services are not practically restorable or are not captured in an equivalency model. For example, the value of recreational fishing in the Clark Fork River may have decreased because of the FCAs for dioxins. This loss may not be adequately captured in a HEA-type model. To assess these lost services, the Trustees may use one of several economic valuation approaches to value the full scope of the damages.
Three different methods that the Trustees may consider are described below, including benefits transfer (BT), travel cost, and contingent valuation (CV) methods.

Benefits Transfer Method

The dollar value of the lost human use may be assessed using the BT approach. BT is commonly used by natural resource economists, and is an accepted methodology under Federal regulations, where it is referred to as the "unit cost" method [43 CFR § 11.83(c)(2)(vi)]. To conduct a BT, one applies unit dollar values (e.g., dollars per day of recreational fishing) from other sites and adjusts for site-specific factors. In an example of the potential loss of recreational activities, the lost human use may be evaluated in terms of reduced recreational trips to the Clark Fork River, or a reduction in the value of the trips. In this case, two main types of information/inputs would be required: (1) an estimate of the number of recreational trips that have been or will be lost due to the lack of recreational opportunities or reduced quality of such opportunities, and (2) the value that people place on the lost trips or the reduced quality of trips still taken.

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

Travel Cost Method

The travel cost method evaluates an individual's incremental travel costs to avoid hazardous substances as a proxy for the price of the services of that area [43 CFR § 11.83(c)(2)(iv)]. The cost of travel reveals what a consumer is willing to pay to utilize a natural resource for activities such as fishing or hunting. Compensable value is the difference between the value of the area with and without the hazardous substances. Consistent with the regulations, the Trustees could use a regional travel cost model to determine the value of the natural resource. Alternately, the Trustees could conduct an original survey to determine, for example, whether recreational anglers incur additional travel costs to fish in a river that does not have FCAs because of dioxins/furans in fish. This change in behavior would reveal what anglers are willing to pay to recreate in a river where hazardous substances were not released.

Contingent Valuation Method

CV is a stated preference method for estimating the total value (use and nonuse values) of lost services resulting from injury to natural resources. CV uses carefully designed surveys to elicit the monetary value of a resource that is measured by what individuals would be willing to pay to return the natural resource and services to their uninjured state.

Fundamentally, all CV surveys have three components in common. First, they describe the problem. Then, they describe a solution. And, finally, they ask a valuation question where respondents choose whether or not they are willing to pay for the solution to solve the problem. These survey results would be used to estimate the collective willingness-to-pay for the resource, which would then be used as a measure of the total value of the injury to the resource. Although the Trustees do not anticipate using a CV method to determine damages, the final selection of methods used to determine damages will be made during the assessment phase, after the Trustees have a more complete dataset for evaluating potential natural resource injuries and service losses.

5.5.3 Restoration Planning

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

Planning Process

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

The restoration planning process will employ the following steps:

1. **Solicit ideas for potential projects**. The Trustees may solicit ideas for potential habitat restoration projects from the PRPs, as well as from other people and organizations known to have an interest in habitat restoration.

2. **Develop evaluation factors to assess potential projects**. Factors will be developed to evaluate each restoration alternative. A list of potential evaluation factors to consider is included in Table 5.5. This list may be refined during the assessment.
3. **Evaluate potential restoration project suitability**. Restoration alternatives will be compared to the evaluation factors and ranked accordingly. Based on this ranking, preferred alternative(s) will be selected.
4. **Select an appropriate scale**. The appropriate scale of the selected alternative(s) will be determined as necessary to offset the damages.

Evaluation Factors

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

1. Technical feasibility, meaning that the technology and management skills necessary are well-known and have a reasonable chance of successful completion.
2. The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources.
3. Cost-effectiveness, which incorporates a consideration of both cost and the level of benefits provided.
4. The results of any actual or planned response actions.
5. The potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources.
6. The natural recovery period determined in 43 CFR § 11.73(a)(1).
7. Ability of the resources to recover with or without alternative actions.
8. Potential effects of the action on human health and safety.
9. Consistency with relevant State and Federal policies.
10. Compliance with applicable State and Federal laws.

Based on the above factors, Table 5.5 presents a more detailed list of potential restoration factors that will be considered when evaluating restoration alternatives.

Table 5.5. Factors that may be considered when evaluating restoration alternatives

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

Table 5.5. Factors that may be considered when evaluating restoration alternatives

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

5.5.4 Development of a Restoration and Compensation Determination Plan

The Trustees may prepare an RCDP as part of the Assessment Plan or during the assessment phase [43 CFR § 11.81]. The RCDP may include:

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

Thus, an RCDP contains both assessment results (i.e., Trustee determinations about restoration alternatives) and assessment planning elements (i.e., identification of compensable valuation methods). While the regulations identify the RCDP as a part of the Assessment Plan, Trustees often do not publish an RCDP until after the injury determination and quantification phases of the assessment are complete. Since injuries and associated service losses have not yet been determined or quantified, it is impossible to identify and select the preferred restoration alternative(s) to address injuries and service losses. Therefore, the Trustees are not including an RCDP as part of this Assessment Plan but may prepare an RCDP during the assessment phase.

6. Supplemental Data Collection

The Trustees have identified data gaps when evaluating the fate, transport, exposure, and potential injuries from releases of dioxins/furans and coplanar PCBs at the Site. The Site was a known generator of dioxins/furans in the 1980s (U.S. EPA, 1990), and most likely generated dioxins/furans in the 1960s and 1970s as well. These persistent organic pollutants can cause natural resource injuries for decades after being released into the environment.

As noted in previous chapters, the Site produced about 1.6 million tons of bleached pulp, a known source of dioxins/furans (U.S. EPA, 1990), with waste sludge deposited onsite in unlined sludge disposal ponds. Dioxins/furans, which are toxic at very low concentrations, have been detected in Site soils, groundwater, and surface water resources. Concentrations of dioxins/furans (and dioxin-like coplanar PCBs) in fish tissues near and downstream of the Site required the State to issue FCAs for rainbow trout and northern pike after the 2013 sampling (MDEQ et al., 2015), and to expand the FCAs to include all fish after the 2018/2019 sampling (MDEQ et al., 2021).

In the Site investigations, a large percentage of environmental and biological tissue samples were collected upstream of the Site. As noted in Chapter 4, the fish tissue data suggest an increase in both dioxins/furans and coplanar PCBs downstream of the Site, near St. Regis. Additional data collection could help to confirm if these increases occur because of ongoing releases from the Site and/or past releases to which biological resources continue to be exposed.

In addition, the Site investigations conducted to date have relied on grab samples of surface water to evaluate potential exposure of biological resources to these persistent organic pollutants. Because these pollutants are highly hydrophobic and toxic at minute concentrations, a small grab sample may not be sufficient to adequately assess the fate and transport of these chemicals and achieve detection limits low enough to determine releases to and exposure in the Clark Fork River. Additional investigations can better assess an exposure pathway from the Site to biological resources such as fish.

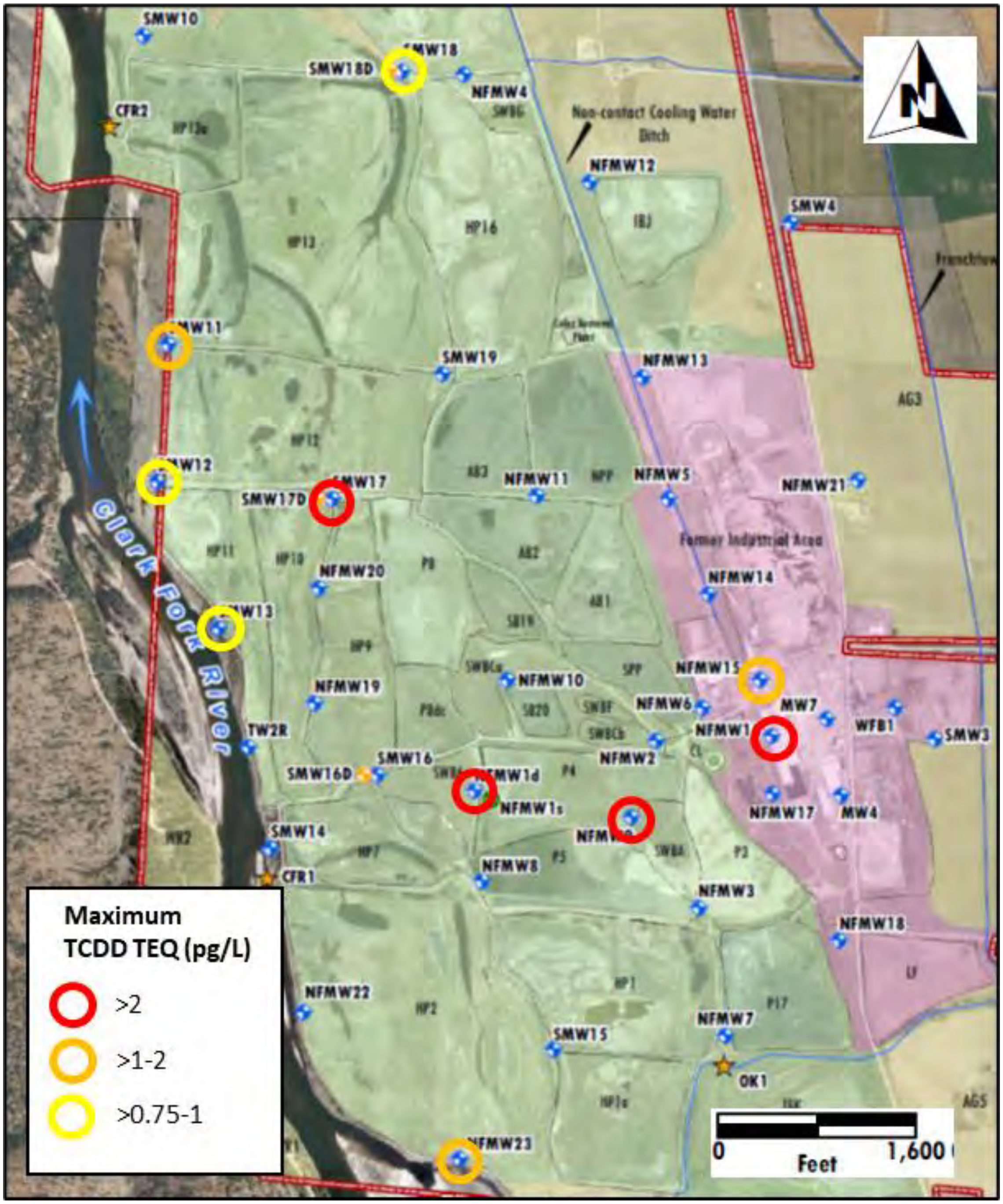
In this chapter, the Trustees propose four studies for characterizing dioxins/furans and coplanar PCB releases, downstream deposition, and biological resource exposure. These include the use of passive sampling devices (PSDs) to assess ongoing releases (Section 6.1); collection of sediment cores upstream and downstream of the Site to assess past releases and potential persistence of those hazardous substances in the Clark Fork River (Section 6.2); collection of additional fish tissue samples, focused on sampling downstream of the Site (Section 6.3); and a preliminary evaluation of potential exposure of ospreys to dioxins/furans and coplanar PCBs through consumption of contaminated fish (Section 6.4).

6.1 Passive Sampling Devices

The sludge and wastewater generated when the Site was manufacturing bleached pulp (1960–1999) were disposed of in a series of unlined basins and ponds. The contamination buried in these disposal basins has not been well-characterized, but it is likely that the basins are contaminated with dioxins, furans, and possibly dioxin-like PCBs, among other hazardous substances. While these contaminants are highly hydrophobic, studies have shown that they are mobilized and transported in colloidal material (Hofmann and Wendelborn, 2007; Persson et al., 2008; Larsson, 2016).

Shallow groundwater generally flows west/northwest from the industrial area and waste storage ponds toward the Clark Fork River (NewFields, 2020). Although variable over time, dioxins and furans are detectable in most shallow groundwater samples under OU2 and OU3 (there are no congener-specific PCB data from groundwater). The spatial pattern of maximum TCDD TEQ concentrations (Figure 6.1) suggests an ongoing transport pathway to the Clark Fork River.

Figure 6.1. Maximum TCDD TEQ (from dioxins and furans) measured in groundwater wells in OU2 and OU3. Shallow groundwater flows to the west/northwest toward the Clark Fork River. The spatial trend suggests a potential pathway to the river.



Background figure source: NewFields, 2020, Figure 5 (modified).

Discharge of contaminated groundwater to the Clark Fork River through upwelling or springs may then be an ongoing source of dioxins/furans and dioxin-like PCBs to surface water and biological resources in the Clark Fork River. A small number of grab samples of surface water from the river may not be adequate for determining this pathway, given the low and variable concentrations of these hydrophobic chemicals that can then bioaccumulate and biomagnify in biological tissues. Therefore, the Trustees propose using PSDs to better evaluate this pathway. PSDs have been successfully deployed in rivers near other paper mills with potential ongoing releases of chlorinated compounds (e.g., Charlestra et al., 2008).

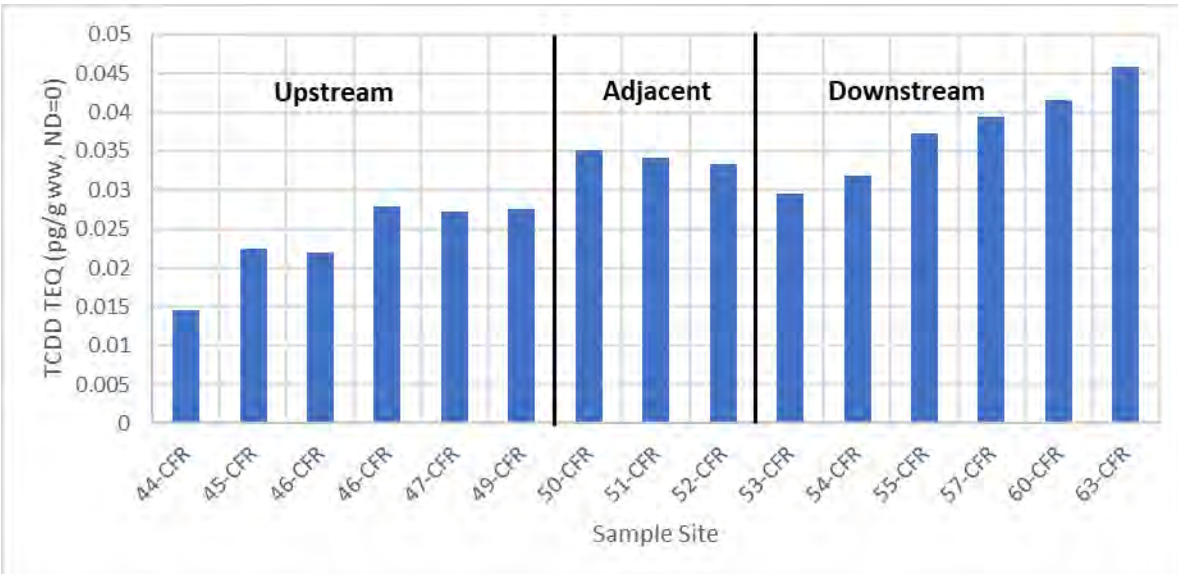
Passive sampling is an alternative water sampling approach that can provide information on contaminant concentrations in groundwater and surface water that is not easily obtained from conventional grab sampling or from the sampling of biota. PSDs are able to effectively sample large volumes of water, concentrating the contaminants as water passes through, which greatly improves detection limits compared to conventional grab sampling methods. This is particularly useful in the characterization of highly hydrophobic contaminants such as dioxins/furans, which have toxicologically relevant exposure thresholds that are near or below detection limits for grab sample methods. In addition, PSDs can be deployed for long periods of time (i.e., days or weeks) to provide a time-weighted average contaminant concentration that is more representative of the contaminant concentrations biota are exposed to over time.

Biota can also accumulate and concentrate hydrophobic compounds to which they are exposed over time. For the BERA, U.S. EPA and SRC (2020) examined dioxin/furan concentrations from composite whole longnose dace (*Rhinichthys cataractae*) collected upstream of, adjacent to, and downstream of the Site (they did not collect PCB congener data). Longnose dace have small home ranges, high site fidelity, and relatively high lipid content (e.g., Burzynski, 2000). Generally, the TCDD TEQ concentrations in dace adjacent to the Site were higher than in dace upstream of the Site, and concentrations increased with increasing distance downstream (Figure 6.2). Nearly 100% of the TEQ in longnose dace was from 2,3,7,8-TCDF, which U.S. EPA (1990) detected in 94% of the wastewater in their study of 104 paper mills, including at the Smurfit mill in Frenchtown. However, the longnose dace study may not adequately assess the possibility that the Site is an ongoing source of dioxins/furans and coplanar PCBs to the Clark Fork River:

- The spatial extent of the study was limited to just a few miles downstream of the Site. The 2019 higher trophic-level fish study showing TCDD TEQ concentrations sufficient to require consumption advisories included rainbow trout collected at St. Regis, well downstream of the lowest dace sampling site.
- The dace were not analyzed for the presence of coplanar PCBs. As noted previously, coplanar PCBs are present in Site soils (in the few composite samples for which they were analyzed), and the 2019 rainbow trout study showed a notable increase in coplanar PCB concentrations in trout downstream of the Site.
- Because fish are mobile, they may not be the best proxies to detect releases of dioxin/furans and dioxin-like coplanar PCBs. For example, if dioxins/furans and coplanar PCBs are released from Site groundwater, it may be miles downstream before those contaminants are fully mixed into the river (the mixing zone boundary was assumed to be six miles downstream of the Site when it was operating and discharging from outfalls [URS, 2011]).

Hence, dace collected near the Site may have avoided exposure if they were close to the opposite bank.

Figure 6.2. TCDD TEQ concentrations (dioxins and furans only) in longnose dace collected upstream of, adjacent to, and downstream of the Site.



PSDs allow for more control over a study assessing a potential source of low concentrations of hydrophobic compounds. These devices can overcome many of the above challenges associated with biota-based biomonitoring (Booij et al., 2006).

The study description below outlines the purpose and goals of the study and provides a general sampling approach, including the proposed number and locations of samples to be collected and a brief description of the sampling methods that could be used. The Trustees will develop a more detailed work plan in the future.

6.1.1 Purpose and Objectives

The goal of the proposed PSD study is to evaluate a potential transport pathway for dioxins/furans and dioxin-like PCBs from Site waste repositories to the Clark Fork River via shallow groundwater. The results of this study will help determine if there are ongoing releases of hazardous substances at the Site, and if those releases are resulting in the exposure of natural resources to these hazardous substances.

The first objective of this study is to evaluate the presence of dioxins/furans and PCBs to the shallow groundwater at the Site. For this objective, the Trustees propose deploying PSDs into a select set of existing monitoring wells. The second objective of this study is to evaluate the potential discharge of dioxins/furans and PCBs from shallow groundwater into the Clark Fork River. For this objective, the Trustees propose deploying PSDs upstream of, adjacent to, and downstream of the Site.

6.1.2 Sampling Locations

To evaluate dioxins/furans and PCBs in onsite groundwater, the Trustees propose deploying PSDs into the following monitoring wells at the Site (Figure 6.3; see also Figure 6.1):

- NFMW9: Primary Treatment
- NMFW16: Industrial Area
- SMW17: OU3 Holding Pond
- SMW11: Adjacent to the Clark Fork River
- SMW12: Adjacent to the Clark Fork River
- SMW13: Adjacent to the Clark Fork River
- NFMW22: Adjacent to the Clark Fork River
- NFMW23: Adjacent to the Clark Fork River.

The first two monitoring wells are located inland at separate source areas within the Site. Dioxins/furans have been detected at concentrations exceeding 2 pg/L total TCDD TEQ in these wells (see Figure 6.1). SMW17 is under the OU3 holding ponds, along the groundwater pathway between the likely source areas and the river. The other selected monitoring wells are adjacent to the Clark Fork River. The Trustees may deploy PSDs that can collect duplicate samples in select wells to assess variability in the analytical results related to the sampling methods.

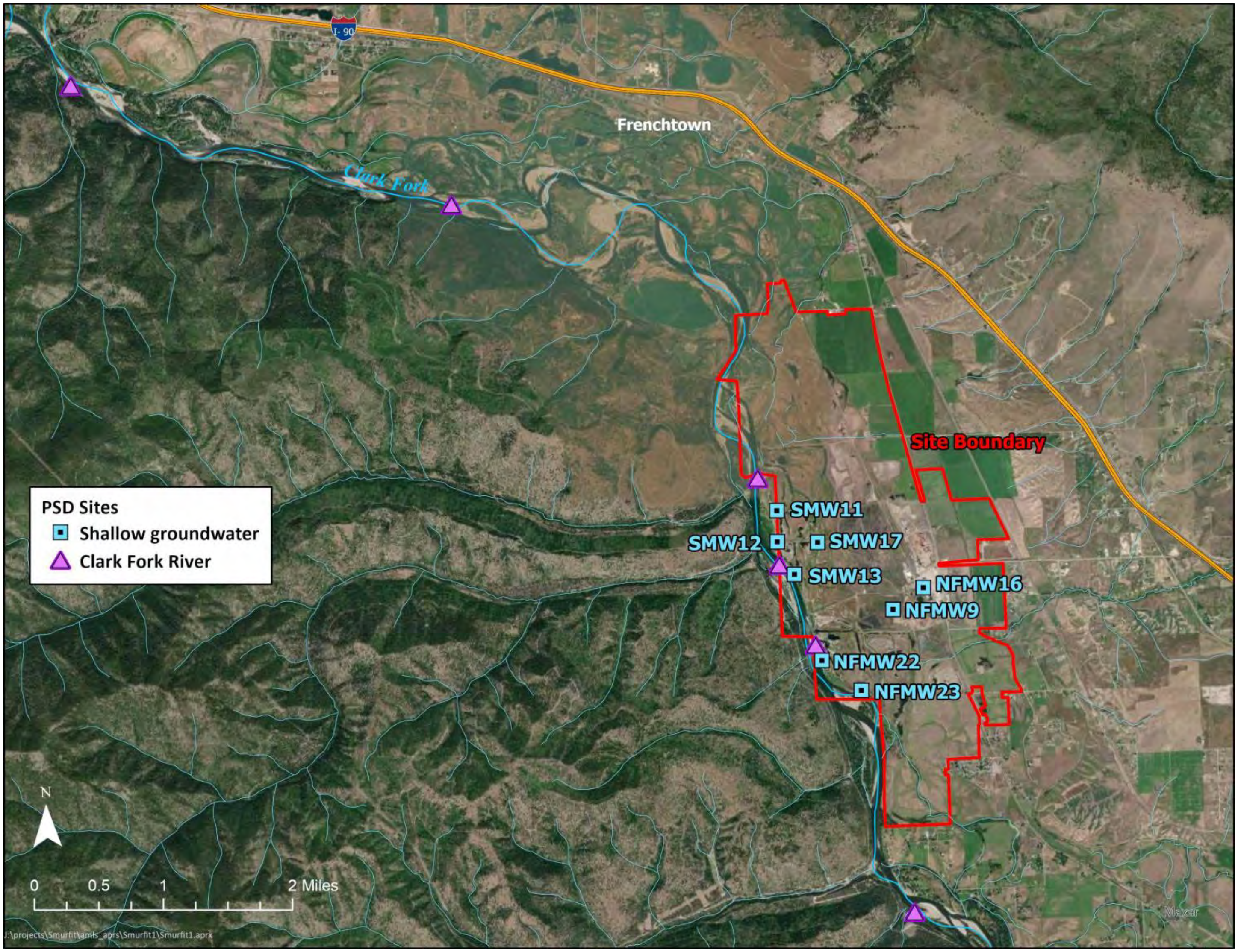
To evaluate discharges of dioxins/furans and dioxin-like PCBs from the Site to the Clark Fork River, the Trustees anticipate deploying PSDs at one upstream location, three locations adjacent to the Site, and two downstream locations (Figure 6.3). At each location, the Trustees propose deploying at least one PSD. Adjacent to the Site, the Trustees may deploy multiple PSDs, perhaps with one deployed in porewater where shallow groundwater may be upwelling into the stream channel, or one deployed near the bank adjacent to the Site and another deployed closer to mid-channel. Duplicate PSDs may be deployed at the upstream sampling location and in one sampling location adjacent to or downstream of the Site. Final sampling locations and the details of the deployment will be developed when the full sampling and analysis plan (SAP) is written.

6.1.3 Approach

Passive samplers will be deployed using standard methods. For groundwater sampling, the Trustees will follow the guidance of a recent U.S. Geological Survey (USGS) document describing different approved protocols and methods available for sampling groundwater wells using passive sampling techniques (Imbrigiotta and Harte, 2020). Similarly, the Trustees will follow EPA guidance on the use of passive sampling for monitoring contaminants in sediments and the water column (Burgess et al., 2017), and other available published literature and guidance documents.

Several commercial laboratories offer end-to-end services for passive sampling, which include selecting the appropriate sampler design, fabricating and preparing PSDs for deployment, assisting with deployment (if needed), extracting and analyzing the device, and processing the data. The Trustees will utilize the expertise of a specialized laboratory when developing the final SAP.

Figure 6.3. Proposed PSD deployment locations. The Trustees propose PSD sampling in three onsite wells with frequent dioxin/furan contamination and five wells adjacent to the Clark Fork River. In addition, the Trustees propose PSD sampling in the Clark Fork River at one location upstream of the Site, three locations adjacent to the Site, and two locations downstream of the Site.



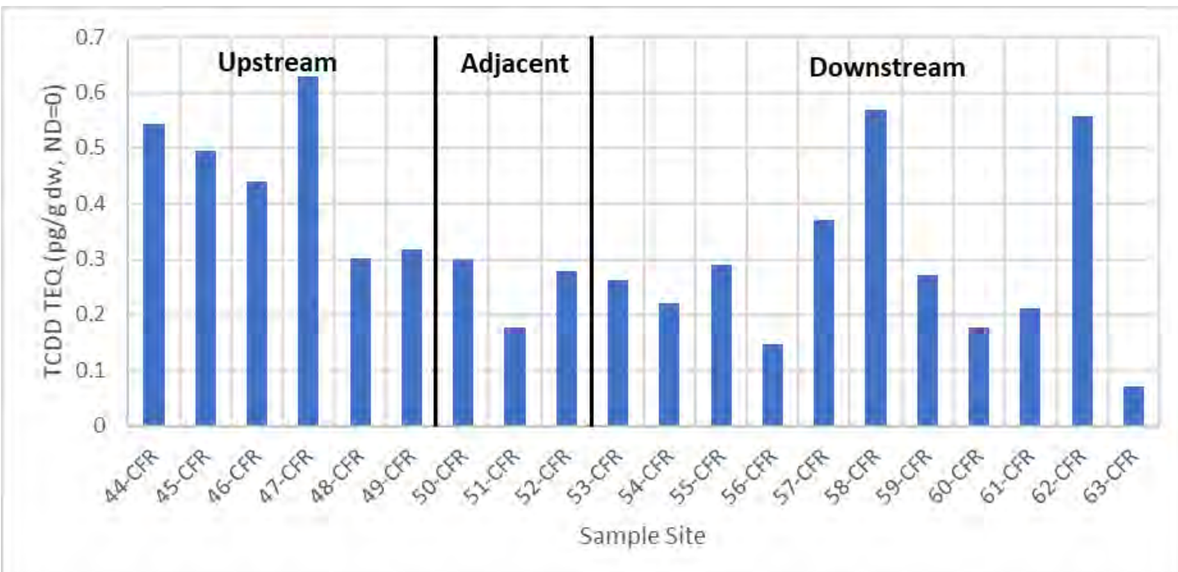
The Trustees will analyze each PSD for dioxin/furan and PCB congeners, using approved high-resolution methods such as EPA Method 8290 for dioxins and furans and EPA Method 1668A/C for congener-specific PCB analysis.

6.2 Sediment Core Collection

Existing fish tissue data show concentrations of dioxins/furans and dioxin-like PCBs increase downstream of the Site. There are no known sources of these contaminants in that reach of the river other than the Site.

Bulk sediment data collected from the upper 6 inches in the Clark Fork River have not shown evidence of increasing TCDD TEQ concentrations adjacent to or downstream of the Site. For example, bulk sediment concentrations in the river were similar at all locations sampled in 2018 (Figure 6.4). None of the concentrations exceeded the SLERA threshold of 0.85 pg/g (U.S. EPA, 2017c).

Figure 6.4. TCDD TEQ concentrations (dioxins and furans only) in Clark Fork River bulk sediment samples collected in 2018.



Data source: EPA Scribe, 2021.

It is possible that the elevated dioxins and furans in fish tissues downstream of the Site are from past releases that have persisted in the environment, where biological resources such as fish continue to be exposed. If past releases of chlorinated compounds occurred while the Site was operating, these compounds would likely be found in depositional areas, and may have been transported well downstream of the Site. To assess this possibility, the Trustees propose to collect sediment cores, primarily downstream of the Site. The cores will include surface sediments, where contaminants are still biologically available; and deeper sediments, which may provide information on dioxin/furan and coplanar PCB releases in the past.

6.2.1 Sampling Locations

The Trustees will target multiple reaches of the Clark Fork River, including one reach upstream of the Site and three reaches downstream of the Site. Specific sampling locations will be determined in the field, following pre-sampling reconnaissance where the Trustees will identify sediment deposition sites within the target reaches. The goal is to locate depositional areas where a sediment corer can extract an intact core that provides a record of sediment deposition over multiple decades.

The target reaches for sediment coring include the following (Figure 6.5):

- Council Grove (immediately upstream of the Site)
- Ninemile (approximately 10 miles downstream of the Site)
- Superior (approximately 50 miles downstream of the Site)
- Thompson Falls (approximately 120 miles downstream of the Site, at the first downstream impoundment).

The Trustees anticipate an intact sediment record at the Thompson Falls Dam impoundment that encompasses the period of operations at the Site – the dam was built over 100 years ago. Suspended sediment in the river is likely to be deposited in the impoundment under most flow regimes. Sediment deposition in other reaches could potentially occur in eddies on flat reaches, or point bars where the river exhibits cut bank/point bar morphology in meanders. Deposition in these areas may be episodic, depending on flow regime. Some may be subject to erosion at some flows and deposition at other flows. The Trustees may collect sediment cores in locations where intact cores can be obtained, without knowing a priori whether the core contains an intact historical record of deposition. Final sampling locations/reaches will be described in the full SAP.

6.2.2 Approach

Sediment cores will be collected using standard methods, following guidance such as the U.S. EPA (2001) *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses*. The Trustees will use a mechanical corer such as a portable Vibracorer to collect sediment cores at depositional areas. For reaches other than Thompson Falls, the core could be collected from a boat or from the bank, depending on available access and flow regime. For the Thompson Falls impoundment, the core will be collected from a boat.

The Trustees will likely collect test cores to determine the depth of sedimentation and the ability to extract intact cores. These details will inform the final sampling plan. Generally, the Trustees will attempt to collect cores up to 1 m in length. Cores will be carefully extracted to maintain integrity, sliced vertically, visually characterized, and cut into slices for sampling. The size of each slice (representing a depth of accumulated sediment) will depend on the size and integrity of the core; each slice may be 5–10 cm. Samples of each slice will be collected for analysis of dioxins/furans (EPA Method 8290A), PCB congeners (EPA Method 1668A/C), and radionuclides for dating (^{127}Cs, ^{210}Pb, ^{226}Ra, ^{7}Be; Holmes, 1998).

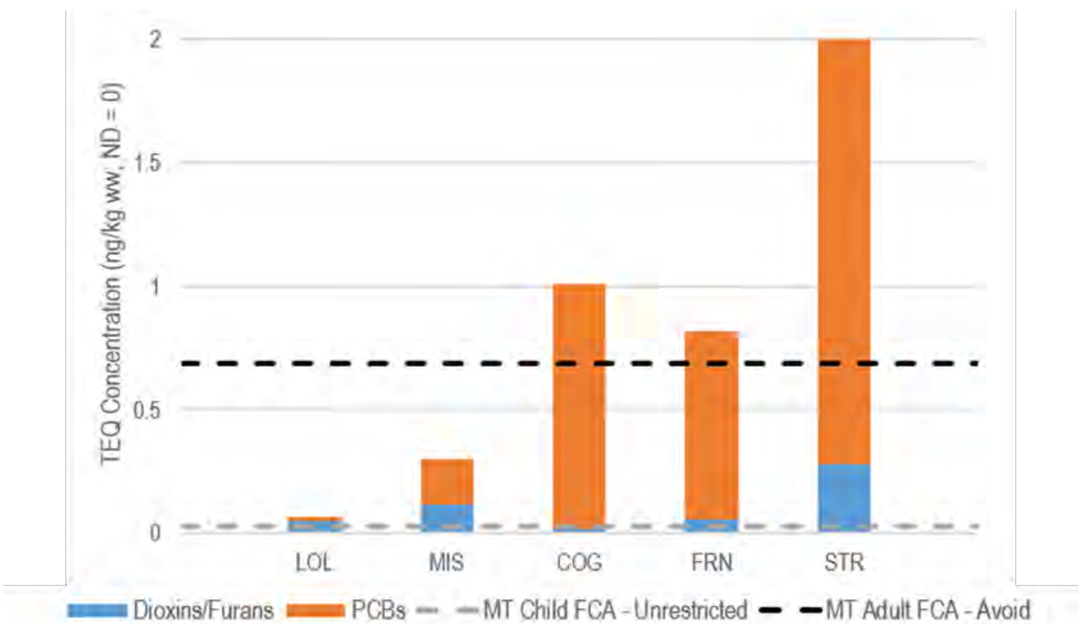
Figure 6.5. Proposed reaches where Trustees will identify depositional areas where sediment cores can be extracted.

6.3 Fish Tissue Collection

As discussed in Chapter 4, MFWP independently sampled rainbow trout and northern pike from immediately downstream of the Site in 2013, where they found elevated total TCDD TEQ concentrations in all species and size classes tested, as well as elevated total PCBs (measured as Aroclor 1254) in the larger northern pike size classes (Schmetterling and Selch, 2013). In 2018 and 2019, EPA collaborated with MFWP to collect additional fish tissue data for the BERA. The 2018 sampling had data quality issues that led EPA to not rely on the data in the BERA (U.S. EPA, 2019), and 2019 sampling had limited sample numbers and sites (U.S. EPA, 2020).

Despite the limited dataset, the 2019 data generally show an increasing trend for both total TCDD and total dioxin-like PCB TEQ concentrations moving from upstream to downstream (e.g., Figure 6.6). The data further confirm the exposure of higher trophic-level fish to dioxins/furans and coplanar PCBs at the Site downstream of the mill property, at concentrations sufficient to require FCAs. As noted previously, the recent collaborations between EPA and MFWP to collect fish tissue for the BERA provided limited data. This study seeks to expand the number of sample sites, the number of species collected, and the sample sizes, to better assess the spatial extent of dioxin/furan and dioxin-like PCB exposure in Clark Fork River fish downstream of the Site.

Figure 6.6. Average total dioxin/furan and dioxin-like PCB TEQ concentrations (ND = zero) by river reach for 2019 rainbow trout fillet tissues. Because they have similar modes of toxicity, these congeners are summed to estimate the health risk from consumption. The sample locations are shown upstream to downstream (left to right on the X axis), including Lolo (LOL), Missoula (MIS), Council Grove (COG), Frenchtown (FRN), and St. Regis (STR).



6.3.1 Target Species and Size Class

The Trustees propose sampling three target species at each sampling location: rainbow trout (*Oncorhynchus mykiss*), mountain whitefish (*Prosopium williamsoni*), and largescale sucker

(*Catostomus macrocheilus*). Each of these species are widely distributed within the study area and therefore should be found at each of the proposed sampling locations. Furthermore, each of these species represent upper trophic-level feeding guilds, which have a higher potential for biomagnification of dioxins/furans and coplanar PCBs. In addition, these fish represent important prey to other top predators in the study area, such as the Federally listed threatened bull trout, and piscivorous raptors like osprey. The sucker is also a long-lived fish with the potential for increased bioaccumulation of the target analytes over time.

For each species, the Trustees propose targeting fish of multiple lengths, including smaller fish that are more likely to be consumed by predators. The specific sampling approach will be described in more detail in the full SAP.

6.3.2 Proposed Sampling Locations

The Trustees propose fish collection from seven reaches of the Clark Fork River (Figure 6.7). Each targeted reach is 5 to 10 river miles; the specific locations will be determined in the field based on site conditions and fish availability. The seven reaches targeted for sampling are:

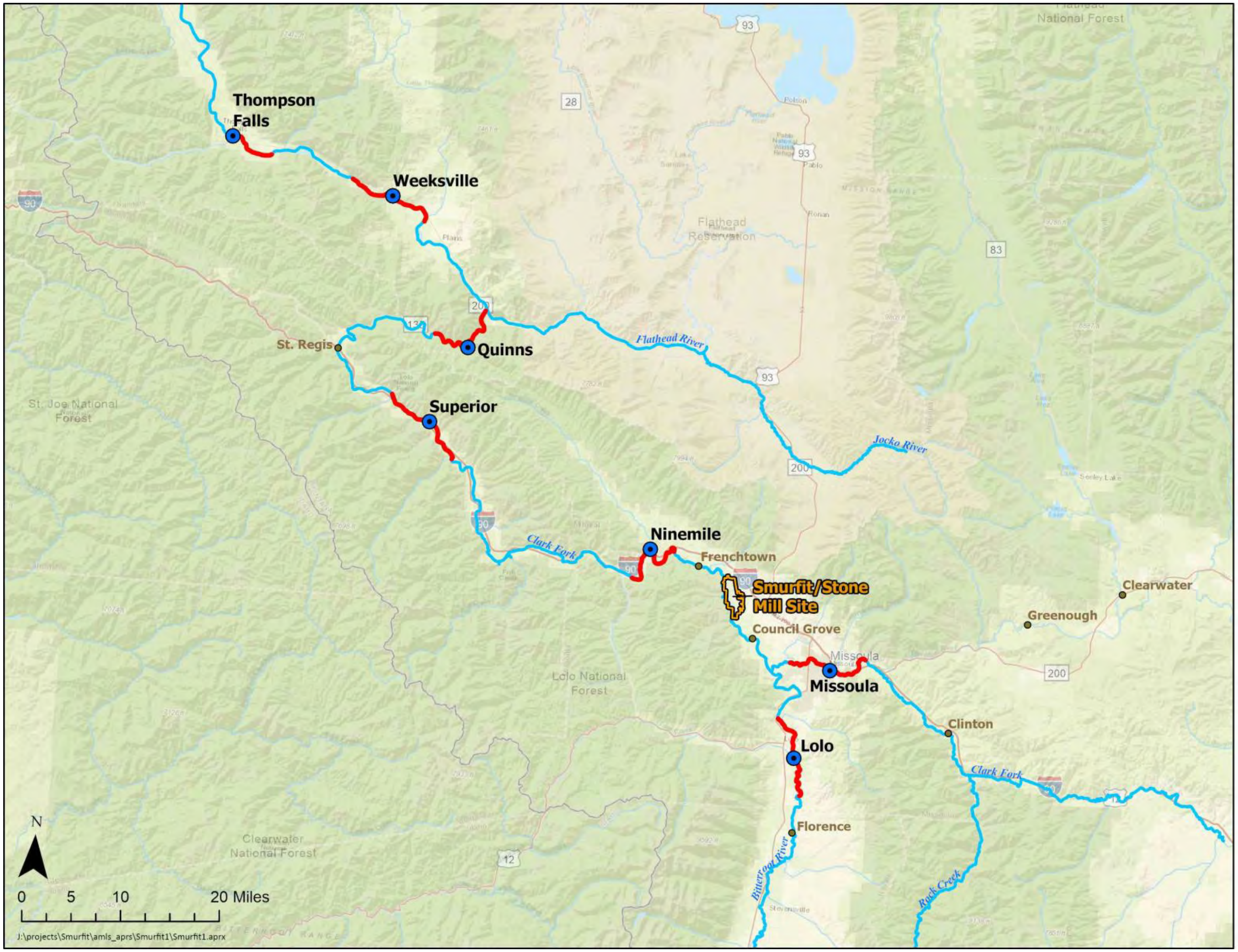
1. Lolo (upstream of the Site on the Bitterroot River)
2. Missoula (upstream of the Site on the Clark Fork River)
3. Ninemile (approximately 10 miles downstream of the Site)
4. Superior (approximately 50 miles downstream of the Site)
5. Quinns (approximately 80 miles downstream of the Site, upstream of the Flathead River confluence)
6. Weeksville (approximately 100 miles downstream of the Site, downstream of the Flathead River confluence)
7. Thompson Falls (approximately 120 miles downstream of the Site, at the first downstream impoundment).

The spatial extent of this sampling will help the Trustees better determine the downstream extent of fish exposure to dioxin/furans and dioxin-like PCBs. The Trustees may consider sampling other reaches, such as Clinton (Clark Fork River upstream of Missoula) or Greenough (Blackfoot River upstream of Missoula; Figure 6.7). Final sampling locations/reaches will be described in the full SAP.

6.3.3 Sampling Methods

The Trustees will aim to collect fish in the spring (March through June) when river conditions are suitable for boat-based sampling. MFWP will use a three-person electrofishing crew and a 6.0-m aluminum jet boat with two bow-mounted boom anodes to sample fish. Power from a 6,600-watt generator will be routed through a Smith Root VVP 15-B rectifying unit that delivers 375 volts to create an electrical field of 3–6 amperes. Following an electroshock, the crew will remove shocked fish using nets. Fish will be placed in live wells for transport back to the shore for sample processing.

Figure 6.7. Proposed fish tissue sampling reaches.



Once captured, the fish will be sorted by length and species. For each target species, up to 10 individual fish will be selected within the target size group. The total length and weight will be measured in selected fish. Whole individual fish will be cleaned and prepared for analysis according to standard methods (U.S. EPA, 2000; MDEQ, 2015). All fish not selected will be immediately released back to the river.

The Trustees intend to analyze whole individual fish rather than composited fillets, if possible. Whole fish better represent total body burden for the fish and the potential exposure to higher trophic-level species that prey on target fish species. In addition, analyzing individual fish provides a better understanding of the variability in contaminant concentrations and congener patterns. However, if necessary, fish tissue samples may be filleted and composited according to standard methods (U.S. EPA, 2000). If filleted, both the carcass and the fillet tissues should be analyzed separately so that whole fish concentrations can be calculated.

All fish tissue samples will be analyzed for dioxin/furan and PCB congeners using approved high-resolution methods, such as EPA Method 8290 for dioxins and furans, and EPA Method 1668A/C for congener-specific PCBs.

6.4 Osprey Exposure

Ospreys (*Pandion haliaetus*) are high trophic-level piscivorous raptors that are considered a sentinel species for assessing contamination in rivers. They nest near rivers on accessible structures, feed locally, live for up to 25 years, and can tolerate removal of one egg from a clutch (Grove et al., 2009; Henny et al., 2010; Greene, 2021). Osprey eggs collected downstream of kraft paper mills have been shown to have significantly higher TCDD TEQ concentrations than eggs collected from reference areas upstream (e.g., Elliott et al., 1998, 2001).

Researchers at the Raptor View Research Institute and The University of Montana (UM) in Missoula have monitored dozens of osprey nests along the Clark Fork River for over 12 years (Greene, 2021), as part of a collaboration called the Montana Osprey Project. Previous research has focused on heavy metals in nestling blood and feathers at nests along the Clark Fork River, extending from the start of the Clark Fork River at Warm Springs to Tarkio, about 25 miles downstream of the Site (e.g., Langner et al., 2012). The Trustees have evaluated chlorinated compounds in osprey tissues at other sites (e.g., Buck and Kaiser, 2011) and will work with Montana Osprey Project researchers on a sampling plan to evaluate dioxins/furans and coplanar PCBs in osprey eggs and nestling tissues collected from nests along the Clark Fork River and the Bitterroot River. The goal of the study is to determine whether ospreys along the Clark Fork River near and downstream of Frenchtown are exposed to dioxins/furans and dioxin-like PCBs, and to assess spatial patterns of exposure relative to the Site.

6.4.1 Proposed Sampling Locations

The Trustees will design the study with collaborators from the Montana Osprey Project. The study will target ospreys in nests upstream of, adjacent to, and downstream of the mill property in Frenchtown. The Montana Osprey Project researchers are aware of many osprey nests in the vicinity of the mill property, including 6 nests along the Bitterroot River between Lolo and Missoula; 6 nests along the Clark Fork River between Clinton and the Bitterroot River confluence; 12 nests along the Clark Fork River from Missoula to the lower Ninemile (including at least 1 nest on the mill property); and 4 nests near St. Regis (Figure 6.8).

Generally, the sampling locations will include:

- Up to 10 nests upstream of the Site, including nests along the Clark Fork River between Clinton and Missoula, and nests along the lower Bitterroot River
- Approximately five nests adjacent to and immediately downstream of the Site, extending downstream to the Ninemile reach identified for fish tissue sampling (see Figure 6.7)
- Up to 10 nests downstream of Ninemile and upstream of Thompson Falls (see Figure 6.7), including nests near St. Regis, and potentially other nests downstream that are not yet in the Montana Osprey Project database.

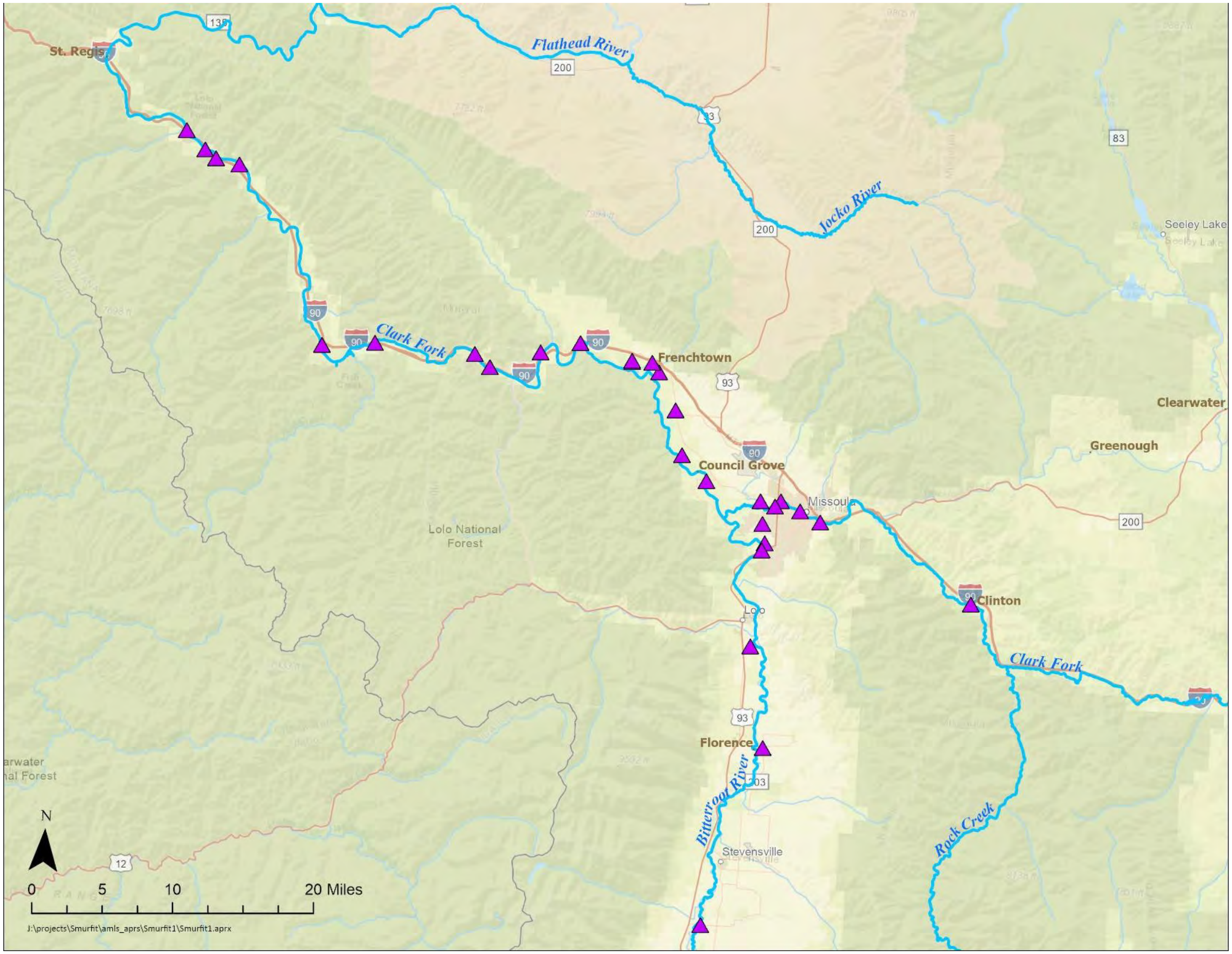
Reconnaissance research will be conducted to identify additional osprey nests downstream of the Ninemile reach. Final sampling locations will be described in the full SAP.

6.4.2 Approach

The Trustees will collaborate with the Montana Osprey Project researchers to collect eggs for analysis of dioxins/furans and dioxin-like PCBs. Previous research has shown that chlorinated compounds are concentrated in osprey egg tissues (Elliott et al., 1998). As noted previously, ospreys are a sentinel species for contaminant monitoring in part because they typically have multiple eggs in a clutch, and the removal of one egg for analysis does not adversely affect reproduction (Grove et al., 2009).

The osprey field researchers will access osprey nests using a bucket truck (Figure 6.9). Egg sampling will follow established protocols, such as those from the Portland Harbor NRDA (Buck and Kaiser, 2011). All egg tissue samples will be analyzed for dioxin/furan and PCB congeners using approved high-resolution methods, such as EPA Method 8290 for dioxins and furans, and EPA Method 1668A/C for congener-specific PCBs.

Figure 6.8. Locations of osprey nests along the Clark Fork and Bitterroot rivers near Frenchtown.



Data source: Dr. Erick Greene, UM.

Figure 6.9. Montana Osprey Project researchers access osprey nests using a bucket truck.

Source: Dr. Erick Greene, UM.

7. Quality Assurance Project Plan

This QAPP has been developed to support studies that may be performed as part of the NRDA. Under the NRDA regulations [43 CFR § 11.31], the QAPP is required to develop procedures to ensure data quality and reliability. This QAPP is intended to provide QA/QC procedures, guidance, and targets for use in future studies that may be conducted for the NRDA. It is not intended to provide a rigid set of predetermined steps with which all studies must conform or against which data quality is measured, nor is it intended that data available from other sources for use in the NRDA must adhere to each of the elements presented in this QAPP. Ultimately, the quality and usability of data are based on methods employed in conducting studies, the expertise of study investigators, and the intended uses of the data. The QAPP has been designed to be consistent with the NCP and EPA's *Guidance for Quality Assurance Project Plans* (U.S. EPA, 2002).

The elements outlined in this plan are designed to:

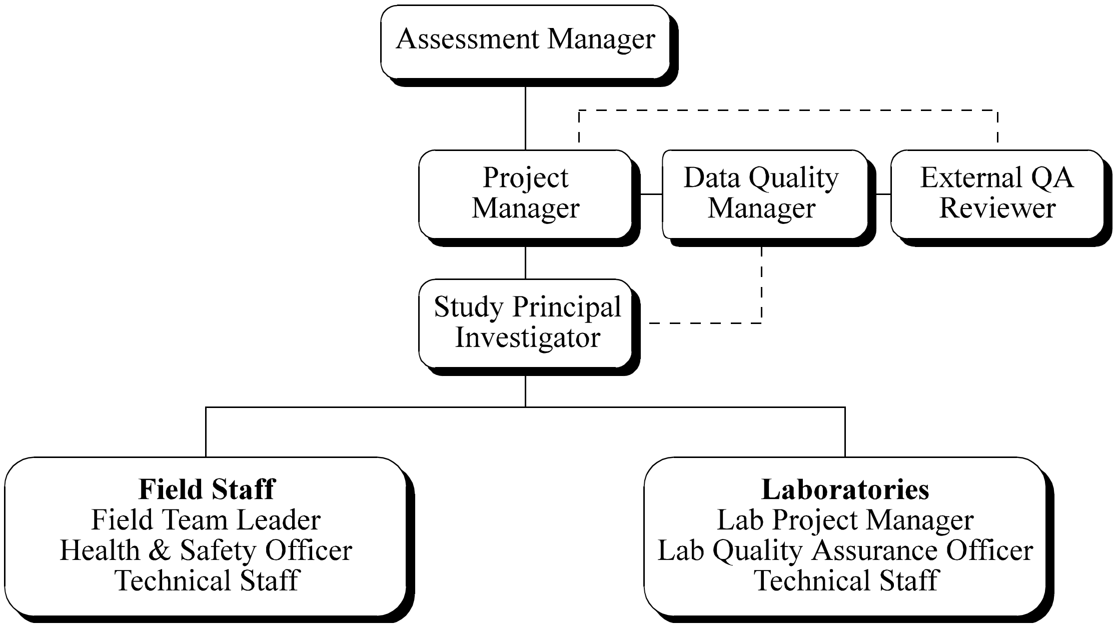
- Provide procedures and criteria for maintaining and documenting custody and traceability of environmental samples
- Provide procedures and outline QA/QC practices for sampling, collecting, and transporting samples
- Outline data quality objectives (DQOs) and data quality indicators
- Provide a consistent and documented set of QA/QC procedures for the preparation and analysis of samples
- Help ensure that data are sufficiently complete, comparable, representative, unbiased, and precise so as to be suitable for their intended uses.

Before the implementation of NRDA studies, study-specific SAPs providing descriptions of study objectives, sampling methods, and QA/QC measures will be developed. To provide an ongoing record of methods and procedures employed in the assessment, developed SAPs will be appended to this Assessment Plan, and may include study-specific QAPPs.

7.1 Project Organization and Responsibility

An example of project QA organization, including positions with responsibility for supervising or implementing QA activities, is shown in Figure 7.1, with key positions and lines of communication and coordination indicated. Defining project organization, roles, and responsibilities helps ensure that individuals are aware of specific areas of responsibility that contribute to data quality. However, fixed organizational roles and responsibilities are not necessary and may vary by study or task. Descriptions of specific QA responsibilities of key project staff are included below. Only the project positions related directly to QA/QC are described; other positions may be described in associated project plans. Specific individuals and laboratories selected to work on an investigation will be summarized and appended to this QAPP or included in study-specific SAPs when they are established.

Figure 7.1. Example of project QA organization.



7.1.1 Assessment Manager and Project Manager

The Assessment Manager (AM) is responsible for all technical, financial, and administrative aspects of the project. The Project Manager (PM) supports the AM and is responsible for producing quality data and work products for this project within allotted schedules and budgets. Duties of both include executing all phases of the project and efficiently applying the full resources of the project team in accordance with the project plans. Specific QA-related duties of the AM and the PM can include:

- Coordinating the development of a project scope, project plans, and DQOs
- Ensuring that written instructions in the form of standard operating procedures (SOPs) and/or associated SAPs are available for activities that affect data quality
- Monitoring investigative tasks for their compliance with plans, written procedures, and QC criteria
- Monitoring the performance of subcontractors in regard to technical performance and specifications, administrative requirements, and budgetary controls
- Participating in performance and/or systems audits, and monitoring the implementation of corrective actions
- Reviewing, evaluating, and interpreting data collected as part of this investigation
- Supervising the preparation of project documents, deliverables, and reports
- Verifying that all key conclusions, recommendations, and project documents are subjected to independent technical review, as scheduled in the project plans.

7.1.2 Data Quality Manager

A Data Quality Manager can be assigned to be responsible for the overall implementation of the QAPP. General duties include conducting activities to ensure compliance with the QAPP, reviewing final QA reports, training field staff in QA procedures, providing technical QA assistance, preparing and submitting QA project reports to the AM and PM, conducting and approving corrective actions, and conducting audits, as necessary. Specific tasks may include:

- Assisting the project team with the development of DQOs
- Managing the preparation of and reviewing data validation reports
- Submitting QA reports and corrective actions to the PM
- Ensuring that data quality, data validation, and QA information are complete and are reported in the required deliverable format
- Communicating and documenting corrective actions
- Maintaining a copy of the QAPP
- Supervising laboratory audits and surveillance
- Ensuring that written instructions in the SOPs and SAPs are available for activities that affect data quality
- Monitoring investigative tasks for their compliance with plans, written procedures, and QC criteria
- Monitoring the performance of subcontractors in regard to technical performance and specifications, administrative requirements, and budgetary controls
- Reviewing, evaluating, and interpreting data collected as part of this investigation.

7.1.3 External Quality Assurance Reviewer

If needed, external QA Reviewers can be assigned to review QA documentation and procedures, perform data validation, and perform field and laboratory audits.

7.1.4 Principal Investigator

Study-specific Principal Investigators (PIs) ensure that QA guidance and requirements are followed. The PI or the designee will note significant deviations from the QAPP for the study. Significant deviations will be recorded and promptly reported to the PM and Data Quality Manager. In addition, the PI typically is responsible for reviewing and interpreting study data and preparing reports.

7.1.5 Field Team Leader

The Field Team Leader (FTL) supervises sample collection, field observations, field measurements, and other day-to-day field investigation tasks. The FTL generally is responsible for all field QA procedures defined in the QAPP, and in associated SAPs and SOPs. Specific responsibilities may include:

- Implementing the field investigation in accordance with project plans
- Supervising field staff and subcontractors to monitor that appropriate sampling, testing, measurement, and recordkeeping procedures are followed
- Ensuring the proper use of SOPs associated with data collection and equipment operation
- Monitoring the collection, transport, handling, and custody of all field samples, including field QA/QC samples
- Coordinating the transfer of field data, including field sampling records, chain-of-custody (COC) records, and field logbooks
- Informing the PI and Data Quality Manager when problems occur, and communicating and documenting any corrective actions that are taken.

7.1.6 Laboratory Project Manager

A Laboratory Project Manager can be responsible for monitoring and documenting the quality of laboratory work. Duties may include:

- Ensuring that the staff and resources required to produce quality results in a timely manner are committed to the project
- Ensuring that the staff are adequately trained in the procedures that they are using so that they are capable of producing high-quality results and detecting situations not within the QA limits of the project
- Ensuring that the stated analytical methods and laboratory procedures are followed and the laboratory's compliance is documented
- Maintaining a laboratory QA manual and documenting that its procedures are followed
- Ensuring that laboratory reports are complete and reported in the required deliverable format
- Communicating, managing, and documenting all corrective actions initiated at the laboratory
- Notifying the Data Quality Manager of any situations that will potentially result in qualification of the analytical data.

7.1.7 Technical Staff

Technical staff should have adequate education, training, and specific experience to perform individual tasks as assigned. They are required to read and understand any documents describing the technical procedures and plans that they are responsible for implementing.

7.2 Quality Assurance Objectives for Measurement Data

7.2.1 Overview

QA objectives are qualitative and quantitative statements that aid in specifying the overall quality of data required to support various data uses. These objectives often are expressed in terms of accuracy, precision, completeness, comparability, representativeness, and sensitivity.

Laboratories involved with the analysis of samples collected in support of this NRDA will make use of various QC samples such as standard reference materials (SRMs), matrix spikes, and replicates to assess adherence to the QA objectives discussed in the following sections and in specific laboratory QA/QC plans. The overall QA objectives are to help ensure that the data collected are of known and acceptable quality for their intended uses. Numeric QC criteria are specific to a study, method, or laboratory; and hence criteria are not included in this QAPP. When appropriate, criteria can be established when study and method procedures are approved; such criteria will be appended to this QAPP or included in study-specific SAPs. Criteria will be determined based on factors that may include:

- Specific analytical methods and accepted industry standards of practice
- Matrix-specific control limits for acceptable sample recovery, accuracy, or precision
- Historical laboratory performance of selected analytical methods
- Intended uses of the data.

Where statistically generated or accepted industry standards of practice are not available, QC criteria may be defined by the Data Quality Manager working with the Laboratory QA Officer and PIs.

7.2.2 Quality Control Metrics

Accuracy

Accuracy is a quantitative measure of how close a measured value lies to the actual or "known" value. Sampling accuracy is partially evaluated by analyzing field QC samples such as field blanks, trip blanks, and rinsates (or equipment blanks). In these cases, the "true" concentration is assumed to be not detectable, and any detected analytes may indicate a positive bias in associated environmental sample data.

Laboratory accuracy is assessed using sample (matrix) spikes and other QC samples. For example, a sample (or blank) may be spiked with an inorganic compound of known concentration and the average percent recovery (%R) calculated as a measurement of accuracy. A second procedure is to analyze a standard (e.g., SRMs or other certified reference materials) and calculate the %R for that known standard. As an additional, independent check on laboratory accuracy, blind SRMs submitted as field samples may be used.

Accuracy criteria are established statistically from historical performance data and often are based on confidence intervals set about the mean. Where historical data are not adequate for statistical calculations, criteria may be set by the Laboratory Project Manager, Data Quality Manager, and PIs. Accuracy criteria will be appended to this QAPP or included in study-specific SAPs when established. Accuracy may be assessed during the data validation or data quality assessment stage of these investigations.

Precision

Precision is a measure of the reproducibility of analytical results under a given set of conditions. The overall precision of a set of measurements is determined by both sampling and laboratory variables. Reproducibility is affected by sample collection procedures, matrix variations, the extraction procedure, and the analytical method.

Field precision typically is evaluated using sample replicates, which are usually duplicate or triplicate samples. Sample replicates may be generated by homogenizing the sample, splitting the sample into several containers, and initiating a blind submittal to the laboratory with unique sample numbers. For a duplicate sample, precision of the measurement process (sampling and analysis) is expressed as:

$$\text{Relative Percent Difference (RPD)} = \frac{2(\text{Duplicate Sample Result} - \text{Sample Result})}{(\text{Duplicate Sample Result} + \text{Sample Result})} \times 100.$$

For a triplicate analysis, precision of the sampling and analysis process is expressed as:

$$\text{Percent Relative Standard Deviation (\%RSD)} = \frac{\sigma_{n-1}}{\text{Mean}} \times 100,$$

where σ_{n-1} is the standard deviation of the three measurements.

Laboratory precision typically is evaluated using laboratory duplicates, matrix spike duplicates, or laboratory control sample or SRM duplicate sample analysis. Duplicates prepared in the laboratory are generated before sample digestion. Laboratory precision is also expressed as the RPD between a sample and its duplicate, or as the %RSD for three values.

Precision criteria are established statistically from historical performance data and are usually based on the upper confidence interval set at two standard deviations above the mean. Where historical data are inadequate for statistical calculations, criteria may be set by the Laboratory Project Manager, Data Quality Manager, and PIs. Precision criteria will be appended to this QAPP or included in study-specific SAPs, when established.

Completeness

Completeness is defined as the percentage of measurement data that remain valid after discarding any invalid data during the field or laboratory QC review process. A completeness check may be performed following a data validation process. Analytical completeness goals may vary depending on study type, methods, and intended uses of the data.

Analytical data completeness will be calculated by analyte. The percent of valid data is 100 times the number of sample results not qualified as unusable divided by the total number of samples analyzed. Data qualified as estimated because of minor QC deviations (e.g., laboratory duplicate RPD exceeded) will be considered valid.

Comparability

Comparability is a qualitative parameter expressing the confidence with which one dataset can be compared to another. Comparability is facilitated by use of consistent sampling procedures, standardized analytical methods, and consistent reporting limits and units. Data comparability is evaluated using professional judgment.

Representativeness

Representativeness expresses the degree to which data accurately and precisely represent a defined or particular characteristic of a population, parameter variations at a sampling point, a processed condition, or an environmental condition. Representativeness is a qualitative parameter that is dependent on the proper design of the sampling program and proper laboratory protocol. Sampling designs for this investigation will be intended to provide data representative of sampled conditions. During development of SAPs and SOPs, consideration will be given to existing analytical data, environmental setting, and potential industrial sources. Representativeness will be satisfied by ensuring that the sampling plan is followed.

Sensitivity

Detection limit targets for each analyte and matrix will be appended to this QAPP or included in study-specific SAPs as they are established.

7.3 Sampling Procedures

7.3.1 Sample Collection

Samples are collected and handled in accordance with the procedures contained in SOPs or associated SAPs. These documents describe sample collection, handling, and documentation procedures to be used during field activities. As appropriate, SOPs and SAPs may cover the following topics:

- Procedures for selecting exact sample locations and frequency of collection
- Sampling equipment operation, decontamination, and maintenance
- Sample collection and processing, which includes sample collection order and homogenization procedures, sample containers, and volume required
- Field QC sample and frequency criteria
- Sample documentation, including COC and field documentation forms and procedures
- Sample packaging, tracking, storage, and shipment procedures.

7.3.2 Sample Containers, Preservation, and Holding Times

Containers will be prepared using EPA specified or other professionally accepted cleaning procedures. Analysis statements for containers prepared by third-party vendors will be included in the project file. Since the investigations involved with this NRDA may involve samples not amenable to typical environmental sample containers (such as whole body tissue samples), multiple types of containers may be required. Sample containers may include aluminum foil and watertight plastic bags for tissue samples and whole body samples.

When appropriate, sample coolers will contain refrigerant in sufficient quantity to maintain samples at the required temperatures until receipt at the laboratories.

7.3.3 Sample Identification and Labeling Procedures

Before transportation, samples should be properly identified with labels, tags, or markings. The sample identification and labeling scheme should result in a unique identification for each sample and be consistent across the Trustees' data collection activities. Identification and labeling typically include, but need not be limited to, the following information:

- Project identification
- Place of collection
- Sample identification
- Analysis request
- Preservative
- Date and time of collection
- Name of sampler (initials)
- Number of containers associated with the sample.

7.3.4 Field Sampling Forms

Field sampling forms should be described in the appropriate SOP or associated SAP, and be designed for ease of use in the field and for completeness of documentation. Forms typically must be completed in the field at the same time as the sample label. At a minimum, date, time, sampler's initials, location, and other specific field observations should be completed at the time of sampling. The FTL should review the field sampling forms, make any necessary corrections, and initial them as approved.

7.3.5 Sample Storage and Tracking

In the field, samples may be stored temporarily in coolers with wet or dry ice (as appropriate). Security should be maintained and proper storage should be documented in the project field notebook. Samples stored temporarily in coolers should be transported to a storage facility as soon as logistically possible. When possible, samples will be shipped directly to the appropriate laboratories from the field.

Samples will be stored under appropriate conditions at the storage facility or laboratory (e.g., refrigerator or freezer) before analysis. Security should be maintained at all times. A log book or inventory record typically is maintained for each sample storage facility refrigerator or freezer. The log books or inventory records are used to document sample movement in and out of the facility. In general, samples will be placed into a freezer and information regarding sample identification, matrix, and study will be recorded. Additional information in the record for each sample may include the date of the initial storage, subsequent removal/return events with associated dates, and initials of the person(s) handling the samples. Additional information may also include the study name and special comments. If required, unused samples or extra samples will be archived in a secure location under appropriate holding conditions to ensure that sample integrity is maintained.

Documentation should allow for unambiguous tracking of the samples from the time of collection until shipment to the laboratory. The tracking system should include a record of all sample movement, and provide identification and verification (initials) of the individuals responsible for the movement.

7.4 Sample Custody

COC procedures are adopted for samples throughout the field collection, handling, storage, and shipment process. Each sample will be assigned a unique identification label and have a separate entry on a COC record. A COC record should accompany every sample and every shipment to document sample possession from the time of collection through final disposal.

7.4.1 Definition of Custody

A sample is defined as being in a person's custody if one of the following conditions applies:

- The sample is in the person's actual possession or view
- The sample was in the person's possession and then was locked in a secure area with restricted access
- The person placed it in a container and sealed the container with a custody seal in such a way that it cannot be opened without breaking the seal.

7.4.2 Procedures

The following information typically will be included on COC forms:

- Place of collection
- Laboratory name and address
- Sample receipt information (total number of containers, whether COC seals are intact, whether sample containers are intact, and whether the samples are cold when received)
- Signature block with sufficient room for "relinquished by" and "received by" signatures for at least three groups (i.e., field sampler, intermediate handler, and laboratory personnel)
- Sample information (e.g., field sample identifier, date, time, matrix, laboratory sample identifier, and number of containers for that sample identifier)
- Name of the sampler
- Airbill number of overnight carrier (if applicable)
- Disposal information (to track sample from "cradle to grave")
- Block for special instructions
- Analysis request information.

The sample identification, date and time of collection, and request for analysis on the sample label should correspond to the entries on the COC form and in associated field log books or sampling forms.

Responsibility for reviewing the completed COC forms lies with the Data Quality Manager or designated representative. Any inconsistencies, inaccuracies, or incompleteness in the forms must be brought to the attention of the field staff completing the form. Corrective action should be taken and documented if the problem is significant. Depending on the problem, this may involve informing the laboratory that a sample identification or analysis request needs to be changed or notifying the FTL that retraining of field staff in COC procedures is indicated. The corrective action and its outcome should be documented.

7.5 Data Validation and Reporting

7.5.1 General Approach

Data generated by the laboratory and during field measurements may undergo data review and validation by an External QA Reviewer. Laboratory data may be evaluated for compliance with DQOs, with functional guidelines for data validation, and with procedural requirements contained in this QAPP.

7.5.2 Data Reporting

Laboratories should provide sufficient information to allow for independent validation of the sample identity and integrity, the laboratory measurement system, the resulting quantitative and qualitative raw data, and all information relating to standards and sample preparation. Laboratories should provide a usable electronic version of their results in a common database format.

7.5.3 Data Review and Validation of Chemistry Data

Data review is an internal laboratory process in which data are reviewed and evaluated by a laboratory supervisor or QA personnel. Data validation is an independent review process conducted by personnel not associated with data collection and generation activities. External and independent data validation may be performed for selected sample sets as determined by the PM and Data Quality Manager. Each data package chosen for review will be assessed to determine whether the required documentation is of known and documented quality. This includes evaluating whether:

- Field COC or project catalog records are present, complete, signed, and dated
- The laboratory data report contains the required deliverables to document procedures.

Two levels of data validation may be performed: full or cursory validation. Initial data packages received for each sample matrix may receive full validation. This consists of a review of the entire data package for compliance with documentation and QC criteria for the following:

- Analytical holding times
- Data package completeness
- Preparation and calibration blank contamination
- Initial and continuing calibration verifications
- Internal standards
- Instrument tuning standards
- Analytical accuracy (matrix spike recoveries and laboratory control sample recoveries)
- Analytical precision (comparison of replicate sample results)
- Reported detection limits and compound quantitation

- Review of raw data and other aspects of instrument performance
- Review of preparation and analysis bench sheets and run logs.

Cursory validation may be performed on a subset of the data packages at the discretion of the PM and Data Quality Manager. Cursory review includes the comparison of laboratory summarized QC and instrument performance standard results to the required control limits, including:

- Analytical holding times
- Data package completeness
- Preparation and calibration blank contamination
- Analytical accuracy (matrix spike recoveries and laboratory control sample recoveries)
- Analytical precision (comparison of replicate sample results).

Both the full and the cursory validation will follow documented QC and review procedures as outlined in the guidelines for data validation (U.S. EPA, 2002) and documented in validation and method SOPs. Various qualifiers, comments, or narratives may be applied to data during the validation process. These qualifier codes may be assigned to individual data points to explain deviations from QC criteria and will not replace qualifiers or footnotes provided by the laboratory. Data validation reports summarizing findings will be submitted to the Data Quality Manager for review and approval.

Laboratory data will be evaluated for compliance with DQOs. Data usability, from an analytical standpoint, may be evaluated during the data evaluation. The data users (the PI, PM, and AM) will determine the ultimate usability of the data.

7.6 Corrective Actions

7.6.1 Definition

Corrective actions consist of the procedures and processes necessary to correct and/or document situations where data quality and/or QA procedures fall outside of acceptance criteria or targets. (These criteria/targets may be numeric goals such as those discussed in Section 6.2, or procedural requirements such as those presented throughout the QAPP and other project documents [e.g., SAPs and SOPs]).

The goal of corrective action is to identify as early as possible a data quality problem and to eliminate or limit its impact on data quality. The corrective action information typically is provided to a Data Quality Manager for use in data assessment and long-term quality management. Corrective action typically involves the following sequential steps:

- Discovering any nonconformance or deviations from DQOs or the plan
- Identifying the party with authority to correct the problem
- Planning and scheduling an appropriate corrective action
- Confirming that the corrective action produced the desired result
- Documenting the corrective action.

7.6.2 Discovery of Nonconformance

The field personnel and bench-level analysts are responsible for initial identification of nonconformance with procedures and QC criteria. Performance and system audits are also designed to detect these problems. However, anyone who identifies a problem or potential problem should initiate the corrective action process by, at the least, notifying a PI or Data Quality Manager of his or her concern.

Deviations from SAP, QAPP, and SOP procedures are sometimes required and appropriate because of field or sample conditions. Such deviations should be noted in field or laboratory logbooks and their effect on data quality evaluated by a PI and Data Quality Manager. Occasionally, procedural changes are made during an investigation because method improvements are identified and implemented. Even though these procedural improvements are not initiated because of nonconformance, they are procedural deviations and typically should be documented.

7.6.3 Planning, Scheduling, and Implementing Corrective Action

Appropriate corrective actions for routine problems depend on the particular situation but may range from documentation of the problem to resampling and reanalysis to the development of new methods. When the corrective action is within the scope of these potential actions, the bench-level analyst or the field staff can identify the appropriate corrective action and implement it. Otherwise, the corrective action should be identified and selected by the PM, the FTL, the Laboratory Manager, or the Data Quality Manager.

7.6.4 Confirmation of the Result

While a corrective action is being implemented, additional work dependent on the nonconforming data should not be performed. When the corrective action is complete, the situation should be evaluated to determine if the problem was corrected. If not, new corrective actions should be taken until no further action is warranted, either because the problem is now corrected or because no successful corrective action has been found.

7.6.5 Documentation and Reporting

Corrective action documentation may consist of the following reports or forms:

- Corrective action forms initiated by project staff that will be collected, evaluated, and filed by the Data Quality Manager
- Corrective action log maintained by the Data Quality Manager to track the types of nonconformance problems encountered and successful completion of corrective actions
- Corrective action plans, if needed, to address major nonconformance issues
- Performance and systems audit reports, if such audits are performed
- Corrective action narratives included as part of data reports from independent laboratories
- Corrective action forms initiated by laboratory staff and summarized in the report narrative.

7.6.6 Laboratory-Specific Corrective Action

The need for corrective action in the analytical laboratory may originate from several sources: equipment malfunction, failure of internal QA/QC checks, method blank contamination, failure of performance or system audits, and/or noncompliance with QA requirements. When measurement equipment or analytical methods fail QA/QC checks, the problem should immediately be brought to the attention of the appropriate laboratory supervisor in accordance with the laboratory's SOP or Quality Assurance Plan. If the failure is due to equipment malfunction, the equipment should be repaired, the precision and accuracy should be reassessed, and the analysis rerun.

All incidents of QA failure and the corrective action tasks should be documented, with the reports placed in the appropriate project file. Corrective action should also be taken promptly for deficiencies noted during spot checks of raw data. As soon as sufficient time has elapsed for a corrective action to be implemented, evidence of correction of deficiencies should be presented to a Data Quality Manager or PI.

Laboratory corrective actions may include, but are not limited to:

- Reanalyzing the samples, if holding time criteria permit and if sample volume is available
- Resampling and analyzing
- Evaluating and amending sampling analytical procedures
- Accepting data and acknowledging the level of uncertainty.

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